Township of Springwater

Midhurst Secondary Plan Area

COMPREHENSIVE STORMWATER MANAGEMENT PLAN

FINAL REPORT

Volume 2 of 4

Appendix D to F-1

June 2020

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CONSULTING
ENGINEERS
PLANNERS

Appendix D

Aquatic Studies Willow Creek, Matheson Creek, and Black Creek

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Baseline Aquatic Studies for Midhurst Secondary Plan – Carson Road Development

2008-2016

Prepared for: Midhurst Landowner Group
Job #: J140054

January, 2018

DRAFT FOR DISCUSSION

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January 19, 2018 HESL Job #: J140054

Midhurst LandownerGroup
c/o Mr. Vimal Patel
Sr. Project Manager, Land Development
Geranium Corporation
3190 Steeles Avenue E., Suite 300
Markham, ON L3R 1G9

Dear Vimal:

Re: J140054 - Draft Report - Baseline Aquatic Studies for Midhurst Secondary Plan - Carson Road

A number of studies have been completed to characterize the baseline chemical and biological conditions of Willow Creek and its tributaries in Midhurst for the proposed Midhurst Secondary Plan Area (MSPA). This report presents the results of baseline studies completed at the site of the Carson Road Development. Information on water quality, flows, benthic invertebrates and fisheries was collected by Gartner Lee Limited and AECOM in 2008-2009 and analyzed by Hutchinson Environmental Sciences Ltd. (HESL), while additional information was collected by HESL in 2015 and 2016. Baseline data were collected to meet the requirements of the Monitoring and Adaptive Management Plan for the Midhurst Secondary Plan Area, monitor the response of the aquatic environment to the development proposed as part of the MSPA and to inform the Adaptive Monitoring and Management Plan to minimize any potential future impacts on the watercourses.

We thank you for the opportunity to assist the Midhurst Development Group with this project and hope that this report meets your needs.

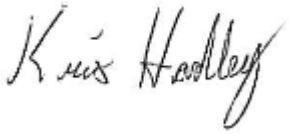
Sincerely,
Hutchinson Environmental Sciences Ltd.



Brent Parsons
brent.parsons@environmentalsciences.ca

Signatures

Report Prepared by:



Kristopher Hadley, Ph.D.
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Principal Aquatic Scientist

Executive Summary

This report summarizes the methods and resultant data used to develop a baseline of water quality and aquatic biology for surface waters in the vicinity of the proposed Carson Road development within the Midhurst Secondary Plan Area (MSPA). The MSPA is located in the Township of Springwater, County of Simcoe, Ontario. Existing development in the Secondary Plan Area includes residential, commercial/industrial, mixed and agricultural uses. Proposed development in the Secondary Plan Area includes residential communities, commercial, industrial, mixed use and employment lands. The details of the planned development for the Midhurst Secondary Plan Area are contained within the Twp. of Springwater Official Plan Amendment (OPA) No. 38 “Midhurst Secondary Plan” and in approved draft plans. Although the total area of the MSPA is approximately 2,813 ha the development will be phased, with 300ha developed in Phase 1 and the Full Build Out occurring over a longer time period.

The proposed Carson Neighbourhood is a mixed density development is approximately 234 hectares (578 acres) in size, bounded by Snow Valley Road to the north, a wooded area and existing estate residential development to the east, the Midhurst Settlement Area boundary to the south, and a tributary of Black Creek to the west. It lies within the Willow Creek subwatershed of the Nottawasaga watershed and contains the headwaters of Black Creek, a tributary of Willow Creek.

The interactions of the MSPA with the aquatic environment will be managed through the stormwater management plan and an adaptive monitoring and management plan which provide the means to minimize any effects of the development on surface water and monitor surface water conditions . Collection of baseline data on water quality and aquatic biology of the study area began in 2008 and continued to the end of 2017. The results from 2017will be integrated into subsequent versions of this report. These data will be used to describe the pre-development conditions, monitor any changes during construction and occupation and inform the Master Drainage Plan.

Black Creek is a coldwater stream that contains sufficient base flow and habitat to support a varied benthic community and an environmentally sensitive brook trout population. Following the initial 2008 survey, it was recommended that additional monitoring be completed to expand our understanding of the baseline condition and natural variability at Carson Road. Natural variability must be considered during future comparisons to assist in identifying if deviations from baseline conditions are within the range of natural variability or if they reflect impacts from the developments. In general, we found that water quality and stream flow did not vary considerably between 2009 and the current program but we have captured an expanded range of values for many key parameters and therefore developed a better understanding of the natural variability of the system.

Benthic invertebrate community indices indicated good to excellent water quality in Black Creek, which was supported by water quality data. High species turnover at some benthic invertebrate stations highlights the high variability in benthic sampling which can limit their usefulness as biological proxies of stream health (Valois et al. 2009).

We noted only a few guideline exceedances in nutrients and metals. These were associated with high suspended sediment loads and therefore not readily biologically available. Likewise, dissolved oxygen concentrations were above guidelines in all, but a few samples collected during a low flow event in 2014. Monitoring of dissolved oxygen is ongoing in 2017 and 2018.

Fish community diversity was limited, consisting of only brook trout at all Carson Road sampling stations. Brook trout are highly sensitive to environmental degradation (e.g., turbidity, chlorine and dissolved oxygen); ranked as the most sensitive species in Toronto-area streams (Wichert and Regier 1998). The Master Drainage Plan will provide guidelines to protect the aquatic environment.

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1. Introduction and Project Understanding

The Midhurst Landowner Group is currently implementing development approvals within the Midhurst Secondary Plan Area of the Township of Springwater, including draft subdivision approvals within the Doran and Carson Neighbourhoods. Three initial summary reports were prepared by AECOM in 2009, including one to describe baseline surface water conditions within and downstream of the Carson Road Development project which drains to Black Creek (GLL/AECOM 2009). HESL initiated a work plan to expand on the baseline datasets in 2014 and continued that data collection in 2015, 2016 and 2017. This report summarizes the data collected in 2014, 2015 and 2016 in the context of the 2008 data and provides an assessment of the baseline water quality data collected in the Carson Road Development Area to date. Additional data were collected in 2017 and will be incorporated in the subsequent versions of this report. Companion reports will address surface water conditions at the Doran Road development (HESL 2017a), Midhurst Heights development (HESL 2017b) and in Willow Creek (HESL 2017c).

Information from these baseline reports informs the ongoing development and implementation of the Adaptive Monitoring and Management Plan (AMMP) as part of the Midhurst Secondary Plan Master Drainage Plan. The purpose of the AMMP is to:

- Identify and assess potential implications of the proposed development
- Design a solution using current best practices
- Implement the design through construction
- Monitor the performance of the design
- Evaluate the results
- Adjust the designs as appropriate

The overall goal of this study was to expand upon the baseline water quality dataset at the Carson Road Development site prior to the approved land use changes associated with the proposed development in the Midhurst Secondary Plan Area. This report compiles the baseline data collected during field programs in 2008, and 2014-2016. This expanded the existing dataset to inform on the natural inter-annual variation within the watercourse thus providing a more robust description of baseline water quality for future assessment to identify any changes to surface water from the proposed methods of stormwater management, and provide guidance for the design and mitigation of the future developments.

2. Description of Carson Road Development

2.1 Carson Road Development

The proposed Carson Road development is approximately 234 hectares (578 acres) in size, bounded by Snow Valley Road to the north, a wooded area and existing estate residential development to the east, the Midhurst Settlement Area boundary to the south, and a tributary of Black Creek to the west (Figure 1). It falls within the Willow Creek subwatershed of the Nottawasaga River watershed and contains the headwaters of Black Creek, a tributary of Willow Creek.

Groundwater from municipal wells will be used as the domestic water supply, while domestic sewage will be collected, treated and discharged to Willow Creek downstream of the community of Midhurst. The Ainley

Group is currently carrying out Phases 3 and 4 of a Class Environmental Assessment (EA) on behalf of the Township of Springwater to finalize the servicing/infrastructure (water, wastewater, transportation) requirements for the Midhurst Secondary Plan. A Master Drainage Plan is also being completed.

2.2 Stormwater Management

On site controls, Low Impact Development (LID) techniques and Best Management Practices (BMP) will be developed and implemented to infiltrate as much stormwater as possible with the target for infiltration in the post-development of 25 mm of rainfall. This will reduce stormwater temperatures and volumes, and improve water quality by removing phosphorus from the stormwater. Stormwater in excess of the infiltration will be collected and treated to, at least, MOE "Enhanced Level" standards (80% removal of Total Suspended Solids) and discharged to tributaries of Willow Creek on site at locations adjacent to the stormwater management ponds (Figure 2).

3. Environmental Setting

3.1 Carson Road Development

The headwaters of Black Creek are contained within the proposed Carson Road Development area. The creek flows northwest past Carson Road before heading north towards Springwater Provincial Park. It then turns westward and runs parallel to Willow Creek before the two water courses merge and enter the Minesing Swamp (Figure 1). The creek has been reported to contain good cold-water habitat and to provide suitable spawning grounds for brook trout (*Salvelinus fontinalis*) and existing brook trout populations have been observed at both Carson Road and Wilson Road (Azimuth 2003; NVCA 2000; HESL 2014a). Brook trout are sensitive to environmental perturbations and thus Black Creek is considered to be an ecologically sensitive coldwater habitat.

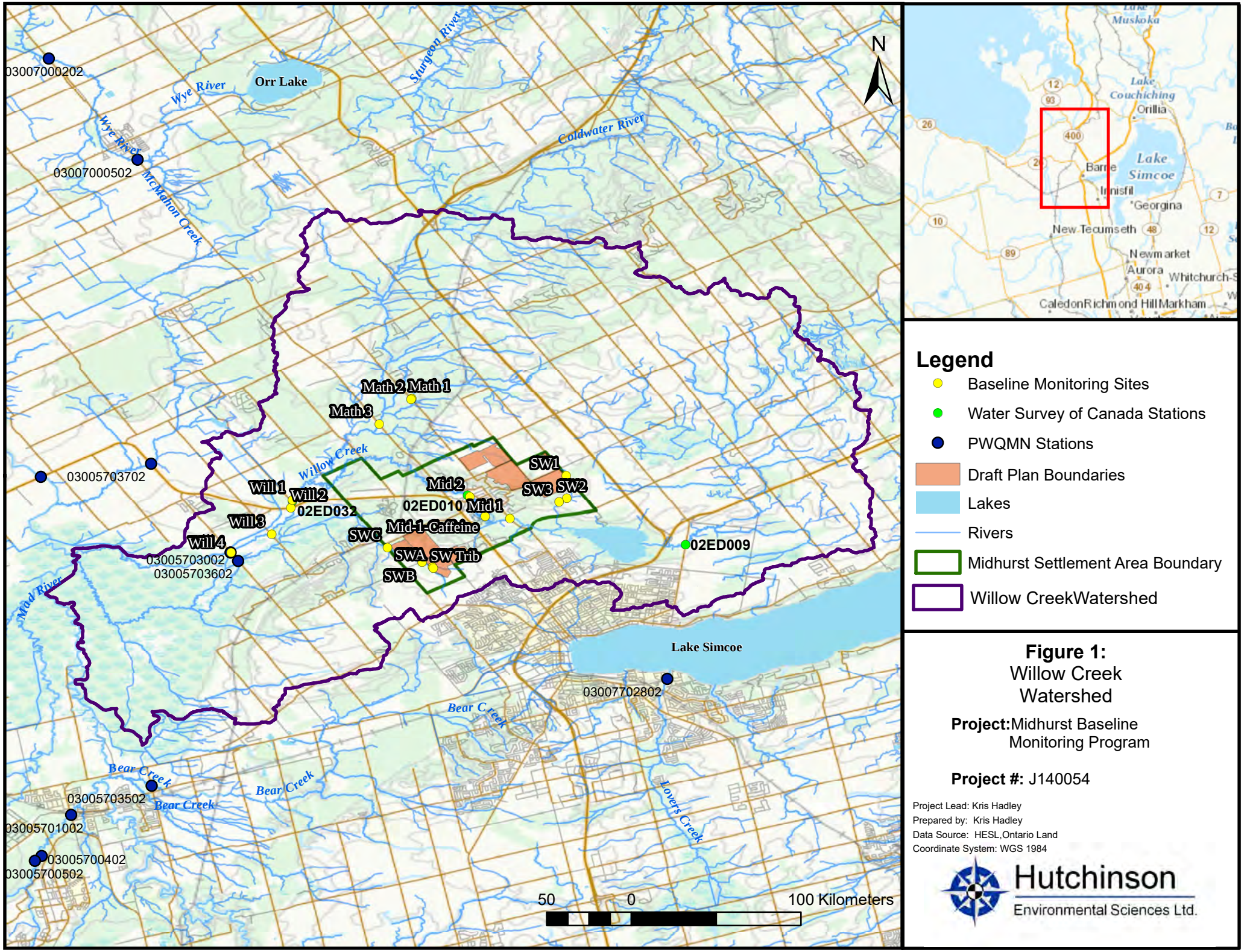


Figure 1:
Willow Creek
Watershed

Project: Midhurst Baseline
Monitoring Program

Project #: J140054

Project Lead: Kris Hadley
Prepared by: Kris Hadley
Data Source: HESL,Ontario Land
Coordinate System: WGS 1984

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3.2 Natural Heritage Features

Five designated environmentally significant areas exist in and around Midhurst that are linked to surface waters of the Willow Creek subwatershed. They are:

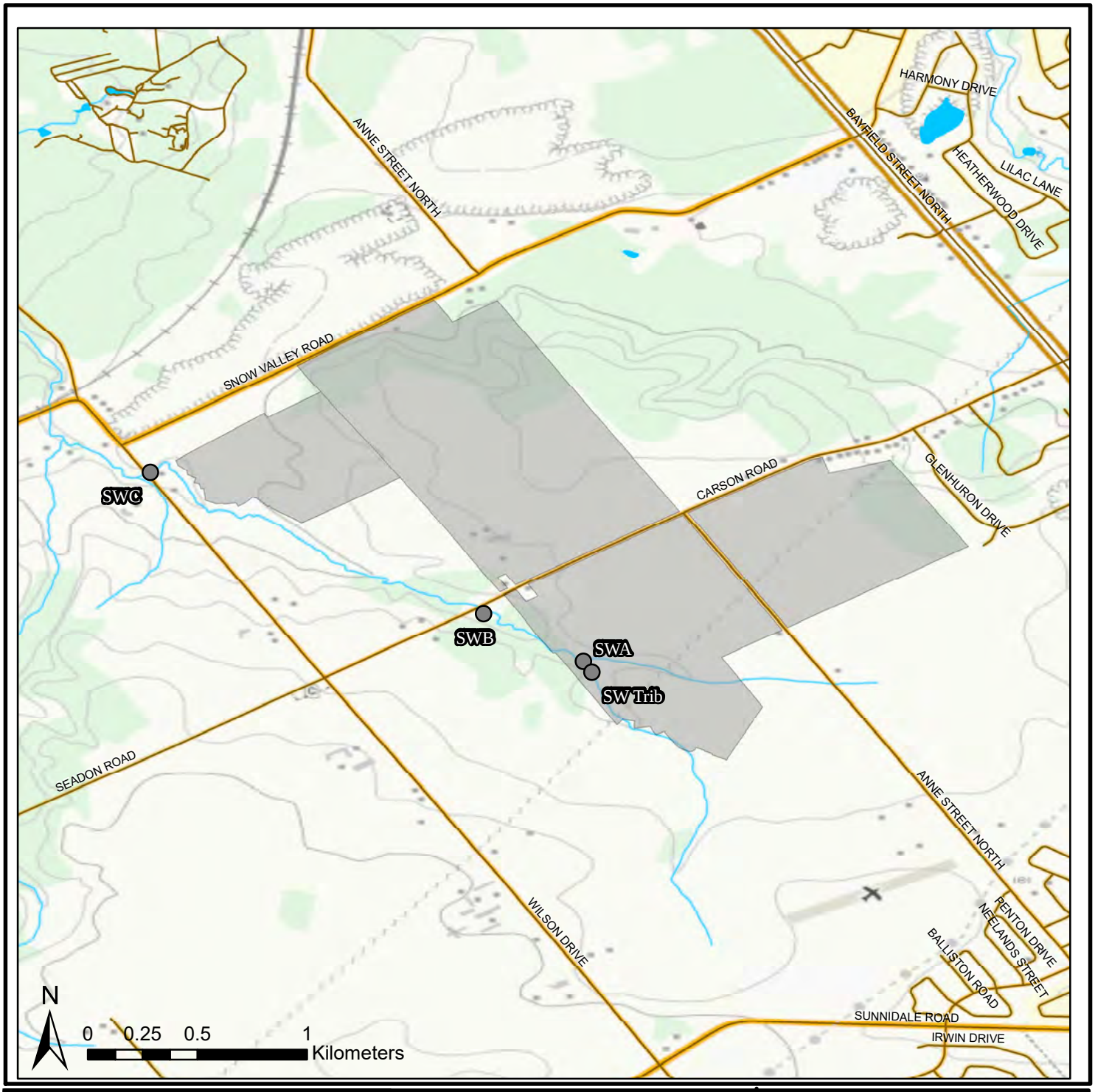
- **Little Lake Provincially Significant Wetland:** A wetland complex of 285 hectares that surrounds Little Lake. It is almost completely lacustrine, however, a small portion in the northwest contains riverine communities where Willow Creek enters Little Lake. Downstream, the reach of Willow Creek under St. Vincent Street is hydrologically connected to the Little Lake PSW.

- **Midhurst Swamp:** Midhurst Swamp is a 450 ha. Wetland, designated EP1 in the Springwater Township OP, 40% of which is comprised of riverine communities associated with Willow Creek. Treated stormwater, discharged at levels sufficient to protect surface waters at the Doran site, will not impact Midhurst Swamp.

- **Springwater Provincial Park:** Springwater Provincial Park is a recreational park located south of Willow Creek. It contains a wide variety of vegetation communities due to varied soils, topography and numerous localized areas of groundwater. Willow Creek flows well north of Springwater Provincial Park and therefore the Doran Road development will have no interaction or impact on it.

- **Minesing Swamp Provincially Significant Wetland:** Minesing Swamp PSW is not only provincially significant but it is also designated as a wetland of international importance by the Ramsar Convention on Wetlands. Willow Creek and its tributaries flow into Minesing Swamp before reaching the Nottawasaga River. Discharge of treated stormwater and sewage effluent at levels sufficient to protect the surface waters of Willow Creek and its tributaries will not impact Minesing Swamp.

- **Simcoe County Greenlands Designation:** The Simcoe County Greenlands Designation is found in the Simcoe County OP (County of Simcoe 2016). It represents areas identified based on criteria outlined within the “Development of a Natural Heritage System for the County of Simcoe” report (GLL 1996). None of the tributaries to Willow Creek in the proposed Doran Neighbourhood are designated as Greenlands.





Legend

- Rivers
- Lakes
- Carson Road Sites
- Carson Road Development Area

Project Lead: Kris Hadley
Prepared by: Kris Hadley
Data Source: HESL,Ontario Land, ESRI
Coordinate System: GCS WGS 1984

Figure 2:
Carson Road
Sampling Sites

Project: Carson Road
Baseline Monitoring

Project #: J140054

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3.3 Hydrogeology

Midhurst is in the Simcoe Upland and Lowland (elevations below 230 masl) physiographic regions (Chapman and Putnam 1984). A survey of the area has identified four regional aquifers (Golder Associates 2015). Aquifer A1 is located beneath the uplands (above 240 masl) while aquifer A2 lies below both the uplands and the lowlands at the Carson Road Development. These two aquifers (A1 and A2) discharge groundwater to local creeks and have elevated nitrate levels, a likely result of agricultural activities and domestic sewage disposal by septic systems. Deeper aquifers A3 and A4 are isolated from direct impact from surface activities and are proposed as the source of municipal water for the Midhurst Secondary Plan area. Willow Creek, downstream of Midhurst receives groundwater inputs from aquifers A1 and A2. Golder (2014) provides detailed descriptions of the groundwater regime, the proposed water supplies and any interactions between groundwater and surface water.

4. Methods – Field Programs

A summary of the field studies conducted as a part of the baseline water quality monitoring at the Carson Road Development to date is provided below (Table 1). Detailed methodology for each field program is described in Sections 4.1 to 4.4, including a summary of the 2008 sampling methods and outlining any necessary deviations from it

Table 1. Summary of the Field Studies Conducted to Describe Baseline Water Quality at the Carson Road Development

Organization	Date	Parameters
Golder Associates	March 25th, 2008	Water Quality
GLL (AECOM)	August 28th, 2008	Fish
	May 13th and 14th, 2008	Benthic Invertebrates
	April 2008 to Sept. 2008	Water Quality
HESL	Sept 3rd, 2014	Fish
	May 13th, 2015	Benthic Invertebrates
	Sept. to October 2014; May to Sept. 2015; March 2016	Water Quality and Flows

4.1 Water Quality

Golder Associates took one sample from Black Creek at Carson Road on March 25, 2008, prior to the onset of the GLL field program in 2008. The results showed high levels of nitrate (15.7 mg/L) but otherwise good water quality, with nitrite, total ammonia and total phosphorus concentrations below the respective detection limits (< 0.1 mg/L nitrite, < 0.01 mg/L each for total ammonia and total phosphorus).

The GLL (AECOM) field program consisted of 6 field visits from April 2008 to September 2008 during which water samples were collected at three sites (SWA, SWB and SWC; Figure 2). Water samples were analyzed for a standard suite of parameters including general chemistry, nutrients and metals by Maxxam Analytics, a fully accredited laboratory. No flow was present at SWA and SWB during the August 28th, 2008 field visit and therefore no water quality data was available. Field measurements, including pH, temperature, conductivity and dissolved oxygen, were collected during each site visit. Continuous temperature loggers ("Tidbits©") were installed at all three sites from mid-April to late September 2008.

The HESL field program revisited the same three sampling stations as GLL (SW-A to SW-C) in 2014 (Sept and Oct), 2015 (May to Sept) and 2016 (Mar). A station was added in 2015 (SW-Trib) to characterize the water quality of the ephemeral stream up-stream of SW-A. Water samples were collected from all stations and analyzed for the same standard suite of parameters including general chemistry, nutrients and metals by ALS Environmental, a fully accredited laboratory. Likewise, field measurements of pH, specific conductivity, water temperature and dissolved oxygen were collected at each station during each site visit. Continuous temperature loggers were installed for the 2014 and 2015 surveys.

4.1.1 Numerical analysis

Summary statistics tabulated include sample size (n), number of samples above the detection limit (n>DL), minimum (Min), maximum (Max), arithmetic mean, and median (Table 2). Boxplots were used to summarize key water quality parameters as they allow for efficient visualization of five summary statistics, the median, two hinges (the 75th and 25th percentiles) and the whiskers which extend from the hinge to the largest and smallest value no further away than 1.5 * the Interquartile Range.

Values below detection limit were replaced with a value equivalent to the detection limit.

4.2 Flows

No continuous flow data for Black Creek was available at our sampling stations, therefore flow was estimated using 1973-1995 data from Environment Canada's HYDAT database for Willow Creek above Little Lake (Station 02ED009; Figure 1). Flows were estimated for the Willow Creek tributary on the east side of the Carson Rd development by prorating on the basis of watershed area using areas of 94.8 km^2 for Willow Creek above Little Lake and 8.9 km^2 for Black Creek.

The field program included stream flow measurements made during each visit at all three sample sites. Sampling followed the methodology employed during initial sampling in 2008 (Ontario Stream Assessment Protocol (Stanfield 2010)). Briefly, the number of cross sectional measurement panels was determined via channel width while stream velocity was measured using a Marsh McBirney Flo Mate in each panel in 2008 and an OIT MF Pro flow mate in 2015. Sampling depth was based on water depth within each measurement panel. Stream profiles, discharges and average velocity were calculated for each site.

4.3 Benthic Invertebrates

The initial benthic invertebrate community study was conducted on the Black Creek tributary by GLL/AECOM on May 13th and 14th, 2008 and followed up by HESL on May 13th, 2015. Qualitative samples were collected at each of the aquatic assessment monitoring locations (SWA, SWB and SWC, [Figure 2]), following the Benthos Sampling Protocol of Gartner Lee Ltd. which included:

- Stations sampled over a constant pre-determined area (2m x 2m) at each station;
- Travelling kick and sweep method utilizing a D-frame net (500 micron), moving upstream from bank to bank, over the entire area; and
- Effort of 2 minutes for each study reach.

Samples were transferred into labelled sample jars and preserved with 70% alcohol solution and submitted to a qualified taxonomist, Richard Bland, for sorting and identification to the lowest taxonomic level possible.

Habitat surveys were also conducted at each of the benthic sampling stations to characterize habitat within the tributary and inform on the importance of habitat in determining benthic community structure. Habitat survey parameters included stream substrate, water depth, flow rates, morphology and surrounding land use.

The following benthic invertebrate metrics were calculated:

- Species richness
- Species diversity (lowest practical level);
- Simpson's Diversity
- Relative abundance of taxonomic groups; and
- Hilsenhoff Biotic Index (HBI)

4.4 Fisheries

A field investigation was conducted to supplement the data collected in 2008 and provide additional information on the fish community and fish habitat present in the Carson Road region. The three Carson Road sites, investigated on August 28, 2008 as part of the initial fisheries survey, were revisited on Sept 3rd, 2014 (Figure 2). Sampling protocols aimed to mirror the initial fish survey and included backpack electrofishing to sample isolated refuge pool(s) at each site. Fish were identified to species, counted, assigned an approximate age, and released alive. Water temperature, conductivity, pH and sampling time, were also recorded for each site. Following sampling methods from 2008, electrofishing at SWA 2 was conducted upstream of the water quality and flow sampling station in small isolated pools near the headwaters of Black Creek, while sampling for SWB was completed downstream of the water quality and flow station on the north side of Carson Road. Electrofishing at SWC was conducted just downstream of Wilson Road in relatively large and deep pools containing substantial lake watercress (*Nasturtium officinale*), and abundant potential spawning gravels and cobbles.

5. Results

5.1 Water Quality

Summary statistics from the 2014-2016 data collection relative to previous data collected in 2008, highlight the range and average values of parameters of interest from the two monitoring periods (Table 2).

Total phosphorus concentrations were below the Provincial Water Quality Objective (PWQO, MOE 1994) of 0.03 mg/L in all but four of the twenty two samples collected across the baseline monitoring programs (Figure 3). Of the four exceedances of the PWQO for total phosphorus, three were associated with elevated

suspended solids and are therefore likely indicative of short-term precipitation/run off events (Figure 4). The other exceedance (0.15 mg/L) was an order of magnitude above the average phosphorus concentration in all other samples and therefore appears to be an outlier, most likely due to sample contamination.

Figure 3. Total Phosphorus Concentrations at Carson Road

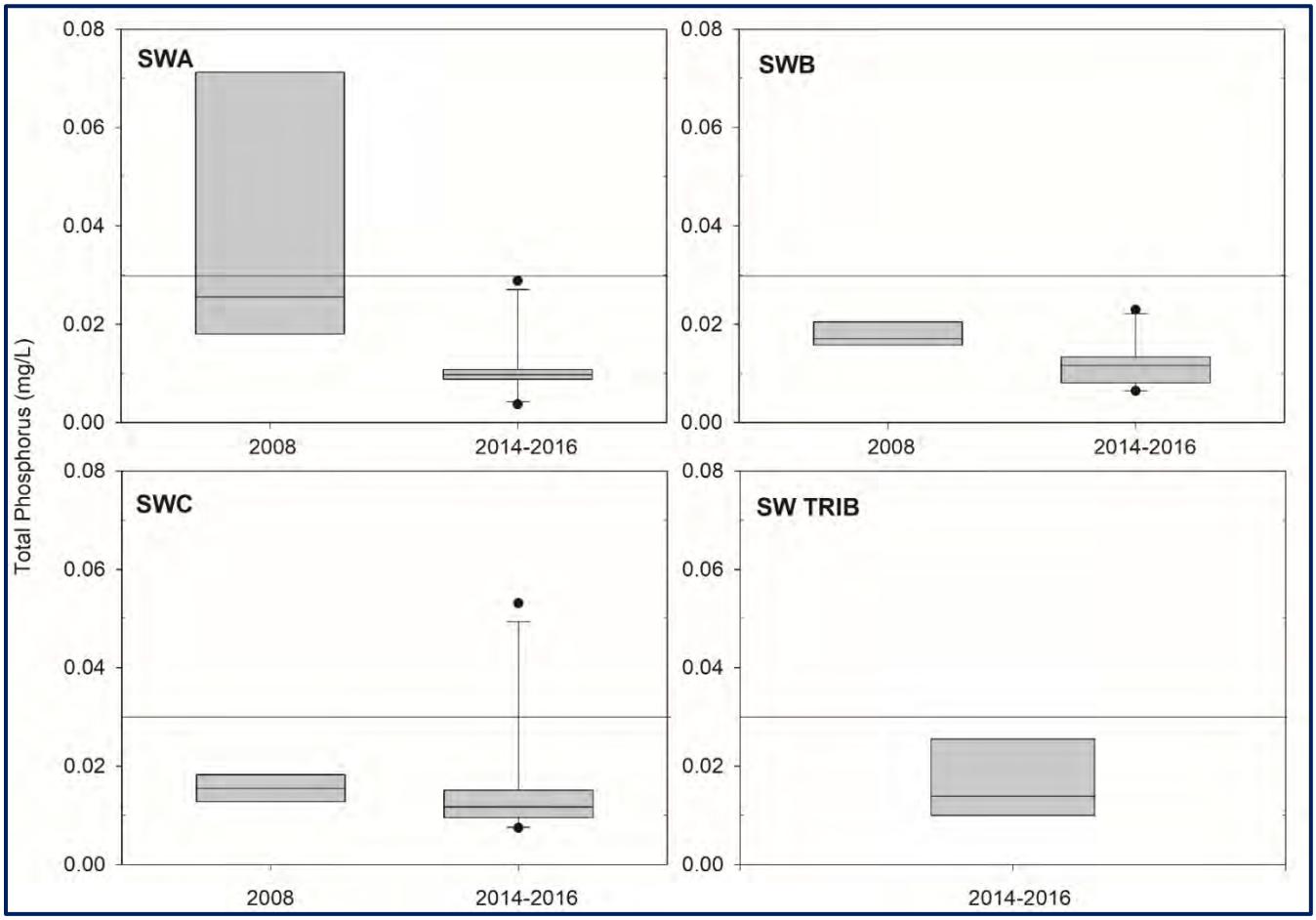
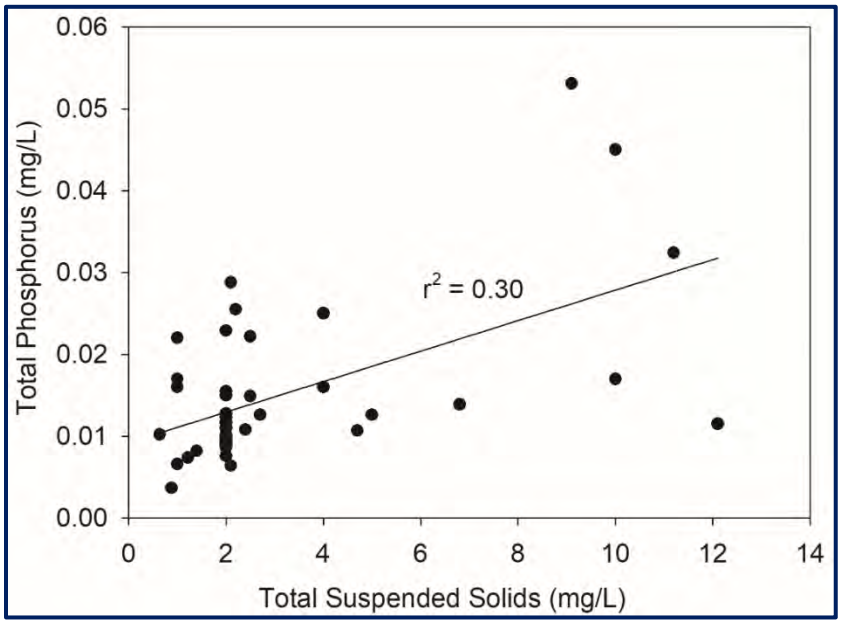


Table 2. Summary Statistics from the 2008 and 2014-2016 Water Quality Sampling Campaigns at the Carson Road Development Stations

Site		SW Trib						SWA									
Date		2014-2016						2008					2014 - 2016				
	Units	Min	Max	Mean	Median	n	n>DL	Min	Max	Mean	Median	n>DL	Min	Max	Mean	Median	n	n>DL
Temperature	^{0}C	6.4	13.1	10.7	11.0	7	7	11.0	13.8	11.6	11.2	6	4.1	13.8	10.6	11.8	9	10
DO	mg/L	7.9	12.3	10.4	10.4	7	7	10.1	12.0	10.9	10.5	6	5.1	12.6	10.0	10.3	9	10
pH		7.5	8.1	7.9	7.9	6	6	7.7	8.0	7.9	7.9	6	7.1	8.2	7.9	8.0	9	10
Cond	µs/cm	11.4	564.0	408.3	453.0	7	7	586.0	615.0	603.0	600.0	5	376.0	671.0	473.5	473.5	9	10
Physical Tests																		
Total Suspended Solids	mg/L	1.0	69.5	13.6	2.5	7	6	10.0	10.0	10.0	10.0	1	0.6	4.7	2.1	1.5	9	4
Turbidity	NTU	0.24	19.30	3.80	0.42	7	7	0.10	0.30	0.25	0.30	6	0.16	1.04	0.50	0.38	9	9
Anions and Nutrients																		
Ammonia, Total (as N)	mg/L	0.04	0.06	0.05	0.05	7	2	0.10	0.10	0.10	0.10	1	0.05	0.16	0.10	0.09	9	4
Nitrate and Nitrite as N	mg/L	8.41	10.9	10.05	10.1	7	7	-	-	-	-	0	10.2	13.2	12.5	12.6	4	10
Nitrate-N (NO3-N)	mg/L	8.41	10.90	10.05	10.10	7	7	11.00	14.00	12.33	12.50	6	10.20	13.20	12.45	12.60	9	10
Nitrite-N (NO2-N)	mg/L	0.01	0.05	0.02	0.01	7	0	-	-	-	-	0	-	-	-	-	0	0
Total Kjeldahl Nitrogen	mg/L	0.15	0.69	0.27	0.15	7	3	0.20	0.70	0.45	0.50	6	0.16	0.38	0.26	0.23	9	5
Organic / Inorganic Carbon																		
Total Phosphorus	mg/L	0.007	0.032	0.017	0.014	7	7	0.018	0.150	0.047	0.026	6	0.004	0.029	0.011	0.010	9	10
Dissolved Organic Carbon	mg/L	1.00	4.20	1.79	1.40	7	5	0.90	2.00	1.50	1.50	6	1.00	3.70	1.98	1.90	9	6
Total Metals																		
Aluminum (Al)-Total	mg/L	0.010	0.214	0.047	0.021	7	6	0.016	0.034	0.026	0.029	6	0.013	0.060	0.023	0.015	9	6
Arsenic (As)-Total	mg/L	0.0001	0.0010	0.0005	0.0002	7	3	-	-	-	-	0	0.0001	0.0002	0.0002	0.0001	4	4
Barium (Ba)-Total	mg/L	0.037	0.048	0.042	0.041	7	7	0.038	0.050	0.045	0.044	6	0.044	0.053	0.047	0.046	9	10
Boron (B)-Total	mg/L	0.010	0.010	0.010	0.010	7	0	0.011	0.011	0.011	0.011	1	0.010	0.012	0.011	0.011	9	2
Calcium (Ca)-Total	mg/L	93.8	105.0	98.6	97.8	7	7	94.0	110.0	105.5	110.0	6	94.9	107.0	100.1	99.7	9	10
Cesium (Cs)-Total	mg/L	0.000	0.000	0.000	0.000	4	0	-	-	-	-	0	-	-	-	-	0	0
Chromium (Cr)-Total	mg/L	0.0008	0.0015	0.0012	0.0012	7	7	-	-	-	-	0	0.0007	0.0015	0.0010	0.0010	4	10
Cobalt (Co)-Total	mg/L	0.000	0.001	0.000	0.000	7	0	-	-	-	-	0	-	-	-	-	0	0
Copper (Cu)-Total	mg/L	0.001	0.001	0.001	0.001	7	0	0.001	0.001	0.001	0.001	1	-	-	-	-	5	0
Iron (Fe)-Total	mg/L	0.05	0.26	0.08	0.05	7	1	-	-	-	-	0	0.065	0.065	0.065	0.065	4	1
Lead (Pb)-Total	mg/L	0.000	0.001	0.000	0.000	7	0	-	-	-	-	0	-	-	-	-	0	0
Lithium (Li)-Total	mg/L	0.0016	0.1	0.0439	0.0022	7	4	-	-	-	-	0	0.002	0.002	0.002	0.002	4	4
Magnesium (Mg)-Total	mg/L	15.9	19.1	17.5	17.0	7	7	16.0	21.0	18.3	18.0	6	15.3	18.6	17.5	17.6	9	10
Manganese (Mn)-Total	mg/L	0.007	0.055	0.024	0.012	7	7	0.010	0.044	0.018	0.013	5	0.002	0.018	0.006	0.005	9	10
Molybdenum (Mo)-Total	mg/L	0.00007	0.00050	0.00027	0.00012	7	4	-	-	-	-	0	0.00012	0.00015	0.00014	0.00014	4	4
Potassium (K)-Total	mg/L	1.1	1.5	1.2	1.2	7	7	1.1	2.0	1.5	1.5	6	1.3	1.8	1.4	1.4	9	10
Rubidium (Rb)-Total	mg/L	0.0004	0.0007	0.0005	0.0005	4	4	-	-	-	-	0	0.00046	0.00092	0.00063	0.00057	4	4
Selenium (Se)-Total	mg/L	0.00009	0.00040	0.00023	0.00010	7	4	-	-	-	-	0	-	-	-	-	0	4
Silicon (Si)-Total	mg/L	7.00	7.95	7.35	7.10	7	7	6.50	7.60	6.93	6.75	6	6.70	7.90	7.38	7.30	9	10
Sodium (Na)-Total	mg/L	3.76	4.09	3.92	3.95	7	7	3.60	4.90	4.35	4.45	6	4.03	4.57	4.35	4.36	9	10
Strontium (Sr)-Total	mg/L	0.19	0.21	0.19	0.19	7	7	0.18	0.22	0.20	0.20	6	0.19	0.20	0.19	0.20	9	10
Sulfur (S)-Total	mg/L	3.92	5.32	4.66	5.00	7	4	-	-	-	-	0	4.78	5.65	5.08	5.00	4	5
Titanium (Ti)-Total	mg/L	0.0004	0.0108	0.0025	0.0010	7	5	-	-	-	-	0	0.0004	0.0028	0.0011	0.0006	4	4
Uranium (U)-Total	mg/L	0.0003	0.0010	0.0006	0.0004	7	4	0.0004	0.0006	0.0006	0.0006	6	0.0007	0.0008	0.0007	0.0008	9	4
Vanadium (V)-Total	mg/L	0.0008	0.0012	0.0010	0.0009	7	7	0.0010	0.0010	0.0010	0.0010	4	0.0007	0.0010	0.0009	0.0009	9	10
Zinc (Zn)-Total	mg/L	0.0030	0.0033	0.0031	0.0030	7	2	0.0090	0.0090	0.0090	0.0090	1	0.0054	0.0054	0.0054	0.0054	9	1

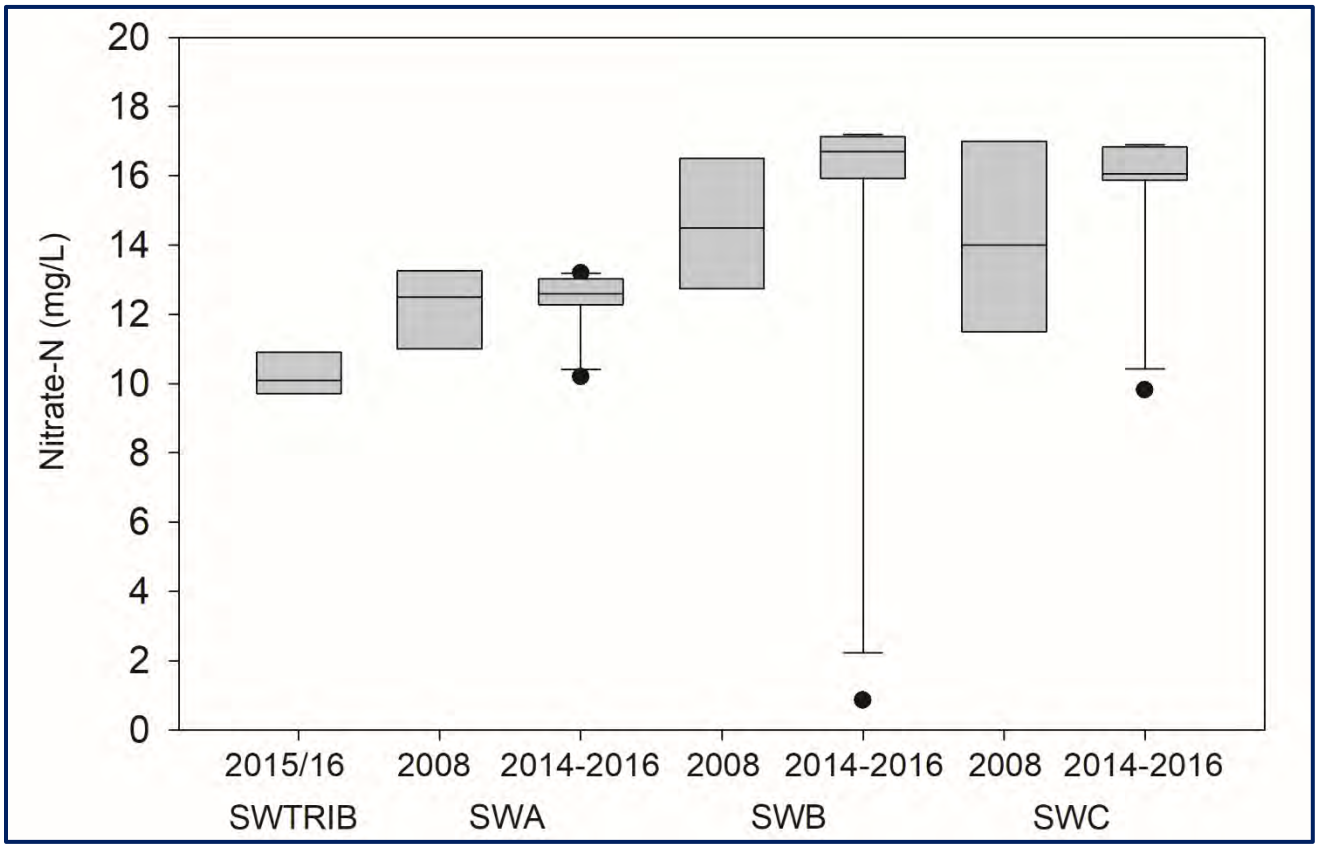
Site		SWB											SWC										
Date		2008					2014-2016						2008					2014-2016					
	Units	Min	Max	Mean	Median	n>DL	Min	Max	Mean	Median	n	n>DL	Min	Max	Mean	Median	n>DL	Min	Max	Mean	Median	n	n>DL
Temperature	^{0}C	11.5	17.9	15.2	16.4	6	3.5	14.3	10.8	11.7	10	10	10.5	18.5	15.6	16.7	6	0.1	16.3	11.8	13.1	10	10
DO	mg/L	8.2	13.8	10.4	9.7	6	6.2	13.6	10.4	10.2	10	10	8.5	14.0	10.6	9.6	6	5.4	13.2	10.2	10.1	10	10
pH		7.8	8.2	8.0	8.0	6	7.3	8.2	8.0	8.0	10	10	7.7	8.5	8.2	8.3	6	7.5	8.6	8.2	8.2	10	10
Cond	µs/cm	549.0	623.0	595.0	608.0	6	368.0	672.0	525.1	496.5	10	10	605.0	780.0	648.5	626.0	6	64.0	700.0	516.9	530.5	10	10
Physical Tests																							
Total Suspended Solids	mg/L	1.0	10.0	4.2	4.0	5	1.4	12.1	3.0	2.0	10	5	1.0	1.0	1.0	1.0	2	1.2	106.0	13.4	2.2	10	6
Turbidity	NTU	0.20	1.10	0.53	0.40	6	0.18	4.38	0.88	0.48	9	9	0.30	0.60	0.40	0.40	6	0.28	2.00	0.79	0.55	9	9
Anions and Nutrients																							
Ammonia, Total (as N)	mg/L	0.08	0.21	0.15	0.15	2	0.05	0.18	0.08	0.06	10	5	0.06	0.06	0.06	0.06	1	0.02	0.09	0.05	0.05	10	3
Nitrate and Nitrite as N	mg/L	-	-	-	-	0	0.855	17.2	14.9978	16.7	10	10	-	-	-	-	0	9.834	16.9	15.6661	16.05	10	10
Nitrate-N (NO3-N)	mg/L	12.00	18.00	14.67	14.50	6	0.86	17.20	15.00	16.70	10	10	10.00	17.00	14.00	14.00	6	9.82	16.90	15.66	16.05	10	10
Nitrite-N (NO2-N)	mg/L	-	-	-	-	0	0.01	0.10	0.04	0.01	10	2	-	-	-	-	0	0.01	0.10	0.04	0.01	10	3
Total Kjeldahl Nitrogen	mg/L	0.30	0.80	0.47	0.45	6	0.15	0.42	0.23	0.19	10	7	0.30	0.60	0.47	0.50	6	0.15	0.38	0.26	0.27	10	7
Organic / Inorganic Carbon																							
Total Phosphorus	mg/L	0.015	0.025	0.018	0.017	6	0.006	0.023	0.012	0.012	10	10	0.012	0.022	0.016	0.016	6	0.007	0.053	0.016	0.012	10	10
Dissolved Organic Carbon	mg/L	1.40	2.10	1.75	1.75	6	1.00	3.40	1.68	1.30	10	6	2.10	2.40	2.22	2.20	6	1.00	6.30	2.04	1.55	10	8
Total Metals																							
Aluminum (Al)-Total	mg/L	0.041	0.100	0.073	0.073	6	0.010	0.121	0.026	0.012	10	7	0.013	0.048	0.022	0.017	6	0.010	0.228	0.050	0.018	10	8
Arsenic (As)-Total	mg/L	-	-	-	-	0	0.0001	0.0010	0.0007	0.0010	10	4	-	-	-	-	0	0.0003	0.0010	0.0007	0.0010	10	4
Barium (Ba)-Total	mg/L	0.041	0.061	0.048	0.048	6	0.048	0.060	0.053	0.052	10	10	0.037	0.050	0.043	0.044	6	0.044	0.055	0.048	0.048	10	10
Boron (B)-Total	mg/L	0.01	0.01	0.01	0.01	1	0.01	0.012	0.0102	0.01	10	1	-	-	-	-	0	0.01	0.015	0.0106	0.01	10	2
Calcium (Ca)-Total	mg/L	98.0	140.0	113.0	110.0	6	60.1	125.0	104.4	107.0	10	10	0.1	110.0	55.1	55.1	6	92.6	118.0	105.6	103.5	10	10
Cesium (Cs)-Total	mg/L	-	-	-	-	0	0.00001	0.00001	0.00001	0.00001	4	0	-	-	-	-	0	0.00001	0.00002	0.00001	0.00001	4	2
Chromium (Cr)-Total	mg/L	-	-	-	-	0	0.0005	0.0014	0.0009	0.0008	10	9	-	-	-	-	0	0.0005	0.0014	0.0009	0.0008	10	9
Cobalt (Co)-Total	mg/L	-	-	-	-	0	0.000	0.001	0.000	0.001	10	0	-	-	-	-	0	0.0001	0.0005	0.000343	0.0005	10	1
Copper (Cu)-Total	mg/L	0.001	0.001	0.001	0.001	2	0.001	0.001	0.001	0.001	10	0	0.001	0.001	0.001	0.001	1	0.001	0.001	0.001	0.001	10	0
Iron (Fe)-Total	mg/L	0.13	0.15	0.14	0.14	2	0.05	0.19	0.0654	0.05	10	2	-	-	-	-	0	0.05	0.222	0.0733	0.05	10	2
Lead (Pb)-Total	mg/L	-	-	-	-	0	0.0001	0.0005	0.000348	0.0005	10	1	-	-	-	-	0	0.0001	0.0005	0.000346	0.0005	10	2
Lithium (Li)-Total	mg/L	-	-	-	-	0	0.0014	0.1	0.06063	0.1	10	4	-	-	-	-	0	0.0011	0.1	0.06056	0.1	10	4
Magnesium (Mg)-Total	mg/L	16.0	22.0	18.7	18.5	6	13.0	19.7	16.3	16.6	10	10	0.0	19.0	9.2	8.5	6	13.1	18.6	16.6	16.9	10	10
Manganese (Mn)-Total	mg/L	0.024	0.091	0.048	0.043	6	0.009	0.020	0.013	0.013	10	10	0.002	0.006	0.004	0.003	5	0.001	0.011	0.003	0.002	10	10
Molybdenum (Mo)-Total	mg/L	-	-	-	-	0	0.00015	0.00050	0.00038	0.00050	10	4	-	-	-	-	0	0.00012	0.00050	0.00036	0.00050	10	4
Potassium (K)-Total	mg/L	1.3	1.9	1.6	1.4	6	1.3	1.8	1.5	1.5	10	10	0.0	0.0	0.0	0.0	5	1.2	2.7	1.6	1.5	10	10
Rubidium (Rb)-Total	mg/L	-	-	-	-	0	0.0005	0.0008	0.0006	0.0006	4	4	-	-	-	-	0	0.0007	0.0017	0.0010	0.0007	4	4
Selenium (Se)-Total	mg/L	-	-	-	-	0	0.00009	0.00040	0.00028	0.00040	10	4	-	-	-	-	0	0.00007	0.00040	0.00028	0.00040	10	4
Silicon (Si)-Total	mg/L	5.10	7.80	6.12	5.95	6	5.81	8.10	6.98	6.98	10	10	1.20	1.90	1.65	1.65	6	6.10	7.80	6.98	6.91	10	10
Sodium (Na)-Total	mg/L	3.60	5.20	4.48	4.55	6	4.16	18.20	5.88	4.50	10	10	3.60	6.50	5.38	5.65	6	6.12	7.02	6.46	6.37	10	10
Strontium (Sr)-Total	mg/L	0.18	0.25	0.20	0.20	6	0.16	0.23	0.19	0.19	10	10	5.60	6.50	6.05	6.10	6	0.17	0.22	0.20	0.20	10	10
Sulfur (S)-Total	mg/L	-	-	-	-	0	4.11	6.34	5.78	6.10	7	7	-	-	-	-	0	4.45	6.52	5.85	5.98	7	7
Titanium (Ti)-Total	mg/L	0.0060	0.0060	0.0060	0.0060	1	0.0003	0.0051	0.0019	0.0020	10	4	0.1900	0.2200	0.2000	0.2000	5	0.0007	0.0111	0.0031	0.0020	10	4
Uranium (U)-Total	mg/L	0.0008	0.0011	0.0009	0.0009	5	0.0005	0.0010	0.0009	0.0010	10	4	0.0000	0.0000	-	-	0	0.0008	0.0010	0.0009	0.0010	10	4
Vanadium (V)-Total	mg/L	0.0010	0.0010	0.0010	0.0010	4	0.0007	0.0010	0.0009	0.0009	10	10	0.0009	0.0011	0.0010	0.0010	6	0.0008	0.0015	0.0010	0.0010	10	10
Zinc (Zn)-Total	mg/L	-	-	-	-	0	0.0030	0.0033	0.0030	0.0030	10	1	0.0010	0.0010	0.0010	0.0010	4	0.0030	0.0192	0.0046	0.0030	10	1

Figure 4. Correlation between Total Phosphorus and Total Suspended Solids at Carson Road.



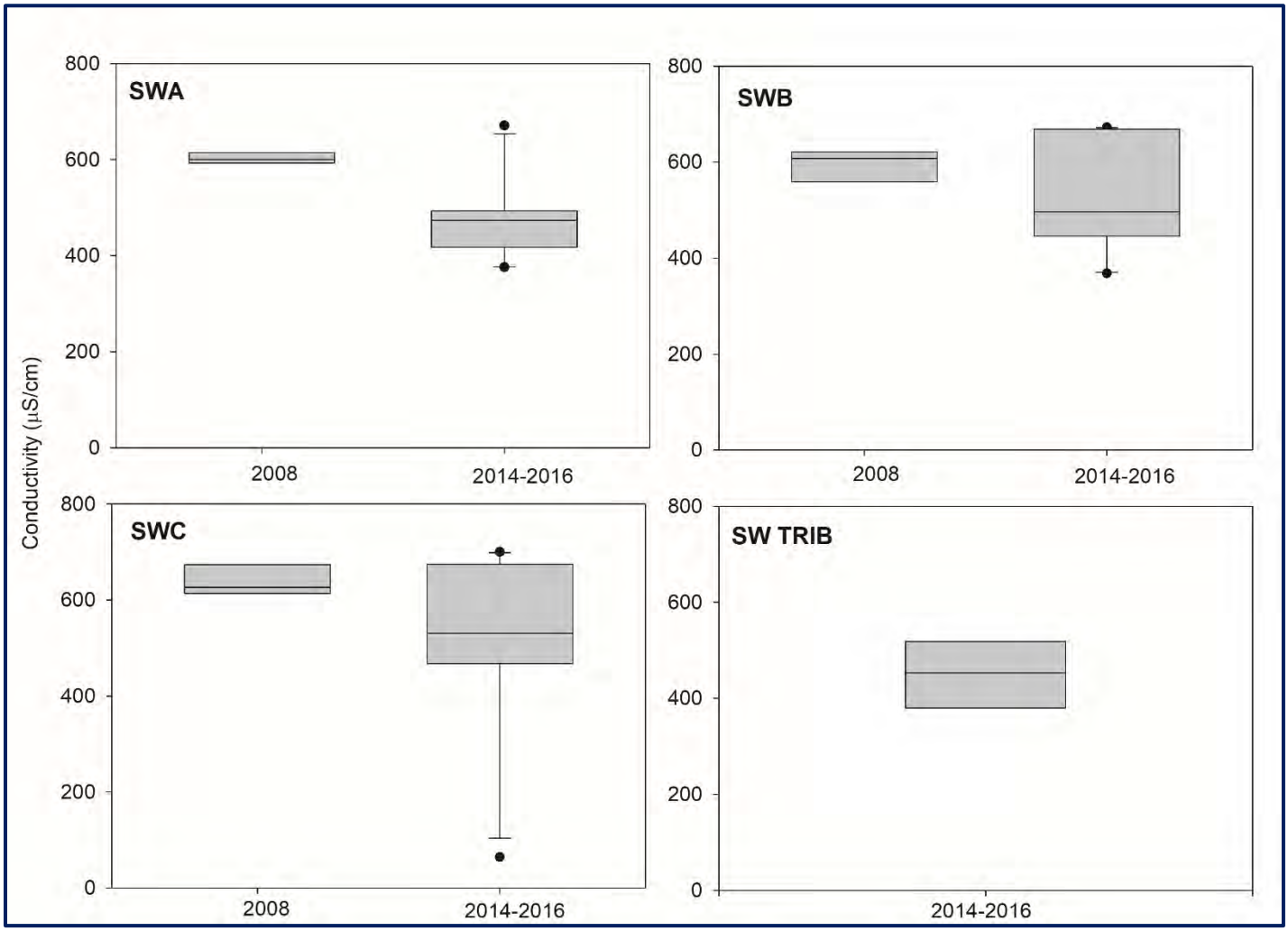
Nitrate levels were elevated relative to other baseline water quality monitoring data collected in the region (e.g., Doran Road Baseline Monitoring) and generally increased from upstream to downstream stations. Concentrations of nitrate exceeded the CCME Guideline for Protection of Aquatic Life (3 mg/L as nitrate-N; CCME, 2012) in all but a single water quality sample, which was collected in early-March and therefore would be expected to have significantly different water quality (Figure 5). Concentrations were comparable to values of 12.2 and 8.1 mg/L recorded for aquifers A1 and A2 (Golder, 2015), which suggests that groundwater is a significant contributor to stream flow. Both nitrite and ammonia concentrations were below the analytical detection limit in ~90% and 78% of the samples collected since 2008, respectively. Calculated unionized ammonia concentrations were below PWQO guideline of (0.020 mg/L) in all samples tested

Figure 5. Nitrate Concentrations at Carson Road



Conductivity was consistent across all three water quality stations. Additional sampling captured a broader gradient of conductivity concentrations expanding our understanding of baseline water quality in the Region (Figure 6). Conductivity data suggest a significant contribution of groundwater in the system which results in increased conductivity as surface water runoff decreases after the spring freshet in April and as the groundwater contribution increases with distance downstream.

Figure 6. Specific Conductivity at Carson Road

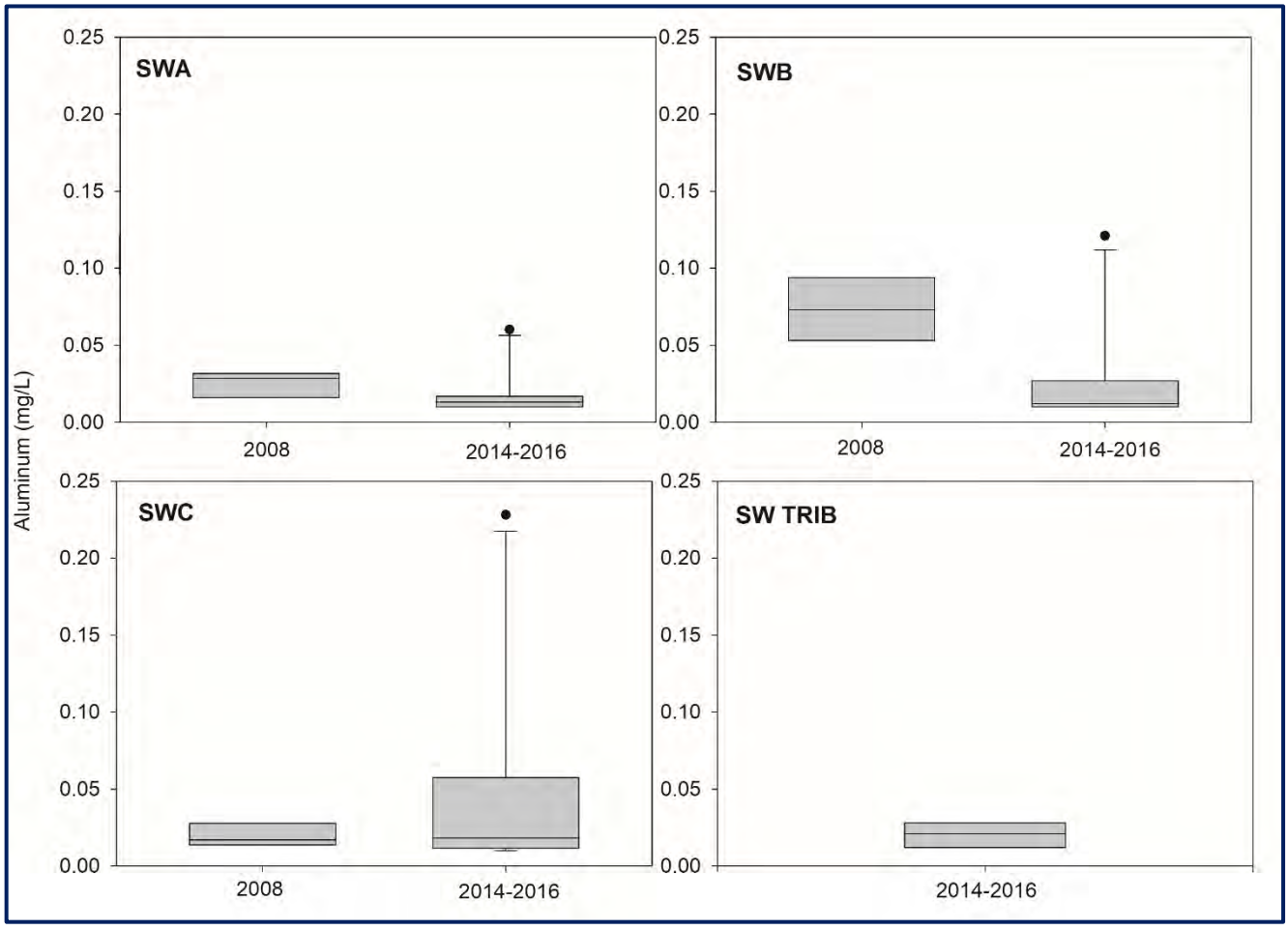


Several total metals, analyzed as a part of both the 2008 and 2014-2016 monitoring programs fell below analytical detection limits in all samples collected including antimony, beryllium, bismuth, cadmium cesium, cobalt, nickel, silver, tellurium, thallium, thorium, tin and tungsten and so no data are presented in Table 2. Total metals concentrations observed above PWQO levels included aluminum (n=7, Figure 7) and zirconium (n=1, not shown), which were associated with suspended solids (Figure 9).

Temperature values indicated a cold-water stream that warmed as it flowed from a forested area through an open field towards Wilson Road. Dissolved oxygen concentrations were consistently above the temperature-dependent Provincial Water Quality Objectives (PWQO) MOE 1994) of 5-8 mg/L for cold water

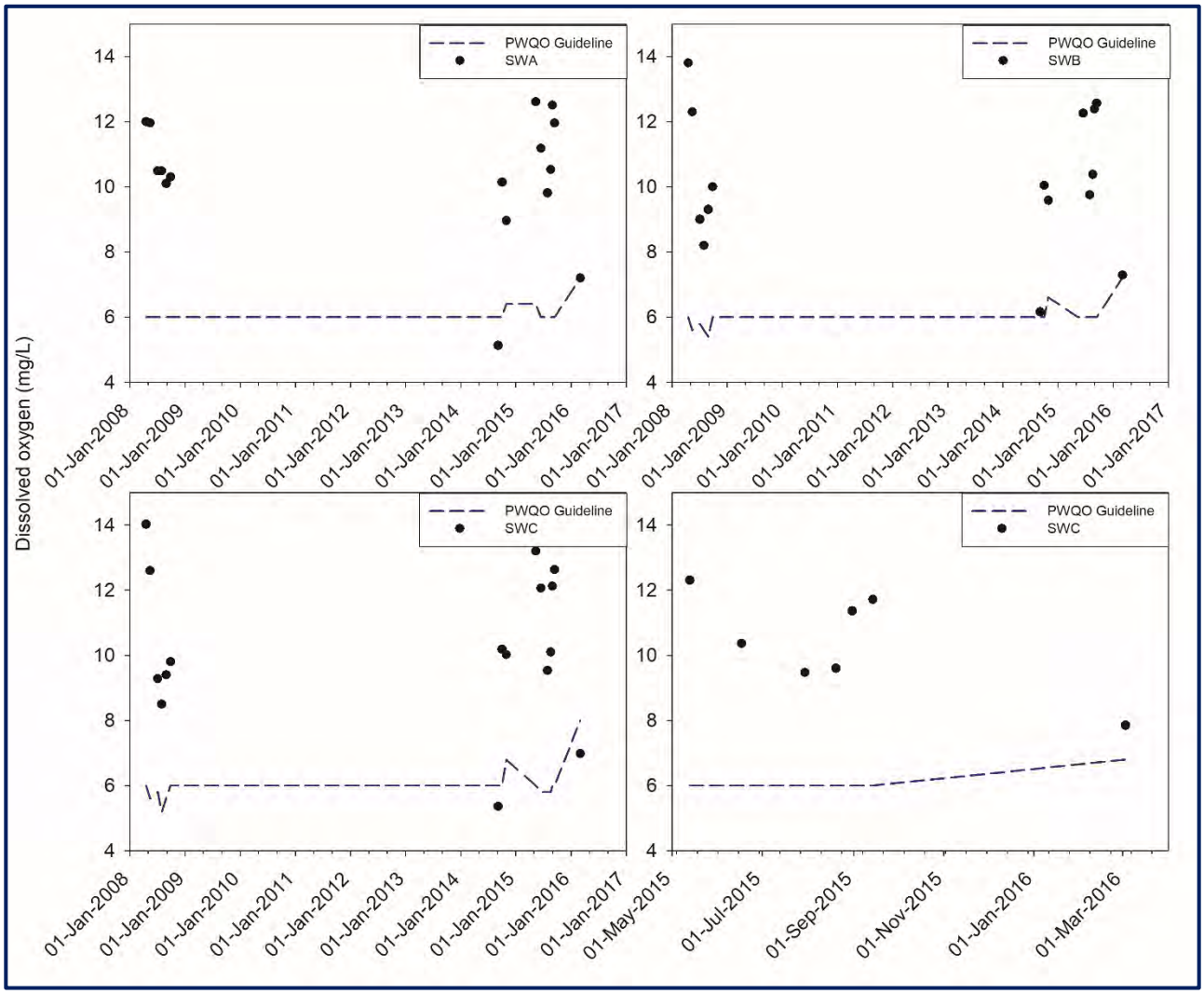
aquatic life, with the exception of three measurements. Two of the dissolved oxygen exceedances (5.13 mg/L and 5.36 mg/L) occurred during a single day of sampling (September 5th, 2014), during a period of particularly low flow while the third was recorded during March sampling, which pre-dated ice off (March 10) by one week and would therefore be indicative of winter conditions (e.g., low winter flow).

Figure 7. Aluminum concentrations recorded at Carson Road stations



Temperature logger data show that Black Creek was a cold-water stream at all monitoring locations. Patterns observed in temperature logger data collected in 2014 and 2015 at SWA-SWC were consistent with what was reported in 2008, including diurnal fluctuations of 3-5°C during the summer months in 2015, however temperatures were lower overall in 2015 than in 2008 when temperatures peaked above 20°C (Figure 10, Figure 11). Water temperatures at SWC were consistently higher than the other stations in 2015, as that station is located within pastureland with exposed channels, while SWA and SWTrib are heavily shaded by the dense surrounding forest.

Figure 8. Dissolved Oxygen concentrations recorded at the Carson Road stations



Dotted line indicates the temperature dependent PWQO guideline 5 – 8 mg/L

Figure 9. Correlation between Aluminum and TSS at Carson Road

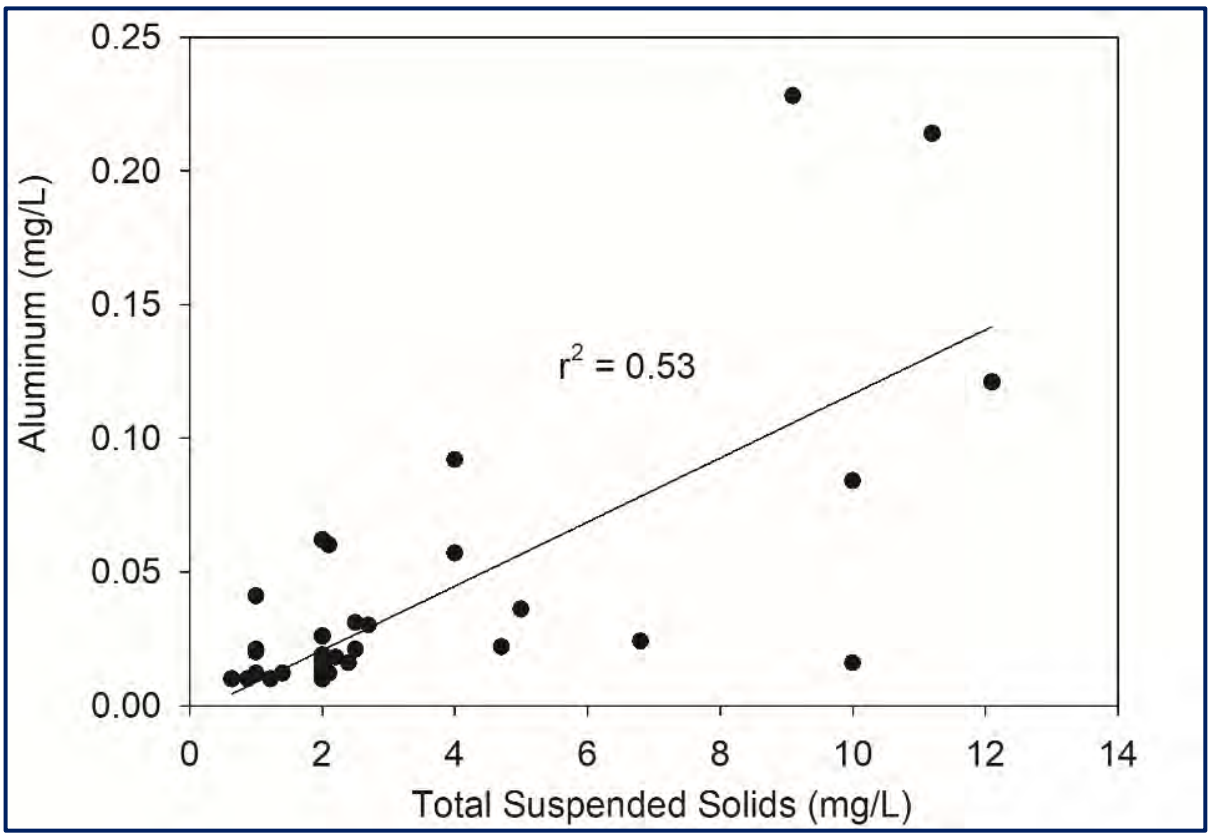


Figure 10. Continuous temperature record for Carson Road sites: April - September 2008.

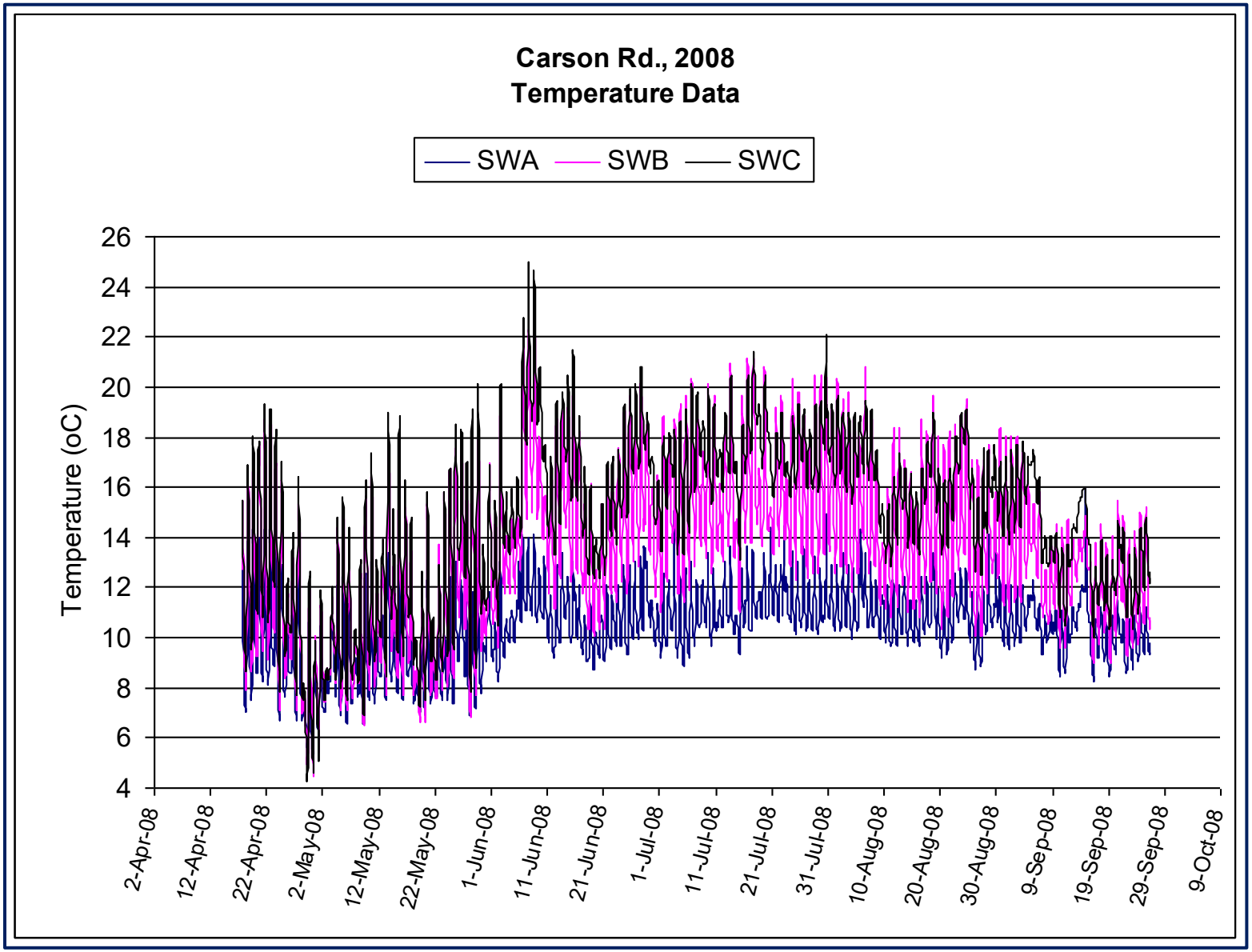
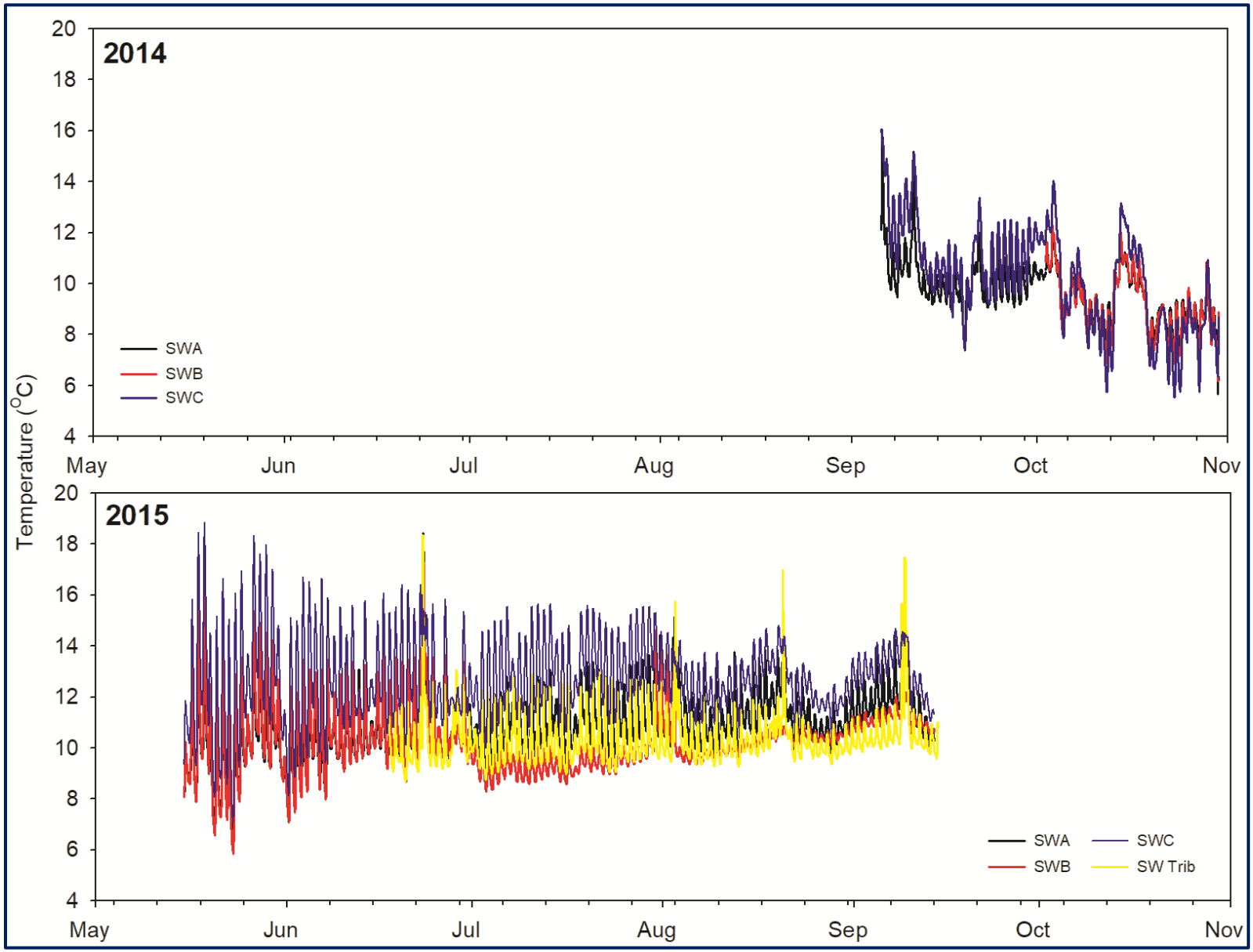


Figure 11. Continuous 2014 and 2015 Temperature Records for Carson Road Development Monitoring Sites.



5.2 Hydrology and Receiver Flow

The hydrology program was focussed on description of the flow characteristics and available assimilation volumes for assimilation of stormwater flows at the Carson Road Development site.

Median flows, based on pro-rated calculations of WSC HYDAT data recorded from 1973-1995, peaked at ~450 L/sec during spring freshet and declined to as low as 1-2 L/sec for extended periods during the summer months (Figure 12).

Measured flows were also recorded at all four sample sites as part of the field programs in 2008, 2014 and 2015 to further characterize the hydrology of the tributary and validate the estimated flows (Table 3). Flows generally increased downstream between SWTrib, SWA and SWB, and no significant difference in flow was noted between 2008 and 2014/2015 sampling periods (Figure 13).

Flows were <5L/sec in the headwaters in late July but did not decline as significantly as predicted in the WSC HYDAT estimations. Storm sampling in August (2015) produced flows of similar magnitude to those recorded during April and May freshet sampling (Table 3). Measured flows collected in the field were lower than those estimated from HYDAT data during spring freshet and early summer recession, and higher than predicted during storm sampling events in the fall (Figure 12).

Table 3. Summary of field flow measurements in L/sec.

Date	SWTrib	SWA	SWB	SWC
17-Apr-08	No Data	13.5	15.7	28.6
14-May-08	No Data	11	19.3	30.8
03-Jul-08	No Data	6.9	12.9	18.4
30-Jul-08	No Data	7.9	17.7	23.4
28-Aug-08	No Data	5.6	14.9	14.4
26-Sep-08	No Data	5.8	11	14.4
05-Sep-14	No Data	3.7	No Data	11
02-Oct-14	No Data	3.2	23.8	17.7
30-Oct-14	No Data	6.3	23.7	21
13-May-15	No Data	7.9	17.6	16.5
17-Jun-15	2.1	4.7	14.4	15
30-Jul-15	1.6	4	12.2	14.2
20-Aug-15	2.7	6.2	20.4	21.7
31-Aug-15	1.6	3.5	19.3	9.8
14-Sep-15	1.5	4.8	17.1	12.4
03-Mar-16	0.4	4.5	7.5	14.3

Figure 12. Summary of estimated daily flows for Black Creek at Wilson Drive.

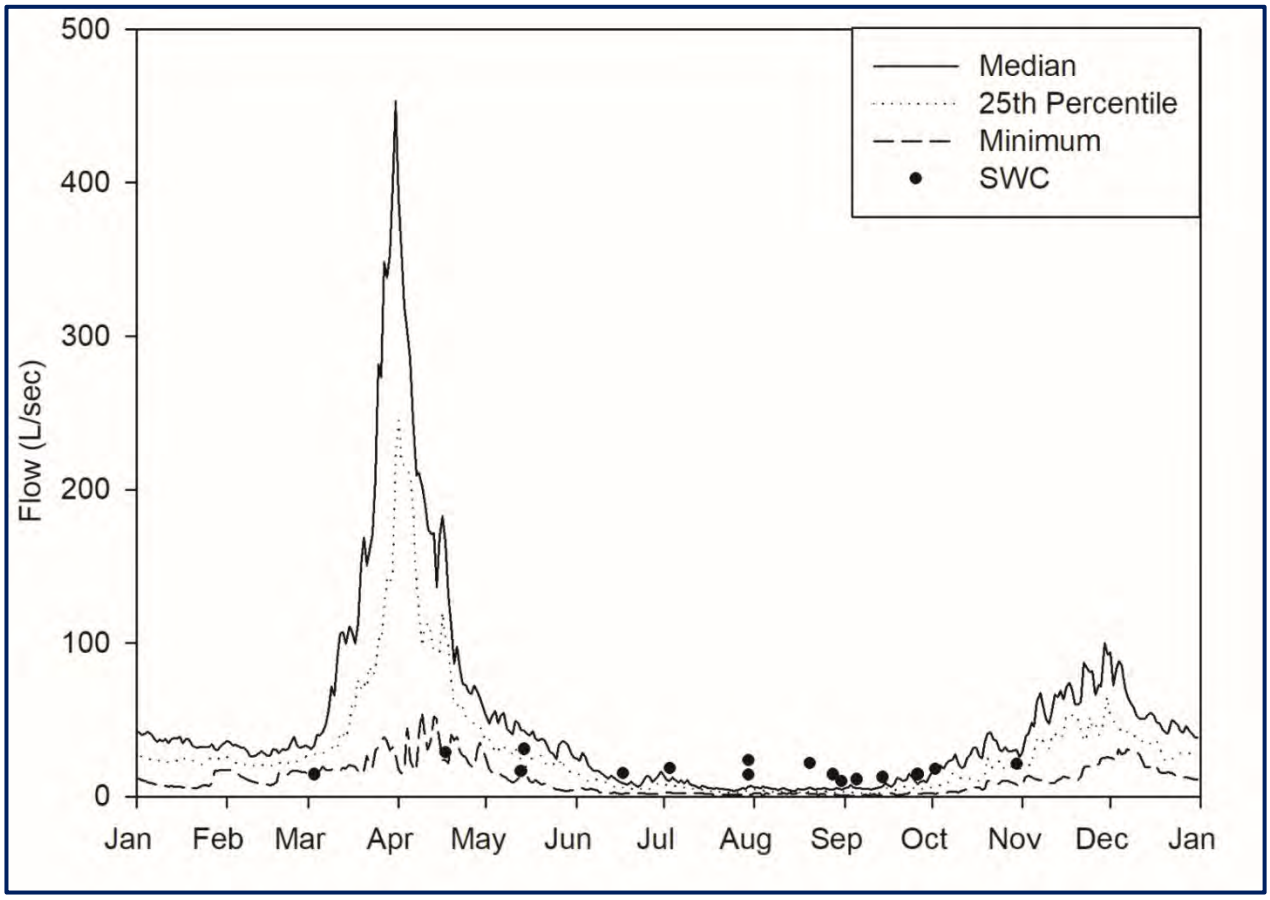
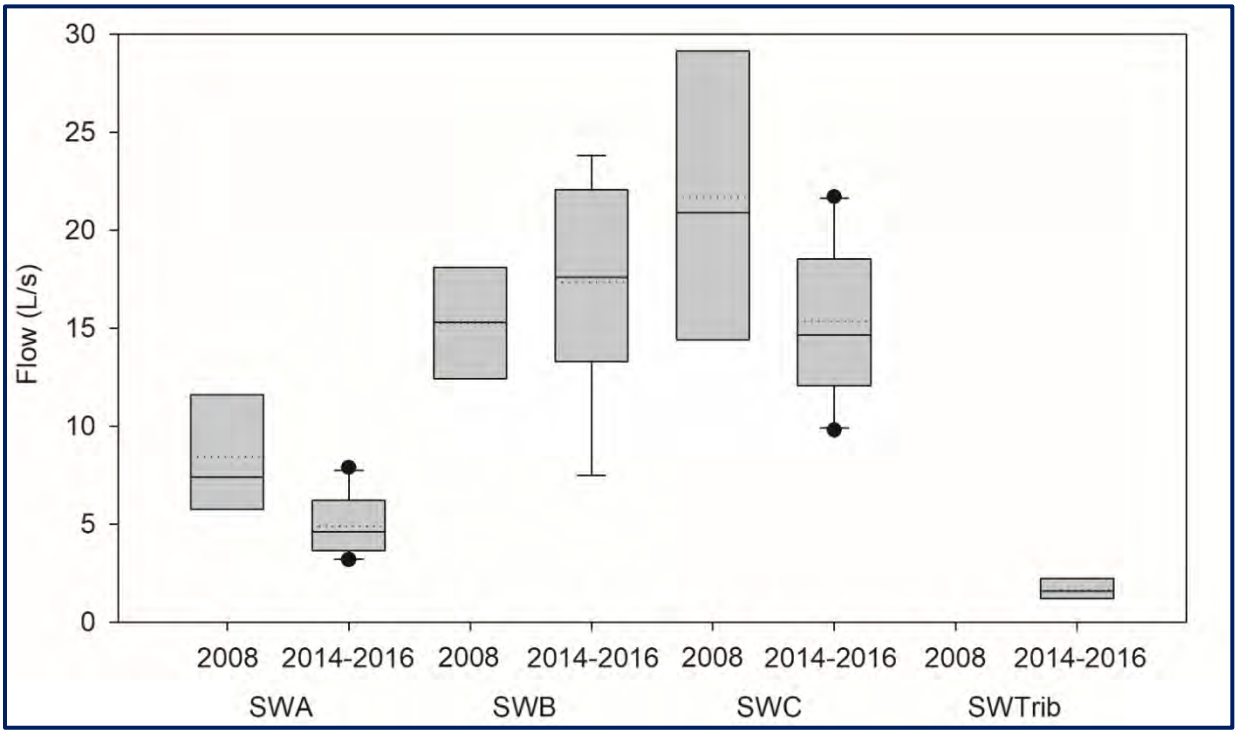


Figure 13. Comparison of field measured flows from 2008 and 2014-2015 field data.



5.3 Aquatic Biota

Benthic invertebrates are a collection of aquatic organisms that are comprised of immature insect stages, worms, snails and clams that inhabit the substrate in streams. Benthic invertebrate community sampling is frequently used for assessing environmental stresses on aquatic environments imposed by degraded water quality or habitat. Benthic invertebrate communities integrate long-term changes in their environment including temperature, nutrients, suspended solids, contaminants, habitat type and food availability, and may also respond to short-term events which cannot always be captured by traditional water quality sampling. Benthic invertebrate data was collected in 2008, and again in 2015 to establish the baseline community structure within the Carson Road Development area, prior to any development, for comparison with future surveys to assess any changes over time.

Benthic invertebrate community sampling conducted in 2015, revisited the same sites sampled in 2008. Station SWA was at the headwaters of the Black Creek tributary in a forested area. SWB was downstream of SWA, just upstream of Carson Road, in a small clearing. SWC was the furthest downstream location, just upstream of Wilson Drive in an open unshaded agricultural reach of the creek. Stream habitat, based on characterizations performed in 2008, consisted of a low gradient run morphology with fine sands, silt and clay substrates (Table 4).

Table 4. Summary of stream habitat conditions.

Reach	Approx. Water Depth (m)	Morphology	Substrate Description
SWA	0.10	low gradient run	cobble, gravel and sand
SWB	0.10	low gradient riffle & run	cobble, boulders and silt
SWC	0.15	low gradient run	cobble, sand and fines (silt/clay)

5.3.1 Species Richness

Species richness is a measure of the total number of different species identified at a sampling station. In 2008, SWA had the highest species richness with a total of 31 species, but was closely comparable to SWC (30 species), while SWB was significantly lower (16 species). Overall, no trends in species richness were reflected when upstream stations were compared to downstream stations.

A total of 61 unique species were collected in 2015 within the study area (all three sites), up from 48 in 2008. Species richness increased slightly at SWC, but declined to 27 at SWA in 2015. At SWB, species richness more than doubled to 34, representing an increase in richness relative to the 2008 sampling event (Table 5 and Table 6).

Table 5. Summary of Black Creek benthic community metric results in 2008.

	SWA	SWB	SWC
Total Number of Organisms	280	910	255
Species Richness	31	16	30
HBI Index	5.01	2.61	3.86
HBI Index WQ Comment	fair	excellent	very good
% EPT	39	97	67
% Chironomidae	24	1	14
% Simulidae	18	1	10
% Other	19	2	9

Table 6. Summary of Black Creek benthic community metric results in 2015.

	SWA	SWB	SWC
Total Number of Organisms	241	607	595
Species Richness	27	34	39
HBI Index	1.91	4.34	3.37
HBI Index WQ Comment	excellent	good	excellent
Simpson's Diversity	0.78	0.79	0.78
%EPT	68	16	63
% Chironomidae	23	82	29
% Ceratopogonidae	0	0	1
% Coleoptera	0	0	1
% Other Diptera	8	1	7
% Other	0	1	1

5.3.2 Relative Abundance

Major taxonomic groups present in both 2008 and 2015 surveys included: *Chironomidae* (non-biting midges), *Ceratopogonidae* (biting midges), EPT [*Ephemeroptera* (mayflies) *Plecoptera* (stoneflies) and *Trichoptera* (caddisflies)], *Coleoptera* (beetles), other *Diptera* (winged flies and other which includes (*Melagoptera* (alderflies), *Amphipoda* (sow bugs), *Hirudinea* (leeches), *Oligochaeta* (aquatic worms), *Gastropoda* (snails), *Hemiptera* (true bugs) and *Odonata* (dragonflies and damselflies). The relative abundance of these groups, however, varied significantly between 2008 and 2015 (Figure 14 and Figure 15).

In 2008, EPT species were the dominant group present at all stations accounting for 39%, 97% and 67% of the total community at SWA, SWB and SWC respectively (Figure 14). *Chironomidae* (midges) taxa were

the second most dominant group at all three sites in 2008, representing 24% and 14% of the total taxa present at SWA and SWC respectively, but only 1% at SWB. In 2015, %EPT increased at SWA, accounting for 68% of the species assemblage, however at SWB we recorded a complete species turnover, with EPT species (97%) being replaced by *Chironomidae* (82%; Table 6).

Chironomid taxa are generalists found in most aquatic environments, while EPT species are known to be sensitive to organic pollution and are therefore frequently used as indicators of good water quality. The marked shift from EPT to chironomid dominated assemblages at SWB does not appear to be linked to significant changes in water quality (See Section 4.1) or hydrology (see Section 5.2). Differing benthic communities may reflect inter-annual variance in temperature or stream flow not captured as a part of the field measurements, or changes in habitat structure although benthic communities are known to be variable and such variance should be considered in the interpretation (Valois et al. 2009).

5.3.3 Hilsenhoff Biotic Index

The Hilsenhoff Biotic Index (HBI) provides an estimate of organic pollution based on published pollution tolerance values for individual benthic invertebrate species (Hilsenhoff, 1987). The HBI is an average of the tolerance values of the individual species which range from 0 to 10, with 0 being intolerant and 10 being very tolerant of organic pollution, thus a lower HBI suggests better water quality.

HBI values in 2015 were significantly lower at SWA (5.01 to 1.91) resulting in a change in water quality descriptor from Fair to Excellent (Table 5 and Table 6). This reflects the marked increase in EPT species from 39 to 68% relative abundance. At SWB, the opposite was observed, with an increase in HBI from 2.61 to 4.34, changing the water quality classification from Excellent to Good. HBI at SWC remained relatively unchanged (3.86 to 3.37), however the change was sufficient to change the water quality at the site from Good to Excellent. Overall, the marked changed in HBI values may be indicative of sampling variability in benthic communities. However no significant changes in water quality or flow were noted that would explain changed in the benthic communities, or raise concerns about water quality in Black Creek.

5.3.4 Summary

Overall, the marked changed in HBI values, increased species richness and transition from dominance by chironomids to more sensitive EPT species may indicate that that water quality and habitat conditions (substrate composition) were better in 2015 than in 2008 although no significant changes in water quality or flow were detected during field visits that would explain these changes. Sampling variability may also have contributed to the observed changes.

Figure 14. Benthic community relative abundance at the Black Creek tributary study area in 2008.

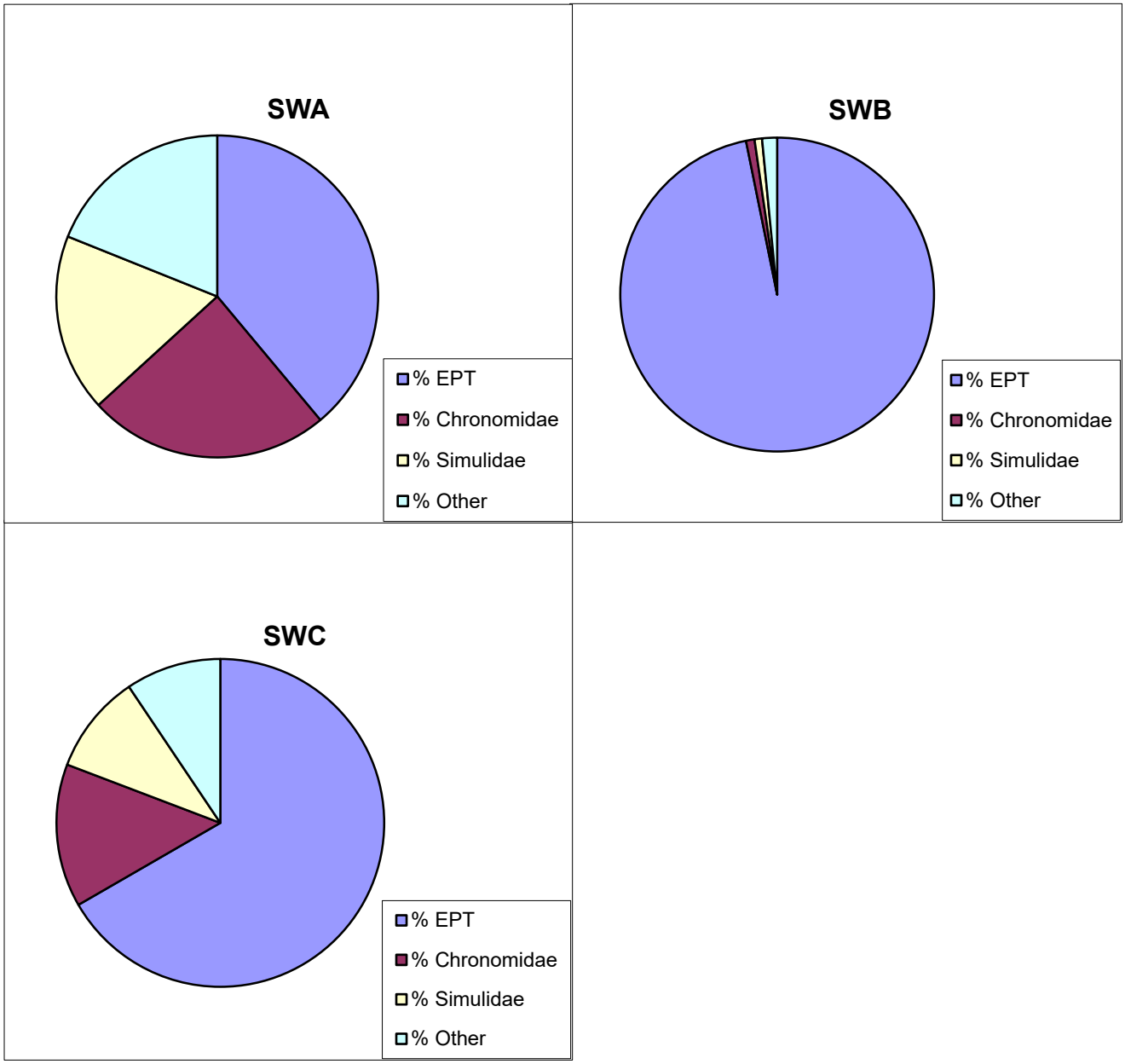
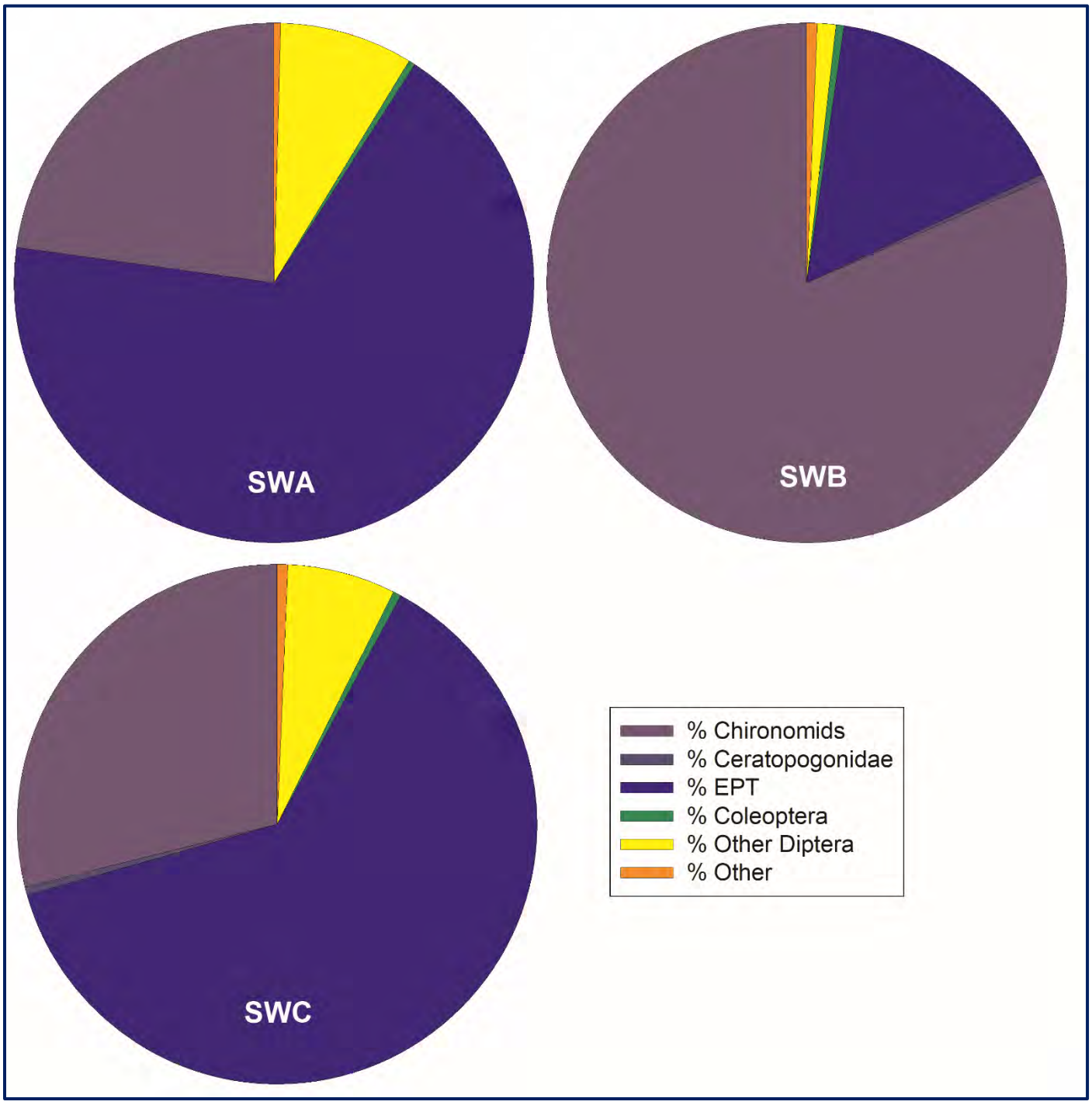


Figure 15. Benthic community relative abundance at the Black Creek tributary study area in 2015



5.4 Fish Community and Habitat

The fish community and associated habitat were assessed in Black Creek. Land use in the vicinity of the study area was agriculturally dominated but included a large woodlot, through which the stream flows, near Carson Road. Riparian vegetation was dominated by mature forest which provided shade and overhead cover, while watercress (*Nasturtium officinale*), mint (*Mentha spp.*) and jewelweed (*Impatiens spp.*) suggest significant groundwater flow. Channel morphology was a mixture of pools, riffles, flats and runs with an inconsistent width to depth ratio. Dense vegetative cover was provided by overhanging forest, undercut banks, woody debris and some log-jams.

In both 2008 and 2015 surveys, brook trout was the only species of fish captured. The presence of brook trout in Black Creek indicates cold and clean water and appropriate spawning habitat. Brook trout have a final-temperature preference (FTP - the temperature that they congregate in when exposed to a full temperature range) of 15.3 °C and are highly sensitive to thermal perturbations (Hasnain et al. 2010). Conditions conducive to brook trout spawning have been observed throughout the study area, including gravel and cobble substrates with significant groundwater upwelling. Higher numbers of fish at SWA and SWB may be the result of cooler waters due to the forested catchment of those locations, relative to the agricultural catchment near SWC.

Table 7. Fisheries assessment results.

Date	Species	SWA	SWB	SWC	Total
28-Aug-08	Brook Trout	7	8	13	28
03-Sep-14	Brook Trout	21	19	4	44

6. Conclusions

Black Creek is a coldwater stream that contains sufficient base flow and habitat to support a varied benthic community and environmentally sensitive brook trout population. Surveys conducted in 2008 and 2014-2015 expanded our understanding of the baseline condition and natural variability of the creek at Carson Road. Natural variability must be considered during future comparisons to assist in identifying if deviations from baseline conditions are within the range of natural variability or if they reflect changes resulting from the developments. In general, we found that water quality and stream flow did not vary considerably between the two sampling programs, however in many cases we have captured an expanded range of values for many key parameters and therefore developed a better understanding of the natural variability of the system.

Benthic invertebrate community indices indicated good to excellent water quality in Black Creek, which was supported by water quality data, however, results varied considerably between the 2008 and 2015 surveys. Benthic surveys and associated measurements of substrate composition will be collected on an ongoing basis as part of the adaptive monitoring and management strategy. We noted only a few guideline exceedances in nutrients and metals which were associated with high suspended sediment loads and

therefore not readily bioavailable[1]- to aquatic organisms. Likewise, dissolved oxygen concentrations were above guidelines in all but a few samples collected during a low flow event in 2014. Ongoing monitoring of dissolved oxygen in 2017 and 2018 should inform on the frequency of these low dissolved oxygen events.

The fish community diversity was limited, consisting of only brook trout at all Carson Road sampling stations. The species is highly sensitive to environmental degradation (e.g., turbidity, chlorine dissolved oxygen) and was ranked as the most sensitive species in Toronto-area streams (Wichert and Regier 1998; Table 7). The stormwater management proposed for the MSPA is focused on maintaining flows and nutrient levels, such that they do not reduce dissolved oxygen concentrations, and on thermal mitigation to maintain cool water temperatures, thereby protecting brook trout.

[1] *Bioavailability refers to the form of a pollutant that can be readily taken up by an organism and is therefore more likely to be toxic. If a metal, for example, is attached to sediment it is less likely to be taken up across the gill of an aquatic organism, and more likely to pass though the digestive tract. In both cases it will not enter the organism and is therefore as likely to be toxic.*

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Baseline Aquatic Studies for Midhurst Secondary Plan – Doran Road Development

2008-2017

Prepared for: Midhurst Landowner Group
Job #: J140054

January, 2018

DRAFT FOR DISCUSSION

1-5 Chancery Lane, Bracebridge, ON P1L 2E3 | 705-645-0021

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January 19, 2018 HESL Job #: J140054

Midhurst Landowner Group
c/o Mr. Vimal Patel
Sr. Project Manager, Land Development
Geranium Corporation
3190 Steeles Avenue E., Suite 300
Markham, ON L3R 1G9

Dear Vimal:

Re: J140054 - Draft Report - Baseline Aquatic Studies for Midhurst Secondary Plan– Doran Road

A number of studies have been completed to characterize the baseline chemical and biological conditions of Willow Creek and its tributaries in Midhurst for the proposed Midhurst Secondary Plan Area (MSPA). This report presents the results of baseline studies completed at the site of the Doran Road Development. Information on water quality, flows, benthic invertebrates and fisheries was collected by Gartner Lee Limited and AECOM in 2008-2009 and analyzed by Hutchinson Environmental Sciences Ltd. (HESL), while additional information was collected by HESL in 2015 and 2016. Baseline data were collected to meet the requirements of the Monitoring and Adaptive Management Plan for the Midhurst Secondary Plan Area, monitor the response of the aquatic environment to the development proposed as part of the MSPA and to inform the Adaptive Monitoring and Management Plan to minimize any potential future impacts on the watercourses.

We thank you for the opportunity to assist the Midhurst Landowner's Group with this project and hope that this report meets your needs.

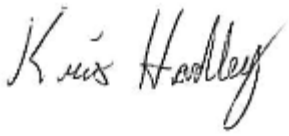
Sincerely,
Hutchinson Environmental Sciences Ltd.



Brent Parsons
brent.parsons@environmentalsciences.ca

Signatures

Report Prepared by:



Kristopher Hadley, Ph.D.
Aquatic Scientist



Brent Parsons
Senior Aquatic Scientist

Report Reviewed by:



Neil Hutchinson, Ph.D.
Principal Aquatic Scientist

Executive Summary

This report summarizes the methods and resultant data used to develop a baseline of water quality and aquatic biology for surface waters in the vicinity of the proposed Doran Road development of the Midhurst Secondary Plan Area (MSPA). The MSPA is located in the Township of Springwater, County of Simcoe, Ontario. Existing development in the Secondary Plan Area includes residential, commercial/industrial, mixed and agricultural uses. Proposed development in the Secondary Plan Area includes residential communities, commercial, industrial, mixed use and employment lands. The details of the planned development for the Midhurst Secondary Plan Area are contained within Springwater Township Official Plan Amendment (OPA) No. 38 Midhurst Secondary Plan and in approved draft plans. Although the total area of the MSPA is approximately 2,813 ha the development will be phased, with 300ha developed in Phase 1 and the Full Build Out occurring over a longer time period.

The proposed Doran Neighbourhood is bounded by Doran Road and Walt Road to the north, the Midhurst Settlement Area boundary to the east, environmental lands and the existing neighbourhood to the south and the existing residential development and Russell Road to the west. It lies within the Willow Creek subwatershed of the Nottawasaga watershed and contains a tributary of Willow Creek that drains into Little Lake. The proposed development is approximately 322 hectares (797 acres) in size.

The interactions of the MSPA with the aquatic environment will be mediated though an advanced stormwater management plan and an adaptive monitoring and management plan which provide the means to minimize any effects of the development on surface water and to monitor surface water responses. Collection of baseline data on water quality and aquatic biology of the study area began in 2008 and continued to the end of 2016. These data will be used to describe the pre-development conditions, monitor any changes during construction and occupation and inform the Master Drainage Plan

The Doran Road development area does not support substantial surface water resources. There is no permanent drainage from the site. The tributary of Willow Creek adjacent to the Doran Road Development is a coldwater, intermittent stream whose small catchment and lack of significant groundwater inputs result in a marked decline in discharge values following spring freshet, from ~130 L/sec to less than 1 L/sec in the summer and fall with some increases following precipitation events.

Following the initial 2008 survey, it was recommended that additional monitoring be completed so that the dataset might capture any changes that occurred between 2009 and 2014, and to document the baseline condition and natural variability at the Doran Road site. Water quality and stream flow were generally consistent between the 2008 and the 2014-2016 sampling programs, but the latter surveys captured an expanded range of values for many key parameters and therefore developed a better understanding of the natural variability of the system. Monitoring continued in 2017 and this report will be updated as data are available.

Benthic habitat quality was deemed to be poor at all locations along the tributary and benthic invertebrate communities varied considerably between the two sampling periods, while fish communities in the tributary were limited to a single species, Northern Redbelly Dace.

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1. Introduction and Project Understanding

The Midhurst Landowner Group is currently implementing development approvals within the Midhurst Secondary Plan Area of the Township of Springwater, including draft subdivision approvals within the Doran and Carson Neighbourhoods. Three initial summary reports were prepared by AECOM in 2009, including one to describe baseline surface water conditions within and downstream of the Doran Road Development project which drains to Willow Creek (GLL/AECOM 2009). HESL initiated a work plan to expand on the baseline datasets in 2014 and continued that data collection in 2015 and 2016. This report summarizes the data collected in 2014, 2015 and 2016 in the context of the 2008 data and provides an assessment of the baseline water quality data collected in the Doran Road Development Area to date. Companion reports will address surface water conditions at the Carson Road development (HESL 2017a), Midhurst Heights development (HESL 2017b) and in Willow Creek at the site of the proposed WWTP (HESL 2017c) and within the Village of Midhurst (HESL 2017d).

Information from these baseline reports informs the ongoing development and implementation of the Adaptive Monitoring and Management Plan (AMMP) as part of the Midhurst Secondary Plan Master Drainage Plan. The purpose of the AMMP is to:

- Identify and assess potential implications of the proposed development
- Design a solution using current best practices
- Implement the design through construction
- Monitor the performance of the design
- Evaluate the results
- Adjust the designs as appropriate

The overall goal of this study was to expand upon the baseline water quality dataset at the Doran Road Development site associated with the proposed development in the Midhurst Secondary Plan Area. This report compiles the baseline data collected during field programs in 2008, and 2014-2016. This expanded the existing dataset to inform on the natural inter-annual variation within the watercourse thus providing a more robust description of baseline water quality for future assessment to identify any impacts to surface water from the proposed methods of stormwater management, and provide guidance for the design and mitigation of the future developments.

2. Description of Projects

2.1 Doran Road Development

The proposed Doran Neighbourhood is bounded by Doran Road and Walt Road to the north, the Midhurst Settlement Area boundary to the east, environmental lands and the existing residential development to the south and the existing residential development and Russell Road to the west (Figure 1). It lies within the Willow Creek subwatershed of the Nottawasaga watershed and contains a tributary of Willow Creek that drains into Little Lake.

The proposed development is approximately 322 hectares (797 acres) in size. Domestic water supply will be provided as groundwater supplied by municipal wells, while domestic sewage will be collected, treated

and discharged to Willow Creek downstream of the community of Midhurst (Figure 1). The Ainley Group is currently carrying out Phases 3 and 4 of a Class Environmental Assessment (EA) on behalf of the Township of Springwater to determine the servicing/infrastructure (water, wastewater, transportation) requirements for the Midhurst Secondary Plan. A Master Drainage Plan is also being completed.

2.2 Stormwater Management

On site controls, Low Impact Development (LID) techniques and Best Management Practices (BMP) will be developed and implemented to infiltrate as much stormwater as possible with the target for infiltration in the post-development of 25 mm of rainfall. This will reduce stormwater temperatures and volumes, and improve water quality by reducing the discharge of storm water and associated pollutants to surface water. Stormwater in excess of the infiltration will be collected and treated to, at least, MOE "Enhanced Level" standards (80% removal of Total Suspended Solids) and discharged to tributaries of Willow Creek on site at locations adjacent to the stormwater management ponds (Figure 2).

3. Environmental Setting

3.1 Doran Road Development

The Doran Road Development is within the Willow Creek subwatershed of the Nottawasaga River watershed and contains a small tributary stream of Willow Creek that has its headwaters in a forested area east of Old Second Sideroad, which eventually drains into Little Lake (Figure 2). Little Lake is surrounded by a Provincially Significant Wetland (PSW) and is one of the few natural lakes in the Nottawasaga watershed. Previous biological surveys (Azimuth 2003) suggest that the tributary has permanent flow but that its potential for fish habitat is poor. however, that assessment was based on a single observation point near the headwaters. Observations made during a preliminary field visit in March 2008 suggested that the both the headwaters and the valley portions of the stream have fish habitat potential but that the valley portions of the stream might have higher potential.

The Doran Road Development area also contains a natural drainage course, i.e., a valley which has ephemeral flow during spring freshet and significant storm events and which forms part of the Willow Creek drainage, entering Willow Creek within Midhurst. Planned discharge of treated stormwater runoff from the proposed development is to be directed to this area, which does not lie within a floodplain nor does it contain any significant natural heritage features.

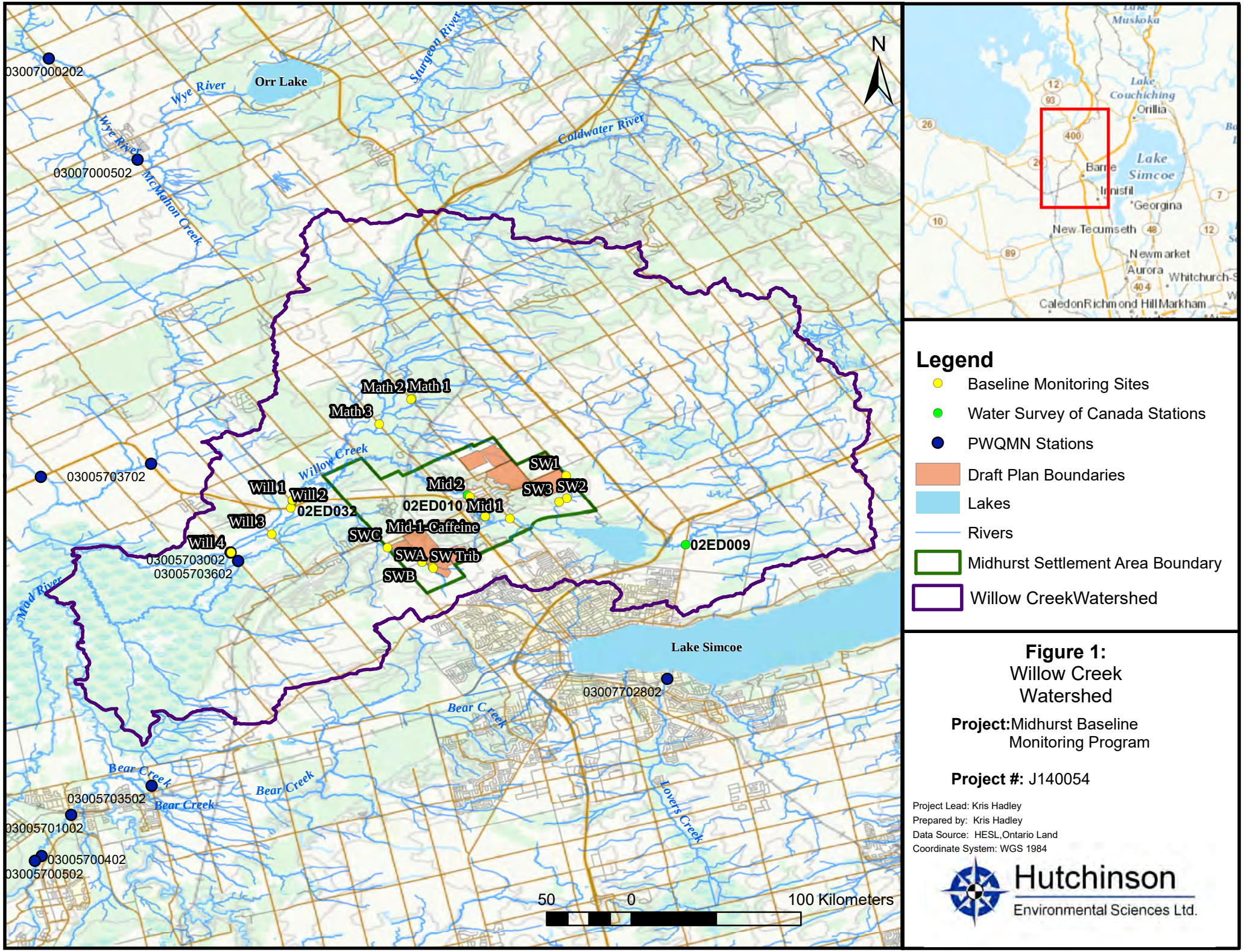


Figure 1:
Willow Creek
Watershed

Project: Midhurst Baseline
Monitoring Program

Project #: J140054

Project Lead: Kris Hadley
Prepared by: Kris Hadley
Data Source: HESL,Ontario Land
Coordinate System: WGS 1984

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3.2 Natural Heritage Features

Five designated environmentally significant areas exist in and around Midhurst that are linked to surface waters of the Willow Creek subwatershed. They are:

- **Little Lake Provincially Significant Wetland:** A wetland complex of 285 hectares that surrounds Little Lake. It is almost completely lacustrine, however, a small portion in the northwest contains riverine communities where Willow Creek enters Little Lake. Downstream, the reach of Willow Creek under St. Vincent Street is hydrologically connected to the Little Lake PSW.

- **Midhurst Swamp:** Midhurst Swamp is a 450 ha. Wetland, designated EP1 in the Springwater Township OP, 40% of which is comprised of riverine communities associated with Willow Creek. Treated stormwater, discharged at levels sufficient to protect surface waters at the Doran site, will not impact Midhurst Swamp.

- **Springwater Provincial Park:** Springwater Provincial Park is a recreational park located south of Willow Creek. It contains a wide variety of vegetation communities due to varied soils, topography and numerous localized areas of groundwater. Willow Creek flows well north of Springwater Provincial Park and therefore the Doran Road development will have no interaction or impact on it.

- **Minesing Swamp Provincially Significant Wetland:** Minesing Swamp PSW is not only provincially significant but it is also designated as a wetland of international importance by the Ramsar Convention on Wetlands. Willow Creek and its tributaries flow into Minesing Swamp before reaching the Nottawasaga River. Discharge of treated stormwater and sewage effluent at levels sufficient to protect the surface waters of Willow Creek and its tributaries will not impact Minesing Swamp.

- **Simcoe County Greenlands Designation:** The Simcoe County Greenlands Designation is found in the Simcoe County OP (County of Simcoe 2016). It represents areas identified based on criteria outlined within the “Development of a Natural Heritage System for the County of Simcoe” report (GLL 1996). None of the tributaries to Willow Creek in the proposed Doran Neighbourhood are designated as Greenlands.

3.3 Hydrogeology

Midhurst is in the Simcoe Upland and Lowland (elevations below 230 masl) physiographic regions (Chapman and Putnam 1984). A survey of the area has identified four regional aquifers in the vicinity of Midhurst (Golder Associates 2008). Aquifer A1 is located beneath the uplands (above 240 masl) while aquifer A2 lies below the lowlands at the Doran Road Development. These two aquifers (A1 and A2) intersect the surface waters of the Willow Creek tributary near the south of the Doran subject property, within the valley. Deeper aquifers A3 and A4 are isolated from direct impact from surface activities and are proposed as the source of municipal water for the Midhurst Secondary Plan area. Willow Creek, downstream of Midhurst receives groundwater inputs from aquifers A1 and A2. Golder (2014) provides

detailed descriptions of the groundwater regime, the proposed water supplies and any interactions between groundwater and surface water.

4. Methods – Field Programs

A summary of the field studies conducted for the baseline water quality monitoring at the Doran Road Development to date is in Table 1. Detailed methodology for each field program is described in Sections 4.1 to 4.4, including a summary of the 2008 sampling methods and outlining any necessary deviations from it.

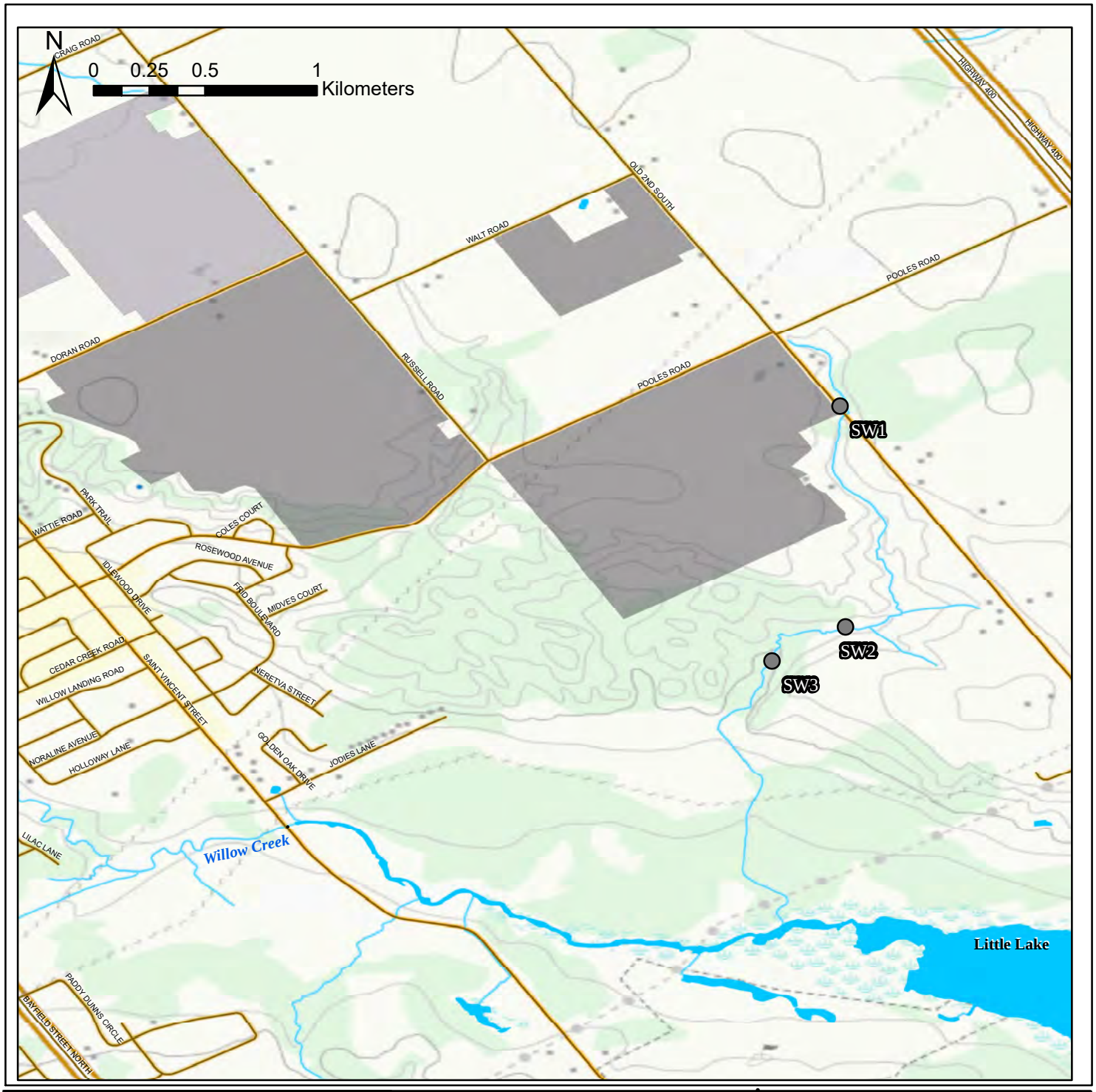
Table 1. Summary of the Field Studies Conducted to Describe Baseline Water Quality at the Doran Road Development

Organization	Date	Parameters
Golder Associates	March 25th, 2008	Water Quality
GLL (AECOM)	August 28th, 2008	Fish
	May 13th and 14th, 2008	Benthic Invertebrates
	April 2008 to Sept. 2008	Water Quality
HESL	Sept 2nd, 2014	Fish
	May 14th, 2015	Benthic Invertebrates
	Sept. to October 2014; May to Sept. 2015; March 2016	Water Quality and Flow

4.1 Water Quality

Golder Associates took a single water quality sample from the Willow Creek Tributary at Second Sideroad on March 25, 2008, prior to the onset of the GLL field program. The results showed waters were low in nutrients, 1.8 mg/L nitrate, < 0.01 mg/L each of nitrite, total ammonia and total phosphorus and 0.14 mg/L of total Kjeldahl nitrogen.

The GLL (AECOM) field program consisted of 6 field visits from April 2008 to September 2008 during which water samples were collected at three sites (SW1, SW2 and SW3; Figure 2). Water samples were analyzed for a standard suite of parameters including general chemistry, nutrients and metals by Maxxam Analytics, a fully accredited laboratory. No flow was present at SW1 and SW2 during the August 28th, 2008 field visit and therefore no water quality data was available. Field measurements, including pH, temperature, conductivity and dissolved oxygen, were collected during each site visit. Continuous temperature loggers ("Tidbits©") were installed at all three sites from mid-April to late September 2008.





Legend

- Rivers
- Lakes
- Doran Road Sampling Sites
- Doran Road Development
- Midhurst Heights Development Area

Project Lead: Brent Parsons
Prepared by: Kris Hadley
Data Source: HESL,Ontario Land, ESRI
Coordinate System: GCS WGS 1984

Figure 2:
Doran Road
Sampling Sites

Project: Doran Road
Baseline Monitoring

Project #: J140054

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The HESL field program revisited the same three sampling stations as GLL (SW1-SW3) in 2014 (Sept and Oct), 2015 (May to Sept) and 2016 (Mar). Water samples were collected and analyzed for the same standard suite of parameters including general chemistry, nutrients and metals by ALS Environmental, a fully accredited laboratory. Likewise, field measurements of pH, specific conductivity, water temperature and dissolved oxygen were collected at each station during each site visit. Temperature loggers were installed for the 2014 and 2015 surveys.

4.1.1 Numerical analysis

Summary statistics tabulated include sample size (n), number of samples above the detection limit (n>DL), minimum (Min), maximum (Max), arithmetic mean, and median (Table 2). Boxplots were used to summarize key water quality parameters as they allow for efficient visualization of five summary statistics, the median, two hinges (the 75th and 25th percentiles) and the whiskers which extend from the hinge to the largest and smallest value no further away than 1.5 * the Interquartile Range.

Values below detection limit were replaced with a value equivalent to the detection limit.

4.2 Flows

No continuous flow data for Willow Creek was available at our sampling stations, therefore flow was estimated using 1973-1995 data from Environment Canada's HYDAT database for Willow Creek above Little Lake (Station 02ED009; Figure 1). Flows were estimated for the Willow Creek tributary on the east side of the Doran Rd development by prorating on the basis of watershed area using areas of 94.8 km^2 for Willow Creek above Little Lake and 2.6 km^2 for the tributary.

The field program included stream flow measurements made during each visit at all three sample sites. Sampling followed the methodology employed during initial sampling in 2008 (Ontario Stream Assessment Protocol (Stanfield 2010)). Briefly, the number of cross sectional measurement panels was determined via channel width while stream velocity was measured using a Marsh McBirney Flo Mate in each panel in 2008 and an OIT MF Pro flow mate in 2015. Sampling depth was based on water depth within each measurement panel. Stream profiles, discharges and average velocity were calculated later for each site.

4.3 Benthic Invertebrates

A benthic macroinvertebrate community study was conducted on the Willow Creek tributary by GLL/AECOM on May 13th and 14th, 2008, and by HESL on May 14th, 2015. Qualitative samples were collected at SW1, SW2 and SW3 (Figure 2). To ensure that data collected in by HESL were comparable to those collected in 2008, sampling methods followed those described for the initial 1-year baseline monitoring performed in 2008 (GLL/AECOM 2009). We followed the Benthos Sampling Protocol of Gartner Lee Ltd. (GLL) on each of the study locations which included the following:

- Stations sampled over a constant pre-determined area (2m x 2m) at each station;
- Travelling kick and sweep method utilizing a D-frame net (500 micron), moving upstream from bank to bank, over the entire area; and
- Effort of 2 minutes for each study reach.

Samples were transferred into labelled sample jars and preserved with 70% alcohol solution and submitted to a qualified taxonomist, Richard Bland, for sorting and identification to the lowest taxonomic level possible.

The taxonomist identified an issue with the preservation of the SW3 benthic sample from 2008. Specifically, the sample may not have been thoroughly mixed and dilution of the alcohol solution may have occurred. As a result, accurate identification of species such as *Simulidae* (black flies) and *Siphlonurids* (mayflies) was not possible, as they were significantly decomposed (pers. comm. R. Bland). Therefore, the SW3 dataset lacked the precision of the other sites; however as the species were not overly abundant and metrics were calculated, the dataset was deemed sufficient for the description of the benthic community at SW3. No sample preservation issues were identified for the 2015 samples.

Habitat surveys were also conducted at each of the benthic sampling stations, to characterize habitat within the tributary and inform on the importance of habitat in determining benthic community structure. Habitat survey parameters included stream substrate, water depth, flow rates, morphology and surrounding land use.

The following benthic invertebrate metrics were calculated:

- Species richness
- Species diversity (lowest practical level);
- Simpson's Diversity
- Relative abundance of taxonomic groups; and
- Hilsenhoff Biotic Index (HBI)

4.4 Fisheries

A field investigation was conducted to supplement the data collected in 2008 and provide additional information on the fish community and fish habitat present in the Doran Road region. The three Doran Road sites investigated on August 28, 2008 as part of the initial fisheries survey were revisited on Sept 2nd, 2014 (Figure 2). Sampling protocols aimed to mirror the initial fish survey and included backpack electrofishing to sample isolated refuge pool(s) at each site. Fish were identified to species, counted, assigned an approximate age, and released alive. Water temperature, conductivity, pH and sampling time, were also recorded for each site. Following sampling methods from 2008, electrofishing at SW3 was conducted downstream of the run in small isolated pools within the wetland habitat, while sampling for SW2 was completed at a much larger (~20 m x 5 m) pool downstream of SW2. No other closer pools existed. Electrofishing at SW2 was restricted to the outer edge of the pool due to dangerous fishing conditions (relatively deep water and soft sediments).

5. Results

5.1 Water Quality

Summary statistics from the 2014-2016 data collection relative to previous data collected in 2008, highlight the range and average values of parameters of interest from the two monitoring periods (Table 2).

Total phosphorus was above PWQO (MOE 1994) levels in ~60% of the baseline samples collected (8 of 13, Figure 3), primarily at SW1, however, elevated total phosphorus concentrations were frequently associated with elevated particulate matter in the fall (September and October) when SW1 was almost dry (AECOM, 2009; Figure 4). Therefore, these results may not be representative of flowing water.

Nitrate was only detectable in surface water in April during 2008 sampling (AECOM, 2009), with previous research suggesting elevated NO_3 concentrations occurred in local groundwater (Golder, 2008). For example, nitrate values of 14.9 mg/L and 27 mg/L were recorded in the upper aquifer site, while the A1 (to ~50m below surface) and A2 (~53-84m depth) aquifers yielded nitrate concentrations ranging from 1.2 – 11 mg/L and 0.1 to 10.5 mg/L respectively (Golder, 2008). Surface water samples collected by HESL had consistently detectable concentrations of nitrate likely owing to improved detection limits beginning in 2015 (0.020 vs 0.1 mg/L), however concentrations recorded were still low (Table 2). Calculated unionized ammonia concentrations were below PWQO guideline in all samples tested (0.020 mg/L).

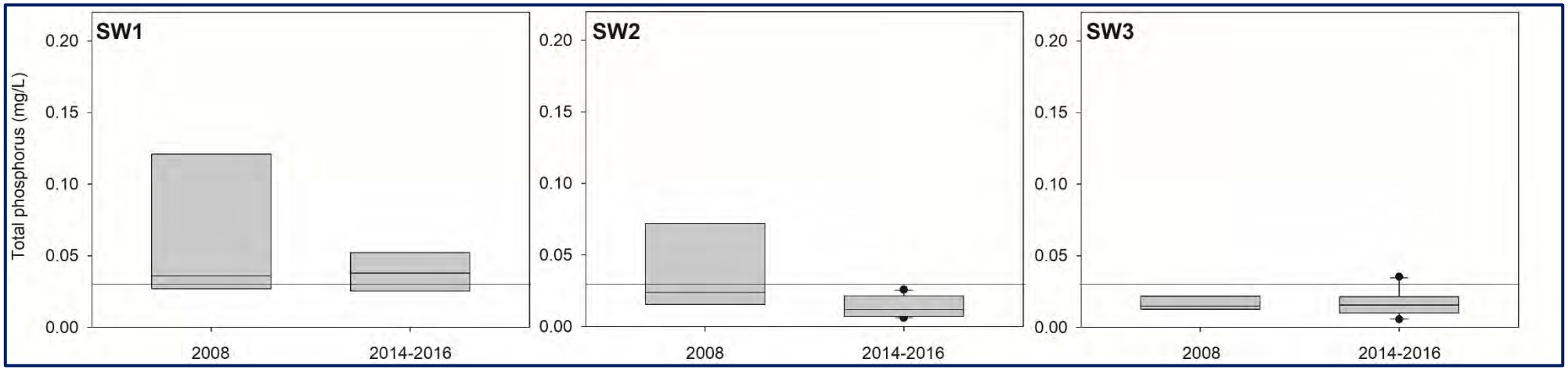
Conductivity was consistent across all three water quality stations. Additional sampling captured a broader gradient of conductivity concentrations expanding our understanding of baseline water quality in the Region (Figure 5).

Dissolved oxygen concentrations were consistent between the two sampling programs (Figure 6). Dissolved oxygen fell below MOE requirements for protection of cold water aquatic life (5-8 mg/L, MOE, 1994) in approximately 18% of samples collected (8 of 44), primarily during low flow periods in late August and September and during winter sampling in March.

Several total metals, analyzed as a part of both the 2008 and 2014-2016 monitoring programs fell below analytical detection limits including antimony, beryllium, bismuth, lithium, silver, tellurium, thallium, thorium, tin and tungsten and so no data are presented in Table 2. Total metals concentrations observed above PWQO levels included aluminum, iron and zinc, which were associated with suspended solids (Figure 7).

Temperature logger data collected in 2014 and 2015 at SW1-SW3 were consistent with what was reported in 2008 (Figure 8). Diurnal fluctuations of ~5^{o}C were observed and consistent between sites in 2014 (though data were limited), however SW2 temperatures differed from those observed at SW1 and SW3 in 2015 (Figure 9). SW2 is located within pastureland with an exposed channel, while SW1 and 3 are shaded by forest, thus water temperatures fluctuated more in SW2 than in SW1 and SW3, particularly during the warmest period (July and August).

Figure 3. Total Phosphorus Concentrations at Doran Road



Horizontal line indicates PWQO Guideline of 0.03 mg/L

Table 2. Summary Statistics from the 2008 and 2014-2016 Water Quality Sampling Campaigns at the Doran Road Development Stations

			SW1											SW2									
Site	Detection Limit		2008					2014 - 2016						2008					2014-2016				
		Units	max	min	mean	median	n>DL	max	min	mean	median	n>DL	n	min	max	mean	median	n>DL	min	max	mean	median	n>DL	n
Temperature		^{0}C	19.0	9.0	14.2	14.0	9	18.9	0.1	12.1	14.7	8	8	12.0	19.0	14.3	12.0	5	0.2	18.4	12.3	13.3	10	10
Dissolved Oxygen		mg/L	9.30	6.80	7.77	7.21	9	9.81	5.74	8.07	8.20	8	8	6.73	13.40	9.40	9.30	5	4.46	9.70	8.09	8.66	10	10
pH			8.00	7.50	7.79	7.84	9	8.30	7.16	7.85	7.82	8	8	7.70	8.40	7.97	7.98	5	7.32	8.22	7.88	7.88	10	10
Specific Conductivity		uS/cm	780.0	510.0	610.8	565.0	9	712.0	317.0	503.1	497.0	8	8	416.0	635.0	541.6	538.0	5	300.0	662.0	470.0	461.0	10	10
Physical Tests (Water)																							
Total Suspended Solids	2.0	mg/L	26.00	1.00	11.50	9.50	8	6.00	1.02	2.74	2.15	5	8	3.00	24.00	10.33	4.00	3	0.80	20.20	4.56	2.25	7	10
Turbidity	0.10	NTU	37.00	0.80	10.26	5.90	9	3.22	0.28	1.34	1.20	6	6	0.50	15.00	6.08	2.10	5	0.22	5.16	1.04	0.66	9	9
Anions and Nutrients (Water)																							
Ammonia, Total (as N)	0.050	mg/L	0.100	0.100	0.100	0.100	5	0.380	0.020	0.110	0.077	5	8	0.080	0.180	0.130	0.130	2	0.050	0.214	0.093	0.067	7	9
Nitrate and Nitrite as N	0.022	mg/L	-	-	-	-	0	3.790	0.022	0.618	0.190	6	8	-	-	-	-		0.022	0.526	0.150	0.124	4	10
Nitrate (as N)	0.020	mg/L	0.600	0.600	0.600	0.600	5	3.790	0.020	0.606	0.140	6	8	0.600	0.600	0.600	0.600	1	0.020	0.526	0.114	0.099	4	10
Total Kjeldahl Nitrogen	0.15	mg/L	2.000	0.500	0.820	0.500	9	0.720	0.210	0.431	0.420	8	8	0.400	1.200	0.680	0.600	5	0.170	0.630	0.365	0.395	10	10
Organic / Inorganic Carbon (Water)																							
Total Phosphorus	0.0030	mg/L	0.2000	0.0270	0.0664	0.0360	9	0.0723	0.0244	0.0401	0.0379	8	8	0.0130	0.1200	0.0398	0.0240	5	0.0061	0.0258	0.0140	0.0120	10	10
Dissolved Organic Carbon	1.0	mg/L	7.7	3.5	5.1	5.0	9	11.2	2.9	6.2	6.2	8	8	3.1	6.2	4.8	5.3	5	1.7	9.1	4.9	4.4	10	10
Total Metals (Water)																							
Aluminum (Al)-Total	0.010	mg/L	0.640	0.016	0.225	0.020	9	0.107	0.010	0.035	0.017	6	8	0.016	1.700	0.382	0.052	5	0.010	0.125	0.043	0.022	10	10
Arsenic (As)-Total	0.00010	mg/L	0.00200	0.00200	0.00200	0.00200	5	0.00100	0.00014	0.00064	0.00068	4	8	-	-	-	-	0	0.00010	0.00100	0.00067	0.00100	4	10
Barium (Ba)-Total	0.00020	mg/L	0.072	0.024	0.034	0.025	9	0.029	0.021	0.024	0.025	8	8	0.011	0.032	0.016	0.013	5	0.015	0.021	0.017	0.017	10	10
Boron (B)-Total	0.010	mg/L	0.025	0.011	0.018	0.017	7	0.019	0.010	0.012	0.011	6	8	0.011	0.011	0.011	0.011	1	0.010	0.017	0.011	0.010	3	10
Cadmium (Cd)-Total	0.000010	mg/L	-	-	-	-	0	0.00009	0.00001	0.00005	0.00005	0	8	0.00030	0.00030	0.00030	0.00030	1	0.00001	0.00009	0.00006	0.00009	1	10
Calcium (Ca)-Total	0.50	mg/L	130.0	83.0	104.6	100.0	9	126.0	80.0	105.4	106.0	8	8	75.0	110.0	92.6	90.0	5	84.7	112.0	98.3	97.3	10	10
Cesium (Cs)-Total	0.000010	mg/L	-	-	-	-	0	0.00001	0.00001	0.00001	0.00001	0	4	-	-	-	-	0	0.00001	0.00001	0.00001	0.00001	0	4
Chromium (Cr)-Total	0.00050	mg/L	-	-	-	-	0	0.00072	0.00050	0.00057	0.00050	3	8	-	-	-	-	0	0.00050	0.00083	0.00058	0.00050	3	10
Cobalt (Co)-Total	0.00010	mg/L	0.0011	0.0011	0.0011	0.0011	5	0.0005	0.0001	0.0003	0.0003	2	8	0.0013	0.0013	0.0013	0.0013	1	0.0001	0.0005	0.0003	0.0005	0	10
Copper (Cu)-Total	0.0010	mg/L	0.0020	0.0010	0.0017	0.0020	7	0.0010	0.0010	0.0010	0.0010	0	8	0.0030	0.0030	0.0030	0.0030	1	0.0010	0.0013	0.0010	0.0010	2	10
Iron (Fe)-Total	0.050	mg/L	5.30	0.35	2.19	0.92	7	0.75	0.07	0.29	0.24	8	8	3.20	3.20	3.20	3.20	1	0.05	0.75	0.17	0.09	8	10
Lead (Pb)-Total	0.00010	mg/L	0.0018	0.0009	0.0014	0.0014	6	0.0005	0.0001	0.0003	0.0004	2	8	0.0013	0.0013	0.0013	0.0013	1	0.0001	0.0005	0.0003	0.0005	0	10
Magnesium (Mg)-Total	0.050	mg/L	13.0	7.9	10.3	9.8	9	12.3	7.7	11.0	11.3	8	8	7.2	12.0	9.7	9.4	5	8.8	12.7	10.6	10.5	10	10
Manganese (Mn)-Total	0.00050	mg/L	3.1000	0.0190	0.7878	0.1700	9	0.2640	0.0389	0.1380	0.1325	8	8	0.0530	1.0000	0.3088	0.0910	4	0.0029	0.2810	0.0581	0.0369	10	10
Molybdenum (Mo)-Total	0.000050	mg/L	-	-	-	-	0	0.00050	0.00006	0.00030	0.00032	4	8	-	-	-	-	0	0.00007	0.00050	0.00034	0.00050	4	10
Nickel (Ni)-Total	0.00050	mg/L	-	-	-	-	0	0.0010	0.0005	0.0008	0.0008	1	8	0.0020	0.0020	0.0020	0.0020	1	0.0005	0.0010	0.0008	0.0010	0	10
Potassium (K)-Total	0.050	mg/L	2.50	1.60	2.02	2.00	9	3.40	1.70	2.56	2.55	8	8	0.31	2.10	0.88	0.55	4	1.00	3.07	1.50	1.35	7	10
Rubidium (Rb)-Total	0.00020	mg/L	-	-	-	-	0	0.0014	0.0006	0.0010	0.0010	4	4	-	-	-	-	0	0.0005	0.0016	0.0008	0.0006	4	4
Selenium (Se)-Total	0.000050	mg/L	-	-	-	-	0	0.00040	0.00006	0.00024	0.00025	4	8	-	-	-	-	0	0.00006	0.00040	0.00027	0.00040	4	10
Silicon (Si)-Total	0.050	mg/L	8.00	4.00	5.68	5.50	9	7.75	4.50	6.32	6.45	8	8	2.40	6.50	3.88	3.50	5	3.80	6.00	4.64	4.45	10	10
Sodium (Na)-Total	0.50	mg/L	25.0	13.0	16.0	14.0	9	26.5	20.5	22.6	22.3	8	8	0.0	0.0	0.0	0.0	5	4.0	15.6	12.3	13.3	10	10
Strontium (Sr)-Total	0.0010	mg/L	0.250	0.140	0.200	0.210	9	0.251	0.166	0.218	0.229	8	8	0.140	0.230	0.178	0.170	5	0.166	0.219	0.197	0.197	10	10
Sulfur (S)-Total	0.50	mg/L	-	-	-	-	0	3.36	0.50	1.43	0.94	3	4	-	-	-	-	0	0.57	5.00	2.95	2.91	4	7
Titanium (Ti)-Total	0.00030	mg/L	0.0340	0.0260	0.0300	0.0300	6	0.0047	0.0003	0.0019	0.0015	3	8	0.0060	0.1100	0.0580	0.0580	2	0.0006	0.0062	0.0025	0.0020	6	10
Uranium (U)-Total	0.000010	mg/L	0.0004	0.0002	0.0003	0.0003	9	0.0100	0.0001	0.0029	0.0007	4	8	0.0002	0.0003	0.0003	0.0003	5	0.0001	0.0010	0.0007	0.0010	4	10
Vanadium (V)-Total	0.00050	mg/L	0.0030	0.0010	0.0020	0.0020	7	0.0010	0.0005	0.0006	0.0005	0	8	0.0040	0.0040	0.0040	0.0040	1	0.0005	0.0005	0.0005	0.0005	0	10
Zinc (Zn)-Total	0.00300	mg/L	1.1000	0.0220	0.2576	0.0490	9	0.0176	0.0005	0.0078	0.0060	5	8	0.0140	0.0140	0.0140	0.0140	1	0.0030	0.0070	0.0035	0.0030	3	10
Zirconium (Zr)-Total	0.00030	mg/L	-	-	-	-	0	0.0096	0.0003	0.0035	0.0022	2	8	0.0020	0.0020	0.0020	0.0020	1	0.0003	0.0040	0.0025	0.0040	0	10

			SW3										
Site	Detection Limit		2008					2014-2016					
		Units	min	max	mean	median	n>DL	min	max	mean	median	n>DL	n
Temperature		^{0}C	12.3	20.5	16.1	15.3	6	0.0	18.4	12.5	14.0	9	9
Dissolved Oxygen		mg/L	5.50	11.00	7.99	7.65	6	5.34	12.46	9.29	9.61	10	10
pH			7.30	8.45	7.85	7.89	6	7.54	8.55	8.12	8.23	10	10
Specific Conductivity		uS/cm	382.0	590.0	493.5	489.5	6	293.0	593.0	456.8	444.5	10	10
Physical Tests (Water)													
Total Suspended Solids	2.0	mg/L	1.00	12.00	5.67	4.00	3	1.21	36.00	7.11	2.00	4	10
Turbidity	0.10	NTU	0.30	1.20	0.82	0.85	6	0.39	4.03	1.36	1.08	9	9
Anions and Nutrients (Water)													
Ammonia, Total (as N)	0.050	mg/L	0.080	0.080	0.080	0.080	1	0.050	0.145	0.069	0.051	5	10
Nitrate and Nitrite as N	0.022	mg/L	-	-	-	-	0	0.022	0.541	0.217	0.200	5	10
Nitrate (as N)	0.020	mg/L	0.400	0.400	0.400	0.400	1	0.021	0.541	0.185	0.100	7	10
Total Kjeldahl Nitrogen	0.15	mg/L	0.300	0.700	0.517	0.500	6	0.200	0.830	0.385	0.375	10	10
Organic / Inorganic Carbon (Water)													
Total Phosphorus	0.0030	mg/L	0.0120	0.0240	0.0167	0.0150	6	0.0056	0.0353	0.0170	0.0156	10	10
Dissolved Organic Carbon	1.0	mg/L	3.4	5.2	4.3	4.5	6	2.4	8.8	4.6	4.4	10	10
Total Metals (Water)													
Aluminum (Al)-Total	0.010	mg/L	0.010	0.290	0.087	0.033	6	0.010	0.204	0.051	0.012	5	10
Arsenic (As)-Total	0.00010	mg/L	-	-	-	-	0	0.00015	0.00100	0.00068	0.00100	4	10
Barium (Ba)-Total	0.00020	mg/L	-	-	-	-	0	0.014	0.031	0.020	0.018	10	10
Boron (B)-Total	0.010	mg/L	0.010	0.020	0.014	0.013	3	0.010	0.015	0.011	0.010	3	10
Cadmium (Cd)-Total	0.000010	mg/L	0.00010	0.00010	0.00010	0.00010	1	0.000	0.000	0.000	0.000	0	10
Calcium (Ca)-Total	0.50	mg/L	75.0	110.0	88.8	87.5	6	76.1	103.0	91.9	93.5	10	10
Cesium (Cs)-Total	0.000010	mg/L	-	-	-	-	0	0.00001	0.000014	0.0000115	0.000011	2	4
Chromium (Cr)-Total	0.00050	mg/L	-	-	-	-	0	0.00050	0.00092	0.00060	0.00050	3	10
Cobalt (Co)-Total	0.00010	mg/L	-	-	-	-	0	0.0001	0.0005	0.0003	0.0005	2	10
Copper (Cu)-Total	0.0010	mg/L	-	-	-	-	0	0.0010	0.0010	0.0010	0.0010	0	10
Iron (Fe)-Total	0.050	mg/L	0.10	0.61	0.29	0.22	4	0.05	0.31	0.16	0.13	9	10
Lead (Pb)-Total	0.00010	mg/L	-	-	-	-	0	0.0001	0.0005	0.0003	0.0005	2	10
Magnesium (Mg)-Total	0.050	mg/L	7.6	12.0	9.5	9.5	6	8.1	14.0	10.9	11.0	10	10
Manganese (Mn)-Total	0.00050	mg/L	0.0100	0.4000	0.1875	0.1790	6	0.0030	0.0805	0.0397	0.0395	10	10
Molybdenum (Mo)-Total	0.000050	mg/L	-	-	-	-	0	0.00007	0.00050	0.00034	0.00050	4	10
Nickel (Ni)-Total	0.00050	mg/L	0.0030	0.0030	0.0030	0.0030	1	0.001	0.001	0.001	0.001	0	10
Potassium (K)-Total	0.050	mg/L	0.70	1.90	1.21	1.20	6	0.94	1.95	1.27	1.15	7	10
Rubidium (Rb)-Total	0.00020	mg/L	-	-	-	-	0	0.0005	0.0015	0.0009	0.0007	4	4
Selenium (Se)-Total	0.000050	mg/L	-	-	-	-	0	0.00006	0.00040	0.00027	0.00040	4	10
Silicon (Si)-Total	0.050	mg/L	2.30	5.20	3.70	3.60	6	4.10	6.20	4.85	4.70	10	10
Sodium (Na)-Total	0.50	mg/L	6.7	8.8	7.8	7.8	6	6.6	12.3	10.0	10.8	10	10
Strontium (Sr)-Total	0.0010	mg/L	0.140	0.220	0.173	0.170	6	0.162	0.199	0.186	0.191	10	10
Sulfur (S)-Total	0.50	mg/L	-	-	-	-	0	0.83	5.00	3.15	2.84	4	7
Titanium (Ti)-Total	0.00030	mg/L	0.0150	0.0170	0.0160	0.0160	2	0.0003	0.0094	0.0030	0.0020	2	10
Uranium (U)-Total	0.000010	mg/L	0.0002	0.0004	0.0003	0.0003	6	0.0001	0.0010	0.0007	0.0010	4	10
Vanadium (V)-Total	0.00050	mg/L	0.0010	0.0010	0.0010	0.0010	1	0.0005	0.0007	0.0005	0.0005	2	10
Zinc (Zn)-Total	0.00300	mg/L	0.0100	0.0100	0.0100	0.0100	1	0.0030	0.0046	0.0032	0.0030	1	10
Zirconium (Zr)-Total	0.00030	mg/L	-	-	-	-	0	0.0003	0.0040	0.0025	0.0040	0	10

Figure 4. Correlation between Total Phosphorus and Turbidity at Doran Road

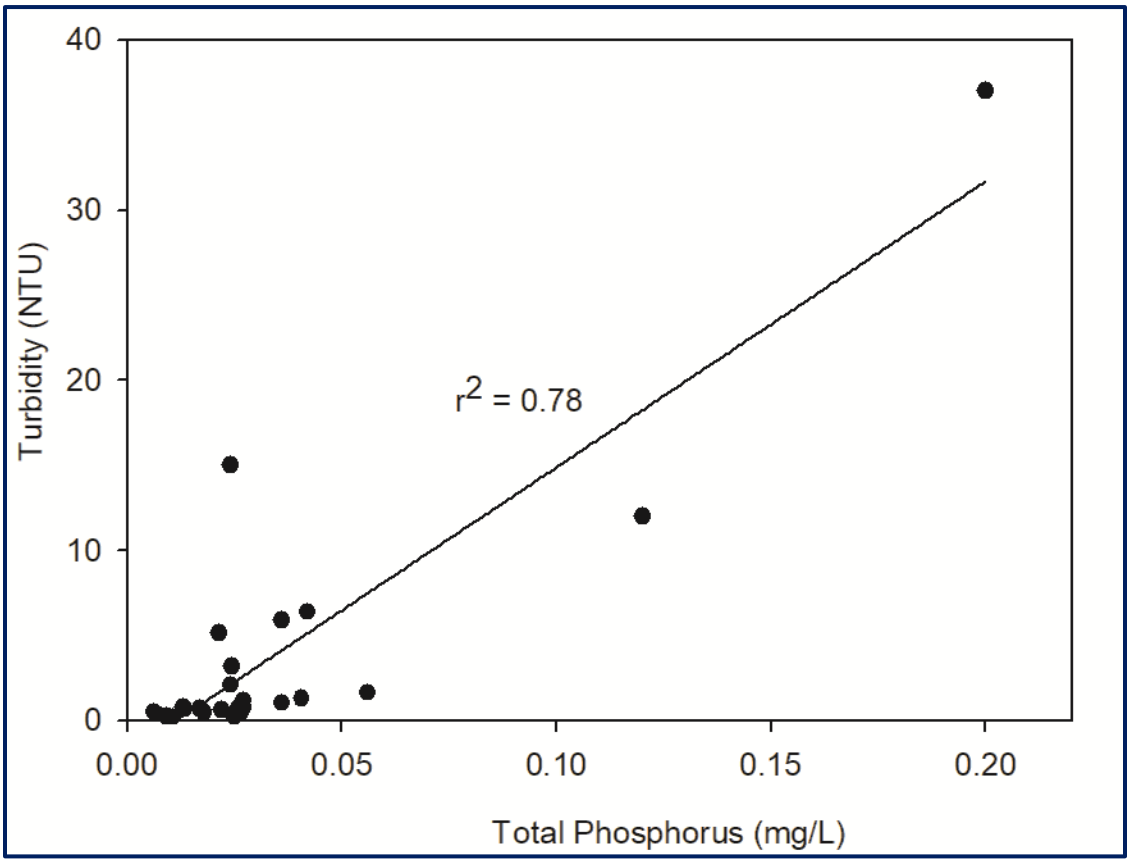


Figure 5. Specific Conductivity at Doran Road

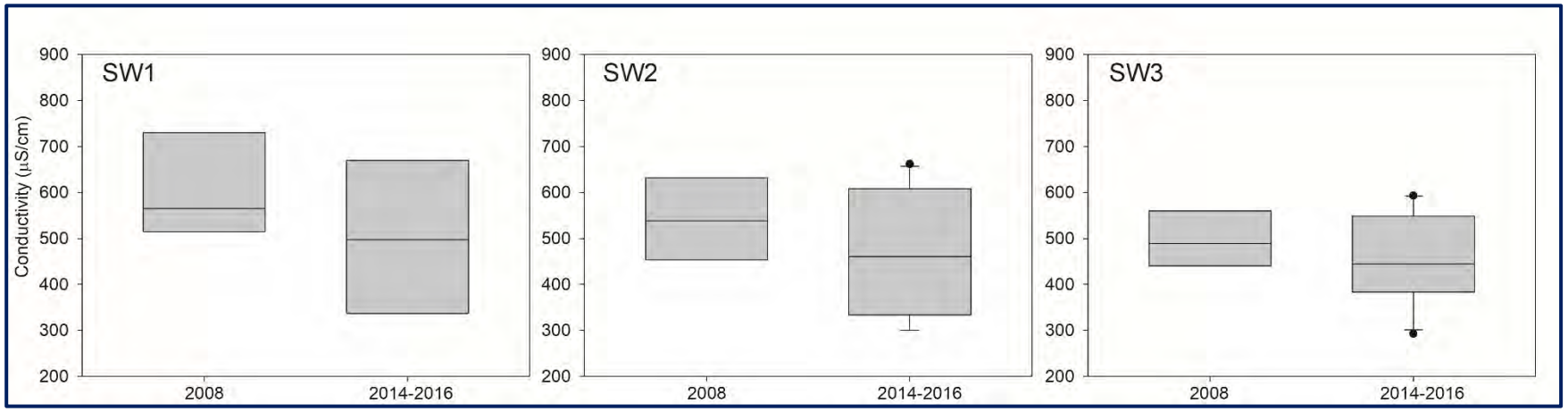
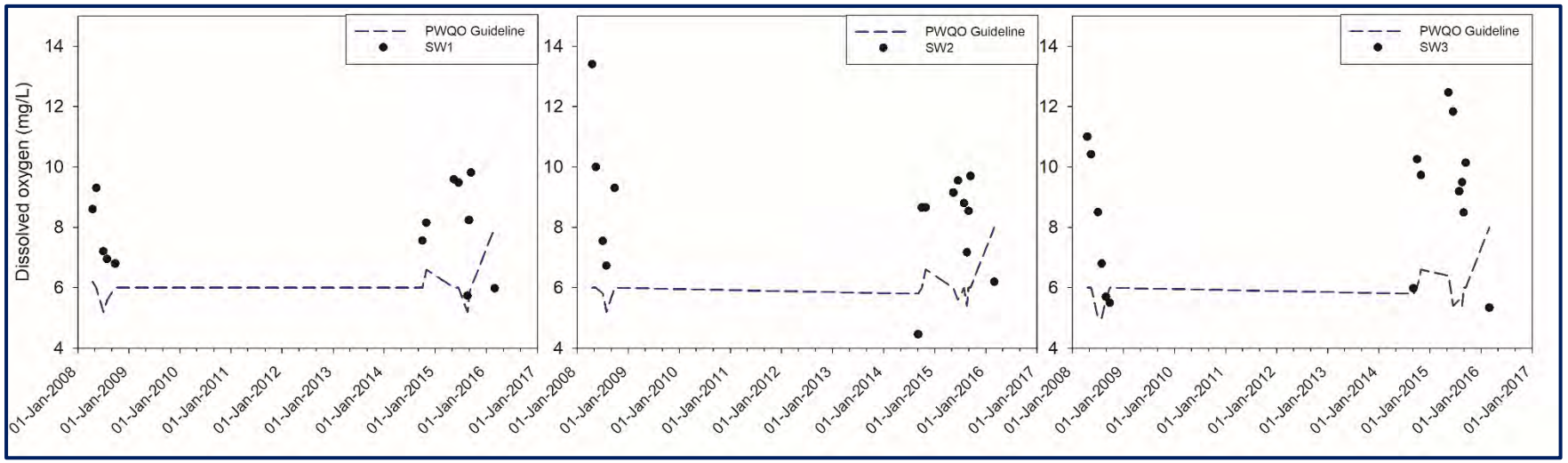


Figure 6. Dissolved Oxygen Concentrations at Doran Road



Dotted line indicates the temperature dependent PWQO guideline 5 – 8 mg/L

Figure 7. Correlations between Selected Total Metals and Turbidity at Doran Road

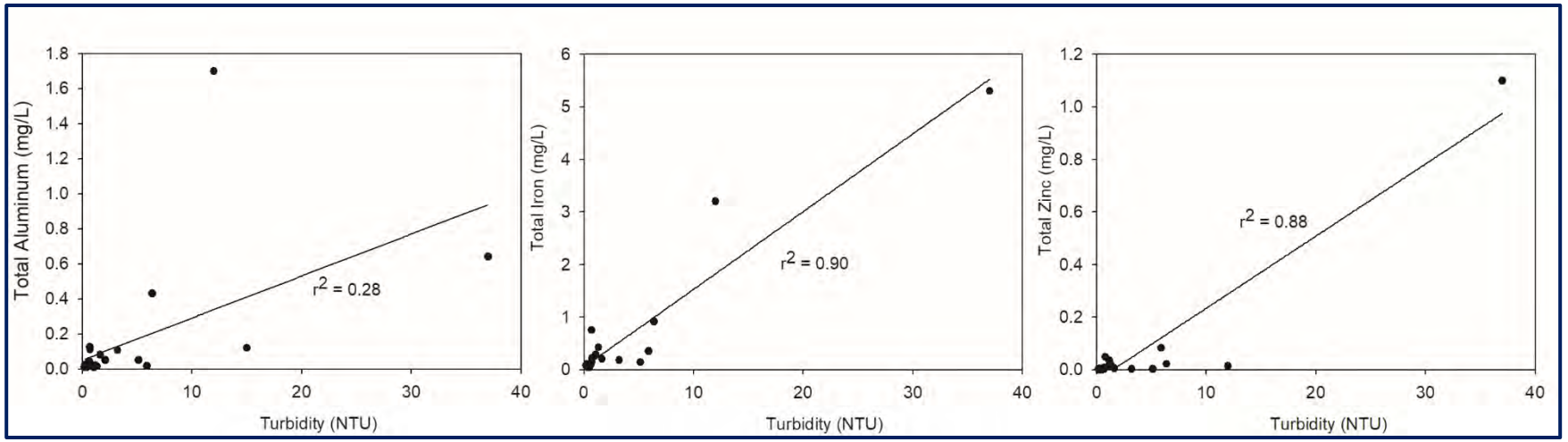


Figure 8. Continuous 2008 Temperature Record for Doran Road Development Monitoring Sites

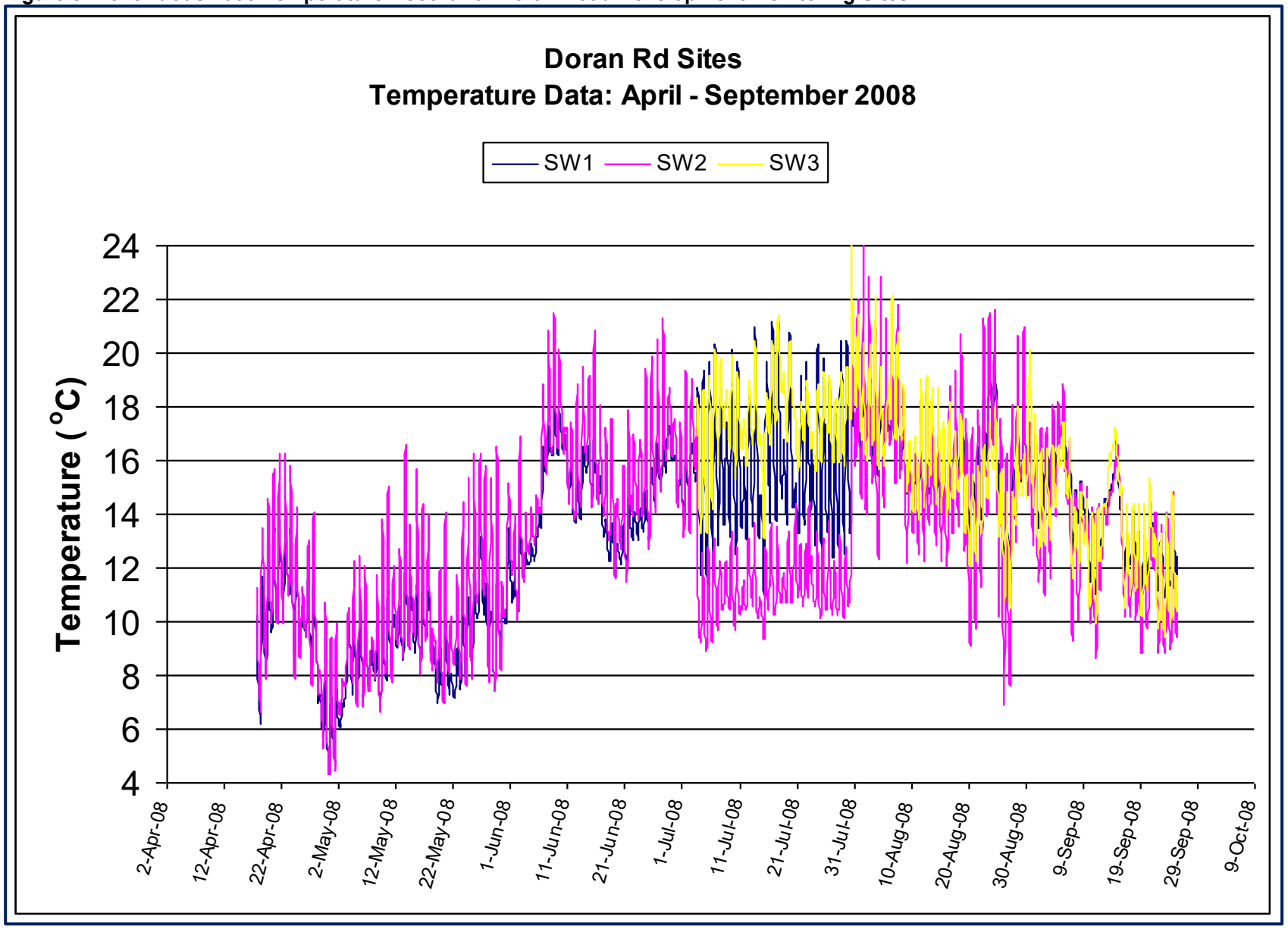
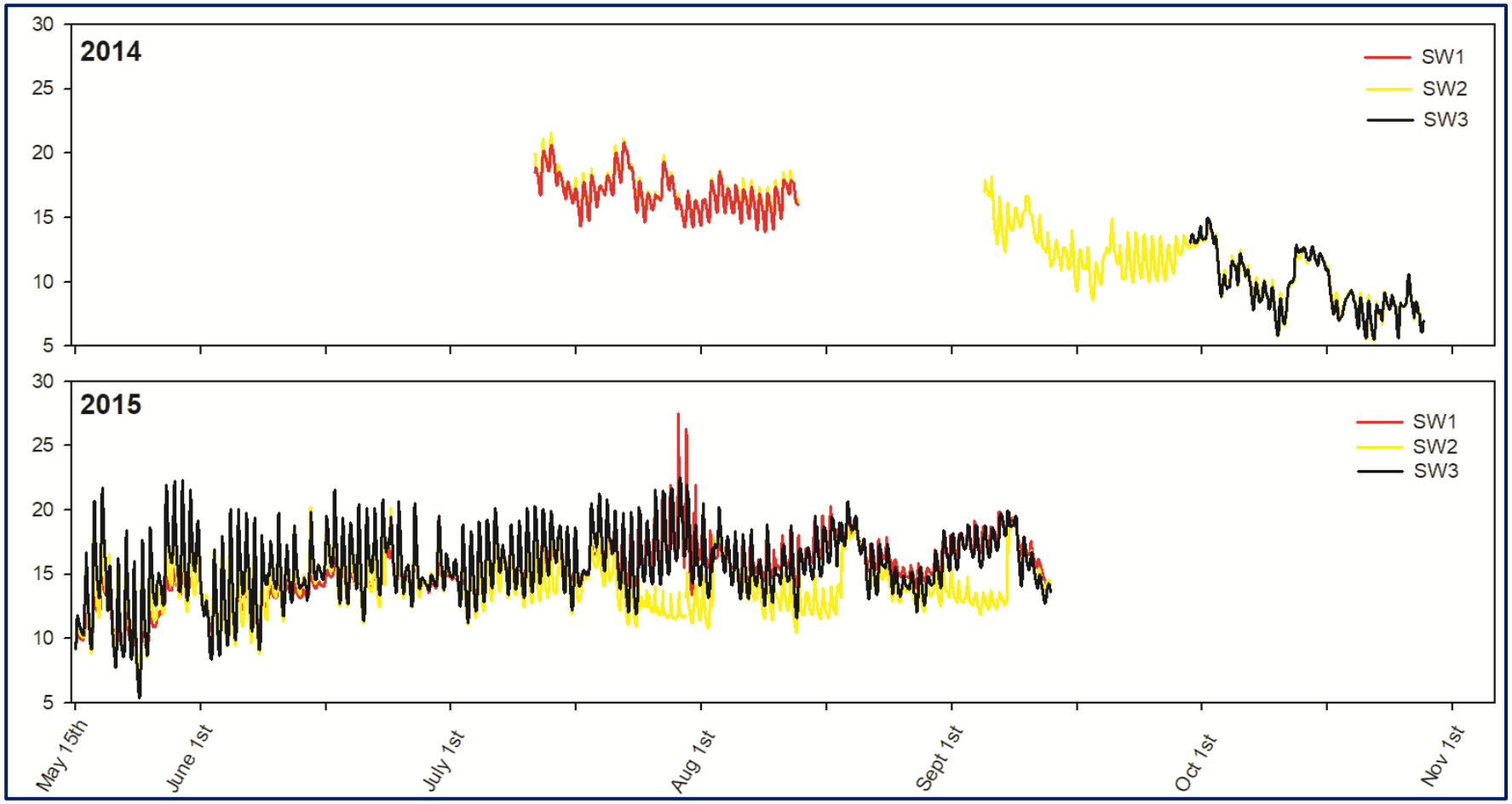


Figure 9. Continuous 2014 and 2015 Temperature Records for Doran Road Development Monitoring Sites



5.2 Hydrology and Receiver Flow

The hydrology program was focussed on description of the flow characteristics and available assimilation volumes for assimilation of stormwater flows at the Doran site.

Median flows, based on pro-rated calculations of WSC HYDAT data recorded from 1973-1995, peaked at ~130 L/sec during spring freshet and declined to as low as 1 L/sec in the summer months, when the tributary has been observed to dry up completely in some locations (Figure 10). Low flows in the summer months are likely a consequence of the small contributing watershed area and suggest the absence of substantial groundwater inputs to the creek at these locations.

Measured flows were also recorded at all three sample sites as part of the field programs in 2008, 2014 and 2015 to further characterize the hydrology of the tributary and validate the estimated flows. Flows generally increased downstream of SW1 in both 2008 and 2014/2015, and no significant difference in flow was noted between sampling periods (Figure 11). Flows were <1L/sec at all sites in late July and no flow occurred in August at any site in 2008, however significant storm flows were recorded in 2014 (September) and 2015 (August), with flows of similar magnitude to those recorded during April sampling (Table 3). Measured flows collected in the field were comparable with those estimated from HYDAT data, with the exception of several storm sampling events in the fall, which help characterize the range of natural variability in the flow of the system (Figure 10).

Table 3. Summary of 2008, and 2014/2015 field flow measurements in L/sec.

Date	SW1	SW2	SW3
17-Apr-08	8.82	13.29	30.81
14-May-08	3.41	7.57	12.33
3-Jul-08	0.85	1.14	0.87
30-Jul-08	0.70	0.92	0.78
28-Aug-08	Dry	Dry	No Flow
25-Sep-08	0.09	0.62	No Flow
05-Sep-14	36.59	No Data	35.25
02-Oct-14	0.00	1.97	2.32
30-Oct-14	0.00	No Data	10.69
14-15-May-15	1.43	8.76	11.25
17-18-June-2015	0.77	1.25	1.93
30-Jul-15	No Flow	0.00	0.00
20-Aug-15	9.76	33.67	19.67
31-Aug-15	No Flow	No Flow	No Flow
14-Sep-15	1.38	4.10	5.26

No Flow indicates that water was present but there was no detectable flow. Dry indicates no water was present.

Figure 10. Comparison of HYDAT Data and Field Measured Stream Flows at SW3

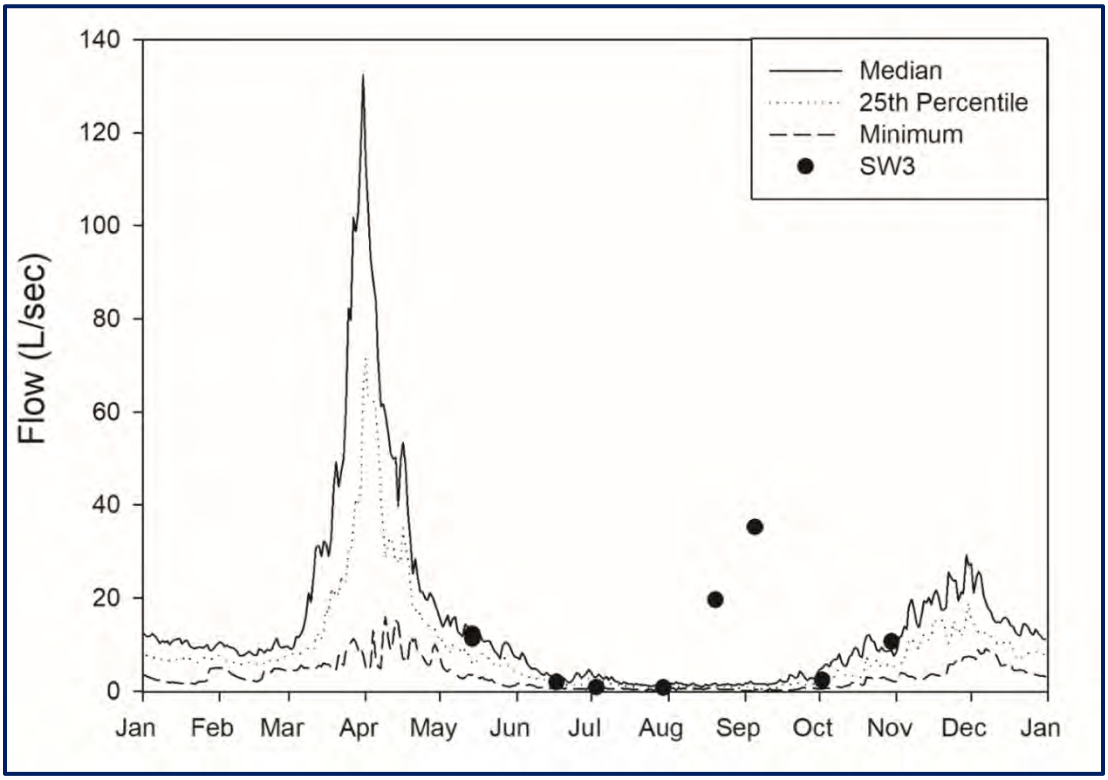
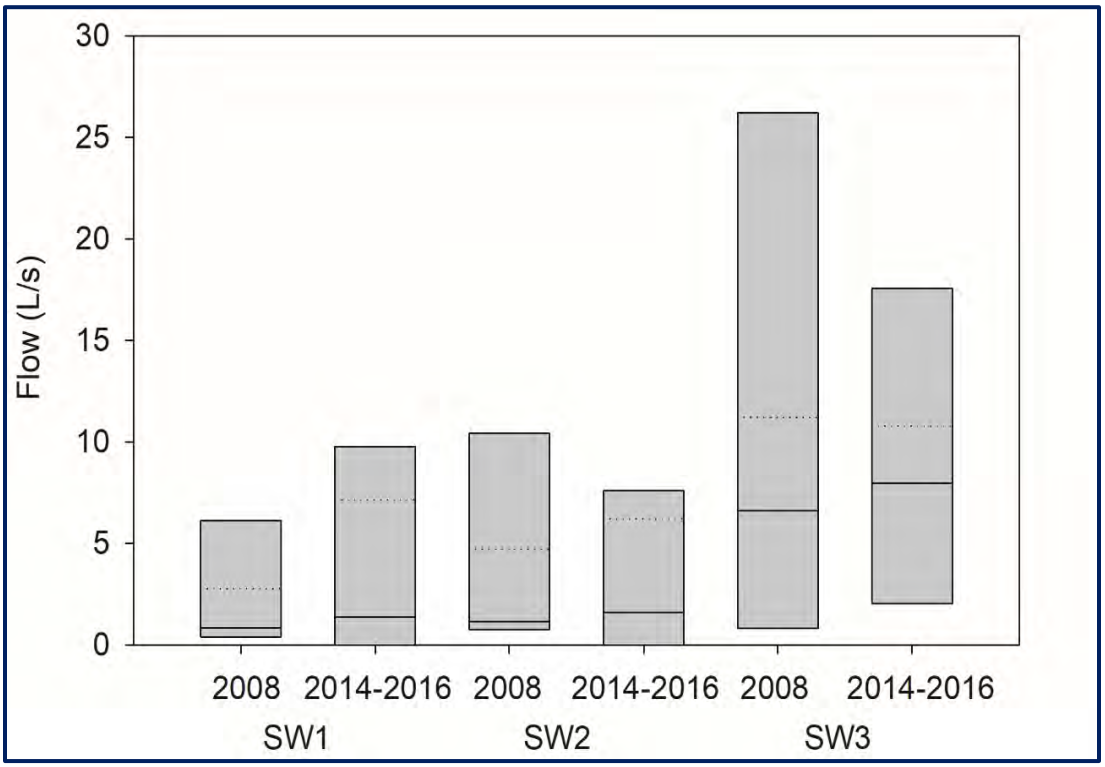


Figure 11. Comparison of flows from 2008 and 2014-2015 field data.



5.3 Aquatic Biota

Benthic invertebrates are a collection of aquatic organisms, comprised of immature insect stages, worms, snails and clams, that inhabit the substrate in streams and lakes. Benthic invertebrate community sampling is frequently used for assessing environmental stresses on aquatic environments which can degrade water quality or benthic habitat. Benthic invertebrate communities integrate long-term changes in their environment including temperature, nutrients, contaminants, suspended solids, habitat type and food availability, and may also respond to short-term events which cannot always be captured by traditional water quality sampling. Benthic invertebrate data was collected in 2008 and again in 2015 to establish the baseline community structure within the Doran Development area, prior to any land use changes, for comparison with future monitoring surveys.

Benthic invertebrate community sampling conducted in 2015, revisited the same sites sampled in 2008. Station SW1 was at the headwaters of the unnamed Willow Creek tributary in a forested area. SW2 was downstream of SW1 in a more open, agriculturally dominated reach of the creek while station SW3 was the furthest downstream location, with surrounding forest similar to station SW1. Stream habitat conditions consisted of a low gradient run morphology with fine sands, silt and clay substrates (Table 4).

Table 4. Summary of basic habitat conditions present at each of the aquatic assessment locations.

Reach	Approx. Water Depth (m)	Morphology	Substrate Description
SW1	0.10	low gradient run	sand and fines (silt/clay)
SW2	0.10	low gradient run	sand and fines (silt/clay)
SW3	0.15	low gradient run	sand and fines (silt/clay)

Habitat quality was poor, with low substrate diversity at all three sites and is therefore unlikely to support a significant number of intolerant or sensitive organisms that are typically associated with high quality aquatic environments. We found a higher species richness at all three stations in 2015 and a markedly different benthic community structure indicating a range of characteristics in the present conditions which may reflect inter annual variance in temperature or stream flow. Benthic communities are known to be variable however and such variance should be considered in the interpretation (Valois et al. 2009).

5.3.1 Species Richness

The SW2 location had the highest species richness (the total number of different species observed at a site), in 2008 with a total of 30 species but species richness was comparable among all stations (Table 5). Station SW1 had 28 species and SW3 had 27 species. Overall, no trends in species richness were reflected when upstream stations were compared to downstream stations.

Species richness was higher at all sites and ranged from 40 to 51 across the three stations in 2015, representing an increase in richness relative to the 2008 sampling event (Table 5 and Table 6). A total of

74 species were collected in 2015 within the study area (all three sites), up from 62 in 2008. Species richness was highest at SW3 (51 species), marginally more than SW1 (40 species) and SW3 (40 species), by contrast SW3 had the lowest species richness in 2008 (27 species).

5.3.2 Relative Abundance

Major taxonomic groups present in both surveys included: *Chironomidae* (non-biting midges), *Ceratopogonidae* (biting midges), EPT [*Ephemeroptera* (mayflies) *Plecoptera* (stoneflies) and *Trichoptera* (caddisflies)], *Coleoptera* (beetles), other *Diptera* (winged flies) and other taxa which included (*Melagoptera* (alderflies), *Amphipoda* (sow bugs), *Hirudinea* (leeches), *Oligochaeta* (aquatic worms), *Gastropoda* (snails), *Hemiptera* (true bugs) and *Odonata* (dragonflies and damselflies). The relative abundance of these groups, however, varied significantly between 2008 and 2015. In 2008, *Chironomidae* species were the dominant group, present at all stations and accounting for 82%, 68% and 69% of the total community at SW1, SW2 and SW3 respectively (Figure 12). We found a significant decrease in chironomids at all stations during the 2015 survey (Table 6). For example, in SW2 chironomids accounted for only 23% of the community. In 2015, SW2 was dominated by EPT (47%), which are sensitive to organic pollution and therefore are often used as indicators of good water quality (Figure 13). %EPT increased at SW1 and SW3 as well, however they were most dominant at SW2.

5.3.3 Hilsenhoff Biotic Index

The Hilsenhoff Biotic Index (HBI) provides an estimate of organic pollution based on published pollution tolerance values for individual benthic invertebrate species (Hilsenhoff, 1987). The HBI is an average of the tolerance values of the individual species which range from 0 to 10, with 0 being intolerant and 10 being very tolerant of organic pollution, thus a lower HBI suggests better water quality.

HBI values in 2015 were lower at SW1 and SW2 and remained the same at SW3 (Table 5 and Table 6), indicating improved water quality. In 2008, SW3 received the lowest HBI at 4.04 (very good water quality) followed by SW1 (5.20 - fair water quality) and SW2 (5.91 - fairly poor water quality). Increased EPT, particularly at SW1 and SW2 are likely responsible for the lower HBI values in 2015, improving the water quality assessments at those sites to very good and excellent respectively.

Table 5. Summary of the Willow Creek tributary benthic community descriptor results 2008.

	SW1	SW2	SW3
Total Number of Organisms	473	328	370
Diversity/Species Richness	28	30	27
HBI Index	5.20	5.91	4.04
HBI Index WQ Comment	fair	fairly poor	very good
% Chironomidae	82	68	69
% EPT	8	6	15
% Ceratopogonidae	0	16	4
% Coleoptera	3	1	8
% Other Diptera	5	4	1
% Other	2	5	4

Table 6. Summary of the Willow Creek tributary benthic community descriptor results 2015.

	SW1	SW2	SW3
Total Number of Organisms	323	441	414
Species Richness	40	40	51
HBI Index	4.11	3.26	4.08
HBI Index WQ Comment	very good	excellent	very good
Simpson's Diversity	0.93	0.90	0.89
%EPT	28	49	34
% Chironomidae	45	23	27
% Ceratopogonidae	9	13	2
% Coleoptera	11	7	12
% Other Diptera	2	4	19
% Other	8	6	8

Figure 12. Benthic community relative abundance at the Willow Creek tributary study area 2008.

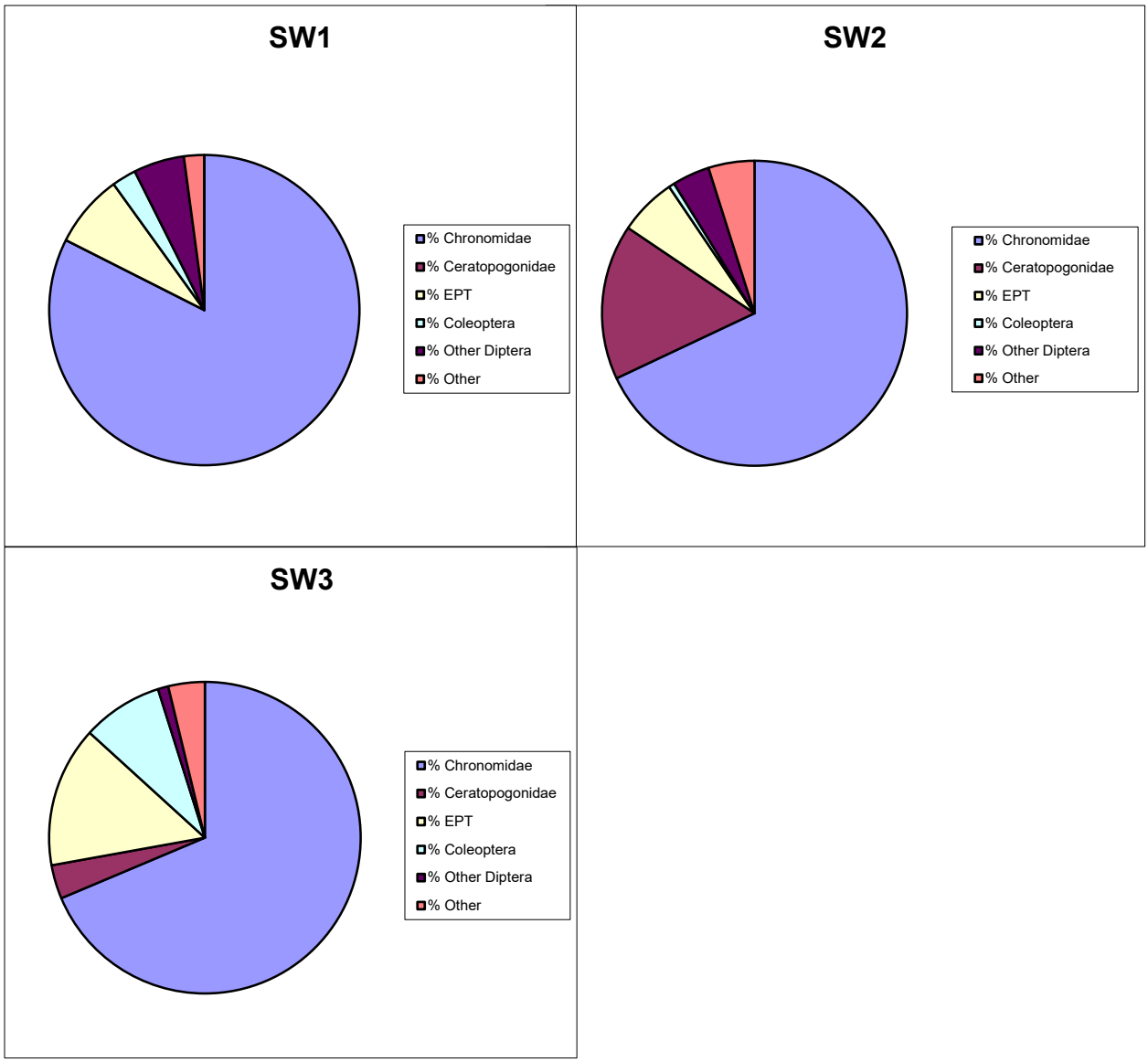
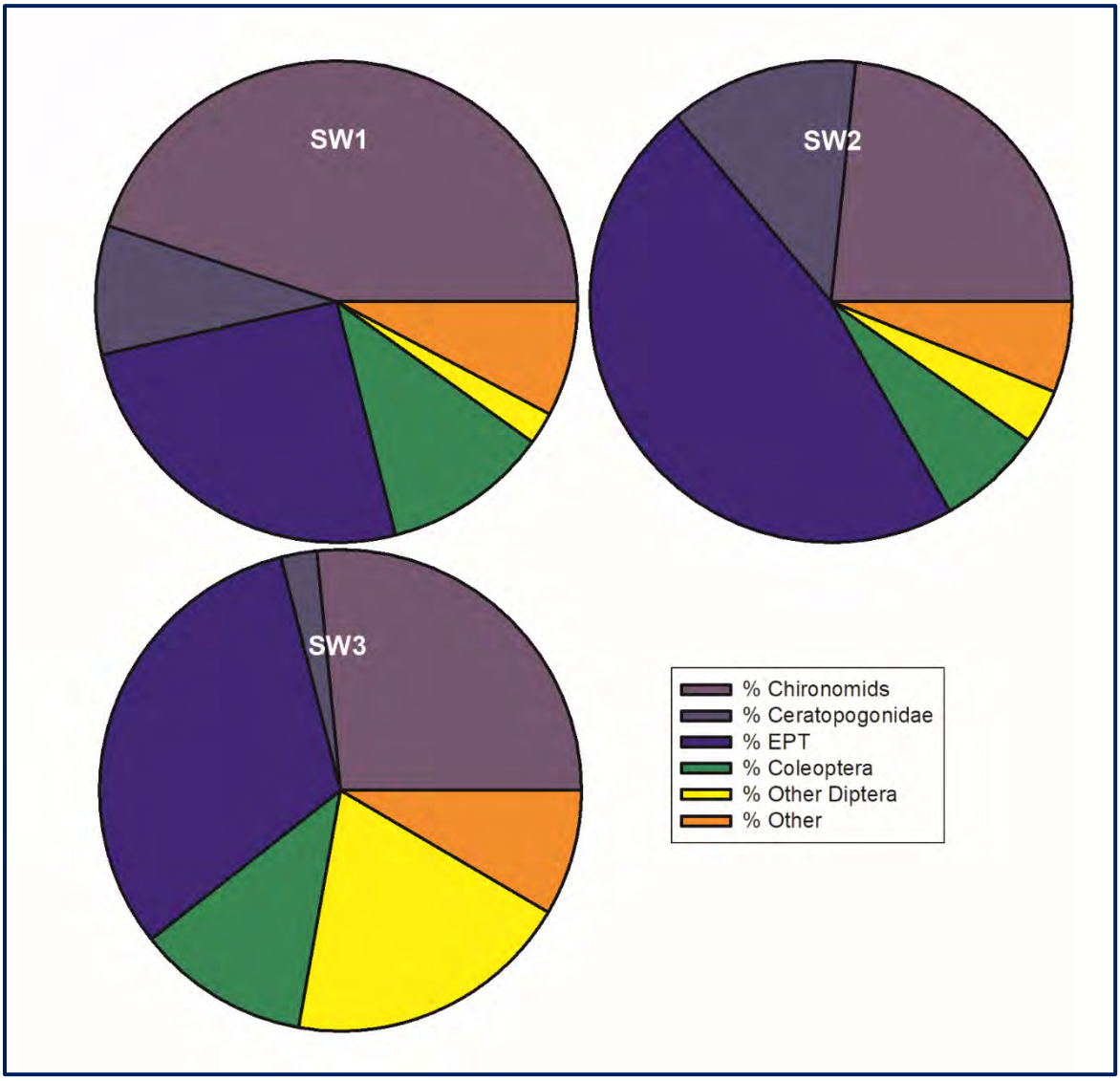


Figure 13. Benthic community relative abundance at the Willow Creek tributary study area 2015



5.3.4 Summary

Overall, the marked changed in HBI values, increased species richness and transition from dominance by chironomids to more sensitive EPT species in 2015 may indicate that that water quality and habitat conditions (substrate composition) were better in 2015 than in 2008 although no significant changes in water quality or flow were detected during field visits that would explain these changes. Sampling variability may also have contributed to the observed changes.

5.4 Fish Community and Habitat

The fish community was assessed in the small, intermittently flowing, first order tributary which drains southerly to Willow Creek from the east side of the study area. The creek's watershed was small (2.6 km^2) and dominated by agricultural fields and natural forested areas with a small number of residential lots and a mix of coniferous and deciduous trees, along with shrubby, meadow and wetland areas along the banks. In general, the watercourse was well-buffered throughout its length within and upstream of the study area, providing excellent shade and overhead cover.

Flows were intermittent (sustained by a seasonally high groundwater table and/or surface water storage areas), with no flows and extended sections of dry channel throughout the study area at the end of August, despite unusually high rainfall through the summer of 2008. There were some refuge pools through the channel and some plant species indicative of a water table close to the surface, despite the intermittent flows. The channel gradient was low, and was situated between rolling hills. Substrates were dominated by fine sediments with some areas of cobble suggesting faster moving water during periods of high flow. A defined channel was present through sections of wetland, which was heavily overgrown with vegetation in sections, providing in stream cover. Beaver dams had created some larger refuge pools within the intermittent habitat. Aquatic habitat was restricted to isolated refuge pools, at the SW2 and SW3 stations.

In both the 2008 and 2014 surveys, Northern redbelly dace (*Phoxinus eos*), a species considered moderately sensitive to environmental pollution, was the only fish species captured. The capture of both adults and immature northern redbelly dace in isolated pools in 2008 suggests that they have adapted to the ephemeral habitat for breeding and nursery purposes.

Table 7. Fisheries assessment results.

Date	Species	SW1	SW2*	SW3
Aug-08	Northern redbelly dace	DRY	27	2
02-Sep-14	Northern redbelly dace		7	15

**Refuge pool downstream of SW2*

6. Conclusions

The tributary of Willow Creek adjacent to the Doran Road Development is a cold water, intermittent stream whose small catchment and lack of significant groundwater inputs result in a marked decline in discharge values following spring freshet and portions of dry channel in the later summer.

Although benthic habitat quality was deemed to be poor at all locations along the tributary, the benthic community indicated fair to good water quality although results varied considerably between 2008 and 2015 sampling periods. Benthic surveys and associated measurements of substrate composition will be collected on an ongoing basis as part of the adaptive monitoring and management strategy.

The fish community was limited to a single species, Northern redbelly dace, in the lower reaches owing to the ephemeral nature of the stream. Northern redbelly dace have been observed elsewhere adapted to

intermittent streams (Morey and Berry 2004).and therefore it is not surprising that they have been found under similar conditions at Doran Road

Following the initial 2008 survey, it was recommended that additional monitoring be completed to expand our understanding of the baseline condition and natural variability at Doran Road. Natural variability must be considered during future impact assessments to assist in identifying if deviations from baseline conditions are within the range of natural variability or if they reflect impacts from the developments. In general, we found that water quality and stream flow did not vary considerably between the two sampling programs, however in many cases we have captured an expanded range of values for many key parameters and therefore developed a better understanding of the natural variability of the system.

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Hutchinson

Environmental Sciences Ltd.

Baseline Aquatic Studies for Midhurst Secondary Plan – Midhurst Heights Development: 2015-2016

Prepared for: Midhurst Landowner Group
Job #: J140054

January, 2018

DRAFT FOR DISCUSSION

1-5 Chancery Lane Bracebridge, ON P1L 2E3 | 705-645-0021

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January 19, 2018 HESL Job #: J140054

Midhurst Landowner Group
c/o Mr. Vimal Patel
Sr. Project Manager, Land Development
Geranium Corporation
3190 Steeles Avenue E., Suite 300
Markham, ON L3R 1G9

Dear Vimal:

Re: J140054 - Draft Report - Baseline Aquatic Studies for Midhurst Secondary Plan– Midhurst Heights Development: 2015-2016

A number of studies have been completed to characterize the baseline chemical and biological conditions of Willow Creek and its tributaries in Midhurst for the proposed Midhurst Secondary Plan Area (MSPA). This report presents the results of baseline studies completed on Matheson Creek near the site of the proposed Midhurst Heights Development. Information on water quality, flows, benthic invertebrates and fisheries was collected by Hutchinson Environmental Sciences Ltd. (HESL) in 2015 and 2016. Baseline data were collected to meet the requirements of the Monitoring and Adaptive Management Plan for the Midhurst Secondary Plan Area, monitor the response of the aquatic environment to the development proposed as part of the MSPA and to inform the Adaptive Monitoring and Management Plan to minimize any potential future impacts on the watercourses.

We thank you for the opportunity to assist the Midhurst Landowner's Group with this project and hope that this report meets your needs.

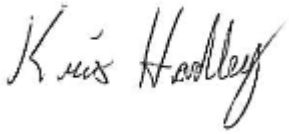
Sincerely,
Hutchinson Environmental Sciences Ltd.



Brent Parsons
brent.parsons@environmentalsciences.ca

Signatures

Report Prepared by:



Kristopher Hadley, Ph.D.
Aquatic Scientist



Brent Parsons
Senior Aquatic Scientist

Report Reviewed by:



Neil Hutchinson, Ph.D.
Principal Aquatic Scientist

Executive Summary

This report summarizes the methods and resultant data used to develop a baseline of water quality and aquatic biology for surface waters in the vicinity of the proposed stormwater discharge from the Midhurst Heights development of the Midhurst Secondary Plan Area (MSPA). The MSPA is located in the Township of Springwater, Ontario. Existing development in the Secondary Plan Area includes residential, commercial/industrial, mixed and agricultural uses. Proposed development in the Secondary Plan Area includes residential communities, commercial, industrial, mixed use and employment lands. The details of the planned development for the Midhurst Secondary Plan Area are contained within Springwater Township Official Plan Amendment (OPA) No. 38 Midhurst Secondary Plan and in approved draft plans. Although the total area of the MSPA is approximately 2,813 ha the development will be phased, with 300ha developed in Phase 1 and the Full Build Out occurring over a longer time period.

The proposed Midhurst Heights Neighbourhood is approximately 97 hectares (240 acres) in size, bounded by Craig Road to the north, Russell Road to the east, Doran Road to the south, and Gill Road to the west. It lies within the Willow Creek subwatershed of the Nottawasaga watershed and contains a tributary of Willow Creek, Matheson Creek, that drains into Willow Creek upstream of the Minesing Wetland.

The interactions of the MSPA with the aquatic environment will be mediated though an advanced stormwater management plan and an adaptive monitoring and management plan which provide the means to minimize any effects of the development on surface water and to monitor surface water responses. Collection of baseline data on water quality and aquatic biology of the study area began in 2008 and continued to the end of 2016. These data will be used to describe the pre-development conditions, monitor any changes during and after construction and inform the Master Drainage Plan.

Data on water quality, flows and aquatic biology were collected at three sites on a major tributary to Matheson Creek. Water Survey of Canada data were pro-rated to estimate daily flows and flows were measured at all three sample sites as part of the field program in 2015 and 2016 to validate the estimated flows. Field measured flows were well above what was predicted by the WSC HYDAT estimations. Storm sampling in August (2015) produced flows of similar magnitude to those predicted to occur during spring freshet by the WSC HYDAT data estimates.

Temperature profiles indicated that Matheson Creek was a cold-water stream at all three monitoring sites and dissolved oxygen concentrations were consistently above the temperature-dependent Provincial Water Quality Objectives. Total phosphorus concentrations were below the Provincial Water Quality Objective, except 2 samples in which high total phosphorus concentrations were related to elevated suspended solids. Matheson Creek receives significant input of groundwater from the A1 and A2 aquifers, which resulted in elevated nitrate concentrations. Total metals concentrations observed above PWQO levels included aluminum, iron, cobalt, copper and zirconium, which were associated with high suspended solids (Figure 8).

Relatively low benthic diversity and low relative abundance of environmentally sensitive EPT species resulted in a fair water quality rating at all Matheson Creek sites, but may be more indicative of habitat quality than water quality. Fish surveys in both 2015 and 2016 captured a diverse community of fish including Brown Trout and Brook Trout (*Salmo trutta* and *Salvelinus fontinalis*), Central Mudminnow (*Umbra limi*), Slimy Sculpin (*Cottus cognatus*), and White Sucker (*Catostomus commersonii*).

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1. Introduction and Project Understanding

The Midhurst Landowners Group is currently implementing development approvals within the Midhurst Secondary Plan Area of the Township of Springwater, including draft subdivision approvals within the Doran and Carson Neighbourhoods. Baseline monitoring to characterize the baseline conditions in Matheson Creek, began in 2015. HESL initiated a work plan to expand on the baseline datasets at Carson Road, Doran Road and Willow Creek in 2014 and continued that data collection in 2015 and 2016, including new monitoring sites on a tributary to Matheson Creek near the Midhurst Heights Development. This report summarizes the data collected in 2015 and 2016 and provides an assessment of the baseline water quality and aquatic habitat data collected in the Midhurst Heights Development Area. Companion reports will address surface water conditions at the Doran Road development (HESL 2017a), Carson Road development (HESL 2017b) Willow Creek in the Village of Midhurst (HESL 2017c) and Willow Creek near the site of the proposed WWTP outfall (HESL 2017d). Additional data, collected in 2017, will be incorporated in the subsequent versions of this report.

Information from these baseline reports informs the ongoing development and implementation of the Adaptive Monitoring and Management Plan (AMMP) as part of the Midhurst Secondary Plan Master Drainage Plan. The purpose of the AMMP is to:

- Identify and assess potential implications of the proposed development
- Design mitigation and Best Management Practices using current best practices
- Implement the designs through construction
- Monitor the performance of the design
- Evaluate the results
- Adjust the designs as appropriate

The overall goal of this study was to characterize baseline water quality in the tributaries to Matheson Creek near the Midhurst Heights Road Development site prior to the approved land use changes associated with the proposed residential development in the Midhurst Secondary Plan Area. This report compiles the baseline data collected during the HESL field programs in 2015 and 2016. Additional data collection is currently underway to expand upon the 2015/2016 data and inform on the natural inter-annual variation within the watercourse.

2. Description of Midhurst Heights Development

2.1 Midhurst Heights Development

The proposed Midhurst Heights development is approximately 97 hectares (240 acres) in size, bounded by Craig Road to the north, Russell Road to the east, Doran Road to the south, and Gill Road to the west (Figure 1). It falls within the Willow Creek subwatershed of the Nottawasaga River watershed.

Groundwater from municipal wells will be used as the domestic water supply, while domestic sewage will be collected, treated and discharged to Willow Creek downstream of the community of Midhurst. The Ainley Group is currently carrying out Phases 3 and 4 of a Class Environmental Assessment (EA) on behalf of the

Township of Springwater to determine the servicing/infrastructure (water, wastewater, transportation) requirements for the Midhurst Secondary Plan. A Master Drainage Plan is also being completed.

2.2 Stormwater Management

On site controls, Low Impact Development (LID) techniques and Best Management Practices (BMP) will be developed and implemented to infiltrate as much stormwater as possible with the target for infiltration of 25 mm of rainfall post-development. This will reduce stormwater temperatures and volumes, and improve water quality by reducing the importance of storm water as a source of phosphorus to the surface waters. Stormwater in excess of the infiltration will be collected and treated to, at least, MOE "Enhanced Level" standards (80% removal of Total Suspended Solids) and discharged to Matheson Creek at Gill Road (Figure 2).

3. Environmental Setting

3.1 Matheson Creek

Matheson Creek originates in the Oro Moraine northwest of Craighurst and flows southward through a forested valley to its confluence with Willow Creek northwest of Midhurst. Matheson Creek stream health is unimpaired from the headwaters to Highway 27, however, near the confluence with Willow Creek both water courses are considered below potential (NVCA 2007). Stream health in Willow Creek declines further downstream as it flows through an agricultural plain due to sparse riparian (streamside) cover and livestock management practices.

3.2 Natural Heritage Features

Five designated environmentally significant areas exist in and around Midhurst that are linked to surface waters of the Willow Creek subwatershed. They are:

- **Little Lake Provincially Significant Wetland:** A wetland complex of 285 hectares that surrounds Little Lake. It is almost completely lacustrine, however, a small portion in the northwest contains riverine communities where Willow Creek enters Little Lake. Downstream, the reach of Willow Creek under St. Vincent Street is hydrologically connected to the Little Lake PSW.

- **Midhurst Swamp:** Midhurst Swamp is a 450 ha. Wetland, designated EP1 in the Springwater Township OP, 40% of which is comprised of riverine communities associated with Willow Creek. Treated stormwater, discharged at levels sufficient to protect surface waters at the Doran site, will not impact Midhurst Swamp.

- **Springwater Provincial Park:** Springwater Provincial Park is a recreational park located south of Willow Creek. It contains a wide variety of vegetation communities due to varied soils, topography and numerous localized areas of groundwater. Willow Creek flows well north of Springwater Provincial Park and therefore the Doran Road development will have no interaction or impact on it.

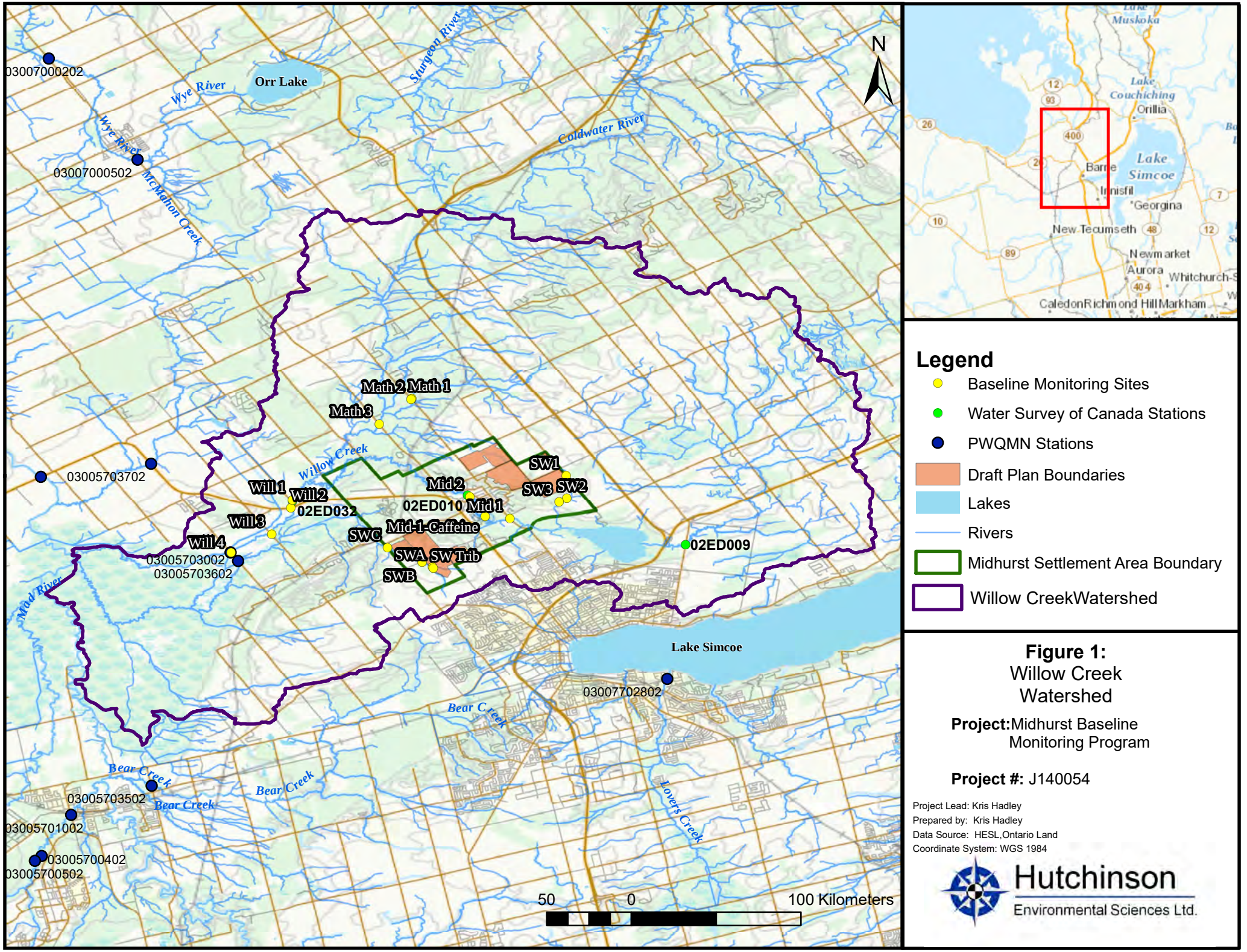


Figure 1:
Willow Creek
Watershed

Project: Midhurst Baseline
Monitoring Program

Project #: J140054

Project Lead: Kris Hadley
Prepared by: Kris Hadley
Data Source: HESL,Ontario Land
Coordinate System: WGS 1984

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- **Minesing Swamp Provincially Significant Wetland:** Minesing Swamp PSW is not only provincially significant but it is also designated as a wetland of international importance by the Ramsar Convention on Wetlands. Willow Creek and its tributaries flow into Minesing Swamp before reaching the Nottawasaga River. Discharge of treated stormwater and sewage effluent at levels sufficient to protect the surface waters of Willow Creek and its tributaries will not impact Minesing Swamp.

- **Simcoe County Greenlands Designation:** The Simcoe County Greenlands Designation is found in the Simcoe County OP (County of Simcoe 2016). It represents areas identified based on criteria outlined within the "Development of a Natural Heritage System for the County of Simcoe" report (GLL 1996). None of the tributaries to Willow Creek in the proposed Doran Neighbourhoodare designated as Greenlands.

3.3 Hydrogeology

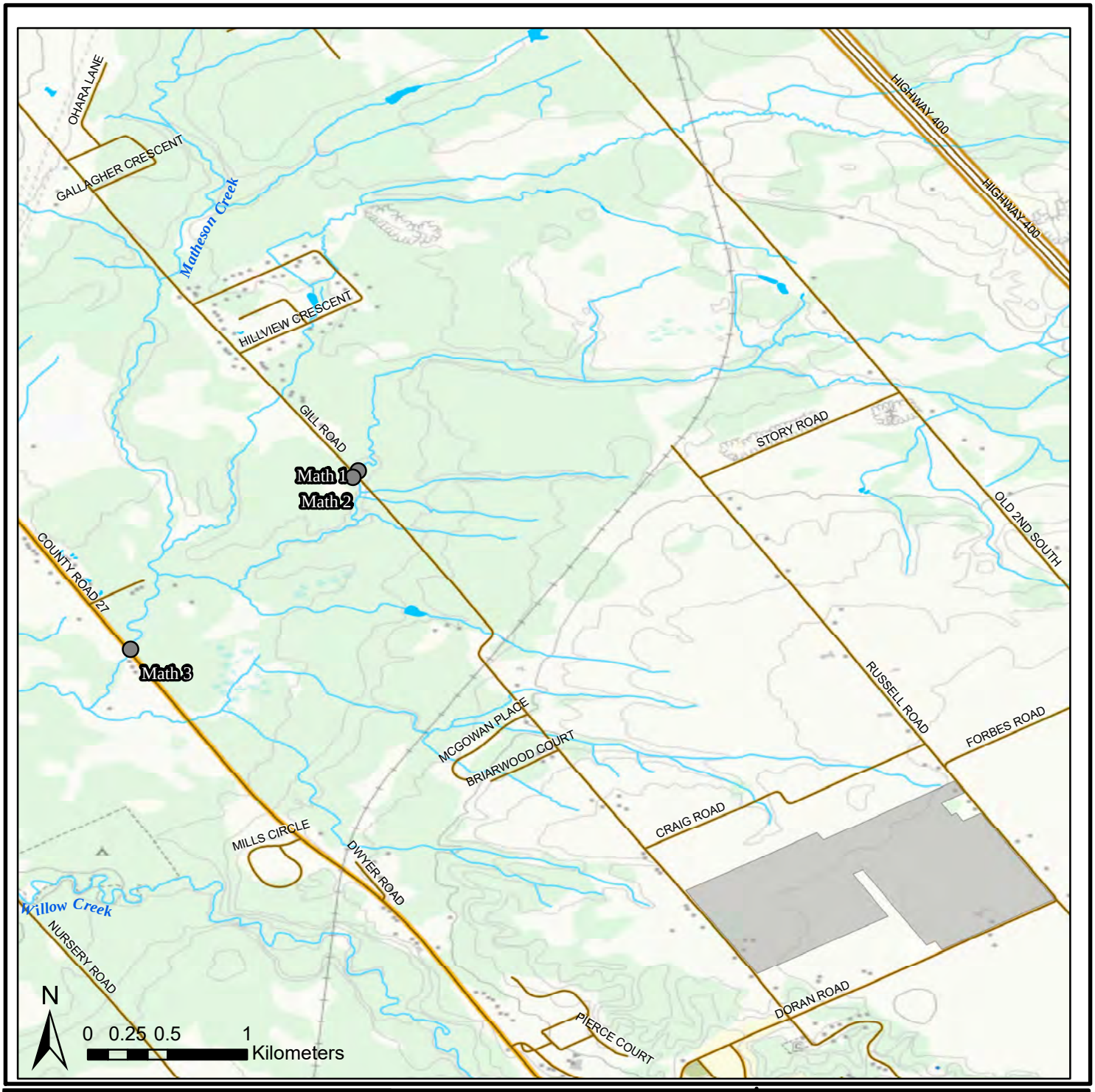
Midhurst is in the Simcoe Upland and Lowland (elevations below 230 masl) physiographic regions (Chapman and Putnam 1984). Matheson Creek is located in the Simcoe Uplands and is steeply incised into the sand plain (GHD, 2016). A regional survey has identified four regional aquifers (Golder Associates 2008). Aquifer A1, located beneath the uplands (above 240 masl), and aquifer A2, which lies below both the uplands and the lowlands, discharge to Matheson Creek (Golder 2014). Nitrate levels are elevated in portions of both of these aquifers as a likely result of agricultural activities and domestic sewage disposal by septic systems. Golder (2014) provides detailed descriptions of the groundwater regime, the proposed water supplies for the MSPA and any interactions between groundwater and surface water.

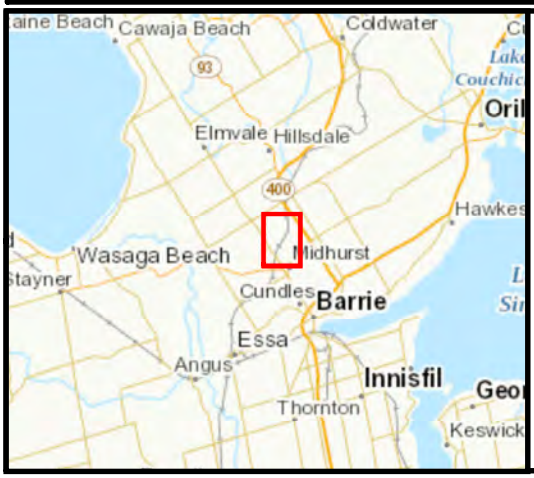
4. Methods – Field Programs

A summary of the field studies conducted as a part of the baseline water quality monitoring at the Midhurst Heights Development to date is provided below (Table 1). Baseline studies continued in 2017 and results will be incorporated into this report. Detailed methodology for each field program is described in Sections 4.1 to 4.4.

Table 1. Summary of the Field Studies Conducted to Describe Baseline Water Quality at the Midhurst Heights Road Development

Organization	Date	Parameters
HESL	Sept 30th, 2015, October 3rd, 2016	Fish
	June 17h, 2015	Benthic Invertebrates
	June to Sept. 2015; March, May to October 2016	Water Quality and Flows





Legend

- Rivers
- Lakes
- Matheson Creek Sampling Sites
- Midhurst Heights Development

Project Lead: Kris Hadley
Prepared by: Kris Hadley
Data Source: HESL,Ontario Land, ESRI
Coordinate System: GCS WGS 1984

Figure 2:
Matheson Creek
Sampling Sites

Project: Matheson Creek Baseline Monitoring

Project #: J140054

Hutchinson Environmental Sciences Ltd.

4.1 Water Quality

The HESL field program established the three sampling sites Math 1 – Math 3, which were visited monthly during the ice-free periods of 2015 (June to September) and 2016 (May to October) and once in March 2016 (Figure 2, Table 1). Water samples were collected from all sites and analyzed for a standard suite of parameters including general chemistry, nutrients and metals by ALS Environmental, a fully accredited laboratory. Additionally, field measurements of flow, pH, specific conductivity, water temperature and dissolved oxygen were collected at each site during each site visit. Continuous temperature loggers were installed for the 2015 and 2016 surveys.

4.1.1 Numerical analysis

Summary statistics tabulated include sample size (n), number of samples above the detection limit (n>DL), minimum (Min), maximum (Max), arithmetic mean, and median (Table 2). Boxplots were used to summarize key water quality parameters as they allow for efficient visualization of five summary statistics, the median, two hinges (the 75th and 25th percentiles) and the whiskers which extend from the hinge to the largest and smallest value no further away than 1.5 * the Interquartile Range.

Values below detection limit were replaced with a value equivalent to the detection limit.

4.2 Flows

No continuous flow data for Matheson Creek was available at our sampling sites or for any location on Matheson Creek. We therefore estimated flow using 2006-2015 data from Environment Canada's HYDAT database for Willow Creek Near Minesing (Station 02ED032; Figure 1). Flows were estimated for Matheson Creek on the east side of County Road 27 by prorating flows from the WSC station on the basis of watershed area using areas of 229.22 km^2 for Willow Creek Near Minesing and 78.2 km^2 for the Matheson Creek at Math 3. Watershed areas were acquired from the Ontario Flow Assessment Tool (OFAT, 2017).

The field program included stream flow measurements made during each visit at all three sample sites, following protocols outlined in Ontario Stream Assessment Protocol (Stanfield 2010). Briefly, the number of cross sectional measurement panels was determined via channel width while stream velocity was measured using an OTT MF Pro flow mate. Sampling depth was based on water depth within each measurement panel. Stream profiles, discharges and average velocity were calculated for each site.

4.3 Benthic Invertebrates

The benthic invertebrate community study was conducted on Matheson Creek tributary on June 17th, 2015. Qualitative samples were collected at each of the aquatic assessment monitoring locations (Math 1, Math 2, and Math 3 [Figure 2]), following the same protocol employed for baseline sampling at the Carson Rd, Doran Rd and Willow Creek sites, which included:

- Sites sampled over a constant pre-determined area (2m x 2m) at each site;
- Travelling kick and sweep method utilizing a D-frame net (500 micron), moving upstream from bank to bank, over the entire area; and
- Effort of 2 minutes for each study reach.

Samples were transferred into labelled sample jars and preserved with 70% alcohol solution and submitted to a qualified taxonomist, Richard Bland, for sorting and identification to the lowest taxonomic level possible.

Habitat surveys were also conducted at each of the benthic sampling sites to characterize habitat within the tributary and inform on the importance of habitat in determining benthic community structure. Habitat survey parameters included stream substrate, water depth, flow rates, morphology and surrounding land use.

The following benthic invertebrate metrics were calculated:

- Species richness
- Species diversity (lowest practical level);
- Simpson's Diversity
- Relative abundance of taxonomic groups; and
- Hilsenhoff Biotic Index (HBI)

4.4 Fisheries

A field investigation was conducted to characterize the fish community and fish habitat present in the Midhurst Heights region. The three sites were sampled on Sept 30th, 2015, and then revisited on October 3rd, 2016 (Figure 2). Sampling protocols mirrored sample collection protocols followed as a part of the other baseline monitoring programs, e.g., Doran Rd and Carson Rd (HESL 2017a, 2017b) including backpack electrofishing at each site. Fish were identified to species, counted, assigned an approximate age, and released alive. Water temperature, conductivity, pH and sampling time were also recorded for each site.

5. Results

5.1 Water Quality

Summary statistics from 2015 and 2016 highlight the range and average values of parameters of interest (Table 2).

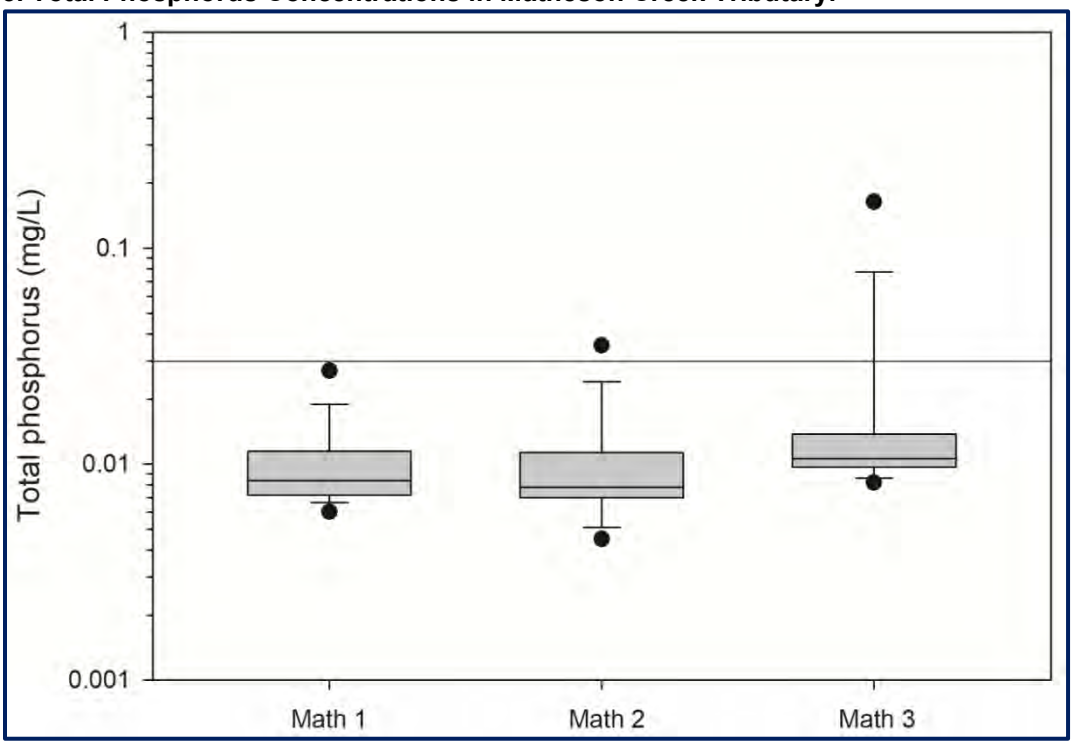
Total phosphorus concentrations were below the Provincial Water Quality Objective (PWQO, MOE 1994) of 0.03 mg/L in all but two samples collected (Figure 3). Both exceedances of the PWQO for total phosphorus occurred on the same sampling day (August 20th, 2015) and were associated with elevated suspended solids and are therefore likely indicative of short-term precipitation/run off events (Figure 4). Sampling of orthophosphate, a more biologically available form of phosphorus, began in 2016 and was at or near detection limit in the majority of samples collected (n=27). Ortho-P was just above detection limit (0.003 mg/L) at all three sites on August 14th, 2016 and was highest on June 16th, 2016 at a concentration of 0.0098 mg/L.

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Table 2. Summary Statistics from the 2015/2016 Water Quality Sampling Campaign in Matheson Creek Tributary Sites.

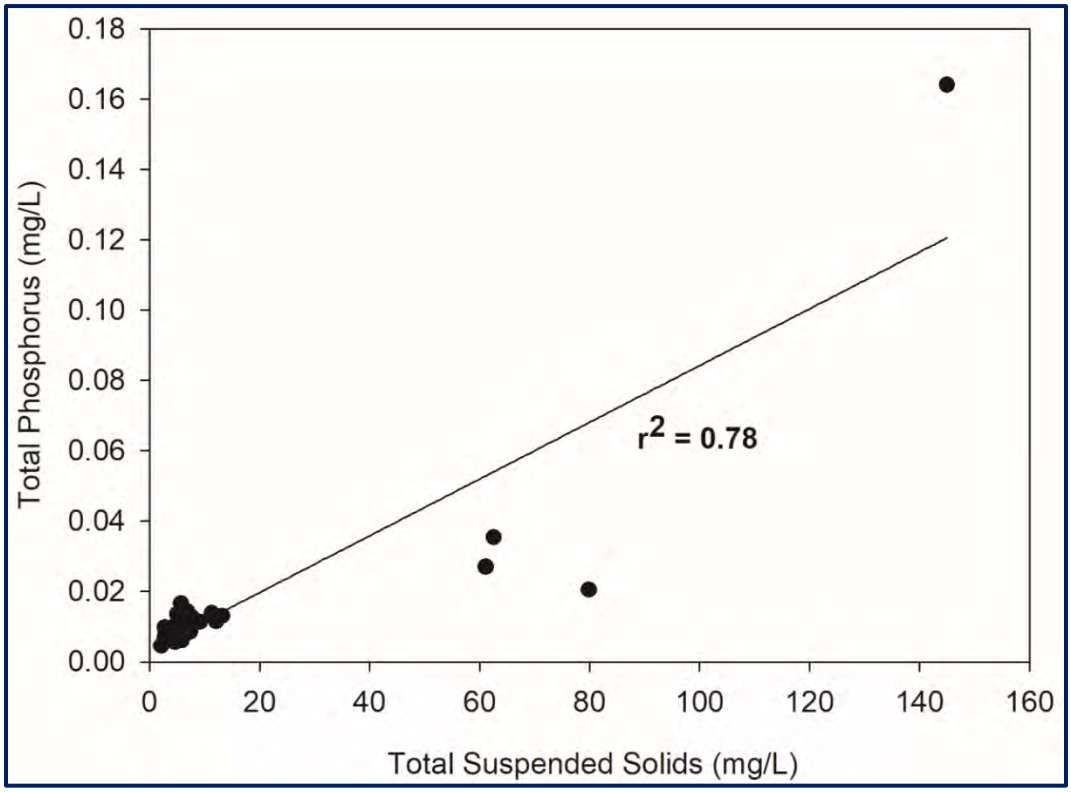
Site	Units	Math 1						Math 2						Math 3					
Date Sampled		**Min**	**Max**	**Mean**	**Median**	**n>DL**	**n**	**Min**	**Max**	**Mean**	**Median**	**n>DL**	**n**	**Min**	**Max**	**Mean**	**Median**	**n>DL**	**n**
Temperature (C)	^{0}C	1.24	15.96	10.9	11.39	15	15	1.26	15.95	10.8	11.24	15	15	0.06	17.32	11.9	12.24	15	15
Dissolved Oxygen	mg/L	6.91	12.79	63.5	10.51	15	15	4.6	12.84	33.0	10.32	15	15	6.62	13.14	10.6	10.51	15	15
pH		7.91	8.37	8.2	8.15	15	15	7.69	8.41	8.1	8.18	15	15	6.52	8.49	8.0	8.09	15	15
Conductivity	µs/cm	281	804	421.6	376	15	15	79	802	400.7	372	15	15	263	763	398.5	351	15	15
Physical Tests																			
Total Suspended Solids	mg/L	2.8	61.1	9.8	5.63	15	15	2.12	62.6	9.3	4.7	15	15	2.8	145	20.3	6.4	15	15
Turbidity	NTU	1	9.95	2.7	1.95	15	15	0.5	4.85	1.9	1.49	15	15	1.66	20.9	6.0	4.73	15	15
Anions and Nutrients																			
Ammonia, Total (as N)	mg/L	0.02	0.163	0.0703	0.05	11	15	0.02	0.246	0.0895	0.057	10	15	0.02	0.204	0.0599	0.05	8	15
Nitrate and Nitrite as N	mg/L	0.44	0.89	0.78	0.81	15	15	0.43	16.20	1.80	0.80	15	15	0.39	0.99	0.78	0.81	15	15
Nitrate (as N)	mg/L	0.44	0.89	0.78	0.81	15	15	0.43	16.20	1.80	0.80	15	15	0.39	0.99	0.78	0.81	15	15
Total Kjeldahl Nitrogen	mg/L	0.15	0.38	0.2313	0.23	12	15	0.15	0.28	0.1973	0.19	10	15	0.15	0.45	0.2820	0.28	14	15
Total Phosphorus	mg/L	0.006	0.027	0.0101	0.0084	15	15	0.0045	0.0354	0.0105	0.0078	15	15	0.0082	0.164	0.0218	0.0106	15	15
Phosphate-P (ortho)	mg/L	0.003	0.0039	0.0033	0.0031	5	9	0.003	0.0047	0.0032	0.003	3	9	0.003	0.0098	0.0038	0.003	2	9
Dissolved Organic Carbon	mg/L	1.1	6.7	3.1067	2.9	15	15	1.1	6.9	3.0786	2.5	14	14	1.5	7.3	3.8133	3.5	15	15
Total Metals																			
Aluminum (Al)-Total	mg/L	0.03	0.298	0.0731	0.052	15	15	0.02	0.297	0.0633	0.049	15	15	0.056	2.89	0.3161	0.106	15	15
Arsenic (As)-Total	mg/L	0.00013	0.001	0.0003	0.00018	13	15	0.00013	0.001	0.0003	0.00019	13	15	0.0002	0.001	0.0004	0.00028	13	15
Barium (Ba)-Total	mg/L	0.0557	0.0749	0.0678	0.0683	15	15	0.049	0.0745	0.0663	0.0669	15	15	0.0492	0.0915	0.0641	0.0634	15	15
Boron (B)-Total	mg/L	0.01	0.013	0.0106	0.01	9	15	0.01	0.013	0.0105	0.01	11	15	0.01	0.014	0.0103	0.01	4	15
Cadmium (Cd)-Total	mg/L	0.00001	0.00009	0.00002	0.00001	1	15	0.00001	0.00009	0.00002	0.00001	1	15	0.00001	0.00009	0.00002	0.00001	1	15
Calcium (Ca)-Total	mg/L	60.9	68.7	64.1	63.5	15	15	61	104	66.3	63.1	15	15	58.3	68.8	62.8	62.4	15	15
Cesium (Cs)-Total	mg/L	0.00001	0.00002	0.00001	0.00001	1	13	0.00001	0.00002	0.00001	0.00001	1	13	0.00001	0.000192	0.00003	0.00001	7	13
Chromium (Cr)-Total	mg/L	0.0005	0.00204	0.0008	0.00065	10	15	0.0005	0.00143	0.0007	0.0007	11	15	0.0005	0.00442	0.0009	0.0005	7	15
Cobalt (Co)-Total	mg/L	0.0001	0.0005	0.0002	0.0001	1	15	0.0001	0.0005	0.0002	0.0001	1	15	0.0001	0.00119	0.0002	0.0001	4	15
Iron (Fe)-Total	mg/L	0.08	0.50	0.14	0.10	15	15	0.05	0.49	0.13	0.10	14	15	0.12	3.07	0.41	0.22	15	15
Lead (Pb)-Total	mg/L	0.0001	0.0005	0.0002	0.0001	5	15	0.0001	0.0005	0.0002	0.0001	3	15	0.0001	0.0017	0.0003	0.00011	6	15
Lithium (Li)-Total	mg/L	0.001	0.1	0.015	0.002	12	15	0.001	0.1	0.015	0.002	12	15	0.001	0.1	0.015	0.002	11	15
Magnesium (Mg)-Total	mg/L	12.3	15.3	13.9	13.9	15	15	12.3	16	14.0	14	15	15	10.8	14.4	12.8	12.8	15	15
Manganese (Mn)-Total	mg/L	0.0123	0.0561	0.0182	0.0151	15	15	0.00784	0.0555	0.0175	0.0148	15	15	0.0195	0.248	0.0418	0.0263	15	15
Molybdenum (Mo)-Total	mg/L	0.0004	0.0005	0.0004	0.0004	13	15	0.0001	0.0005	0.0004	0.0004	13	15	0.0003	0.0005	0.0004	0.0004	13	15
Nickel (Ni)-Total	mg/L	0.0005	0.001	0.0006	0.0005	2	15	0.0005	0.001	0.0006	0.0005	1	15	0.0005	0.002	0.0007	0.0005	2	15
Potassium (K)-Total	mg/L	1.3	1.9	1.5	1.5	15	15	1.4	1.8	1.5	1.5	15	15	1.2	2.4	1.5	1.5	15	15
Rubidium (Rb)-Total	mg/L	0.00052	0.0013	0.0007	0.00066	13	13	0.00053	0.00127	0.0007	0.00062	13	13	0.0007	0.005	0.001	0.001	13	13
Selenium (Se)-Total	mg/L	0.000068	0.0004	0.0001	0.000088	13	15	0.000065	0.0004	0.0001	0.000085	13	15	0.00006	0.0004	0.0001	0.00008	13	15
Silicon (Si)-Total	mg/L	5.0	6.3	5.8	5.9	15	15	4.9	6.7	5.8	5.8	15	15	4.3	10.8	6.2	6.0	15	15
Sodium (Na)-Total	mg/L	16.7	19.5	18.1	18.2	15	15	4.4	19.7	17.1	17.9	15	15	10.9	22.6	15.3	14.3	15	15
Strontium (Sr)-Total	mg/L	0.16	0.19	0.18	0.18	15	15	0.17	0.19	0.18	0.18	15	15	0.16	0.19	0.17	0.18	15	15
Sulfur (S)-Total	mg/L	3.25	5	3.9	3.76	13	15	3.14	6.1	4.0	3.77	13	15	3.03	5	3.8	3.77	13	15
Titanium (Ti)-Total	mg/L	0.0014	0.0149	0.0036	0.0024	13	15	0.0011	0.0132	0.0029	0.0021	13	15	0.003	0.15	0.016	0.006	14	15
Uranium (U)-Total	mg/L	0.0004	0.001	0.0006	0.0005	13	15	0.0004	0.001	0.0006	0.0005	13	15	0.0004	0.001	0.0006	0.0005	13	15
Vanadium (V)-Total	mg/L	0.0006	0.0016	0.0008	0.0007	15	15	0.0006	0.0016	0.0008	0.0007	15	15	0.0007	0.006	0.0012	0.0009	15	15
Zinc (Zn)-Total	mg/L	0.003	0.005	0.003	0.003	1	15	0.003	0.004	0.003	0.003	3	15	0.003	0.010	0.003	0.003	1	15

Figure 3. Total Phosphorus Concentrations in Matheson Creek Tributary.



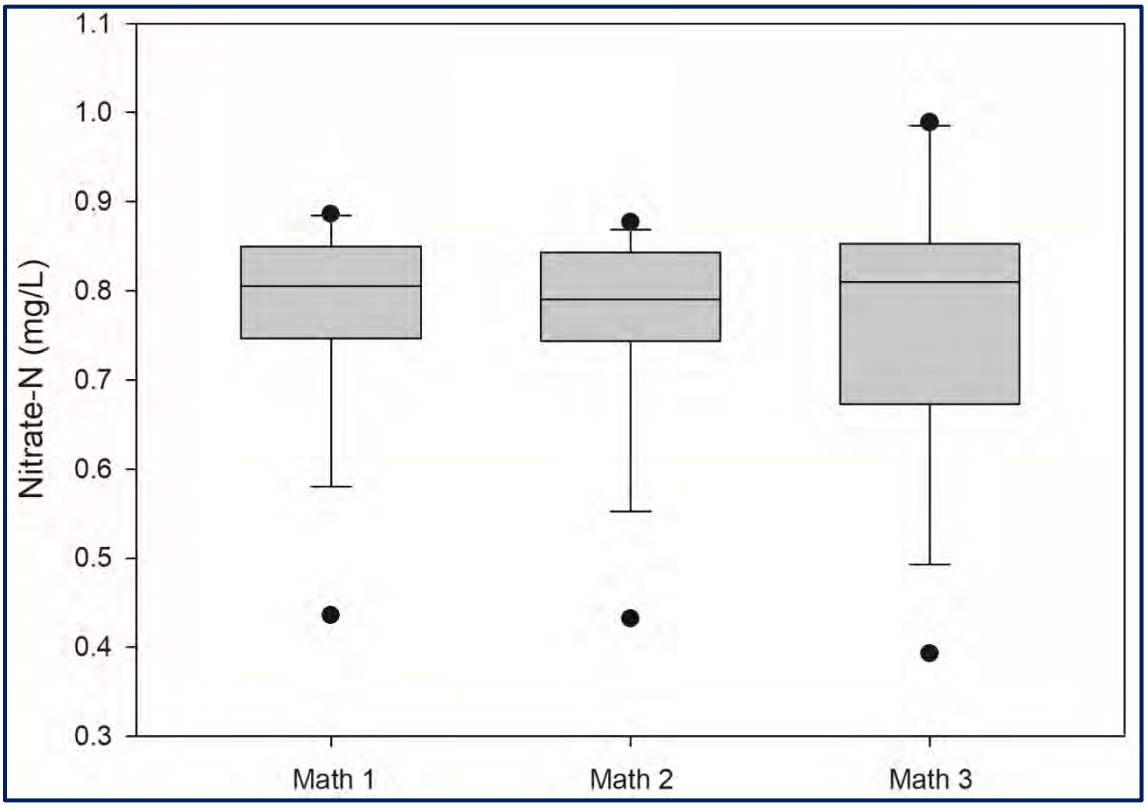
Horizontal line indicates PWQO Guideline of 0.03 mg/L

Figure 4. Correlation between Total Phosphorus and Total Suspended Solids in Matheson Creek tributary.



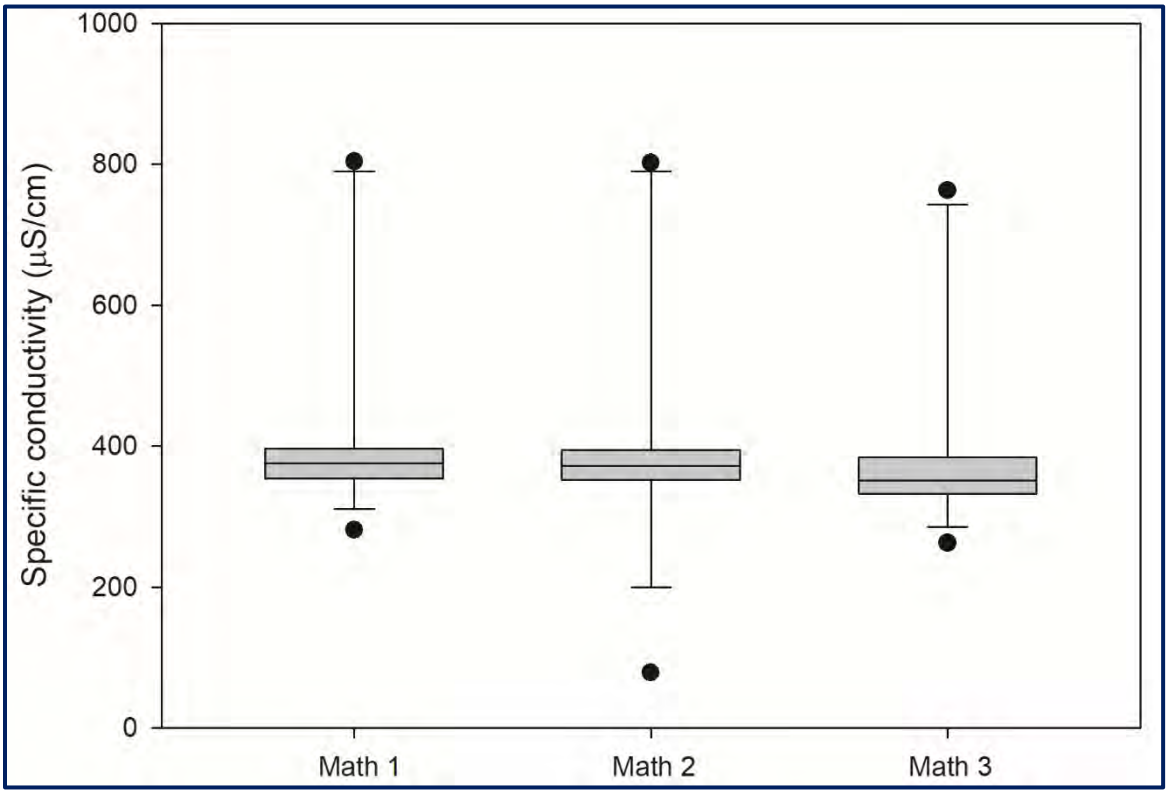
Nitrate levels were elevated at Midhurst Heights. Matheson Creek tributary receives significant input of groundwater from A1 and A2 aquifers, which have been shown to be elevated in nitrate (Golder 2014), however, concentrations of nitrate did not exceed the CCME Guideline for Protection of Aquatic Life (3 mg/L as nitrate-N; CCME, 2012) in any single water quality sample (Figure 5). Nitrite concentration fell below the analytical detection limit in 100% of samples tested, ammonia in 36% of samples. Calculated unionized ammonia concentrations were below PWQO guideline of 0.020 mg/L in all samples tested.

Figure 5**. Nitrate Concentrations in Matheson Creek tributary.**



Conductivity was variable within each site but consistent across all three water quality sites (Figure 6). Consistent conductivity data upstream and downstream suggest that the relative contribution of groundwater to Matheson Creek is constant at all sites.

Figure 6. Specific Conductivity Concentrations in Matheson Creek tributary.

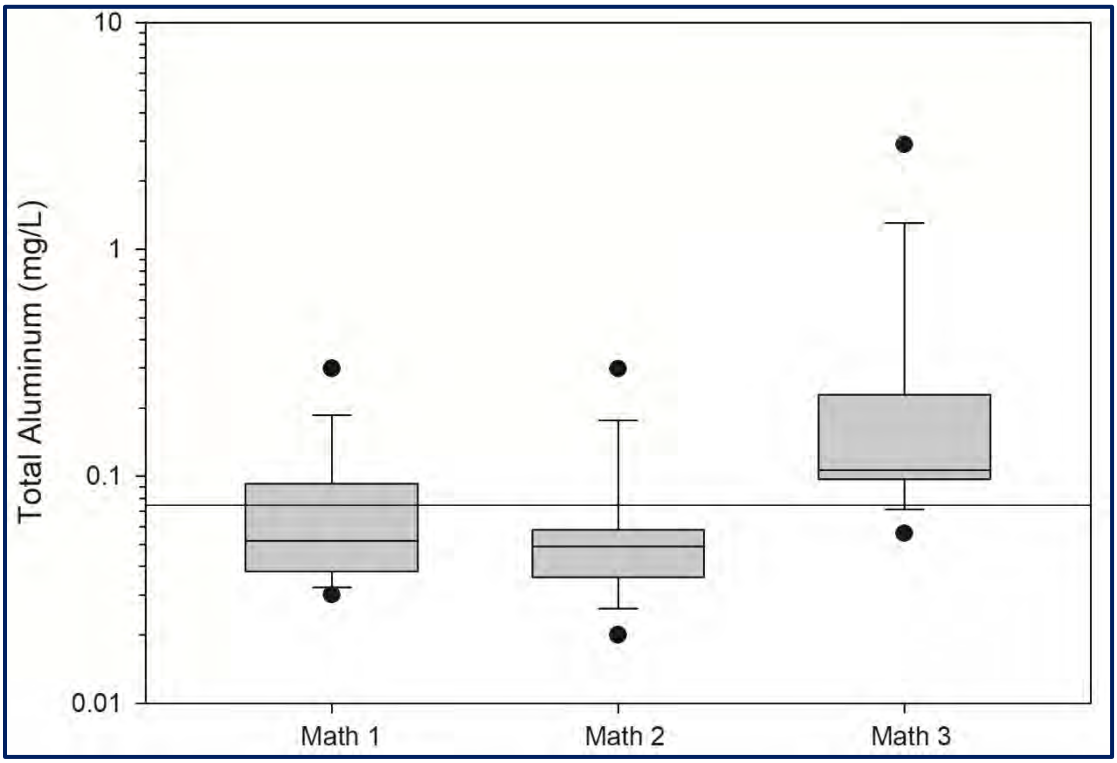


Beryllium, bismuth, silver, tellurium, and tungsten fell below analytical detection limits in all samples collected, while antimony, cadmium, copper, thallium, thorium, tin and zirconium were only detectable in 1 to 3 samples each (7 - 20%, n=13-15), and thus no data are presented in Table 2. Total metals concentrations observed above PWQO levels included aluminum (n=20, Figure 7), iron (n=6), cobalt (n=1), copper (n=1) and zirconium (n=1, not shown), which were more common at Math 3 and were associated with high suspended solids (Figure 8). Note that the detection limit for copper was equivalent to the guideline. While there was a single detection of copper all other values were below the detection limit.

Temperature records indicated that the Matheson Creek tributary was a cold-water stream at all three monitoring sites and that there was no difference between temperatures at the Math 1 and Math 2 sites (Table 2, Figure 9). Temperatures were consistently higher downstream at Math 3 (Figure 9), which receives water from Math 1 and 2, as well as several other tributary streams which run through less sheltered areas North and East of County Road 27 (Figure 2). Patterns observed in temperature logger data collected in 2015 and 2016 included diurnal fluctuations of 4-6°C during the summer months, with maximum temperatures that did not exceed 20°C (Figure 9).

Dissolved oxygen concentrations were consistently above the temperature-dependent Provincial Water Quality Objectives (PWQO) MOE 1994) of 5-8 mg/L for cold water aquatic life, with the exception of three measurements (Figure 10). All three guideline exceedances occurred during the March sampling event during cold weather (-25 °C) and are likely therefore not indicative of typical open water flow conditions.

Figure 7. Aluminum concentrations recorded in Matheson Creek tributary.



Horizontal line indicates PWQO Guideline of 0.075 mg/L

Figure 8. Correlation between Total Iron and Aluminum and TSS in Matheson Creek tributary.

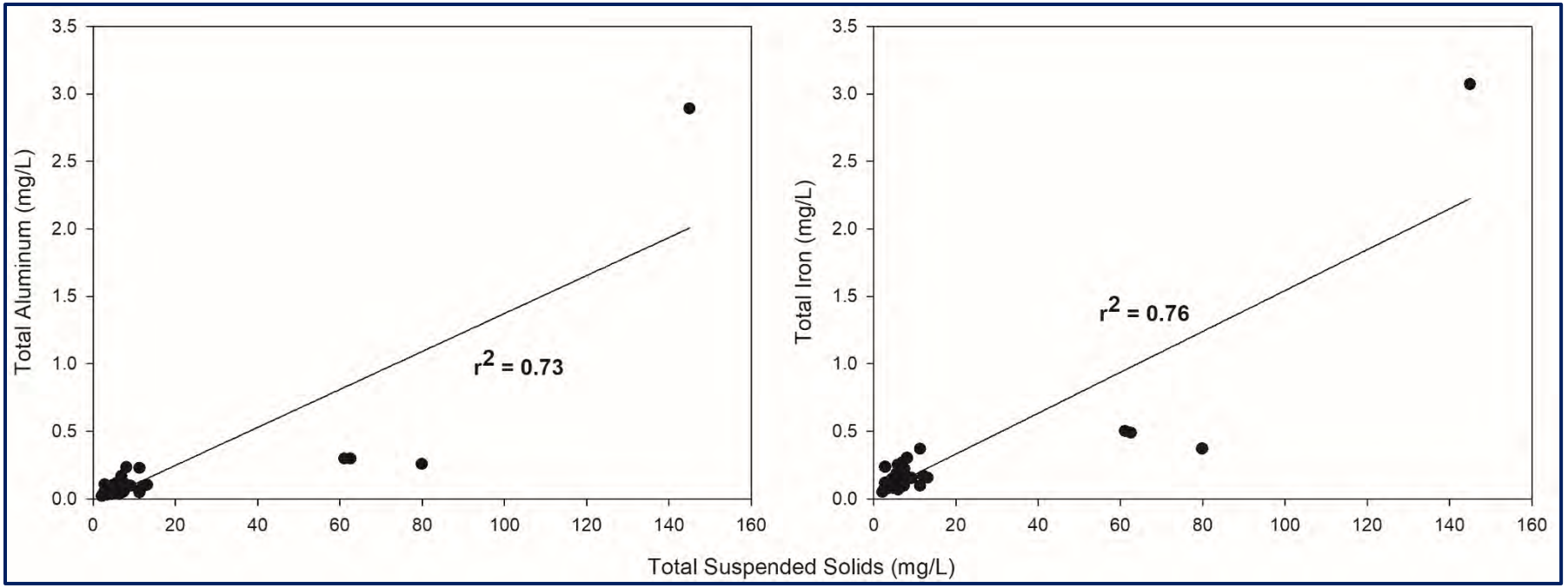


Figure 9. Continuous 2015 and 2016 Temperature Records for Matheson Creek Tributary.

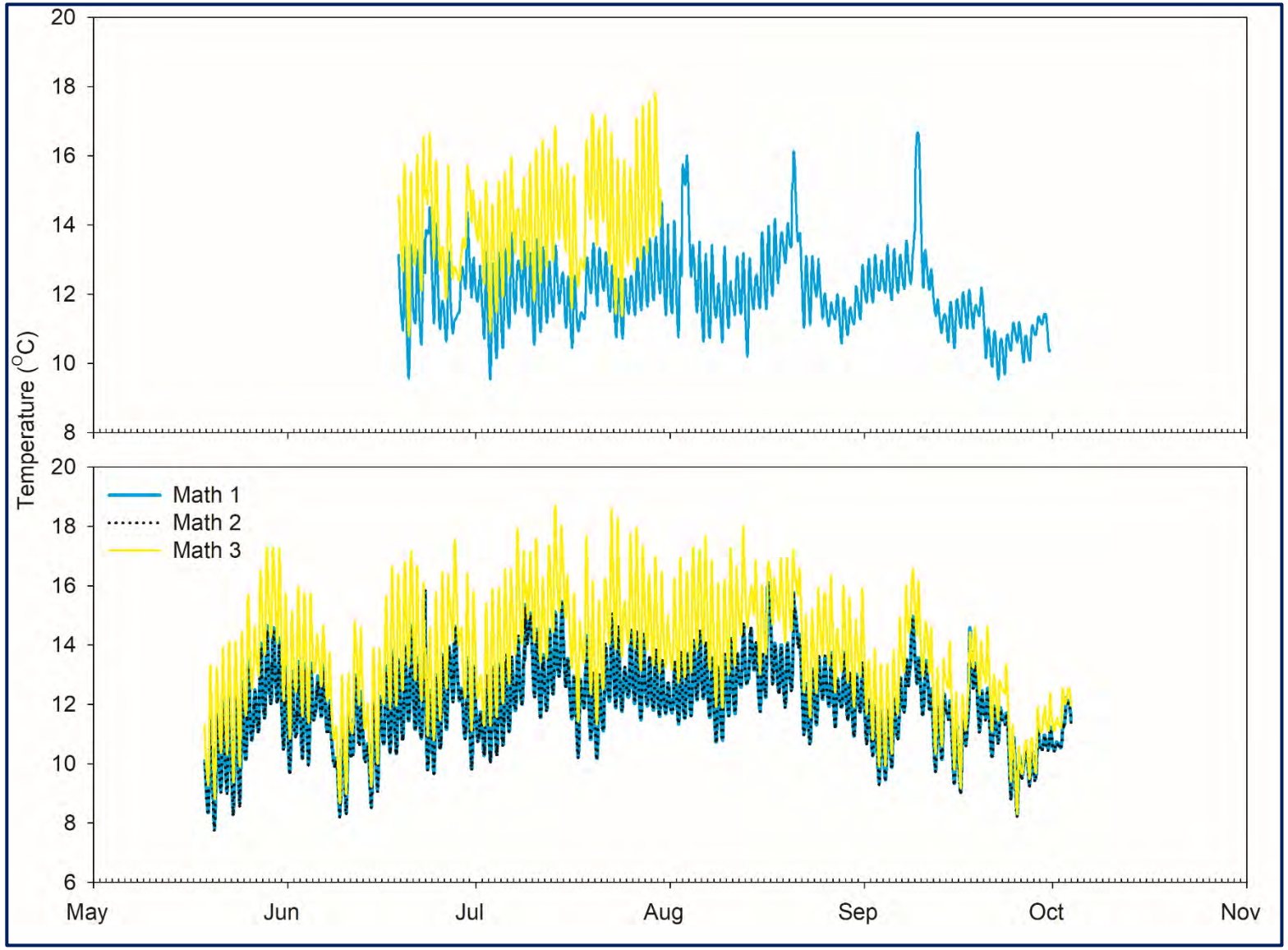
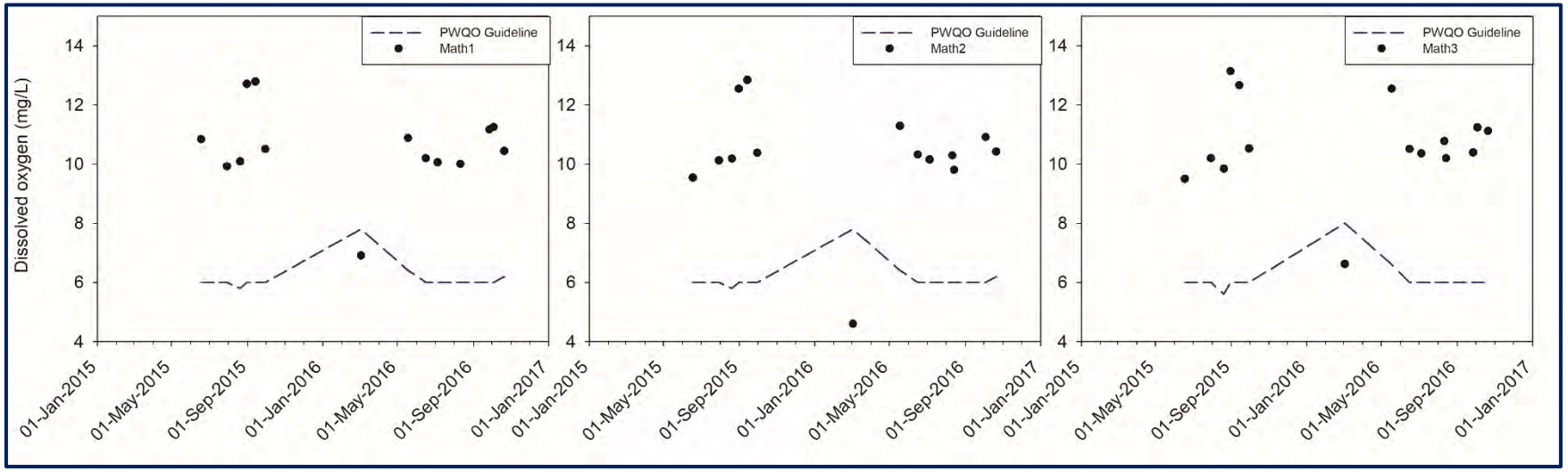


Figure 10. Dissolved oxygen concentrations recorded in Matheson Creek Tributary.



Dotted line indicates PWQO Guideline of 5-8 mg/L

5.2 Hydrology and Receiver Flow

The hydrology program was focussed on characterizing flow, aquatic habitat and describing the available assimilation volumes for stormwater flows.

Median flows, based on pro-rated calculations of WSC HYDAT data recorded from 2006-2015, peaked at ~2200 L/sec during spring freshet and declined to 350-400 L/sec for extended periods during the summer months (Figure 11).

Flows were also measured at each site as part of the field program in 2015 and 2016 to further characterize the hydrology of the tributary and validate the estimated flows (Table 3). Flows were similar at Math 1 and Math 2 which are both near Gill Road, separated by a few hundred metres, but were significantly higher at Math 3, which receives flow from several additional tributaries of Matheson Creek (Figure 12).

Field measured flows did not fall below 600 L/sec in 2015 and 2016, were well above the median daily flows and similar to the maximum flows predicted in the WSC HYDAT estimations (Figure 11). Storm sampling in August (2015) produced flows of similar magnitude to those predicted to occur during spring freshet by the WSC HYDAT data estimates. WSC HYDAT pro-rated median flow estimates significantly underpredicted the measured flows collected in the field throughout the year (Figure 11). The WSC data for Willow Creek does not appear to be sufficient to estimate flows in Matheson Creek. Willow Creek has different flow characteristics as flows are altered by Little Lake and receive a greater influence of surface water than Matheson Creek, which is groundwater dominated and arises on the Oro-Medonte Moraine (NVCA 2007). Flow data will continue to be collected on an ongoing basis as part of the adaptive monitoring and management strategy.

Table 3. Summary of field flow measurements in Matheson Creek tributary in L/sec.

	Math1	Math2	Math3
18-Jun-15	282	259	1036
30-Jul-15	227	235	714
20-Aug-15	654	544	1929
31-Aug-15	284	261	838
14-Sep-15	328	308	1280
30-Sep-15	275	238	849
03-Mar-16	301	325	1856
18-May-16	333	348	1548
16-Jun-16	284	302	813
05-Jul-16	248	246	861
11-Aug-16	268	202	672
14-Aug-16	275	211	882
03-Oct-16	308	264	967
21-Oct-16	345	330	1303

Figure 11. Comparison of estimated flows at Matheson Creek tributary site Math 3 with 2014-2016 field measurements.

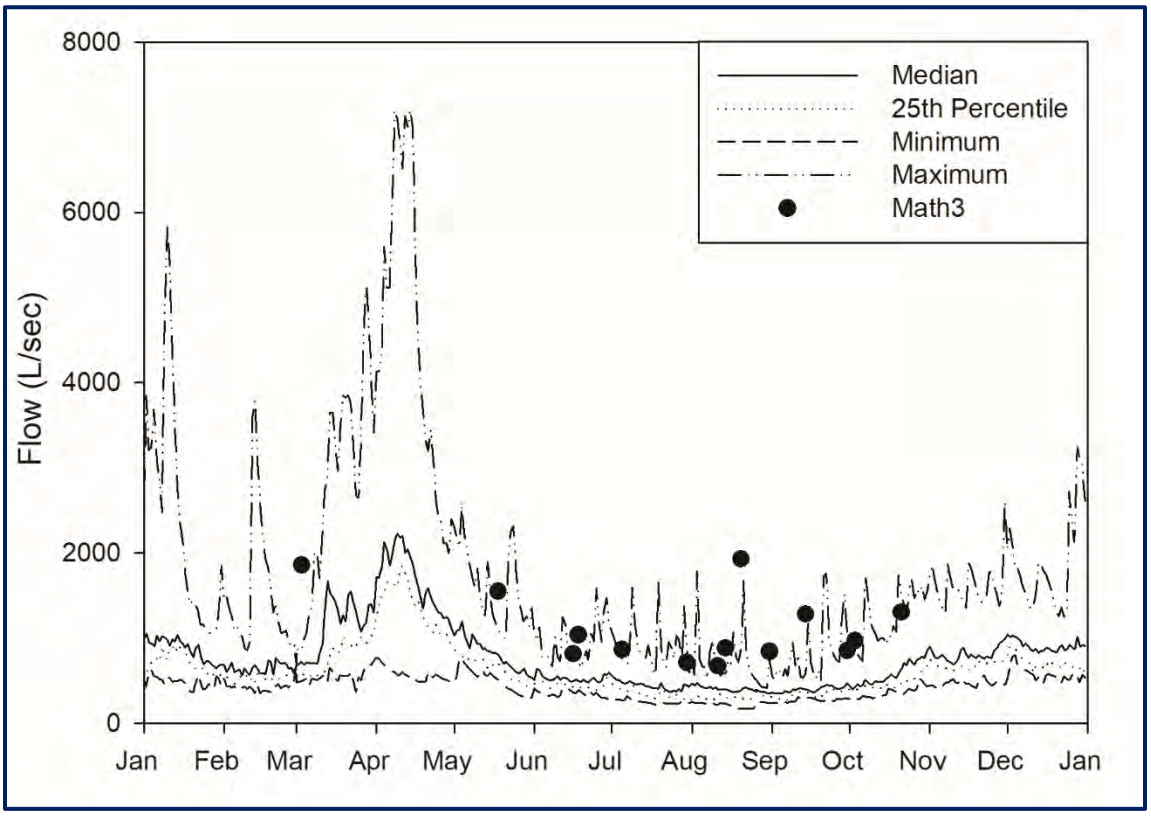
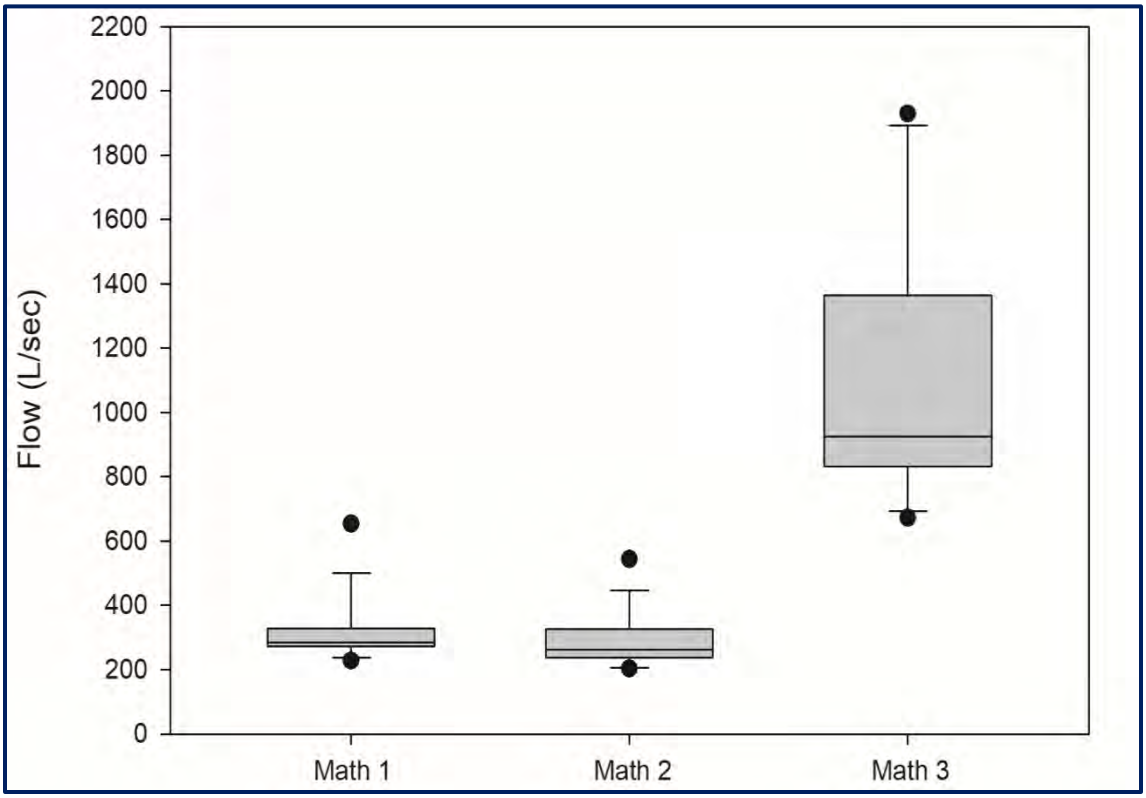


Figure 12. Summary of field measured flows from 2015-2016 field data at Matheson Creek.



5.3 Aquatic Biota

Benthic invertebrates are a collection of aquatic organisms that are comprised of immature insect stages, worms, snails and clams which inhabit substrate in streams. Benthic invertebrate community sampling is frequently used for assessing environmental stresses on aquatic environments imposed by environmental stressors such as degraded water quality or habitat. Benthic invertebrate communities integrate long-term changes in their environment including temperature, nutrients, contaminants, suspended solids, habitat type and food availability, and may also respond to short-term events which cannot always be captured by traditional water quality sampling. Benthic invertebrate data was collected in 2015 to establish the baseline community structure within the Matheson Creek study area, prior to any development, for comparison with future surveys to assess any changes over time.

Benthic invertebrate community sampling was conducted at the same sites sampled for fish, water quality and hydrological assessments. Site Math 1 was in a tributary of Matheson Creek in a forested area just North of Gill Road. Math 2 was downstream of Math 1, just south of Gill Road. Math 3 was the furthest downstream location, in a small clearing just upstream of County Road 27. Stream habitat, based on characterizations performed in 2015, consisted of a low gradient run morphology with fine sands, and silts, limited aquatic vegetation and woody debris (Table 4).

Table 4. Summary of stream habitat conditions.

Reach	Approx. Water Depth (m)	Morphology	Substrate Description
Math1	0.3	low gradient run	sand and fines (silt/clay), sparse aquatic vegetation (Lake Watercress) and woody debris
Math2	0.3	low gradient run	sand and fines (silt/clay), sparse aquatic vegetation (Lake Watercress) and woody debris
Math3	0.3	low gradient run and pool	Sand, with some rocky substrate, silts and organics; sparse aquatic vegetation (Lake Watercress) and substantial large woody debris

5.3.1 Species Richness

Species richness is a measure of the total number of different species identified at a sampling site. A total of 41 species were collected in 2015 from all three sites within the study area. Species richness at Math 1 was the highest at 24 species, but declined downstream to 20 and 18 at Math 2 and Math 3 respectively. Sites Math 1 and Math 2 are located in a less agriculturally developed tributary of Matheson Creek, with significant forest cover and lower and less variable water temperature which may account for the slightly higher benthic invertebrate richness. The number of organisms recovered from Math 1 samples was an order of magnitude greater (n = 443) than at the other two sites (n = 48 and 45) due to high numbers of several Amphipoda species.

Table 5. Summary of Matheson Creek tributary benthic community metric results in 2015.

	Math 1	Math 2	Math 3
Total Number of Organisms	443	48	45
Species Richness	24	20	18
HBI Index	5.43	5.45	5.15
HBI Index WQ Comment	fair	fair	fair
Simpson's Diversity	0.84	0.93	0.84
% *Chironomidae*	31	46	67
% *Amphipoda*	33	10	4
% EPT	12	15	16
% *Simulidae*	22	17	2
% *Coleoptera*	0	0	4
% Other *Diptera*	0	8	4
% Other	1	4	2

5.3.2 Relative Abundance

Major taxonomic groups present in the 2015 surveys included: *Chironomidae* (non-biting midges), *Simulidae* (black flies), EPT [*Ephemeroptera* (mayflies) *Plecoptera* (stoneflies) and *Trichoptera* (caddisflies)], *Amphipoda* (sow bugs), other *Diptera* and Other which includes (*Coleoptera* (beetles), *Melagoptera* (alderflies), *Oligochaeta* (aquatic worms), *Gastropoda* (snails), *Hemiptera* (true bugs) and *Odonata* (dragonflies and damselflies; Figure 13).

Chironomidae (midges) taxa were the dominant group present at Math 2 (48%) and Math 3 (67%), but were only the second most dominant group at Math 1, where 33% of the assemblages was comprised of *Amphipoda* species. EPT (*Ephemeroptera*, *Plecoptera* and *Trichoptera*) and *Simulidae* species accounted for the majority of the rest of the species assemblages at all three sites with minor populations of *Coleoptera* and other *Diptera* (Figure 13).

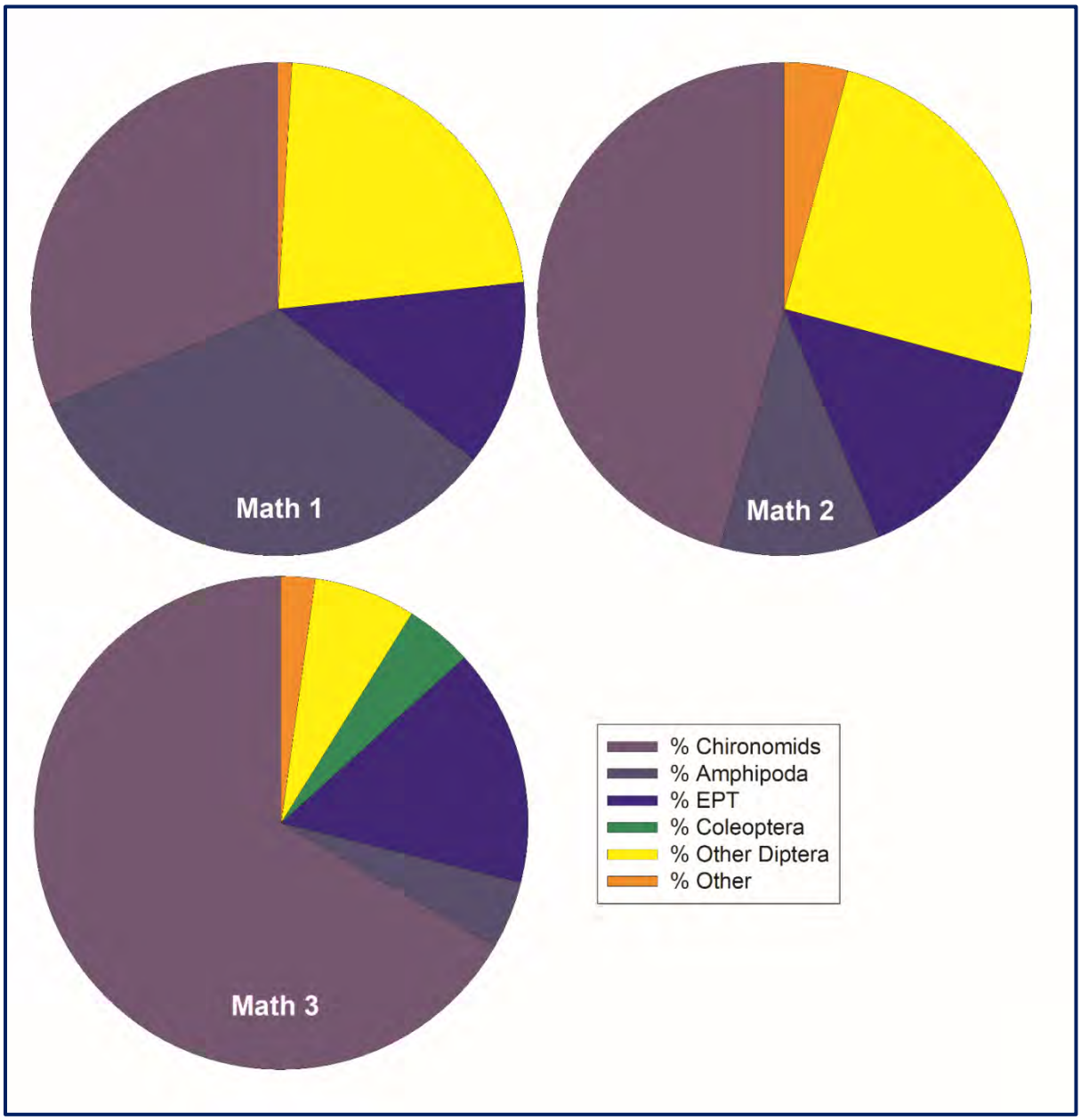
Chironomid and Amphipod taxa are generalists found in most aquatic environments, while EPT species are known to be sensitive to organic pollution and are therefore frequently used as indicators of good water quality.

5.3.3 Hilsenhoff Biotic Index

The Hilsenhoff Biotic Index (HBI) provides an estimate of organic pollution based on published pollution tolerance values for individual benthic invertebrate species (Hilsenhoff, 1987). The HBI is an average of the tolerance values of the individual species which range from 0 to 10, with 0 being intolerant and 10 being very tolerant of organic pollution, thus a lower HBI suggests better water quality.

HBI values in 2015 were consistent across all three sites on Matheson Creek resulting in a water quality descriptor of “Fair” (Table 5). This reflects the high abundance of chironomid species and relatively low EPT species at all sites and is influenced by the consistent silt/sand habitat with little rocky cobble and resultant low habitat diversity for of benthic invertebrates.

Figure 13. Benthic community relative abundance at the Matheson Creek tributary study area in 2015



5.4 Fish Community and Habitat

In both the 2015 and 2016 surveys, a diverse community of fish was captured. Fish species identified included Brown and Brook Trout (*Salmo trutta* and *Salvelinus fontinalis*), Central Mudminnow (*Umbra limi*), Slimy Sculpin (*Cottus cognatus*), and White Sucker (*Catostomus commersonii*) during both field visits and a single Brook Stickleback during sampling in October of 2016 (Table 6).

Brook trout was only captured in the small tributary sites (Math 1 and 2), and is highly sensitive to environmental degradation (e.g., turbidity, chlorine and dissolved oxygen). It was ranked as the most sensitive species in Toronto-area streams (Wichert and Regier 1998; Table 6). Presence of brook trout at these sites indicates cold and clean water and appropriate spawning habitat. Brook trout have a final-temperature preference (FTP - the temperature that they congregate in when exposed to a full temperature range) of 15.3 °C and are highly sensitive to thermal perturbations (Hasnain et al. 2010). Lack of Brook Trout at the Math 3 site may be the result of higher and more variable water temperature downstream (Figure 9), as no significant differences in water quality were noted. The protection of sensitive brook trout populations will require mitigation associated with the proposed development including high level stormwater management focussed on maintaining nutrient levels, such that they do not reduce dissolved oxygen concentrations, and on thermal mitigation to maintain cool water temperatures.

Table 6. Fisheries assessment results on Matheson Creek.

Date	Species	Math 1	Math 2	Math 3	Total
30-Sep-15	Brook Trout	9	-	-	9
	Brown Trout	6	7	3	16
	Central Mudminnow	1	2	-	3
	Slimy Sculpin	10	8	1	19
	White Sucker	-	-	7	7
03-Oct-16	Brook Stickleback	-	1	-	1
	Brook trout	3	4	-	7
	Brown Trout	5	4	3	12
	Central Mudminnow	1	1	-	2
	Slimy Sculpin	9	14	12	35
	White Sucker	-	-	5	5

6. Conclusions

The Matheson Creek tributary is a cold water stream that contains sufficient base flow and habitat to support a varied benthic community and diverse fish population, including environmentally sensitive brook trout.

Analysis of data collected during field seasons in 2015 and 2016, showed only a few guideline exceedances in nutrients and metals and these were associated with high suspended sediment loads and therefore not

readily biological available to aquatic organisms. Likewise, dissolved oxygen concentrations were consistently above guidelines in all but a few samples collected during a March sampling event in 2016 prior to freshet and therefore not typical of flowing water conditions.

Stream flows, estimated by pro-rating WSC data from Willow Creek, consistently under-predicted actual flows measured in the field. Flow data will continue to be collected and reviewed on an ongoing basis as part of the adaptive monitoring and management strategy.

Benthic invertebrate communities were characterized by low species richness and a lack of environmentally sensitive EPT species, thus water quality indices indicated only fair water quality in Matheson Creek at all three sampling sites, but the assessment also indicated the consistent silt/sand habitat with little rocky cobble and resultant low habitat diversity for benthic invertebrates.

Fish community diversity was greater than that at the other MSPA baseline water quality monitoring locations (e.g., Doran Road, and Carson Road). Brook and brown trout, Slimy sculpin, White Sucker and Central Mudminnows were present. Brook trout, an environmentally sensitive species, was not detected downstream owing to higher water temperatures at that location. Protection of the cold water habitat and sensitive brook trout populations in the Matheson Creek tributary will require stormwater management focussed on reducing suspended solids in runoff, mitigating nutrient levels, such that they do not reduce dissolved oxygen concentrations, and thermal mitigation to maintain cool water temperatures.

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Baseline Aquatic Studies for Midhurst Secondary Plan - Midhurst Village

2015-2016

Prepared for: Midhurst Landowner Group
Job #: J140054

January 2018

DRAFT FOR DISCUSSION

1-5 Chancery Lane Bracebridge, ON P1L 2E3 | 705-645-0021

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Environmental Sciences Ltd.

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January 19, 2018 HESL Job #: J140054

Midhurst Landowner Group
c/o Mr. Vimal Patel
Sr. Project Manager, Land Development
Geranium Corporation
3190 Steeles Avenue E., Suite 300
Markham, ON L3R 1G9

Dear Vimal:

Re: J140054 - Draft Report - Baseline Aquatic Studies for Midhurst Secondary Plan: Midhurst Village: 2015-2016.

A number of studies have been completed to characterize the baseline chemical and biological conditions of Willow Creek and its tributaries in Midhurst in connection with the implementation of development within the Midhurst Secondary Plan, including draft approved subdivisions located in the Carson and Doran Neighbourhoods. This report presents the results of baseline studies completed on the main stem of Willow Creek within existing developed lands in the Midhurst Secondary Plan Area ("Midhurst Village", as identified on Map 2). Information on water quality, flows, benthic invertebrates and fisheries was collected by HESL in 2015 and 2016. Baseline data were collected to meet the requirements of the Monitoring and Adaptive Management Plan, which is a requirement of the master drainage plan for the Midhurst secondary plan application, monitor the response of the aquatic environment to development as it proceeds, and to inform the Adaptive Monitoring and Management Plan to minimize any potential future impacts on the watercourses.

We thank you for the opportunity to assist the Midhurst Development Group with this project and hope that this report meets your needs.

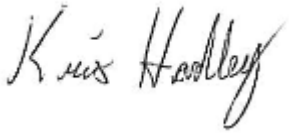
Sincerely,
Hutchinson Environmental Sciences Ltd.



Brent Parsons
brent.parsons@environmentalsciences.ca

Signatures

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Kristopher Hadley, Ph.D.
Aquatic Scientist



Brent Parsons
Senior Aquatic Scientist

Report Reviewed by:



Neil Hutchinson, Ph.D.
Principal Aquatic Scientist

Executive Summary

This report summarizes the methods and resultant data used to develop a baseline of water quality and aquatic biology for surface waters in the Midhurst Village downstream of the stormwater discharge from the proposed Doran Road development of the Midhurst Secondary Plan Area (MSPA). The MSPA is located in the Township of Springwater, County of Simcoe. Ontario. Existing development in the Secondary Plan Area includes residential, commercial/industrial, mixed and agricultural uses. Proposed development in the Secondary Plan Area includes residential communities, commercial, industrial, mixed use and employment lands. The details of the planned development for the Midhurst Secondary Plan Area are contained within Official Plan Amendment (OPA) No. 38 Midhurst Secondary Plan and in approved draft plans. Although the total area of the MSPA is approximately 2,813 ha, the development will be phased, with 300ha developed in Phase 1 and the Full Build Out occurring over a longer time period.

Monitoring performed at two sites on Willow Creek adjacent to and within Midhurst Village was aimed at establishing baseline conditions and to aid in our ability to detect any future changes resulting from flows from the three stormwater management ponds included in the Doran Development, upstream and the influence of existing stormwater discharges within Midhurst. Sampling was conducted during dry and wet events to separate baseline conditions from those associated with stormwater runoff.

Average total phosphorus concentrations were below the Provincial Water Quality Objective of 0.03 mg/L at both stations while nitrate levels were significantly elevated downstream, and regularly exceeded the CCME Guideline for Protection of Aquatic Life (3 mg/L as nitrate-N; CCME, 2012). Calculated unionized ammonia concentrations were below the PWQO of 0.02 mg/L (as ammonia) in all samples tested. Total metals concentrations observed above PWQO levels were associated with high suspended solids and are therefore indicative of runoff and erosional events and are less biologically available.

Temperatures in Willow Creek were significantly higher with greater diurnal variation upstream but were tempered downstream as a likely response to groundwater inputs such that the stream was considered cold water habitat. Dissolved oxygen concentrations were consistently above the temperature-dependent Provincial Water Quality Objectives (PWQO) MOE 1994) of 5-8 mg/L for cold water aquatic life.

Biotic indices of water quality varied significantly between the two Midhurst Village stations. Scores improved from “very poor” upstream (Mid 1) to “Good” downstream (Mid 2) owing to the high abundance of pollution tolerant *Amphipoda* species at Mid 1. Environmentally sensitive EPT species were not detected at either station.

Fish sampling captured a diverse community including several game fish (brown and rainbow trout and largemouth bass). Fish communities varied considerably between the two stations sampled, likely owing to much cooler water temperatures downstream at Mid 2, where sheltered conditions and habitat supported a diverse community of cool water fish species.

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1. Introduction and Project Understanding

The Midhurst Landowner Group is currently implementing development approvals within Midhurst Secondary Plan Area of the Township of Springwater, including draft subdivision approvals within the Doran and Carson Neighbourhoods. Three initial summary reports were prepared by AECOM in 2009 to describe baseline surface water conditions within and downstream of the Doran Road Development project which drains to Willow Creek within the Midhurst Village (GLL/AECOM 2009). Baseline monitoring focussed on Doran Road Development Area at that time. This report supplements that with additional data collected for the main stem of Willow Creek in 2014-2017 by Hutchinson Environmental Sciences Ltd. (Figure 1).

Three stormwater management ponds, two in Phase 1 and one in Phase 2 (Full Build Out), have been proposed to treat stormwater at the Doran Road development. They will ultimately discharge to Willow Creek within Midhurst Village and it is therefore necessary to quantify current conditions of water quality and aquatic habitat within the Midhurst Village in the local reach of Willow Creek to provide a baseline for post-development comparisons.

This report summarizes the data collected in 2015 and 2016 at two new monitoring locations, upstream (Mid 1) and downstream (Mid 2) of the Midhurst Village stormwater outfall and provides an assessment of the current baseline water quality. Additional data were collected in 2017 to expand upon the 2015/2016 data and inform on the natural inter-annual variation within the watercourse. This will provide a more robust description of baseline water quality for future assessment, improve the ability of the Adaptive Monitoring and Management Plan to detect any changes to surface water from stormwater management, and provide guidance for the design and mitigation of the development. These will be incorporated in the subsequent versions of this report.

2. Environmental Setting

2.1 Willow Creek at Midhurst Village

Willow Creek, downstream of Little Lake, flows through the Midhurst Village (Pop. 3000) prior to it's confluence with Matheson Creek upstream of the Minesing wetland (Figure 2). Little Lake is surrounded by a Provincially Significant Wetland (PSW) and is a natural lake in the Nottawasaga watershed. Currently, this reach of Willow Creek receives discharge from the existing stormwater outfall of the Midhurst Village whose impacts on the water quality in Willow Creek have not been quantified. Two monitoring locations were established, upstream (Mid 1) and downstream (Mid 2) of the Midhurst Village stormwater outfall to provide an assessment of the current baseline water quality and inform post-development water quality comparisons.

2.2 Natural Heritage Features

Five designated environmentally significant areas exist in and around Midhurst that are linked to surface waters of the Willow Creek subwatershed. They are:

- **Little Lake Provincially Significant Wetland:** A wetland complex of 285 hectares that surrounds Little Lake. It is almost completely lacustrine, however, a small portion in the

northwest contains riverine communities where Willow Creek enters Little Lake. Downstream, the reach of Willow Creek under St. Vincent Street is hydrologically connected to the Little Lake PSW.

- **Midhurst Swamp:** Midhurst Swamp is a 450 ha. Wetland, designated EP1 in the Springwater Township OP, 40% of which is comprised of riverine communities associated with Willow Creek. Treated stormwater, discharged at levels sufficient to protect surface waters at the Doran site, will not impact Midhurst Swamp.

- **Springwater Provincial Park:** Springwater Provincial Park is a recreational park located south of Willow Creek. It contains a wide variety of vegetation communities due to varied soils, topography and numerous localized areas of groundwater. Willow Creek flows well north of Springwater Provincial Park and therefore the Doran Road development will have no interaction or impact on it.

- **Minesing Swamp Provincially Significant Wetland:** Minesing Swamp PSW is provincially significant and is designated as a wetland of international importance by the Ramsar Convention on Wetlands. Willow Creek and its tributaries flow into Minesing Swamp before reaching the Nottawasaga River. Discharge of treated stormwater and sewage effluent at levels sufficient to protect the surface waters of Willow Creek and its tributaries will not impact Minesing Swamp.

- **Simcoe County Greenlands Designation:** The Simcoe County Greenlands Designation is found in the Simcoe County OP (County of Simcoe 2016). It represents areas identified within the Development of a Natural Heritage System for the County of Simcoe report (GLL 1996). None of the tributary to Willow Creek in the proposed Doran Neighbourhood is designated as greenlands.

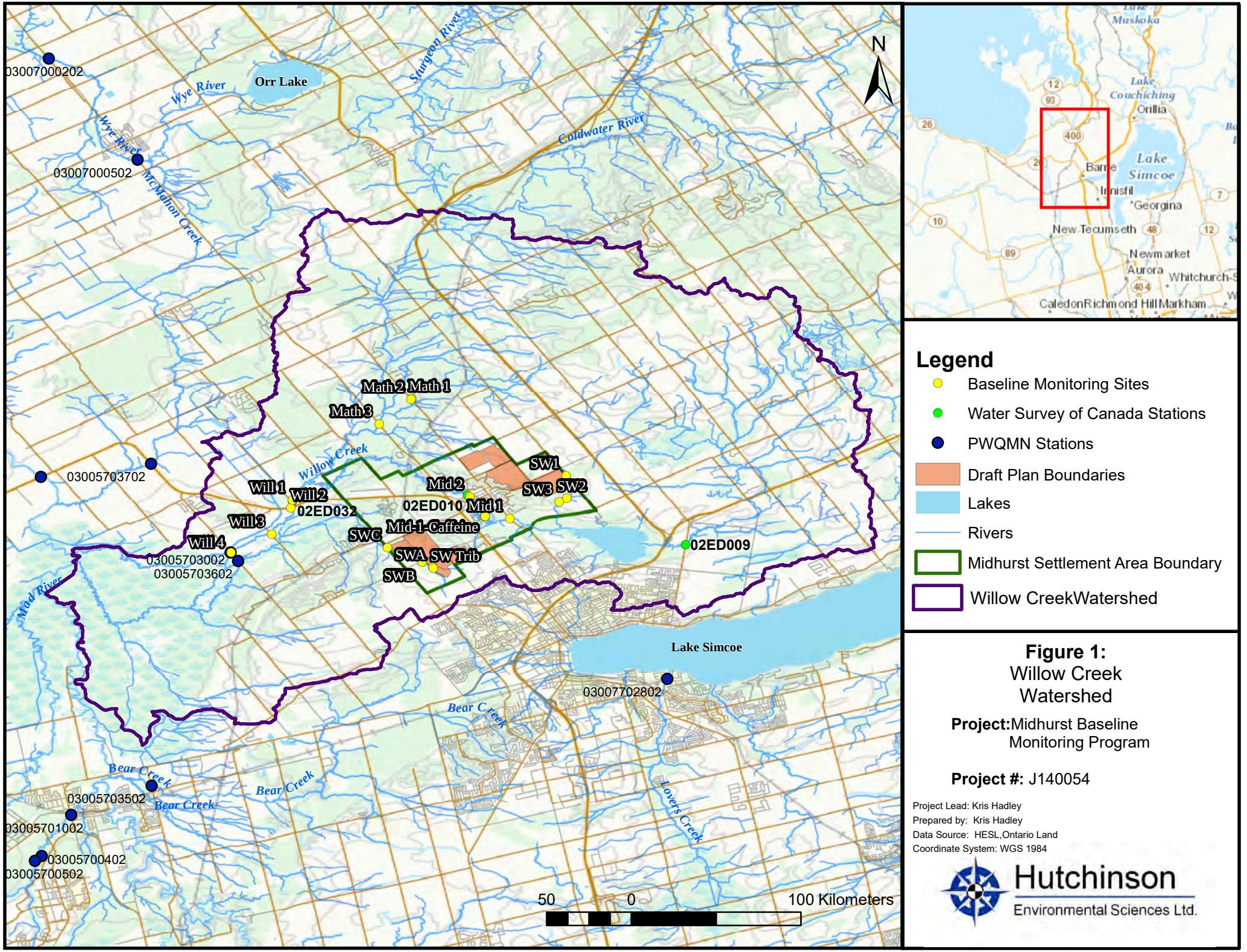


Figure 1:
Willow Creek
Watershed

Project: Midhurst Baseline
Monitoring Program

Project #: J140054

Project Lead: Kris Hadley
Prepared by: Kris Hadley
Data Source: HESL,Ontario Land
Coordinate System: WGS 1984

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Legend

- Rivers
- Lakes
- Village of Midhurst Sites
- Doran
- Midhurst Heights

Project Lead: Kris Hadley
Prepared by: Kris Hadley
Data Source: HESL,Ontario Land, ESRI
Coordinate System: GCS WGS 1984

Figure 2:
Village of Midhurst
Sampling Sites

Project: Village of Midhurst
Baseline Monitoring

Project #: J140054

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3. Methods – Field Programs

A summary of the field studies conducted as a part of the baseline water quality monitoring at the Midhurst Village to date is provided below (Table 1). Detailed methodology for each field program is described in Sections 4.1 to 4.4. Data collection for 2017 has been completed and the report will be updated as soon as results are received and compiled.

Table 1. Summary of the Field Studies Conducted to Describe Baseline Water Quality at the Midhurst Village

Organization	Date	Parameters
HESL	Sept 30th, 2015, October 3rd, 2016	Fish
	June 17th, 2015	Benthic Invertebrates
	June to Sept. 2015; March, May to October 2016/2017	Water Quality and Flows

3.1 Water Quality

The HESL field program established the two sampling stations Mid 1 and Mid 2, which were each visited monthly in the ice free seasons of 2015 (June to September) and 2016 (May to October) and in March of 2016 (Figure 2, Table 1). Water samples were collected and analyzed for a standard suite of parameters including general chemistry, nutrients and metals by ALS Environmental, a fully accredited laboratory. Additionally, field measurements of pH, specific conductivity, water temperature and dissolved oxygen were collected at each station during each site visit.

3.1.1 Numerical analysis

Summary statistics tabulated include sample size (n), number of samples above the detection limit (n>DL), minimum (Min), maximum (Max), arithmetic mean, and median (Table 2). Boxplots were used to summarize key water quality parameters as they allow for efficient visualization of five summary statistics, the median, two hinges (the 75th and 25th percentiles) and the whiskers which extend from the hinge to the largest and smallest value no further away than 1.5 * the Interquartile Range.

Values below detection limit were replaced with a value equivalent to the detection limit for statistical summaries.

3.2 Flows

No long-term data for flow in Willow Creek was available at our sampling stations, we therefore estimated daily flow using 2006-2015 data from Environment Canada's HYDAT database for Willow Creek above Little Lake (Station 02ED009; Figure 1) and collected spot flow measurements to compare with the estimates. Flows were estimated for Willow Creek on the east side of Finlay Mill Road by prorating flows from the WSC station on the basis of watershed area using areas of 94.8 km^2 for Willow Creek above Little

Lake and 128.6 km^2 for the Willow Creek at Mid 2. Watershed areas were acquired from the Ontario Flow Assessment Tool (OFAT, 2017).

The field program included stream flow measurements made during each visit at both sample sites, following protocols outlined in Ontario Stream Assessment Protocol (Stanfield 2010). Briefly, the number of cross sectional measurement panels was determined via channel width while stream velocity was measured using an OTT MF Pro flow mate. Sampling depth was based on water depth within each measurement panel. Stream profiles, discharges and average velocity were calculated for each site.

3.3 Benthic Invertebrates

The benthic invertebrate community study was conducted on Willow Creek near the Midhurst Village on June 17th, 2015. Qualitative samples were collected at each of the aquatic assessment monitoring locations (Mid 1 and Mid 2 [Figure 2]), following the same protocol employed for baseline sampling at Carson Rd, Doran Rd and Matheson Creek, which included:

- Stations sampled over a constant pre-determined area (2m x 2m) at each station;
- Travelling kick and sweep method utilizing a D-frame net (500 micron), moving upstream from bank to bank, over the entire area; and
- Effort of 2 minutes for each study reach.

Samples were transferred into labelled sample jars, preserved with 70% alcohol solution and submitted to a qualified taxonomist, Richard Bland, for sorting and identification to the lowest taxonomic level possible.

Habitat surveys were also conducted at each of the benthic sampling stations to characterize habitat within the creek and inform on the importance of habitat in determining benthic community structure. Habitat survey parameters included stream substrate, water depth, flow rates, morphology and surrounding land use.

The following benthic invertebrate metrics were calculated:

- Species richness
- Species diversity (lowest practical level);
- Simpson's Diversity Index
- Relative abundance of taxonomic groups; and
- Hilsenhoff Biotic Index (HBI)

3.4 Fisheries

A field investigation was conducted to characterize the fish community and fish habitat present in the Midhurst Village sites on Willow Creek on Sept 30th, 2015, and then revisited on October 3rd, 2016 (Figure 2). Sampling protocols mirrored sample collection protocols followed as a part of the other baseline monitoring programs, e.g., Doran Rd and Carson Rd (HESL 2017a, 2017b) including backpack electrofishing at each site. Fish were identified to species, counted, assigned an approximate age, and released alive. Water temperature, conductivity, pH and sampling time were also recorded for each site.

4. Results

4.1 Water Quality

Summary statistics from the 2015-2016 data collection highlight the range and average values of parameters of interest (Table 2).

Average total phosphorus concentrations were below the Provincial Water Quality Objective (PWQO, MOE 1994) of 0.03 mg/L (Figure 3). Exceedances of the PWQO occurred in individual measurements at both sites and these were correlated to suspended sediments, particularly after excluding an outlier (TSS = 27.5 NTU) which resulted from localized ice cover conditions on the creek at the time of sampling (Figure 4). Dissolved P concentrations at Mid 1 were above the detection limit more frequently than has been observed elsewhere in the Midhurst Secondary Plan Area (e.g., Matheson Creek) which may suggest a local source of dissolved phosphorus. Mid 1 is located immediately downstream of the Little Lake Provincially Significant Wetland, and wetlands can be a source of dissolved organic and inorganic P (Gu et al. 2017).

Nitrate levels were significantly elevated at Mid 2, relative to Mid 1 (Figure 5) and concentrations regularly exceeded the CCME Guideline for Protection of Aquatic Life (3 mg/L as nitrate-N; CCME, 2012). These exceedances occurred in 2016 in 5 of the 8 samples collected at Mid 2, when flows were low. The groundwater from A1 and A2 aquifers is known to be elevated in nitrate (Golder 2014) and the cooling of water temperature between Mid 1 and Mid 2 suggest that groundwater made a substantial contribution to the observed water quality. Lower flow in 2016 would have resulted in less surface water runoff and greater dominance of groundwater. Average conductivity was higher at Mid 2 and dissolved organic carbon lower, both suggesting a greater influence of groundwater and lower influence of surface water than at Mid 1.

Nitrite concentration fell below the analytical detection limit in ~75% of samples tested, while ammonia was BDL in 25% of samples and did not vary between Mid 1 and Mid 2. Calculated unionized ammonia concentrations were below PWQO guideline in all samples tested (0.020 mg/L).

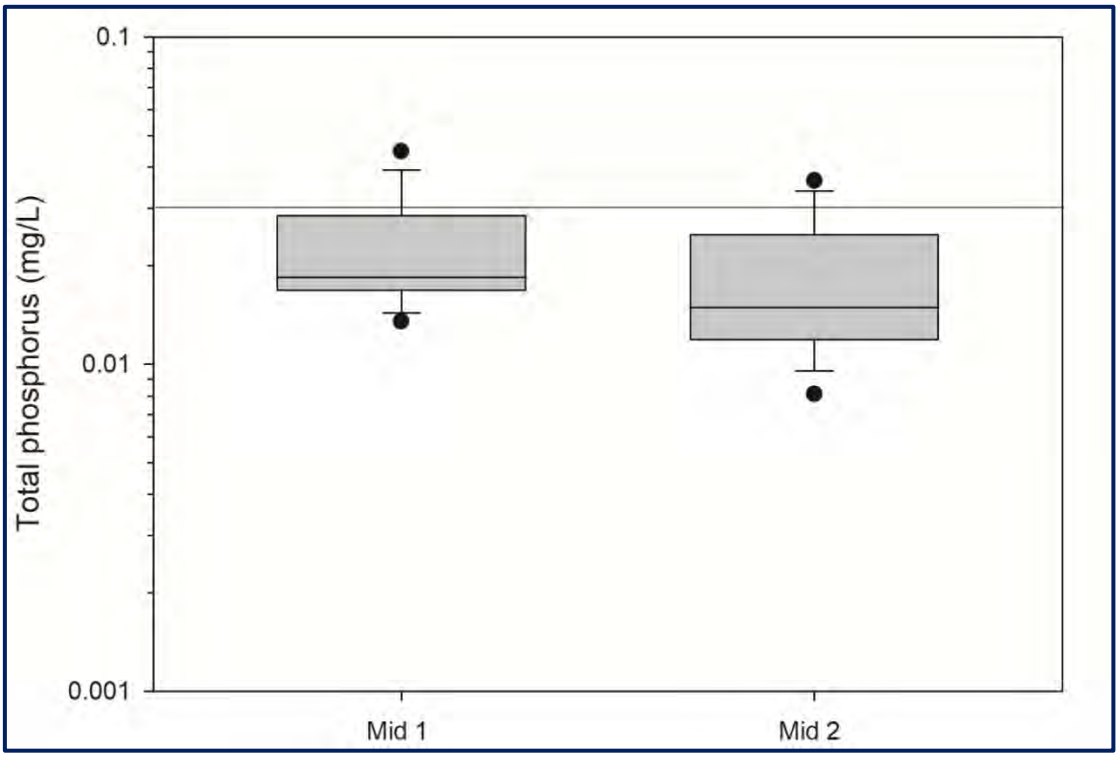
The range of conductivity was consistent between both water quality sites but median and average values were higher at Mid 2 (Figure 6).

Beryllium, bismuth, silver, tellurium, thorium, tungsten, and zirconium fell below analytical detection limits in all samples collected, while cadmium, cesium, cobalt, copper, thallium, and tin were only detectable in 1 to 3 samples each (7 - 20%, n=12-15). Total metals concentrations observed above PWQO levels included aluminum (n=2, Figure 7), iron (n=4), copper (n=1) and zirconium (n=1, not shown), and these were associated with high suspended solids (Figure 8).

Table 2. Summary Statistics from the 2015/2016 Water Quality Sampling Campaign at the Midhurst Village stations

Site		Mid 1 (SW4)						Mid 2 (SW5)					
Field Measurements	**Units**	**n**	**n>DL**	**min**	**max**	**mean**	**median**	**n**	**n>DL**	**min**	**max**	**mean**	**median**
Temperature	^{0}C	14	14	0.9	24.8	18.3	20.2	15	15	0.0	23.0	15.6	15.9
Dissolved Oxygen	mg/L	13	14	5.0	16.3	9.4	9.7	15	15	6.8	11.3	9.1	9.1
pH		14	14	7.1	8.8	8.1	8.1	15	15	7.5	8.2	7.9	7.9
Conductivity	µs/cm	14	14	333	2208	621	454	15	15	335	1385	630	529
Physical Tests (Water)													
Total Suspended Solids	mg/L	14	9	1.3	5.8	2.7	2.1	15	10	0.6	27.5	3.9	2.0
Turbidity	NTU	14	14	0.9	5.3	2.4	2.2	15	15	0.6	10.0	2.4	1.3
Anions and Nutrients (Water)													
Ammonia, Total (as N)	mg/L	14	11	0.023	0.3	0.1	0.1	15	11	0.0	0.3	0.1	0.1
Nitrate and Nitrite as N	mg/L	14	13	0.022	1.9	0.3	0.1	15	15	0.1	4.8	1.9	1.3
Nitrate (as N)	mg/L	14	13	0.020	1.9	0.3	0.1	15	15	0.1	4.8	1.9	1.3
Nitrite (as N)	mg/L	14	2	0.010	0.018	0.011	0.010	15	6	0.010	0.026	0.013	0.010
Total Kjeldahl Nitrogen	mg/L	14	14	0.4	0.8	0.7	0.7	15	15	0.5	0.9	0.6	0.6
Phosphate-P (ortho)	mg/L	7	5	0.003	0.008	0.005	0.004	8	3	0.003	0.006	0.004	0.003
Organic / Inorganic Carbon (Water)													
Total Phosphorus	mg/L	14	14	0.014	0.045	0.023	0.018	15	15	0.008	0.036	0.018	0.015
Dissolved Organic Carbon	mg/L	14	14	6.8	12.2	9.4	9.4	15	15	2.2	17.0	7.4	7.6
Total Metals (Water)													
Aluminum (Al)-Total	mg/L	14	10	0.01	0.04	0.02	0.02	15	12	0.01	0.33	0.05	0.02
Antimony (Sb)-Total	mg/L	14	2	0.0001	0.0005	0.0002	0.0001	15	1	0.0001	0.0005	0.0002	0.0001
Arsenic (As)-Total	mg/L	14	12	0.0002	0.0010	0.0004	0.0003	15	13	0.0002	0.0010	0.0004	0.0003
Barium (Ba)-Total	mg/L	14	14	0.03	0.08	0.05	0.04	15	15	0.03	0.1	0.1	0.1
Boron (B)-Total	mg/L	14	12	0.010	0.022	0.015	0.015	15	13	0.010	0.027	0.018	0.017
Cadmium (Cd)-Total	mg/L	14	1	0.00001	0.00009	0.00002	0.00001	15	1	0.00001	0.00009	0.00002	0.00001
Calcium (Ca)-Total	mg/L	14	14	34.9	78.9	57.3	53.2	15	15	41.7	87.3	66.9	66.6
Chromium (Cr)-Total	mg/L	14	4	0.0005	0.0007	0.0005	0.0005	15	9	0.0005	0.0008	0.0006	0.0005
Iron (Fe)-Total	mg/L	14	14	0.06	0.53	0.16	0.11	15	14	0.05	0.51	0.15	0.13
Lead (Pb)-Total	mg/L	14	2	0.0001	0.0005	0.0002	0.0001	15	2	0.0001	0.0005	0.0002	0.0001
Lithium (Li)-Total	mg/L	14	4	0.0010	0.1000	0.0153	0.0010	15	8	0.0010	0.1000	0.0146	0.0013
Magnesium (Mg)-Total	mg/L	14	14	7.9	11.7	10.0	10.0	15	15	8.1	13.4	10.9	10.5
Manganese (Mn)-Total	mg/L	14	14	0.01	0.49	0.11	0.05	15	15	0.02	0.08	0.04	0.04
Molybdenum (Mo)-Total	mg/L	14	12	0.0003	0.0009	0.0004	0.0004	15	13	0.0003	0.0005	0.0004	0.0003
Nickel (Ni)-Total	mg/L	14	0	0.0005	0.0010	0.0006	0.0005	15	5	0.0005	0.0010	0.0006	0.0005
Potassium (K)-Total	mg/L	14	13	1.0	2.2	1.5	1.5	15	14	1.0	2.0	1.7	1.7
Rubidium (Rb)-Total	mg/L	12	12	0.0007	0.0012	0.0009	0.0009	13	13	0.0006	0.0012	0.0008	0.0008
Selenium (Se)-Total	mg/L	14	12	0.0001	0.0004	0.0001	0.0001	15	13	0.0001	0.0004	0.0001	0.0001
Silicon (Si)-Total	mg/L	14	14	0.4	6.9	3.4	2.9	15	15	0.8	5.2	3.7	3.8
Sodium (Na)-Total	mg/L	14	14	27.7	124.0	52.4	39.1	15	15	31.0	73.0	47.3	44.0
Strontium (Sr)-Total	mg/L	14	14	0.2	0.3	0.2	0.2	15	15	0.2	0.3	0.2	0.2
Sulfur (S)-Total	mg/L	14	12	2.2	21.1	5.7	3.9	15	13	3.0	11.4	5.3	5.0
Titanium (Ti)-Total	mg/L	14	9	0.0003	0.0020	0.0010	0.0008	15	9	0.0003	0.0157	0.0022	0.0008
Uranium (U)-Total	mg/L	14	12	0.0003	0.0010	0.0006	0.0006	15	13	0.0003	0.0010	0.0006	0.0006
Vanadium (V)-Total	mg/L	14	13	0.0005	0.0012	0.0008	0.0008	15	14	0.0005	0.0013	0.0008	0.0007
Zinc (Zn)-Total	mg/L	14	1	0.0030	0.0037	0.0031	0.0030	15	2	0.0030	0.0091	0.0034	0.0030

Figure 3. Total Phosphorus Concentrations at the Midhurst Village stations



Horizontal line indicates PWQO Guideline of 0.03 mg/L

Figure 4. Correlation between Total Phosphorus and TSS at the Midhurst Village sites

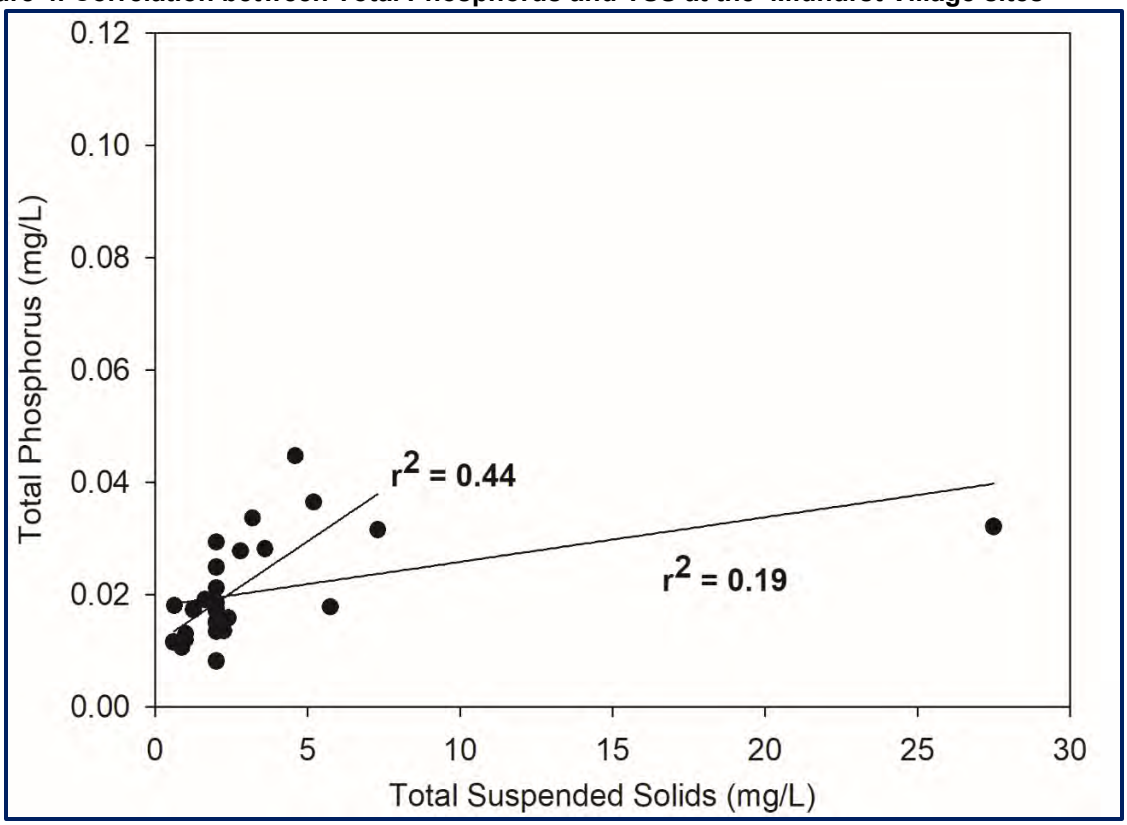
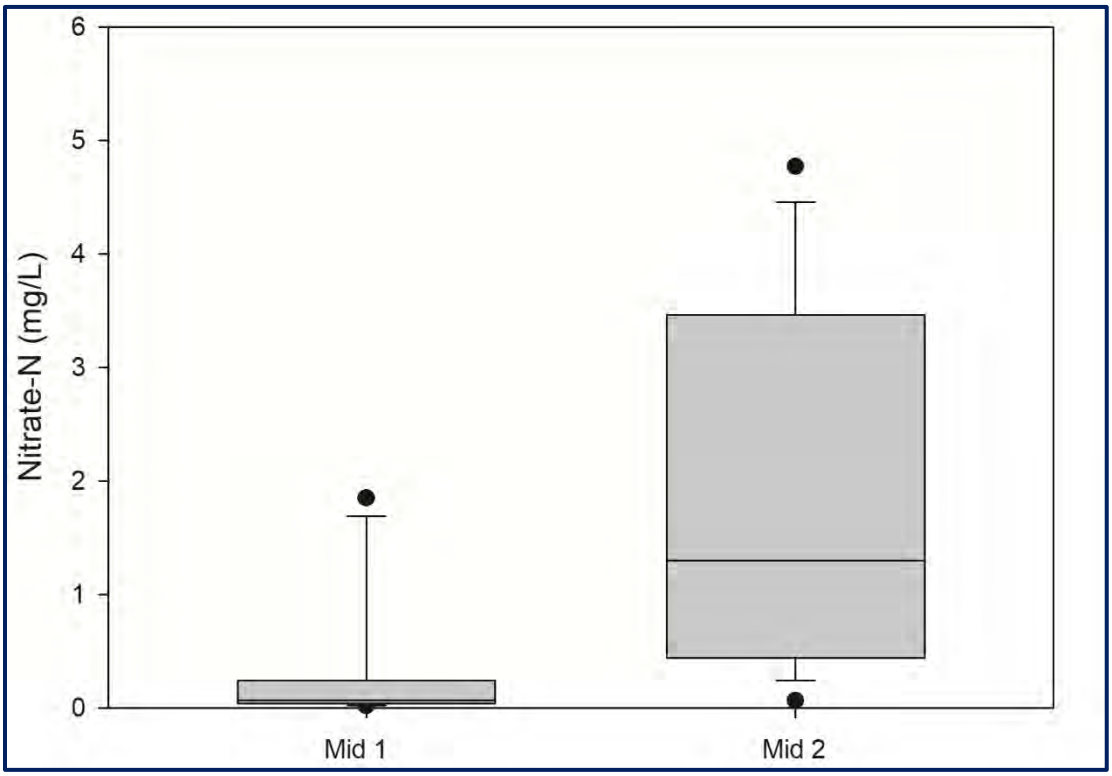


Figure 5. Nitrate Concentrations at the Midhurst Village stations



Field temperature measurements showed average water temperatures of 18.3 and 15.6 °C at Mid 1 and Mid 2, respectively. Continuous temperature profiles indicated Willow Creek was a cold-water stream at Mid 2 with temperatures consistently below 20 °C, however temperatures at Mid 1 were significant higher with greater diurnal variation. Site Mid 2 is located in a heavily forested area near the Hunter Russell Nature Trail and is therefore significantly more sheltered than Mid 1. Increased average conductivity and nitrate concentrations at Mid 2 also indicate groundwater inputs

Dissolved oxygen concentrations were consistently above the temperature-dependent Provincial Water Quality Objectives (PWQO) MOE 1994) of 5-8 mg/L for cold water aquatic life, with the exception of four measurements, two of which were during March sampling and are therefore not indicative of typical open water flow conditions (Figure 10). Both of the other occurrences below PWQO guideline were at Mid 1 near the Little Lake Wetland in 2015 during periods of low flow.

Figure 6. Specific Conductivity Concentrations at the Midhurst Village stations

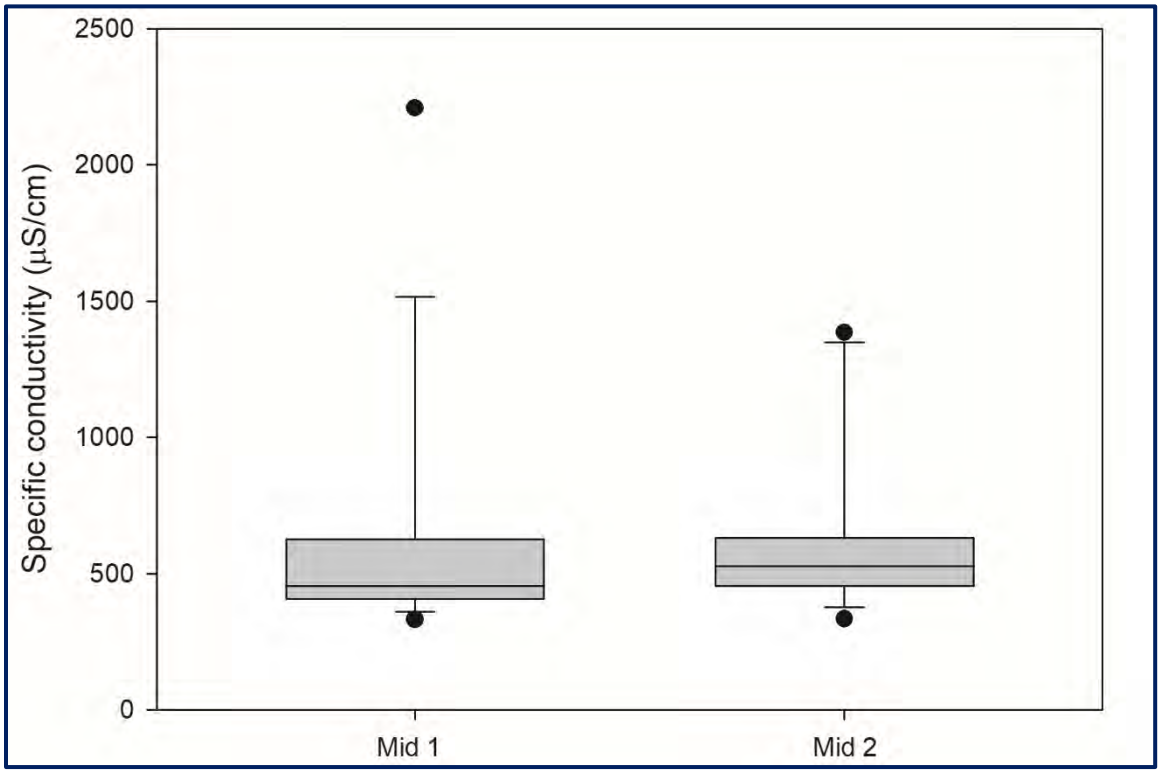
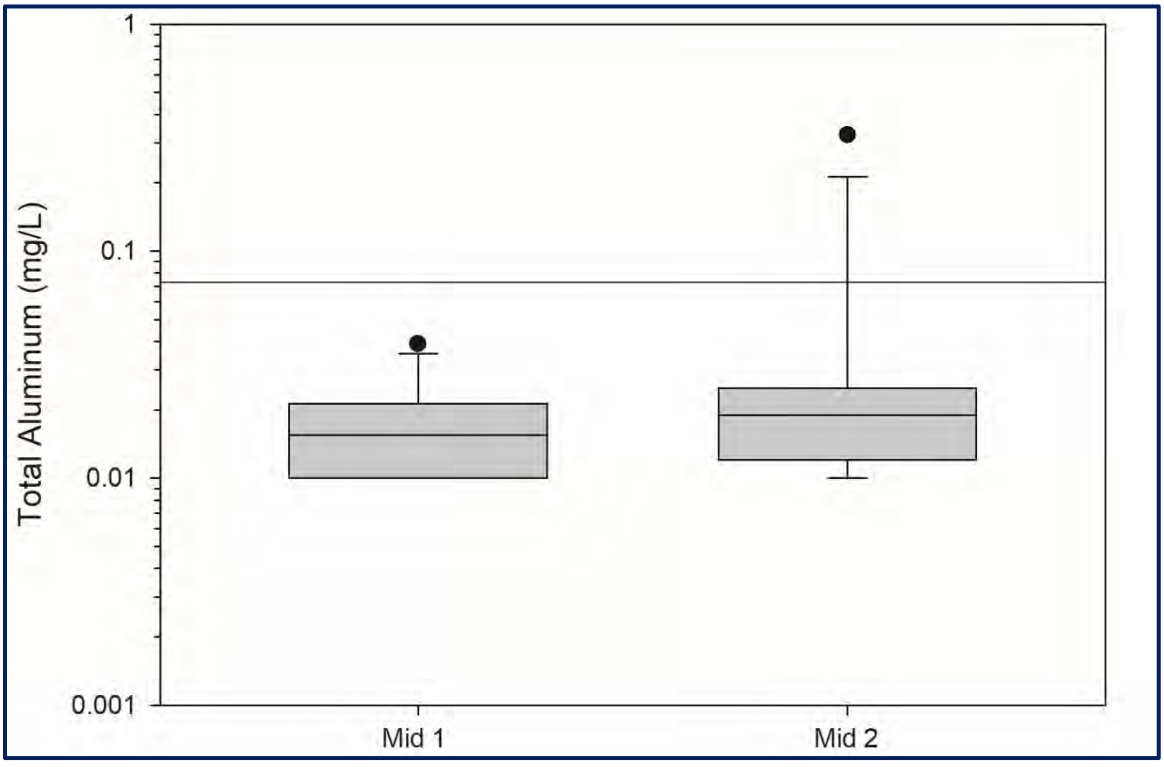


Figure 7. Aluminum concentrations recorded at the Midhurst Village stations



Horizontal line indicates PWQO Guideline of 0.075 mg/L

Figure 8. Correlation between Total Iron and Aluminum and TSS at the Midhurst Village stations

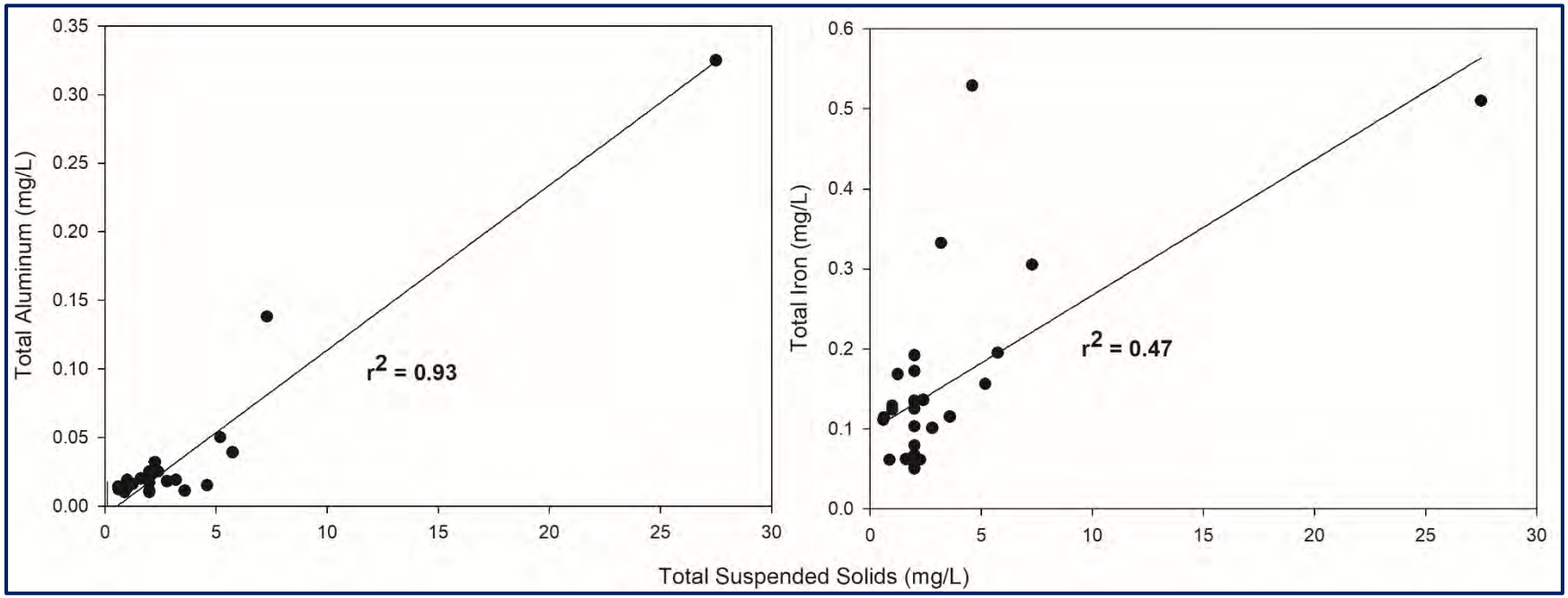


Figure 9. Continuous 2015 and 2016 Temperature Records at the Midhurst Village sites.

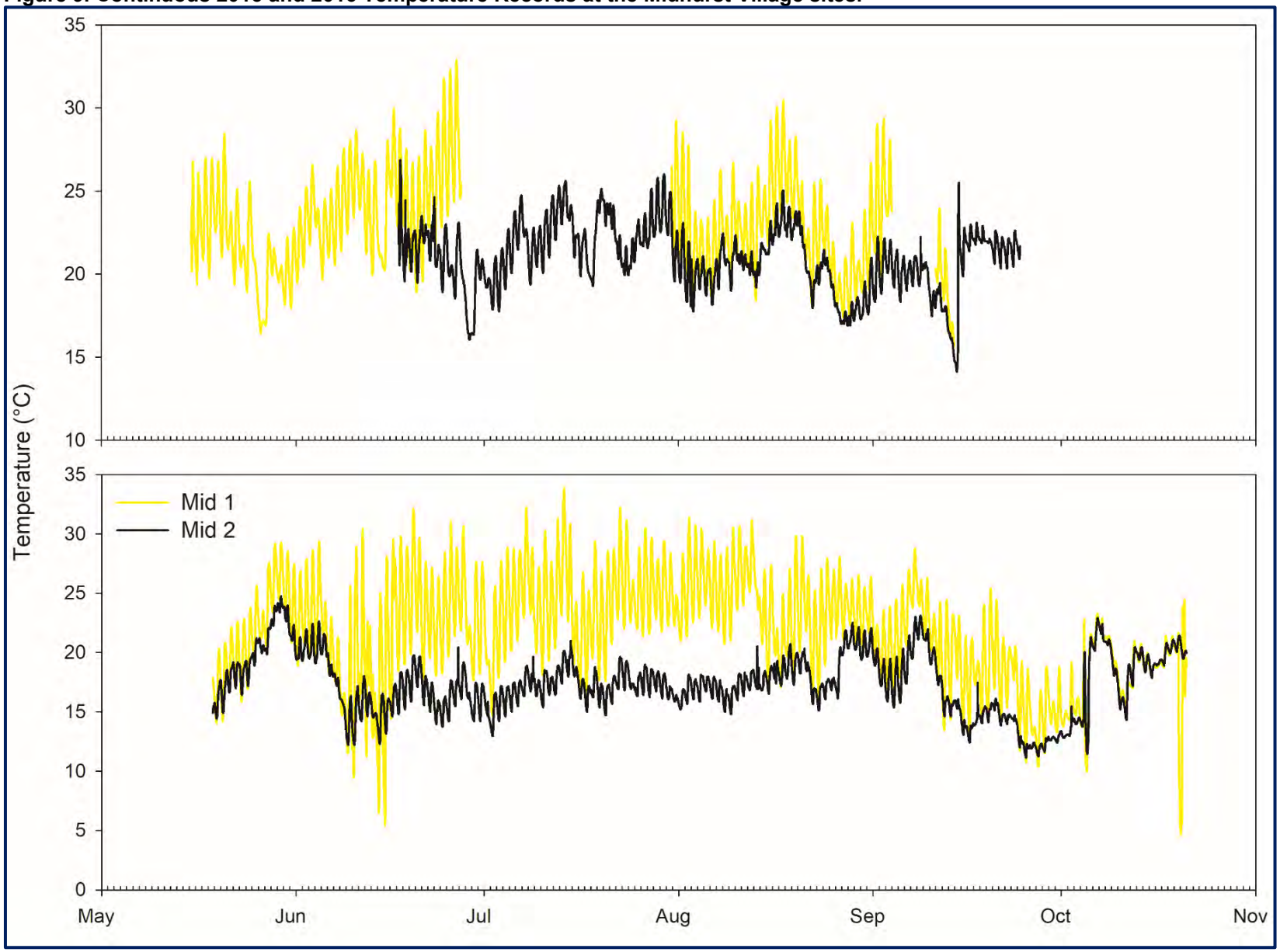
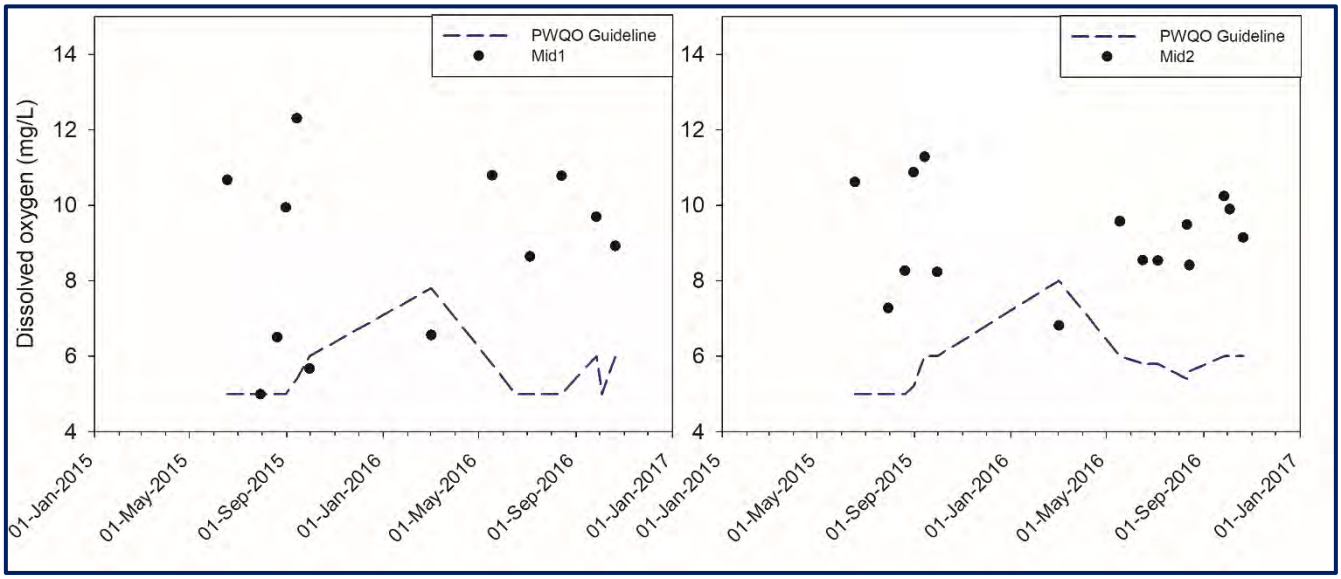


Figure 10. Dissolved oxygen concentrations recorded at the Midhurst Village stations



Dashed line indicates PWQO Guideline of 5-8 mg/L

4.2 Hydrology and Receiver Flow

The hydrology program at the Midhurst Village stations on Willow Creek was focussed on characterizing flow and describing the available volumes for assimilation of stormwater flows.

Median flows, based on pro-rated calculations of WSC HYDAT data recorded from 2006-2015, peaked at ~6500 L/sec during spring freshet and declined to 50-100 L/sec for extended periods during the summer months (Figure 11).

Flows were also measured at both sample sites as part of the field program in 2015 and 2016, including both high and low flow conditions to further characterize the hydrology of the tributary and validate the estimated flows (Table 3). Flows were typically lower at Mid 1 than Mid 2 (Figure 12).

Field measured low flows at Mid 2 were typically between 50-100 L/sec in 2016, consistent with what was predicted in the WSC HYDAT estimations. Likewise, WSC HYDAT pro-rated flow estimates during high flow events were reasonably consistent with the measured flows collected in the field throughout the year (Figure 11). Additional flow data collected as part of the adaptive monitoring program will further inform the variability of flows within Willow Creek at the Midhurst Village.

Table 3. Summary of field flow measurements at the Midhurst Village Stations in L/sec.

	Mid 1	Mid 2
17-06-2015	981	949
30-07-2015	137	204
20-08-2015	602	895
31-08-2015	180	269
14-09-2015	2295	435
30-09-2015	188	297
03-03-2016	-	-
18-05-2016	1281	1323
16-06-2016	19	139
05-07-2016	No Flow	82
11-08-2016	No Flow	45
14-08-2016	36	109
03-10-2016	68	109
21-10-2016	85	194

Dashes indicate flows were not collected

Figure 11. Comparison of estimated flows in Willow Creek with 2015-2016 field measurements at Mid 2.

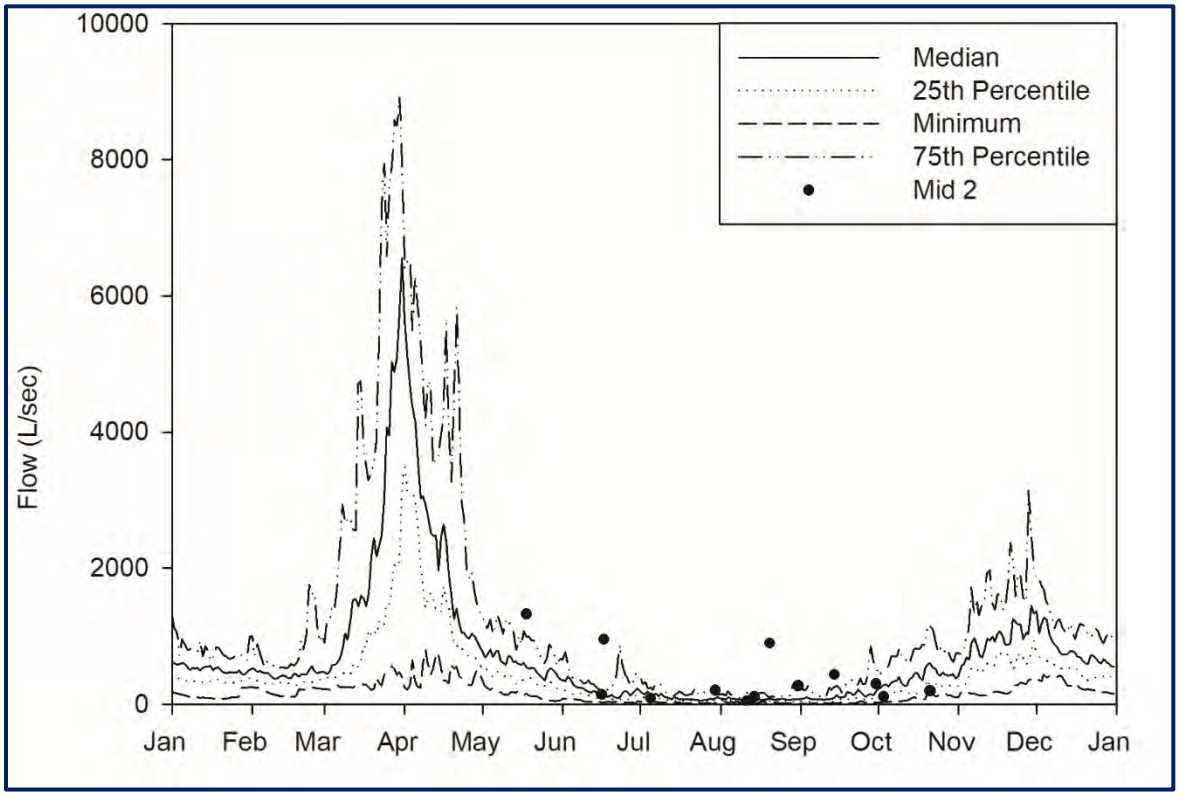
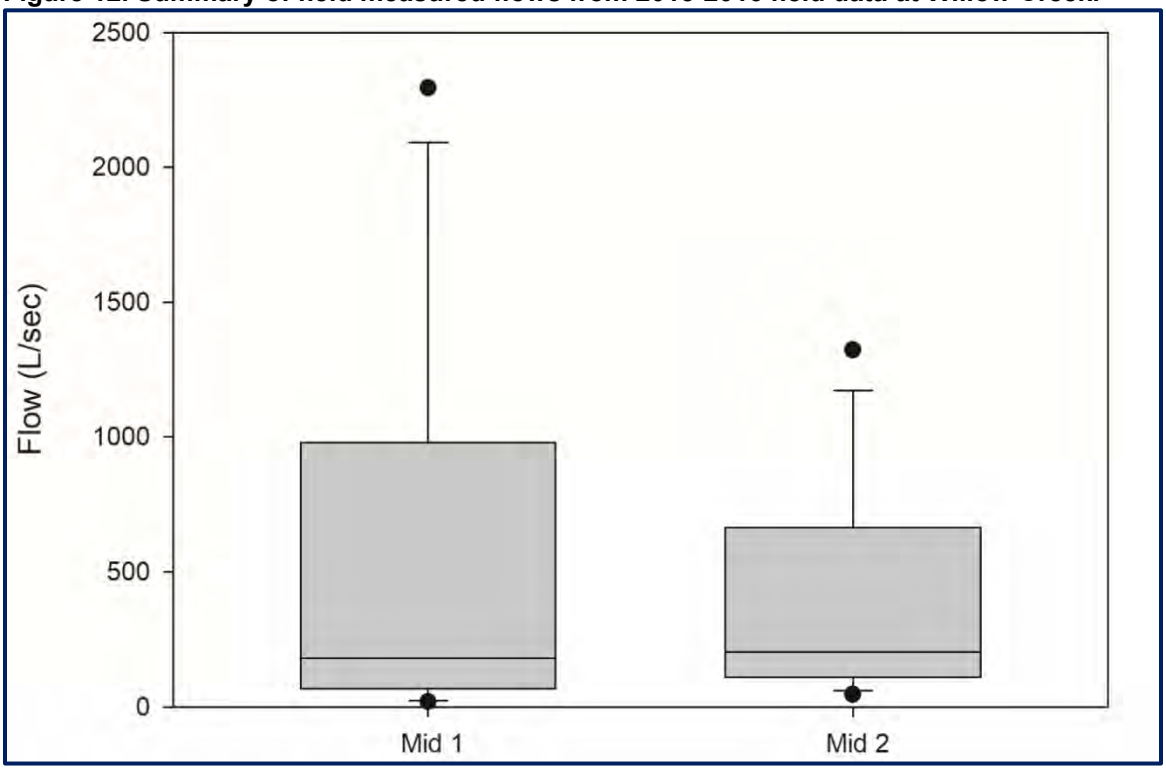


Figure 12. Summary of field measured flows from 2015-2016 field data at Willow Creek.



4.3 Aquatic Biota

Benthic invertebrates are a collection of aquatic organisms that are comprised of immature insect stages, worms, snails and clams which inhabit the substrate in streams. Benthic invertebrate community sampling is frequently used for assessing environmental stresses on aquatic environments imposed by environmental stressors by degraded water quality or habitat. Benthic invertebrate communities integrate long-term changes in their environment including temperature, nutrients, contaminants, suspended solids, habitat type and food availability, and may also respond to short-term events which cannot always be captured by traditional water quality sampling. Benthic invertebrate data was collected in 2015 to establish the baseline community structure within Willow Creek at the Midhurst Village study area, prior to any additional land use changes, for comparison with future surveys.

Benthic invertebrate community sampling was conducted at the same sites sampled for fish, water quality and flow. Station Mid 1 was located just east of Saint Vincent Street in a forested area (Figure 2). Mid 2 was downstream of Mid 1, just east of Finlay Mill Road. Stream habitat consisted of a low gradient riffle and run morphology with fine sand, gravel and cobble substrates at both sites (Table 4). Mid 1 contained a significant organic sediment component and macrophyte cover, however no aquatic vegetation was noted at Mid 2.

Table 4. Summary of stream habitat conditions at the Midhurst Village.

Reach	Approx. Water Depth (m)	Morphology	Substrate Description
Mid 1	0.7	low gradient riffle & run	cobble, gravel and sand, organic substrates up to 10 cm, Pondweed, water celery and duckweed, sparse woody debris
Mid 2	0.5	low gradient riffle & run	cobble, gravel and sand, no aquatic vegetation, sparse woody debris

4.3.1 Species Richness and Simpson's Diversity

Species richness is a measure of the total number of different species identified at a sampling station. A total of 31 unique species were collected in 2015 within the study area. Species richness at Mid 1 was the lowest of the two stations (15 species), while 20 species were identified at Mid 2 downstream. Simpson's Diversity is a measure used to quantify habitat biodiversity which takes into account not only the number of species present but also the relative abundance of each of those species. Here, Simpson's Index of Diversity has been expressed as (1-D) meaning that the values of the index range between 0 and 1 where higher values represent high sample diversity. Diversity at Mid 1 was significantly higher than at Mid 2 (Table 5). Mid 1 is located just downstream of the Little Lake wetland, with less forest cover relative to Mid 2 upstream at Finlay Mills Road. As a result, we recorded lower and less variable water temperature at Mid 2 which may account for the higher benthic invertebrate richness despite similar water quality recorded at both sites.

Table 5. Summary of Willow Creek benthic community metric results in 2015 at the Midhurst Village.

	Mid 1	Mid 2
Total Number of Organisms	303	171
Diversity/Species Richness	15	20
HBI Index	7.68	4.95
HBI Index WQ Comment	very poor	good
Simpson's Diversity (1-D)	0.32	0.83
% Chironomidae	12	35
% Amphipoda	66	0
% EPT	0	0
% Coleoptera	0	63
% Isopoda	19	0
% Other Diptera	0	0
% Other	3	2

4.3.2 Relative Abundance

Major taxonomic groups present in the 2015 surveys included: *Coleoptera* (beetles), *Chironomidae* (non-biting midges), *Amphipoda* (sow bugs), "Other" which includes (*Melagoptera* (alderflies), *Oligochaeta* (aquatic worms), *Simulidae* (black flies), *Gastropoda* (snails), *Hemiptera* (true bugs) and *Odonata* (dragonflies and damselflies; Figure 13).

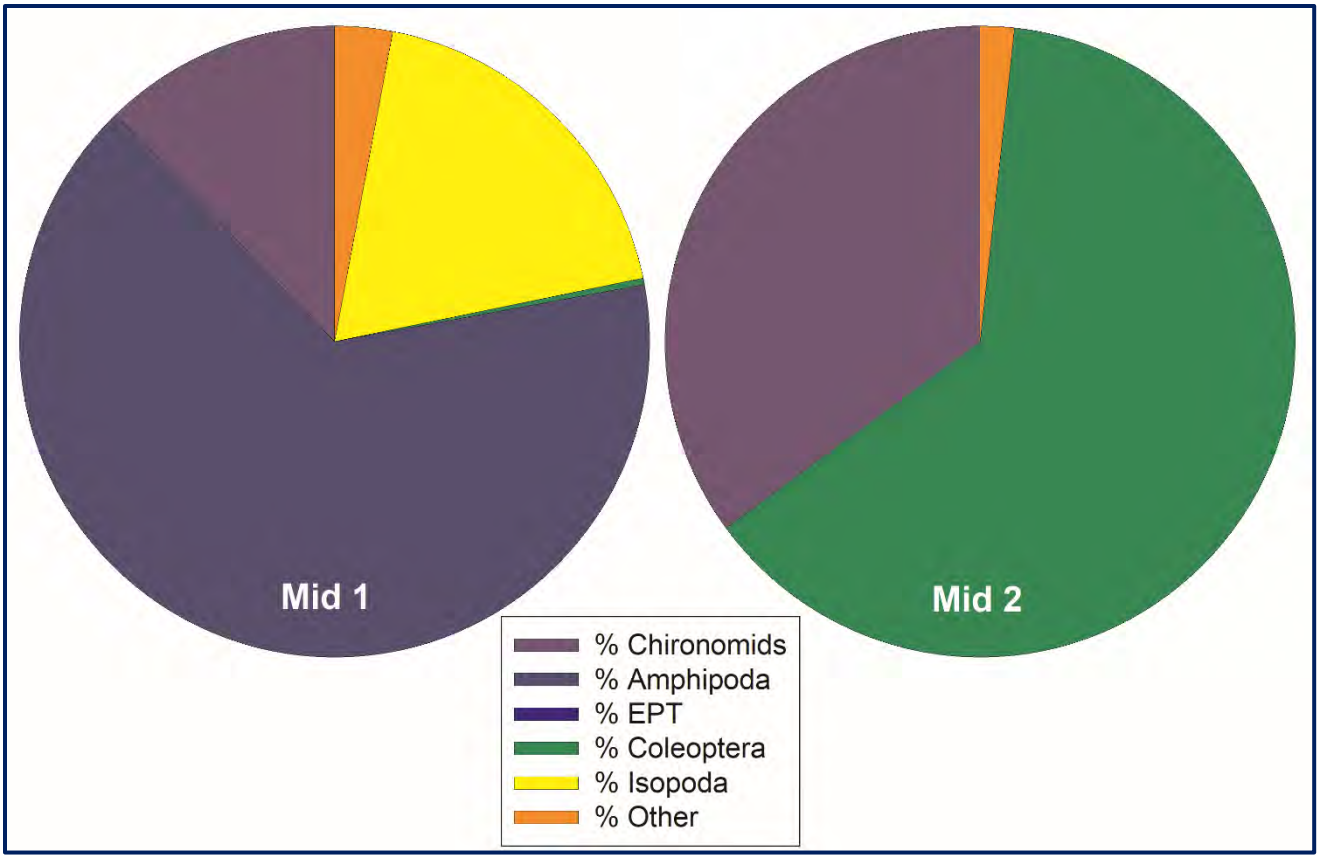
Amphipoda (sow bugs) taxa were the dominant group present at Mid 1 accounting for two thirds of the total benthic invertebrate community. By contrast, at Mid 2, two thirds of the benthic community was comprised of *Coleoptera* taxa. Chironomids and Isopoda taxa made up the majority of the remainder of the benthic communities at the Midhurst Village stations. Sensitive EPT (*Ephemeroptera*, *Plecoptera* and *Trichoptera*) species were not present at either station.

4.3.3 Hilsenhoff Biotic Index

The Hilsenhoff Biotic Index (HBI) provides an estimate of organic pollution based on published pollution tolerance values for individual benthic invertebrate species (Hilsenhoff, 1987). The HBI is an average of the tolerance values of the individual species which range from 0 to 10, with 0 being intolerant and 10 being very tolerant of organic pollution, thus a lower HBI suggests better water quality.

HBI values in 2015 varied significantly between the two Midhurst Village stations (Table 5). At Mid 1 the dominance of pollution tolerant Amphipoda taxa (66% relative abundance, pollution tolerance 8/10) and lack of environmentally sensitive EPT species resulted in a "very poor" water quality rating. By contrast, at Mid 2, the benthic community was dominated by more sensitive Coleoptera taxa (63%, pollution tolerance 4-6/10) resulting in a water quality rating of "Good".

Figure 13. Benthic community relative abundance at the Willow Creek study area in the Midhurst Village in 2015



4.4 Fish Community and Habitat

In both 2015 and 2016 surveys, a diverse community of fish was captured. Fish species identified included Brown Trout (*Salmo trutta*), Rainbow Trout (*Oncorhynchus mykiss*), Creek Chub (*Semotilus atromaculatus*), Pumpkinseed (Lepomis gibbosus), Johnny Darter (*Etheostoma nigrum*), Largemouth Bass (*Micropterus salmoides*), Logperch, Longnose Dace (*Rhinichthys cataractae*), Northern Brook Lamprey (*Ichthyomyzon fossor*), Northern Pike (*Esox Lucius*), Rock Bass (*Ambloplites rupestris*), Spotted Shiner (*Notropis hudsonius*), Slimy Sculpin (*Cottus cognatus*), and White Sucker (*Catostomus commersonii*) (Table 6).

Fish communities were much more diverse at Mid 2, likely owing to the sheltered catchment and more moderate water temperatures. The dominant presence of slimy sculpin and longnose dace at Mid 2 suggests that habitat and conditions are appropriate for cool water species, by contrast largemouth bass dominated the upstream reach of Willow Creek near Little Lake where water temperatures were much higher and fish diversity was much lower.

Table 6. Fisheries assessment results on Willow Creek in the Midhurst Village.

Date	Species	Mid 1	Mid 2	Total
30-Sep-15	Brown Trout	-	1	1
	Rainbow Trout	-	2	2
	Johnny Darter	-	10	10
	Largemouth Bass	11	-	11
	Log Perch	2	-	2
	Longnose Dace	-	7	7
	Slimy Sculpin	-	6	6
	Northern Brook Lamprey	-	1	1
	Northern Pike	1	-	1
	Rock Bass	1	-	1
	Spotted Shiner	-	1	1
	White Sucker	1	-	1
03-Oct-16	Brown Trout	-	3	3
	Johnny Darter	3	-	3
	Longnose Dace	-	17	17
	Slimy Sculpin	-	24	24
	Creek Chub	-	11	11
	White Sucker	-	2	2
	Pumpkinseed	-	1	1

5. Summary and Conclusions

Monitoring performed on the reach of Willow Creek adjacent to and within the Midhurst Village was undertaken to establish baseline conditions and to aid in our ability to assess any future changes resulting from the discharge from three stormwater management ponds included in the upstream Doran Road Development.

Average total phosphorus concentrations were below the Provincial Water Quality Objective at both stations while nitrate levels were significantly elevated at Mid 2, relative to Mid 1 where concentrations regularly exceeded the CCME Guideline for Protection of Aquatic Life (3 mg/L as nitrate-N; CCME, 2012). Calculated unionized ammonia concentrations were below PWQO guideline in all samples tested (0.020 mg/L). Total metals concentrations observed above PWQO levels were associated with high suspended solids and are therefore likely biologically unavailable and indicative of short-term events.

Temperature profiles indicated Willow Creek was a cold-water stream at Mid 2, however temperatures at Mid 1 were significant higher with greater diurnal variation. Dissolved oxygen concentrations were consistently above the temperature-dependent Provincial Water Quality Objectives (PWQO) MOE 1994) of 5-8 mg/L for cold water aquatic life.

HBI indices of water quality varied significantly between the two Midhurst Village stations, between “very poor” (Mid 1) and “Good” (Mid 2) owing to the high abundance of pollution tolerant *Amphipoda* species at Mid 1. Environmentally sensitive EPT species were not detected at either station.

Fish sampling captured a diverse community within the Midhurst Village relative to other baseline monitoring at the Doran Road Development including several game fish (brown and rainbow trout and largemouth bass). Fish communities varied considerably between the two stations sampled, likely owing to much cooler water temperatures downstream at Mid 2, where sheltered conditions and habitat supported a diverse community of cool water fish species.

Monitoring was continued in 2017 and this report will be updated accordingly.

6. References

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Appendix E

Midhurst Hydrogeological Study, Midhurst Water Supply Exploration Program – Golder Associates Ltd., May 2018

&

Report on Carson and Doran Neighbourhoods Proposed Water Supply Groundwater Modelling – Golder Associates Ltd., May 2018

Report on Carson and Doran Neighbourhoods Water Supply – Midhurst Secondary Plan: Supplementary Hydrologic Modelling – Golder Associates Ltd., January 2017

May 2018

HYDROGEOLOGICAL STUDY

Midhurst Water Supply Exploration Program, Township of Springwater, Ontario

Submitted to:
The Township of Springwater c/o Ainley & Associates
2231 Nursery Road
Minesing ON L0L 1Y2

REPORT

Report Number: 13-1170-0040

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1 Copy - Golder Associates Ltd.

Golder Associates

[DHP 00480240]

Executive Summary

The Midhurst Landowner's Group retained Golder Associates Ltd. (Golder) to conduct a water supply exploration program and well development program as part of Phases 3 and 4 of the Municipal Class Environmental Assessment for the Midhurst Secondary Plan area. Phases 1 and 2 of the Class Environmental Assessment identified Aquifers A3 and A4 as the preferred alternative for water supply development. Aquifer A3 is a regionally extensive aquifer and is the source of water for the municipally serviced areas of existing Midhurst and Snow Valley, among others. The A3 Aquifer was the target for the exploration program.

Field work was conducted between December 2013 and October 2014. Well drilling was completed at ten sites, and included the installation of four 203 mm nominal test wells. The test wells were constructed with 203 mm diameter steel casing with stainless steel screens and were pumped with submersible pumping equipment. These wells were designed and constructed to exceed the standards in Ontario Regulation 903. Each well was developed to yield clear, sand-free water. The test wells generally underwent stepped rate pumping tests, constant rate pumping tests, suspended sediment tests, and comprehensive water quality tests. The monitoring wells were completed using a PVC casing, and airlifted following installation. Water quality sampling was conducted at all observation well locations.

Numerical groundwater modelling was completed to assist in the evaluation of the sustainability of, and potential groundwater impacts from, the long-term operation of water supply wells at the test well locations. The modelling was undertaken using an updated version of the existing three-dimensional (3D) Kempenfelt Bay FEFLOW numerical model. The model was calibrated and then used to assess potential drawdown, well interference, and baseflow losses as a result of the additional pumping at the water supply wells.

Test well TW22 was constructed at Site 1 (Snow Valley Road). A 72-hour pumping test was conducted at a rate of 36.5 L/s. The drawdown at the end of the pumping test was 23.03 m and the available drawdown is 69 m. Observation well monitoring in the vicinity indicated a weak connection between the deep pumping zone and shallower aquifers. Water quality samples collected at both 1 hour and 36 hours from the pumping well met the ODWS for all parameters tested. Interpolation of the drawdown versus time data indicated that at 20 years of well operation at 36.5 L/sec the drawdown is predicted to be 27.6 m or 40% of the available drawdown.

Test Well TW21 was constructed at Site 3 (Old Second Road South). A 72-hour pumping test was conducted at a rate of 27.8 L/s, and the drawdown at the end of the pumping test was 45.23 m. Shallow observation well monitoring in the vicinity did not show any response to pumping. Water quality samples collected after 24 and 72 hours from the pumping well met the ODWS for all parameters tested, with the exception of colour. Interpolation of the drawdown versus time data for TW21 indicated that after 20 years of well operation at 20 L/sec the drawdown was predicted to be 36 m or 59% of the available drawdown.

Test well TW34 was constructed at Site 7 (Snow Valley West). A 72-hour pumping test was conducted at a rate of 20 L/s, and the drawdown at the end of the pumping test was 15.46 m. Water level monitoring in the vicinity showed no response to the pumping in private wells or observation wells constructed in shallower aquifers. Water quality samples collected after 24 hour and 71 hours from the pumping well met the ODWS for all parameters tested, with the exception of iron, methane, and manganese. The water had a slight sulphurous odour and an

acceptable taste. Interpolation of the drawdown versus time data for TW34 indicated that after 20 years of well operation at 20 L/sec the drawdown is predicted to be 16.7 m or 13% of the available drawdown.

Test well PW1 was constructed at Site 10. Both a 72-hour and 48-hour pumping test were conducted at a rate of 45 L/s, with drawdown at the end of the 72-hour pumping test of 19.45 m. Observation well monitoring in the vicinity in the shallow aquifer showed no response to the pumping. Interpolation of the drawdown versus time data for PW1 indicated that after 20 years of well operation at 45 L/sec the drawdown is predicted to be 24 m or 40% of the available drawdown.

Wells installed as part of the water supply exploration program conducted in the Midhurst area have a sum capacity of 129.3 L/sec. Wells have been tested in the Doran Road area that had a water production rate of 72.8 L/sec. Both well sites in this area can support twinned wells and a potential of production rate of 140 L/sec. Wells have been tested in the Carson Road area that had a water production rate of 56.5 L/sec. Well sites in this area can support twinned wells, and a potential production rate of 81 L/s. Based on the potential for twinning, 221 L/sec is available from groundwater resources in the area. Numerical groundwater modelling indicates that a future water taking of 221 L/sec is sustainable from the Regional A3/A4 Aquifer in the area. The additional pumping is not expected to adversely affect the performance of the existing Midhurst, Barrie, or Snow Valley water supply systems.

The firm capacity of the water supply system can be addressed by the construction of additional alternative supply wells at each of the test well sites. The presence of suitable aquifer materials at each site is sufficiently predictable to allow for the planning of additional lands to be set aside for the construction of additional wells. It is expected that any two of the wells would be operated simultaneously, resulting in drawdown among the wells similar to that demonstrated during the various pumping tests.

The hydrogeological assessment has addressed source water protection through the development of well capture zones (eventual wellhead protection areas) paired with existing aquifer vulnerability mapping. The assessment indicates that the water supply system has a low vulnerability to surficial contaminants and causes minimal interference to surrounding municipal wells. The modelling analysis conducted in this study provides the foundation for meeting the Technical Rules: Assessment Report requirements as governed by the Clean Water Act, 2006. An Assessment Report will ultimately be prepared by the South Georgian Bay Lake Simcoe source protection committee.

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1.0 INTRODUCTION

The Midhurst Landowner's Group retained Golder Associates Ltd. (Golder) to conduct a water supply exploration program and well development program as part of Phases 3 and 4 of the Municipal Class Environmental Assessment for the Midhurst Secondary Plan area. Phases 1 and 2 of the Class Environmental Assessment identified Aquifers A3 and A4 as the preferred alternative for water supply development.

1.1 Scope of Work

The objective of the work was to evaluate the potential sources of potable water supply for residential land development applications in Midhurst. The scope of work included:

- Identify locations for test drilling;
- Conduct service locates for buried utilities;
- Conduct preliminary contaminant source identification;
- Investigate sites with pilot hole drilling, logging and sampling;
- Conduct grain size analyses and determine the potential for pilot hole locations for well construction;
- Conduct water quality monitoring at observation wells;
- Construct municipal grade test wells;
- Conduct stepped rate and constant rate pumping tests;
- Conduct water quality assessments at production well locations;
- Prepare a hydrogeological assessment of the groundwater resources of the area;
- Prepare a water budget for the proposed development lands; and,
- Undertake a numerical groundwater modelling analysis to assess potential impacts of the proposed water supply pumping on the groundwater system.

2.0 ASSESSMENT PROCEDURE

2.1 Site Selection Procedure

Field work was conducted between December 2013 and October 2014. Well drilling was completed at ten sites, namely: Site 1: Snow Valley Road (Gravel Pit); Site 2: Pooles Road; Site 3: Old Second Road; Site 4: Doran Road; Site 5: Anne Street; Site 6: Hickling Farm; Site 7: Snow Valley Road (West); Site 8: Walt Road; Site 9: Old Second (Coutts); and Site 10: Russell Road (Alliance). The wells were drilled on lands owned by the proponents, The Midhurst Landowner's Group. The locations of the observation wells and test wells constructed as part of the water supply exploration are shown on Figures A-1 to A-6.

Well drilling was done to evaluate the presence and characteristics of the two main municipal water supply aquifers in Simcoe County, Regional Aquifers A3 and A4 (Golder, 2004). It was anticipated that Aquifer A3 would be present throughout the area; however, it was also recognized that flowing artesian conditions may exist in the

low-lying valley areas. When selecting well drilling locations, Golder took this into consideration in order to avoid flowing conditions. Well drilling into Aquifer A3 at ground surface elevations of below approximately 230 metres above sea level (masl) in the Doran Road area and below 225 masl in the Carson Road area were avoided. However, even with these precautions, one flowing well was intersected.

2.2 Observation Well and Test Well Construction

Observation wells and test wells were constructed at the ten locations for the groundwater supply exploration program between January 2014 and April 2014 (Figure A-1 to A-6). Observation wells, defined as 50 mm in diameter, were drilled by Allan Wright Water Wells Inc. using a mud rotary rig. The wells were installed at all sites and screened within select intervals of Aquifers A1, A2, A3 and A4 (provided these units were encountered during drilling). Each observation well location was developed using air lift pumping to remove the drilling fluids from the well bore and aquifer surrounding the well screen. Water quality was collected from the screened intervals to document the water quality of the aquifer units. The as-built driller logs are contained in Appendices B to K.

Test wells, defined as being constructed with 203 mm diameter steel casing with stainless steel screens, are intended to be pumped with submersible pumping equipment. These wells were designed and constructed to exceed the standards in Ontario Regulation 903 as they will remain as municipal water supply wells for the Midhurst Development when required. Grain size analysis was completed on the Aquifer A3 materials at most locations in order to determine the most favourable locations for setting well screens and to determine the gradation for the filter pack and screen slot size (Appendices B to K). The test wells were only installed at pilot holes where the potential for water supply was promising. Each well was developed to yield clear, sand-free water. The test wells underwent stepped rate pumping tests, constant rate pumping tests, suspended sediment tests, and comprehensive water quality tests.

2.2.1 Site 1: Snow Valley Road (Gravel Pit)

A total of seven wells were installed at the Snow Valley Road Site (Gravel Pit) (Figure A-2), namely: OW19#6 (i.e. TW19), TW22, OW19#1, OW19#2, OW19#3, OW19#4 and OW19#5. The borehole (TW19) was completed to a depth of 100 metres below ground level (mbgl) on January 13 and 14, 2014. The borehole intersected Aquifers A1, A2, A3 and A4 as shown on Figure A-7. The target Aquifer A4 was encountered between 81 to 95 mbgl at TW19/14. A 50 mm 10-slot well screen was placed from 93.9 mbgl to 96.9 mbgl in Aquifer A4 (Figure B-1), and the well was re-designated as OW19#6 (from TW19).

A second borehole (TW22) was drilled on February 4, 2014 to a depth of 95.4 mbgl. The borehole intersected Aquifers A1, A2, A3 and A4 as shown on Figure A-7. The target Aquifer A4 was encountered between 75 mbgl to 95 mbgl. A 203 mm diameter well with 9.1 m of nominal 203 mm diameter, 50-slot well screen was placed in Aquifer A4 from 81.1 m to 89.9 m with a sand pack from 72 m to 90 m (Figure B-2).

Five additional observation wells were installed in Aquifers A1, A2 and A3. OW19#1 was drilled on March 7, 2014 to a depth of 16.1 mbgl. A 50 mm diameter, 10-slot screen was placed in Aquifer A2 between 13.1 mbgl and 16.1 mbgl (Figure B-1). OW19#2 was drilled on March 7, 2014 to a depth of 23.4 mbgl. A 50 mm 10-slot screen was placed in Aquifer A3 between 20.4 mbgl and 23.4 mbgl (Figure B-1). OW19#3 was drilled on February 28, 2014 to a depth of 35.3 mbgl. A 150 mm 16-slot screen was placed in Aquifer A3 between 34.1 mbgl and 35.3 mbgl (Figure B-1). OW19#4 and OW19/14-#5 were drilled on April 11, 2014 to a depth of 64.0 mbgl and 73.2 mbgl, respectively. A 50 mm 10-slot screen was placed in Aquifer A3 between 61.0 and 64.0 mbgl at OW19#4 and between 70.1 mbgl and 73.2 mbgl at OW19#5 (Figure B-1).

2.2.2 Site 2: Pooles Road

Three boreholes were drilled at the Pooles Road Site (Figure A-3), namely: TW20, TW25 (i.e. TH25) and TW28 (i.e., OW28), all of which are located along Pooles Road near the Russell Road intersection. The first borehole (TW20) was completed to a depth of 152 mbgl on January 15 and 16, 2014, and intersected Aquifers A1, A2, A3, and A4 as shown in Figure A-8. Aquifer A4 was encountered between 137 mbgl to 148 mbgl and Aquifer A3 was encountered between 126 mbgl to 133 mbgl. A 150 mm well with 1.5 m of 12-slot well screen was placed in Aquifer A3 between 60.4 m and 61.9 m (Figure C-1). The grain size analysis for TW20 can be found on Figure C-3 which indicates a medium sand aquifer with screen slot sizes ranging from 18 to 20 for the Aquifer A3 portion of this test hole.

A second borehole (TW25) was drilled on February 19 and 20, 2014 to a depth of 131.4 mbgl. The borehole intersected Aquifers A1, A2, and A3 as shown on Figure A-8. Aquifer A3 at this location was finer grained than at TW20 and the borehole (re-designated TH25) was abandoned according to Ontario Regulation 903 (Figure C-2).

A third borehole (TW28) was drilled on March 26 and 27, 2014 to a depth of 133 mbgl. The borehole intersected Aquifers A1, A2, and A3 as shown on Figure A-8. Aquifer A3 was encountered at 108 mbgl to 133 mbgl. A 50 mm well with 10-slot screen was placed in Aquifer A3 between 129.3 mbgl and 132.3 mbgl (Figure C-1), and the borehole was re-designated OW28.

Observation well OW3 is located near TW20 and was constructed under a separate investigation by Golder (2008). OW3 is constructed on Pooles Road to a depth of 66.2 mbgl approximately 30 m northeast of TW20. A 50 mm well screen was placed in Aquifer A1 between 34.4 mbgl and 41.2 mbgl as well as a 50 mm well screen in Aquifer A2 between 59.5 mbgl and 66.2 mbgl (Figure C-1).

2.2.3 Site 3: Old Second Road

Two boreholes, TW21 and TW24, were drilled at the Old Second Road Site (Figure A-3). The first borehole (TW21) was completed to a depth of 151 mbgl on January 20, 2014. The borehole intersected Aquifers A1, A2 and A3 as shown in Figure A-8. The target Aquifer A3 was encountered between 112 mbgl to 131 mbgl. A 203 mm diameter well with 12.1 m of nominal 203 mm diameter, 12-slot screen and 3.1 m of 6-slot screen was placed between 113.0 m and 128.2 m with a sand pack between 103.0 m and 128.2 m (Figure D-1).

A second borehole (TW24) was drilled on February 18 and 19, 2014 to a depth of 134 mbgl. The borehole intersected Aquifers A1, A2 and A3 as shown on Figure A-8. The target Aquifer A3 was encountered at 107 mbgl to 132 mbgl. A 50 mm well screen was place in Aquifer A3 from 125.0 to 131.1 mbgl (Figure D-2), and the well was designated as OW24.

An existing observation well (OW1) located near TW21 was constructed under a separate investigation (Golder, 2008). TW1/08 is constructed on Old Second Road South to a depth of 91 mbgl approximately 300 m northeast of TW21. A 50 mm well screen was placed in Aquifer A1 between 16 mbgl and 19 mbgl as well as a 50 mm well screen in Aquifer A2 between 73 mbgl and 82 mbgl (Figure D-2).

2.2.4 Site 4: Doran Road

One borehole was drilled at the Doran Road Site (Figure A-4). The borehole (TW23) was completed to a depth of 137 mbgl on February 10 and 13, 2014. The borehole intersected Aquifers A1, A2 and A3 as shown on Figure A-8. The target Aquifer A3 was encountered between 125 mbgl to 140 mbgl. Aquifer A3 at this location was not

adequate for water supply and thus TW23 was re-designated as TH23 and abandoned in accordance with Ontario Regulation 903 (Figure E-1).

2.2.5 Site 5: Anne Street

One borehole was drilled at the Anne Street Site (Figure A-5). The borehole (TW26) was completed to a depth of 152 mbgl on March 18 through March 21, 2014. The pilot hole intersected Aquifers A1, A2, A3 and A4 as shown on Figure A-9. The target Aquifers A3 and A4 were not adequate for water supply and thus TW26 was re-designated as TH26, and abandoned in accordance with Ontario Regulation 903 (Figure F-1).

2.2.6 Site 6: Hickling Farm

One borehole was drilled at the Hickling Farm Site (Figure A-2). The borehole (TW27) was completed to a depth of 102 mbgl on March 26 through March 27, 2014. Due to rapidly warming temperatures and snow melt the drilling equipment had to be moved off the site and on June 2 to 5, 2014 a second TW27 borehole was completed to a depth of 140 mbgl. The borehole intersected Aquifers A1, A2, A3 and A4 as shown on Figure A-9. Aquifers A3 and A4 were encountered but were not adequate for water supply and thus TW27 was re-designated as TH27 and abandoned in accordance with Ontario Regulation 903 (Figure G-1).

2.2.7 Site 7: Snow Valley Road (West)

A total of six boreholes were drilled at the Snow Valley Road Site (West) (Figure A-6). The first borehole TW29 (OW29#4) was completed to a depth of 106 mbgl on April 16, 2014. The borehole intersected Aquifers A1, A2, A3 and A4 as shown on Figure A-10. The target Aquifer A4 was encountered between 89 mbgl to 104 mbgl. A 50 mm observation well was placed in Aquifer A4 between 96.6 mbgl and 99.6 mbgl (Figure H-1), and designated as OW29#4. Additionally, a test well (TW34) was drilled on August 5 and August 6, 2014 to a depth of 104 mbgl, intersecting Aquifers A1, A2, A3 and A4 as shown on Figure A-10. The target Aquifer A4 was encountered at 90 mbgl to 105 mbgl. A 200 mm diameter well with 9 m of 50-slot well screen was placed in Aquifer A4 from 94 m to 103 m with a sand pack from 88 m to 103 m (Figure H-1).

A second borehole (TW33) was drilled on June 9, 2014 to a depth of 36.6 mbgl. The borehole intersected Aquifers A1 and A2 and reached the top of Aquifer A3 as shown on Figure A-10. The target Aquifer A3 was encountered at 36.6 mbgl but flowing conditions were encountered so drilling was stopped and the borehole (re-designated as TH33) was abandoned in accordance with Ontario Regulation 903 (Figure H-2).

Three additional observation wells were installed in Aquifers A1, A2 and A3. OW29#1 was drilled on September 6, 2014 to a depth of 4.3 mbgl. A 50 mm 10-slot screen was placed in Aquifer A1 between 2.7 mbgl and 4.3 mbgl (Figure H-1). OW29#2 was drilled on September 7, 2014 to a depth of 21.3 mbgl. A 50 mm 10-slot screen was placed in Aquifer A2 between 18.3 mbgl and 21.3 mbgl (Figure H-1). OW29 #3 was drilled on September 7, 2014 to a depth of 54.9 mbgl. A 50 mm 10-slot screen was placed in Aquifer A3 between 51.8 mbgl and 54.9 mbgl (Figure H-1).

2.2.8 Site 8: Walt Road

Two boreholes were drilled at the Walt Road Site (Figure A-3) during June 2 to 4, 2014 to a depth of 143.3 mbgl. Borehole TW30 intersected Aquifers A1, A2, A3 and A4 as shown on Figure A-11. The target Aquifer A4 was encountered at 137.2 to 143.3 mbgl. An observation well was placed in Aquifer A4. A 50 mm well screen was placed between 125.0 to 143.3 mbgl (Figure I-1) and designated as OW30. The grain size analysis for OW30 is provided on Figure I-3.

A second borehole (TW31) was drilled on June 6, 2014 to a depth of 122.0 mbgl. The borehole intersected Aquifers A1, A2, A3 and A4 as shown on Figure A-11. The target aquifer was encountered at 99.7 to 118.9 mbgl. The target aquifers encountered at TW31 were not as high yielding as those encountered at TW30 and henceTW31 was re-designated TH31 and abandoned according to the Ontario Regulation 903 (Figure I-2).

An existing observation well (OW4) is located near OW30 and was constructed under a separate investigation (Golder, 2008). TW4#1 and TW4#2 are constructed on Walt Road, approximately 240 m to the southwest of OW30, to a depth of 44.2 mbgl and 57.9 mbgl, respectively. A 50 mm screen is placed in Aquifer A1 between 41.2 and 44.2 mbgl (OW4#1) and a 50 mm is placed in Aquifer A2 between 51.8 to 57.9 mbgl (Figure I-2).

2.2.9 Site 9: Coutts

A borehole was drilled at the Coutts Site (Figure A-3) on June 9 to 10, 2014 to a depth of 138.7 mbgl. The borehole (TW32) intersected Aquifers A1, A2, A3 and A4 as shown on Figure A-8. The target Aquifer A4 was encountered between 112.8 mbgl to 134 mbgl. An observation well was planned to be placed in Aquifer A4 from 115.8 mbgl to 118.9 mbgl but the well casing was vandalized, resulting in the abandonment of TW32 (re-designated OW32) in accordance with Ontario Regulation 903 (Figure J-1). The grain size analysis for TW32 can be found on Figure J-2.

An existing observation well (OW2) is located near TW32 and was constructed under a separate investigation by Golder (2008). OW2#1 and OW2#2 are constructed on Pooles Road to a depth of 32.0 and 61.9 mbgl, respectively, approximately 110 m to the northeast of TW32. A 50 mm screen is placed in Aquifer A1 between 29.0 and 32.0 mbgl (OW2#1) and a 50 mm is placed in Aquifer A2 between 55.8 to 61.9 mbgl (Figure J-1).

2.2.10 Site 10: Alliance

A borehole was drilled at the Alliance Site (Figure A-4) on July 10 and 11, 2014 to a depth of 125.0 mbgl. The borehole (TW35) intersected Aquifers A1, A2, A3 and A4 as shown on Figure A-12. The target Aquifer A4 was encountered between 109.7 mbgl and 123.7 mbgl. A 50 mm observation well was placed in Aquifer A4 between 118.9 mbgl to 121.9 mbgl (Figure K-1), and designated as OW35.

An existing test well (PW1) is located near OW35 and was constructed under a separate investigation by Wilson Associates of Stratford on the proposed Alliance Development. A 254 mm diameter well was placed in Aquifer A3 with 10 and 12 slot screen between 110.3 and 125.6 mbgl (Figure K-2).

2.3 Water Quality Testing

Water quality samples were collected from select observation well locations (Table A-2). The samples were analyzed for general chemistry parameters. The water samples were collected in laboratory prepared bottles and couriered to either Caduceon Analytical Laboratories in Ottawa or Central Ontario Analytical Laboratory in Orillia for analysis. The water quality analysis results can be found in Appendix L.

Table A-2: Water Quality Sampling Locations

Site	Well	Unit	Date	Analysis
Snow Valley (Gravel Pit)	OW19#1 OW19#2 OW19#4 OW19#5	A1 A2 A3 A3	23-May-2014 23-May-2014 30-May-2014 30-May-2014	General Chemistry
Snow Valley (Gravel Pit)	TW22	A4	16-Apr-2014	• Two bacteria samples collected during the first 24 hours of pumping • General Chemistry at 1 hour of pumping • Item 31 of the Ontario Drinking Water Standards after 24 hours of pumping
Old Second	OW24	A3/A4	04-Jun-2014	General Chemistry
Snow Valley (West)	OW29	A4	23-May-2014	General Chemistry
Walt Road	OW30	A3/A4	04-Jun-2014	General Chemistry
Old Second	OW1#1	A1	30-May-2014	General Chemistry
Pooles Road	OW3#1 OW3#2	A1 A2	28-May-2014	General Chemistry
Walt Road	OW4#1 OW4#2	A1 A2	30-May-2014	General Chemistry
Hickling Farm	OW8I OW8D House Well	A3 A4 A1	28-May-2014 04-Jun-2014 30-May-2014	General Chemistry
Alliance	PW1	A4	July 22, 2014	General Chemistry

2.4 Numerical Modelling

Numerical groundwater modelling was completed to assist in the evaluation of the sustainability of, and potential groundwater impacts from, the long-term operation of water supply wells at the test well locations. The modelling was undertaken using an updated version of the existing three-dimensional (3D) Kempenfelt Bay FEFLOW numerical model. Model input parameters including layer elevations, hydraulic conductivity and storage terms were updated in accordance with new information obtained from the recent drilling and aquifer testing programs described herein. Subsequently, the model underwent a calibration process until simulated groundwater levels and Willow Creek baseflow rates satisfactorily corresponded to conditions observed in the field. The model was then utilized to assess potential drawdown, well interference and baseflow losses as a result of the additional pumping at the water supply wells. A detailed description of the model analysis and results is provided in Appendix M.

3.0 EXISTING CONDITIONS

3.1 Physical Setting

Midhurst is located in the Simcoe Upland and Lowland physiographic regions as defined by Chapman and Putnam (1984). The Lowland area is located at elevations below approximately 230 masl and is occupied by Little Lake, Willow Creek and Matheson Creek; all of which flow through the Minesing Swamp via the Nottawasaga River on route to Georgian Bay. The upland areas are drained by relatively few small streams, which attest to the sandy nature of the upland area. The Upland area is largely underlain by relatively permeable soils with favourable recharge characteristics. The Lowland area hosts wetland areas around Little Lake and along Willow Creek between Midhurst and the Minesing Swamp.

3.2 Hydrogeological Setting

The MOE water well database and digital topographic maps have been used to prepare a location map and hydrogeological cross-sections through the exploration area (see Figure A-1 for cross-section locations). The aquifers have been classified into four regional aquifers referred to as Aquifers A1 through A4 (Golder, 2004). Aquifer A1 is present under the Upland area while Aquifer A2 can be present in both Upland and Lowland areas. Aquifers A3 and A4 are found predominantly between elevations of approximately 170 masl to 110 masl. The thickness and distribution of aquifers present in the area are shown on Figures A-7 through A-13.

Aquifer A1 is the uppermost aquifer in the area and is mainly under unconfined, or partially confined, water table conditions. It is present at elevations above approximately 240 masl, which limits its presence mainly to Upland areas. Aquifer A1 either pinches out or merges with Aquifer A2 in the steeply sloping lands between Upland and Lowland areas. Typically, there is a strong vertical downward hydraulic gradient between Aquifers A1 and A2. These aquifers are commonly used for private domestic well supplies.

Aquifer A2 is found between elevations of approximately 225 masl to 200 masl in the Upland area and at slightly lower elevations in Lowland areas. This aquifer appears to be under confined artesian or confined water table conditions in Upland areas and under unconfined water table conditions or flowing artesian conditions in valley areas. In some areas, especially on the flanks of the Uplands, water well records indicate the confining layer is absent between Aquifers A1 and A2.

Aquifer A3 is a regionally extensive aquifer and is the source of water for the municipally serviced areas of existing Midhurst and Snow Valley, among others. This aquifer has been observed at most deep wells throughout the Willow Creek Valley and to the north in the Matheson Creek Valley. While Aquifer A3 is found in Upland areas as well as Lowland areas its presence in Upland areas is more variable than in the valleys. The aquifer is under confined artesian conditions and is overlain by a lacustrine silt and clay confining layer (referred to as hydrostratigraphic unit C2) with varying thicknesses. This water supply aquifer is part of a tunnel channel aquifer complex that is similar to other tunnel channel aquifers that are used to supply communities such as Angus, Barrie, CFB Borden, Hillsdale, Anten Mills and Wasaga Beach.

Aquifer A4 represents the lowest portion of the regional aquifer system and previous to this investigation had been primarily recognized in the deepest municipal wells in the City of Barrie and Wasaga Beach. Aquifer A4 is typically found between elevations of approximately 125 masl to 110 masl.

The Uplands to the south are likely of glaciofluvial or subglacial origin and consist of sandy deposits. The Lowlands to the north occupied by Willow Creek may be underlain by glaciolacustrine silts and clay and/or organic muck.

The upgradient lands are thought to provide significant recharge for the deep regional aquifer system (Golder, 2004).

3.3 Groundwater Recharge and Flow

The groundwater flow in the deep confined aquifer system (Aquifers A3 and A4) is governed by regional topographic features, while groundwater flow in the upper aquifer system (Aquifers A1 and A2) is mainly governed by local surface topography and discharge to surface water features. The regional groundwater flow pattern for Aquifers A3 is illustrated on Figure A–14. The potentiometric map surface is based upon recorded static water levels for wells constructed since approximately 1950.

The flow in the lower aquifers is generally towards the west with a horizontal hydraulic gradient of 0.004 to 0.005 m/m. Groundwater flows from the Oro upland area to the west toward a regional topographic low located in the Nottawasaga River Valley at an elevation of approximately 180 masl. The valleys of Willow Creek and Matheson Creek are right bank tributaries to the Nottawasaga River. These streams receive discharge from Aquifers A1 and A2 along their length, while Aquifers A3 and A4 remain confined and ultimately discharge to Nottawasaga Bay.

The creek and river valleys in Simcoe County have been recognized as containing high yielding aquifers and are a focus for groundwater flow. The strongly channelized shape of the valleys is considered to be a result of a sub-glacial erosional process that created what are known as tunnel valleys. Within the tunnel valleys, coarse-grained aquifer materials are common and there is a well-documented history of high yielding wells within the valleys. Thick and uniformly sorted sand deposits are found on the flanks of the coarse-grained valley gravels. These aquifers also serve as conduits that have relatively high groundwater flow velocities. The surface expression of the tunnel valleys terminates to the east of the Nottawasaga River Valley; however, large, high capacity aquifers have been identified in the lowland areas at Wasaga Beach, CFB Borden/Angus, Alliston and Beeton.

3.4 Existing Private Water Supplies

Private water supply wells throughout the area are constructed mainly in Aquifers A1 and A2 where they are present. The water yield of these aquifers is adequate to more than adequate for individual private water supplies or small communal supplies (Table A-1). In the lowland area to the west, mainly shallow dug wells are used because of the extremely high above ground head in the confined aquifer (Aquifer A3).

In the Russell Road area, almost all of the private wells are constructed in Aquifers A1 and A2. In this area, the confining layer below Aquifer A2 is uniformly thick and is described as silt and clay in water well records. Aquifer A2 wells are prolific producers where private water supplies are not the drilling objective, as demonstrated at TW13/08 that was pumped at 4.5 L/s. Whereas Aquifers A1 and A2 may provide water supply to small domestic wells, Aquifer A3 and A4 wells are typically the choice for municipal supply wells and have good drawdown to well yield ratios.

3.5 Existing Barrie Municipal Water Supplies

There are 17 municipal wells constructed in the City of Barrie; three wells are located in the north part, one is located in the south part and 11 are constructed in the central and lakeshore areas. The three wells located in the north end (Wells 9, 13 and 16) will be of focus herein.

The City of Barrie (Barrie) Well 9 has a well casing diameter of 0.305 mm and was tested at 75.8 L/s. Barrie Well 13 has a well casing diameter of 0.356 mm and was tested at 75.8 L/s. Both wells are located on Johnson Street in the north east part of Barrie. Barrie Well 16 has a well casing diameter of 0.400 mm, was tested at 90.9 L/s and is located on Brownwood Drive in the north part of Barrie. Wells 9, 13 and 16 are operated at rates of 43, 53 and 64 L/s, respectively.

3.6 Existing Midhurst Municipal Water Supplies

There are currently four wells supplying water to the existing development of Midhurst. Three are within the existing development of Midhurst and the fourth is located on Carson Road in the Glenbrook Subdivision. Midhurst Well 4, located on Green Pine Drive, has a well casing diameter of 203 mm and was tested at 19 L/s. Midhurst Well 2 and Well 3 have diameters of 150 mm and 305 mm, respectively. Both are located on Idlewood Drive. The wells are operated at rates of 23, 7.2 and 34 L/sec, respectively. The Carson Road Well has a diameter of 203 mm and was tested at 19 L/sec but is operated at 12.4 L/sec. This reduction in yield is due to demand rather than the ability of the well to support the taking.

All of the Midhurst wells take water from Aquifer A3, which is found at elevations between 152 masl to 186 masl in the Midhurst area. The combined permitted taking of the four Midhurst wells is 76.96 L/sec. It is understood that the MDD (maximum day demand) for existing development in Midhurst is approximately 45 L/sec; the supply from the wells therefore has an excess permitted capacity of approximately 30 L/sec.

4.0 WATER SUPPLY POTENTIAL

The water supply potential has been assessed with borehole drilling, observation well construction, test well construction, and aquifer testing at Sites 1, 3, 7, and 10. All of the well drilling and aquifer testing was contracted to Allan Wright Water Wells Inc. of Hillsdale (License Number 5528). The work was conducted using conventional mud rotary drilling equipment. The wells constructed as part of the investigation are all built to municipal standards and have been designed by Golder based on hydrogeological experience, stratigraphic logging, and grain size analyses. The experience gained from previous municipal well construction and earlier investigations for this area (Wilson, 2008 and Golder, 2008) provided aquifer testing information that indicates high well yields are obtainable from Aquifer A3/A4 in this area.

4.1 Site 1: Snow Valley Road Site (TW22)

A brown/grey, medium grained sand aquifer was encountered between 79.9 mbgl and 95.4 mbgl at TW22 and similar conditions were present at the location of OW19. The aquifer is correlated to Aquifer A4 as shown in Figure A-7. The borehole logs for this site are shown in Figures B-1 and B-2. The gradation analyses for the Aquifer A4 portion of the aquifer at OW19 indicated a potential screen with a slot size of 16 to 20 would be appropriate for a production well on this site. Coarser aquifer material was encountered at TW22 and a 50-slot screen was selected for the completion (Figures B-3 and B-4).

4.1.1 Well Construction and Development

A 203 mm diameter well (TW22) was constructed with a nominal 203 mm diameter, 50-slot stainless steel well screen between 81.1 and 89.9 mbgl. Following construction the well was developed using air lift pumping at rates up to 45 L/sec. The theoretical transmitting capacity of the well screen is 61 L/sec.

A stepped rate pumping test was conducted on April 14, 2014. The test consisted of three 60 minute steps at rates of 17.5, 27.0 and 36.5 L/s. Table B-3 provides a summary of the step test data for TW22, OW19#4, OW19#5 and OW19#6.

Table B-3: Stepped Rate Pumping Test Results

Pumping Rate (L/s)	Drawdown at TW22	Drawdown at OW19/14#4	Drawdown at OW19/14#5	Drawdown at OW19/14#6
17.5	9.48	0.75	1.35	0.59
27.0	14.7	1.27	2.09	1.02
36.5	20.17	1.81	2.86	1.44

A 72-hour pumping test was also conducted from April 15, 2014 to April 17, 2014 at a rate of 36.5 L/s (Figures B-5 to B-7). During the test, data loggers were placed in OW19#1, OW19#2, OW19#3, OW19#4, OW19#5, OW19#6 and OW9/01. Water levels were also manually taken at TW22, OW19#4, OW19#5 and OW19#6 (Figures B-5 to B-11).

4.1.2 Aquifer Testing Results

TW22 has demonstrated the ability to yield 36.5 L/s for a period of 72 hours while recording a drawdown within the well of 23.03 m (Figures B-5 to B-7). Within a few minutes of the start of the pumping test, the deep observation wells established a steady drawdown trend of approximately 0.9 m per log cycle (Figure B-7 to B-11). All on-site wells reacted to the pumping except the shallowest observation well (OW09-01) which is constructed in the till at the base of the sand and gravel deposit in the pit at a depth of 7.6 m. Although a short-term test (72 hours), this is a positive indication for minimal interactions with the upper Aquifer A1.

Well screen intervals at OW19#5 and OW19#6 are separated by a 3.7 m thick layer described as sandy till. The reaction of the two well screens at these observation wells indicates a hydraulic connection between aquifer units Aquifer A3 and A4, which are discussed as Aquifer A3/A4 at this site. The drawdown vs distance graph (Figure B-12) indicates the strong hydraulic connection of OW19#5 and OW19#6 and the weaker connection of shallower observation wells. The shallower wells are separated from the deep Aquifer A3/A4 aquifer unit by a confining layer, described as clay, between 61 and 71 m at TW19 and TW22 (Figure B-1 and B-2).

Off-site water levels were monitored at several locations on Site 6 (Hickling) (Figure B-6). Water levels did not decline at these observation wells as a result of the operation of TW22.

The aquifer is under semi-confined conditions with a transmissivity of approximately 600 m^2/day and a storativity of $4.6x10^{-4}$ was calculated using the Cooper-Jacob analytical method. The Thiem analytical method indicates a similar transmissivity of 580 m^2/day, suggesting the aquifer conditions are relatively homogenous and isotropic in the vicinity of TW22.

4.1.3 Water Quality Testing

Water quality samples were collected from OW19#1, OW19#2, OW19#4, OW19#5 and TW22 (Tables L-1 and B-2). Water quality samples were collected at TW22 during the pumping test after 1 hour and 36 hours of pumping.

Additionally, water quality samples were collected from OW19#1, OW19#2, OW19#4, and OW19#5 after the pumping test was completed. In Aquifer A1 and A2 the general chemistry of the groundwater is acceptable;

however, signs of road salt impact that decrease with depth are observed at the location of OW19 (Appendix L). The chloride concentration decreases steadily from 530 mg/L in OW19#2 to 30 mg/L in TW22.

Water quality samples collected at both 1 hour and 36 hours met the ODWS for all parameters tested. The nitrate concentration was/ below the ODWS standard but is higher than expected, at 7.9 mg/L at 1 hour and 7.7 mg/L after 36 hours. The elevated nitrate at this site is likely attributable to the intensive livestock agriculture that was formerly present in the capture zone. Dissolved VOC and pesticide concentrations were below their respective detection levels. Aesthetically, the groundwater has no discernible odour and has an acceptable taste. At the request of the Township, the well was retested in early October and sampled for trihalomethane (THM) formation testing. The laboratory results indicate that THM levels met ODWS criteria (Table B-2).

4.1.4 Water Supply Potential

Treatment of nitrate is proposed for the water from TW22 and OW19. Details regarding nitrate treatment and alternatives will be completed by Black and Veatch.

Extrapolation of the drawdown versus time data for TW22 indicates there is an abundant water supply. The pumping level at the end of the pumping test indicates a drawdown of 23 m compared with an available drawdown of 69 m or 34% of the available drawdown. At 20 years of well operation at 36.5 L/sec the drawdown would be 27.6 m or 40% of the available drawdown.

Based on the pumping tests, there is potential to twin the water supply at this location without impacting the ability of TW22 to provide its design yield and without adversely affecting other water supply wells in the area. An evaluation of the mutual interference between TW22 and a second well to be constructed at the location of OW19 (Figure B-14) indicates that each of the wells could be pumped at a rate of 36.5 L/sec (Table B-4). Groundwater flow modelling indicates that the offsite interference at the nearest well (Vespra Hills Golf Course) would be approximately 1.5 m under long term pumping conditions. This amount of drawdown is not expected to reduce the capacity of the well.

4.1.5 Municipal Well Construction

TW22 is constructed with a 203 mm diameter casing and 9.1 m of well screen that has a theoretical transmitting capacity of 61 L/sec. The static water level is approximately 12 m below the ground level and long term pumping levels are expected to be approximately 40 m below ground level. A submersible well pump capable of yielding 36.5 L/sec with a below ground head of 40 m is a viable option for this well. A production well at the location of OW19 (i.e. TW19; Figure B-14) would have a similar construction to TW22, but with a longer well screen because the aquifer is finer grained.

Table B-4: Extrapolation of 20 Year Drawdown at Maximum Day Rate

Well	Pumping Rate (L/sec)	Drawdown Due to Pumping (m)	Interference from Twin Well (m)	Drawdown + Interference (m)	Available Drawdown (m)
TW22	36.5	27.4	5.9	33.3	65
Twin Well (TW19)	36.5	5.9	27.4	33.3	65

4.2 Site 3: Old Second Road South (TW21)

A brown, fine to medium grained sand aquifer was encountered between 95 mbgl and 134 mbgl at TW21 and similar conditions were noted at OW24 (Figures D-1 and D-3). The aquifer is correlated to Aquifer A3 as shown on Figure A-8. The gradation analyses for Aquifer A3 indicate the aquifer is composed of fine to medium grained sand (Figure D-3).

4.2.1 Well Construction and Development

A 203 mm diameter well (TW21) was constructed with 16.6 m of nominal 203 mm diameter, 12-slot and 6-slot stainless steel well screen between 113.0 and 128.2 mbgl. Following construction the well was developed using air lift pumping at rates up to 30 L/sec prior to testing.

A stepped rate pumping test was conducted on July 30, 2014. The test consisted of three 60 minute steps at rates of 18.9, 25.3 and 31.6 L/s. Table D-3 provides a summary of the step test data for TW21 and OW24. After the stepped rate pumping test OW24 was further developed as a result of the lack of drawdown seen during the test.

Table D-3: Stepped Rate Pumping Test Results

Pumping Rate (L/s)	Drawdown at TW21	Drawdown at OW24
18.9	23.1	0.02
25.3	37.3	0.05
31.6	49.4	0.09

A 72-hour pumping test was also conducted from July 31 to August 3, 2014 at a rate of 27.8 L/s (Figures D-5 to D-7). During the test, data loggers were placed in TW24, OW1#1 and OW1#2, OW2#1 and OW2#2, OW3#1 and OW3#2, TW28, OW4#1 and OW4#2, OW30, TW35 and TW17 (Figures D-5 to D-11).

4.2.2 Aquifer Testing Results

TW21 has demonstrated the ability to yield 27.8 L/s for a period of 72 hours while recording a drawdown of 45.23 m (Figures D-5 and D-7). The wells constructed in Aquifer A3 within 2,500 m of TW21 (OW24, OW28, OW30, OW35) reacted to the withdrawal of water from the aquifer, however TW17, which is located 4.7 km to the north did not react to the water taking. The interference at the observation wells is significantly less than that noted in the drawdown at TW21 with 47 m of drawdown at TW21 and 2.5 m of interference at OW24, which is located 155 m to the west. The fine nature of the aquifer acts to increase the well losses in the well, thereby reducing the unit well yield from wells in this area.

The observation wells constructed in Aquifer A1 and A2 did not react to the operation of TW21 (Figure D-6). The lack of drawdown in Aquifer A1 also means that there could not have been a reduction in the water level in surface water features.

An aquifer transmissivity of 470 m^2/day and storativity of $3.3x10^{-4}$ was calculated using the Cooper-Jacob analytical method. A transmissivity of 524 m^2/day is calculated using the Thiem equation (Figure D-12). The results of the two methods of calculation are very similar indicating uniform aquifer conditions in the area.

4.2.3 Water Quality

Water quality samples were collected from TW21 (Table D-2) and OW1#1 (Table L-1). In Aquifer A1 the general chemistry of the groundwater was acceptable; however, the nitrate concentration (24.3 mg/L) at OW1#1 was above the ODWS guideline. Water quality samples from TW21 were collected during the pumping test at 24 hours and 72 hours of pumping (Table D-2). The samples collected at both 24 hour and 72 hours meet the ODWS for all parameters tested with the exception of color which had a concentration of 8 TCU. The nitrate concentration was below the ODWS standard at 3.3 mg/L and 3.1 mg/L at 24 hours and 72 hours, respectively. VOC and pesticide concentrations were below their respective detection limits. Aesthetically, the groundwater at TW21 had no discernable odour and an acceptable taste.

4.2.4 Municipal Well Construction

Table D-4 (below) demonstrates that TW21 could be paired with another close by well ("twinned") to result in the site's water production being increased to 40 L/sec. The calculation assumes that both the existing well and a new well on the site operate continuously at the maximum day rate indefinitely. This is an overestimation and in reality the wells will operate at approximately 50% of their respective MDD rates, therefore the drawdown in the aquifer will be less.

The drilling and sampling of OW24 indicates the site of OW24 would support the construction of a 20 L/sec water supply well. The aquifer materials at OW24 are similar to those at TW21 and testing has indicated that the aquifer could support additional water taking. A proposed design for a 203 mm diameter well is presented in Figure D-4. The 12.2 m long well screen would have a theoretical transmitting capacity of approximately 27 L/sec. The actual yield of the site would have to be evaluated with test well construction and pumping tests; however, the pumping test of TW21 indicates that a twin well is theoretically viable.

The ability for two wells at the site, TW21 and the twin well, to each yield 20 L/sec was evaluated during the pumping test of TW21 by monitoring the water level change in OW24. The drawdown trend established during the 72-hour test interpolated for the Wells to 20-years indicates that there would be 4.0 m of drawdown at OW24. It is reasonable to assume that if a twin well located at OW24 (i.e. TW24) and was operated at 20 L/sec it would also have 4.0 m of interference at TW21. Therefore, by adding the drawdown at TW21 to the interference from the twin at TW24, the resulting drawdown at TW21 would be 40 m. The same would be true for the twin at TW24, as shown in Table D-4.

Table D-4: Extrapolation of 20 Year Drawdown at Maximum Day Rate

Well	Pumping Rate (L/sec)	Drawdown Due to Pumping (m)	Interference from Twin Well (m)	Drawdown + Interference (m)	Available Drawdown (m)
TW21	20	36	4.0	40	61
Twin Well (TW24)	20	4.0	36	40	67

There is 21 to 27 m of available drawdown remaining after accounting for drawdown and interference to accommodate pumping equipment and declines in well efficiency that may occur as the wells age.

4.3 Site 7: Snow Valley West Site (TW34)

A brown coloured, fine to medium grained sand aquifer was encountered between 89.0 mbgl and 104.2 mbgl at the TW34 Snow Valley (West) site. The aquifer is correlated with Aquifer A4 as shown on Figure A-10. The borehole log for this well is shown in Figure H-1. The gradation analyses for the Aquifer A4 in TW34 and OW29 indicated a fine to medium sand aquifer with 50% particle sizes ranging from 0.3 to 0.45 mm (12 to 18-slot; Figures H-3 and H-4).

4.3.1 Well Construction and Development

A 203 mm diameter well (TW34) was constructed with 9 m of nominal 203 mm diameter 20-slot stainless steel well screen between 94.0 mbgl and 103.0 mbgl. Following construction, the well was developed using air lift pumping to remove drilling fluids.

A stepped rate pumping test was conducted on September 8, 2014. The test consisted of three 60 minute steps at rates of 17.7, 22.7 and 27.8 L/s. Table H-3 provides a summary of the step test data for TW34 and OW29#1, #2, #3 and #4.

Table H-3: Stepped Rate Pumping Test Results

Pumping Rate (L/s)	Drawdown at TW34	Drawdown at OW29#1	Drawdown at OW29#2	Drawdown at OW29#3	Drawdown at OW29#4
17.7	9.52	0	0	0	2.61
22.7	13.46	0	0	0	3.69
27.8	16.31	0	0	0	4.52

A 72-hour pumping test was conducted from September 9, 2014 to September 11, 2014 at a rate of 20 L/s (Figure H-5). During the test, data loggers were placed in Aquifer A1 (OW29#1 and BH8-1), Aquifer A2 (OW29#2, house 1, house 2, house 3, house 4), Aquifer A3 (OW29#3, SVR OW, SV OW1, SV OW2, SVPark OW) and Aquifer A4 (OW29#4) (Figures H-5 to H-11).

4.3.2 Aquifer Testing Results

TW34 has demonstrated the ability to yield 20 L/s for a period of 72 hours while recording a drawdown of 15.46 m (Figure H-5). TW34 and OW29#4 establish a steady drawdown trend of approximately 1 m/log cycle until approximately 1,000 minutes into the test. Between 1,000 minutes and the end of the test, the drawdown trend steepens to 2.8 m/log cycle. There was 15.46 m of drawdown at TW34 and 6.29 m of drawdown at TW29#4 at the end of the 72 hour pumping test. The available drawdown at TW34 is 71.5 m of available drawdown between the static water level and the top of the well screen, and at the end of the pumping test approximately 21.6% of the available drawdown was used.

Water levels were monitored at a variety of locations with wells constructed in Aquifer A1, Aquifer A2 or Aquifer A3. Well locations included four private residences, three municipal observation wells, two commercial wells, and one well at the closed Simcoe County landfill on George Johnson Road. None of these wells reacted to the pumping of TW34.

Aquifer transmissivity of approximately 305 m^2/day was calculated from data recorded at OW29#4 using the Copper-Jacob analytical method. A storativity of $1.5x10^{-5}$ was calculated from OW29#4 data.

4.3.3 Water Quality

Water quality samples were collected from TW34 (Table H-2) and OW29#4 (Table L-1). Water quality samples were collected at OW29#4 following installation of the observation well and prior to construction of TW34. Water quality samples were also collected from TW34 during the pumping test after 24-hours and 71 hours.

The results from the 24-hour sample indicated that the water is bacteria free and had nitrate concentrations below detection limits and chloride and sodium that were 1.4 and 5.2 mg/L, respectively. The iron concentration (1.45 mg/L) was above the ODWS aesthetic guideline of 0.3 mg/l and the manganese concentration (0.289 mg/L) was above the ODWS aesthetic guideline of 0.05 mg/L. VOC and pesticide concentrations were also below their respective detection limits. The water had a slight sulphurous odour and an acceptable taste. It is important to note that the parameters only exceed the aesthetic guideline (i.e., non-human health issue), however, will be treated regardless at the proposed water treatment plant. Gas, which is presumed to be methane, could be seen in the discharge water.

4.3.4 Long Term Pumping Levels and Interference

OW29#4 was the only observation well that experienced interference due to the operation of TW34 (Figure H-5). Nearby private wells were monitored throughout the pumping of TW34 and no drawdown was measured (Figures H-6 to H-10). The water taking from this well site is not expected to adversely affect the normal operation of the private wells in the area.

Water levels were closely monitored in a very shallow observation well (OW29#1) which is just upstream of a spring line. This monitoring location was unaffected by the water taking from Aquifer A4. The confining layer composed of hard grey clay between 32.9 m and 50 m depth forms a hydraulic barrier between Aquifer A3 and Aquifer A2, and there is a sequence of silt and clay layers between 71 mbgl and 89 mbgl that isolates Aquifer A3 from the drawdown that occurred in Aquifer A4 during the pumping test. The operation of wells constructed in Aquifer A4 did not affect the surface water levels in Aquifer A1; therefore there is little potential for the taking of water from Aquifer A4 to adversely affect the flow of springs or surface water levels.

The ability for two wells at the site, TW34 and a twin well (at site of OW29) to each yield 20 L/sec was evaluated during the pumping test of TW34 by monitoring the water level change at OW29#4. Extrapolating the drawdown trend established during the last two days of the 72-hour test to 20-years and indicates that there would be 16.7 m of drawdown at the location of OW29. It is reasonable to assume that if a twin well is located at OW29 and is operated at 20 L/sec it would have 16.7 m of interference at TW34. Therefore, by adding the drawdown at TW34 to the interference from the twin at TW29, the resulting drawdown at each well would be 44 m, as shown in Table H-4.

Table H-4: Extrapolation of 20 Year Drawdown

Well	Pumping Rate (L/sec)	Drawdown (m)	Interference (m)	Drawdown + Interference (m)	Available Drawdown (m)
TW34	20	16.7	27.3	44	71.6

Well	Pumping Rate (L/sec)	Drawdown (m)	Interference (m)	Drawdown + Interference (m)	Available Drawdown (m)
Twin Well OW29#4	20	27.3	16.7	44	70.5

There is 26.5 to 27.6 m of available drawdown remaining after accounting for drawdown and interference to accommodate pumping equipment and declines in well efficiency that may occur as the wells age.

4.4 Site 10: Alliance Site (PW1)

A fine brown sand aquifer was encountered between 109.7 mbgl and 123.7 mbgl at OW35. The aquifer was correlated with Aquifer A3 as shown on Figure A-10. The borehole log for this well is shown in Figure K-1. The gradation analyses for the Aquifer A3 portion of this test hole indicated a fine sand aquifer with the 50% grain sizes ranging from 0.25 to 0.35 mm, or 9 to 14-slot (Figure K-3).

Water quality samples were collected from PW1 during the test (Table K-2). Laboratory analytical results from the collected samples met the ODWS parameters, with the exception of iron, the concentration of which (0.383 mg/L) exceeded the aesthetic guideline of 0.3 mg/L. The nitrate concentration was below the detection limits and chloride and sodium concentrations were 2.1 and 5.2 mg/L, respectively. Aesthetically the water from Aquifer A3 at PW1 had a faint sulphurous odour and no discernable taste. Previous testing of the water indicated it met the ODWS standards for all health related parameters (Wilson, 2008).

4.4.1 Well Construction and Development

A 254 mm diameter well (PW1) was previously constructed with 15.6 m of nominal 254 mm diameter, 10-slot and 12-slot stainless steel well screen between 110.0 and 125.6 mbgl.

Wilson Associates tested PW1 in 2008 as well at a rate of 45 L/sec and a maximum drawdown of 19.45 m after 72 hours was observed. A 48-hour pumping test was also conducted from July 31 to August 3, 2014 at a rate of 45 L/s (Figure K-4 to K-7). During the test, data loggers were placed in all aquifers present in the area. Shallow aquifers within 30 m of PW1 were monitored to assess the potential impact on near-by private water supply wells and impacts to surface water resources. Deep Aquifer A3/A4 wells were monitored at various distances from PW1 to assess the potential impact on other municipal water supply wells in the area.

4.4.2 Aquifer Testing Results

PW1 has demonstrated the ability to yield 45 L/s for a period of 72 hours and drawdown characteristics were confirmed in at 48-hour pumping test where drawdown of 17.94 m was recorded (Figures K-4 to K-11). A steady drawdown trend was established in Aquifer A3/A4 wells within the first 10 minutes of the pumping test at PW1 and TW35 (Figures K-7 and K-8) and this trend continued for the duration of the test.

Drawdown was observed in all of the observation wells installed in Aquifers A3/A4. The more distant observation wells located at between 1,500 and 2,400 m from PW1 began reacting to the withdrawal of water between 300 and 1,100 minutes after pumping commenced (Figures K-9, K-10, and K-11). TW17 is also constructed in Aquifer A3, at a distance of 2.5 km and showed a very slight amount of drawdown just before the end of the first day of testing.

Water levels were monitored in Aquifer A1 locations at OW1#1, OW2#1, OW3#1, and OW4#1 and at Aquifer A2 locations at OW1#2, OW2#2, OW3#2, OW4#2, (Figures K-5 and K-6) and the on-site TH3 (Wilson, 2008). Water levels in the Aquifer A1 and A2 wells were not affected by the pumping of PW1. Water levels in surface water features in the area are supported by discharge from Aquifer A1; therefore no change in surface water levels is expected because Aquifers A1 and A2 were not affected.

Aquifer transmissivity was calculated to be 560 m^2/day and storativity was calculated to be $2x10^{-4}$ using the Copper-Jacob analytical method. The drawdown in Aquifer A3 at the end of the pumping test was plotted against the distance from PW1 (Figure K-12). The transmissivity calculated using the Thiem equation resulted in an aquifer transmissivity of 550 m^2/day. The agreement of the Cooper-Jacob solution and the Thiem solution indicates that Aquifer A3 is a large, relatively isotropic and homogenous aquifer.

4.4.3 Municipal Well Construction

Table K-3 illustrates that PW1 could be twinned to increase the site's water production rate to 100 L/sec. The following assessment was done assuming that both the existing well and a new well on the site operate continuously at the maximum day rate indefinitely. This assessment indicates acceptable results even though the duration of pumping used is an overestimate of the actual water taking by approximately 50%.

The drilling and sampling of OW35 indicates the site of OW35 would support the construction of a 55 L/sec water supply well. The well drilling and production well design methods employed at other locations during this investigation indicate that the aquifer materials at OW35 were slightly coarser than at PW1 and, with the use of a gravel pack well design, the aquifer could support the construction of a 305 mm diameter well with an 18-slot well screen and a uniformly graded sand filter pack. The theoretical transmitting capacity of the well screen described above would be 62 L/sec. The actual yield of the site would have to be evaluated with test well construction and pumping tests; however, the open area of the well screen in the twin well is higher than in PW1 indicating a greater water supply potential than PW1. Also, pumping tests at PW1 indicate the aquifer at this location yields good water supplies.

The ability for two wells at the site, PW1 and the twin well, to yield at total of 100 L/sec was evaluated during the pumping test of PW1 by monitoring the water level change in OW35. The drawdown trend established during the 48-hour test is the same as was established during the 72-hour test (Wilson, 2008) and extrapolation of the drawdown trend to 20-years indicates that there would be 9.5 m of drawdown at OW35 (Figure K-13). It is reasonable to assume that if a twin well (i.e. TW35) is located at OW35 and is operated at 55 L/sec it would have 22% more drawdown at PW1 than at OW35 (i.e. 11.6 m of interference at PW1). Adding the drawdown at PW1 (24 m) to the interference from the twin at OW35 the resulting drawdown at PW1 would be 35.6 m. The total drawdown at TW35 is expected to be 38.8 m, as shown in Table K-3.

Table K-3: Extrapolation of 20 Year Drawdown at Maximum Day Rate

Well	Pumping Rate (L/sec)	Drawdown Due to Pumping (m)	Interference from Twin Well (m)	Drawdown + Interference (m)	Available Drawdown (m)
PW1	45	24	11.6	35.6	59.9
Twin Well (at OW35)	55	29.3	9.5	38.8	59.9

There is 21.1 to 23.3 m of available drawdown remaining after accounting for drawdown and interference to accommodate pumping equipment and declines in well efficiency that may occur as the wells age.

4.5 Firm Capacity

The Firm Capacity of the water supply system can be addressed by the construction of additional Alternative Supply Wells at each of the municipal well sites. The presence of suitable aquifer materials at each of the proposed well sites is sufficiently predictable to allow for the planning of additional lands to be set aside for the construction of additional wells. There should be an offset from the existing wells of between 80 to 100 m to allow for mutual drawdown among the wells, the operation of the wells in the wellfield should be such that any two of the wells can be operated simultaneously, hence the drawdown among the wells would be similar to what has been demonstrated during the various pumping tests. Figure 1 shows the location of Alternative Supply wells, which are identified as ASW 1, ASW2, and ASW3.

5.0 NUMERICAL GROUNDWATER MODELLING

Numerical groundwater modelling was undertaken to assess any long-term hydrogeological impacts that may occur as a result of the proposed water supply pumping (221 L/s at full build-out). Potential impacts were assessed on the basis of incremental aquifer drawdown, well interference, and baseflow losses in Willow Creek (baseflow is the component of stream flow provided by groundwater discharge). In addition, capture zones for the proposed wells and aquifer vulnerability were assessed. A detailed description of the model background, construction, calibration and results is provided in Appendix M whereas a brief synopsis of the modelling analysis is provided below.

The modelling was conducted using an updated version of the pre-existing Barrie (or “Kempenfelt Bay”) groundwater model, originally constructed in the early 2000s in support of the South Simcoe Groundwater Study (Golder, 2004). The model was developed using the flow-code software FEFLOW and provides a computer-based, mathematical representation of the three-dimensional (3D) hydrogeologic system as understood through available physiographic mapping, borehole logs, well water levels, aquifer testing results, stream flow measurements and other field observations. The model domain is regional in scale, encompassing an area of 746 km^2 (Figure 1 of Appendix M). The Willow Creek watershed, wherein the proposed developments are located, lies almost entirely within the model domain.

An Existing Conditions model scenario was refined and further calibrated in Midhurst and greater Willow Creek watershed areas in accordance with recent drilling, aquifer testing, and stream flow data. Subsequently, a Future Conditions model scenario, which added the new wells at their prescribed rates and screened intervals, simulated anticipated water taking at full build-out.

The following results were obtained from the model simulations:

- The additional Carson and Doran water takings resulted in drawdown of up to 10 m in Aquifer A3 in the area of the Doran Neighbourhood, with a lateral zone of influence reaching 6 km from the proposed development.
- Well interference at surrounding municipal systems was minimal (1.7 metres or less) and is not expected to adversely affect well operation.

- Percent baseflow reductions at Willow Creek were highest during the late summer period. The maximum reduction simulated was about 9% in the Midhurst area. The Willow Creek catchment experienced between 3% to 7% baseflow loss depending on the time of year.
- Capture zones for the Midhurst and Paddy Dunn's Circle and Carson and Doran Neighbourhood wells were developed by delineating the 2 year, 5 year, 10 year and 25 year capture zones at each well. Most capture zones were directed east to northeast in conformance with regional flow patterns emanating from the Oro-Medonte uplands. The 25-year time of travel zones reached upgradient distances ranging from about 1 km to 5 km in length.
- Water supply Aquifers A3 and A4 had a "low vulnerability" Aquifer Vulnerability Index (AVI) in the areas of the capture zones.

6.0 CONCLUSIONS

- Aquifer A3 and Aquifer A4 are the primary targets for water supply development in the Midhurst area. The existing municipal water supply wells are constructed in the Regional Aquifer A3.
- Aquifer A3 was intersected at all boreholes drilled in the in the Doran Road area and analysis of pumping test data indicated that the hydraulic characteristics of the aquifer are relatively consistent across the area. At several locations the aquifer material was found to be too fine-grained for the construction of a high capacity water supply well.
- Aquifer A3/A4 is present throughout the Carson Road area. Confined artesian conditions were noted over the western part of the area, and semi-confined conditions over the eastern part. The aquifer material was not considered suitable for high capacity well construction at all locations.
- Water supply exploration conducted in the Doran Road and Carson Road area resulted in the construction of groundwater supply wells with a sum capacity of 129.3 L/sec. Testing has been completed that indicates three of these sites can support twinning of the wells and 221 L/sec is available from groundwater resources in the area.
- Wells have been tested in the Doran Road area that had a water production rate of 72.8 L/sec. Both well sites in this area can support twinned wells and a potential of production rate of 140 L/sec. There are other potential well sites in the area that would support smaller yielding water supply wells if required.
  - TW21 had a tested yield of 27.8 L/sec. TW21 and a twinned well at OW24 could both operate at 20 L/sec, for a total operating capacity of 40 L/sec
  - PW1 had a tested yield of 45 L/sec. The site is capable of supporting a yield of 100 L/sec with the construction of a twin well at the location of OW35, with PW1 operating at 45 L/sec and the twin well operating at 55 L/sec.
- Wells have been tested in the Carson Road area that had a water production rate of 56.5 L/sec. Well sites in this area can support twinned wells, and a potential production rate of 81 L/s.
  - TW22 has a tested yield of 36.5 L/sec, and a twinned well could be installed at this location. With installation and operation of a twinned well it may be possible to ameliorate the higher than expected

nitrate concentration noted at TW22 with a lower nitrate concentration source. Alternatively, the nitrate can be treated at a water treatment plant.

- TW34 has a tested yield of 20 L/sec and the site is capable of yielding 40 L/sec with a twinned well at or near the location of TW29 and both wells could operate at 20 L/sec.

- The firm capacity of the water supply system can be addressed by the construction of additional alternative supply wells at each of the test well sites. The presence of suitable aquifer materials at each site is sufficiently predictable to allow for the planning of additional lands to be set aside for the construction of additional wells. It is expected that any two of the wells would be operated simultaneously, resulting in drawdown among the wells similar to that demonstrated during the various pumping tests.

- Groundwater at all of the test wells was fresh, bacteria free and calcium bicarbonate hydrogeochemical type. A summary of individual test well results during the pumping tests is as follows:

  - TW22: all tested parameter concentrations were below their respective ODWS guidelines. The chloride concentration was 38 mg/L, and nitrate concentrations were below the ODWS but were higher than expected at 7.7 mg/L. The measured nitrate concentrations at this site were attributed to the intensive livestock agriculture in the capture zone for this well. This activity has ceased and it is expected that the nitrate rich water will flush out of the system in the future. The changes in groundwater chemistry throughout the stratigraphic profile at this location indicate that the aquifer at TW22 is protected from direct contact with surface water by several relatively thin confining layers. VOC, pesticide, and TMH concentrations were below their respective detection levels. The water had no discernable odour and an acceptable taste.

  - TW21: all tested parameter concentrations were below their respective ODWS guidelines. The chloride concentration was 28 mg/L, and the nitrate concentration was 3.1 mg/L. VOC and pesticide concentrations were below their respective detection limits. The water had no discernable odour and an acceptable taste.

  - TW34: all tested parameter concentrations were below their respective ODWS guidelines, with the exception of iron (1.45 mg/L) and manganese (0.289 mg/L). The chloride concentration was 1.2 mg/L and the nitrate concentration was below the detection limit. VOC and pesticide concentrations were also below their respective detection limits. The water was noted to be degassing (presumed to be methane) and a slight sulphurous odour, and an acceptable taste.

  - Elevated concentrations of the parameters mentioned above may be treated to meet ODWS at a water treatment plant.

- Numerical groundwater modelling indicates that the future water taking of 221 L/sec is sustainable from the Regional A3/A4 Aquifer in the area. The additional pumping is not expected to adversely affect the performance of the existing Midhurst, Barrie, or Snow Valley water supply systems.

- Water level monitoring was conducted at the former Vespra landfill, located on George Johnson Road and in other Aquifer A1 and A2 locations in the Snow Valley area. No interference was noted in any of the shallow aquifers and numerical modelling indicates minimal impact to surface water resources.

7.0 LIMITATIONS

This preliminary hydrogeological assessment was prepared for Midhurst Development Doran Road Inc. and Carson Road Development Inc. to support the water supply portion of a Class Environmental Assessment for proposed development in the Midhurst Secondary Plan area. This report is based on borehole drilling, pumping tests and water quality analyses collected during this investigation and previous hydrogeological investigations conducted in 2008. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the sole responsibility of such third parties.

Golder has conducted test drilling and testing at specific locations, the stratigraphic conditions between these locations may change.

8.0 CLOSURE

We trust this document meets your current requirements. Should you have any questions or comments, please do not hesitate to contact the undersigned.

Report Signature Page

GOLDER ASSOCIATES LTD.



John Easton, M.Sc., P.Geo.

JAE/DH/plc

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9.0 REFERENCES

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APPENDIX A

Site Location Maps

HIGHWAY 26

HIGHWAY 26

GILL ROAD

BAYFIELD STREET

RUSSELL ROAD

DORAN ROAD

WALT ROAD

POOLES ROAD

OLD SECOND

SNOW VALLEY ROAD

CARSON ROAD

WILSON DRIVE

Carson Road

Paddy Dunn's Circle

Greenacres

Idlewood Drive

Midhurst

Snow Valley

SPRINGWATER

BARRIE

Black Cr

Willow Cr

Little Lake

PROJECT NORTH // GEODETIC

A
A'
B
B'
C
C'
D
D'
E
E'
F
F'

TH33
OW29
TW34
OW19
TW22
OW9
OW8
TH27
OW11; TW13
TH26
OW10
OW15
OW35
PW1
TH23
OW4
TH31
OW30
TW18
TH25
OW3
TW20
OW28
OW32
OW25
OW24
OW1
TW21

PLAN LEGEND

- Existing Municipal / Public Supply Well
- Proposed Municipal Well Site
- 2008 Investigations
- 2014 Investigations
- Proposed Development
- Midhurst Growth Area Boundary
- Municipal Boundary

NOTES:

1. Base Mapping from Terenet Mapping 2009
2. Development Plan Geranium Corporation 2013
3. Mapped features are approximate and Not to Scale

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SCALE 1:30000
Plotted 11x17 Landscape

metres

PROJECT

MIDHURST WATER SUPPLY EXPLORATION

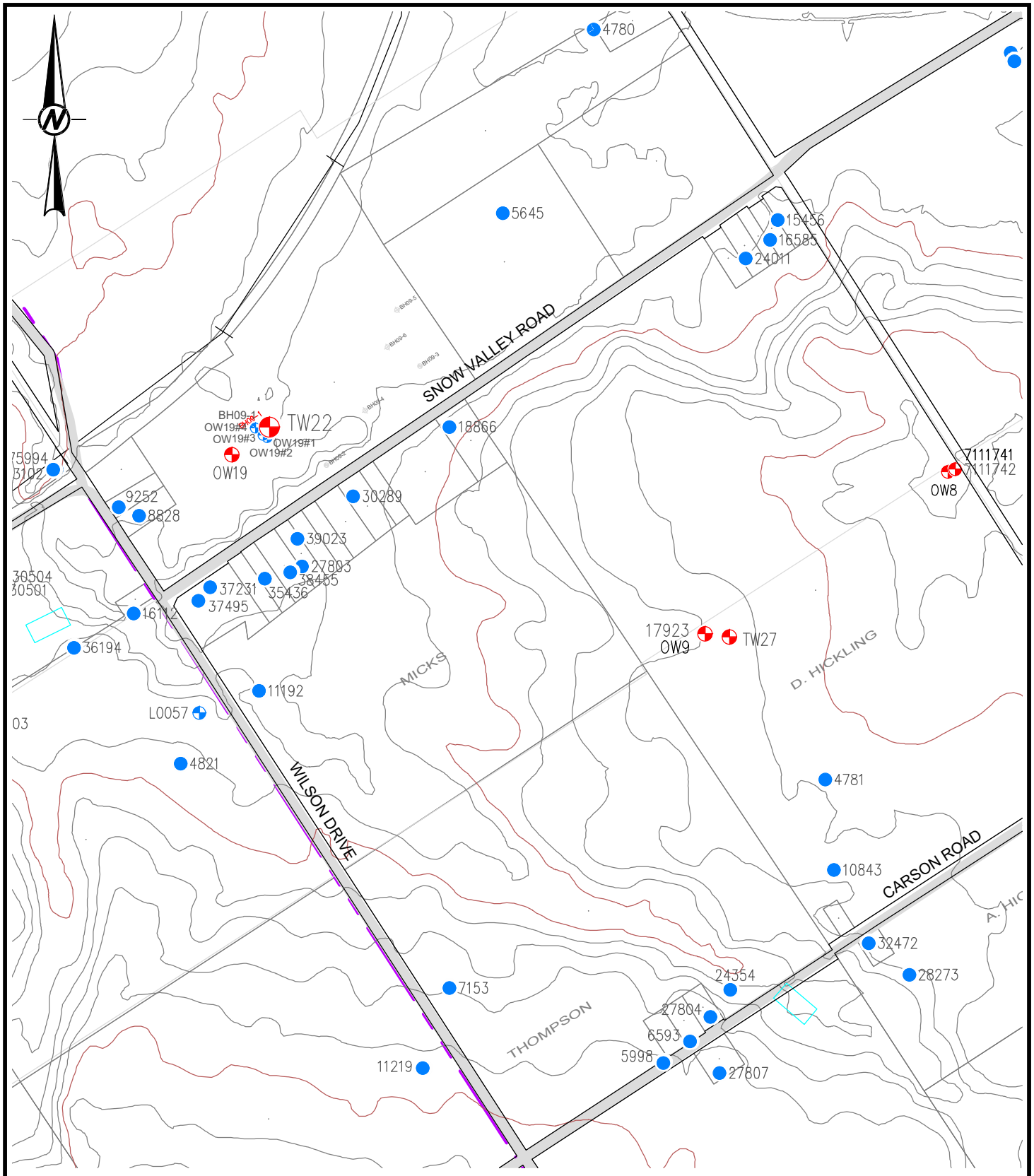
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AREA LOCATION MAP

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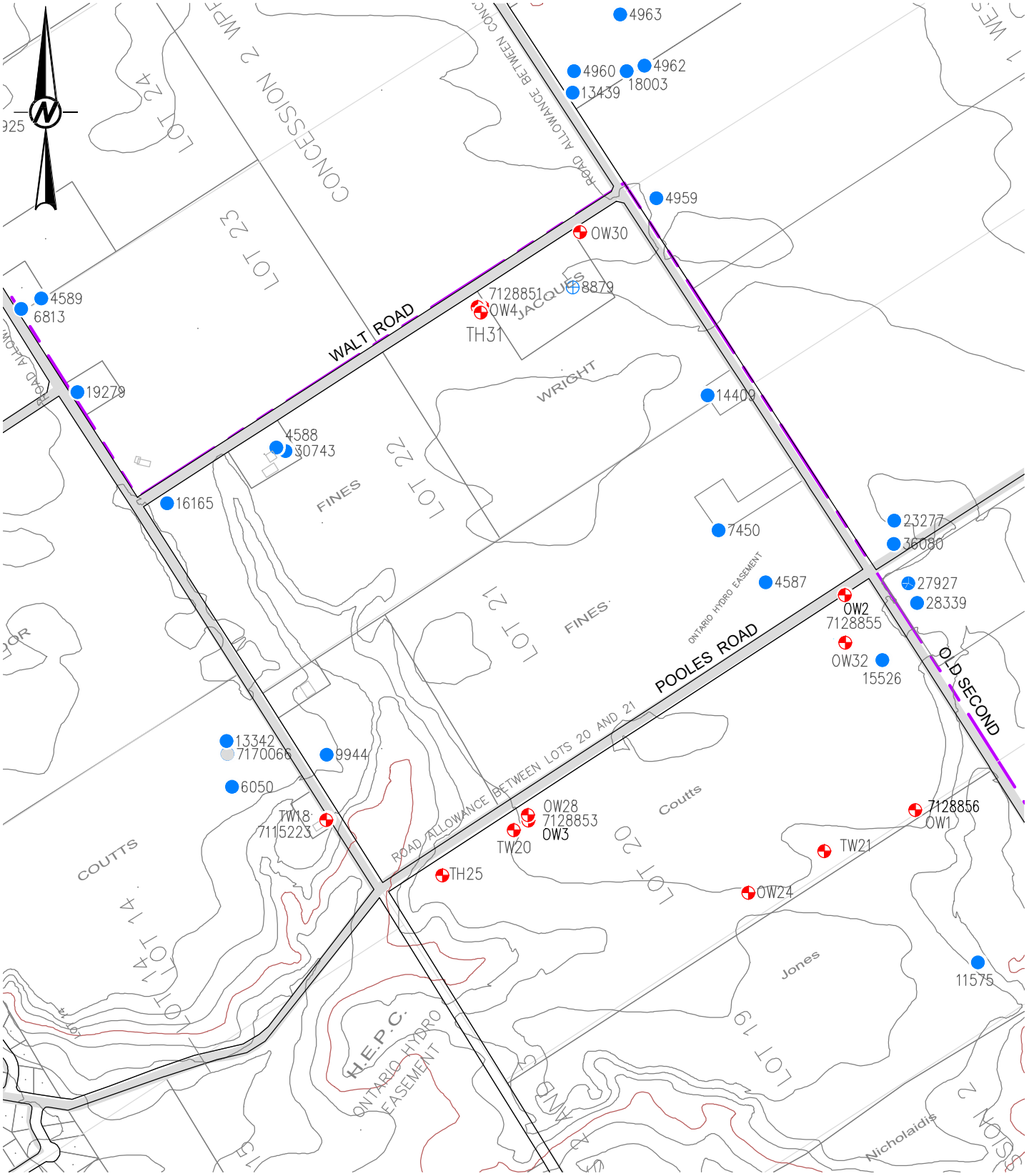
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SITE LOCATION MAP
SNOW VALLEY ROAD (GRAVEL PIT) AND D. HICKLING FARM

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE
A-2

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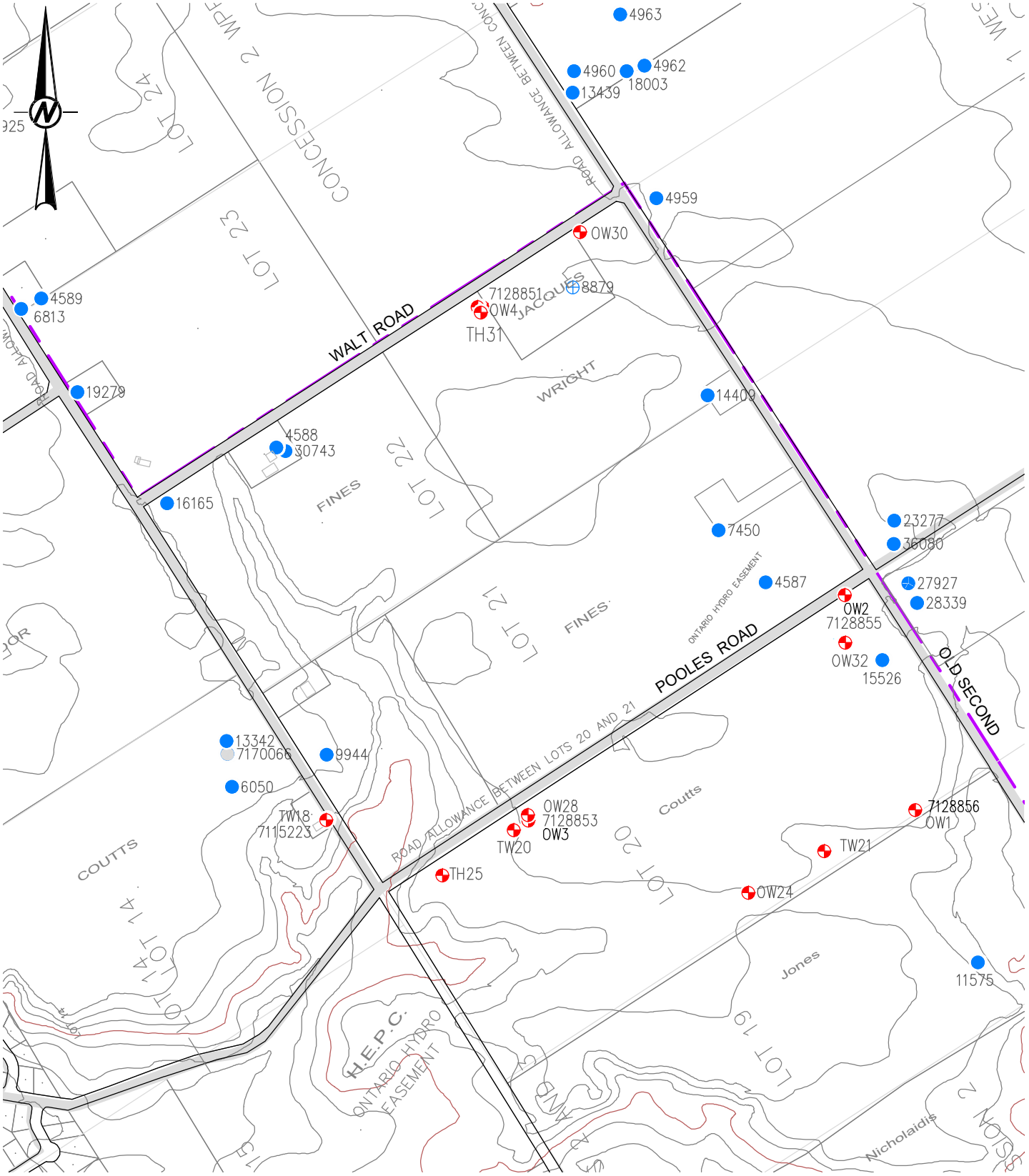
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SITE LOCATION MAP
POOLES ROAD; OLD 2ND ROAD; COUTTS FARM

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE
A-3

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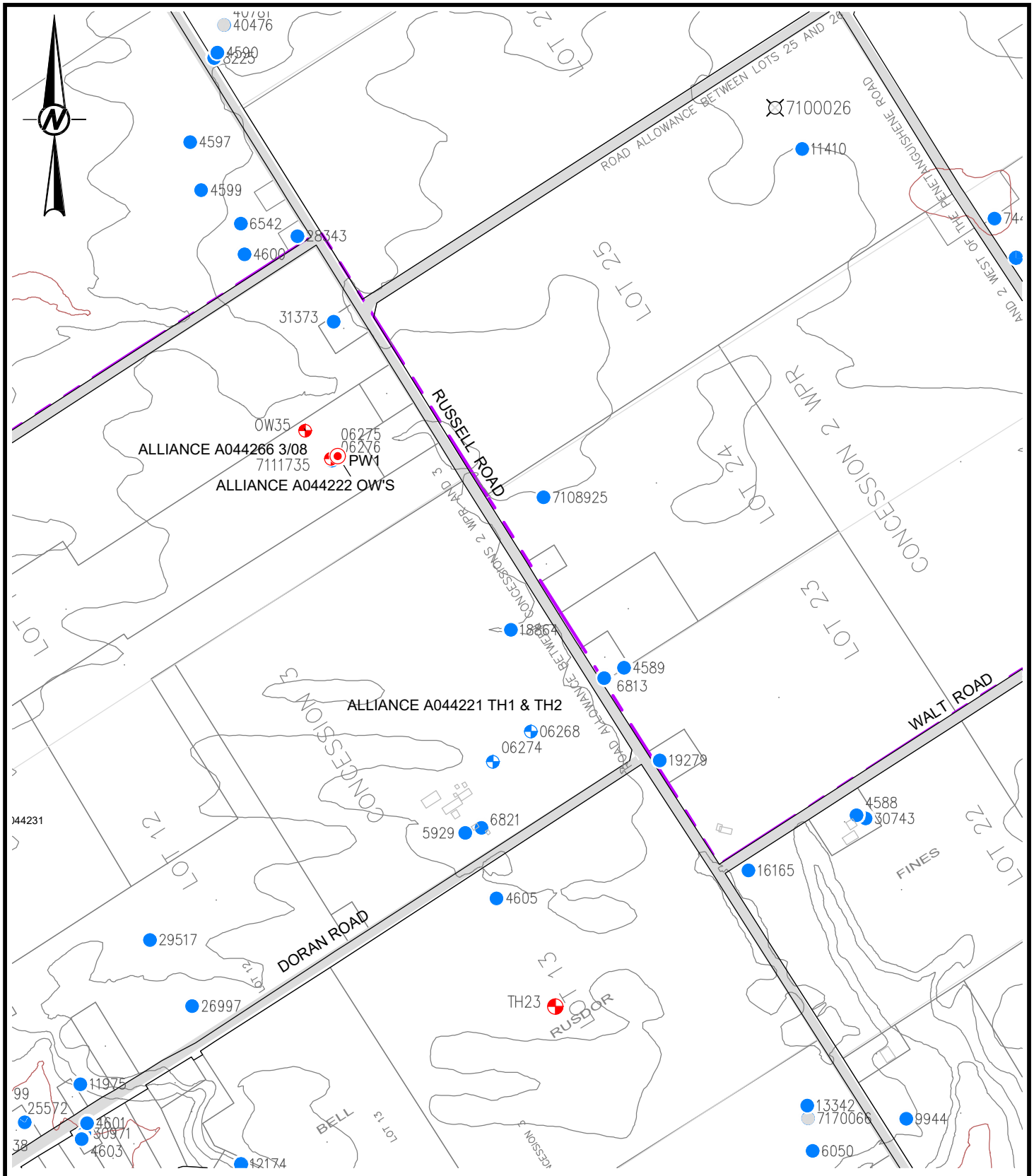
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SITE LOCATION MAP
POOLES ROAD; OLD 2ND ROAD; COUTTS FARM

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE
A-3

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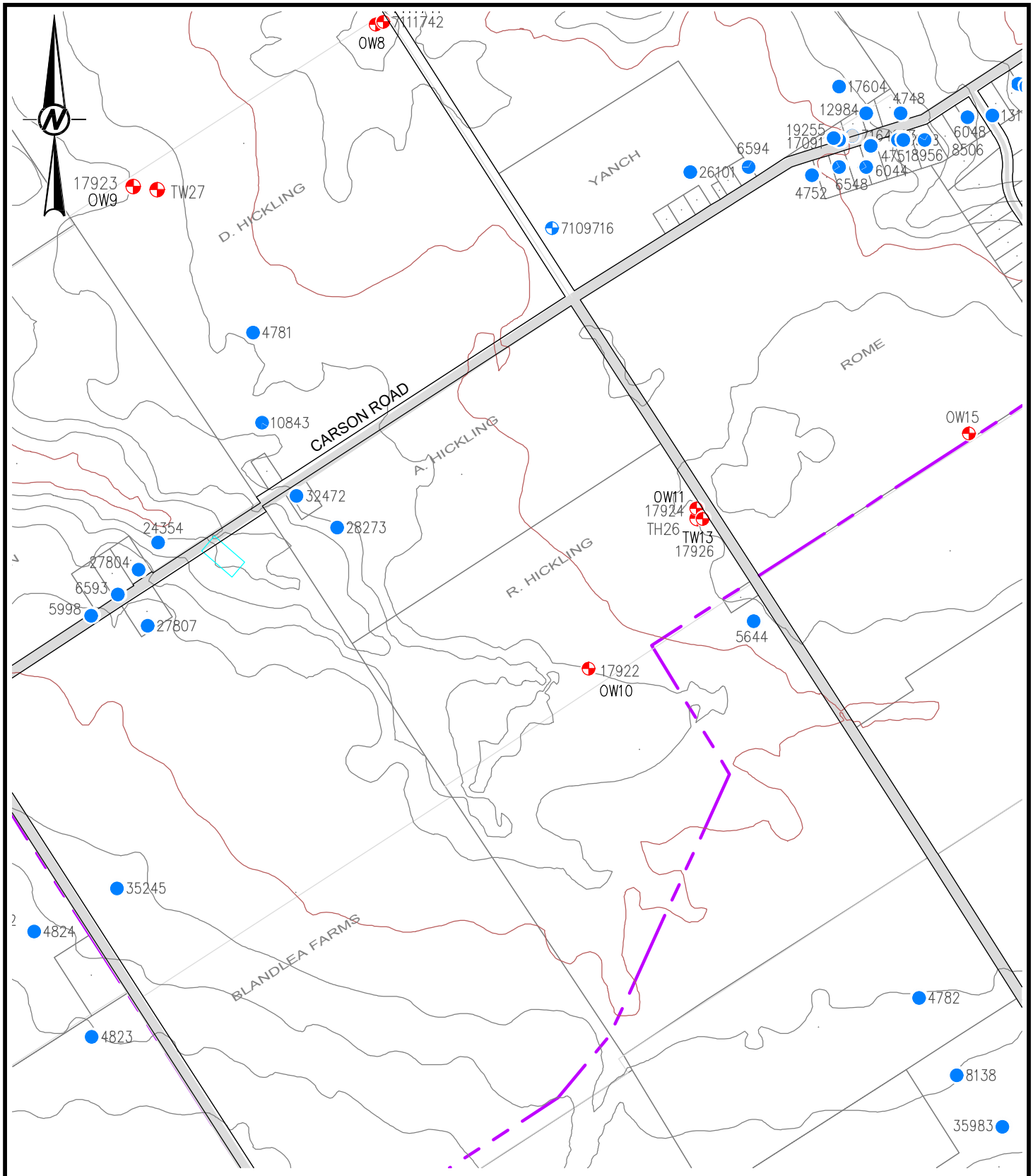
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SITE LOCATION MAP
DORAN ROAD

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE **A-4**

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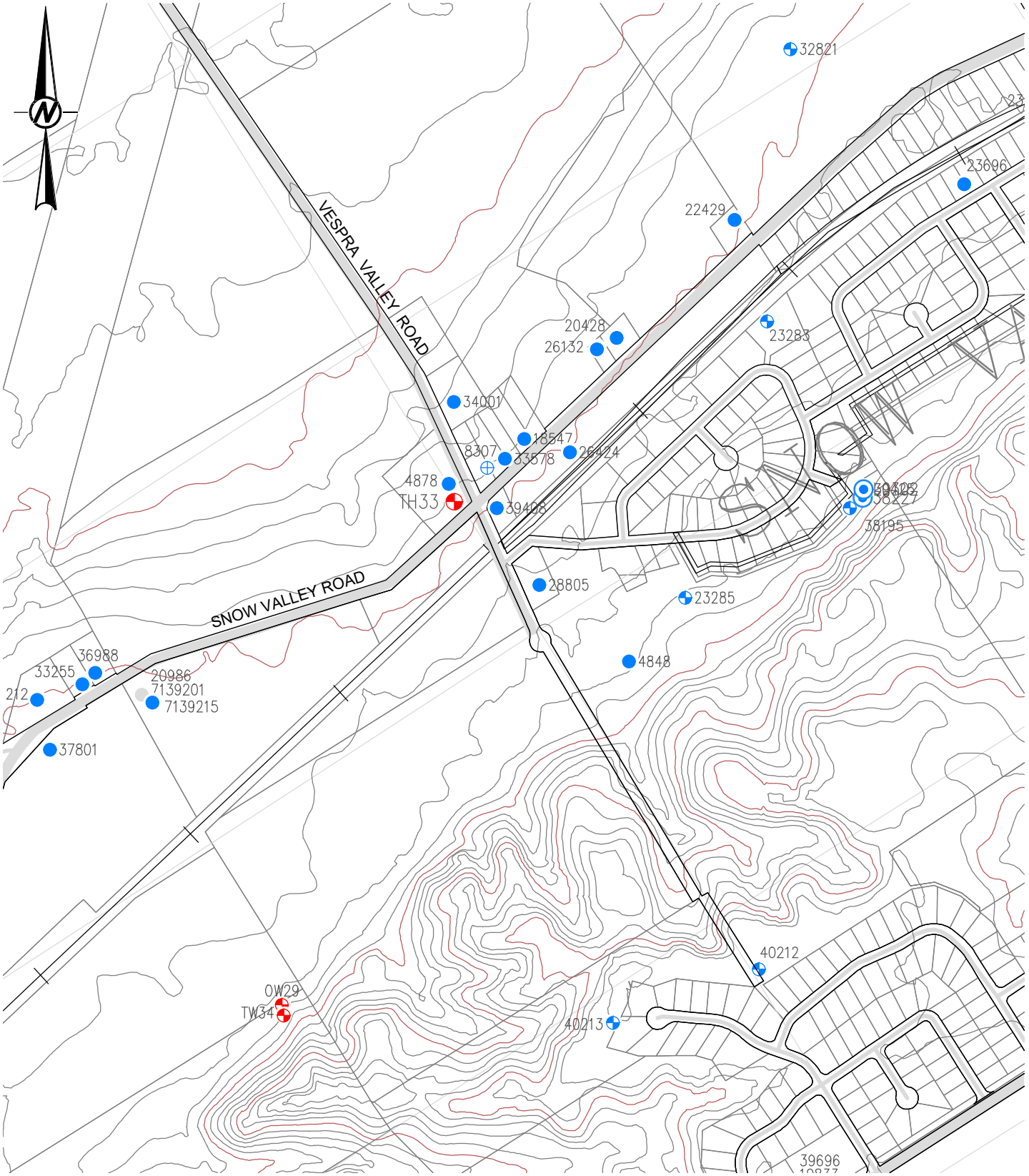
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SITE LOCATION MAP
ANNE STREET

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE
A-5

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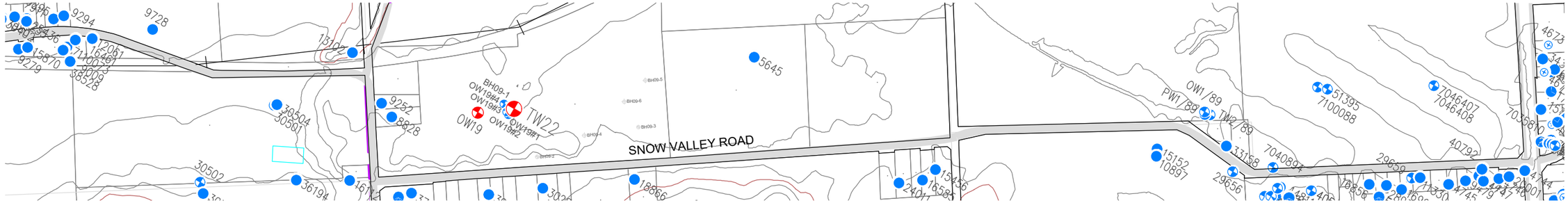
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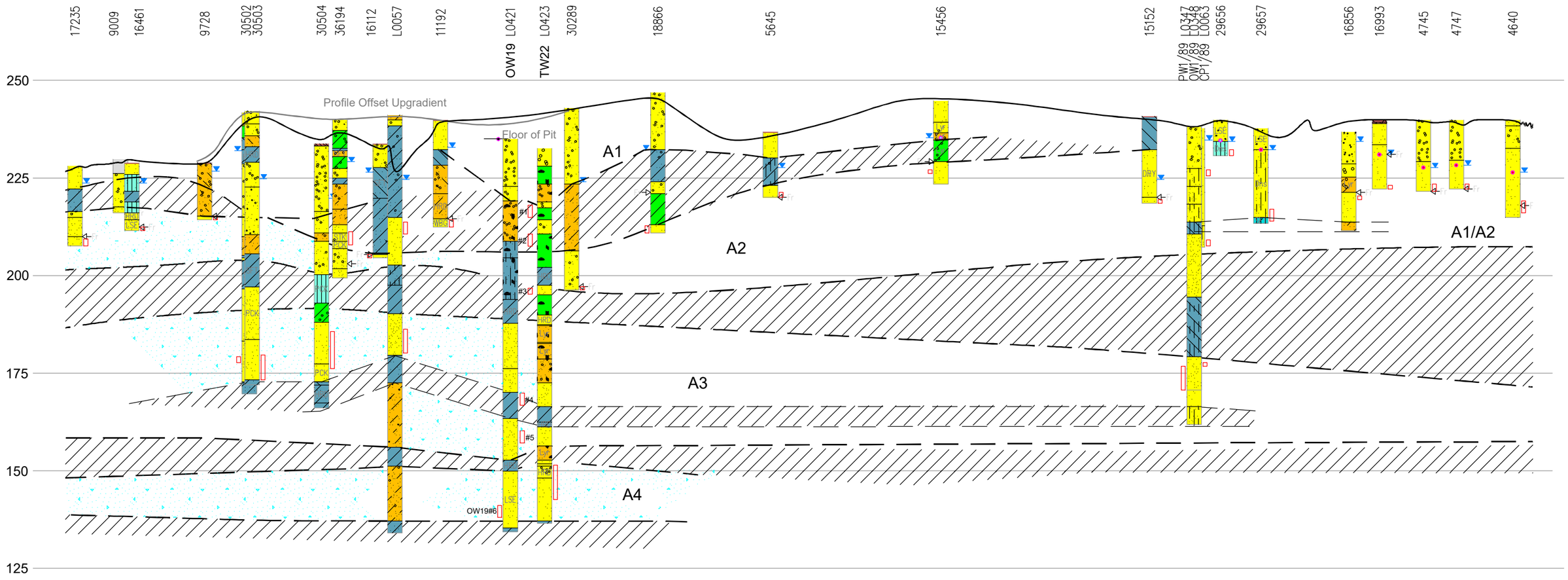
SITE LOCATION MAP
SNOW VALLEY ROAD (WEST)

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE **A-6**

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Refer to Figure A-13 for Legend and Notes

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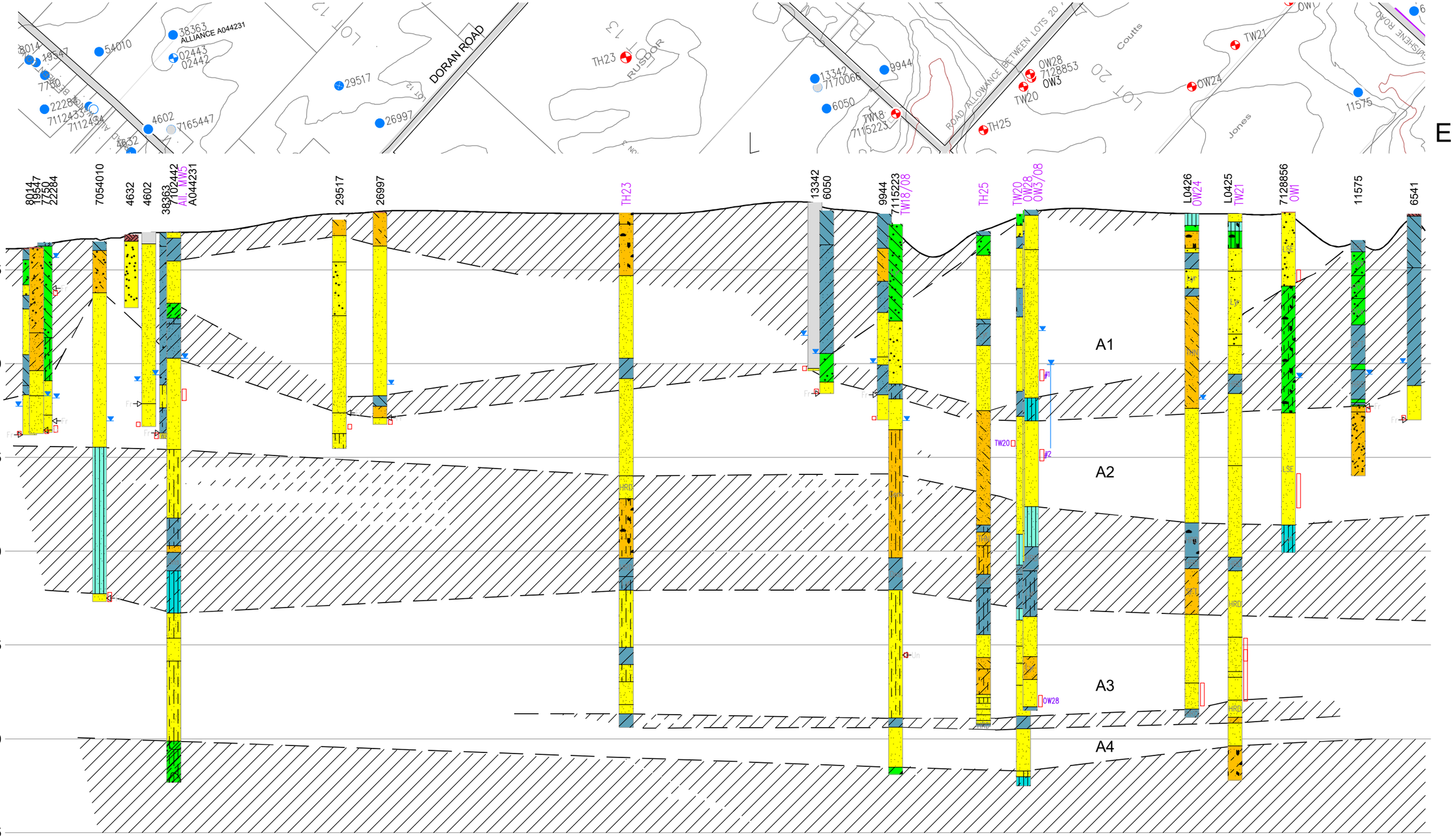
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HYDROGEOLOGICAL SECTION A - A'

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE **A-7**

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Refer to Figure A-13 for Legend and Notes

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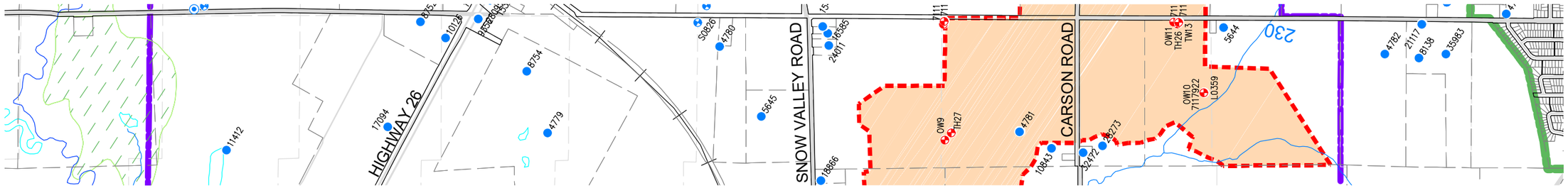
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HYDROGEOLOGICAL SECTION B - B'

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE
A-8

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S

34381 34379 11412 | 17094 | 8752 | 10126 | 9356 | 8754 | 4779 | S0826 | 4780 | 5645 | 15456 16585 | OW9 OW8 | 4781 | 10843 | 32472 | 28273 | 7117924 L0428 | 7117922 | 5644 | 4782 | 8138 21117 | 9829 | 4757

MIDHURST COMMUNITY LIMITS

SITE

OGS BH31 (Offset) | TW22 (Offset) L0423 | TH27 (Offset) | OW11 TH26 | OW10

OW9#1 OW8 OW9#2

GRADE AT OW9 & TH27

SA

A1

A1 / A2

A2

A3

A4

TW13

Offset

ELEVATION: metres above Sea-level

275 250 225 200 175 150

0 200 500 1000 1500

SCALE 1:20000 metres

Plotted Tabloid 11X17

Refer to Figure A-13 for Legend and Notes

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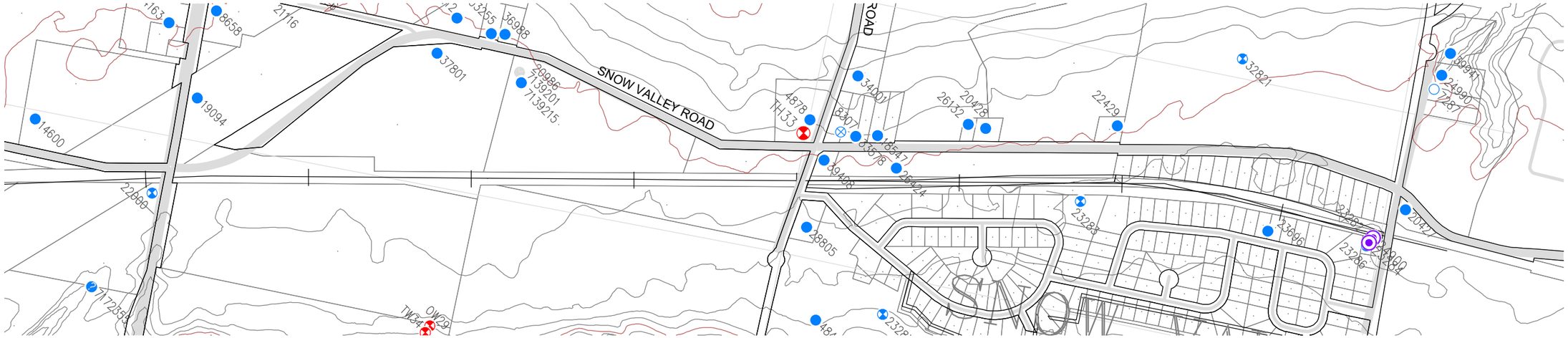
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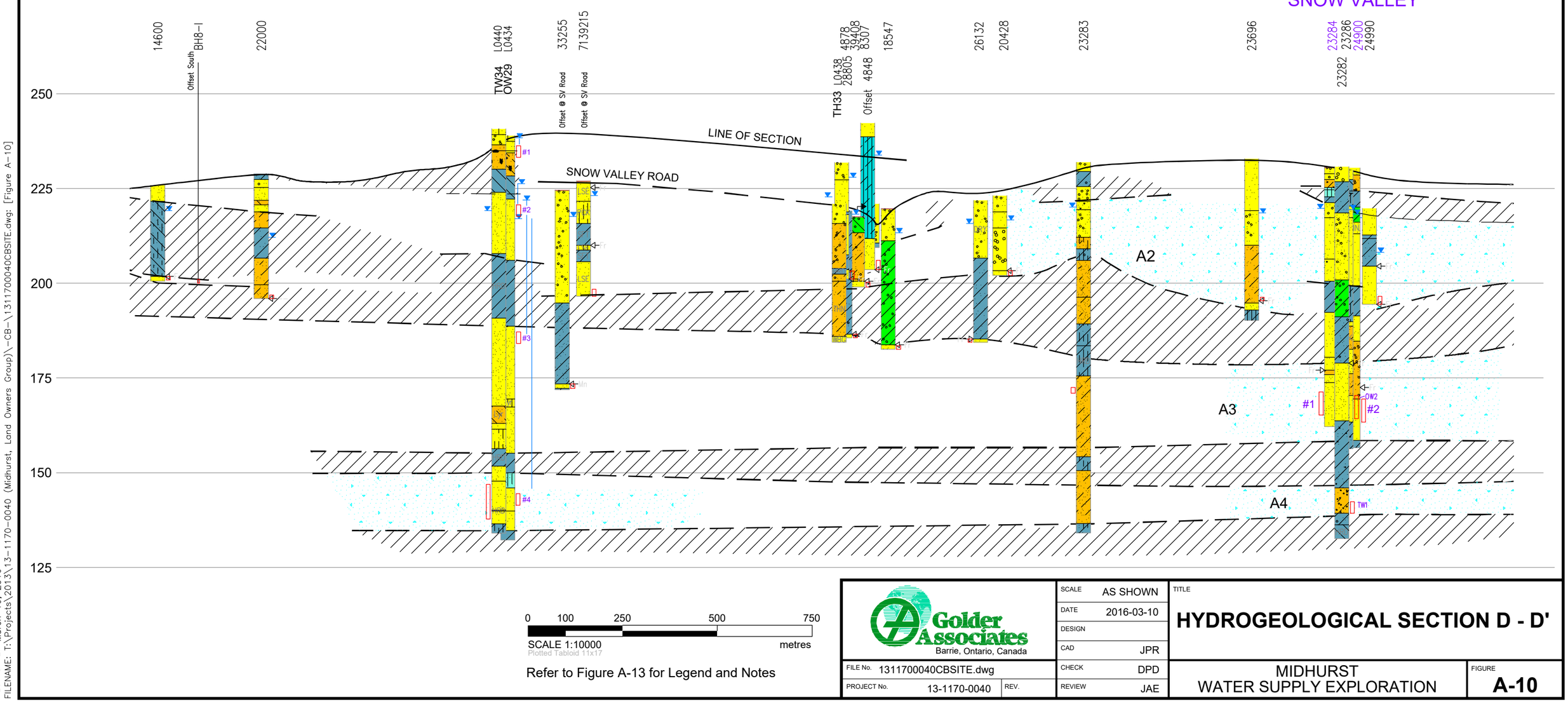
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MIDHURST
WATER SUPPLY EXPLORATION

FIGURE **A-9**

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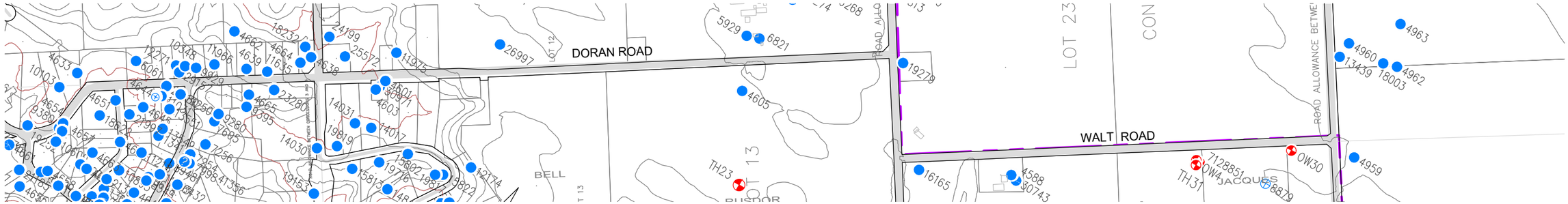
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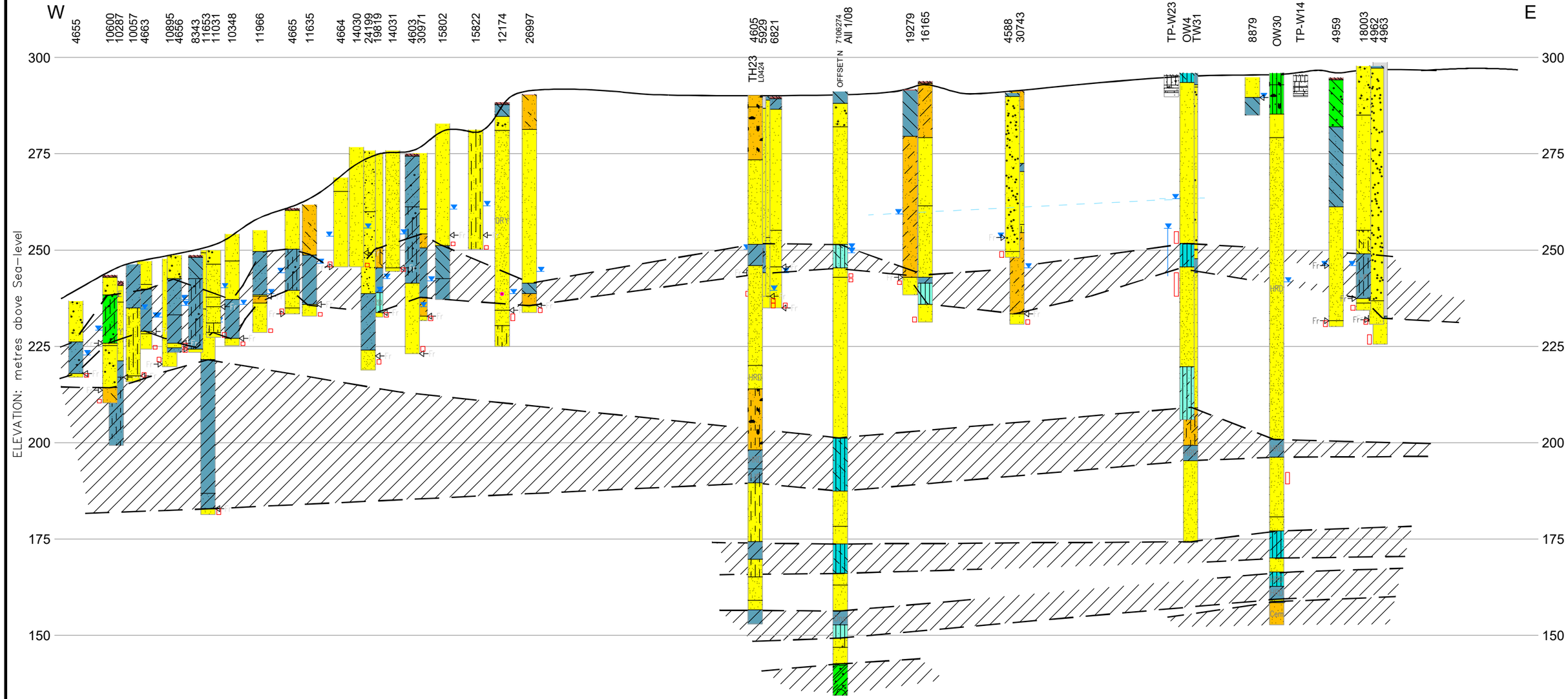
Plotted Tabloid 11x17

Refer to Figure A-13 for Legend and Notes

Golder Associates Barrie, Ontario, Canada	SCALE AS SHOWN	TITLE	
	DATE 2016-03-10	**HYDROGEOLOGICAL SECTION D - D'**	
	DESIGN		
	CAD JPR		
FILE No. 1311700040CBSITE.dwg	CHECK DPD		
PROJECT No. 13-1170-0040 REV.	REVIEW JAE	MIDHURST WATER SUPPLY EXPLORATION	FIGURE **A-10**

PLOT DATE: March 10, 2016
FILENAME: I:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-CB-\1311700040CBSITE.dwg: [Figure A-10]





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SCALE 1:10000 metres

Plotted Tabloid 11x17

Refer to Figure A-13 for Legend and Notes

Golder Associates
Barrie, Ontario, Canada

FILE No.	1311700040CBSITE.dwg
PROJECT No.	13-1170-0040
REV.	
SCALE	AS SHOWN
DATE	2016-03-10
DESIGN	
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CHECK	DPD
REVIEW	JAE

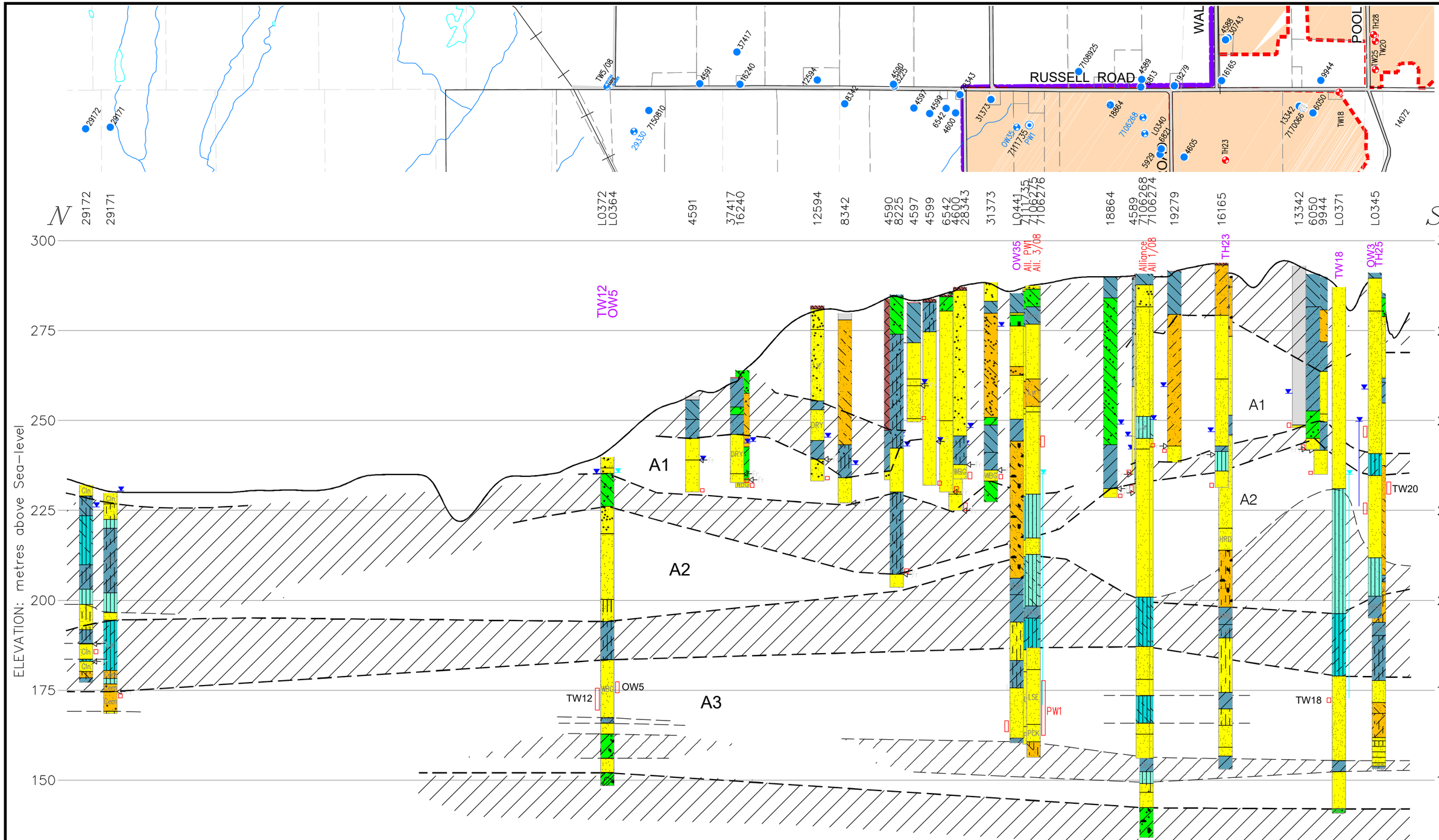
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HYDROGEOLOGICAL SECTION E - E'

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE **A-11**

PLOT DATE: March 10, 2016
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-CB-\1311700040CBSITE.dwg: [Figure A-11]



Refer to Figure A-13 for Legend and Notes

PLOT DATE: March 10, 2016
FILENAME: I:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-CB-\1311700040CBAREA.dwg

Golder Associates
Barrie, Ontario, Canada

FILE No.	1311700040CBAREA.dwg
PROJECT No.	13-1170-0040
REV.	

SCALE	AS SHOWN
DATE	2014-10-01
DESIGN	
CAD	JPR
CHECK	
REVIEW	

TITLE

HYDROGEOLOGICAL SECTION F - F'

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE
A-12

STRATIGRAPHIC PATTERN

- Unoxidized CLAY, Blue, Grey, White, or Undefined CLAY
- Oxidized CLAY, Brown, Red, Yellow
- SILT
- SAND
- GRAVEL
- STONES, Rounded GRAVEL, PEBBLES
- BOULDER
- TILL
- SHALE
- DOLOSTONE
- LIMESTONE
- CRYSTALLINE ROCK

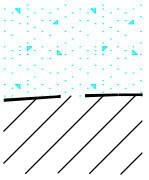
GENERIC MATERIALS

- UNKNOWN OR PREVIOUSLY DUG
- PEAT/LOAM
- SANDS & GRAVELS
- GRANULAR TILL
- SILT
- SILT CLAYEY
- CLAY
- TILL
- LIMESTONES
- SHALES
- PRECAMBRIAN

	SECONDARY/ SOME	TRACE	MINOR	
Clayey				Clay
Silty				Silt
Sandy				Granular

- Screen
- Recorded Static Water Level
- Water Producing Zone
- Flowing Well
- 23453 MOE Recorded Private Well

STRATIGRAPHY (see Notes)



AQUIFER

HYDROSTRATIGRAPHIC CONTACT

CONFINING MATERIAL

MAP SYMBOLS

- Shallow Dug or Bored <10 m
- Deep Bored Well >10 m
- Drilled Overburden Well
- Test or Observation Well
- Test Pit
- Drilled Bedrock Well
- Sandpoint
- Municipal / Public Supply

NOTES

On all sections, boundaries between soil strata have been determined only at well and test well locations. Between the wells and test wells, boundaries are not proven but are assumed from geological evidence.

Wells are located to MOE Water Well Bulletin Data. Locations and elevations are subject to field verification.

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-07-04
DESIGN	
CAD	JPR
CHECK	
REVIEW	

TITLE

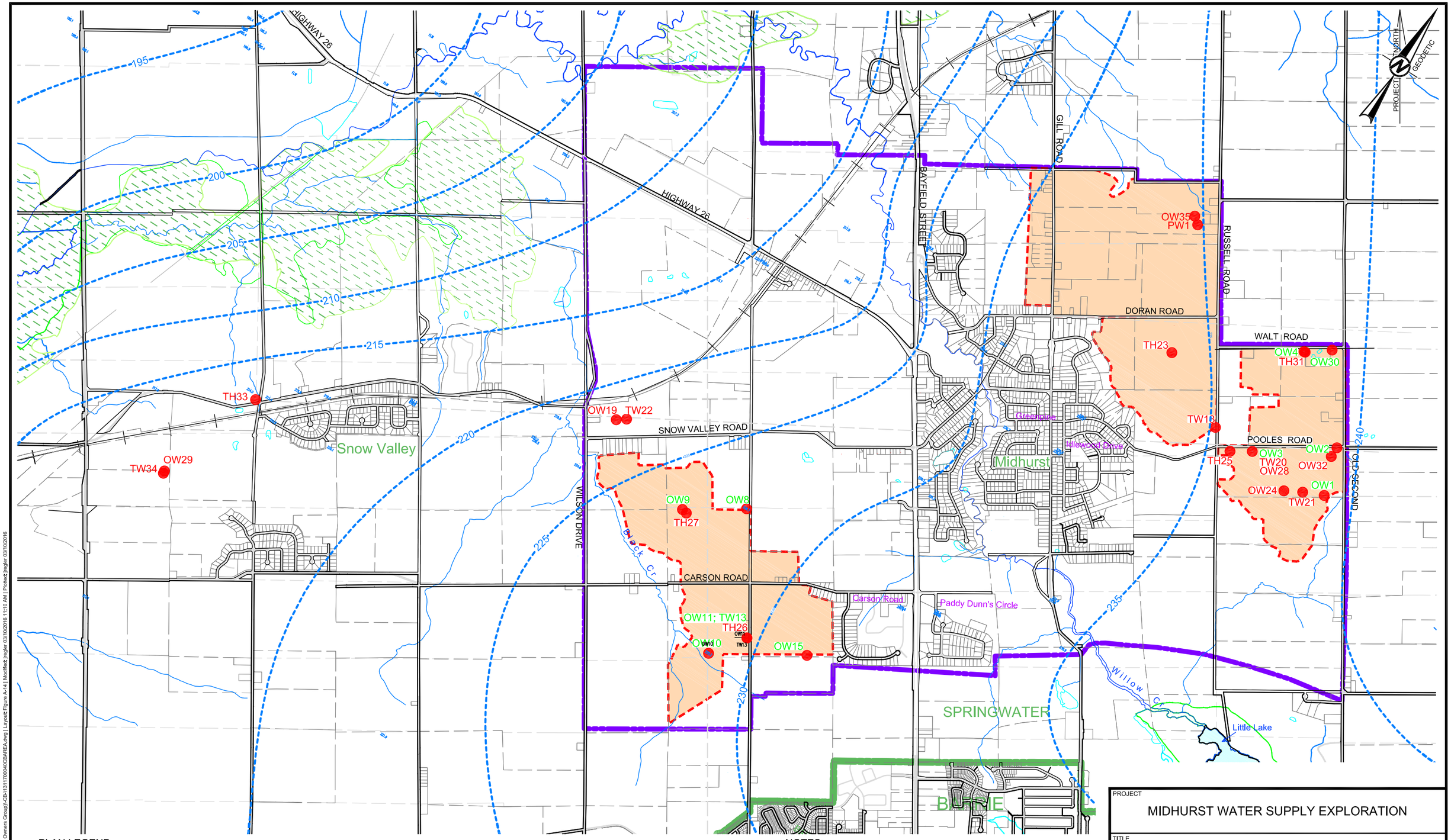
HYDROGEOLOGICAL SYMBOLS

FILE No. 1311700040CBSITE.dwg
PROJECT No. 13-1170-0040 REV.

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE
A-13

PLOT DATE: October 1, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-CB-\1311700040CBSITE.dwg: [Figure A-13]



PLAN LEGEND

- Existing Municipal / Public Supply Well
- Proposed Municipal Well Site
- Proposed Development
- Midhurst Growth Area Boundary
- Municipal Boundary
- Lower Aquifer Equipotential Line (masl)

NOTES:

1. Base Mapping from Terenet Mapping 2009
2. Development Plan Geranium Corporation 2013
3. Mapped features are approximate and Not to Scale
4. Lower Aquifer Potentiometric Surface, Golder 2007 Tier 3 Groundwater Studies

0 200 500 1000 2000

SCALE 1:30000 metres

Plotted 11x17 Landscape

PROJECT

MIDHURST WATER SUPPLY EXPLORATION

TITLE

EQUIPOTENTIAL SURFACE
LOWER AQUIFERS

Golder Associates

PROJECT No.	13-1170-0040		FILE No.	1311700040CBAREA
DESIGN			SCALE	AS SHOWN
CADD	JPR	2016-03-10	FIGURE	
CHECK	DPD	2016-03-10		A-14
REVIEW	JAE	2016-03-10		

T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)-CB\13117700040CBAREA.dwg | Layout: Figure A-14 | Modified: jregler 03/10/2016 11:10 AM | Plotted: jregler 03/10/2016

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
4585	1 16	Jul-67	604973 4921695	286.8	3.7	-			4.0	9			4608 BR	WS DO	**MOE# 5704585** 0.0 TPSL 0.3 GRVL 1.2 MSND 4.0
4587	2 21	Nov-64	603719 4923275	292.9	49.4	Fr	51.2	-1.2	44.8	14	60	45.1	5510 CT	WS DO	**MOE# 5704587** 0.0 TPSL 0.3 CLAY 7.3 CLAY MSND STNS 8.2 CLAY MSND 21.6 MSND 43.6 CLAY MSND HPAN 49.4 MSND 53.6
4588	2 22	Aug-64	602814 4923524	290.8	37.5	Fr	41.1	-1.5	37.5	45	120	40.2	1510 CT	WS ST	**MOE# 5704588** 0.0 BRWN CLAY 0.9 GRVL MSND 41.1 CSND 42.7
4589	2 24	Sep-67	602378 4923800	290.8	61.0	Fr	58.8	-1.8	48.8	91	90	51.8	1510 CT	WS ST	**MOE# 5704589** 0.0 TPSL CLAY TPSL 0.9 BRWN CLAY 15.2 CSND 51.8 CLAY MSND HPAN 57.9 CSND 61.0
4597	3 10	Apr-66	601566 4924784	282.9	23.2	Fr	31.7	-0.9	22.6	32	120	27.4	3203 CT	WS ST	**MOE# 5704597** 0.0 TPSL 0.3 BRWN CLAY 11.3 BRWN MSND 21.3 FSND 23.2 FSND MSND 32.3 FSND 33.2
4598	3 10	Jul-60	600352 4924239	278.0	46.3	Fr	46.3	-2.4	36.6	68	120	38.1	1510 CT	WS ST	**MOE# 5704598** 0.0 BRWN CLAY BLDR 9.1 WHTE CLAY HPAN 30.5 FSND 33.5 BLUE CLAY 42.7 CSND 48.8
4599	3 10	Sep-66	601587 4924694	283.8	39.6	Fr	50.6	-1.2	39.6	45	120	43.3	1510 CT	WS ST	**MOE# 5704599** 0.0 TPSL 0.9 HPAN 9.1 CSND 51.8
4600	3 11	Jun-66	601668 4924574	285.9	61.0	Fr	58.8	-2.1	42.7	45	120	44.2	1510 CT	WS ST	**MOE# 5704600** 0.0 TPSL CLAY TPSL 0.6 BRWN CLAY STNS 25.9 HPAN STNS 42.7 FSND 56.4 MSND 61.0
4601	3 12	Jun-60	601374 4922948	276.8	28.7	Fr	27.4	-1.2	19.5	23	120	25.6	1510 CT	WS DO	**MOE# 5704601** 0.0 RED MSND 7.6 GRVL 22.9 CSND 28.7
4602	3 12	Jun-65	600970 4923311	285.0	45.7	Fr	50.6	-1.2	39.6	45	120	42.1	1510 CT	WS ST	**MOE# 5704602** 0.0 PRDG 3.0 FSND 45.7 CSND 51.8
4603	3 12	May-66	601364 4922918	274.9	51.8	Fr	50.0	-1.2	39.6	23	120	44.2	1510 CT	WS DO	**MOE# 5704603** 0.0 TPSL 0.6 CLAY MSND STNS 13.7 HPAN 33.5 MSND 51.8
4604	3 13	Jun-55	601679 4922249	244.4	10.7	Fr	11.6	-1.2	4.0	27	90	5.5	1510 JT	WS DO	**MOE# 5704604** 0.0 MSND 2.4 CLAY LMSN 5.2 BLUE CLAY 10.7 BLDR GRNT 12.8
4605	3 13	Jun-65	602140 4923369	289.9	45.7	Fr	50.6	-1.2	39.6	45	120	42.7	1510 CT	WS ST	**MOE# 5704605** 0.0 PRDG 3.0 FSND 38.1 HPAN 45.7 CSND 51.8
4606	3 15	Nov-64	602503 4921247	235.6	11.0	Fr	11.0	-1.2	3.7	14	120	9.1	1510 CT	WS DO	**MOE# 5704606** 0.0 TPSL MSND 0.9 RED MSND STNS 4.0 QSND 11.0 FSND 12.2
4607	3 15	Jul-66	602497 4921307	236.8	9.1	Fr	11.0	-0.9	5.2	27	60	10.1	2514 CT	WS DO	**MOE# 5704607** 0.0 MUCK 0.6 MSND 6.1 CSND GRVL 6.4 YLLW MSND 11.6 CLAY 12.2
4627	4 9	Jul-58	599421 4923634	239.0	24.4	Fr			9.1	14	720	21.3	1419 DM	WS DO	**MOE# 5704627** 0.0 TPSL 0.6 MSND 21.3 QSND 24.4
4628	4 9	Jun-66	599358 4923765	238.7	4.3	Fr			3.7	9			4608 BR	WS DO	**MOE# 5704628** 0.0 FSND 6.7

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
4629	4 10	Sep-64	599844 4923125	249.9	13.7	Fr	14.0	-1.2	9.1	18	480	12.8	1510 CT	WS DO	**MOE# 5704629** 0.0 BRWN CLAY MSND 1.2 HPAN 13.7 FSND 15.2
4630	4 10	Jul-66	599575 4923354	241.7	13.1	Fr			13.1	9			4608 BR	WS DO	**MOE# 5704630** 0.0 FSND 16.2
4631	4 11	Jan-52	600589 4923754	279.8	44.8	Fr	43.6	-4.3	36.9	209	30	37.8	5510 CT	WS DO	**MOE# 5704631** 0.0 TPSL 1.2 CLAY STNS 4.3 MSND CLAY 14.6 MSND 27.1 CLAY 32.9 CLAY MSND 43.0 MSND 47.9
4632	4 11	Apr-56	600910 4923264	284.4					NR				1637 CT	AS -	**MOE# 5704632** 0.0 TPSL 1.8 GRVL 19.5
4633	4 12	Jan-59	600712 4922583	253.0	12.2	Fr			12.2	32	180	13.4	1510 JT	WS DO	**MOE# 5704633** 0.0 CLAY 12.2 CSND 19.8
4634	4 11	Nov-61	600340 4922566	243.8	28.0	Fr	28.0	-1.8	20.7	68	120	22.6	1510 CT	WS PU	**MOE# 5704634** 0.0 GRVL MSND STNS 4.0 HPAN BLDR 13.7 BLUE CLAY STNS 25.9 HPAN STNS 28.0 GRVL 29.9
4635	4 12	Aug-62	600617 4922353	239.9	25.6	Fr	26.2	-1.2	16.5	159	120	18.3	1510 CT	WS DO	**MOE# 5704635** 0.0 MSND GRVL 4.6 HPAN MSND 25.6 CSND 27.4
4636	4 12	Mar-64	600510 4922462	243.8	22.9	Fr			16.8	14	120	19.8	1510 CT	WS PU	**MOE# 5704636** 0.0 RED MSND STNS 3.0 MSND CLAY STNS 16.8 HPAN 22.9 GRVL 24.4
4637	4 11	Jun-64	600953 4923213	285.0	42.7	Fr	50.0	-1.2	42.7	45	60	44.5	1510 CT	WS DO	**MOE# 5704637** 0.0 BRWN CLAY 1.2 GRVL HPAN 50.0 CSND 51.2
4638	4 11	Oct-66	601187 4922906	271.9	39.3	Fr	44.8	-0.9	36.6	23	120	38.1	4715 CT	WS ST	**MOE# 5704638** 0.0 PRDG 2.4 CLAY MSND 39.3 FSND 45.7
4639	4 11	Dec-67	601065 4922801	260.9	8.8	Fr	8.8	-0.9	4.6	18	120	9.8	2514 CT	WS DO	**MOE# 5704639** 0.0 TPSL MSND 0.3 YLLW MSND BLDR 9.8 FSND CLAY 12.8 BRWN CLAY 14.6
4640	4 12	Jul-51	600646 4921717	239.9	21.9	Fr	20.7	-3.0	13.4	18	90	14.9	5510 CT	WS DO	**MOE# 5704640** 0.0 FSND 1.5 MSND GRVL 7.3 MSND 25.0
4641	4 12	Sep-53	600980 4922400	246.9	15.8	Fr	21.0	-1.2	7.3	23	60	10.4	1637 JT	WS DO	**MOE# 5704641** 0.0 MSND 7.6 SILT 15.2 CLAY 15.8 FSND 20.7 CSND 22.3
4642	4 12	Jun-56	600950 4922068	237.7	17.7	Fr			3.4	36	120	5.5	1510 JT	WS DO	**MOE# 5704642** 0.0 CLAY 3.4 HPAN 9.8 BLUE CLAY 22.9
4643	4 12	Aug-58	600470 4922210	229.8	15.2	Fr			15.2	32	120	16.5	1510 JT	WS DO	**MOE# 5704643** 0.0 TPSL 1.8 GRVL 11.6 CSND 19.5
4644	4 12	Aug-59	600907 4922629	249.9	9.1	Fr	11.3	-1.8	8.2	18	120		1510 JT	WS DO	**MOE# 5704644** 0.0 BRWN CLAY 9.1 CSND 13.1
4645	4 12	Aug-59	600894 4922592	249.9	16.5	Fr	16.5	-1.8	9.4	27	120		1510 JT	WS DO	**MOE# 5704645** 0.0 BRWN FSND 18.3
4646	4 12	Apr-61	600980 4922366	243.8	24.4	Fr	22.6	-1.8	12.2	45	120		1510 JT	WS DO	**MOE# 5704646** 0.0 RED MSND 4.3 CLAY MSND 15.2 CSND 24.4
4647	4 12	May-61	601011 4921953	236.8	17.7	Fr	15.8	-1.8	11.6	18	120		1510 JT	WS DO	**MOE# 5704647** 0.0 GRVL 9.8 FSND 15.2 CSND 17.7

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
4648	4 12	Aug-62	600541 4922389	240.8	14.9	Fr	17.4	-1.5	9.4	45	120	11.6	1637 CT	WS DO	**MOE# 5704648** 0.0 BRWN CLAY 1.8 GREY CLAY 9.8 CLAY MSND 14.9 MSND 18.9
4649	4 12	Aug-62	600968 4922275	237.7	19.2	Fr	19.5	-1.2	12.8	23	120	14.6	1510 CT	WS DO	**MOE# 5704649** 0.0 FSND 3.7 HPAN CLAY 19.2 CSND 20.7
4650	4 13	Apr-65	600659 4921693	240.8	22.6	Fr	21.3	-1.2	15.2	23	120	18.3	1510 CT	WS DO	**MOE# 5704650** 0.0 RED MSND 0.6 GRVL STNS 12.2 FSND 22.6
4651	4 12	Aug-65	600827 4922573	248.1	19.2	Fr	18.0	-1.2	11.9	23	120	14.6	4715 CT	WS DO	**MOE# 5704651** 0.0 MSND 7.6 CLAY 17.7 CSND 18.0 CLAY MSND 18.3 FSND CSND 19.2
4652	4 12	Feb-65	600896 4922340	242.9	62.2	Fr	62.2	-0.9	9.8	45	120	44.8	2514 CT	WS DO	**MOE# 5704652** 0.0 MSND 0.9 MSND CLAY 21.3 BLUE CLAY FSND 45.1 BLUE CLAY 56.4 WHTE MSND SILT 62.2 MSND 63.1
4653	4 12	Aug-65	600851 4922392	246.0	17.7	Fr	19.8	-1.2	13.1	23	180	14.3	4715 CT	WS DO	**MOE# 5704653** 0.0 PRDG 11.0 MSND 17.7 FSND 21.0
4654	4 12	Sep-65	600745 4922459	247.2	16.2	Fr	19.2	-1.2	15.8	23	720	15.8	4715 CT	WS DO	**MOE# 5704654** 0.0 MSND 15.8 GRVL 16.2 MSND 20.4
4655	4 12	Feb-66	600731 4922272	236.8	18.9	Fr	18.9	-0.9	14.0	23	180	15.2	4715 CT	WS DO	**MOE# 5704655** 0.0 MSND GRVL BLDR 10.7 CLAY MSND GRVL 18.9 MSND 19.8
4656	4 12	Mar-66	600888 4922490	248.7	22.9	Fr	22.9	-1.2	13.1	18	240	19.8	4715 CT	WS DO	**MOE# 5704656** 0.0 MSND GRVL 6.1 CLAY MSND 15.5 GREY CLAY 22.9 FSND 24.1 CLAY MSND 25.3
4657	4 12	Jul-66	600742 4922444	244.8	18.0	Fr	18.0	-0.9	9.1	27	330	17.7	2514 CT	WS DO	**MOE# 5704657** 0.0 TPSL 0.3 MSND GRVL BLDR 6.1 GREY FSND 9.1 BLUE CLAY 18.0 MSND 19.8
4658	4 12	Aug-66	600771 4922339	242.9					NR				4715 CT	AS -	**MOE# 5704658** 0.0 CLAY GRVL 11.0 GRVL BLDR 12.8 CLAY MSND 17.4 CLAY 24.1 CLAY SILT 28.7 MSND SILT 31.4 CLAY 33.5
4659	4 12	Aug-66	600758 4922329	242.9	17.4	Fr	19.8	-0.9	17.4	23	120	17.7	4715 CT	WS DO	**MOE# 5704659** 0.0 MSND GRVL 13.1 MSND 13.4 MSND GRVL 17.4 FSND CSND 20.7
4660	4 12	Dec-66	601062 4922417	246.9	19.8	Fr	20.1	-0.9	7.6	23	120	10.7	4715 CT	WS DO	**MOE# 5704660** 0.0 MSND 1.2 BRWN CLAY BLDR 10.7 BRWN CLAY MSND 12.2 MSND 21.0
4661	4 12	May-67	600657 4922346	237.4	18.9	Fr	18.6	-1.2	14.6	9	120	18.0	3203 CT	WS DO	**MOE# 5704661** 0.0 TPSL 0.6 BRWN CLAY MSND 5.5 CLAY MSND STNS 18.9 MSND 19.2 MSND GRVL CLAY 19.8
4662	4 12	Jun-67	600993 4922866	264.9	22.9	Fr	21.6	-1.2	12.2	36	120	18.3	1510 CT	WS DO	**MOE# 5704662** 0.0 TPSL MSND 3.7 CLAY MSND 12.2 HPAN 20.7 CSND 22.9

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
4663	4 12	Oct-67	600843 4922433	245.4	18.3	Fr	21.9	-0.9	14.6	27	180	19.8	3203 CT	WS DO	**MOE# 5704663** 0.0 YLLW MSND 6.1 GREY MSND 7.3 GREY CLAY 18.3 FSND 18.9 GREY MSND 22.9
4664	4 12	Sep-67	601171 4922881	268.8	23.2	Fr	21.9	-1.2	15.2	23	60	18.3	1510 CT	WS DO	**MOE# 5704664** 0.0 RED MSND 3.7 CSND 23.2
4665	4 12	Sep-67	601102 4922750	260.9	27.4	Fr	26.2	-1.2	16.8	45	60	19.8	1510 CT	WS PU	**MOE# 5704665** 0.0 TPSL MSND 0.6 MSND 10.7 HPAN CLAY 21.3 FSND 25.9 CSND 27.4
4666	4 13	Jul-53	600986 4921851	238.0	15.8	Fr	18.3	-1.2	12.2	45	60	16.8	1637 JT	WS DO	**MOE# 5704666** 0.0 GRVL MSND 15.2 FSND 18.3 CSND 19.8
4667	4 13	Jul-54	601023 4921723	237.7	15.5	Fr	17.1	-1.2	13.4	36	60	15.2	1637 JT	WS DO	**MOE# 5704667** 0.0 TPSL MSND 0.9 CSND 9.8 GRVL MSND CLAY 13.4 FSND 17.1 MSND CSND 18.3
4668	4 13	Sep-54	601078 4921880	235.6	14.9	Fr	17.4	-1.2	14.9	27	120	16.2	1637 JT	WS DO	**MOE# 5704668** 0.0 FSND 5.2 CSND GRVL 13.1 GRVL CLAY 14.6 FSND 17.1 CSND 18.6
4669	4 13	Sep-55	600709 4921700	239.9	12.8	Fr			10.4	32	120	12.2	1510 JT	WS DO	**MOE# 5704669** 0.0 GRVL 3.7 CSND 25.6
4670	4 13	Sep-55	600911 4921635	239.0	11.6	Fr	20.7	-2.4	10.4	27	120	12.5	1510 JT	WS DO	**MOE# 5704670** 0.0 GRVL 6.1 MSND 23.2
4671	4 13	Oct-56	601093 4921737	234.4	12.2	Fr	19.8	-3.0	11.6	27	60	12.2	1510 JT	WS DO	**MOE# 5704671** 0.0 MSND 22.9
4672	4 13	Apr-58	601092 4921934	235.0	13.1	Fr			13.1	23	120	14.6	1510 JT	WS DO	**MOE# 5704672** 0.0 GRVL 7.9 TPSL MSND 12.2 CSND 18.3
4673	4 13	Sep-58	600749 4921564	239.9	9.8	Fr	13.4	-1.8	9.8	32	120	10.7	1510 JT	WS DO	**MOE# 5704673** 0.0 GRVL 9.8 MSND 15.2
4674	4 13	Sep-58	600853 4921403	239.9	10.4	Fr	12.2	-1.8	9.4	27	120	10.7	1510 JT	WS CO	**MOE# 5704674** 0.0 GRVL 10.4 CSND 14.0
4675	4 13	Oct-60	600944 4921708	239.0	17.7	Fr	15.8	-1.8	11.6	23	60		1510 JT	WS DO	**MOE# 5704675** 0.0 GRVL 12.2 CSND 17.7
4676	4 13	Dec-60	600773 4921502	239.9	17.7	Fr	15.8	-1.8	11.6	27	60		1510 JT	WS DO	**MOE# 5704676** 0.0 GRVL 10.4 CSND 17.7
4677	4 13	Oct-61	600787 4921511	239.9	16.5	Fr	16.5	-1.8	12.2	23	120		1510 JT	WS DO	**MOE# 5704677** 0.0 CSND 10.7 MSND 18.3
4678	4 13	Oct-61	600875 4921430	239.9	19.8	Fr	19.5	-1.2	8.5	55		10.4	1637 CT	WS DO	**MOE# 5704678** 0.0 MSND 19.8 CSND 20.7
4679	4 13	Oct-62	601062 4922290	239.9	1.2	Fr			NR				1510 CT	WS DO	**MOE# 5704679** 0.0 BRWN CLAY 1.2 CSND 4.9 QSND 33.5
4680	4 13	May-63	601312 4922245	239.9	16.5	Fr	15.2	-1.2	3.0	23	60		1510 JT	WS DO	**MOE# 5704680** 0.0 MSND TPSL 3.0 MSND CLAY 15.2 CSND 16.5
4681	4 13	Sep-63	600984 4921810	237.7	19.8	Fr	18.6	-1.2	12.2	23	60	15.2	1510 CT	WS DO	**MOE# 5704681** 0.0 RED MSND 12.2 FSND 19.8
4682	4 13	Jan-65	601299 4922228	239.9	16.5	Fr	16.8	-0.9	2.4	23	120	5.5	1510 CT	WS DO	**MOE# 5704682** 0.0 TPSL 1.8 RED MSND 16.5 CSND 17.7

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
4683	4 13	Apr-65	600967 4921752	239.0	13.1	Fr	17.7	-1.8	13.1	23	120	15.2	1626 DM	WS DO	**MOE# 5704683** 0.0 PRDG 12.5 GRVL 15.8 GREY MSND 19.5
4684	4 13	Jun-65	600876 4921433	239.9	15.8	Fr	17.4	-1.2	11.3	23	120	14.6	4715 CT	WS DO	**MOE# 5704684** 0.0 GRVL 6.1 FSND 15.8 FSND CSND 18.6
4685	4 13	Jun-66	600860 4921527	239.9	19.5	Fr	18.3	-1.2	12.2	23	120	16.8	1510 CT	WS PU	**MOE# 5704685** 0.0 TPSL 0.3 RED MSND 9.1 CSND 12.2 FSND 19.5
4686	4 13	Jun-66	600888 4921472	239.9	18.9	Fr	17.7	-1.2	12.2	23	120	15.2	1510 CT	WS DO	**MOE# 5704686** 0.0 TPSL 0.3 GRVL 9.1 MSND 18.9
4687	4 13	Jun-67	601389 4922193	239.9	24.4	Fr	23.2	-1.2	3.7	23	120	15.2	1510 CT	WS DO	**MOE# 5704687** 0.0 TPSL 0.3 RED TPSL 12.2 CLAY MSND 15.2 FSND 21.3 MSND 24.4
4688	4 14	Sep-54	601162 4920950	235.0	16.2	Fr	14.9	-1.2	4.9	14	120	10.7	5510 CT	WS DO	**MOE# 5704688** 0.0 MSND 16.2
4689	4 14	May-56	601059 4921122	237.1	20.7	Fr			7.9	14	120	8.2	5510 CT	WS DO	**MOE# 5704689** 0.0 MSND GRVL HPAN 18.9 MSND 20.7
4690	4 14	Aug-59	600974 4921221	236.8	11.0	Fr	13.4	-1.8	11.0	14	120		1510 JT	WS DO	**MOE# 5704690** 0.0 GRVL 12.2 MSND 15.2
4691	4 14	Nov-59	600967 4921265	236.8	14.9 8.2	Fr Fr	14.9	-1.8	8.2	32	120	9.1	1510 JT	WS DO	**MOE# 5704691** 0.0 GRVL 16.8
4692	4 14	Nov-59	601105 4921077	235.9	18.3	Fr	16.5	-1.8	6.1	18	120	7.6	1510 CT	WS DO	**MOE# 5704692** 0.0 GRVL 6.1 MSND 18.3
4693	4 14	Aug-60	601292 4920819	234.7	10.4	Fr	11.3	-1.5	4.0	14	180	8.5	1637 CT	WS DO	**MOE# 5704693** 0.0 MSND 4.6 GREY CLAY STNS 10.4 FSND 12.8
4694	4 14	Jul-62	601832 4921754	235.9	13.4	Fr	11.6	-1.8	6.1	23	120		1510 JT	WS DO	**MOE# 5704694** 0.0 RED MSND 1.8 GRVL MSND 11.6 MSND GRVL 13.4
4695	4 14	Sep-64	601006 4921950	236.8	18.0	Fr	18.0	-1.2	11.0	14	120	11.0	4715 CT	WS DO	**MOE# 5704695** 0.0 MSND 2.4 CSND FSND 7.0 MSND SILT GRVL 19.2 GREY CLAY 21.3
4696	4 14	Jul-65	601169 4920980	234.7	4.9	Fr	15.2	-1.5	4.9	18	120	6.4	1626 DM	WS DO	**MOE# 5704696** 0.0 TPSL 0.3 RED MSND 1.5 GREY FSND 13.7 GREY MSND 16.8
4697	4 14	Sep-65	601189 4920916	234.7	4.6	Fr	13.1	-1.8	3.7	18	120		1626 DM	WS DO	**MOE# 5704697** 0.0 PRDG 4.3 GREY FSND 9.1 GREY MSND STNS 12.8 GREY CSND 15.2
4698	4 14	Dec-65	601237 4920973	234.7	5.2	Fr	14.3	-1.5	5.2	23	240	8.2	1626 DM	WS DO	**MOE# 5704698** 0.0 PRDG 2.4 GREY MSND 13.7 GREY CSND STNS 16.8
4699	4 15	Aug-57	602176 4921262	234.7	16.8	Fr			2.4	23	120	3.7	5510 CT	WS DO	**MOE# 5704699** 0.0 TPSL MSND 0.3 MSND 11.6 CLAY STNS 15.5 MSND 19.2
4700	4 15	Apr-58	601286 4920780	234.7	9.4 3.4	Fr Fr			2.1	23	180	3.7	1510 JT	WS CO	**MOE# 5704700** 0.0 FSND 3.4 QSND 5.5 CLAY 9.4 GRVL 12.2

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
4701	4 15	Aug-61	601375 4920755	234.7	13.7	Fr	13.7	-2.4	1.5	23	180		1510 JT	WS DO	**MOE# 5704701** 0.0 FSND 13.7 CSND 16.2
4702	4 15	Jul-62	601791 4921064	230.7	13.4	Fr	12.5	-1.2	7.6	9	60	11.9	2514 CT	WS DO	**MOE# 5704702** 0.0 FSND 13.7 BLUE CLAY 15.5
4703	4 15	Apr-65	601374 4920654	234.7	2.4	Fr	8.8	-1.8	2.4	27	270	4.6	1626 DM	WS DO	**MOE# 5704703** 0.0 TPSL 0.3 GRVL 1.8 GREY CLAY 7.3 CSND 10.7
4704	4 15	May-65	602056 4921479	236.8	17.4	Fr	17.4	-0.9	3.0	64	90	13.7	2514 CT	WS DO	**MOE# 5704704** 0.0 FILL 0.3 MSND 10.7 BLUE CLAY STNS 16.8 MSND 18.6
4705	4 15	Jul-65	601822 4921326	234.7	18.9 13.4	Fr Fr	20.4	-0.9	3.0	68	60	15.8	2514 CT	WS DO	**MOE# 5704705** 0.0 PRDR 13.4 MSND 15.8 BLUE CLAY 18.9 FSND MSND 21.3
4706	4 15	Mar-68	601322 4920741	234.7	24.4	Fr	23.2	-1.2	0.6	45	60	18.3	1510 CT	WS CO	**MOE# 5704706** 0.0 TPSL 0.3 RED MSND 3.7 CLAY MSND 12.2 BLUE CLAY 21.3 CSND 24.4
4707	5 16	Jul-65	601418 4920153	245.1	21.3	Fr	23.2	-1.2	12.2	18	120	18.9	1510 CT	WS DO	**MOE# 5704707** 0.0 FSND 9.1 FSND CLAY 21.3 MSND 24.4
4710	4 17	Apr-55	602001 4919736	269.7	48.8 12.2	Fr Fr			22.9	14	5760	45.7	2529 CT	WS ST	**MOE# 5704710** 0.0 MSND 36.6 GRVL 37.8 MSND 71.6 GRVL CSND 73.2
4735	5 9	Jul-63	599419 4923439	237.4	6.1	Fr	23.2	-0.9	5.5	14	120	22.9	4816 CT	WS DO	**MOE# 5704735** 0.0 RED MSND 2.7 BLUE CLAY 3.7 GREY FSND 27.4
4736	5 9	Jun-67	599421 4923244	212.8	25.0	Fr	23.8	-1.2	12.8	45	120	18.9	1510 CT	WS DO	**MOE# 5704736** 0.0 TPSL MSND 6.4 MSND CLAY 12.2 FSND 21.3 CSND 25.0
4737	5 11	May-52	599160 4921941	233.8	19.2	Fr	19.2	-3.4	12.2	23	30	12.8	5510 CT	WS DO	**MOE# 5704737** 0.0 TPSL MSND 0.3 FSND 19.2 MSND 22.6
4738	5 11	Oct-59	598949 4921903	229.8	5.8	Fr	10.4	-1.2	5.8	23	180	6.7	1510 JT	WS DO	**MOE# 5704738** 0.0 MSND 1.8 FSND 11.6
4739	5 11	Mar-64	599142 4921721	233.8	19.5	Fr	17.7	-1.8	10.4	23	60		1510 JT	WS DO	**MOE# 5704739** 0.0 RED MSND 11.0 FSND 19.5
4740	5 11	Nov-66	599343 4921971	235.9	24.4	Fr	23.2	-1.2	12.2	45	60	13.7	1510 CT	WS DO	**MOE# 5704740** 0.0 TPSL 0.3 RED MSND 7.6 CLAY MSND 21.3 MSND 24.4
4741	5 12	Jun-62	599685 4921958	240.8	28.7	Fr	26.8	-1.8	16.5	18	120		1510 JT	WS PU	**MOE# 5704741** 0.0 GRVL 21.3 FSND 28.7
4742	5 14	Jul-56	600926 4920905	235.0	23.5	Fr	20.4	-3.0	2.4	14	120	7.0	5510 CT	WS PU	**MOE# 5704742** 0.0 TPSL 0.3 MSND GRVL 11.6 CLAY MSND BLDR 19.2 MSND 23.5
4743	5 14	Sep-59	600764 4921207	239.9	15.2	Fr			9.1	23	120	10.7	1419 CT	WS DO	**MOE# 5704743** 0.0 PRDG 8.8 GRVL 11.9 FSND 15.2 GRVL 16.5

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
4744	5 14	Jan-60	600853 4921274	239.9	12.2	Fr	16.5	-1.8	10.7	18	120	12.2	1510 JT	WS CO	**MOE# 5704744** 0.0 CSND GRVL 12.2 MSND 18.3
4745	5 14	Feb-60	600711 4921153	239.9	18.3	Fr	16.5	-1.8	12.2	23	180	12.8	1510 JT	WS DO	**MOE# 5704745** 0.0 GRVL 10.7 CSND 18.3
4746	5 14	Oct-60	600809 4921226	239.9	16.2	Fr	15.2	-0.9	11.6	45	60	12.8	1510 CT	WS DO	**MOE# 5704746** 0.0 GRVL 12.2 CSND 16.2
4747	5 14	Dec-60	600780 4921202	239.9	17.7	Fr	16.5	-1.2	11.6	45	120	13.7	1510 CT	WS DO	**MOE# 5704747** 0.0 GRVL 10.4 CSND 17.7
4748	5 15	May-66	600927 4919921	266.7			15.2	-1.2	11.6	18	120	13.7	4715 CT	WS DO	**MOE# 5704748** 0.0 MSND 14.9 FSND 16.5 MSND SILT 18.0
4749	5 16	Nov-51	601798 4919738	275.8	28.7	Fr	27.7	-3.4	19.2	18	30	31.1	5510 CT	WS ST	**MOE# 5704749** 0.0 PRDG 15.2 MSND 31.1
4750	5 16	Sep-65	601450 4920165	245.1	18.3	Fr	26.2	-1.2	12.2	23	120	18.3	1510 CT	WS DO	**MOE# 5704750** 0.0 BRWN CLAY 0.9 BRWN CLAY STNS 15.2 FSND 18.3 MSND 27.4
4751	5 16	Jun-66	600871 4919860	271.9	20.4	Fr	20.7	-1.2	16.8	18	120	18.3	4715 CT	WS DO	**MOE# 5704751** 0.0 MSND 16.5 CLAY MSND 20.4 FSND 21.9 MSND 22.3
4752	5 16	Sep-67	600760 4919805	275.2	30.5	Fr	29.3	-1.2	22.9	45	60	24.4	1510 CT	WS DO	**MOE# 5704752** 0.0 TPSL 0.9 CLAY MSND 11.6 FSND 25.9 CSND 30.5
4777	6 8	May-52	596735 4922632	194.8	3.7	Fr			FLW				5510 CT	WS ST	**MOE# 5704777** 0.0 TPSL 0.6 MSND CLAY STNS 4.0 BLUE CLAY 19.5 CLAY MSND 36.6
4778	6 11	Jan-59	599010 4921933	230.7	14.3	Fr	13.4	-0.9	7.0	32	120	13.7	2514 CT	WS DO	**MOE# 5704778** 0.0 PRDG 6.1 MSND 14.3
4779	6 11	Feb-59	598498 4921373	210.9	40.8	Fr			-3.0	114	90	4.6	2514 CT	WS DO	**MOE# 5704779** 0.0 TPSL 0.3 MSND 1.2 BLCK MUCK FSND CLAY 33.2 FSND 35.4 BLUE CLAY 39.6 MSND 40.2 GRVL 40.8
4780	6 13	Oct-67	599282 4920915	239.9	18.9	Fr			16.8	9			4608 BR	WS CO	**MOE# 5704780** 0.0 MSND 18.9
4781	6 15	Dec-67	599715 4919511	271.0	27.4	Fr	28.3	-1.8	21.3	36	120	25.9	1510 CT	WS ST	**MOE# 5704781** 0.0 TPSL 0.6 BRWN CLAY 5.8 HPAN 27.4 CSND 30.5
4818	7 9	Sep-51	596940 4921859	219.8	21.3	Fr	20.1	-2.4	17.4	9	30	18.0	5510 CT	WS ST	**MOE# 5704818** 0.0 PRDG 10.7 MSND 15.8 CLAY GRVL 19.5 MSND 23.8
4819	7 9	Oct-58	596167 4921693	199.9	10.4	Fr	10.1	-1.8	5.8	32	180	7.0	1510 JT	WS DO	**MOE# 5704819** 0.0 BRWN CLAY 1.8 BLUE CLAY 10.4 GRVL 11.9
4820	7 10	Jun-59	597015 4921778	221.0	19.8	Fr	16.2	-3.7	12.5	14	120	13.1	5510 CT	WS DO	**MOE# 5704820** 0.0 TPSL 0.3 MSND 1.2 MSND CLAY STNS 2.7 MSND CLAY 4.3 BLUE CLAY MSND BLDR 16.2 MSND 19.8

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
4821	7 14	Dec-66	598509 4919541	246.9	30.5	Fr	29.3	-1.2	16.8	45	120	19.8	1510 CT	WS ST	**MOE# 5704821** 0.0 TPSL 0.6 BRWN CLAY 4.9 HPAN BLDR 28.0 CSND 30.5
4822	7 16	Sep-57	599195 4918411	289.0	22.9	Fr			18.3	23		30.5	2529 CT	WS ST	**MOE# 5704822** 0.0 FSND 36.6 CSND 38.1
4824	7 16	Aug-61	599305 4918390	285.9	36.6	Fr	30.5	-3.7	22.3	273	1200	25.9	1413 CT	WS ST	**MOE# 5704824** 0.0 CLAY STNS 6.1 MSND GRVL 22.3 MSND 36.6
4848	8 14	Jan-65	596266 4918298	242.3	38.7	Fr	36.3	-2.4	8.5	36	240	21.3	3414 CT	WS CO	**MOE# 5704848** 0.0 BRWN MSND 3.7 SILT CLAY 30.5 FSND 38.7
4878	9 13	May-67	595932 4918627	219.2	32.6	Fr	32.6	-0.9	0.9	9	120	19.8	4715 CT	WS DO	**MOE# 5704878** 0.0 CLAY MSND 15.8 MSND 16.2 CLAY MSND GRVL 32.6 MSND GRVL 33.5
4952	1 17	Oct-59	604813 4922101	286.2					NR				1510 JT	AS -	**MOE# 5704952** 0.0 BLUE CLAY 82.3
4953	1 17	Oct-59	604768 4922133	289.0					NR				4102 CT	AS -	**MOE# 5704953** 0.0 BLUE CLAY 30.5
4954	1 17	Sep-63	604718 4922118	287.7	12.8	Fr	11.6	-1.2	6.1	91	120	6.7	1510 CT	WS ST	**MOE# 5704954** 0.0 CLAY 6.1 MSND 10.7 CSND 12.8
4959	1 22	Dec-64	603517 4923986	294.7	63.1 48.8	Fr Fr	63.1	-1.5	48.8	23	240	61.0	1510 CT	WS ST	**MOE# 5704959** 0.0 TPSL 0.6 BRWN CLAY STNS 12.8 BRWN CLAY MSND 33.5 FSND 63.1 MSND 64.6
4960	1 23	Aug-55	603364 4924221	297.8	62.8	Fr	61.3	-1.5	46.9	23	60	49.7	5510 CT	WS ST	**MOE# 5704960** 0.0 TPSL 0.3 MSND GRVL STNS 52.4 BLUE CLAY 57.6 QSND 58.8 GRVL 62.8
4993	2 16	Nov-58	604837 4921693	286.8					NR				5510 CT	AS -	**MOE# 5704993** 0.0 BRWN CLAY STNS MUCK 26.8 MSND 28.7 HPAN 29.3 BRWN CLAY MSND 42.7
4994	2 17	May-56	604678 4922031	283.8	9.1	Fr			1.2	23	120	4.3	2529 CT	WS DO	**MOE# 5704994** 0.0 CLAY 1.2 CLAY MSND 9.1 GRVL 9.8
5644	6 17	May-68	600652 4918971	278.0	25.3	Fr	30.5	-0.9	17.4	36	90	30.2	2514 CT	WS DO	**MOE# 5705644** 0.0 FILL 0.3 BRWN CLAY MSND 3.7 CSND 21.3 FSND CLAY 25.3 YLLW FSND 31.4
5645	6 14	Jun-68	599112 4920571	236.8	16.8	Fr	15.5	-1.2	9.1	45	120	15.2	1510 CT	WS DO	**MOE# 5705645** 0.0 TPSL 0.3 MSND 6.7 HPAN 13.7 CSND 16.8
5648	4 12	Feb-68	600992 4922451	249.9	15.8	Fr	20.7	-1.8	12.2	36	120	18.3	3203 CT	WS DO	**MOE# 5705648** 0.0 TPSL 0.3 CLAY MSND 5.5 YLLW MSND 14.0 GREY CLAY MSND 15.8 GREY FSND 22.6 CLAY 22.9
5929	3 12	Apr-70	602082 4923491	289.9	51.8	Fr	53.6 52.4	-1.2 -1.2	50.3	45	120	50.3	1510 CT	WS ST	**MOE# 5705929** 0.0 BRWN CLAY TPSL 0.9 GREY MSND 36.6 GREY FSND 51.8 GREY CSND 54.9
5997	4 13	May-68	601262 4922221	239.9	13.7	Fr	17.1	-0.9	12.5	18	120	14.3	1204 CT	WS DO	**MOE# 5705997** 0.0 MSND GRVL 18.0 GREY CLAY 18.3

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
5998	6 15	Jun-68	599412 4918981	270.1	24.7	Fr	27.4	-0.9	NR	32	120		1204 CT	WS DO	**MOE# 5705998** 0.0 CLAY MSND BLDR 4.0 CLAY GRVL 24.7 MSND GRVL CLAY 26.8 MSND 28.3
5999	5 14	Jun-68	600582 4921041	239.9	10.7	Fr	14.3	-0.9	7.9	18	120	11.6	1204 CT	WS DO	**MOE# 5705999** 0.0 GRVL 10.7 MSND 15.2 GREY CLAY 15.5
6006	4 14	Aug-68	601147 4921316	229.8	10.1	Fr	16.2	-1.8	7.9	32	60	9.1	1204 CT	WS DO	**MOE# 5706006** 0.0 TPSL 0.3 MSND GRVL 7.9 CSND 18.0
6044	5 16	Apr-68	600862 4919821	272.8	24.4	Fr	23.2	-1.2	15.2	23	120	19.8	1510 CT	WS DO	**MOE# 5706044** 0.0 TPSL 0.3 RED MSND 14.9 CLAY MSND 21.9 MSND 24.4
6045	5 16	Jan-68	601472 4920192	244.4	30.5	Fr	29.3	-1.2	6.1	23	120	18.3	1510 CT	WS DO	**MOE# 5706045** 0.0 HPAN STNS 27.4 CSND 30.5
6048	5 16	Jun-68	601052 4919914	260.0	15.2	Fr	12.8	-2.4	11.6	14	120	12.8	1510 CT	WS DO	**MOE# 5706048** 0.0 TPSL 0.3 MSND 9.1 CLAY MSND 15.2
6050	3 14	May-68	602732 4922896	290.8	48.8	Fr	47.5	-1.2	38.1	45	120	47.2	1510 CT	WS ST	**MOE# 5706050** 0.0 BRWN CLAY 9.1 CLAY MSND 38.1 BLUE CLAY STNS 45.7 CSND 48.8
6051	4 10	May-68	599861 4923001	243.8	19.8	Fr	18.6	-1.2	13.7	45	120	16.8	1510 CT	WS DO	**MOE# 5706051** 0.0 TPSL MSND 0.3 RED MSND STNS 17.7 CSND 19.8
6057	3 15	Oct-68	602162 4921481	237.7	12.2	Fr	11.0	-1.2	4.6	27	60	9.1	1510 CT	WS DO	**MOE# 5706057** 0.0 TPSL 0.6 BRWN CLAY MSND 10.7 MSND 12.2
6059	3 15	Nov-68	602112 4921521	236.8	14.6	Fr	13.4	-1.2	4.6	45	60	6.7	1510 CT	WS DO	**MOE# 5706059** 0.0 TPSL 0.6 MSND 10.7 CSND 14.6
6061	4 11	Dec-68	600822 4922681	253.9	19.8	Fr	18.6	-1.2	9.1	50	60	15.2	1510 CT	WS CO	**MOE# 5706061** 0.0 TPSL 1.5 BRWN CLAY MSND 12.2 FSND 15.2 CSND 19.8
6220	5 9	Feb-69	599491 4923391	237.7	18.3	Fr	17.1	-1.2	10.7	18	60	16.8	1510 CT	WS DO	**MOE# 5706220** 0.0 OBDN 1.5 RED MSND 13.7 FSND 18.3
6236	4 13	Apr-69	600792 4921521	239.9	12.2	Fr	14.3	-0.9	10.1	23	120	10.7	1204 CT	WS DO	**MOE# 5706236** 0.0 TPSL 0.3 MSND GRVL 3.7 MSND 15.2
6239	4 13	Apr-69	601512 4922371	249.9	11.9	Fr	14.3	-0.9	6.7	18	120	11.0	1204 CT	WS DO	**MOE# 5706239** 0.0 MSND 6.4 BRWN CLAY 9.1 GREY CLAY 11.9 MSND 15.2
6280	4 14	May-69	601212 4921051	234.7	57.9 54.9	Fr Fr	56.1	-2.4	3.4	227	1440	14.6	4816 CT	WS DO	**MOE# 5706280** 0.0 FSND 9.1 GREY CLAY SILT 32.3 GREY CLAY 45.4 SILT 52.1 FSND 57.0 MSND 58.5
6432	4 12	Jul-69	601062 4922471	253.0	26.5	Fr	26.5	-1.2	4.9	18	120	7.3	1204 CT	WS DO	**MOE# 5706432** 0.0 MSND 14.0 GREY CLAY 25.6 SILT 26.5 FSND 27.7
6541	1 19	May-69	604312 4922741	289.9	54.9	Fr	53.6	-1.2	39.6	45	120	45.7	1510 CT	WS DO	**MOE# 5706541** 0.0 TPSL CLAY 0.6 BRWN CLAY 14.3 BLUE CLAY 45.7 CSND 54.9

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
6542	3 11	Aug-69	601661 4924631	285.0	54.9	Fr	53.3	-1.5	41.1	45	120	47.2	1510 CT	WS ST	**MOE# 5706542** 0.0 TPSL CLAY 0.6 CLAY STNS 4.6 CSND 35.1 MSND 54.9
6548	5 16	May-69	600812 4919821	274.9	27.4	Fr	26.2	-1.2	18.3	23	60	21.3	1510 CT	WS DO	**MOE# 5706548** 0.0 TPSL 0.3 RED MSND 20.4 FSND CLAY 24.4 MSND 27.4
6552	1 16	Jun-69	604962 4921721	287.7	61.0	Fr	58.5	-2.4	36.6	45	120	48.8	1510 CT	WS DO	**MOE# 5706552** 0.0 TPSL 0.6 BRWN CLAY STNS 9.1 HPAN 54.9 CSND 61.0
6588	9 16	Aug-69	595612 4916521	292.9	41.5	Fr	42.7	-2.7	41.8	14	150	41.8	1204 CT	WS DO	**MOE# 5706588** 0.0 FILL GRVL 0.9 BRWN MSND GRVL CLAY 18.6 GREY GRVL MSND 29.9 GREY MSND 45.7
6589	4 13	Aug-69	600620 4921750	239.9	13.4	Fr	20.1	-0.9	12.5	23	75	14.0	1204 CT	WS DO	**MOE# 5706589** 0.0 MSND GRVL 6.1 MSND 21.0
6593	6 15	Aug-69	599462 4919021	268.8	21.9	Fr	25.9	-1.2	14.0	18	60	19.8	1204 CT	WS DO	**MOE# 5706593** 0.0 BRWN CLAY MSND 0.3 GREY MSND CLAY BLDR 6.1 GREY MSND CLAY 19.8 GREY GRVL MSND CLAY 20.4 BRWN MSND CLAY 21.9 BRWN MSND SILT 29.0 BLUE CLAY MSND 35.1
6594	5 15	Sep-69	600642 4919821	276.8	23.8	Fr	29.0	-0.9	20.4	18	60	23.8	1204 CT	WS DO	**MOE# 5706594** 0.0 BRWN FILL 0.9 MSND CLAY 5.5 MSND 30.2 SILT 32.0
6620	4 13	Aug-69	601412 4922211	239.9	22.3	Fr	23.8	-0.9	1.8	23	60	15.2	3203 CT	WS DO	**MOE# 5706620** 0.0 TPSL 0.3 MSND 11.9 CLAY 15.8 MSND CLAY 16.5 CLAY 22.3 MSND GRVL 24.1 MSND 24.7
6813	2 24	Sep-69	602341 4923781	289.9	54.9	Fr	53.6	-1.2	44.2	45	60	51.8	1510 CT	WS DO	**MOE# 5706813** 0.0 TPSL CLAY 0.6 BRWN CLAY 14.3 BLUE CLAY 30.5 CSND 54.9
6818	4 13	Oct-69	600942 4921621	238.7	19.8	Fr	18.6	-1.2	12.2	23	60	15.2	1510 CT	WS DO	**MOE# 5706818** 0.0 TPSL MSND 0.3 MSND GRVL 15.2 MSND 19.8
6821	3 12	Sep-69	602112 4923501	289.9	54.9 44.2	Fr Fr	53.6	-1.2	45.7	18	60	51.8	1510 CT	WS ST	**MOE# 5706821** 0.0 TPSL CLAY 0.6 CLAY MSND 3.4 CSND 34.7 FSND 44.2 CSND 54.9
6835	3 13	Sep-69	601612 4922341	249.9	23.5	Fr	23.5	-0.9	4.0	36	90	6.7	1204 CT	WS DO	**MOE# 5706835** 0.0 MSND 1.8 GREY MSND CLAY BLDR 7.3 GREY CLAY GRVL BLDR 14.6 GREY CLAY 18.9 GREY CLAY MSND GRVL 23.5 MSND 24.7
6849	4 13	Nov-69	601362 4922241	239.9	21.3	Fr	20.1	-1.2	1.2	23	60	9.1	1510 CT	WS DO	**MOE# 5706849** 0.0 TPSL 0.3 RED MSND 4.6 HPAN CLAY 12.2 MSND CLAY 18.3 CSND 21.3
6929	4 14	Nov-69	600962 4921271	236.8	9.8	Fr	15.2	-0.9	9.8	14	60	12.5	1204 CT	WS DO	**MOE# 5706929** 0.0 PRDG 7.9 BRWN MSND 16.2

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
6959	4 12	Dec-69	600862 4922321	240.8	14.3	Fr	15.5	-1.5	9.4	32	90	12.5	2514 CT	WS DO	**MOE# 5706959** 0.0 FILL 0.6 MSND BLDR 3.4 GREY CLAY BLDR 5.5 YLLW FSND 14.3 GREY MSND 17.1
7052	4 12	Jan-70	600572 4922361	240.8	30.5	Fr	27.4	-3.0	18.3	14	120	24.4	1510 CT	WS DO	**MOE# 5707052** 0.0 RED MSND STNS 19.8 MSND GRVL STNS 27.4 FSND 30.5
7075	4 12	Mar-70	600922 4922351	243.8	18.3	Fr	20.4	-0.9	12.2	27	60	15.2	3203 CT	WS DO	**MOE# 5707075** 0.0 BRWN MSND 9.1 GREY CLAY MSND 17.1 GREY MSND CLAY 18.3 GREY MSND 21.3
7076	4 13	Mar-70	601362 4922171	239.9	15.8	Fr	18.0	-0.9	1.8	9	60	15.8	3203 CT	WS DO	**MOE# 5707076** 0.0 BRWN TPSL 0.3 BRWN MSND 6.1 BRWN MSND GRVL 8.5 GREY MSND CLAY 15.8 GREY MSND GRVL 18.9
7153	6 15	May-70	599012 4919121	264.9	27.4	Fr	25.9	-1.5	15.2	23	120	18.3	1510 CT	WS ST	**MOE# 5707153** 0.0 BRWN CLAY BLDR 9.1 HPAN STNS 21.3 FSND 27.4
7155	8 9	Apr-70	594711 4921121	192.9	27.4	Fr			FLW				1510 CT	WS DO	**MOE# 5707155** 0.0 TPSL MSND 0.3 MSND CLAY 3.7 BLUE CLAY 24.4 FSND 27.4
7209	4 12	Feb-69	600922 4922331	241.7					NR				4715 CT	AS -	**MOE# 5707209** 0.0 GREY CLAY 32.0
7254	4 12	May-70	601052 4922551	255.7	22.3	-	27.7	-0.9	15.2	45	60	18.3	3203 CT	WS DO	**MOE# 5707254** 0.0 BRWN MSND 12.8 BRWN MSND CLAY 16.2 GREY CLAY MSND 22.3 GREY MSND 28.7
7256	4 12	Jun-70	601072 4922591	261.2	26.2	Fr	28.7	-0.9	19.5	27	60	24.1	3203 CT	WS DO	**MOE# 5707256** 0.0 BRWN MSND 14.0 GREY CLAY 25.6 GREY MSND 29.6
7262	8 9	Mar-70	595571 4921361	189.9	23.8	Fr	23.8	-0.9	-4.9	136	120	15.2	2514 CT	WS DO	**MOE# 5707262** 0.0 TPSL 0.3 YLLW MSND CLAY 3.7 GREY CLAY 22.6 YLLW MSND CSND 24.7
7287	7 12	Jun-70	596938 4919690	224.9	9.1 5.5	Fr Fr			5.5	23	60	7.6	4608 BR	WS DO	**MOE# 5707287** 0.0 GREY MSND 9.1
7448	1 24	Jul-70	603071 4924641	299.9	65.5	Fr	67.1	-1.2	54.9	45	120	57.9	1510 CT	WS ST	**MOE# 5707448** 0.0 BRWN TPSL 0.6 CLAY MSND STNS 15.2 HPAN 27.4 GRVL 39.6 CSND 65.5 FSND 68.6
7450	2 21	Aug-70	603632 4923371	292.9	51.8	Fr	50.6	-1.2	42.7	23	60	45.7	1510 CT	WS ST	**MOE# 5707450** 0.0 BRWN CLAY STNS 5.8 BLUE CLAY STNS 27.1 GREY CSND 47.2 CSND 51.8
7492	3 15	Sep-70	602672 4921401	239.0	19.8	Fr	20.7	-1.2	4.9	45	60	7.6	1510 CT	WS DO	**MOE# 5707492** 0.0 BRWN MSND 0.6 GREY CSND 7.0 HPAN STNS 19.8 CSND 21.9
7494	4 10	Sep-70	599841 4922971	240.8	15.2	Fr	18.3	-1.2	12.2	23	60	13.7	1510 CT	WS DO	**MOE# 5707494** 0.0 RED MSND 9.1 GREY CSND GRVL 15.2 CSND 19.8

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
7605	4 12	Oct-70	601062 4922651	259.1	21.6	Fr	29.0	-0.9	21.6	32	60	24.7	3203 CT	WS DO	**MOE# 5707605** 0.0 BRWN MSND CLAY 5.5 BRWN MSND 11.9 GREY CLAY 21.0 GREY CLAY MSND 21.6 BRWN MSND 29.9
7700	4 13	Sep-70	601462 4922221	240.8	21.3	Fr			2.4	45	60	15.2	2514 CT	WS DO	**MOE# 5707700** 0.0 YLLW MSND 16.8 BLUE CLAY MSND GRVL 21.3 GRVL 21.6
7734	4 14	Oct-70	602022 4921501	236.8	11.9	Fr	11.9	-0.9	2.4	68	90	9.1	2514 CT	WS DO	**MOE# 5707734** 0.0 TPSL 0.3 BRWN MSND CLAY SILT 4.3 YLLW MSND 12.8
7735	3 15	Jul-70	602712 4921431	239.9	7.3	Fr	8.2	-0.9	4.9	23	120	7.6	2514 CT	WS DO	**MOE# 5707735** 0.0 TPSL 0.3 RED MSND 1.5 GREY CLAY MSND GRVL 7.3 YLLW MSND 9.1
7750	4 11	Oct-70	600741 4923521	281.9	47.2	Fr	48.5	-1.8	41.1			41.1	1510 CT	WS ST	**MOE# 5707750** 0.0 CLAY TPSL 0.6 BRWN CLAY STNS 25.0 HPAN STNS 36.6 RED MSND 45.7 MSND 50.3
7767	4 14	May-71	601192 4920921	234.7	16.2	Fr	15.2	-0.9	2.4	9	60	14.0	3203 CT	WS DO	**MOE# 5707767** 0.0 BLCK TPSL 0.3 BRWN SAND CLAY 9.8 BRWN SAND 16.2
7839	4 14	Dec-70	601912 4921681	234.7	12.2	Fr	15.2	-1.5	3.7	36	60	6.1	1510 CT	WS DO	**MOE# 5707839** 0.0 RED MSND STNS 4.3 HPAN 13.7 MSND 16.8
7910	3 14	May-71	601982 4921761	235.6	13.4	Fr	13.4	-1.2	3.0	45	60	3.0	1510 CT	WS DO	**MOE# 5707910** 0.0 RED TPSL SAND 0.6 HPAN STNS 9.1 HPAN 12.2 CSND 14.6
7911	7 13	May-71	597552 4919765	226.8	1.2	Fr	13.7	-1.5	4.9	23	60	4.9	1510 CT	WS DO	**MOE# 5707911** 0.0 BRWN CLAY MSND 0.9 MSND STNS 9.1 BLUE CLAY MSND 12.2 MSND 15.2
7948	3 15	May-71	602462 4921281	235.9	9.1	Fr	9.1	-0.9	3.0	14	90	9.1	2514 CT	WS DO	**MOE# 5707948** 0.0 BRWN CSND FSND 9.1 BRWN FSND 10.1
7952	3 15	Apr-71	602162 4921481	237.7	16.8	Fr	17.1	-1.2	3.7	45	60	4.6	1510 CT	WS DO	**MOE# 5707952** 0.0 TPSL SAND 0.3 RED SAND 8.2 HPAN 14.9 CSND 18.3
7980	7 13	Jun-71	597499 4919737	225.6	15.2	Fr	15.2	-1.2	6.1	23	60	6.1	1510 CT	WS DO	**MOE# 5707980** 0.0 MSND 1.2 CLAY MSND STNS 13.7 MSND 16.8
7981	3 13	Jul-71	601492 4922511	260.9	30.5	Fr	31.1	-1.2	21.3	23	60	24.4	1510 CT	WS DO	**MOE# 5707981** 0.0 BRWN TPSL MSND 0.9 WHTE CSND 27.4 MSND 30.5 FSND 32.3
7983	3 15	Jun-71	602112 4921521	236.8	14.9	Fr	14.9	-1.2	3.0	23	60	6.1	1510 CT	WS DO	**MOE# 5707983** 0.0 BRWN TPSL SAND 0.6 RED SAND 6.7 HPAN STNS 13.4 MSND 16.8
7984	3 14	Jun-71	602052 4921631	236.8	12.2	Fr			3.7	23	60	6.1	1510 CT	WS DO	**MOE# 5707984** 0.0 BRWN TPSL 0.6 HPAN 5.8 HPAN GRVL 12.2 MSND 13.7

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7985	3 13	Jul-71	601532 4922471	260.3	29.0	Fr	29.3	-1.2	18.3	45	60	19.8	1510 CT	WS DO	**MOE# 5707985** 0.0 BRWN OBDN MSND 6.4 CSND 25.9 WHTE MSND 30.5
7998	4 12	Apr-71	601062 4922531	254.5	27.4 23.8	Fr Fr	26.5	-0.9	14.3	45	60	17.4	3203 CT	WS DO	**MOE# 5707998** 0.0 BRWN SAND 11.9 GREY CLAY SILT 23.8 GREY SAND 26.2 BRWN SAND 27.4
8006	3 15	Jan-71	602812 4921501	241.7	37.2	Fr	36.9	-0.9	5.5	23	120	22.9	3203 CT	WS DO	**MOE# 5708006** 0.0 BRWN SAND FILL 0.9 BRWN SAND 3.0 BRWN CLAY 4.6 GREY CLAY 19.2 GREY CLAY STNS SILT 37.2 GREY SAND 37.8
8008	4 12	Jun-71	601002 4922341	242.9	15.5	Fr	14.6	-0.9	4.0	23	60	11.3	3203 CT	WS DO	**MOE# 5708008** 0.0 BLCK TPSL 0.6 BRWN SAND 3.0 GREY CLAY SAND 8.8 BRWN SAND 9.4 GREY CLAY 10.7 BRWN SAND 15.5
8014	4 11	Jun-71	600711 4923571	280.7	49.7	Fr	48.8	-0.9	42.1	27	90	42.7	3203 CT	WS DO	**MOE# 5708014** 0.0 BLCK TPSL 0.3 YLLW CLAY 3.0 GREY CLAY STNS 9.8 GREY SAND GRVL 12.5 BRWN CLAY 16.2 BRWN SAND 28.3 BRWN CLAY 36.6 BRWN CLAY SAND 39.0 BRWN SAND 49.7
8135	4 13	Aug-71	601472 4922421	253.9	16.5	Fr	16.5	-1.2	10.7	18	60	15.2	1510 CT	WS DO	**MOE# 5708135** 0.0 RED SAND 4.6 HPAN STNS 12.2 CSND 18.3
8137	1 16	Jul-71	605062 4921621	285.0	45.7	Fr	45.7	-1.2	42.7	45	60	45.7	1510 CT	WS DO	**MOE# 5708137** 0.0 BRWN CLAY TPSL 0.6 BRWN CLAY STNS MSND 8.2 HPAN STNS 25.6 CSND 35.1 WHTE HPAN 45.7 CSND 51.8
8216	4 12	Jun-71	601002 4922271	236.8	19.2	Fr	20.4 19.5	-0.9 -0.9	12.2	27	60	15.8	1204 CT	WS DO	**MOE# 5708216** 0.0 BRWN SAND 11.0 GREY CLAY SAND 19.2 BRWN FSND 21.3
8225	2 27	Sep-71	601611 4924941	285.0	77.7	Fr	76.2	-1.2	42.1	45	60	42.1	1510 CT	WS ST	**MOE# 5708225** 0.0 BRWN CLAY TPSL 0.6 BRWN CLAY STNS 11.0 HPAN SAND 42.7 CSND 54.9 GREY HPAN 77.7 CSND 81.4
8260	5 11	Aug-71	599462 4921971	239.9					12.2	23	90	16.5	3203 CT	WS DO	**MOE# 5708260** 0.0 BLCK TPSL 0.3 YLLW MSND STNS 7.3 GREY MSND 21.0 BRWN MSND CLAY 21.9
8264	5 11	Aug-71	599180 4921807	233.8	6.4	Fr	13.7	-0.9	10.7	18	121	12.8	3203 CT	WS DO	**MOE# 5708264** 0.0 YLLW MSND 6.4 GREY MSND 14.6
8307	8 13	Sep-71	596004 4918656	219.8	8.8	Fr			8.8	14	60	10.4	4608 BR	WS DO	**MOE# 5708307** 0.0 GREY GRVL 10.4 GREY CLAY 11.6
8341	3 15	Oct-71	602162 4921471	237.7	18.3	Fr	17.4	-0.9	3.0	23	60	10.7	1510 CT	WS DO	**MOE# 5708341** 0.0 TPSL 0.3 RED SAND 6.4 CLAY SAND 15.2 CLAY 17.4 CSND 18.3

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8343	4 12	Oct-71	600992 4922441	248.7	24.4	Fr	24.4	-0.9	11.6	23	60	15.2	1510 CT	WS DO	**MOE# 5708343** 0.0 BRWN TPSL 0.6 BRWN CLAY SAND 6.1 HPAN CLAY 24.4 CSND 25.3
8497	4 14	Jun-71	602042 4921521	236.8	7.6	Fr	10.1	-0.9	3.4	27	60	6.7	3203 CT	WS DO	**MOE# 5708497** 0.0 BRWN SAND 11.0
8506	5 16	Oct-71	600972 4919871	266.4	19.8 17.7	Fr Fr	18.9	-0.9	9.1	18	90	15.5	3203 CT	WS DO	**MOE# 5708506** 0.0 YLLW SAND 7.3 GREY SAND 11.9 YLLW SAND CLAY 17.7 GREY SAND 19.8
8540	4 15	Dec-71	602192 4921271	234.7	6.1	Fr			4.3	9	60	6.1	4608 BR	WS DO	**MOE# 5708540** 0.0 BRWN SAND 5.2 GREY CLAY 6.7
8658	9 13	Nov-71	594753 4917849	224.9	7.6	Fr			2.7	32	90	6.1	2514 CT	WS DO	**MOE# 5708658** 0.0 TPSL 0.3 YLLW SAND GRVL BLDR 7.6 GRVL 8.2
8747	4 13	Mar-72	601032 4921691	236.8	13.1	Fr	17.4	-0.9	13.1	18	90	16.2	1204 CT	WS DO	**MOE# 5708747** 0.0 GREY GRVL 9.1 BRWN SAND 18.3
8752	6 10	Mar-72	598611 4922161	224.9	28.0 22.9	Fr Fr	23.2	-4.6	6.1	446	1890	21.6	2402 CT	WS IR	**MOE# 5708752** 0.0 SAND 4.3 HPAN 11.0 MSND 29.0
8753	5 11	Feb-72	599961 4922621	235.0	30.5 27.4	Fr Fr	29.3	-1.2	18.6	91	360	29.0	2402 CT	WS DO	**MOE# 5708753** 0.0 SAND OBDN 8.2 CLAY 16.5 SAND 25.9 MSND 30.8
8754	6 11	Feb-72	598690 4921614	218.8	67.4 64.0	Fr Fr	65.5 64.3	-1.5 -1.2	5.2	191	600	59.7	2402 CT	WS PU	**MOE# 5708754** 0.0 SAND 21.9 CLAY 50.6 FSND 63.7 CSND 65.5 MSND 67.4
8825	4 11	May-72	600041 4922821	241.7	64.3	Fr	63.1	-1.2	13.1	36	120	45.7	3414 CT	WS DO	**MOE# 5708825** 0.0 TPSL 0.3 CLAY SAND GRVL 21.3 CLAY 45.7 SILT 62.5 MSND 64.3
8827	5 11	May-72	599062 4921821	232.0	9.8	Fr	15.5	-1.5	9.1	9	60	14.6	1204 CT	WS DO	**MOE# 5708827** 0.0 BRWN SAND 17.4 GREY SILT SAND 27.4
8828	6 13	Apr-72	598431 4920005	233.8	27.7	Fr	28.0	-0.9	5.8	27	60	10.7	1204 CT	WS DO	**MOE# 5708828** 0.0 BRWN SAND GRVL 3.7 GREY SAND GRVL CLAY 9.1 GREY CLAY SAND 27.7 BRWN SAND 29.0
8879	2 22	Jul-72	603362 4923821	294.7	5.2	Fr			5.2	14	60	7.3	4608 BR	WS DO	**MOE# 5708879** 0.0 GREY SAND 5.2 BRWN CLAY 9.8
8917	4 15	May-72	602062 4921471	236.8	14.6 12.8	Fr Fr	13.7	-0.9	2.4	73	60	12.2	2514 CT	WS DO	**MOE# 5708917** 0.0 YLLW SAND 8.5 BRWN CLAY SAND STNS 12.8 YLLW MSND CSND 14.6
8938	5 16	Jun-72	600922 4919871	269.7	48.8 46.3	Fr Fr	47.9	-0.9	27.4	36	60	33.5	3203 CT	WS DO	**MOE# 5708938** 0.0 BRWN SAND 12.5 BRWN SAND CLAY 15.5 GREY CLAY 42.1 GREY CLAY SAND 43.9 GREY SAND CLAY 46.3 SAND 48.8

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8956	5 16	Apr-72	600932 4919871	268.8	46.6 44.2	Fr Fr	45.7	-0.9	25.9	36	75	32.0	3203 CT	WS DO	**MOE# 5708956** 0.0 BRWN TPSL 0.3 YLLW SAND 6.7 GREY SAND 12.2 YLLW SAND CLAY 16.8 GREY CLAY SILT 32.0 GREY CLAY 40.2 GREY SAND CLAY 44.2 GREY SAND 46.6
8960	3 13	Jun-72	601672 4922211	242.9	21.3 19.5	Fr Fr	20.4	-0.9	3.7	36	60	15.5	3203 CT	WS DO	**MOE# 5708960** 0.0 BRWN SAND 5.5 GREY CLAY 11.6 GREY CLAY STNS 17.1 GREY GRVL SAND CLAY 19.2 GREY CLAY 19.5 GREY SAND 21.3
8966	3 13	Jun-72	601712 4922181	242.9	18.3	Fr	18.9	-0.9	3.0	27	60	13.7	3203 CT	WS DO	**MOE# 5708966** 0.0 BRWN SAND 4.6 GREY CLAY SILT 10.4 GREY CLAY STNS 15.8 GREY GRVL SAND 17.7 GREY CLAY 18.3 GREY SAND 19.8
8976	4 13	Jan-72	601042 4921881	236.8	23.2 15.2	Un Fr	22.3	-0.9	15.2	18	120	18.3	3203 CT	WS DO	**MOE# 5708976** 0.0 TPSL 0.3 BRWN SAND CLAY 2.4 BRWN SAND 23.2
8983	4 13	Apr-72	601062 4921821	235.9	20.7 18.3	Fr Fr	19.8 18.9	-0.9 -0.9	11.6	36	120	19.8	2514 CT	WS PU	**MOE# 5708983** 0.0 BRWN SAND GRVL 7.6 YLLW MSND FSND 20.7
9009	7 13	Jun-72	597666 4919744	229.8	13.7 12.2	Fr Fr	12.5	-1.2	3.7	23	60	6.1	1510 CT	WS DO	**MOE# 5709009** 0.0 PRDG 3.7 SAND STNS 12.2 FSND 13.7
9015	4 13	Jan-72	601122 4922228	237.7	18.3	Fr	18.3	-1.2	3.0	23	60	6.1	1510 CT	WS DO	**MOE# 5709015** 0.0 RED SAND 3.0 RED SAND STNS 7.6 HPAN CLAY 16.8 FSND 19.8
9016	2 17	Jun-72	604562 4922191	283.8					NR				1510 CT	AS -	**MOE# 5709016** 0.0 BRWN CLAY 3.7 HPAN 12.8 BLUE CLAY HPAN 102.7
9114	3 15	Sep-72	602952 4921571	246.9	9.1	Fr			9.1	23	90	14.9	4608 BR	WS DO	**MOE# 5709114** 0.0 GREY SAND 2.1 GREY CLAY STNS 16.5
9116	3 13	Sep-72	601732 4922131	240.8	4.9	Fr			4.9	23	30	6.4	4608 BR	WS DO	**MOE# 5709116** 0.0 GREY SAND 8.5
9252	6 13	Aug-72	598393 4920021	233.8	28.0	Fr	28.3	-0.9	4.6	9	60	25.9	1204 CT	WS DO	**MOE# 5709252** 0.0 BRWN SAND GRVL 3.7 GREY CLAY SAND 28.0 BRWN SAND 29.3
9264	5 11	Oct-72	599810 4922188	242.9	24.4	Fr	24.4	-3.0	18.0	159	120	22.3	4816 RC	WS PU	**MOE# 5709264** 0.0 SAND 13.7 GRVL 14.6 SAND 27.4
9272	4 14	Apr-72	601451 4921941	236.5	21.3	Fr	20.7 18.9	-1.8 -1.8	7.9	218	480	14.3	4816 RC	WS PU	**MOE# 5709272** 0.0 FSND 5.8 MSND FSND 22.6 GREY CLAY SAND 49.1 CLAY GRVL 53.0 SAND GRVL 53.6 CLAY 57.3 GRVL 57.6 CLAY 68.3 SILT FSND 80.5 CLAY 86.9
9279	7 13	Oct-72	597572 4919691	228.9	15.2	Fr	14.0	-1.5	4.6	36	120	11.6	4816 CT	WS DO	**MOE# 5709279** 0.0 SAND 0.9 CLAY SAND 4.9 CLAY 6.7 FSND 15.5
9280	4 12	Oct-72	601062 4922671	264.3	23.8 20.7	Fr Fr	20.7	-3.0	9.4	45	120	18.0	4816 CT	WS DO	**MOE# 5709280** 0.0 MSND 14.6 FSND 23.8

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
9289	3 15	Jun-72	602712 4921421	239.0	18.0 16.2	Fr Fr	16.5	-0.9	4.0	45	120	12.8	4816 CT	WS DO	**MOE# 5709289** 0.0 SAND GRVL 8.5 GREY CLAY 10.7 SAND 16.2 CSND 18.0
9291	4 13	Jul-72	600932 4921571	239.0	20.4	Fr	19.2	-1.2	10.4	9	120	18.3	4816 CT	WS DO	**MOE# 5709291** 0.0 PRDG 12.2 FSND 20.4
9292	7 10	Jul-72	597061 4921861	222.8	32.3	Fr	32.3	-1.2	10.4	18	120	28.0	4816 CT	WS DO	**MOE# 5709292** 0.0 SAND 9.1 SAND CLAY 15.8 SAND SILT 31.7 FSND 33.5
9294	7 13	Jul-72	597626 4919816	228.9	18.3	Fr	17.4	-1.2	4.6	23	60	16.8	4816 CT	WS DO	**MOE# 5709294** 0.0 SAND 10.1 CLAY 12.8 FSND 18.6
9295	7 13	Jul-72	597608 4919797	228.9	19.8	Fr	19.2	-1.2	4.6	32	60	16.2	4816 CT	WS DO	**MOE# 5709295** 0.0 SAND 3.7 CLAY 8.5 FSND 20.4
9307	5 12	May-72	599652 4922001	240.5	25.9	Fr	25.6	-1.2	17.1	50	210	25.3	4816 RC	WS PU	**MOE# 5709307** 0.0 SAND 8.5 GRVL SAND 14.6 FSND 25.6 MSND 27.1 CLAY SAND 38.1
9326	4 17	Oct-72	602844 4920577	232.9	64.6	Fr	67.1	-4.6	-3.0	200	120		2801 RC	TH NU	**MOE# 5709326** 0.0 BRWN SAND 0.9 GREY CLAY SAND 6.4 GREY CLAY 18.9 GRVL SAND CLAY 20.1 GREY CLAY 49.4 GREY CLAY SAND 51.2 GREY FSND CLAY STNS 57.3 GREY CLAY SAND 64.9 GREY FSND CLAY STNS 70.7 GREY FSND CLAY 74.7 GREY CLAY 79.2 GREY CLAY SAND GRVL 82.6 GREY CLAY SAND GRVL 85.0 GREY CLAY SAND 87.2 GREY CLAY SAND GRVL 91.7 SAND GRVL 98.1 BLDR GRNT 99.1 GREY CLAY GRVL 109.7 BRWN LMSN 111.3
9327	4 16	Jan-72	602550 4920870	229.8	72.2 65.5	Fr Fr	65.5	-6.7	4.0	255	360	5.5	2801 RC	TH NU	**MOE# 5709327** 0.0 BLCK MUCK 1.5 WHTE FSND CLAY 5.2 GREY CLAY FSND 12.8 GREY CLAY 16.8 GREY FSND CLAY 46.9 GREY GRVL SAND 47.5 GREY CLAY 54.6 GREY SAND CLAY 61.3 GREY CLAY 65.8 GREY SAND GRVL CLAY 73.5 GREY CLAY 78.3 GREY SAND GRVL CLAY 91.4 SAND GRVL 96.9 BRWN LMSN 99.1
9354	5 11	Oct-72	599212 4921971	233.8	15.2	Fr	14.9	-1.2	11.9	23	60	12.2	1510 CT	WS DO	**MOE# 5709354** 0.0 RED CSND 12.2 BLCK FSND 16.2
9355	5 11	Oct-72	599292 4921981	234.7	16.8 15.2	Fr Fr	15.5	-1.2	10.7	23	60	13.7	1510 CT	WS DO	**MOE# 5709355** 0.0 RED SAND 12.2 MSND 16.8
9356	5 11	Nov-72	598770 4921940	226.8	14.6	Fr	13.1	-1.8	9.8	23	60	13.7	1510 CT	WS DO	**MOE# 5709356** 0.0 RED SAND 12.8 MSND 14.9
9380	4 12	Sep-72	600752 4922441	244.8	19.5 16.2	Fr Fr	18.0	-1.5	7.0	27	240	17.7	2514 CT	WS DO	**MOE# 5709380** 0.0 YLLW SAND BLDR 11.6 YLLW FSND 16.2 YLLW SAND 19.5
9381	3 15	Sep-72	602782 4921471	239.9	11.6 8.5	Fr Fr	10.7	-0.9	6.1	32	150	10.7	2514 CT	WS DO	**MOE# 5709381** 0.0 YLLW SAND 11.6

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
9382	4 13	Oct-72	600962 4921471	235.9	19.5 15.2	Fr Fr	17.7	-1.8	11.9	73	60	17.7	2514 CT	WS DO	**MOE# 5709382** 0.0 BRWN SAND GRVL 9.1 YLLW MSND 19.5
9383	4 13	Oct-72	600962 4921451	235.9	18.6 15.2	Fr Fr	17.1	-1.5	11.6	82	60	15.8	2514 CT	WS DO	**MOE# 5709383** 0.0 BRWN SAND GRVL 9.1 YLLW MSND FSND 18.6
9384	4 13	Oct-72	601052 4921771	237.1	22.6 21.3	Fr Fr	21.6	-0.9	12.8	91	120	20.4	2514 CT	WS DO	**MOE# 5709384** 0.0 SAND GRVL 11.9 BRWN SAND CLAY 21.3 CSND 22.6
9392	4 11	Nov-72	600382 4922421	239.9	29.0 27.1	Fr Fr	28.0 27.1	-0.9 -0.9	17.1	41	90	26.8	2514 CT	WS DO	**MOE# 5709392** 0.0 BRWN SAND GRVL BLDR 25.9 SAND GRVL 29.0
9393	4 11	Oct-72	600362 4922411	240.8	31.1 29.9	Fr Fr			18.3	18	210	29.9	2514 CT	WS DO	**MOE# 5709393** 0.0 BRWN SAND GRVL 0.6 GREY SAND 1.5 BRWN SAND GRVL CLAY 29.9 BRWN SAND GRVL SILT 31.1
9394	4 12	Nov-72	600472 4922351	232.9	30.2 29.0	Fr Fr	29.3	-0.9	18.6	27	220	29.0	2514 CT	WS DO	**MOE# 5709394** 0.0 SAND GRVL BLDR 16.8 BRWN SAND GRVL CLAY 30.2
9395	4 12	Oct-72	601112 4922721	267.3	26.2 19.2	Fr Fr	25.0	-0.9	18.0	91	90	21.3	2514 CT	WS DO	**MOE# 5709395** 0.0 YLLW SAND 4.6 BRWN CLAY 15.2 GREY CLAY FSND 19.2 YLLW MSND 26.2
9426	3 14	Sep-72	601962 4921801	235.3	4.6	Fr			4.6	23	60	6.4	4608 BR	WS DO	**MOE# 5709426** 0.0 GREY SAND 7.3
9479	5 14	Oct-72	600742 4921181	239.9	11.0 	Fr 	14.9	-0.9	11.0	55	60	11.6	1204 CT	WS DO	**MOE# 5709479** 0.0 BRWN SAND GRVL 15.8
9520	5 16	Sep-72	601472 4920191	244.8	24.4 16.2	Fr Fr	23.5	-0.9	16.2	32	60	20.1	3203 CT	WS DO	**MOE# 5709520** 0.0 BRWN CLAY 2.4 BRWN SAND 24.4
9521	5 16	Sep-72	601382 4920123	246.0	25.0 15.8	Fr Fr	24.1	-0.9	15.8	45	60	20.7	3203 CT	WS DO	**MOE# 5709521** 0.0 BRWN CLAY 2.7 BRWN SAND 25.0
9533	4 13	Dec-72	601362 4922171	239.9	19.8 18.6	Fr Fr	18.9	-0.9	9.1	32	60	13.7	3203 CT	WS DO	**MOE# 5709533** 0.0 BRWN SAND 17.7 BRWN CLAY 18.6 BRWN SAND CLAY 19.8
9550	3 15	May-72	602892 4921521	239.9	41.5 39.3	Fr Fr	40.5	-0.9	8.5	32	60	27.4	3203 CT	WS DO	**MOE# 5709550** 0.0 BLCK TPSL 0.6 BRWN SAND 4.9 GREY CLAY STNS 18.9 GREY CLAY GRVL 39.3 GREY SAND 41.5
9553	3 13	Sep-72	601762 4922181	241.7	21.0 19.2	Un Fr	20.1	-0.9	0.3	36	75	16.8	3203 CT	WS DO	**MOE# 5709553** 0.0 BRWN SAND CLAY STNS 6.1 GREY CLAY SAND 8.5 GREY CLAY 15.8 BRWN SAND CLAY 19.2 BRWN SAND 21.0
9554	3 15	Sep-72	602472 4921281	235.9	11.9 10.1	Fr Fr	11.0	-0.9	3.0	18	60	9.4	3203 CT	WS DO	**MOE# 5709554** 0.0 BRWN SAND CLAY 6.1 GREY SAND CLAY BLDR 7.6 GREY SAND GRVL 10.1 GREY SAND 11.9
9607	4 9	Jan-73	599361 4923721	237.7	7.6	Fr			7.6	14	60	10.4	4608 BR	WS DO	**MOE# 5709607** 0.0 GREY SAND 11.6
9728	7 13	Jan-73	597827 4919896	227.7	13.7 	Fr 	13.7	-0.9	2.1	14	65	12.2	3203 CT	WS DO	**MOE# 5709728** 0.0 BLCK TPSL 0.3 BRWN SAND STNS CLAY 13.7 BRWN SAND 14.6

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
9743	3 13	Jan-73	601502 4922521	264.3	30.5	Fr	29.6	-1.2	22.9	23	120	25.9	4816 CT	WS DO	**MOE# 5709743** 0.0 FSND 24.4 MSND 30.8
9929	4 12	May-73	600957 4922741	254.8	22.3	Fr	26.2	-0.9	14.9	45	60	18.0	3203 CT	WS DO	**MOE# 5709929** 0.0 BRWN SAND CLAY 13.1 GREY CLAY 22.3 BRWN SAND 27.1
9939	5 11	Apr-73	599249 4921990	234.7	12.2	Fr	16.8	-0.9	2.4	18	90	9.1	3203 CT	WS DO	**MOE# 5709939** 0.0 BRWN SAND 12.2 BRWN SAND 17.7
9944	2 21	Jun-73	602907 4922956	289.9	48.2	Fr	53.9	-0.9	39.6	45	75	44.2	3203 CT	WS DO	**MOE# 5709944** 0.0 BRWN CLAY SAND 9.1 BRWN SAND CLAY 18.0 GREY CLAY SAND 26.2 BRWN SAND 38.1 GREY FSND 40.2 GREY CLAY SAND 48.2 BRWN SAND 54.9
10026	9 13	Jun-73	594867 4918029	223.7	5.5	Fr			4.9		60	5.5	1830 BR	WS DO	**MOE# 5710026** 0.0 TPSL SNDY DNSE 0.3 BRWN MSND STNS PCKD 1.5 BRWN CLAY SNDY PCKD 5.5 GREY MSND LOOS 5.8 GREY CLAY SNDY STNS 7.6
10057	4 12	Jun-73	600832 4922394	246.3	29.0	Fr	28.0	-1.2	11.6	45	120	30.5	4816 RC	WS DO	**MOE# 5710057** 0.0 CLAY SAND 11.3 FSND SILT 29.0 FSND 30.5
10099	4 10	Jun-73	599923 4922806	239.0	18.3	Fr	19.8	-1.5	12.2	45	120	12.2	1510 CT	WS DO	**MOE# 5710099** 0.0 BRWN TPSL 1.2 BRWN SAND 21.3
10100	4 15	Jul-73	601362 4920641	234.7	23.2 6.1	Fr Fr	2.7	-1.2	1.2	23	120	19.8	1510 CT	WS ST	**MOE# 5710100** 0.0 BRWN FILL GRVL 1.5 BRWN MSND 6.1 GREY CSND 10.7 GREY CLAY SNDS 19.8 GREY HPAN 23.2 CSND 25.3
10103	4 12	Aug-73	600692 4922531	250.2	14.6	Fr	26.2	-0.9	13.7	36	120	15.2	1510 CT	WS DO	**MOE# 5710103** 0.0 PRDG 3.7 BRWN SAND GRVL 4.6 GREY CLAY 13.7 YLLW FSND 14.3 MSND 27.1
10126	6 10	May-73	598611 4922021	224.9	27.4 25.9	Fr Fr	26.2	-1.2	6.7	91	240		2402 CT	WS DO	**MOE# 5710126** 0.0 SAND 13.4 SAND SILT 21.9 MSND 27.4
10181	3 13	Aug-73	601662 4922291	246.9	17.7	Fr	18.3	-0.9	4.6	45	60	11.6	1204 CT	WS DO	**MOE# 5710181** 0.0 BRWN SAND 0.9 BRWN SAND CLAY GRVL 6.1 BRWN SAND 8.5 BRWN SAND GRVL CLAY 10.7 GREY CLAY SAND 17.7 BRWN SAND 19.2
10286	4 12	Oct-73	600812 4922321	242.0	17.7	Fr	18.6	-0.9	14.9	14	120	17.1	1510 CT	WS DO	**MOE# 5710286** 0.0 BRWN TPSL SNDY LOOS 0.6 GRVL BLDR LOOS 4.9 BRWN FSND 17.1 BRWN MSND 17.7 GREY MSND 19.5 GREY CLAY SAND SLTY 19.5
10287	4 12	Sep-73	600812 4922321	242.0	25.0	-			NR				1510 CT	AS -	**MOE# 5710287** 0.0 BRWN TPSL LOOS 1.2 GRVL LOOS 5.5 GREY FSND DRY 20.7 GREY CLAY SAND 25.0 GREY CLAY SAND MUCK 42.7
10288	4 12	Sep-73	600812 4922321	242.0					NR				1510 CT	AS -	**MOE# 5710288** 0.0 BRWN TPSL LOOS 0.9 GRVL LOOS 4.3 YLLW SAND 15.5 YLLW FSND CLAY LYRD 18.0 GREY SAND CLAY SLTY 18.0

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
10332	3 13	Sep-73	601622 4922346	249.9	24.1	Fr	25.3	-0.9	4.6	36	80	7.6	3203 CT	WS DO	**MOE# 5710332** 0.0 BRWN SAND STNS 7.6 GREY CLAY SAND STNS 24.1 GREY SAND 26.2
10336	4 10	Aug-73	600551 4923821	278.3	37.2	Fr	48.5	-0.9	30.5	36	90	39.6	3203 CT	WS DO	**MOE# 5710336** 0.0 BRWN SAND CLAY STNS 20.7 BRWN CLAY 37.2 BRWN SAND 49.4
10348	4 12	Aug-73	600932 4922731	254.2	27.1	Fr	28.0	-0.9	18.3	36	70	22.9	3203 CT	WS DO	**MOE# 5710348** 0.0 BRWN SAND 7.0 BRWN SAND 17.1 GREY CLAY 27.1 GREY SAND 29.0
10366	7 9	Sep-73	595815 4921748	192.9	18.3	Fr	19.8	-1.5	3.4	136	120	7.0	2514 CT	WS DO	**MOE# 5710366** 0.0 TPSL 0.3 GREY CLAY 12.5 GREY SAND CLAY GRVL 18.3 GREY MSND 21.3 GREY SAND CLAY 22.6
10403	5 11	Sep-73	599160 4921990	233.8	12.2	Fr	14.9	-0.9	9.4	32	90	14.6	2514 CT	WS DO	**MOE# 5710403** 0.0 YLLW FSND CLAY 15.8
10599	5 11	Nov-73	598892 4921958	228.9	6.1	Fr	12.8	-0.9	5.8	27	60	9.1	1204 CT	WS DO	**MOE# 5710599** 0.0 BRWN SAND 9.8 BRWN SAND STNS 13.7
10600	4 12	Dec-73	600752 4922411	245.1	29.9 17.7	Fr Fr	32.3	-0.9	14.3	23	120	22.9	1510 CT	WS DO	**MOE# 5710600** 0.0 BRWN TPSL 0.6 BRWN SAND GRVL 5.2 GREY HPAN BLDR 17.7 BRWN SAND 18.3 GREY SAND STNS 29.3 BRWN SAND CLAY 33.2
10722	5 10	Jan-74	599361 4922571	234.7	53.0 19.5	Fr Fr	53.3	-1.5	17.7	18	360	19.5	2340 CT	WS DO	**MOE# 5710722** 0.0 BLCK FILL 0.3 BRWN SAND CLAY FILL 0.9 BRWN SAND SILT FGRD 14.6 BLGR CLAY SILT PORS 19.5 GREY SAND SILT FGRD 21.6 BLUE CLAY SILT PCKD 25.0 BRWN SAND STNS CLAY 25.3 BLGR SAND CLAY SILT 37.5 BLUE CLAY PCKD DNSE 53.0 GREY SAND SILT LOOS 55.8 GREY SILT 55.8
10725	4 13	Jan-74	601489 4922122	239.9	17.1 13.4	Fr Fr	20.1	-1.8	12.8	14	120	18.9	1510 CT	WS DO	**MOE# 5710725** 0.0 BRWN TPSL SAND 0.6 BRWN GRVL SAND 9.8 GREY SAND CLAY 13.4 GREY SAND STNS SILT 17.1 GREY SAND CLAY 19.2 GREY MSND STNS 21.9
10833	9 15	Jan-74	596612 4917321	314.9	70.1	Fr	71.6	-1.5	61.3	45	90	73.2	2514 CT	WS DO	**MOE# 5710833** 0.0 TPSL LOOS DKCL 0.3 RED SAND LOOS 1.5 GREY HPAN BLDR PCKD 16.8 YLLW SAND LOOS 26.2 BRWN CLAY SAND PCKD 31.7 GREY SAND SILT PCKD 59.4 YLLW FSND LOOS 70.1 YLLW SAND PCKD 73.2
10843	6 15	Jan-74	599731 4919342	266.7	16.8	Fr	22.6	-1.8	16.8	45	90	19.8	3203 CT	WS DO	**MOE# 5710843** 0.0 BRWN TPSL 0.3 BRWN SAND STNS PCKD 11.9 BRWN SAND LOOS DRY 16.8 BRWN SAND WBRG 24.4
10895	4 12	Sep-73	600921 4922429	247.8	27.4	Fr	25.6	-1.2	15.2	18	120	22.9	4816 CT	WS DO	**MOE# 5710895** 0.0 SAND 20.7 FSND 28.0
10896	4 14	Sep-73	602014 4921483	236.8	20.4	Fr	18.0	-1.2	5.2	27	120	14.9	4816 CT	WS DO	**MOE# 5710896** 0.0 FSND 20.4 CLAY 20.7

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
10897	5 14	Aug-73	600069 4920855	240.8	20.1	Fr	19.5	-1.5	5.8	91	120	18.9	4816 CT	WS IN	**MOE# 5710897** 0.0 SAND GRVL 6.4 CLAY SAND 12.8 GREY FSND 20.1 BRWN FSND 22.3
10985	6 11	May-74	598861 4921971	228.9	18.3	Fr	19.2	-0.9	9.1	14	110	17.1	1204 CT	WS DO	**MOE# 5710985** 0.0 GREY FSND LOOS 8.2 GREY SILT FSND 16.8 GREY FSND SILT CLAY 19.5 GREY FSND 20.7
10989	8 16	Mar-74	596962 4917121	314.9	56.4	Fr	64.3	-1.8	56.4	27	60	57.9	1204 CT	WS DO	**MOE# 5710989** 0.0 BRWN SAND 21.0 GREY SAND GRVL CLAY 22.9 GREY CLAY 25.3 BRWN SAND 27.7 BRWN SAND GRVL CMTD 54.6 BRWN SAND 66.1
11031	4 12	May-74	600919 4922638	249.9	14.6	Fr	21.3	-1.2	9.8	32	120	12.2	1452 CT	WS DO	**MOE# 5711031** 0.0 BRWN GRVL STNS 3.7 GREY FSND 12.2 GREY FSND 14.6 FSND 18.9 YLLW FSND SILT 21.3 YLLW MSND 22.6
11034	4 12	Nov-73	600521 4922268	221.6					NR				1510 CT	AS -	**MOE# 5711034** 0.0 BRWN SAND GRVL 5.5 GREY HPAN 17.1 SAND GRVL 23.2 STNS 23.5
11144	8 8	Jun-74	594311 4921171	219.8	44.8 21.9	Fr Fr	46.0	-0.9	25.3	45	120	29.0	1452 CT	WS DO	**MOE# 5711144** 0.0 BRWN FILL 0.6 BRWN TPSL 1.2 YLLW GRVL SAND 7.9 YLLW FSND 15.8 GREY CLAY 32.0 GREY FSND SILT CLAY 36.6 GREY HPAN CLAY LYRD 44.8 YLLW FSND MSND 46.9
11192	6 14	Apr-74	598656 4919677	239.9	25.3	Fr	25.6	-1.8	7.0	45	60	15.2	3203 CT	WS DO	**MOE# 5711192** 0.0 BRWN TPSL 0.3 YLLW SAND 7.6 BRWN CLAY 11.6 BRWN SAND GRVL CLAY 18.9 GREY SAND CLAY HARD 25.3 BRWN SAND WBRG 27.4
11218	4 12	Feb-74	600947 4922494	249.9	9.1	Fr	22.6	-0.9	9.1	27	70	13.7	3203 CT	WS DO	**MOE# 5711218** 0.0 PRDG 1.5 BRWN SAND CLAY 12.5 BRWN SAND 23.5
11219	7 15	Feb-74	598962 4918971	271.3	18.3	Fr	19.8	-1.8	9.1	45	60	13.7	3203 CT	WS DO	**MOE# 5711219** 0.0 BRWN TPSL 0.3 YLLW SAND GRVL STNS 6.1 BRWN SAND GRVL STNS 18.3 BRWN SAND WBRG 21.6
11276	4 11	Jul-74	600150 4922418	224.9	31.7	Fr	30.2	-1.2	19.5	23	120	25.0	1413 RC	WS DO	**MOE# 5711276** 0.0 GRVL 10.7 GREY CLAY STNS 25.9 GREY SAND 31.7
11277	4 11	Jul-74	600143 4922415	224.9	32.0	Fr	30.8	-1.2	19.2	27	120	24.4	1413 RC	WS DO	**MOE# 5711277** 0.0 BRWN SAND GRVL 12.2 BLUE CLAY SAND 24.4 BRWN SAND 32.0
11296	3 13	Jun-74	601712 4922221	243.8	91.1 17.7	Fr Fr	96.6	-3.0	14.9	341	1440	21.9	4816 RC	WS MU	**MOE# 5711296** 0.0 SAND STNS 7.0 CLAY GRVL 17.7 SAND GRVL 25.3 CLAY SILT 43.6 CLAY GRVL 51.2 SILT CLAY 72.2 CLAY 86.9 SAND GRVL 101.5

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
11326	9 8	Aug-74	594252 4921086	219.8	32.3	Fr	41.8	-0.9	22.9	23	120	29.0	1452 CT	WS DO	**MOE# 5711326** 0.0 BLCK TPSL STNS SAND 0.6 BRWN GRVL 8.5 YLLW SAND 9.8 GREY SAND CLAY 11.6 GREY FSND 18.3 GREY CLAY 32.3 GREY SAND SILT 38.4 YLLW MSND 42.7
11330	5 14	Aug-74	600644 4921132	239.9	10.1	Fr	14.9	-0.9	10.1	27	65	11.3	1204 CT	WS DO	**MOE# 5711330** 0.0 GREY CSND 2.7 GREY GRVL 6.1 GREY CSND CGVL 15.8
11410	2 25	Feb-74	602711 4924771	294.7	78.6	Fr	78.6	-2.4	47.5	136	1200	68.6	2402 CT	WS IR	**MOE# 5711410** 0.0 SAND 3.0 CLAY 6.1 HPAN 14.0 SAND 16.2 GRVL 20.4 SAND GRVL 22.9 HPAN 63.4 CLAY 67.1 SAND 76.2 GRVL 81.1
11412	6 9	Mar-74	597606 4922599	205.4	21.0	Fr			-1.8				2402 CT	WS IR	**MOE# 5711412** 0.0 SAND 0.9 CLAY BLDR 4.0 SAND 10.1 CLAY 12.5 SAND 21.0
11575	2 19	Nov-74	604112 4922571	282.9	44.2	Fr	44.5	-1.2	35.7	45	90	36.0	2801 RC	WS DO	**MOE# 5711575** 0.0 BRWN CLAY SNDY LOOS 3.0 GREY CLAY STNS PCKD 9.4 GREY CLAY GRVL PCKD 15.5 GREY CLAY STNS PCKD 22.6 GREY CLAY SOFT 32.9 GREY CLAY GRVL BLDR 34.4 GREY CLAY HARD 42.4 GREY CLAY GRVL 43.3 GREY CLAY 43.9 GREY CLAY GRVL BLDR 44.2 GRVL SAND CLAY 45.7 GRVL SAND CLAY 62.8
11635	4 12	Aug-74	601112 4922821	261.8	25.9	Fr	28.0	-0.9	15.2	36	120	18.3	3203 CT	WS DO	**MOE# 5711635** 0.0 BRWN SAND CLAY 13.1 GREY CLAY 25.9 BRWN SAND 29.0
11653	4 12	Jul-74	601012 4922471	249.9	67.1	Fr	67.1	-1.5	18.6	32	120	65.8	2514 CT	WS DO	**MOE# 5711653** 0.0 YLLW SAND FILL 0.3 BRWN SAND TPSL 0.6 YLLW SAND 15.2 GREY SAND 28.3 GREY CLAY 63.1 GREY CLAY FSND VERY 67.1 GREY FSND 68.6
11656	3 14	Sep-74	602012 4921671	235.9	8.8	Fr	10.1	-0.9	2.7	23	210	8.2	2514 CT	WS DO	**MOE# 5711656** 0.0 YLLW SAND GRVL 5.5 YLLW GRVL SILT STNS 8.8 YLLW CSND 11.0
11846	4 10	Oct-74	599911 4922821	239.9	20.1	Fr	17.7	-1.2	10.7	23	120	16.5	4816 CT	WS DO	**MOE# 5711846** 0.0 SAND GRVL 10.7 SAND CMTD 15.2 FSND 20.1
11867	10 15	Sep-74	595466 4916545	289.9	86.9	Fr	85.0	-0.9	66.8	36	300		4816 RC	WS DO	**MOE# 5711867** 0.0 CLAY 2.7 CLAY GRVL 23.2 SAND GRVL 32.3 SAND GRVL CMTD 42.1 SAND SILT 47.9 SAND 51.2 SILT 61.9 CLAY 78.6 MSND FSND 87.2
11966	4 12	Aug-74	600992 4922771	255.1	17.1	Fr	25.6	-0.9	16.5	27	60	18.6	1204 CT	WS DO	**MOE# 5711966** 0.0 GREY CSND 5.5 GREY CLAY SAND 16.8 GREY CSND 17.1 GREY SAND CLAY 18.9 GREY FSND 26.5

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
11975	3 12	Jan-75	601362 4923021	282.9	51.2 36.6	Fr Fr	53.0	-1.8	46.6	23	120	48.5	1452 CT	WS ST	**MOE# 5711975** 0.0 BRWN TPSL STNS 0.6 BRWN SAND GRVL CLAY 16.5 GREY CLAY STNS 36.6 YLLW SAND CLN SHRP 38.4 GREY HPAN STNS 43.0 YLLW MSND GRVL DRY 51.2 YLLW FSND MSND WBRG 55.8
11983	3 14	Dec-74	601910 4921975	238.0	78.9	Fr	73.2	-4.6	2.7	646	1441	14.9	4816 RC	WS MU	**MOE# 5711983** 0.0 SAND GRVL 2.4 SAND CLAY LYRD 14.9 FSND 16.8 CLAY 24.1 MSND 29.6 FSND 41.5 CLAY 52.4 FSND 64.9 CLAY SAND SILT 72.8 MSND 78.9
11984	3 13	Jun-74	601899 4922306	251.2	91.1 17.7	Fr Fr	96.6	-3.0	14.9	341	1440	21.9	4816 RC	WS MU	**MOE# 5711984** 0.0 SAND STNS 7.0 CLAY GRVL 17.7 SAND GRVL 25.3 CLAY SILT 43.6 CLAY GRVL 51.2 SILT CLAY 72.2 FSND 86.9 CLAY 91.1 SAND GRVL 101.5
12061	7 13	Nov-74	597713 4919803	228.6	7.6	Fr	16.5	-0.9	6.1	36	130	9.1	3203 CT	WS DO	**MOE# 5712061** 0.0 BRWN CLAY 7.6 BRWN SAND 17.4
12071	3 14	Dec-74	602012 4921671	235.9	8.2	Fr	8.2	-0.9	1.5	91	60	4.3	2514 CT	WS DO	**MOE# 5712071** 0.0 TPSL DKCL 0.3 BRWN MSND CSND 9.1
12072	3 13	Jun-74	601912 4922321	251.2	91.1 17.7	Fr Fr	96.6	-3.0	14.9	341	1440	21.9	4816 RC	WS MU	**MOE# 5712072** 0.0 SAND STNS 7.0 CLAY GRVL 17.7 SAND GRVL 25.3 CLAY SILT 43.6 SILT CLAY 72.2 FSND 86.9 CLAY 91.1 SAND GRVL 101.5
12098	5 16	Jan-75	601162 4919971	253.9	7.3	Fr	8.2	-1.5	2.4	32	60	7.6	2514 CT	WS DO	**MOE# 5712098** 0.0 FILL LOOS 0.6 BRWN CLAY SOFT 2.7 GREY CLAY GRVL SAND 5.8 YLLW SAND SILT PCKD 7.3 YLLW SAND LOOS 9.8
12099	4 9	Feb-75	599411 4923671	239.0	16.2	Fr			7.3	64	60	15.8	2514 CT	WS DO	**MOE# 5712099** 0.0 TPSL DKCL 0.3 BRWN SAND BLDR 1.2 BRWN MSND 11.0 GREY CLAY SAND 16.2 YLLW MSND CSND 18.6
12173	4 13	May-75	601112 4922071	230.7	13.7	Fr	16.8	-0.9	8.5	23	120	12.2	1452 CT	WS DO	**MOE# 5712173** 0.0 BRWN TPSL SAND STNS 0.9 YLLW CSND CGVL 11.0 YLLW MSND 14.6 YLLW FSND 17.7
12174	3 12	May-75	601662 4922871	288.3	53.9	Fr	54.9	-1.8	49.7	23	120	51.5	1452 CT	WS DO	**MOE# 5712174** 0.0 BRWN TPSL STNS 0.6 BRWN CLAY SAND 3.7 BRWN GRVL SAND 7.3 YLLW FSND MSND DRY 53.9 YLLW FSND 57.9 GREY FSND SILT DRTY 63.4
12271	4 12	May-75	600912 4922721	254.2	22.3	Fr	19.8	-1.2	NR	36	120	19.2	4816 CT	WS DO	**MOE# 5712271** 0.0 MSND 14.6 GREY FSND 18.6 BRWN FSND 22.3
12500	4 11	Jul-75	600162 4922521	239.3			29.0	-0.9	18.3	136			5206 RC	WS DO	**MOE# 5712500** 0.0 BRWN SAND BLDR 9.1 GRVL CLAY 31.7
12522	6 11	Sep-75	598961 4921971	229.8	12.2	Fr	14.3	-1.2	8.2	23	120	13.1	1452 CT	WS DO	**MOE# 5712522** 0.0 BLCK TPSL SAND 0.6 BRWN SAND STNS DRY 12.2 YLLW FSND STNS MSND 15.8

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
12595	4 13	Oct-75	601012 4921571	235.9	12.8	Fr	18.9	-1.2	12.2	23	120	16.5	1452 CT	WS DO	**MOE# 5712595** 0.0 BLCK TPSL SAND 0.6 YLLW FSND 1.8 YLLW GRVL STNS 9.8 BRWN SAND 15.2 YLLW SAND CLAY LYRD 20.1
12884	3 14	Mar-76	602012 4921771	236.8	6.4	Fr	7.3	-0.9	1.8	68	60	3.7	1452 CT	WS DO	**MOE# 5712884** 0.0 BLCK TPSL SAND 0.3 BRWN MSND 6.4 YLLW MSND FSND 8.2
12926	5 11	Nov-75	599412 4921971	239.0	28.3 13.7	Fr -	28.0	-1.5	13.7	73	60	18.3	2340 CT	WS DO	**MOE# 5712926** 0.0 BLCK SAND TPSL 0.3 BRWN MSND LOOS 2.4 BRWN MSND CLAY PCKD 18.3 BRWN SAND GRVL PCKD 21.6 GREY FSND SILT PCKD 22.6 BRWN CLAY SILT PCKD 26.8 BRWN SAND LOOS 29.6
12984	5 15	Feb-76	600862 4919921	269.7	18.3	Fr	24.4	-0.9	NR	23	120	21.3	3660 CT	WS DO	**MOE# 5712984** 0.0 BRWN SAND DRY 24.4 YLLW MSND 25.6
13060	3 15	Jan-76	602312 4921271	234.7	9.8	Fr	9.8	-1.2	2.1	18	140	10.1	2514 CT	WS DO	**MOE# 5713060** 0.0 YLLW SAND SILT 9.8 YLLW FSND 11.0
13071	4 13	Mar-76	601412 4922411	253.0	23.2	Fr	23.5	-0.9	13.1	64	60	21.9	2514 CT	WS DO	**MOE# 5713071** 0.0 BRWN FSND CLAY 11.0 GREY CLAY 18.6 BRWN CLAY SAND 23.2 YLLW MSND FSND 24.4
13102	7 13	May-75	598271 4920091	221.9	25.0	Fr	25.9	-0.9	4.0	91	60	13.7	2514 CT	WS DO	**MOE# 5713102** 0.0 PRDG 9.1 GREY SAND SILT BLDR 25.0 WHTE FSND MSND 26.8
13114	9 16	Jul-75	595692 4916551	296.0	46.6	Fr			42.1	23	80	45.7	2514 CT	WS DO	**MOE# 5713114** 0.0 BLCK TPSL 0.3 BRWN SAND GRVL BLDR 20.4 BRWN SAND GRVL LOOS 39.6 GREY SAND CLAY 46.6 YLLW SAND 48.2
13127	9 16	Sep-75	595582 4916501	292.0	78.6	Fr	78.6	-2.4	69.5	45	120	76.2	2514 CT	WS DO	**MOE# 5713127** 0.0 TPSL LOOS DKCL 0.3 BRWN CLAY PCKD 1.8 BRWN CLAY SAND PCKD 8.2 YLLW SAND GRVL BLDR 43.6 YLLW SAND SILT PCKD 47.2 YLLW SAND PCKD 50.3 GREY SAND CLAY LYRD 61.9 GREY CLAY HARD 78.6 GREY SAND PCKD 81.1
13138	5 16	Oct-75	601098 4919917	311.8	37.8	Fr	38.7	-1.2	18.0	18	60	37.8	2514 CT	WS DO	**MOE# 5713138** 0.0 TPSL LOOS 0.3 BRWN CLAY BLDR PCKD 4.3 BRWN CLAY SAND PCKD 6.1 GREY CLAY SAND PCKD 7.3 YLLW SAND SILT PCKD 9.8 GREY SILT PCKD 14.3 GREY CLAY STKY 21.6 GREY CLAY SNDY HARD 37.8 YLLW SAND PCKD 39.9
13148	3 14	Dec-75	602182 4921431	237.7	7.3	Fr	7.6	-0.9	3.0	45	120	7.3	2514 CT	WS DO	**MOE# 5713148** 0.0 BRWN SAND CLAY 5.2 YLLW SAND 8.5
13190	4 13	Apr-76	600972 4921471	235.9	12.5	Fr	21.0	-1.2	11.9	32	120	15.5	1452 CT	WS DO	**MOE# 5713190** 0.0 BLCK TPSL 0.6 BRWN FILL SAND TPSL 1.5 YLLW GRVL SNDY 9.8 BRWN SAND STNS 16.2 YLLW FSND 22.3

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
13313	4 10	Jul-76	599851 4922931	239.9	16.8	Fr	23.8	-0.9	14.9	27	60	19.8	1204 CT	WS DO	**MOE# 5713313** 0.0 BRWN SAND GRVL BLDR 11.9 BRWN SAND CLAY DRTY 16.8 BRWN FSND 24.7
13342	3 14	Jun-76	602722 4922981	292.9			43.6	-1.2	35.4	32	120		1452 CT	WS DO	**MOE# 5713342** 0.0 PRDR 44.2 FSND MSND 44.8
13343	3 14	Jun-76	602162 4921471	237.7	7.3	Fr			1.8	14	120	4.9	1452 CT	WS DO	**MOE# 5713343** 0.0 BLCK TPSL SAND DRY 0.6 BRWN SAND 1.8 BRWN GRVL STNS LOOS 4.9 GREY CLAY STNS 7.6 BRWN SAND CLAY LYRD 11.3
13344	4 14	Jun-76	601712 4921971	237.7					1.8	45	120	3.7	1452 CT	WS DO	**MOE# 5713344** 0.0 BLCK TPSL SAND 0.6 BRWN SAND STNS 1.8 GREY GRVL CLAY 8.2 GREY CLAY SAND STNS 12.8 GREY CSND STNS 15.5
13345	4 13	Jul-76	601212 4922161	239.0	18.0	Fr	19.5	-0.9	5.8	32	120	9.1	1452 CT	WS DO	**MOE# 5713345** 0.0 BLCK TPSL SAND 0.6 BRWN CLAY 1.2 RED SAND STNS 9.1 GREY GRVL CLAY LOOS 16.8 GREY SAND STNS CLAY 20.4 SILT 20.4
13412	4 12	Feb-75	600962 4922551	252.4	17.1	Fr	18.6	-0.9	12.8	32	60	15.2	3203 CT	WS DO	**MOE# 5713412** 0.0 BRWN SAND 4.3 BRWN CLAY 6.7 GREY CLAY SAND 8.8 GREY CLAY 17.1 GREY SAND 19.5
13439	1 23	May-75	603362 4924181	297.8	56.7	Fr	60.0	-0.9	50.3	32	60	53.3	3203 CT	WS DO	**MOE# 5713439** 0.0 BRWN SAND CLAY STNS 47.9 GREY CLAY 56.7 BRWN SAND 61.9
13549	4 12	Aug-76	600962 4922571	250.9	18.0	Fr	20.1	-0.9	11.6	32	120	14.0	1452 CT	WS DO	**MOE# 5713549** 0.0 BRWN FILL SAND SOFT 2.4 BRWN SAND SOFT 3.7 GREY GRVL SAND SOFT 6.4 GREY CLAY SAND STNS 13.4 YLLW SAND SOFT 15.5 YLLW FSND 21.0 GREY SAND SILT 21.0
13551	4 12	Sep-76	600952 4922621	250.5	17.7	Fr	19.5	-0.9	11.3	23	120	13.7	1452 CT	WS DO	**MOE# 5713551** 0.0 BRWN TPSL SAND 0.6 BRWN FILL SAND 2.4 GREY SAND CLAY STNS 6.1 GREY FSND 18.3 YLLW SAND 20.4 GREY SAND SILT 20.4
13598	5 14	Jul-76	600762 4921121	237.7	8.2	Fr	8.2	-1.8	-0.9	14	60	9.4	2514 CT	WS DO	**MOE# 5713598** 0.0 TPSL LOOS 0.3 GREY CLAY PCKD 1.8 GREY HPAN BLDR HARD 8.2 YLLW FSND CLAY LYRD 10.1
13603	3 15	May-76	602412 4921271	234.7	7.9	Fr	7.9	-0.9	4.9	18	60	8.5	2514 CT	WS DO	**MOE# 5713603** 0.0 TPSL LOOS DKCL 0.3 BRWN SAND LOOS 1.5 YLLW SAND PCKD 3.4 YLLW SAND GRVL SILT 7.9 YLLW SAND LOOS 8.8
13610	7 9	Jul-76	596111 4921821	198.7	19.2	Fr	19.5	-0.9	6.1	55	90	11.3	1204 CT	WS DO	**MOE# 5713610** 0.0 BRWN CLAY SOFT 4.9 BRWN CLAY SAND SOFT 11.0 GREY CLAY SILT 19.2 GREY CSND 20.4

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13634	4 12	Sep-76	600912 4922321	240.8					NR				1452 CT	WS DO	**MOE# 5713634** 0.0 BRWN TPSL STNS LOOS 1.2 BRWN SAND STNS 3.7 GRVL 6.1 GREY CLAY SAND 14.6 GREY CLAY STNS 16.2 GREY CLAY SILT 21.3
13635	4 12	Sep-76	600912 4922371	243.8	14.6	Fr	16.5	-0.9	7.0	45	60	10.1	1452 CT	WS DO	**MOE# 5713635** 0.0 BRWN TPSL SAND 0.6 BRWN SAND LOOS 4.6 GREY SAND STNS LOOS 6.7 GREY SAND CLAY LYRD 9.1 YLLW FSND 17.4
13838	4 10	Sep-76	600551 4923821	278.3	48.8	Fr	49.1	-0.9	35.7	27	60	42.7	1204 CT	WS DO	**MOE# 5713838** 0.0 BRWN SAND CLAY 13.7 BRWN SAND 29.6 GREY SAND CLAY 39.6 BRWN SAND 50.0
13842	4 13	Sep-76	601162 4922121	235.9	18.3	Fr	18.9	-0.9	13.4	18	120	16.5	1452 CT	WS DO	**MOE# 5713842** 0.0 BRWN TPSL 1.2 BRWN GRVL FILL 2.1 YLLW SAND STNS 7.0 YLLW GRVL 9.8 YLLW SAND STNS 15.2 GREY SAND SILT CLAY 19.8
13845	4 13	Oct-76	601172 4922121	235.9	18.3	Fr	17.4	-0.9	10.7	14	120	14.6	1452 CT	WS DO	**MOE# 5713845** 0.0 BRWN SAND FILL LOOS 0.9 BRWN SAND STNS 4.9 BRWN SAND GRVL 10.7 GREY GRVL SAND CLAY 12.8 GREY SAND GRVL CLAY 18.3 GREY SAND GRVL CLAY 19.2
13846	4 13	Oct-76	600862 4921641	239.9	18.3	Fr	19.2	-0.9	13.1	45	180	15.8	1452 CT	WS DO	**MOE# 5713846** 0.0 BRWN SAND STNS LOOS 3.0 GREY CGVL CSND 9.1 GREY SAND GRVL 12.2 BRWN SAND STNS 17.4 BRWN SAND LOOS 21.0
14017	3 12	Jan-77	601402 4922831	276.8	39.9	Fr	40.2	-1.2	35.7	36	60	40.2	2514 CT	WS DO	**MOE# 5714017** 0.0 BRWN SAND BLDR 3.0 BRWN SAND 24.4 BRWN SAND CLAY 25.9 GREY CLAY SAND SILT 39.9 BRWN FSND MSND 41.5
14018	5 16	Jan-77	601290 4920065	248.1	6.4	Fr	7.3	-1.5	-0.3	23	60	7.6	2514 CT	WS DO	**MOE# 5714018** 0.0 BRWN SAND CLAY STNS 6.4 YLLW FSND 8.8 BRWN CLAY 8.8
14023	5 11	Oct-76	599482 4922001	239.9	26.8	Fr	26.8	-0.9	11.9	41	120	23.5	2514 CT	WS DO	**MOE# 5714023** 0.0 PRDG 13.1 YLLW SAND SILT 26.8 YLLW MSND 27.7
14030	3 12	Dec-76	601312 4922721	276.8	27.4	Fr	30.2	-0.9	21.0	82	60	28.0	2514 CT	WS DO	**MOE# 5714030** 0.0 YLLW SAND 31.1
14031	3 12	Dec-76	601362 4922821	275.8	30.5	Fr	30.5	-0.9	21.6	45	120	27.7	2514 CT	WS DO	**MOE# 5714031** 0.0 FSND MSND 30.5 YLLW MSND 31.4
14124	4 13	May-77	600962 4921571	237.7	17.4	Fr	16.2	-1.2	6.1	23	180	15.2	4004 CT	WS DO	**MOE# 5714124** 0.0 UNKN 1.2 BRWN CLAY BLDR 10.7 SAND CLAY 15.2 SAND DRTY 18.0

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
14137	4 13	Mar-77	600912 4921671	238.7	13.4	Fr	19.8	-2.1	11.9	36	120	16.2	1452 CT	WS DO	**MOE# 5714137** 0.0 BRWN TPSL LOOS 0.6 BRWN SAND STNY 1.2 BRWN GRVL 12.2 GREY SAND FGRD 22.3 GREY SILT 22.3
14157	4 13	Nov-76	601062 4921821	235.9	19.2	Fr	20.1	-0.9	13.1	45	120	15.2	1452 CT	WS DO	**MOE# 5714157** 0.0 BRWN TPSL LOOS 0.6 BRWN FILL STNS SAND 1.2 BRWN GRVL SAND HARD 10.7 BRWN SAND STNS LOOS 17.4 BRWN GRVL SAND LOOS 18.3 BRWN SAND LOOS 21.6
14163	10 13	Jan-76	594692 4917752	224.9	21.6	Fr	22.3	-0.9	10.7	45	90	15.2	3203 CT	WS DO	**MOE# 5714163** 0.0 BRWN SAND 4.6 GREY SAND CLAY WBRG 9.8 GREY CLAY 21.6 GREY SAND GRVL 23.2
14220	9 13	Apr-76	594834 4918011	223.1	21.6	Fr	22.3	-0.9	6.1	45	90	11.3	3203 CT	WS DO	**MOE# 5714220** 0.0 FILL 1.5 BRWN SAND GRVL 7.0 GREY CLAY SILT 12.5 GREY CLAY 21.6 GREY SAND WBRG 23.2
14356	4 9	Jun-77	599411 4923671	239.0	10.7	Fr	17.4	-0.9	7.0	23	90	13.4	3135 CT	WS DO	**MOE# 5714356** 0.0 BRWN CLAY 4.6 SAND HARD PCKD 11.6 SAND LOOS WBRG 18.3
14409	2 22	Jun-77	603612 4923621	293.8	50.3	Fr	52.1	-1.2	44.5	32	60	45.7	1452 CT	WS DO	**MOE# 5714409** 0.0 BRWN CLAY STNS 2.4 BRWN SAND STNS 6.7 YLLW SAND DRY 36.0 GREY CLAY 38.4 GREY SAND CLAY 41.8 GREY CLAY 43.3 GREY SAND CLAY 48.8 GREY SAND 50.9 GREY SAND FGRD 53.3
14414	9 13	Jun-77	594674 4917826	220.4	11.9	Su	11.9	-0.9	2.7	14	60	10.7	3660 CT	WS DO	**MOE# 5714414** 0.0 BLCK TPSL 0.3 GREY SAND GRVL DRY 11.9 GREY SAND GRVL WBRG 12.8
14597	5 16	Jul-77	601212 4920021	249.9	6.7	Fr	7.9	-0.9	0.3	5	85	7.9	1222 CT	WS DO	**MOE# 5714597** 0.0 BRWN GRVL FILL 0.9 BRWN CLAY SAND 6.7 BRWN SAND FGRD 9.1
14600	10 13	Sep-77	594622 4917373	225.9	24.1	Fr	24.1	-0.9	6.7	55	105	14.3	1222 CT	WS DO	**MOE# 5714600** 0.0 BRWN FSND 4.3 BRWN CLAY SAND SILT 24.1 GREY SAND 25.3
14811	5 14	Nov-77	600365 4920942	236.5	15.2	Fr	17.4	-1.2	7.3	32	60	12.2	1452 CT	WS IN	**MOE# 5714811** 0.0 BRWN TPSL STNS 0.6 YLLW GRVL STNY LOOS 7.9 GREY SAND SILT FGRD 19.2
14812	5 11	Nov-77	599112 4921921	232.9	14.0	Fr	17.1	-0.9	8.8	23	120	13.1	1452 CT	WS DO	**MOE# 5714812** 0.0 BRWN FILL SAND 0.3 BLCK TPSL SAND 0.9 BRWN SAND 14.0 YLLW FSND MSND 18.0
14813	4 13	Nov-77	601412 4922271	240.8	15.8	Fr	19.5	-0.9	2.4	23	60	6.7	1452 CT	WS DO	**MOE# 5714813** 0.0 BLCK TPSL SAND 0.3 BRWN FILL SAND STNS 1.2 BRWN SAND LOOS 4.6 BRWN CLAY SAND STNS 8.5 BRWN GRVL SAND 14.9 GREY CLAY SAND 15.8 BRWN SAND 20.4

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
14844	3 12	Nov-77	601512 4922721	280.4	52.4	Fr	50.3	-1.2	41.5	36	120	46.9	4816 CT	WS DO	**MOE# 5714844** 0.0 SAND 14.6 SAND GRVL 16.8 SAND 32.6 GREY CLAY 42.7 SAND CMTD 45.4 MSND 48.5 FSND 52.4
14996	4 15	Oct-77	602162 4921321	234.7	18.9	Fr	18.9	-0.9	FLW	32	80	7.6	3135 CT	WS DO	**MOE# 5714996** 0.0 BLCK TPSL 0.9 BRWN SAND 4.3 GREY CLAY SILT SAND 18.9 GREY SAND 19.8 GREY SAND CLAY 20.4
15074	3 15	Jul-77	602462 4921271	235.9	20.1	Fr	20.1	-0.9	NR	91	120		2514 CT	WS DO	**MOE# 5715074** 0.0 PRDR 8.8 BRWN CLAY SAND 20.1 YLLW SAND CGRD 21.0
15152	5 15	Apr-78	600062 4920871	240.8	20.7	Fr	21.3	-0.9	16.2	23	60	17.7	3660 CT	WS DO	**MOE# 5715152** 0.0 BLCK TPSL 0.3 BRWN CLAY 8.5 BRWN SAND DRY 20.7 BRWN SAND 22.3
15324	4 13	Jul-78	601112 4921821	234.7	14.6	Fr	16.8	-0.9	13.1	18	120	15.2	1452 CT	WS DO	**MOE# 5715324** 0.0 BRWN TPSL SAND 0.6 BRWN SAND CGRD 2.7 GREY GRVL 7.9 GREY SAND STNS 18.3 GREY CLAY 18.3
15326	5 11	Jul-78	598911 4921921	228.9	10.4	-	12.5	-0.9	5.8	23	120	9.4	1452 CT	WS DO	**MOE# 5715326** 0.0 BRWN TPSL SAND 0.6 BRWN SAND LOOS 7.9 GREY GRVL SAND 10.1 BRWN MSND FSND 13.7
15353	7 9	Jul-78	596711 4922421	189.9	40.5	Fr	40.5	-0.9	FLW	23	60	35.1	1222 CT	WS DO	**MOE# 5715353** 0.0 BRWN FSND 1.5 GREY CLAY SILT 40.5 GREY SAND 41.5
15374	5 11	Jul-78	599412 4921921	239.0	21.3	Fr	22.3	-1.2	14.6	36	90	19.8	3602 CT	WS DO	**MOE# 5715374** 0.0 BRWN SAND 0.6 CLAY SNDY 21.3 BRWN SAND WBRG 23.5
15456	6 14	Aug-78	599626 4920558	244.8	15.5	Fr	17.7	-0.9	9.4	23	75		4816 RC	WS DO	**MOE# 5715456** 0.0 MSND 5.5 MSND GRVL LYRD 8.2 GRVL CLAY LYRD 10.1 CLAY GRVL LYRD 15.5 MSND 21.3
15462	4 13	Jul-77	601512 4922171	239.9	18.9	Fr	17.4	-1.8	3.4	14	180	8.5	1452 CT	WS DO	**MOE# 5715462** 0.0 PRDR CLAY STNS 18.9 BRWN GRVL CLAY 19.2 GREY SILT 19.5
15526	2 20	Jul-78	603935 4923131	290.8	47.5 18.3	Fr -	53.9	-1.2	43.3	32	60	47.5	1452 CT	WS ST	**MOE# 5715526** 0.0 PRDG 1.5 YLLW CLAY 18.3 BRWN CLAY GVLY 36.6 BRWN SAND STNS 47.2 YLLW FSND CLN 55.2
15527	4 14	Aug-78	601212 4921021	234.7	33.5 17.1	Fr -	34.1	-0.9	1.8	32	60	10.7	1452 CT	WS DO	**MOE# 5715527** 0.0 BLCK TPSL SAND 0.3 YLLW FILL SAND 1.5 BRWN SAND 6.4 GREY SILT STNS DRTY 17.7 GREY CLAY SOFT 33.5 BRWN FSND 35.4
15530	4 14	Sep-78	601112 4921121	235.9	12.5	Fr	16.8	-0.9	4.9	23	60	14.0	1452 CT	WS DO	**MOE# 5715530** 0.0 PRDG 3.0 MSND LOOS 17.7 CLAY SILT SAND 17.7

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
15754	4 13	Dec-78	600812 4921421	239.9	18.6	Fr	20.4	-0.9	10.7	68	60	10.7	1452 CT	WS DO	**MOE# 5715754** 0.0 BLCK TPSL SAND 0.6 BRWN SAND GRVL DRY 18.6 BRWN CSND 21.9
15755	4 13	Dec-78	600912 4921521	239.0	21.3	Fr	22.6	-1.2	12.2	32	60	20.1	1452 CT	WS DO	**MOE# 5715755** 0.0 PRDG 1.8 BRWN GRVL 9.8 BRWN FSND 24.1 GREY SILT 24.1
15802	3 12	Jul-78	601512 4922821	282.9	29.0	Fr	30.8	-0.9	22.3	36	120	25.9	2514 RC	WS DO	**MOE# 5715802** 0.0 YLLW SAND 31.7 BRWN CLAY 40.2 BLUE CLAY 45.7
15813	3 12	Aug-78	601412 4922721	285.0	36.9	Fr	36.9	-1.2	28.0	55	120	36.0	2514 RC	WS DO	**MOE# 5715813** 0.0 BRWN SAND 17.7 BRWN SAND CLAY 36.9 BRWN FSND MSND 38.1
15822	3 12	Oct-78	601612 4922821	281.3	27.4	Fr	30.2	-0.9	19.8	55	60	27.4	2514 CT	WS DO	**MOE# 5715822** 0.0 BRWN SAND SILT 31.1
15870	7 13	Oct-78	597589 4919706	228.9	9.8	Fr	15.8	-0.9	3.7	45	60	8.2	1222 CT	WS DO	**MOE# 5715870** 0.0 GREY SAND GRVL 4.6 GREY SAND CLAY 9.8 GREY FSND 16.8
15970	4 13	Jan-79	601062 4921871	235.9	17.7	Fr	18.9	-2.1	12.2	23	120	14.0	1452 CT	WS DO	**MOE# 5715970** 0.0 PRDG 1.2 BRWN SAND STNS DRY 11.6 BRWN FSND DRY 17.7 BRWN SAND WBRG 21.3 WHTE CLAY 21.3
16103	4 14	Apr-79	601012 4921571	235.9	2.4	Fr	14.0	-0.9	2.4	114	60	4.3	3203 CT	WS DO	**MOE# 5716103** 0.0 BRWN TPSL 0.3 BRWN SAND CLAY 2.4 BRWN SAND 14.9
16104	4 14	Apr-79	601712 4921371	234.7	10.7	Fr	12.8	-0.9	6.1	23	60	10.7	3203 CT	WS DO	**MOE# 5716104** 0.0 BRWN SAND 13.7 GREY SAND 15.8 GREY CLAY 28.0
16105	7 9	Jun-78	596761 4922171	197.8	18.0	Fr	21.9	-0.9	14.9	45		16.5	3203 CT	WS DO	**MOE# 5716105** 0.0 TPSL 0.3 BRWN SAND CLAY 7.0 BRWN SAND GRVL PCKD 18.0 BRWN SAND 22.9
16112	7 13	Jun-79	598421 4919822	233.8	28.3	Fr	28.3	-0.9	7.3	55	60	12.8	1222 CT	WS DO	**MOE# 5716112** 0.0 BLCK TPSL 0.3 BRWN SAND GRVL STNS 6.1 BRWN CLAY SAND SOFT 14.0 GREY CLAY SAND BLDR 28.3 GREY FSND 29.3
16165	2 23	May-79	602612 4923421	293.8	53.3	Fr	61.3	-1.2	46.9	45	90	49.4	1452 CT	WS DO	**MOE# 5716165** 0.0 BLCK TPSL 0.6 GREY SAND CLAY 14.6 BRWN CSND 32.3 GREY FSND 50.9 GREY CLAY 52.4 GREY SILT 57.9 GREY CSND 62.5
16325	4 9	Aug-79	599661 4923571	244.8	12.2	Fr	14.9	-1.2	9.8	23	120	11.9	1452 CT	WS DO	**MOE# 5716325** 0.0 BRWN FSND 17.4
16460	5 11	Jul-79	599784 4922159	241.4			24.4	-2.4	17.1	45	300	21.6	4816 RC	WS PU	**MOE# 5716460** 0.0 SAND GRVL LYRD 15.2 MSND 28.7 CLAY 29.0 MSND 36.9 FSND CLAY 44.8 CLAY 47.2

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
16461	7 13	Sep-79	597679 4919780	228.9	16.5	Fr	16.5	-0.9	5.2	36	120	10.7	3660 CT	WS DO	**MOE# 5716461** 0.0 BLCK TPSL 0.3 WHTE SAND 3.0 GREY SILT SAND 7.3 BLUE CLAY 10.1 BRWN SILT 12.8 BRWN FSND HARD 14.6 BRWN FSND LOOS 17.4
16462	5 11	Jul-79	599755 4922017	241.7	25.9	-	25.9	-2.4	16.5	68	480	22.6	4816 RC	WS PU	**MOE# 5716462** 0.0 FSND GRVL 12.2 FSND 16.8 MSND FGVL LYRD 21.3 MSND 25.3 CLAY 25.9 MSND 29.6 CLAY 30.5
16466	7 8	Aug-79	595561 4921921	189.9	36.0	Fr	36.9	-1.2	-3.0				4816 RC	WS DO	**MOE# 5716466** 0.0 CLAY SOFT 29.0 SILT CLAY SAND 36.0 FSND SILT 39.3 SILT CLAY 53.3 CLAY SAND 58.5 SAND SILT 75.3 LMSN 76.8
16585	6 14	Nov-79	599612 4920521	246.0	12.5	Fr	19.8	-1.2	12.5	32	120	19.5	4816 CT	WS DO	**MOE# 5716585** 0.0 MSND 18.3 FSND 22.3
16587	4 15	Nov-79	602112 4920921	229.8	20.7	Fr	21.3	-0.9	0.6	36	120	6.1	3203 CT	WS DO	**MOE# 5716587** 0.0 BLCK TPSL 0.3 BRWN SAND 2.1 GREY SILT CLAY 5.5 GREY CLAY 20.7 GREY SAND 22.3 GREY SAND CLAY 22.3
16745	4 11	Jul-79	600262 4922471	239.9	29.3	Fr	29.9	-0.9	14.3	18	90	29.0	2514 RC	WS DO	**MOE# 5716745** 0.0 YLLW SAND 23.8 YLLW SAND CLAY 29.3 YLLW SAND 30.8
16801	4 15	Jun-80	601812 4921221	232.9	6.1	Fr	9.8	-0.9	2.4	36	75	8.5	3203 CT	WS DO	**MOE# 5716801** 0.0 BRWN SAND 10.7 GREY CLAY 10.7
16856	5 14	Apr-80	600546 4921056	239.3	15.5	Fr	16.5	-0.9	2.4	45	120		4816 RC	WS CO	**MOE# 5716856** 0.0 FGVL SAND 8.2 CGVL 11.6 CGVL CLAY LYRD 15.5 MSND 23.2 SAND CLAY 25.3
16922	5 11	Jul-80	599144 4921727	234.1	47.5	Fr	47.5	-1.2	11.9	36	60		1467 CT	WS IN	**MOE# 5716922** 0.0 GREY FILL 1.2 BRWN SAND 17.1 GREY FSND VERY SLTY 31.7 GREY CLAY STNS 45.7 GREY CLAY GRVL LYRD 47.5 GREY FSND 49.1 CLAY 49.1
16993	5 14	Aug-80	600620 4921085	239.9	8.8	Fr	16.8	-0.9	8.8	27	90	12.5	1222 CT	WS DO	**MOE# 5716993** 0.0 GREY FILL 0.6 BLCK TPSL 0.9 GREY SAND BLDR 6.4 GREY SAND 17.7
17091	5 16	Oct-80	600812 4919871	274.9	28.0	Fr	28.0	-2.1	14.6	18	120	28.3	1467 CT	WS DO	**MOE# 5717091** 0.0 BRWN SAND 21.3 GREY SAND CLAY 28.0 BRWN FSND VERY 30.8 GREY CLAY 30.8
17094	5 11	Sep-80	598111 4922021	222.8	14.9	Fr	15.2	-1.2	NR	23	60	12.8	1467 CT	WS DO	**MOE# 5717094** 0.0 PRDG 6.1 BRWN SAND 14.9 GREY SAND CLAY 16.5
17235	7 13	Nov-80	597525 4919754	226.5	18.0	Fr	18.6	-1.8	4.3	45	60	12.2	1467 CT	WS DO	**MOE# 5717235** 0.0 BRWN SAND 5.8 GREY CLAY SAND 11.6 BRWN SAND STNS 13.1 BRWN FSND VERY 18.0 BRWN FSND LTCL 20.4

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17236	5 11	Nov-80	599112 4921812	232.9	18.9	Fr	19.5	-1.8	8.8	18	120	17.7	1467 CT	WS DO	**MOE# 5717236** 0.0 BRWN SAND 10.4 GREY SAND 18.9 BRWN FSND VERY 21.6
17456	1 16	Apr-81	605012 4921621	285.0	41.8	-	46.9	-1.2	41.8	23	150	43.6	3135 CT	WS DO	**MOE# 5717456** 0.0 TPSL 0.3 SAND 5.5 SAND GRVL PCKD 25.0 SAND DRY 41.8 FSND 48.2
17604	5 15	Jul-81	600812 4919971	271.0	16.8	Fr	17.7	-1.8	13.4	23	60	16.8	1467 CT	WS DO	**MOE# 5717604** 0.0 BLCK TPSL 0.3 BRWN SAND 21.0 GREY SAND CLAY LYRD 33.5
17606	4 13	May-81	600812 4921471	239.9	17.7	Fr	20.1	-0.9	10.7	36	60	12.2	1467 CT	WS DO	**MOE# 5717606** 0.0 BLCK TPSL 0.3 BRWN SAND GRVL DRY 12.8 BRWN SAND DRY 17.7 BRWN CGVL CSND 21.0
17758	7 9	Sep-81	595716 4921496	191.7	12.2	Fr	13.4	-0.9	FLW	45	30		1467 CT	WS DO	**MOE# 5717758** 0.0 BRWN TPSL 0.3 BRWN SAND LOOS 1.2 GREY CLAY LOOS 11.9 GREY CLAY SILT 12.2 BRWN CSND 14.6 GREY SAND SLTY 14.6
17760	7 10	Sep-81	597099 4921391	194.8	5.8	Fr	14.6	-0.9	FLW	45		5.5	1467 CT	WS DO	**MOE# 5717760** 0.0 RED TPSL SAND 0.9 GREY CLAY STNS 5.8 GREY MSND 15.8 GREY CLAY HARD 15.8
17967	4 12	Sep-81	600612 4922271	232.6	22.9	Fr	22.9	-0.9	9.1	23	60	22.6	2514 CT	WS DO	**MOE# 5717967** 0.0 YLLW SAND GRVL STNS 10.4 YLLW CLAY SAND 11.0 YLLW SAND SILT LYRD 22.9 YLLW SAND SILT 23.8
18003	1 23	Mar-81	603462 4924221	297.8	60.4	Fr	62.2	-1.2	51.8	45	195	56.4	3203 CT	WS DO	**MOE# 5718003** 0.0 BRWN SAND STNS GRVL 12.8 BRWN SAND 42.7 BRWN FSND SILT CLAY 48.8 GREY CLAY SILT LYRD 60.4 BRWN SAND GRVL 61.6 BRWN SAND 63.4
18023	4 12	Apr-82	600462 4922371	235.9	15.5	Fr	28.0	-0.9	13.1	14	840	24.1	1467 CT	WS DO	**MOE# 5718023** 0.0 BLCK TPSL 0.6 BRWN SAND LTCL 7.0 GREY GRVL 15.5 GREY SAND STNS CMTD 29.3
18061	1 16	Sep-81	605012 4921621	285.0	44.2	Fr	50.6	-0.9	44.2	32	90	47.2	3135 CT	WS DO	**MOE# 5718061** 0.0 BLCK TPSL 0.3 BRWN SAND DRY 44.2 BRWN SAND 51.5
18232	4 12	Jul-82	601162 4922921	269.1			30.8	-1.5	17.4	45			4816 CT	WS DO	**MOE# 5718232** 0.0 BRWN SAND 25.3 FSND 32.6 CLAY 32.6
18298	7 9	Dec-82	596161 4921721	199.9	10.4	Fr	11.0	-1.2	5.8	9	1440	11.0	1467 CT	WS DO	**MOE# 5718298** 0.0 PRDG 1.5 GREY CLAY 10.4 BRWN FSND 12.2 GREY FSND CLAY DKCL 12.2
18391	4 15	Sep-81	601962 4921621	234.7	12.2	Fr	11.3	-1.8	2.4	59	120	7.3	4816 RC	WS DO	**MOE# 5718391** 0.0 FSND 14.6
18481	4 15	Jun-82	602212 4921221	233.8	19.5	Fr	19.8	-0.9	-0.3	41	60	18.3	2514 CT	WS DO	**MOE# 5718481** 0.0 FILL 1.5 SAND SILT 11.0 GREY SAND SILT 19.5 YLLW SAND SILT 20.7

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
18544	4 13	Apr-83	601661 4922219	243.2	20.4	Fr	20.7	-0.9	10.1	23	60	17.7	1467 CT	WS DO	**MOE# 5718544** 0.0 BRWN TPSL 0.3 BRWN GRVL 4.9 BRWN SAND 20.4 GREY SAND 21.6
18545	4 13	Apr-83	601062 4921721	237.4	15.5	Fr	18.9	-1.2	12.2	18	360	18.9	1467 CT	WS DO	**MOE# 5718545** 0.0 BLCK TPSL 0.3 BRWN SAND GRVL 9.4 BRWN SAND 15.5 GREY SAND 20.1
18547	8 13	Aug-82	596072 4918710	219.8	36.0	Fr	36.3	-0.9	6.4	27	600	33.5	3135 CT	WS DO	**MOE# 5718547** 0.0 TPSL 0.3 SAND GRVL STNS 8.5 CLAY GRVL STNS 36.0 SAND 37.2
18551	4 14	Mar-83	601062 4921071	235.9	14.9	Fr	16.2	-1.2	4.0	45	60	12.2	1467 CT	WS DO	**MOE# 5718551** 0.0 BRWN SAND FILL 0.3 GREY SAND 14.9 BRWN CSND 16.2
18581	1 18	May-83	604612 4922421	286.8	75.6	Fr	75.9	-0.9	43.9	68	60	54.9	3660 CT	WS ST	**MOE# 5718581** 0.0 BLCK TPSL 0.3 BRWN SAND 6.1 GREY CLAY GRVL 15.2 BLUE CLAY 59.4 GREY CLAY SAND 70.1 GREY SILT 71.9 GREY SAND GRVL CMTD 75.6 BRWN FSND WBRG 76.8
18621	7 10	Jul-83	597086 4921738	220.4	26.8	Fr	26.2	-1.2	14.3	18	120	26.8	1467 CT	WS DO	**MOE# 5718621** 0.0 BRWN TPSL 0.3 BRWN SAND STNS GRVL 16.5 BRWN CSND 18.9 GREY CLAY SAND 27.4 GREY SAND GRVL CMTD 27.4
18622	4 13	Jul-83	600812 4922521	246.6	12.2	Fr	14.9	-1.2	7.6	32	120	11.9	1467 CT	WS DO	**MOE# 5718622** 0.0 BRWN TPSL 0.3 BRWN SAND CLAY 6.4 GREY CLAY 12.2 GREY CLAY SAND 14.9 BRWN SAND 16.2 GREY CLAY 16.5
18625	5 16	Aug-83	601353 4920073	246.9	21.6	Su	21.6	-1.2	9.1	23	900	18.3	1467 CT	WS DO	**MOE# 5718625** 0.0 BRWN SAND CLAY 5.8 BRWN GRVL 11.9 GREY SAND GRVL CMTD 17.1 GREY CLAY 21.6 GREY FSND CLAY LYRD 22.9 GREY CLAY 22.9
18641	8 9	May-83	595411 4921471	189.9			31.4	-0.9	FLW	182			4816 RC	WS ST	**MOE# 5718641** 0.0 TPSL 0.3 MSND 0.9 GREY MSND CLAY 14.0 CSND CLAY 16.2 FSND CLAY 27.7 MSND CLAY 29.3 MSND 32.0 FSND CLAY 33.5 GREY CLAY FGVL SNDY 53.6 GREY FSND SILT CLAY 61.0
18677	3 12	Aug-83	601111 4923071	282.9	44.2	Fr	47.9	-0.9	41.1	36	60	48.8	3660 RC	WS DO	**MOE# 5718677** 0.0 BRWN CLAY 6.1 BRWN SAND CLAY 22.9 WHTE SAND GRVL 44.2 BRWN MGVL MSND LOOS 49.4
18711	4 15	Aug-83	601262 4920721	234.7	14.9	Fr	14.9	-0.9	2.7	23	120	13.4	1467 CT	WS DO	**MOE# 5718711** 0.0 PRDG 3.0 GREY CLAY SAND GRVL 14.9 GREY SAND 15.8 GREY CLAY 15.8
18712	4 13	Sep-83	601412 4922321	244.8	11.0	Fr	14.6	-1.2	3.4	36	120	8.8	1467 CT	WS DO	**MOE# 5718712** 0.0 BRWN SAND 5.8 BRWN SAND CLAY 7.9 BRWN CGVL CSND 11.0 GREY MSND 12.2 GREY SAND 14.6 UNKN 15.8

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
18774	4 13	Sep-83	601412 4922321	244.8			11.9	-1.8	1.2	45			4816 CT	WS DO	**MOE# 5718774** 0.0 SAND CLAY LYRD 9.1 FSND 15.2
18775	3 14	Sep-83	601894 4921956	237.7	70.7	-	70.7	-7.9	2.1	2187	1440		4816 RC	WS MU	**MOE# 5718775** 0.0 SAND CLAY FGVL 7.3 GREY CLAY SILT GRVL 32.9 MSND PCKD 37.8 GREY FSND CLAY SLTY 60.0 MSND 63.4 GREY CLAY SLTY 66.1 FSND SILT CLAY 71.3 MSND SILT 80.5 FSND CLAY SILT 96.6
18864	3 11	Jun-83	602165 4923871	289.9	58.8	Fr	60.4	-0.9	40.8	45	90	44.2	2514 RC	WS DO	**MOE# 5718864** 0.0 BRWN CLAY 5.8 BRWN CLAY GRVL 46.6 BLUE CLAY 58.8 YLLW SAND 61.3
18866	6 14	Sep-83	599012 4920171	246.9	25.6	Fr	34.1	-1.8	14.6	114	150	24.4	2514 RC	WS CO	**MOE# 5718866** 0.0 YLLW SAND GRVL 14.6 GREY CLAY SAND GRVL 22.9 YLLW SAND GRVL 25.9 GREY CLAY BLDR 33.8 CSND 36.0
19094	9 13	Oct-83	594862 4917671	226.8	21.3	Fr	22.9	-0.9	NR	45	90	15.2	3135 CT	WS DO	**MOE# 5719094** 0.0 TPSL 0.3 SAND 12.8 CLAY SAND 21.3 SAND 23.8
19095	3 15	Feb-84	602212 4921221	233.8	36.3	Fr	36.3	-0.9	NR	27	120	36.0	2514 CT	WS DO	**MOE# 5719095** 0.0 BRWN SAND GRVL FILL 0.6 BRWN MUCK DKCL 2.1 YLLW SAND 4.6 GREY SILT CLAY SAND 36.3 GREY FSND SILT 37.2
19153	3 13	Feb-84	601362 4922621	280.1	50.3	Fr	50.9	-2.1	43.6	36	60	45.7	1467 CT	WS DO	**MOE# 5719153** 0.0 BRWN SAND STNS 10.1 GREY SAND CLAY 10.7 BRWN SAND 35.1 GREY SAND CLAY 43.3 GREY CLAY 47.5 GREY FSND SLTY 50.3 BRWN FSND 53.3 GREY CLAY SAND 53.3
19154	4 13	Apr-84	601012 4921921	236.8	18.3	Fr	19.2	-1.2	13.7	18	120	18.3	1467 CT	WS DO	**MOE# 5719154** 0.0 BLCK TPSL 0.3 BRWN SAND GRVL 13.7 BRWN SAND LTCL 18.3 BRWN SAND CLAY DKCL 20.7 GREY CLAY 20.7
19245	4 14	May-83	602277 4921182	232.9	20.7	Fr	21.6	-0.9	1.8	27	60	15.2	3203 CT	WS DO	**MOE# 5719245** 0.0 FILL 0.6 BLCK CLAY SILT 4.6 GREY CLAY 6.4 BRWN SAND CLAY 8.8 GREY CLAY 20.1 GREY SILT 20.7 GREY SAND 22.6 GREY CLAY 22.6
19250	4 12	Jul-84	600956 4922666	252.7	17.7	-	18.3	-1.2	8.2	36	60	11.6	1467 CT	WS DO	**MOE# 5719250** 0.0 BRWN SAND 2.7 BRWN SAND CLAY 14.3 BRWN SAND DRY 17.7 BRWN SAND WBRG 19.8
19252	4 12	Jun-84	600672 4922411	244.8	24.7	Fr	24.7	-0.9	15.2	23	120	23.8	1467 CT	WS DO	**MOE# 5719252** 0.0 BRWN TPSL SAND 0.3 BRWN SAND STNS CMTD 11.6 BRWN SAND 19.5 GREY SAND GRVL CMTD 24.7 BRWN CSND 25.6 GREY CLAY GRVL 25.6
19253	5 11	May-84	599233 4921989	234.4	15.2	Fr	15.8	-1.8	10.4	23	120	12.8	1467 CT	WS DO	**MOE# 5719253** 0.0 BRWN SAND STNS 11.9 BRWN SAND 17.7 GREY SAND CLAY 18.0

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
19254	4 9	May-84	599377 4923686	238.7	12.2	Fr	13.7	-1.2	6.4	36	60	9.1	1467 CT	WS DO	**MOE# 5719254** 0.0 BRWN TPSL 0.3 BRWN SAND STNS 4.6 BRWN SAND 12.2 GREY FSND WBRG 14.9 GREY CLAY SAND 14.9
19255	5 16	May-84	600801 4919875	274.3	13.1	Fr	19.5	-1.8	13.7	23	120	19.5	1467 CT	WS DO	**MOE# 5719255** 0.0 GREY CLAY FILL 0.6 BRWN SAND 13.1 GREY FSND 21.6 GREY CLAY SAND 21.6
19279	2 23	Aug-84	602446 4923627	291.7	48.8	Fr	49.7	-0.9	32.3	14	120	48.2	3660 RC	WS DO	**MOE# 5719279** 0.0 BLCK TPSL 0.3 BRWN CLAY 12.2 GREY SAND CLAY 48.8 BRWN FSND MGRD 53.3
19339	7 8	Jun-83	595511 4922021	189.9			29.9	-1.5	FLW	14	1440		4816 RC	WS DO	**MOE# 5719339** 0.0 TPSL 0.3 SILT 2.7 CLAY 29.3 SILT 31.7 SILT CLAY 60.4 CLAY 61.9 BRWN SHLE 64.9 GREY SHLE 65.8
19547	4 11	Jun-84	600728 4923560	281.0	48.8	Fr	48.8	-0.9	39.6	45	120	46.9	4816 CT	WS DO	**MOE# 5719547** 0.0 TPSL 0.3 SAND GRVL CLAY 22.9 FSND CLAY 32.9 MSND CSND 39.6 FSND 49.7
19679	4 9	Jan-85	599462 4923583	239.9	14.3	Fr	14.6	-1.2	7.0	18	60	13.4	1467 -	WS DO	**MOE# 5719679** 0.0 BLCK TPSL 0.3 BRWN SAND CLAY 5.8 GREY CLAY 14.3 BRWN SAND CLAY 17.1
19716	3 12	Jan-85	601461 4922768	284.1	36.6	Fr	37.2	-0.9	25.6	68	120	33.5	2514 CT	WS DO	**MOE# 5719716** 0.0 YLLW SAND 23.8 GREY CLAY SILT 30.2 YLLW SAND 38.1
19815	8 8	Jun-84	594356 4921156	220.1	45.1	Fr	45.4	-0.9	24.7	91	60	36.9	2514 CT	WS DO	**MOE# 5719815** 0.0 TPSL SNDY 0.3 YLLW SAND 18.0 GREY FSND CLAY 21.0 GREY CLAY 26.5 GREY SAND CLAY HARD 45.1 YLLW MSND 46.3
19817	3 15	Sep-84	601595 4922811	282.5	19.8	Fr	21.3	-0.9	11.9	9	90	19.8	2514 RC	WS DO	**MOE# 5719817** 0.0 YLLW SAND 1.2 BRWN CLAY 13.7 YLLW SAND 22.3
19819	3 12	Jul-84	601352 4922750	274.9	41.1	Fr	41.1	-1.2	32.3	45	60	39.6	2514 CT	WS DO	**MOE# 5719819** 0.0 YLLW SAND 24.4 YLLW SAND SILT CLAY 29.6 GREY CLAY 36.0 GREY SILT HARD 41.1 YLLW MSND FSND 42.4
19820	5 9	Oct-84	599521 4923321	239.3	23.8	Fr	23.8	-0.9	14.9	45	60	23.2	2514 CT	WS DO	**MOE# 5719820** 0.0 YLLW SAND 24.7
19821	3 22	Jul-84	601659 4922769	278.3	30.5	Fr	31.1	-0.9	17.4	68	90	27.4	2514 RC	WS DO	**MOE# 5719821** 0.0 BRWN CLAY SAND 27.4 YLLW SAND 32.0
19912	4 11	Apr-85	600180 4922519	239.6	28.3	Fr	28.0	-0.9	16.5	36	60		4816 CT	WS DO	**MOE# 5719912** 0.0 OBDN 0.6 SAND SLTY CLAY 22.6 SILT 24.1 SAND CMTD 25.3 FSND SLTY 28.3 BRWN MSND 29.0 SAND SLTY 30.2

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
20001	5 14	Apr-85	600827 4921242	239.9	19.8	Fr	20.1	-0.9	8.2	23	120	16.8	1467 CT	WS DO	**MOE# 5720001** 0.0 BRWN SAND STNS 9.4 BRWN FSND 17.4 BRWN CLAY SAND 18.0 GREY CLAY SAND GRVL 19.8 GREY MSND MSND 21.0 GREY CLAY 21.0
20003	3 10	Jun-85	600531 4924039	281.0	44.5	Fr	45.4	-1.2	37.5	23	150	39.3	1467 CT	WS DO	**MOE# 5720003** 0.0 BLCK TPSL 0.3 BRWN SAND CLAY STNS 11.6 GREY CLAY SAND 19.5 BRWN CSND DRY 32.9 BRWN SAND CLAY 39.0 BRWN CLAY 43.0 GREY CLAY SAND 44.5 BRWN SAND 46.9
20127	1 16	Jul-85	604920 4921832	289.6	47.2	Fr	48.2	-1.2	39.9	45	120	42.7	3660 CT	WS DO	**MOE# 5720127 TAG#ASSMNT** 0.0 BRWN SAND GRVL 15.2 GREY CLAY SAND 20.4 BRWN SAND 43.6 BRWN FSND WBRG 47.2 YLLW MSND WBRG 49.4
20293	4 15	Jul-85	602113 4921430	236.5	19.8	Fr	20.4	-1.2	2.4	64	60	19.8	2514 CT	WS DO	**MOE# 5720293** 0.0 YLLW SAND 11.3 GREY CLAY 19.5 YLLW MSND SILT 21.6
20295	9 13	Nov-85	594765 4917969	222.8	14.9	Fr	14.9	-1.2	5.8	9	60	14.0	2514 CT	WS DO	**MOE# 5720295** 0.0 BRWN SAND GRVL BLDR 4.6 GREY CLAY 13.1 GREY SAND SILT 14.9 MSND 16.2
20388	4 12	Sep-84	601060 4922266	239.3	12.2	Fr	22.9	-0.9	9.1	36	60	13.7	3203 CT	WS DO	**MOE# 5720388** 0.0 PRDG 12.2 GREY SAND 23.8
20390	4 13	Oct-85	601015 4922225	234.4	12.5	Fr	20.4	-0.9	11.6	27	60	16.5	3203 CT	WS DO	**MOE# 5720390** 0.0 TPSL 0.6 BRWN SAND CLAY 11.0 BRWN SAND 12.5 GREY SAND 21.6 GREY SAND CLAY 21.6
20427	6 11	Nov-11	597084 4919440	227.7	9.4	Fr	25.9	-0.9	4.0		75	7.9	2514 RC	WS DO	**MOE# 5720427** 0.0 PRDG 9.1 GREY SAND SILT BLDR 25.0 WHTE MSND FSND 26.8
20428	8 13	Oct-85	596243 4918897	223.1	19.8	Fr	19.8	-1.2	6.4	23	180	16.2	1467 RC	WS DO	**MOE# 5720428** 0.0 MSND MGVL 4.3 CSND 8.5 CGVL 19.8 MSND 21.0
20516	2 18	Oct-85	604350 4922568	281.6					NR				3660 -	- -	**MOE# 5720516** 0.0 BLCK TPSL 0.3 BRWN SAND CLAY 4.9 GREY CLAY GRVL 18.3 GREY CLAY 59.7 GREY SILT CLAY 67.1 BRWN SAND CLAY 74.1
20986	4 13	Jun-86	595364 4918237	225.6	9.8	Fr	11.9	-1.2	1.5	18	150	11.6	1467 CT	WS DO	**MOE# 5720986** 0.0 BRWN SAND 4.3 GREY SAND CLAY 9.8 GREY FSND 13.1
21116	9 13	Aug-86	594832 4917991	224.0	15.5	Fr	15.5	-0.9	5.5	45	60	12.2	2514 CT	WS DO	**MOE# 5721116** 0.0 PRDG 5.5 GREY CLAY 15.2 MSND CGRD CMTD 16.5
21185	12 4	Oct-86	600709 4922306	239.6	18.3	Fr	19.2	-1.2	13.1	23		14.6	1467 CT	WS DO	**MOE# 5721185** 0.0 BRWN FILL 0.3 BRWN SAND GRVL STNS 14.0 GREY SAND GRVL CMTD 18.3 BRWN SAND 20.7 GREY GRVL CMTD 20.7

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
21364	4 16	Oct-85	600905 4922395	246.0	9.1	Fr	19.8	-0.9	9.1	32	60	16.5	3203 CT	WS DO	**MOE# 5721364 TAG#ASSMNT** 0.0 FILL 0.6 BRWN SAND CLAY 4.9 BRWN SAND 9.1 BRWN SAND 15.8 GREY SAND 21.0
21481	7 9	Nov-86	596193 4921713	200.3	13.7	Fr	14.3	-1.2	1.8	64	60	13.7	2514 CT	WS DO	**MOE# 5721481** 0.0 TPSL 0.3 BRWN SAND CLAY 0.9 BRWN CLAY 3.0 GREY CLAY SOFT 7.6 GREY SAND SILT 13.7 YLLW FSND MGRD 15.5
21883	10 17	May-87	595219 4916893	275.5			68.6	-0.9	NR				1583 RC	OW NU	**MOE# 5721883** 0.0 SAND GRVL 25.9 BRWN CLAY 26.8 SAND GRVL 30.8 GREY CLAY SILT 46.0 GREY CLAY 59.1 GREY FSND 73.2 GREY CLAY SILT 79.2
21997	4 13	Jul-87	600873 4922560	249.6	21.3	Fr	21.3	-0.9	10.1	23	120	10.1	3660 CT	WS DO	**MOE# 5721997** 0.0 BRWN SAND 21.3 GREY FSND WBRG 22.3
22000	10 14	Jul-87	594939 4917437	228.9	32.9	-	32.0	-0.9	16.8	27	120	30.5	1583 RC	OW MU	**MOE# 5722000** 0.0 CLAY SAND 1.5 SAND GRVL 3.7 BRWN FSND 7.0 BRWN SAND CLAY 8.2 GREY FSND 10.1 GREY SAND CLAY 14.3 GREY CLAY SAND 22.3 GRN SAND CLAY 29.3 GREY FSND CLAY 32.9
22278	4 17	Jul-85	601643 4922758	276.5	30.5	Fr	32.0	-1.2	17.4	45	90	23.5	3135 CT	WS DO	**MOE# 5722278** 0.0 SAND DRY PCKD 30.5 SAND WBRG 33.2
22282	4 10	Jul-87	599953 4922781	239.9	18.3	Fr	18.3	-2.1	10.7	14	150	18.3	3135 CT	WS DO	**MOE# 5722282** 0.0 SAND GRVL 4.6 FSND CLAY 18.3 SAND WBRG 21.3
22283	5 11	Jul-86	598811 4922066	226.8	17.7	Fr	18.0	-0.9	4.6	23	150	14.3	3135 CT	WS DO	**MOE# 5722283** 0.0 TPSL 0.3 SAND 3.4 SAND CLAY 17.7 SAND WBRG 18.9
22284	4 22	Jul-86	600717 4923434	282.2	12.2	Fr	12.8	-1.2	4.0	45	90	9.1	3135 CT	WS DO	**MOE# 5722284** 0.0 CLAY SAND 12.2 SAND 14.0
22291	4 17	Jul-85	602647 4920211	241.7	12.2	Fr	19.8	-1.2	12.2	45	90	16.5	3135 CT	WS DO	**MOE# 5722291** 0.0 SAND CLAY 12.2 SAND WBRG 21.0
22294	2 15	Mar-84	604963 4921449	284.1	51.8	Fr	52.7	-1.2	41.8	32	120	44.8	3135 CT	WS DO	**MOE# 5722294** 0.0 TPSL 0.3 SAND 9.1 SAND CLAY 51.8 SAND WBRG 53.9
22297	3 23	Apr-87	602417 4921327	236.5	27.4	Fr	29.0	-0.9	21.6	36	60	28.0	2514 CT	WS DO	**MOE# 5722297** 0.0 YLLW SAND 29.9 YLLW SAND CLAY 29.9
22298	5 16	Jul-87	601147 4919976	254.8	5.5	Fr	8.5	-0.9	0.9	36	90	7.6	2514 CT	WS DO	**MOE# 5722298** 0.0 TPSL 0.6 BRWN CLAY SAND 5.5 YLLW FSND MSND 9.4
22428	5 11	Sep-87	599106 4921890	232.6	14.9	Fr	17.4	-1.2	9.1	23	120	9.4	1467 CT	WS DO	**MOE# 5722428** 0.0 BRWN SAND 9.4 GREY SAND CLAY 14.9 BRWN FSND 18.9 BRWN SAND CLAY 18.9
22429	8 13	Aug-87	596461 4919115	224.9	14.6	Fr	15.5	-1.2	3.0	45	90	9.1	1467 CT	WS DO	**MOE# 5722429** 0.0 BLCK TPSL 0.3 BRWN SAND GRVL 7.9 BRWN CLAY 9.1 GREY CLAY GRVL 14.6 BRWN CSND 16.8

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
22762	9 13	Oct-87	594632 4917997	211.2	12.2	Fr	13.4	-1.2	NR	18	210	12.8	1467 CT	WS DO	**MOE# 5722762** 0.0 BRWN GRVL 1.8 GREY SAND GRVL 9.4 GREY GRVL CLAY 14.6
22764	4 13	Oct-87	600618 4921721	240.8	18.9	Fr	20.4	-1.2	14.0	23	120	16.8	1467 CT	WS DO	**MOE# 5722764** 0.0 BRWN TPSL 0.3 BRWN SAND GRVL 6.4 BRWN FSND 18.9 BRWN MSND 21.9 RED CLAY 21.9
22778	7 9	Dec-87	595827 4921636	192.9	18.3	Fr	18.9	-0.9	5.5	91	60	13.7	2513 CT	WS DO	**MOE# 5722778** 0.0 TPSL DKCL 0.3 BRWN CLAY 6.1 YLLW SAND SILT 12.2 GREY CLAY SAND SILT 18.3 YLLW SAND MGRD 19.8
23277	2 19	Mar-88	603957 4923389	289.9	48.5	Fr	52.1	-1.2	46.0	27	120	49.1	1467 CT	WS DO	**MOE# 5723277** 0.0 BRWN SAND 4.3 GREY CLAY SAND 17.4 GREY CLAY CGVL 25.0 GREY CLAY 30.8 GREY CLAY GRVL 48.5 BRWN MSND 53.3
23280	4 7	Apr-88	601149 4922791	261.5	28.3	Fr	29.3	-1.2	22.6	36	150	25.9	1467 CT	WS DO	**MOE# 5723280** 0.0 BRWN FILL 1.8 BRWN SAND GRVL STNS 7.9 GREY SAND 17.7 BRWN CLAY 19.5 GREY CLAY 26.5 GREY SAND CLAY 28.3 BRWN SAND 30.8
23282	8 13	Jan-88	597072 4919336	229.8	51.8	Fr	88.4	-3.0	11.3	68	180	20.7	2801 RC	OW NU	**MOE# 5723282** 0.0 CGVL FGRD 4.0 GREY CLAY SNDY 12.2 FSND GRVL 29.9 GREY CLAY GRVL 39.6 GREY CLAY SNDY GRVL 51.8 FSND CGRD 67.1 GREY CLAY SNDY FGVL 84.7 FGVL SAND CLAY 91.4 GREY CLAY SNDY GRVL 94.5 BRWN CLAY HARD 98.1
23283	8 13	Feb-88	596521 4918927	232.0			59.4	-1.5	11.9	114	240	13.1	2801 RC	OW NU	**MOE# 5723283** 0.0 SAND GRVL STNS 2.4 CLAY SNDY GRVL 6.4 GRVL MSND SNDY 10.4 SAND FGVL SNDY 12.5 FSND GRVL 19.8 FSND SLTY CLAY 22.9 CLAY SLTY GRVL 25.9 FSND SNDY CLAY 35.7 FSND SNDY CLAY 42.7 CLAY SLTY SAND 48.5 GREY CLAY SLTY HARD 56.4 FSND CLAY SNDY 77.7 GREY CLAY SLTY 81.4 GREY FSND MGRD CLAY 95.4 CLAY SLTY FSND 97.8
23284	8 13	Mar-88	597076 4919325	230.7	53.6	Fr	59.4	-6.1	11.0				2801 RC	WS MU	**MOE# 5723284** 0.0 TPSL 0.3 MGVL MSND 1.8 MSND MGVL 3.4 MSND FGVL CLAY 5.5 SILT 6.1 SILT 7.9 GREY CLAY 9.4 MSND MGVL 13.4 MSND 24.4 MSND FGVL 30.2 GREY CLAY 38.4 MSND 50.3 MSND 53.6 MSND FGVL CLAY 54.9 FSND 57.0 FSND 68.6

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
23285	8 14	Jan-88	596370 4918416	241.1			67.1	-1.5	19.2	64	180	21.3	2801 RC	OW NU	**MOE# 5723285 TAG#ASSMNT** 0.0 FSND FGVL BLDR 2.4 BRWN FSND SNDY CLAY 15.8 GREY CLAY SLTY SNDY 22.9 GREY CLAY SLTY FSND 27.4 GREY CLAY SLTY HARD 31.7 GREY CLAY SNDY FGVL 36.3 GREY CLAY SLTY HARD 36.9 GREY CLAY SNDY HARD 53.9 GREY CLAY SLTY HARD 60.7 GREY CLAY SNDY FGVL 66.8 GREY CLAY SNDY FGVL 86.9 GREY CLAY SLTY FGVL 90.5
23286	8 13	Feb-88	597095 4919324	229.8			59.4	-6.1	11.6	114	240	13.4	2801 RC	OW NU	**MOE# 5723286** 0.0 SAND GRVL STNS 2.4 BRWN CLAY SNDY 5.5 BRWN CLAY SLTY 6.1 GREY CLAY SLTY 9.4 FSND FGVL 12.5 FSND 30.5 GREY CLAY SLTY 39.9 FSND 41.1 GREY FSND CLAY PCKD 47.2 FSND VERY 53.6 FSND SNDY CLAY 59.4 FSND 66.4 GREY CLAY SNDY FGVL 73.5
23696	6 14	Jun-88	596886 4919181	232.9	37.5	Fr	36.6	-0.9	14.3	23	180	36.0	1583 RC	WS DO	**MOE# 5723696** 0.0 BRWN SAND 13.7 BRWN SAND GRVL 22.9 GREY SAND CLAY 38.1 FSND MSND 39.9 CLAY SILT 42.7
24011	6 14	Sep-88	599566 4920486	246.0	20.7	Fr	20.7	-1.8	9.1	36	120	14.0	1467 CT	WS DO	**MOE# 5724011** 0.0 BRWN SAND GRVL 9.4 BRWN FSND 21.0 BRWN MSND FSND 22.6 GREY SAND 22.6
24199	3 12	Oct-88	601200 4922972	275.8	53.3	Fr	54.3	-1.2	36.6	23	180		5022 RC	WS DO	**MOE# 5724199** 0.0 BRWN FSND FGVL 15.8 FGVL SAND 37.2 GREY CLAY SAND 51.8 FSND MSND 57.0
24202	5 14	Oct-88	601016 4920919	234.1	38.7	Fr	36.9	-1.8	3.7	136	135	33.5	1583 RC	WS CO	**MOE# 5724202** 0.0 BRWN SAND 18.3 CLAY 22.9 SAND CLAY 25.9 FSND 33.5 MSND 39.6 GREY FSND 42.7 CLAY 43.9
24354	6 15	Nov-88	599537 4919118	256.0	24.7	Fr	25.3	-1.2	14.6	36	120	19.5	1467 CT	WS DO	**MOE# 5724354** 0.0 BRWN TPSL 0.3 BRWN SAND CLAY GRVL 16.5 BRWN SAND DRY 24.7 BRWN MSND 26.5
24625	5 11	Dec-88	599682 4922266	239.9	54.9	Fr	51.2	-3.7	23.2	36	1440	40.5	3903 RC	WS MU	**MOE# 5724625** 0.0 BRWN SAND LOOS 1.2 BRWN FSND LOOS 15.8 BRWN MSND LOOS 25.9 BRWN FSND LOOS 30.5 BRWN FSND CLAY LYRD 32.9 BRWN FSND CLAY LYRD 41.5 BRWN CLAY STNS HARD 44.2 BRWN MSND STNS LYRD 55.8 GREY CLAY DNSE 56.4 GREY FSND GRVL CMTD 57.0 GREY SAND CLAY HARD 61.6
24656	5 16	Jan-89	601506 4920131	245.4	83.2	Fr	80.2	-3.0	5.5	609	1440	35.1	1583 RC	WS MU	**MOE# 5724656** 0.0 BRWN CLAY GRVL 6.7 GRVL CLAY 28.0 BRWN SAND 41.1 GREY CLAY SAND 70.1 BRWN MSND 75.6 BRWN SAND CLAY 78.6 BRWN MSND 83.5 CLAY SILT 87.2 GREY CLAY 92.0

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
24785	5 11	Feb-89	599887 4922236	241.1					NR				3903 RC	TH NU	**MOE# 5724785** 0.0 BRWN CSND PCKD 1.5 BRWN FSND CLAY GRVL 35.4 GREY CLAY SOFT 40.8 GREY CLAY FSND STNS 61.0 GREY FSND CLAY STNS 74.7 GREY CLAY DNSE 93.0 GREY CLAY STNS CMTD 103.9 GREY CLAY DNSE 107.9 GREY ROCK DNSE 110.0
24786	5 11	Feb-89	599887 4922246	241.1	27.7	Fr	24.7	-3.0	17.4	55	960	24.4	3903 RC	WS MU	**MOE# 5724786** 0.0 BRWN CSND PCKD 2.7 BRWN FSND CLAY LYRD 14.0 BRWN MSND FSND LYRD 15.2 BRWN CSND FSND LYRD 19.8 BRWN FSND LOOS 21.9 BRWN FSND CLAY LYRD 28.0 BRWN CLAY DNSE 29.9 GREY CLAY DNSE 31.1
24787	5 11	Feb-89	599762 4922321	239.9					NR				3903 RC	TH NU	**MOE# 5724787** 0.0 BRWN FSND VERY PCKD 9.4 BRWN FSND VERY CSND 14.6 BRWN CLAY SAND LYRD 21.6 GREY CLAY STNS HARD 25.9 GREY CLAY DNSE 27.7 GREY SAND CLAY SILT 38.4 GREY CLAY SILT LYRD 40.5
24802	5 15	Apr-89	601211 4920204	242.6	17.7	Fr	19.2	-1.2	4.0	45	480	9.1	3660 CT	WS DO	**MOE# 5724802** 0.0 BRWN GRVL FILL 1.5 GREY CLAY GRVL 8.5 GREY CLAY SOFT 17.7 GREY FSND WBRG 20.4
24900	8 13	May-89	597075 4919340	230.4	57.9	Fr	61.0	-6.1	13.1	909	240	32.6	2801 RC	WS MU	**MOE# 5724900** 0.0 MSND 1.8 MGVL MSND CLAY 6.1 GREY CLAY 10.4 GREY CLAY MGVL 14.3 MSND THIN MGVL 17.4 MSND 31.1 GREY CLAY 39.0 MSND 45.7 MSND MGVL CLAY 61.0 MSND 71.9 GREY CLAY 73.8
24990	6 21	Jun-01	596927 4919726	219.8	25.3 15.2	Fr Fr	23.2	-2.1	11.6	55	60	18.3	9999 RC	WS DO	**MOE# 5724990** 0.0 MSND 7.0 GREY CLAY 7.9 GREY CLAY MSND 15.2 MSND 25.3
24991	3 17	Aug-88	601609 4922695	270.7	39.6	Fr			29.0	55	90	30.5	3135 CT	WS DO	**MOE# 5724991** 0.0 SAND CLAY 7.6 SAND 32.3 CLAY 36.6 SAND CLAY 39.6 SAND 41.1
25264	5 16	Jul-89	601513 4920127	246.3	82.3	Fr	79.2	-4.3	17.7	600	1440	35.4	1583 RC	WS MU	**MOE# 5725264** 0.0 GRVL CLAY STNS 22.9 GREY CLAY SILT 47.2 GREY CLAY HARD 57.9 GREY CLAY SILT 66.4 SAND SILT 70.1 GREY FSND 73.8 GREY CLAY SAND SILT 78.6 GREY MSND 84.7 BRWN MSND 89.0 CLAY SAND TILL 93.0
25436	7 13	Aug-89	597554 4919759	227.1	19.5	Fr	17.7	-1.8	4.6	55	120		1583 CT	WS DO	**MOE# 5725436** 0.0 BRWN SAND CLAY 2.4 SAND CLAY HARD 5.5 GREY FSND CLAY 8.5 GREY CLAY 10.4 GREY FSND CLAY 11.6 GREY FSND 20.1
25572	3 12	Aug-89	601258 4922950	274.9	42.7	Fr	46.9	-1.2	35.7	27	60	44.2	3660 CT	WS DO	**MOE# 5725572** 0.0 BRWN SAND DRY 26.8 BRWN CLAY 29.0 BRWN SAND DRY 42.7 BRWN SAND WBRG 48.2

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
26046	7 13	Nov-89	597373 4919723	225.2	23.5	Fr	21.3	-1.8	5.5	68	240		1583 RC	WS -	**MOE# 5726046** 0.0 BRWN FSND 4.6 GREY CLAY SILT 9.8 BRWN FSND 25.0 SILT VERY FSND 29.0 GREY CLAY SILT 33.5
26101	6 15	Nov-89	600533 4919811	277.7	46.0	Fr	46.0	-1.8	41.5	27	240	44.2	1467 CT	WS DO	**MOE# 5726101** 0.0 BRWN SAND 21.0 BRWN SAND CLAY 28.0 BRWN CLAY SAND 30.8 GREY CLAY SAND 46.0 GREY SAND 47.9
26132	8 13	May-89	596206 4918876	221.9	36.6	Fr	36.6	-0.9	6.1	32	150	35.1	3135 CT	WS DO	**MOE# 5726132** 0.0 SAND GRVL DRY 15.2 CLAY SAND 36.6 SAND 37.5
26337	3 16	Feb-90	602564 4920896	230.1	67.1	Fr	67.1	-6.1	-2.7	182	180	36.0	2801 RC	OW NU	**MOE# 5726337** 0.0 FILL 1.5 BRWN CLAY SLTY SAND 2.7 GREY CLAY SLTY FSND 20.7 GREY FSND CLAY 28.0 FSND CLAY VERY 49.1 FSND FGVL CLAY 49.7 GREY CLAY HARD 56.1 GREY FSND CLAY 60.0 GREY CLAY SAND HARD 67.4 FSND CLAY PCKD 69.5 GREY FSND FGVL CLAY 73.8 GREY CLAY HARD 74.7
26424	8 13	Feb-90	596156 4918685	225.2	36.6	Fr	37.5	-1.5	-1.8	45	120	12.2	3660 CT	WS DO	**MOE# 5726424** 0.0 BRWN SAND FILL 1.5 BRWN CLAY GRVL 5.2 BRWN GRVL DRY 32.0 GREY GRVL CMTD 36.6 GREY FSND WBRG 39.6
26577	4 14	May-90	601052 4921091	236.8	50.6	Fr	50.6	-1.2	5.8	36	120	27.4	1467 CT	WS DO	**MOE# 5726577** 0.0 TPSL 0.3 BRWN SAND 9.4 BRWN SAND CLAY 19.5 GREY SAND SILT 29.6 GREY CLAY SAND 39.3 GREY CLAY 47.9 GREY CLAY SAND 50.6 GREY SAND CLAY 51.8
26850	7 10	Jun-90	597021 4921795	221.0	29.9	Fr	34.4	-1.8	14.6	68	180	30.2	5528 RC	WS DO	**MOE# 5726850** 0.0 TPSL 0.3 BRWN CLAY 4.9 GREY CLAY SAND GRVL 10.7 GREY CLAY 18.0 BRWN SAND FGVL 18.9 GREY CLAY 20.7 BRWN CSND 22.9 GREY CLAY 23.8 GREY SAND CMTD 29.9 BRWN MSND 37.2 GREY CLAY 38.4
26997	3 12	Jul-90	601571 4923167	290.5	54.9	Fr	55.5	-1.2	46.0	36	150	48.8	1467 CT	WS DO	**MOE# 5726997** 0.0 BRWN TPSL 0.3 BRWN SAND CLAY 9.1 BRWN SAND 49.1 BRWN CLAY 51.8 GREY SAND CLAY 54.9 GREY SAND 56.7 GREY CLAY 56.7
27481	9 13	Oct-90	594587 4918068	199.0	6.7	Fr	11.3	-0.9	13.1	32	60	7.6	3660 CT	WS DO	**MOE# 5727481** 0.0 BRWN SAND GRVL 6.7 BRWN MSND CSND WBRG 12.5
27742	4 23	Dec-90	600395 4922387	239.9	19.8	Fr	20.4	-1.2	9.1	36	120	13.4	1467 CT	WS DO	**MOE# 5727742** 0.0 BRWN GRVL CLAY SAND 10.4 GREY CLAY 19.8 BRWN SAND 21.6 GREY CLAY 21.6

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
27803	6 14	Jun-89	598736 4919910	239.9	36.9	Fr	36.6	-0.9	16.8	41	120	27.4	3203 CT	WS CO	**MOE# 5727803** 0.0 BRWN CLAY SAND 4.9 GREY CLAY SAND STNS 36.0 GREY SAND CLAY 36.9 GREY SAND WBRG 39.3
27804	6 15	Jul-89	599500 4919067	264.9					18.6	14	120	22.9	3203 CT	WS DO	**MOE# 5727804** 0.0 BRWN CLAY 4.9 GREY CLAY GRVL 18.9 GREY CLAY 22.3 GREY SAND SILT 26.8
27806	4 9	Jan-89	599342 4923731	238.4	12.8	Fr	15.5	-1.2	9.8	45	90	11.6	3203 CT	WS DO	**MOE# 5727806** 0.0 BRWN SAND FILL 0.9 BRWN SAND DRY 5.8 BRWN SAND CLAY 12.8 GREY SAND 17.7 GREY SAND CLAY 17.7
27807	6 16	Aug-89	599517 4918962	270.1	19.8	Fr	24.1	-1.8	19.8	32		21.3	3203 CT	WS DO	**MOE# 5727807** 0.0 TPSL 0.3 GREY GRVL CLAY 14.0 GREY SAND DRY 19.8 GREY SAND WBRG 26.2 GREY SAND 26.2
27906	4 13	Jan-91	600864 4922282	239.9	19.5	Fr	22.3	-1.2	11.3	36	120	13.1	1467 CT	WS DO	**MOE# 5727906** 0.0 BRWN TPSL 0.3 BRWN SAND 4.9 BRWN CLAY SAND 7.3 GREY CLAY 9.4 GREY SAND CLAY 19.5 BRWN SAND 23.5
27927	1 20	Nov-90	603983 4923273	289.6	56.4	Fr	60.0	-2.4	50.0	68	240	59.4	1851 RC	WS DO	**MOE# 5727927 TAG#ASSMNT** 0.0 BLCK TPSL 0.3 BRWN SAND CLAY 20.4 BRWN SAND 38.4 BRWN SAND SLTY 42.7 BRWN SAND CLAY 56.4 GREY SAND WBRG 62.5
28025	5 11	Apr-91	598919 4921951	229.8	46.0	Fr	45.1	-0.9	8.5	45	180	12.2	1413 RC	WS DO	**MOE# 5728025** 0.0 BRWN SAND LOOS 7.0 BRWN SAND GRVL LOOS 15.2 BRWN CLAY SAND SOFT 18.3 GREY CLAY DNSE 24.7 GREY CLAY SAND LYRD 33.5 GREY CLAY STNS STNY 43.0 BRWN GRVL SAND LOOS 46.0
28078	10 12	May-91	594658 4917845	219.8	6.1	-			6.1	45	60	13.7	4919 BR	WS DO	**MOE# 5728078** 0.0 BRWN TPSL 0.3 BRWN SAND CLAY PCKD 6.1 GREY CLAY HARD 15.8
28094	5 11	May-91	598947 4921943	229.8	47.9	Fr	46.9	-0.9	9.4	45	150	12.2	1413 RA	WS DO	**MOE# 5728094 TAG#ASSMNT** 0.0 BRWN FSND 7.0 BRWN CLAY STNS SOFT 9.4 BRWN GRVL SAND LOOS 11.9 BRWN CLAY SAND GRVL 16.8 BRWN CLAY SAND SOFT 23.8 GREY CLAY HARD 34.4 GREY CLAY SAND LYRD 36.9 GREY CLAY STNS HARD 44.2 BRWN SAND GRVL 47.9
28095	5 11	May-91	598875 4921942	228.6	45.7	Fr	43.9	-1.8	7.9	45	120	13.7	1413 RC	DW DO	**MOE# 5728095** 0.0 BRWN SAND LOOS 7.6 BRWN SAND GRVL LOOS 14.3 BRWN CLAY SAND SOFT 22.3 GREY CLAY STNS HARD 38.1 GREY SAND CLAY LYRD 40.5 GREY CLAY SAND HARD 42.7 GREY FSND 45.7
28180	4 12	Jun-91	600917 4922666	250.9	13.7	Fr	17.1	-1.2	8.5	45	60	13.7	3660 CT	WS DO	**MOE# 5728180** 0.0 BRWN SAND 0.9 BRWN CLAY 5.2 GREY CLAY HARD 7.0 BRWN SAND 13.7 BRWN MSND WBRG 18.3

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
28243	4 16	Mar-91	601784 4920238	239.3	68.3	Fr	68.6	-4.6	7.9	341	1440	16.5	5528 RC	WS MU	**MOE# 5728243 TAG#ABND TW** 0.0 BRWN SAND GRVL 5.2 BRWN CLAY SAND GRVL 7.6 BRWN SAND GRVL 18.0 GREY CLAY 19.5 BRWN FSND 32.3 GREY SILT CLAY 46.9 GREY SILT FSND 63.7 GREY FSND 67.7 GREY CLAY 68.3 GREY FSND 73.8 GREY CLAY SILT 78.0 GREY FSND 81.4 GREY CLAY 86.0
28273	6 16	Jul-91	599872 4919146	264.9	41.5	Fr	41.8	-1.2	30.8	36	180	35.4	1467 CT	WS DO	**MOE# 5728273** 0.0 CLAY SAND GRVL 7.0 GREY SAND CLAY 10.4 BRWN SAND 25.6 GREY CLAY SAND 27.7 GREY CLAY 41.5 BRWN SAND 43.9
28339	1 20	Jul-91	603999 4923237	289.9	57.9	Fr	61.0	-0.9	42.7	23	240	60.0	1851 CT	WS DO	**MOE# 5728339** 0.0 BRWN TPSL 0.3 BRWN GRVL 3.0 BRWN CLAY 6.4 BLUE CLAY 28.3 BLUE CLAY SOFT 33.5 RED SAND CGVL 49.1 RED SAND 50.6 GREY CLAY 55.5 GREY CLAY 57.9 GREY MSND WBRG 65.5
28343	3 10	Jul-91	601768 4924608	287.1	49.4	Fr	51.5	-1.8	39.0	68	120	44.2	1851 CT	WS DO	**MOE# 5728343 TAG#ASSMNT** 0.0 BRWN TPSL SAND 0.9 BRWN SAND GRVL 41.5 GREY CLAY SAND SLTY 49.4 BRWN SAND WBRG 53.3
28565	4 15	Oct-91	602274 4921279	235.0	22.9	Fr	23.8	-1.2	1.8	27	120		1456 CT	WS DO	**MOE# 5728565** 0.0 GREY SAND 13.1 GREY CLAY 21.0 CLAY SAND 22.9 MSND 25.0
28575	4 14	Oct-91	601052 4921134	236.8	59.4	Fr	59.7	-1.2	8.5	36	150	16.5	1467 CT	WS CO	**MOE# 5728575** 0.0 BRWN SAND 3.4 BRWN GRVL SAND 15.8 BRWN SAND 22.6 GREY CLAY SAND 40.5 GREY CLAY 59.4 GREY SAND 61.0 GREY CLAY 61.0
28671	4 16	Aug-91	601795 4920244	239.3	64.0	Fr	64.0	-4.6	8.2	364	1440	13.7	5528 RC	WS MU	**MOE# 5728671** 0.0 BRWN SAND GRVL 5.5 BRWN CLAY GRVL SAND 17.1 GREY CLAY 19.8 BRWN SAND 32.3 GREY SILT CLAY 47.2 GREY SILT 61.9 GREY MSND 67.1 GREY FSND 73.5 GREY CLAY 76.2
28687	1 23	Dec-91	603112 4924567	299.0	61.3	Fr	62.8	-1.2	52.4	45	210	59.4	1467 CT	WS DO	**MOE# 5728687** 0.0 TPSL 0.3 BRWN SAND GRVL 33.2 GREY SAND CLAY 41.5 BRWN SAND CLAY 51.5 GREY CLAY 59.1 GREY SILT 61.3 GREY SAND 64.0
28805	8 21	Oct-91	596100 4918440	232.0	30.8	Fr	28.7	-2.1	4.0	91	120	6.1	1456 CT	WS DO	**MOE# 5728805** 0.0 BRWN GRVL SAND 4.6 BRWN SAND 13.1 GREY CLAY 13.7 GREY SAND 24.4 GREY CLAY SAND 28.3 GREY SAND CLN 30.8
28933	5 14	Dec-91	600583 4921075	239.9	38.4	Fr	38.7	-1.2	8.5	36	210	27.4	1467 CT	WS DO	**MOE# 5728933** 0.0 BRWN TPSL 0.3 BRWN SAND GRVL 12.5 BRWN CLAY SAND 20.7 GREY CLAY SAND 38.4 BRWN SAND 39.9 GREY CLAY GRVL 39.9

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
29157	4 12	Apr-92	600927 4922711	254.2	15.2	Fr	16.8	-0.9	10.4	45	60	13.7	3660 CT	WS DO	**MOE# 5729157** 0.0 BLCK TPSL 0.3 BRWN SAND GRVL 1.8 BRWN CLAY SAND GRVL 4.6 GREY CLAY HARD 5.8 BRWN SAND 15.2 BRWN FSND WBRG MGRD 18.3
29252	4 14	May-92	601247 4920836	235.3	10.1	Fr	10.4	-1.8	1.5	45	120	9.1	1851 CT	WS DO	**MOE# 5729252** 0.0 BRWN FILL 0.6 BRWN TPSL 0.9 GREY SILT 5.8 RED CGVL 7.0 GREY SAND SLTY 10.1 GREY MSND WBRG 13.1
29277	3 5	May-92	601847 4921681	234.7	9.4	Fr	9.4	-1.8	3.7	68	90	9.4	2514 CT	WS DO	**MOE# 5729277** 0.0 TPSL 0.3 BRWN SAND 3.7 BRWN SAND CLAY 9.4 BRWN SAND 11.3 BRWN SAND CLAY 16.5
29457	5 2	Jul-92	599216 4921919	234.4	21.3	Fr	23.2	-1.2	11.6	55	60	19.8	3602 RA	WS DO	**MOE# 5729457** 0.0 BRWN SAND CLAY 18.3 GREY CLAY HARD 21.3 BRWN SAND CLN WBRG 24.4
29517	3 12	Aug-91	601491 4923291	288.3	51.5	Fr	54.6	-1.2	NR	77	210	55.8	2431 RC	WS DO	**MOE# 5729517** 0.0 BRWN SAND CLAY 4.3 BRWN CSND 11.3 BRWN CSND GRVL BLDR 25.6 BRWN FSND MSND 51.5 BRWN MSND 57.0 GREY FSND SLTY 61.0
29655	5 14	Oct-92	600383 4920871	237.4			11.0	-3.0	9.1				1839 BR	OW NU	**MOE# 5729655** 0.0 BRWN SAND LOOS 14.0 GREY SILT SAND STNS 14.9 GREY CLAY TILL 14.9
29656	5 14	Oct-92	600247 4920916	239.9			7.6	-1.5	5.5				1839 BR	OW NU	**MOE# 5729656** 0.0 BRWN SAND FGVL LOOS 5.5 GREY SILT SAND DNSE 9.1
29657	5 14	Oct-92	600367 4920916	235.9			20.7	-3.0	5.5				1839 -	- -	**MOE# 5729657** 0.0 BRWN SAND FGVL LOOS 5.5 GREY SAND SILT DNSE 22.9 GREY SILT CLAY SOFT 24.4
29658	5 14	Oct-92	600398 4920908	235.0			5.5	-1.5	4.6				1839 -	OW NU	**MOE# 5729658** 0.0 BLCK SAND GRVL 7.6
29659	5 14	Nov-92	600627 4921121	239.9					NR				1839 RC	OW NU	**MOE# 5729659** 0.0 BRWN SAND PCKD 7.0
29663	4 15	Oct-90	601301 4920741	234.7	36.3 10.4	Fr Mn			1.2	41	2160	18.3	1851 CT	WS DO	**MOE# 5729663** 0.0 BRWN FILL 0.6 BRWN TPSL 0.9 GREY SILT 5.8 RED GRVL 7.0 SAND 10.1 GREY MSND WBRG 13.1 GREY CLAY STKY 30.8 GREY CLAY CMTD 36.3 CGVL WBRG 38.7
30064	4 7	Jul-93	600266 4924231	274.9	42.1	Fr	42.4	-1.2	37.5	23	150	39.3	1467 CT	WS DO	**MOE# 5730064** 0.0 BRWN TPSL 0.3 BRWN SAND GRVL 12.5 GREY SAND GRVL CLAY 20.7 BRWN SAND 29.6 GREY CLAY SAND 42.1 BRWN SAND 43.6

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
30128	5 16	Nov-92	601254 4920044	249.9	26.8 22.9	Fr Fr	30.5	-1.8	7.3	45	150	24.4	6386 CT	WS DO	**MOE# 5730128** 0.0 BRWN SAND SILT GRVL 18.6 GREY SILT SAND STNS 22.3 GREY HPAN ROCK SILT 22.9 BRWN SAND GRVL LOOS 24.4 GREY HPAN GRVL SILT 26.2 GREY HPAN SAND GRVL 26.8 GREY SAND SILT LYRD 29.9 BRWN SAND SILT LYRD 32.3
30133	4 14	Aug-93	600970 4921235	237.7	14.6	Fr	15.2	-1.2	7.9	45	120	11.3	1467 CT	WS DO	**MOE# 5730133** 0.0 BRWN TPSL 0.3 BRWN SAND GRVL 12.8 BRWN SAND CLAY 14.6 RED SAND 16.5
30289	6 15	Sep-93	598832 4920041	242.9	45.7	Fr	45.7	-0.9	18.9	91	90	22.9	2514 RC	WS DO	**MOE# 5730289** 0.0 BRWN SAND GRVL 19.5 GREY SAND CLAY 36.6 BRWN SAND GRVL 46.6
30401	5 9	Oct-93	599279 4923652	234.1	14.6	Fr	15.2	-1.2	7.3	36	150	10.1	1467 CT	WS DO	**MOE# 5730401** 0.0 BRWN TPSL 0.3 BRWN SAND 8.8 GREY SAND CLAY 14.6 BRWN SAND 16.5
30402	7 13	Dec-93	597499 4919732	226.2	13.7	Fr	14.0	-2.4	4.3	36	150	8.5	1467 CT	WS DO	**MOE# 5730402** 0.0 BRWN SAND 3.0 GREY SAND CLAY 9.1 BRWN SAND 11.3 GREY SAND 13.7 BRWN FSND 16.5
30403	5 14	Nov-93	600395 4920930	235.9	15.8	Fr	17.1	-2.4	6.4	36	120	14.9	1467 CT	WS IN	**MOE# 5730403 TAG#ASSMNT** 0.0 BRWN SAND 7.3 GREY SAND CLAY GRVL 15.8 GREY FSND 19.5
30501	7 13	May-93	598172 4919885	233.8			31.4	-1.5	5.8				2801 RC	OW NU	**MOE# 5730501** 0.0 TPSL 0.6 BRWN CLAY SNDY 12.8 BRWN CLAY SNDY GRVL 15.8 SAND GRVL BLDR 23.2 BRWN SAND GRVL CLAY 25.0 SILT SNDS 33.8 SILT PCKD 35.1
30502	7 13	Jun-93	598112 4919636	241.7			62.5	-1.5	9.8				2801 RC	OW NU	**MOE# 5730502** 0.0 GRVL BLDR CSND 3.4 BLDR SNDS 6.4 BRWN CLAY SNDY 9.4 GREY CLAY HARD 13.1 GRVL SAND 31.7 SAND CLAY 36.6 GREY CLAY SNDY 37.2 GREY SAND 37.8 GREY CLAY SOFT 45.1 GREY FSND 58.5 FSND CGRD 68.9 GREY CLAY SNDY 71.9
30503	7 13	Jun-93	598132 4919616	244.8			62.5	-6.4	17.4	1137	1320	29.6	2801 RC	WS CO	**MOE# 5730503** 0.0 GRVL BLDR SAND 3.4 SAND STNS 6.4 BRWN SAND CLAY 9.1 GREY CLAY HARD 13.1 GRVL SAND 19.5 SAND FGVL 31.7 GREY SAND CLAY 36.6 GREY CLAY SOFT 45.1 FSND PCKD 58.5 GREY SAND 68.9 GREY CLAY SNDY 70.1
30504	7 13	May-93	598177 4919891	233.8			48.2	-9.4	14.0	682	20	27.7	2801 RC	WS IR	**MOE# 5730504** 0.0 TPSL 0.6 GRVL SAND BLDR 17.4 SAND GRVL BLDR 22.9 SAND GRVL CLAY 25.0 SAND GRVL 33.5 GREY SILT PCKD 40.8 GREY CLAY GRVL 45.7 SAND 56.4 GREY SAND PCKD 61.0 BRWN CLAY SAND 61.9 CLAY SAND HARD 66.4 CLAY SAND 67.7

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
30743	2 22	Jun-94	602831 4923518	291.4	57.9	Fr	59.4	-1.2	46.0	36	240	52.4	1467 CT	WS DO	**MOE# 5730743** 0.0 BRWN TPSL 0.3 BRWN SAND CLAY 4.9 BRWN SAND 18.9 GREY CLAY SAND 21.0 GREY SAND 34.7 BRWN SAND SILT 36.9 GREY SAND CLAY 57.9 GREY SAND 60.7
30971	3 12	Aug-94	601369 4922929	275.2	42.4	Fr	42.4	-1.2	33.2	23	180	36.9	1467 CT	WS DO	**MOE# 5730971** 0.0 BRWN SAND 14.6 GREY SAND 21.0 GREY SAND CLAY 24.7 GREY CLAY 37.5 GREY SAND CLAY 42.4 BRWN SAND 43.6 GREY CLAY SAND 43.6
31212	9 13	Dec-94	595171 4918227	224.6	29.9	Fr	30.2	-1.2	3.4	36	150	19.8	1467 CT	WS DO	**MOE# 5731212 TAG#ASSMNT** 0.0 BRWN TPSL 0.3 BRWN SAND GRVL STNS 14.3 GREY SAND GRVL 22.3 GREY CLAY GRVL 29.9 BRWN SAND 31.4 GREY CLAY GRVL 31.4
31213	5 11	Oct-94	599144 4921991	233.5	14.3	Fr	15.2	-1.2	9.4	32	150	11.6	1467 CT	WS DO	**MOE# 5731213** 0.0 BRWN TPSL 0.3 BRWN SAND 3.4 GREY SAND 14.3 BRWN SAND 16.5 BRWN SAND GRVL 16.5
31373	3 11	Sep-94	601836 4924448	288.3	52.1	Fr	53.3	-1.2	12.2	36	120	50.3	1851 RC	WS DO	**MOE# 5731373** 0.0 RED GRVL 5.2 BRWN CLAY 8.5 BRWN GRVL CLAY 37.5 GREY CLAY STNS 39.6 BRWN CLAY 47.2 GREY CLAY 52.1 BRWN MSND WBRG 55.2 BRWN CLAY STNS 61.0
31939	10 13	Oct-95	594493 4917955	198.4	14.6	-	14.6	-1.2	FLW	27	120	7.9	1467 CT	WS DO	**MOE# 5731939** 0.0 BRWN FILL SAND 0.6 GREY CLAY SAND 14.6 GREY SAND 15.8 GREY CLAY 15.8
32299	5 12	Jun-95	599194 4921900	234.4	16.2	Fr	16.2	-1.2	10.4	27	120	16.2	2431 RC	WS DO	**MOE# 5732299** 0.0 BRWN FSND 17.4 GREY FSND SLTY 22.3 GREY SILT FSND CLAY 27.4
32472	6 16	Sep-96	599796 4919205	265.5	42.1	Fr	42.4	-1.2	26.2	73	120	32.0	1467 CT	WS DO	**MOE# 5732472** 0.0 BRWN TPSL 0.3 BRWN CLAY SAND 5.2 GREY SAND CLAY 41.1 GREY CLAY GRVL 42.1 BRWN CSND 43.6
32821	8 12	May-97	596564 4919431	222.8	44.2	-			NR				2576 RA	TH NU	**MOE# 5732821** 0.0 BRWN TPSL SILT 0.6 BRWN SAND GRVL 3.7 BRWN SAND 9.1 GREY SILT SAND 11.0 BRWN SAND FGVL 26.8 GREY GRVL SAND 31.4 GREY SAND 44.2 BRWN SAND WBRG 53.6
32988	8 9	Aug-97	595636 4921511	190.8	9.1	Fr	10.1	-0.9	NR	36	60		2514 CT	WS DO	**MOE# 5732988** 0.0 BLCK TPSL 0.3 BLCK FILL 1.5 GREY SILT CLAY SNDY 9.1 GREY SAND 11.0
33077	3 14	Sep-97	602514 4922061	255.7	25.3	Fr	25.6	-1.5	14.0	68	60	24.1	2513 CT	WS DO	**MOE# 5733077** 0.0 YLLW SAND 4.6 GREY CLAY SAND 15.2 GREY CLAY 18.9 GREY SILT SAND CMTD 25.3 YLLW FSND 27.1

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
33158	5 13	Sep-97	600202 4920962	240.5	31.1	Fr	31.7	-0.9	8.8	55	60	21.3	3660 CT	WS DO	**MOE# 5733158** 0.0 BRWN SAND FILL 0.9 BRWN SAND GRVL 15.2 GREY SAND GRVL WBRG 18.3 GREY CLAY 31.1 GREY SAND MGRD WBRG 32.6
33191	2 16	Nov-97	604919 4921541	285.3	17.4	Fr	16.2	-1.2	12.2	32	120	15.2	4645 RC	WS DO	**MOE# 5733191** 0.0 BRWN SAND GRVL LOOS 1.2 BRWN CLAY SILT HARD 14.3 BRWN SAND GRVL LOOS 17.4 BRWN CLAY SAND HARD 54.9
33255	9 13	Nov-97	595254 4918256	224.6	51.2	Mn	51.2	-1.2	7.0	45	150	17.7	1467 CT	WS DO	**MOE# 5733255** 0.0 BRWN TPSL 0.3 BRWN SAND GRVL 29.9 GREY CLAY FSND 51.2 GREY SAND 52.4 GREY CLAY 52.7
33452	4 16	May-98	601776 4920263	237.4	61.3	Fr	61.3	-10.1	2.1	727	4320	4.0	5528 RC	WS MU	**MOE# 5733452** 0.0 BRWN SAND 5.8 BRWN SAND GRVL CLAY 16.8 GREY CLAY 18.3 BRWN SILT SAND 25.9 GREY SILT CLAY 44.5 GREY CLAY SILT 46.6 GREY SILT 60.7 GREY FSND 72.2 GREY CLAY SAND LYRD 75.0
33549	2 17	Jan-98	604587 4922184	285.0	3.7	Fr			2.4	91	120	7.6	3413 BR	WS DO	**MOE# 5733549** 0.0 BRWN GRVL CGRD 3.7 GREY CLAY 8.5
33578	8 13	May-98	596036 4918673	220.1	38.4	Fr	39.9	-1.2	NR	23	1080	12.5	1467 CT	WS DO	**MOE# 5733578** 0.0 BRWN TPSL 0.3 BRWN SAND GRVL 12.8 GREY CLAY GRVL 38.4 GREY FSND 41.1
33595	7 9	Aug-98	596736 4922241	193.9	38.7	Fr	42.4	-1.2	NR	45	60	3.4	1467 CT	WS DO	**MOE# 5733595** 0.0 BRWN TPSL 0.3 RED SAND 0.9 GREY CLAY 34.7 GREY CLAY GRVL 36.9 GREY SILT 38.7 BRWN SAND 43.6 GREY CLAY 43.6
34001	8 13	Dec-98	595942 4918779	211.5	18.0	Fr	16.5	-1.5	1.8	68	150	4.9	7074 CT	WS DO	**MOE# 5734001** 0.0 GREY CLAY SAND 7.9 GREY CLAY CSND 16.5 BRWN SAND CLAY 18.0
34038	6 10	Nov-98	597151 4922019	222.8					NR				2513 -	AB NU	**MOE# 5734038** 0.0
34146	4 4	Apr-99	599392 4923657	238.7	10.1	Fr	13.7	-1.2	6.7	23	120	10.7	1467 CT	WS DO	**MOE# 5734146** 0.0 BRWN SAND 10.1 GREY SAND WBRG 14.9 GREY SAND CLAY 14.9
34300	4 13	May-99	600754 4921528	239.9	15.5	Fr	16.5	-1.2	12.2	23	60	13.7	1467 CT	WS DO	**MOE# 5734300** 0.0 BRWN TPSL 0.3 GREY SAND GRVL 15.5 BRWN SAND 17.7 GREY SAND CLAY 17.7
34379	5 9	Aug-99	598118 4923057	212.1	21.3	-	21.3	-1.5	FLW	18	180	18.3	5528 RC	OW MU	**MOE# 5734379** 0.0 BRWN SAND 2.1 BRWN CLAY SOFT 6.7 BRWN CLAY 14.6 BLDR 15.5 GREY CLAY GRVL 19.5 BRWN SAND 25.9 GREY SILT 28.0 GREY CLAY SILT 34.7 GREY CLAY HARD 41.1 GREY SILT 46.3 GREY CLAY 48.8 GREY FSND SILT 59.7 GREY CLAY SILT 64.0 GREY CLAY HARD 67.1

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
34380	5 10	Aug-99	598510 4922524	226.5					NR				5528 RC	AS MU	**MOE# 5734380** 0.0 BRWN SAND 3.7 BRWN CLAY 7.3 BRWN SAND 21.9 GREY CLAY SAND 28.3 GREY CLAY 29.3 GREY CLAY 33.5 GREY FSND SILT 41.1 GREY SILT 51.2 GREY CLAY 56.1 GREY SILT 71.9 GREY CLAY 81.7 GREY SILT CLAY 89.9 GREY SAND CLAY 91.4 GREY CLAY TILL 100.6
34381	5 10	Aug-99	598080 4923089	208.2					NR				5528 RC	AB MU	**MOE# 5734381** 0.0 BRWN SAND 1.5 BRWN CLAY SOFT 8.5 GREY CLAY SOFT 12.8 GREY CLAY GRVL 21.9 GRVL SAND STNS 24.4
34452	4 14	Jul-99	600968 4921207	238.0	16.5	Fr	15.5	-0.9	9.4	41		13.4	2514 CT	WS DO	**MOE# 5734452** 0.0 BLCK SAND GRVL TPSL 0.6 BRWN SAND GRVL 14.9 BRWN SAND 16.5
34824	5 14	Dec-99	600844 4921126	236.8	16.2	Fr	14.9	-1.2	8.5	36	180	14.3	2514 CT	WS DO	**MOE# 5734824** 0.0 BRWN GRVL SAND SNDY 12.2 BRWN SAND CLAY 14.9 BRWN MSND 16.2
35105	4 12	May-00	602494 4922159	239.0	20.1	Fr	17.4	-2.7	11.3	45	390	16.8	2514 CT	WS DO	**MOE# 5735105** 0.0 BRWN SAND CLAY 13.7 BRWN SAND 17.4 GREY FSND 20.1
35245	7 16	May-00	599460 4918471	281.9	23.8	Fr	32.9	-3.7	23.8	91	90	25.6	6409 CT	WS DO	**MOE# 5735245** 0.0 BLCK TPSL FILL 1.2 BRWN CLAY STNS 6.4 BRWN SAND LOOS DRY 23.8 BRWN SAND WBRG 36.6
35436	6 14	Jul-00	598666 4919887	239.9	25.0	Fr	23.2	-2.1	12.2	136	90	19.8	3602 RC	WS DO	**MOE# 5735436 TAG#ASSMNT** 0.0 BRWN SAND GRVL CLAY 7.6 BRWN CLAY HARD 7.9 BRWN SAND CLAY GRVL 12.2 BRWN CLAY HARD 13.7 BRWN CLAY SAND 15.2 BRWN SAND 18.3 BRWN SAND GRVL 19.8 BRWN CLAY 23.2 BRWN SAND WBRG 25.0
35502	4 12	Aug-00	602462 4922133	252.4	36.6	Fr	33.8	-2.7	11.9	68	360	32.3	2514 CT	WS DO	**MOE# 5735502** 0.0 BRWN SAND CLAY SAND 13.7 BRWN SAND 17.4 GREY SAND FSND 21.3 GREY SAND CLAY SAND 32.0 BRWN SAND FSND 36.6
35952	4 14	May-01	601434 4921874	237.4					NR				2801 RC	AQ MU	**MOE# 5735952** 0.0
36080	1 21	May-01	603956 4923346	290.5	53.6	Fr	53.9	-1.2	43.3	23	270	46.9	1467 CT	WS DO	**MOE# 5736080** 0.0 BLCK TPSL 0.3 BRWN SAND CLAY 14.3 GREY CLAY 20.1 GREY CLAY SAND 30.8 BRWN SAND CLAY LYRD 48.2 GREY CLAY 53.6 BRWN SAND 55.5 GREY CLAY SAND 55.5

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
36194	7 13	Jul-01	598309 4919758	239.9	36.9	Fr	28.7	-3.4	10.7	64	60	13.7	2801 RC	WS CO	**MOE# 5736194** 0.0 GRVL SAND BLDR 2.7 CLAY GRVL 7.3 CLAY SNDY GRVL 7.9 GRVL CLAY SOFT 9.4 GREY CLAY STNS 12.5 GRVL SAND BLDR 14.9 CLAY 16.5 SAND GRVL CLAY 22.9 SAND SNDY CLAY 26.8 SAND 29.0 SAND GRVL STKY 31.1 SAND PCKD 32.9 FSND GRVL 38.1 FSND FSND 40.5
36333	5 17	Jul-01	601034 4920744	237.1	25.3	Fr	21.9	-3.0	2.7	136	90	17.1	2513 CT	WS IR	**MOE# 5736333** 0.0 YLLW SAND 4.6 GREY SAND GRVL 13.1 GREY SAND SILT 14.0 GREY SAND 21.0 GREY FSND 25.3
36619	5 9	Jan-02	599363 4923509	236.8	27.4	-	25.6	-1.2	13.1	55	90	20.7	2576 CT	WS DO	**MOE# 5736619** 0.0 PRDR 19.8 GREY SAND 25.0 BRWN SAND 27.4
36620	4 9	Jan-02	599512 4923687	240.8	17.4	Fr	14.3	-1.2	7.6	36	90	11.9	2576 CT	WS DO	**MOE# 5736620** 0.0 BRWN SAND 6.7 GREY SAND 14.6 BRWN SAND 17.4
36644	5 17	Feb-02	601651 4919778	271.9	46.9	-	44.2	-2.4	36.6	55	180	41.1	2514 CT	WS DO	**MOE# 5736644** 0.0 BLCK TPSL 0.3 BRWN SAND MSND 20.1 GREY SAND CLAY 36.6 GREY SAND 46.9
36694	7 14	Mar-02	597809 4919103	280.4					NR				2801 -	AB NU	**MOE# 5736694** 0.0 SAND 4.6 SAND GRVL 10.7 BRWN CLAY 13.1 SAND GRVL 21.3 BRWN CLAY 21.9 SAND GRVL 39.9 GREY CLAY 43.9 CLAY GRVL 47.9 GREY SAND GRVL 68.9 GREY CLAY 75.3 SAND SILT 82.0 GREY CLAY GRVL 83.8 SAND SLTY 91.7 MSND 113.4 MSND 132.6 GREY CLAY STNS HARD 134.4
36988	9 13	Jun-02	595278 4918277	224.9	22.3	Fr	27.4	-1.2	13.4	41	60	19.8	7088 CT	WS DO	**MOE# 5736988** 0.0 BRWN SAND SILT 22.3 BRWN SAND 28.7 GREY SAND SILT 30.5
37087	5 9	Jun-02	599283 4923488	235.3	9.4	Fr	16.8	-1.2	7.0	23	120	12.5	1467 CT	WS DO	**MOE# 5737087** 0.0 BLCK TPSL 0.3 BRWN SAND STNS 2.1 BRWN SAND CLAY 9.4 BRWN SAND 18.0
37142	7 10	Aug-02	596970 4921744	218.8	35.4 32.9	Fr Fr	33.5	-0.9	NR	27	90		2576 RA	WS DO	**MOE# 5737142** 0.0 TPSL 0.3 BRWN SAND GRVL 5.5 GREY SILT GRVL 16.2 BRWN GRVL SAND WBRG 24.1 GREY SILT GRVL 27.1 GREY SILT CLAY GRVL 32.9 GREY SAND GRVL SILT 35.4
37146	4 12	Jul-02	602455 4922116	251.5	22.3 20.4	Fr Fr	19.8	-1.8	10.1	68	240	18.3	2514 CT	WS DO	**MOE# 5737146** 0.0 BRWN SAND GRVL FILL 0.9 BLCK SAND TPSL 1.2 BRWN SAND 9.1 GREY SAND CLAY SAND 18.3 BRWN SAND MSND 22.3

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
37231	14	Sep-02	598564 4919871	239.9	31.1 27.4	Fr Fr	29.0	-2.1	15.2	68	70	24.4	3602 RA	WS DO	**MOE# 5737231** 0.0 BRWN SAND GRVL STNS 7.9 BRWN SAND CLAY GRVL 15.5 BRWN SAND CLAY SNDY 27.4 BRWN SAND CLN WBRG 31.1
37242	5	Jun-02	600916 4923028	271.3	42.7	Fr	43.9	-2.4	30.5	55	150	39.6	1467 CT	WS DO	**MOE# 5737242** 0.0 BRWN TPSL 0.3 BRWN SAND 2.1 BRWN CLAY 7.9 BRWN SAND CMTD 42.7 BRWN SAND 45.4
37495	6 14	Dec-02	598542 4919846	239.9	28.7	Fr	29.0	-1.8	12.5	91	600		6300 RC	WS CO	**MOE# 5737495** 0.0 TPSL 0.6 BRWN SAND GRVL 2.4 BRWN SAND 10.4 BRWN CLAY 18.6 SAND 28.7 SAND CLN 31.1
37655	3 13	Feb-03	601652 4922230	243.5					NR				7144 -	AB -	**MOE# 5737655** 0.0 UNKN 2.1 UNKN 19.8 STNS 21.0
37801	9 13	Feb-03	595194 4918135	225.9	28.7	Fr	28.7	-1.2	8.5	32	90	27.4	5528 CT	WS DO	**MOE# 5737801** 0.0 BRWN GRVL STNS 9.1 GREY SAND SILT 13.1 GREY SAND CLAY SILT 27.4 GREY CLAY 28.3 GREY FSND 30.2
37827	9 13	Apr-03	594715 4917969	221.6	49.7	Fr	50.3	-1.2	4.9	36	120	14.0	1467 CT	WS DO	**MOE# 5737827** 0.0 TPSL 0.3 BRWN SAND GRVL 7.3 GREY SAND GRVL 17.4 GREY SILT 33.8 GREY CLAY HARD 46.9 GREY SAND 48.5 GREY CLAY 49.7 GREY SAND 51.2 GREY CLAY 51.5
37998	5 14	Jun-03	600496 4920946	235.0	21.6	Fr	20.1	-1.5	10.1	45	90	18.3	2514 CT	WS DO	**MOE# 5737998** 0.0 BRWN SAND GRVL 4.6 BRWN GRVL 6.7 BRWN SAND MSND 21.6
38195	9 13	Dec-02	596674 4918582	244.1			62.5	-7.6	23.8				2801 RC	OW NU	**MOE# 5738195** 0.0 SAND GRVL 5.5 SAND CLAY SILT 13.1 GREY CLAY 15.8 SAND CLAY LYRD 17.4 SAND 20.7 GREY CLAY SAND LYRD 24.1 GREY CLAY 25.6 FSND PCKD 43.0 GREY CLAY 44.2 SAND CLAY PCKD 46.9 GREY CLAY 54.3 SAND VERY PCKD 75.6 SAND VERY GRVL 77.7 SAND GRVL 80.5 GREY CLAY SNDY 89.9 GREY CLAY HARD 92.7
38227	8 13	Jul-03	596698 4918601	244.1			62.5	-10.1	24.7	1137	4320	39.3	2801 RC	WS MU	**MOE# 5738227** 0.0 SAND GRVL PCKD 4.3 SAND GRVL CMTD 7.0 SAND PCKD 12.8 GREY CLAY HARD 16.5 GREY SAND PCKD 20.7 GREY CLAY 25.9 SAND PCKD 43.0 GREY CLAY 44.5 SAND PCKD 46.6 GREY CLAY 54.9 SAND PCKD 75.6
38363	3 10	Sep-03	601099 4923536	284.7	53.3	Fr	53.3	-1.5	37.8	45	480	48.2	1851 CT	WS DO	**MOE# 5738363** 0.0 BRWN CLAY SAND 3.7 GREY CLAY SAND GRVL 40.5 BRWN SAND DRTY 46.6 GREY CLAY FSND SILT 53.3 GREY FSND WBRG 54.9

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
38422	4 11	Oct-03	599951 4922799	279.5	28.0	Fr	26.5	-1.5	11.6	5	120	26.5	2514 CT	WS DO	**MOE# 5738422** 0.0 BRWN FSND 20.7 GREY CLAY SAND SNDY 26.2 GREY FSND 28.0
38455	6 14	Dec-03	598714 4919899	239.9	36.0	Fr	34.7	-1.2	20.7	91	120	27.4	7074 CT	WS DO	**MOE# 5738455** 0.0 BRWN SAND GRVL 4.3 GREY CLAY 18.9 BRWN SAND GRVL 23.8 GREY CLAY SAND 35.1 BRWN CSND 36.0
38528	7 13	Jul-03	597694 4919729	230.1	4.6	Fr	60.7	-2.4	7.0	118	60	53.0	1663 RC	WS CO	**MOE# 5738528** 0.0 BRWN FSND GRVL 11.9 BRWN CLAY SNDY GRVL 13.7 BRWN SAND GRVL 20.7 BRWN CLAY 22.3 BRWN SAND CLAY 27.4 BLUE CLAY FSND 44.5 GREY MSND FSND 63.1
38845	8 16	May-04	596979 4917121	314.9	52.7	Fr	64.9	-2.1	53.6	9	60	185.0	7222 CT	WS DO	**MOE# 5738845 TAG#A003945** 0.0 BRWN SAND FGVL LOOS 67.1
38949	4 13	Jan-04	600870 4921370	239.9	10.7	Fr	6.1	-3.0	NR				6607 -	TH -	**MOE# 5738949 TAG#A007302** 0.0 BRWN SAND GRVL STNS 9.1
39023	6 14	Aug-04	598727 4919962	239.9	39.3	Fr	39.3	-1.2	16.8	32	120	36.6	1851 CT	WS IN	**MOE# 5739023 TAG#A003719** 0.0 BRWN GRVL SAND CLAY 10.7 GREY CLAY GRVL 20.1 BRWN GRVL CLAY 27.4 BRWN SAND DRTY 29.3 GREY CLAY STNS 38.1 GREY SAND SILT 39.3 BRWN SAND WBRG 40.5
39139	3 14	Aug-04	602438 4921985	256.9	27.1	Fr	26.2	-2.7	12.5			16.8	2514 CT	WS DO	**MOE# 5739139 TAG#A003188** 0.0 BRWN SAND GRVL SOFT 3.0 GREY CLAY SAND LYRD 24.4 BRWN SAND 29.0
39284	2 27	Oct-04	602485 4925381	281.0	53.0	Fr	51.8	-1.2	33.5	227	120	37.2	7074 RC	WS DO	**MOE# 5739284 TAG#A000683** 0.0 GREY CLAY SAND 8.2 BRWN SAND 36.6 GREY CLAY 50.3 BRWN SAND 53.0
39408	8 13	Oct-04	596021 4918582	217.6	17.1	Fr	17.4	-1.2	FLW	27	990	14.3	1467 CT	WS DO	**MOE# 5739408 TAG#A018286** 0.0 BRWN TPSL 0.3 BRWN CLAY STNS 4.3 GREY SAND CLAY GRVL 17.1 BRWN SAND 18.6
39425	8 14	Oct-04	596700 4918617	244.1	61.9	Fr	62.8	-9.8	23.5	1141	2520	39.6	2801 RC	WS MU	**MOE# 5739425 TAG#A011213** 0.0 SAND GRVL 6.4 FSND CLAY LYRD 20.7 SAND GRVL CLAY 25.6 FSND GRVL CLAY 44.2 CLAY LYRD SAND 56.7 FSND PCKD 76.8 FSND CLAY PCKD 78.6
39665	5 7	Jan-05	597678 4923800	199.9	26.8	Fr	26.5	-6.7	-0.9	9	60	61.0	2576 RA	WS -	**MOE# 5739665 TAG#A024711** 0.0 BRWN SAND 4.6 GREY CLAY SOFT 19.8 GREY SILT FSND 32.9 GREY CLAY 33.2
39677	4 12	Apr-05	601045 4923052	282.9	44.2	Fr	44.2	-2.4	31.1	45	60	39.9	7075 RC	WS DO	**MOE# 5739677 TAG#A020798** 0.0 TPSL 0.3 BRWN CSND 21.0 BRWN SAND CLAY LYRD 23.5 BRWN FSND 46.6
39696	9 15	Apr-05	596612 4917321	314.9					NR				2801 DG	AB -	**MOE# 5739696** 0.0 0.0

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
39881	4 14	Jun-05	600950 4921247	237.7					8.8	9	120	11.6	7074 CT	WS DO	**MOE# 5739881 TAG#A023948** 0.0 BRWN SAND MSND 7.9 GREY CLAY SAND 8.5 BRWN SAND CSND 19.2
39941	7 12	Jul-05	596907 4919777	222.8	25.6	Fr	24.4	-1.2	12.8	45	60	15.2	7075 RC	WS DO	**MOE# 5739941 TAG#A027101** 0.0 BLCK TPSL 0.3 BRWN FSND 8.8 GREY CLAY SILT HARD 21.9 BRWN SAND 25.6
40212	9 15	Sep-05	596506 4917729	294.7			53.3	-3.0	55.5				7075 RC	OW -	**MOE# 5740212 TAG#A030121** 0.0 TPSL 0.3 BRWN CSND CGVL STNS 15.8 BRWN CSND CGVL 56.4
40213	9 15	Sep-05	596236 4917630	245.7			59.7	-3.0	17.1				7075 RC	OW MU	**MOE# 5740213 TAG#A030101** 0.0 BRWN CSND CGVL STNS 14.6 BRWN CSND CGVL 62.8
40223		Sep-05	596737 4917299	314.9			6.7 21.9	-3.0 -3.0	24.1				7075 RC	OW MU	**MOE# 5740223 TAG#A030103** 0.0 TPSL 0.3 BRWN SAND LOOS 1.2 BRWN CSND CGVL 4.3 GREY CLAY TILL HARD 11.0 BRWN CSND CGVL 25.3
40325	7 8	Sep-05	596648 4922557	191.1	38.7	Un	43.0	-1.2	5.8	14	180	4.0	1467 CT	WS DO	**MOE# 5740325 TAG#A026875** 0.0 BRWN TPSL 0.3 GREY CLAY 38.7 GREY SAND 44.2 GREY CLAY 44.8
40481	4 12	Nov-05	601433 4922435	255.4	29.3	Fr	29.3	-1.2	15.5	27	300	27.4	1851 CT	WS DO	**MOE# 5740481 TAG#A024307** 0.0 GREY CLAY SAND 22.9 GREY CLAY DNSE 29.3 BRWN SAND WBRG 30.8 GREY SILT CLAY SAND 31.4
40551		Sep-05	600417 4920784	239.9			21.0	-3.0	NR				1737 RC	OW NU	**MOE# 5740551 TAG#A032270** 0.0 BLCK FILL 0.6 BRWN FSND 2.4 GREY CLAY SILT SOFT 5.2 GREY SAND GRVL CLAY 24.1
40552		Sep-05	600394 4920929	235.0					NR				1737 RC	OW NU	**MOE# 5740552 TAG#A032272** 0.0 BRWN FILL SAND GRVL 2.1 BRWN CSND 7.6 BRWN MSND 18.3
40553		Sep-05	600433 4920972	235.0			8.5	-3.0	NR				1737 RC	OW NU	**MOE# 5740553 TAG#A032271** 0.0 BRWN CGVL 2.4 BRWN MSND CLAY 11.6
40554		Sep-05	600433 4920972	235.0			24.1	-3.0	NR				1737 RC	OW NU	**MOE# 5740554 TAG#A032271** 0.0 BRWN CSND CGVL 2.4 BRWN MSND 11.3 GREY CLAY SILT SOFT 20.7 GREY MSND 27.4
40555		Sep-05	600343 4920903	239.0			3.0	-3.0	NR				1737 RC	OW NU	**MOE# 5740555 TAG#A032275** 0.0 BRWN GRVL SAND STNS 6.1
40556		Sep-05	600384 4920889	236.5					NR				1737 RC	OW NU	**MOE# 5740556 TAG#A032273** 0.0 BLCK FILL 1.8 BRWN CSND 5.8 BRWN CGVL 7.9 BRWN MSND 18.3
40561		Sep-05	600343 4920903	239.0					NR				1737 RC	OW NU	**MOE# 5740561 TAG#A032274** 0.0 BLCK FILL 1.5 BRWN CGVL CSND 8.2 BRWN MSND 18.3
40620		Dec-05	600360 4920936	237.1			9.1	-3.0	NR				6032 -	OW NU	**MOE# 5740620 TAG#A005465** 0.0 BRWN SAND 3.0 BRWN SAND 11.9

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
40792	5 14	Apr-06	600762 4921225	239.9	18.0	Un	18.6	-0.9	9.8	59	60	11.6	2513 CT	WS DO	**MOE# 5740792 TAG#A015087** 0.0 YLLW SAND GRVL BLDR 3.4 GREY SAND GRVL BLDR 7.3 YLLW SAND GRVL 19.5
41263	5 12	Aug-06	599189 4921860	234.1	27.4	Fr	27.4	-1.5	9.1	45	60		2576 RA	WS DO	**MOE# 5741263 TAG#A048809** 0.0 BRWN SAND 21.6 GREY CLAY 27.4 GREY SAND 29.0 GREY SILT 29.6
41287		Aug-06	600356 4920911	237.7			2.7	-3.0	NR				6032 -	TH NU	**MOE# 5741287 TAG#A005219** 0.0 BLCK GRVL 0.3 BRWN SAND SILT 3.7 BRWN SAND GRVL 5.8
7035794		Sep-06	600865 4921358	239.9	10.7	Fr	9.1	-6.1	NR				6607 -	OW -	**MOE# 7035794 TAG#A046475** 0.0 BRWN SAND GRVL 1.5 BRWN CGVL SAND 4.6 BRWN FSND FGVL 9.1 GREY FSND 15.2
7035810		Sep-06	600865 4921358	239.9	10.7	Fr	9.1	-3.0	NR				6607 -	OW -	**MOE# 7035810 TAG#A046480** 0.0 BRWN SAND CGVL 1.5 BRWN SAND 6.1 GREY FSND 12.2
39205		Nov-06	600885 4921363	239.9	10.7	Fr	9.1	-3.0	NR				6607 -	OW -	**MOE# 7039205 TAG#A051199** 0.0 BRWN SAND CGVL 4.6 BRWN SAND FSND 9.1 GREY FSND 12.2
7040894		Nov-06	600325 4920974	240.5	10.1	Fr			NR				1129 RC	OW NU	**MOE# 7040894 TAG#A039909** 0.0 BRWN SAND SAND 12.2 BRWN SAND 21.3
41785	5 21	Feb-07	600004 4922834	241.1					NR				2514 -	AS NU	**MOE# 7041785 TAG#A048109** 0.0 67.1
7046407		Apr-07	600560 4921340	239.9	9.8	Un	14.9	-0.3	NR				6607 -	OW -	**MOE# 7046407 TAG#A048432** 0.0 BLCK FILL 4.6 BRWN SAND 6.1 SAND 9.8 SAND WBRG 15.2
7046408		May-07	600560 4921340	239.9	9.8	Un	9.1	-3.0	NR				6607 -	OW -	**MOE# 7046408 TAG#A048431** 0.0 BLCK FILL 4.6 BRWN SAND 6.1 BRWN SAND 9.8 BRWN SAND WBRG 12.2
7048679		Jul-07	595081 4916854	261.8					NR				6809 -	OW MO	**MOE# 7048679 TAG#A053003** 0.0 BRWN SAND GRVL 15.2 BRWN CSND GRVL WBRG 15.8 BRWN FSND SILT 24.1
51395		May-07	600343 4921203	239.9					NR				1129 OTH	OW -	**MOE# 7051395 TAG#A055379** 0.0 SAND GRVL 0.9 BRWN FSND MSND 11.9 BRWN SAND MSND 15.8
54010	3 11	Dec-07	600897 4923544	282.5	95.1	Fr	93.6	-2.4	47.9		60		5224 RA	WS DO	**MOE# 7054010 TAG#A059122** 0.0 BRWN CLAY SAND 2.4 BRWN SAND GRVL CLAY 13.7 BRWN SAND 54.9 GREY SILT SAND 93.9 GREY SAND 96.0
7100088		Nov-07	600320 4921195	240.2					NR				1129 -	OW MO	**MOE# 7100088 TAG#A060920** 0.0 BRWN SAND 12.2 GREY SAND WBRG 21.3

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
2442	3 11	Jan-08	601084 4923476	285.0			41.8	-3.0	33.5				5528 RC	OW NU	**MOE# 7102442 TAG#A044231** 0.0 BRWN SAND 1.5 GREY CLAY 7.6 BRWN SAND MSND 18.9 GREY CLAY SAND TILL 22.9 GREY CLAY SILT 24.4 GREY CLAY SAND FSND 33.5 BRWN SAND MSND 57.9 BRWN SAND SILT 76.2 GREY CLAY SILT 83.5 GREY SAND CLAY SILT 85.3 GREY CLAY DNSE 90.2 GREY SILT CLAY 101.5 GREY SAND SILT FSND 108.2 BRWN SAND MSND 114.3 BRWN SAND SILT DRTY 135.6 GREY CLAY SILT TILL 146.3
2443	3 11	Jan-08	601084 4923476	285.0					NR				5528 RC	OW CO	**MOE# 7102443 TAG#A044231** 0.0 BRWN SAND 1.5 GREY CLAY 7.6 BRWN MSND CSND 18.9 GREY CLAY GRVL TILL 22.9 GREY CLAY SILT 24.4 GREY CLAY FSND 33.5 BRWN MSND 57.9 BRWN SAND SILT 76.2 GREY CLAY SILT 83.5 GREY SAND CLAY SILT 85.3 GREY CLAY DNSE 90.2 GREY SILT CLAY 101.5 GREY FSND SILT 108.2 BRWN MSND 114.3 BRWN SAND SILT DRTY 135.6 GREY CLAY SILT TILL 146.6
3469		Oct-07	600862 4921415	239.9	10.4	Fr			NR				6607 BR	WS TH	**MOE# 7103469 TAG#A065551** 0.0 BRWN SAND SILT FSND 17.4
6268	3 11	Jan-08	602204 4923681	290.8					NR				 RC	OW CO	**MOE# 7106268 TAG#A044221** 0.0 BRWN CLAY 3.0 BRWN SAND GRVL 9.1 BRWN FSND 39.6 BRWN SILT SAND CLAY 45.7 BRWN FSND 48.2 BRWN MSND 89.9 BRWN SILT CLAY SAND 103.6 BRWN FSND 112.8 BRWN MSND 117.3 BRWN SILT CLAY SAND 125.0 BRWN FSND 128.0 BRWN MSND 134.7 GREY CLAY DNSE 138.4 BRWN SILT SAND DRTY 141.7 BRWN SAND SILT STNS 144.2 BRWN MSND CSND 148.4 GREY CLAY STNS TILL 156.7
6274	3 11	Feb-08	602133 4923624	290.8			47.2	-0.9	40.5				5528 RC	OW NU	**MOE# 7106274 TAG#A044221** 0.0 BRWN CLAY 3.0 BRWN SAND GRVL 9.1 BRWN SAND FSND 39.6 BRWN SILT SAND LYRD 45.7 BRWN SAND FSND 48.8 BRWN SAND MSND 89.9 BRWN SILT CLAY SAND 103.6 BRWN SAND FSND 112.8 BRWN SAND MSND 117.3 BRWN SILT CLAY SAND 125.0 BRWN SAND FSND 128.0 BRWN SAND MSND 134.7
7108925	2 12	May-08	602228 4924119	289.6	64.3	Fr	63.1	-1.2	41.5	91	120	43.9	7074 RC	WS DO	**MOE# 7108925 TAG#A023980** 0.0 BRWN CLAY SAND 1.2 BRWN SAND MSND 25.6 GREY CLAY 35.1 GREY CLAY SILT 57.3 GREY SILT SAND FSND 61.9 BRWN SAND 64.3
7109716	5 15	Jun-08	600274 4919706	275.2	14.9	Fr	19.8	-1.5	NR				7190 RC	OW NU	**MOE# 7109716 TAG#A047918** 0.0 BRWN TPSL 0.6 BRWN SAND GRVL SILT 15.2 GREY SAND GRVL SILT 21.3

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
7110073		Jul-08	597670 4919755	229.5	12.2	Fr			6.1	68	60	7.6	7075 RA	WS -	**MOE# 7110073 TAG#A066540** 0.0 BRWN SAND LOOS 3.4 GREY CLAY SILT HARD 10.7 BRWN FSND LOOS 24.1
7111735	3 10	Aug-08	601830 4924191	286.8	110.9	Un	116.4 110.3	-9.1 -6.1	51.2	250	120	57.0	5528 RC	WS MU	**MOE# 7111735 TAG#A044266** 0.0 BRWN SAND GRVL 0.9 BRWN CLAY GRVL STNS 5.8 BRWN CLAY 10.7 BRWN SAND MGRD 25.9 BRWN SAND CLAY LYRD 33.5 BRWN SAND MGRD 35.1 BRWN SAND MGRD CGRD 57.9 BRWN SILT SAND DRTY 70.1 BRWN SAND FGRD 74.7 BRWN SILT SAND CLAY 89.0 GREY CLAY DNSE 92.4 GREY SILT CLAY 100.6 BRWN SAND FGRD 106.7 BRWN SAND MGRD LOOS 121.9 BRWN SAND MGRD PCKD 126.8
7111741	6 15	Aug-08	599944 4920087	279.8	71.0 123.1	Un Un	70.7 122.5	-3.0 -3.0	NR				5528 RC	OW MO	**MOE# 7111741 TAG#A044256** 0.0 BRWN SAND 15.2 BRWN CLAY 15.8 BRWN SAND 32.0 CLAY SLTY 62.5 FSND 76.2 CLAY SAND 85.3 GREY CLAY 95.4 BRWN FSND CLAY LYRD 101.2 BRWN FSND 108.8 BRWN SAND CLAY LYRD 112.8 GREY CLAY SILT 118.9 FSND 127.7 GREY CLAY 130.1
7111742	6 15	Aug-08	599958 4920092	279.8	29.0	Un	29.0	-3.0	NR				5528 RC	OW MO	**MOE# 7111742 TAG#A044260** 0.0 TPSL 0.6 BRWN SAND 15.2 BRWN CLAY 15.8 BRWN SAND 33.2 GREY CLAY 43.9
7112433	4 10	Aug-08	600834 4923410	282.5	45.1	Fr	45.1	-0.9	37.2	55	120	42.1	1851 CT	WS DO	**MOE# 7112433 TAG#A067196** 0.0 TPSL 0.6 BRWN CLAY SAND 3.0 GREY CLAY GRVL CMTD 37.8 BRWN SAND 42.1 BRWN CLAY SAND LYRD 45.1 BRWN SAND WBRG 46.0
7112434	4 10	Sep-08	600844 4923400	282.5					37.2				1851 -	- -	**MOE# 7112434 TAG#A067205** 0.0
7115223	3 13	Oct-08	602906 4922835	285.3	114.9	Un	114.3	-1.2	52.4	45	70	58.8	5528 RC	WS DO	**MOE# 7115223 TAG#A043145** 0.0 BRWN CLAY GRVL LYRD 25.9 BRWN SAND STNS 42.7 GREY CLAY SILT 46.6 BRWN SAND 54.9 BRWN SAND SILT CMTD 89.0 GREY CLAY DNSE 97.5 BRWN SAND SILT 131.7 GREY CLAY 134.1 BRWN SAND 144.8 GREY CLAY TILL 146.6
17922	6 16	Jul-08	600342 4918882	270.4	6.7 46.3 108.2 108.2 108.2 108.2 108.2	Fr Fr Fr Fr Fr Fr Fr	109.7 52.4	-3.0 -6.1	NR				7075 RA	TH TH	**MOE# 7117922 TAG#A066557** 0.0 BRWN SAND SLTY 19.8 GREY CLAY SLTY HARD 46.3 BRWN FSND 68.6 GREY CLAY SLTY HARD 82.3 GREY SAND SLTY 96.0 BRWN MSND 99.7 GREY CLAY HARD 102.4 GREY SILT 108.2 BRWN MSND 114.6 GREY CLAY HARD 119.5 SAND SLTY 121.0 CLAY HARD 126.5

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
17923	6 15	Jul-08	599491 4919785	265.5	47.5 16.2	Fr Fr	61.0 18.3	-3.0 -3.0	NR				7075 RA	TH MO	**MOE# 7117923 TAG#A066541** 0.0 BRWN SAND MSND LOOS 21.3 BRWN SAND SILT LOOS 31.4 GREY CLAY HARD 47.5 BRWN SAND MGRD LOOS 64.0 GREY CLAY SILT SOFT 71.6 GREY CLAY HARD 71.6
17924	6 16	Jul-08	600544 4919182	279.2	14.3 56.1	Fr Fr	61.0 35.1	-3.0 -3.0	NR				7075 RA	TH TH	**MOE# 7117924 TAG#A066556** 0.0 FSND MSND TILL 4.6 BRWN FSND 15.2 BRWN MSND FSND 41.1 FSND SLTY 45.1 GREY CLAY HARD 56.1 BRWN FSND 76.2 GREY FSND SLTY 81.4 GREY SILT CLAY HARD 83.8
17925	5 16	Aug-08	601054 4919322	282.5	17.7 58.8	Un Un	62.5 30.5	-3.0 -3.0	17.4				7075 RA	OW MO	**MOE# 7117925 TAG#A045940** 0.0 BRWN CLAY SAND HARD 12.2 GREY CLAY HARD 13.7 BRWN FSND LOOS 36.6 GREY SILT SAND LOOS 43.6 GREY CLAY SILT HARD 58.8 BRWN FSND LOOS 76.8 GREY SILT SAND LOOS 77.7
17926	6 16	Aug-08	600556 4919162	280.1	56.1	Fr	67.1	-7.6	42.7	273	60	49.4	7075 RA	OW -	**MOE# 7117926 TAG#A066565** 0.0 BRWN FSND LOOS 41.1 GREY FSND SILT LOOS 45.1 GREY CLAY HARD 56.1 BRWN FSND 74.7
7128851	3 20	Mar-08	603186 4923785	296.0			51.8 41.1	-6.1 -3.0	45.7				7075 RA	OW MU	**MOE# 7128851 TAG#A066563** 0.0 BLCK TPSL 0.3 BRWN SILT CLAY HARD 2.4 BRWN SAND GRVL LOOS 44.2 GREY SILT CLAY PCKD 50.3 BRWN MSND LOOS 79.2 GREY SILT CLAY PCKD 90.8
7128853	2 20	Mar-08	603280 4922834	290.5			64.0 47.2	-6.1 -3.0	42.4				7075 RA	OW MU	**MOE# 7128853 TAG#A066564** 0.0 BLCK TPSL 0.3 BRWN CLAY SAND 1.5 BRWN SAND GRVL LOOS 10.7 BRWN MSND LOOS 50.3 GREY CLAY SILT HARD 56.4 BRWN MSND LOOS 79.2 GREY CLAY SILT PCKD 93.0 GREY CLAY HARD 96.0
7128855	2 20	Mar-08	603865 4923251	290.5			55.8 29.0	-6.1 -3.0	43.0				7075 RC	OW MU	**MOE# 7128855 TAG#A066561** 0.0 BLCK TPSL 0.3 BRWN SAND GRVL LOOS 4.6 BRWN CLAY SILT SOFT 6.1 GREY CLAY STNS HARD 29.0 BRWN SAND GRVL LOOS 41.1 BRWN SAND SILT LOOS 49.4 GREY CLAY SILT HARD 54.3 BRWN SAND MSND LOOS 79.6 GREY SILT CLAY PCKD 84.7
OW1		Mar-08	603995 4922853	290.5			69.8 15.5	-9.1 -3.0	44.2				7075 RC	OW MU	**MOE# 7128856 TAG#A045971** 0.0 BLCK TPSL 0.3 BRWN SAND GRVL LOOS 19.8 GREY CLAY TILL SILT 53.6 BRWN SAND MSND LOOS 83.5 SILT CLAY LYRD 90.8
7139215		Jan-09	595384 4918222	225.6	17.1 1.8	Fr Fr	28.7	-1.8	4.0	59	60	12.2	7222 CT	RP DO	**MOE# 7139215 TAG#A080750** 0.0 BRWN TPSL 0.3 BRWN SAND LOOS 5.5 BRWN SAND SILT PCKD 11.3 GREY CLAY SOFT 17.1 BRWN SAND SILT LOOS 18.3 GREY CLAY SOFT 21.3 BRWN SAND LOOS 30.5

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
7156883	4 10	Nov-10	600540 4923806	278.3	48.2	Fr			36.6	91	60	43.3	4645 RC	WS DO	**MOE# 7156883 TAG#A108089** 0.0 BLCK TPSL SOFT 0.3 BRWN CLAY SILT SOFT 9.1 BRWN SAND CLAY LYRD 15.2 BRWN SAND LOOS 29.0 BRWN CLAY SOFT 39.6 BRWN SAND LOOS 48.8
7167766		Oct-10	601291 4920584	235.0					NR				6607 BR	OW MO	**MOE# 7167766 TAG#A100962** 0.0 BRWN SAND SILT WBRG 4.6
89481	4 12	Aug-12	601018 4922506	251.8	23.2	Fr			9.4	23	60	16.5	1851 CT	WS DO	**MOE# 7189481 TAG#A118937** 0.0 BRWN SAND 4.6 GREY CLAY DNSE 19.8 GREY SAND SILT 22.3 GREY SAND WBRG FGRD 24.4
91815		Oct-12	599968 4922870	241.7	19.8	Fr			NR				3213 CT	WS DO	**MOE# 7191815 TAG#A136911** 0.0 SAND GRVL 10.7 SAND CMTD 15.2 FSND 20.1
L0053	5 11	Jun-89	599682 4922191	239.9			21.9 -3.0		16.5				9999 RC	OW PU	**MOE# DHL0053** 0.0 BRWN CSND 2.7 GREY FSND CLAY 14.0 MSND CSND 15.2 SAND CLAY FSND 19.8 FSND 21.9 FSND CLAY LYRD 28.0 BRWN CLAY FSND LYRD 29.9 BRWN CLAY 31.1
L0054	5 11	Jun-89	599620 4922191	239.9					NR				9999 RC	TH NU	**MOE# DHL0054** 0.0 BRWN CSND 1.5 BRWN FSND CLAY MGVL 35.4 BRWN CLAY 40.8 BRWN CLAY FSND PGVL 61.0 GREY FSND CLAY STNS 74.7 BRWN CLAY DNSE 93.0 BRWN CLAY PGVL CMTD 103.9 BRWN CLAY DNSE 107.9 GREY LMSN 110.0
L0055	5 11	Jun-88	599614 4922197	239.9			51.2 -3.7		23.2				9999 RC	WS PU	**MOE# DHL0055** 0.0 MSND 1.2 FSND 15.8 MSND CSND 25.9 FSND 30.5 FSND CLAY 31.4 FSND THIN CLAY 36.0 BRWN CLAY THIN FSND 41.5 FSND CLAY BLDR 49.4 CSND THIN CGVL 56.4 FSND SILT MGVL 57.0 FSND SILT 61.3
L0056	5 11	Jun-89	599512 4922255	239.9					NR				9999 RC	TH NU	**MOE# DHL0056** 0.0 BRWN FSND 9.4 BRWN FSND CSND 14.6 GREY CLAY MSND 15.5 GREY CLAY 18.3 GREY CLAY FSND 21.6 BRWN CLAY PGVL SOFT 25.9 BRWN CLAY HARD 27.7 GREY FSND SILT CLAY 38.4 BRWN CLAY SILT LYRD 40.5
L0057	7 13	Jan-91	598544 4919636	241.1			54.9 27.4	-6.1 -3.0	16.5				9999 RC	TH CO	**MOE# DHL0057** 0.0 FSND CLAY 1.2 MGVL MSND 2.7 GREY CLAY MSND MGVL 26.2 MSND 38.4 GREY CLAY MSND SILT 43.6 GREY CLAY 50.9 FSND MSND 61.6 GREY CLAY MSND 68.6 MSND CLAY FGVL 85.0 GREY CLAY 89.9 FSND CLAY MGVL 103.9 GREY CLAY MSND MGVL 107.0
L0063	5 13	Jan-89	599717 4921130	236.5			10.7 28.7	-1.5 -1.5	3.0				9999 CT	OW IN	**MOE# DHL0063** 0.0 SAND FGRD 25.0 SAND SILT 30.5

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
WELL4	3 4	Jun-90	601427 4921884	236.2			69.8	-6.1	4.9	1137	1440	20.4	9999 RC	WS MU	**MOE# DHL0194** 0.0 SAND GRVL CLAY 15.2 SILT SAND GRVL 24.1 GREY CLAY 30.5 GREY CLAY GRVL 34.7 SAND GRVL 36.6 CLAY GRVL SAND 49.4 GRVL SAND CLAY 54.3 GREY CLAY STNY HARD 60.4 SAND GRVL CLAY 64.3 CLAY GRVL HARD 68.9 FSND GRVL CLAY 77.7 CLAY SAND 78.9
PW1/89	5 13	Nov-89	600119 4921001	238.0			60.4	-0.9	NR				9999 RC	TH IN	**MOE# DHL0347** 0.0 BRWN SAND GRVL 10.7 GREY SAND SILT 15.2 GREY MSND FSND SILT 19.8 SAND SILT CGVL 24.4 BRWN CLAY SILT 27.4 BRWN FSND MSND 43.6 BRWN CLAY SILT 58.8 BRWN FSND 67.4
OW1/89	5 13	Nov-89	600115 4921006	238.0			61.3	-6.1	NR				9999 RC	OW IN	**MOE# DHL0348** 0.0 GREY SAND GVLY 10.7 GREY SAND SILT 15.2 GREY FSND MSND SILT 19.8 GREY SAND SILT GRVL 24.4 BRWN CLAY SILT 27.4 BRWN FSND MSND SLTY 43.6 CLAY SILT 58.8 BRWN SAND FGRD 71.6 BRWN SAND SILT FGRD 76.2
OW19	6 13	Jan-14	598604 4920119	236.5			93.9	-3.0	NR				9999 RC	TH PU	**MOE# DHL0421** 0.0 GRVL CGRD 12.2 GRVL SAND MGRD 15.8 BRWN GRVL SAND TILL 26.2 BRWN TILL SILT SAND 30.5 BRWN TILL SILT SAND 41.1 GREY CLAY HARD 47.2 BRWN FSND 58.8 GREY MSND FSND 64.9 GREY CLAY 71.6 BRWN FSND 82.3 GREY CLAY HARD 85.0 BRWN MSND LOOS 99.7 GREY CLAY 100.6
TW20	2 20	Jan-14	603253 4922816	289.9			60.4	-1.5	NR				9999 RC	TH PU	**MOE# DHL0422 TAG#A153125** 0.0 BRWN TILL STNY 3.0 GRVL 6.1 GREY CLAY 9.1 BRWN FSND 19.8 BRWN TILL SAND LYRD 27.4 BRWN MSND 47.2 GREY CLAY 53.9 BRWN FSND MSND 85.3 GREY SILT 93.6 GREY CLAY HARD 96.0 CLAY SAND SILT 105.2 GREY SILT 108.2 GREY FSND 115.2 BRWN FSND 119.8 BRWN SAND 125.6 BRWN MSND 133.8 GREY CLAY 137.2 BRWN MSND CSND 148.4 SAND SLTY 150.0 GREY SILT CLAY DKCL 152.4

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
TW22	6 13	Feb-14	598675 4920171	232.6			81.1	-8.8	NR				9999 RC	OW CO	**MOE# DHL0423** 0.0 CGVL 4.6 BRWN TILL 9.1 GREY GRVL TILL STNS 13.7 BRWN GRVL STNS SAND 15.2 GREY TILL 18.3 BRWN SAND GRVL 21.9 GREY TILL 30.5 GREY CLAY HARD 35.1 BRWN SAND 37.5 BRWN TILL 42.7 BRWN SAND HARD 45.1 STNS 45.4 BRWN SAND TILL LYRD 49.7 STNS 50.0 BRWN SAND TILL LYRD 53.9 BRWN FSND STNS TILL 60.0 BRWN FSND 66.1 GREY CLAY 70.1 GREY CLAY HARD 71.3 BRWN SAND 76.2 BRWN SAND TILL LYRD 79.9 BRWN CSND 80.8 STNY 81.4 GRVL HARD 84.4 BRWN CSND 95.4 BLGR CLAY 96.0
TW23	3 13	Feb-14	602250 4923166	290.2					NR				9999 RC	TH PU	**MOE# DHL0424** 0.0 BRWN SAND TILL 16.8 BRWN MSND CSND 38.7 CLAY 44.2 BRWN FSND MSND 70.1 BRWN FSND HARD 76.2 SAND TILL SLTY 92.0 GREY CLAY HARD 96.9 CLAY SILT LYRD 100.6 BRWN SAND SLTY 115.8 GREY CLAY 120.4 BRWN FSND SLTY 125.0 BRWN FSND 131.1 BRWN MSND 133.5 GREY CLAY 137.2
TW21	2 20	Jan-14	603827 4922777	289.9			116.1 113.1	-3.0 -16.8	NR				9999 RC	TH PU	**MOE# DHL0425** 0.0 BRWN SAND 2.1 BRWN SILT SAND TILL 4.6 GREY SILT TILL 9.1 BRWN SAND FGVL 15.2 SAND FGVL LYRD 32.0 GRVL 35.1 BRWN FSND 42.7 GREY CLAY HARD 47.9 BRWN MSND 67.1 BRWN FSND 91.4 GREY CLAY HARD 95.1 GREY SAND HARD 112.8 BRWN MSND FSND 121.9 BRWN FSND 123.4 BRWN MSND 129.5 MSND CSND HARD 134.1 SAND CLYY 135.6 GREY MSND CSND 141.7 GREY SAND TILL CLYY 150.9
OW24	2 20	Feb-14	603687 4922700	289.9			125.0	-6.1	49.4				9999 RC	TH PU	**MOE# DHL0426** 0.0 SILT 3.0 BRWN TILL 4.6 GREY SAND TILL 9.1 FGVL 10.4 GREY CLAY 14.6 BRWN SAND GRVL LYRD 19.8 GREY CLAY 21.9 BRWN SAND CLAY THIN 51.8 BRWN FSND 82.3 BRWN TILL FGRD HARD 91.4 GREY CLAY HARD 94.5 GREY SAND CLAY SOFT 106.7 BRWN FSND 125.0 BRWN FSND MSND 132.0 CLAY SAND HARD 134.1

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
TW25	2 20	Feb-14	603120 4922732	285.3					NR				9999 RC	TH PU	**MOE# DHL0427** 0.0 BRWN CLAY 1.2 GREY CLAY GRVL SNDY 6.4 BRWN FSND MSND 23.5 BRWN CLAY 24.7 GRN CLAY SAND LYRD 30.5 BRWN FSND MSND 47.9 BRWN FSND MSND CLAY 78.3 CLAY SILT SAND 80.2 GREY FSND CLAY THIN 83.8 SAND SILT CLAY 91.4 GREY CLAY HARD 95.1 CLAY SLTY 107.6 GREY MSND FSND 113.7 BRWN FSND MSND CLAY 116.7 GREY SAND CLAY SLTY 123.4 GREY FSND MSND 124.4 FSND SILT 125.9 BRWN FSND 127.4 BRWN FSND MSND 128.9 FSND MSND 130.5 GREY FSND 131.4 GREY CLAY HARD 132.0
TH26	6 16	Mar-14	600546 4919163	280.1					NR				9999 RC	TH CO	**MOE# DHL0428** 0.0 BRWN CLAY SNDY 1.5 GREY CLAY SNDY GVLY 5.8 CGVL SAND 8.8 SAND 23.5 BRWN FSND 43.0 GREY CLAY SAND LYRD 48.8 GREY CLAY SILT 56.1 BRWN FSND 66.8 GREY CLAY SILT 73.2 GREY SILT CLAY 81.1 GREY SILT CLAY 91.7 SAND SLTY 107.0 SAND SILT CLAY 116.7 GREY FSND 123.4 GREY SAND SILT CLAY 125.3 CLAY SAND HARD 129.2 GREY CLAY SAND HARD 135.0 GREY CLAY SAND STNS 141.1 CLAY STNY HARD 152.4
TW27	6 18	Mar-14	599535 4919778	265.5					NR				9999 RC	TH PU	**MOE# DHL0429** 0.0 BRWN SAND CLAY THIN 7.0 BRWN SAND GRVL THIN 21.6 GREY CLAY 23.2 BRWN SAND 29.3 GREY CLAY SAND LYRD 33.8 GREY CLAY 37.8 BRWN SAND 41.1 GREY CLAY SAND LYRD 51.8 SAND CLAY THIN 64.0 GREY CLAY SILT LYRD 68.9 GREY CLAY 73.5 SAND SLTY 75.3 GREY CLAY HARD 77.1 CLAY SLTY 79.9 GREY CLAY 82.3 SAND 90.8 BRWN FSND MSND 92.4 BRWN FSND 97.2 GREY CLAY 98.1 GREY SAND SLTY LYRD 102.1
TH28	2 18	Mar-14	603279 4922844	290.5			129.2	-3.0	NR				9999 RC	TH PU	**MOE# DHL0433** 0.0 BRWN TILL STNS 3.0 GRVL 5.5 GREY CLAY 9.1 BRWN FSND 19.8 BRWN MSND 47.9 GREY CLAY 54.9 BRWN SAND 85.3 SAND DRTY 93.6 CLAY HARD 96.0 CLAY SILT LYRD 108.2 GREY FSND 118.9 FSND CLAY LYRD 125.0 BRWN MSND 132.3 GREY CLAY 133.2

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
OW29	9 14	Apr-14	595623 4917663	239.0			51.8 94.5	-3.0 -3.0	21.9				9999 RC	OW PU	**MOE# DHL0434** 0.0 SAND SLTY 1.5 BRWN CSND 4.6 BRWN SAND CLAY TILL 10.7 BRWN CLAY 16.8 BRWN FSND 32.9 GREY CLAY 50.3 BRWN FSND 69.5 SAND SILT LYRD 71.6 BRWN FSND 83.8 GREY CLAY 89.0 BRWN QSND 93.0 BRWN SAND FGRD 99.1 BRWN MSND 104.2 GREY CLAY 106.7
TW30	2 14	Jun-14	603375 4923923	296.0			103.6	-2.4	54.3				9999 RC	OW CO	**MOE# DHL0435** 0.0 BRWN SILT TILL SAND 3.0 BRWN SILT TILL FGVL 10.7 BRWN SAND FGRD 16.8 BRWN FSND MSND HARD 95.1 GREY CLAY HARD 99.7 BRWN FSND 115.2 BRWN FSND MSND 118.9 SILT CLAY SAND 125.9 BRWN FSND 129.5 SILT CLAY HARD 133.2 GREY CLAY HARD 136.6 MSND FSND 137.2 BLDR 137.5 SAND HARD CMTD 143.3
TW31	3 17	Jun-14	603191 4923774	296.0					NR				9999 RC	TH PU	**MOE# DHL0436** 0.0 BRWN CLAY 3.0 CGVL 3.7 BRWN SAND GRVL CGRD 45.7 SILT SAND 46.0 MSND 48.2 GREY CLAY 51.8 MSND FSND 86.9 SAND SILT CLAY 96.6 GREY CLAY HARD 100.6 BRWN FSND 121.6 GREY CLAY 121.9
TW32	2 20	Jun-14	603887 4923245	290.5			115.8	-3.0	NR				9999 RC	OW PU	**MOE# DHL0437** 0.0 BRWN CLAY 3.0 BRWN TILL SNDY 4.6 GREY CLAY 7.6 BRWN TILL STNY 11.6 BRWN SAND 12.2 GREY CLAY HARD 15.8 BRWN SAND SILT 17.4 GREY CLAY HARD 27.4 BLDR 27.7 GREY CLAY 29.3 FGVL 29.9 BRWN SAND SILT LYRD 54.9 GREY CLAY 64.0 BRWN FSND 68.6 FSND MSND HARD 92.4 GREY CLAY HARD 96.0 SILT FSND 112.8 BRWN FSND 121.9 TILL HARD STNY 132.0 BRWN MSND 134.1 GREY CLAY STNS HARD 138.7
TH33	9 13	Jun-14	595943 4918594	221.0					-1.8				9999 RC	OW CO	**MOE# DHL0438** 0.0 CSND GRVL STNS 5.2 GREY CSND GRVL CLAY 17.1 GREY CLAY HARD 18.6 SAND GRVL CLAY 20.4 SAND CLAY THIN 35.1 SAND WBRG 36.6
TW34	6 18	Jul-14	595627 4917644	105.2			93.9	-9.1	21.6				9999 RC	TH PU	**MOE# DHL0440** 0.0 SAND DRTY 1.5 GRVL STNS 4.3 BRWN SAND TILL 10.7 BRWN CLAY 16.8 BRWN FSND VERY 32.9 GREY CLAY HARD 50.0 BRWN FSND 73.2 BRWN SAND CLAY LYRD 77.7 BRWN MSND 79.2 BRWN SAND SILT DRTY 84.4 GREY CLAY HARD 89.0 BRWN FSND 93.0 BRWN MSND 100.6 BRWN MSND HARD 100.9 BRWN SAND MGRD 104.2 GREY CLAY SILT 106.7

LABEL	CON LOT	DATE mmm-yr	EASTING NORTHING	ELEV masl	WTR mbgl	FND Qu	SCR TOP mbgl	LEN m	SWL mbgl	RATE L/min	TIME min	PL mbgl	DRILLER METHOD	TYPE STAT	WELL NAME DESCRIPTION OF MATERIALS
OW35	2 18	Jul-24	601782 4924244	285.3			118.9	-3.0	NR				9999 RC	TH PU	**MOE# DHL0441** 0.0 BRWN CLAY 5.5 BRWN SAND 6.1 GREY TILL 9.1 BRWN SAND 20.4 STNS GRVL TILL 22.9 BRWN SAND 35.1 GREY CLAY 41.1 BRWN SAND TILL CLAY 79.2 GREY CLAY SAND LYRD 83.8 GREY CLAY 91.4 FSND SILT 102.1 CLAY DRTY 109.7 BRWN FSND 123.7 GREY CLAY HARD 125.0
S0822		Jan-06	600624 4923215	285.0					NR				9999 RC	TH NU	**MOE# OGS0822** 0.0 SAND 1.5 SILT SAND TILL 4.0 SILT 4.9 UNKN 5.2 SAND 5.8 SILT SAND TILL 7.6 SAND 33.5 SILT 44.5 SAND 58.8
S0826		Jan-06	599320 4921063	238.0					NR				9999 RC	TH NU	**MOE# OGS0826** 0.0 SAND 32.9 CLAY 34.7 SAND 35.1 CLAY 38.1 SAND 39.3 CLAY 43.3 SAND 47.2 SILT SAND TILL 53.3 SAND 54.6 SILT SAND TILL 55.8 SAND 57.0 SILT SAND TILL 59.7 SILT 64.9 SAND 69.2
M0017	10 14	Jun-85	595266 4916774	275.5			23.5	-0.9	17.7				9999 RC	OW PU	**MOE# SIM0017** 0.0 BRWN SAND SILT TILL 11.0 BRWN SAND 25.6
M0018	10 14	May-87	595321 4916854	279.8			68.0	-1.8	54.9				9999 RC	OW PU	**MOE# SIM0018** 0.0 BRWN SAND SILT TILL 12.2 BRWN SAND 44.2 GREY SILT SAND 59.1 GREY SAND 72.8 GREY SILT CLAY 78.9

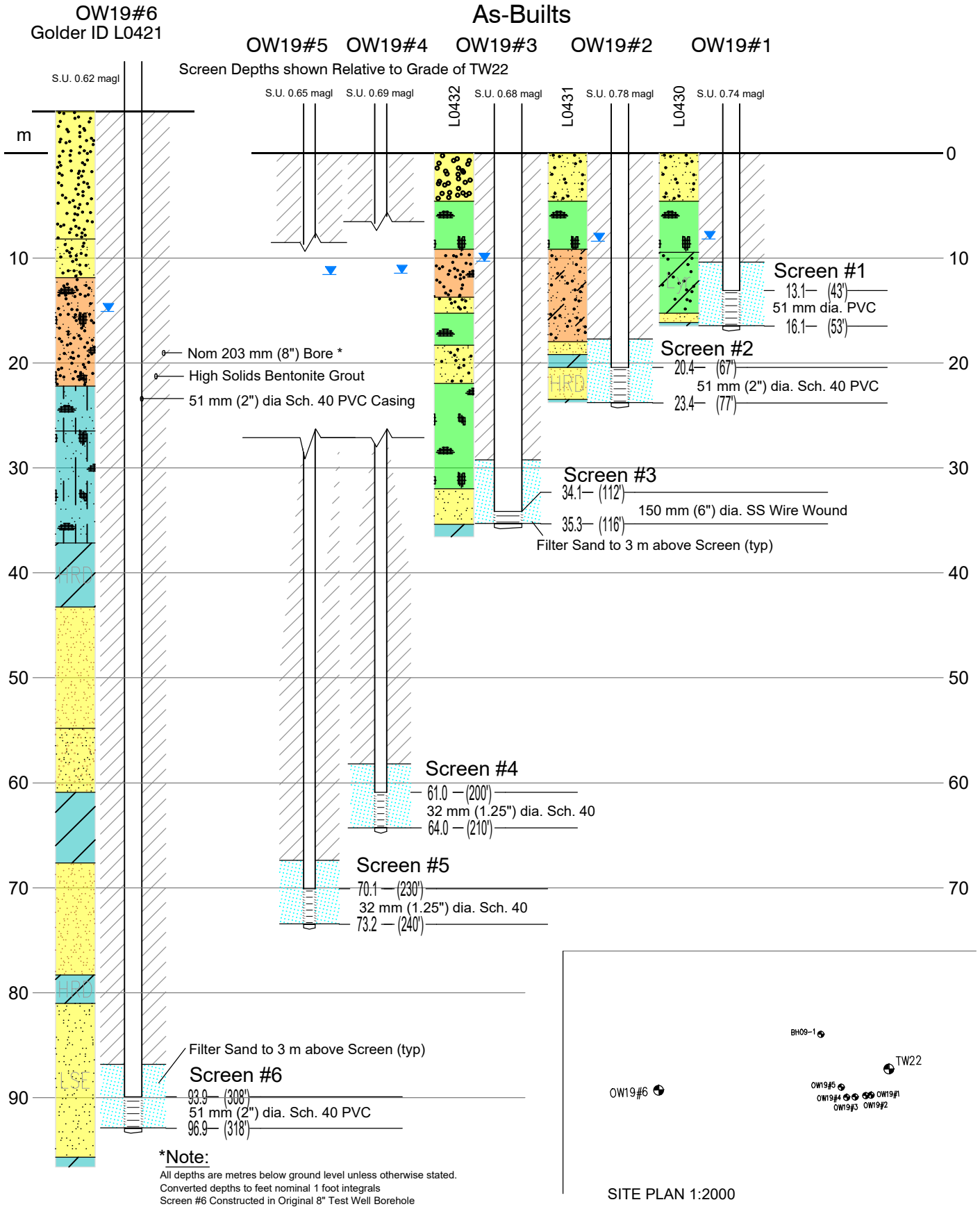
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Mn	Mineral	AQ	Abandoned Quality	DO	Domestic	IR	Irrigation	JT	Jetting
Sa	Salty	AS	Abandoned Supply	MU	Municipal	AL	Alteration	RC	Rotary Conventional
Su	Sulphur	AB	Abandonment Record	PU	Public	RP	Replacement	RA	Rotary Air
--	Unrecorded	TH	Test Hole or Observation	ST	Stock	-	Not Recorded	BR	Boring

Easting and Northings UTM NAD 83 Zone 17, Translated from Recorded UTM NAD, subject to Field Verified Location or Improved Location Accuracy.

Records Copyright Ministry of Environment Queen's Printer. Selected information tabulated to metric with changes and corrections subject to Driller's Records.

APPENDIX B

Site 1: Well Construction and Testing Snow Valley Road



Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-07-08
DESIGN	
CAD	JPR
CHECK	
REVIEW	

TITLE

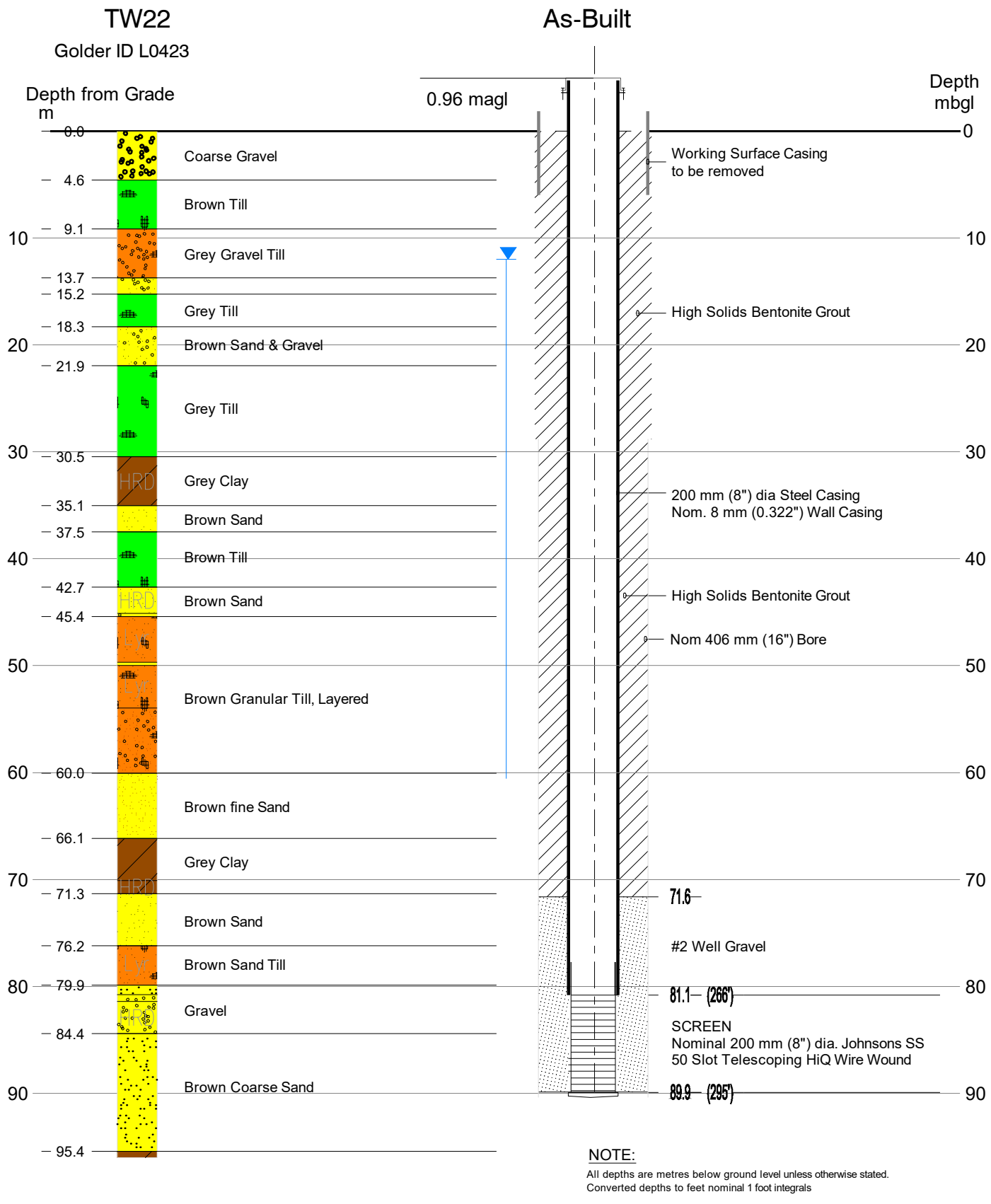
OBSERVATION WELL OW19 AS-BUILT

FILE No. 1311700040CBLOGS.dwg
PROJECT No. 13-1170-0040 REV.

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE **B-1**

PLOT DATE: October 28, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-CB-\1311700040CBLOGS.dwg: [Figure B-1]



NOTE:
All depths are metres below ground level unless otherwise stated.
Converted depths to feet nominal 1 foot integrals

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-07-08
DESIGN	
CAD	JPR
CHECK	
REVIEW	

TITLE

PRODUCTION WELL TW22
AS-BUILT

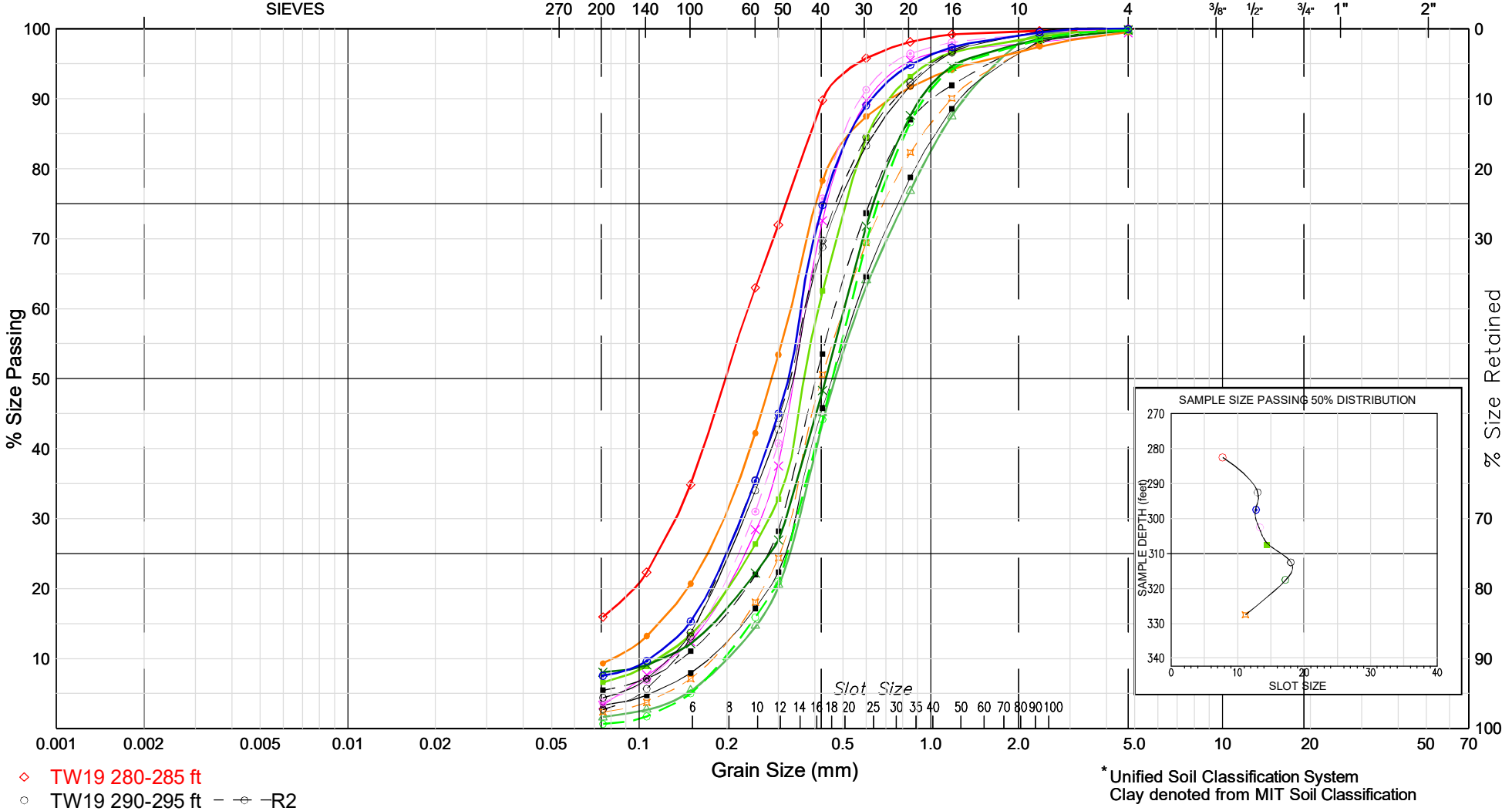
FILE No. 1311700040CBLOGS.dwg
PROJECT No. 13-1170-0040 REV.

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE
B-2

PLOT DATE: July 8, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-CB-\1311700040CBLOGS.dwg: [Figure B-2]

PLOT DATE: July 21, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-BA-\1311700040BASVE19.dwg



- TW19 280-285 ft
- TW19 290-295 ft – R2
- TW19 295-300 ft
- TW19 300-305 ft – R2
- TW19 305-310 ft
- TW19 310-315 ft – R2
- TW19 315-320 ft – R2
- TW19 320-325 ft
- TW19 325-330 ft – R2

*Unified Soil Classification System
Clay denoted from MIT Soil Classification

TITLE

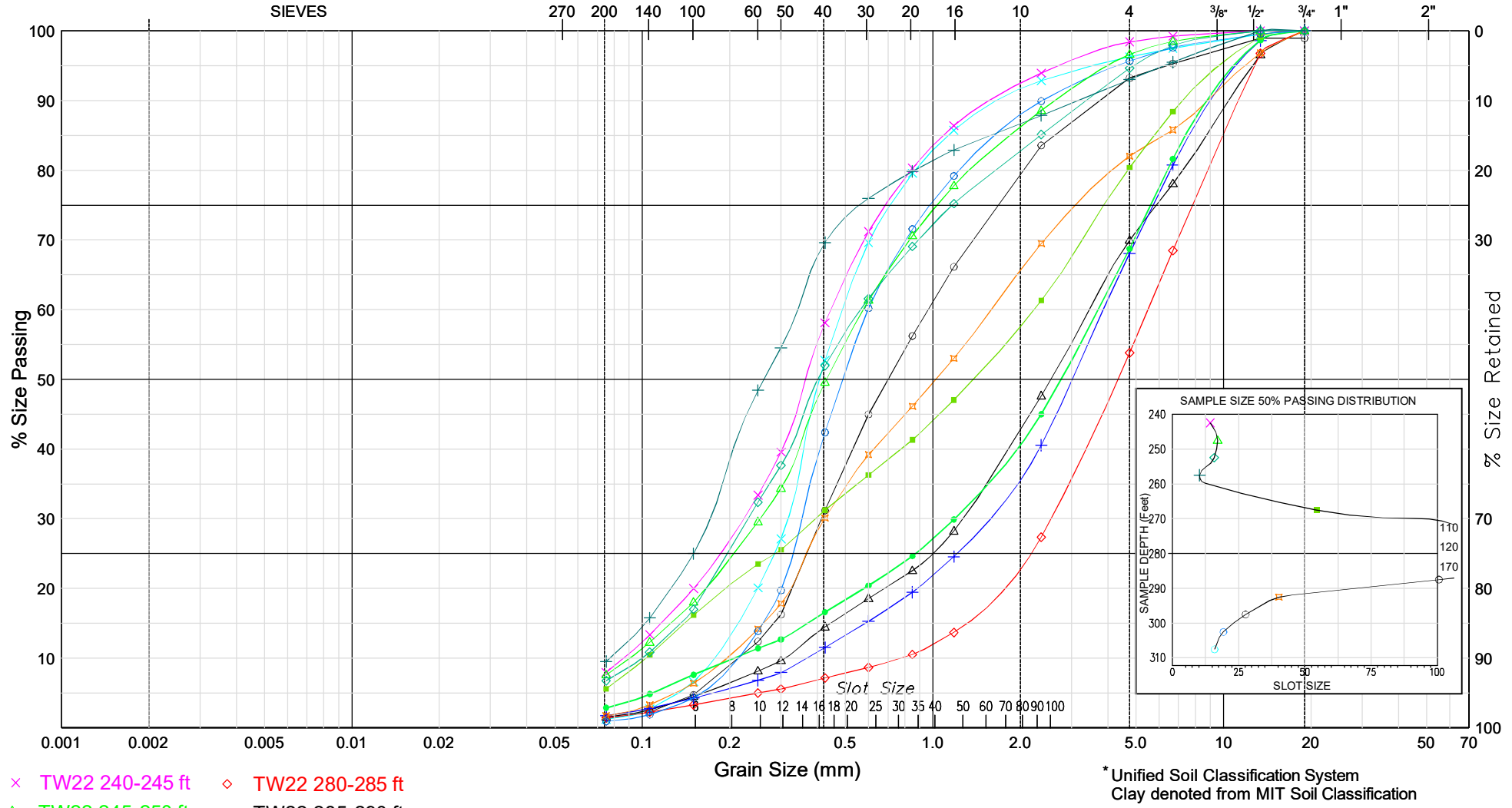
GRAIN SIZE CURVES
OW19#6

MIDHURST
WATER SUPPLY EXPLORATION

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-01-27
CAD	JPR
CHECK REVIEW	
FILE No.	1311700040BASVE19.dwg
PROJECT No.	13-1170-0040
REV.	
FIGURE	B-3

PLOT DATE: July 21, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-BA-\1311700040BASVE22.dwg



× TW22 240-245 ft
△ TW22 245-250 ft
◇ TW22 250-255 ft
+ TW22 255-260 ft
▪ TW22 265-270 ft
• TW22 270-275 ft
+ TW22 275-280 ft
◇ TW22 280-285 ft
△ TW22 285-290 ft
⌑ TW22 290-295 ft
○ TW22 295-300 ft
○ TW22 300-305 ft
× TW22 305-310

*Unified Soil Classification System
Clay denoted from MIT Soil Classification

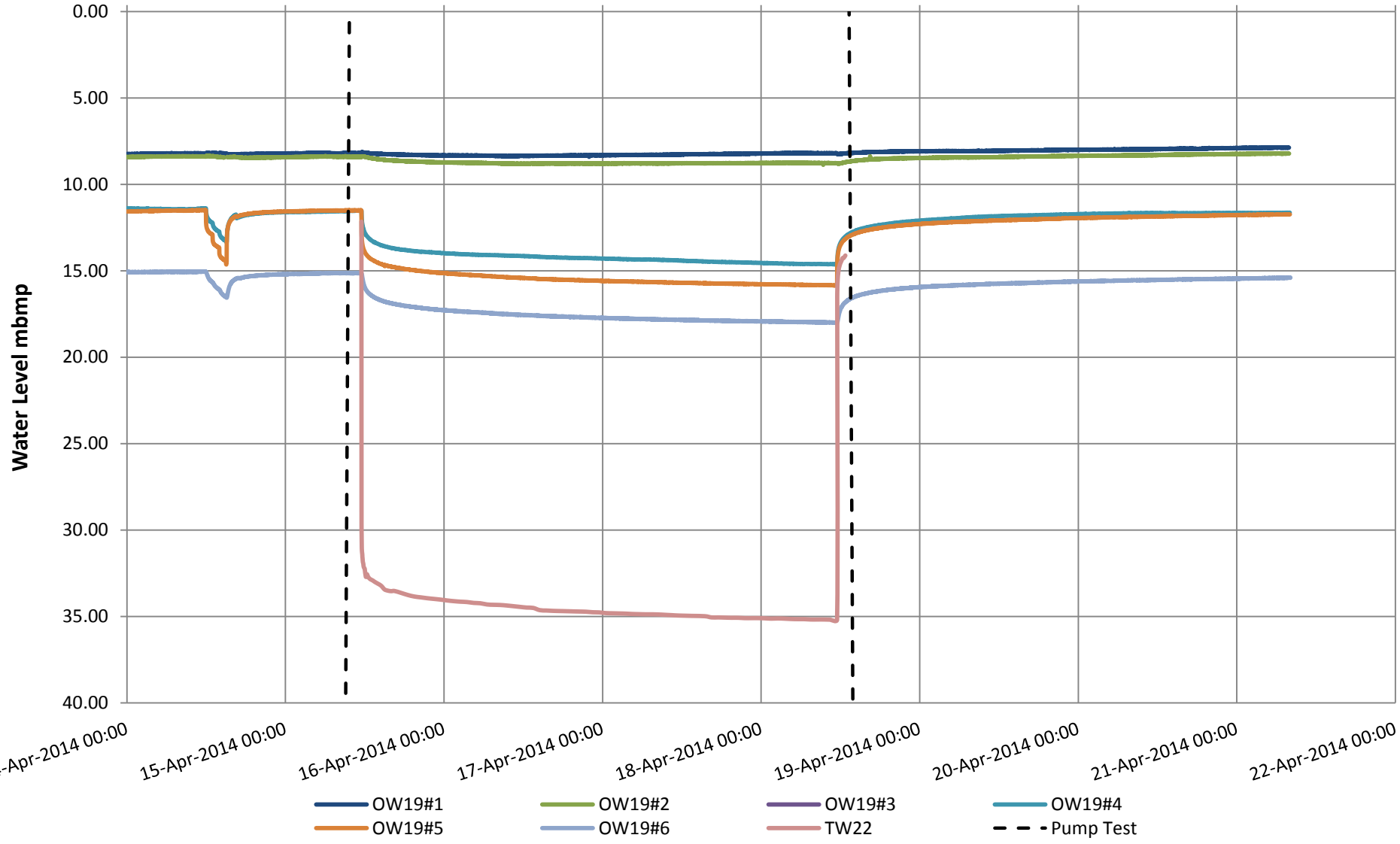
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GRAIN SIZE CURVES
TW22

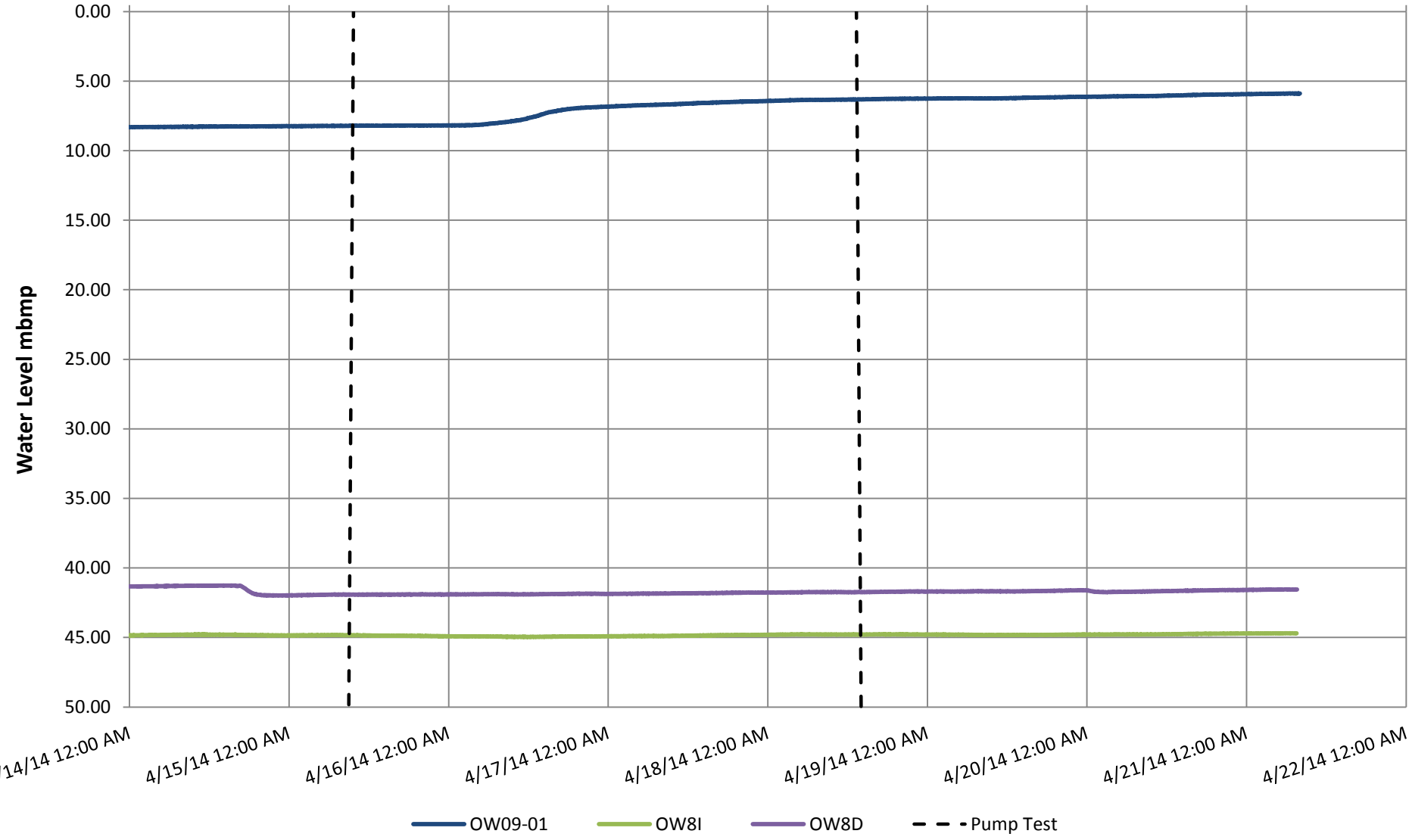
MIDHURST
WATER SUPPLY EXPLORATION

Golder Associates
Barrie, Ontario, Canada

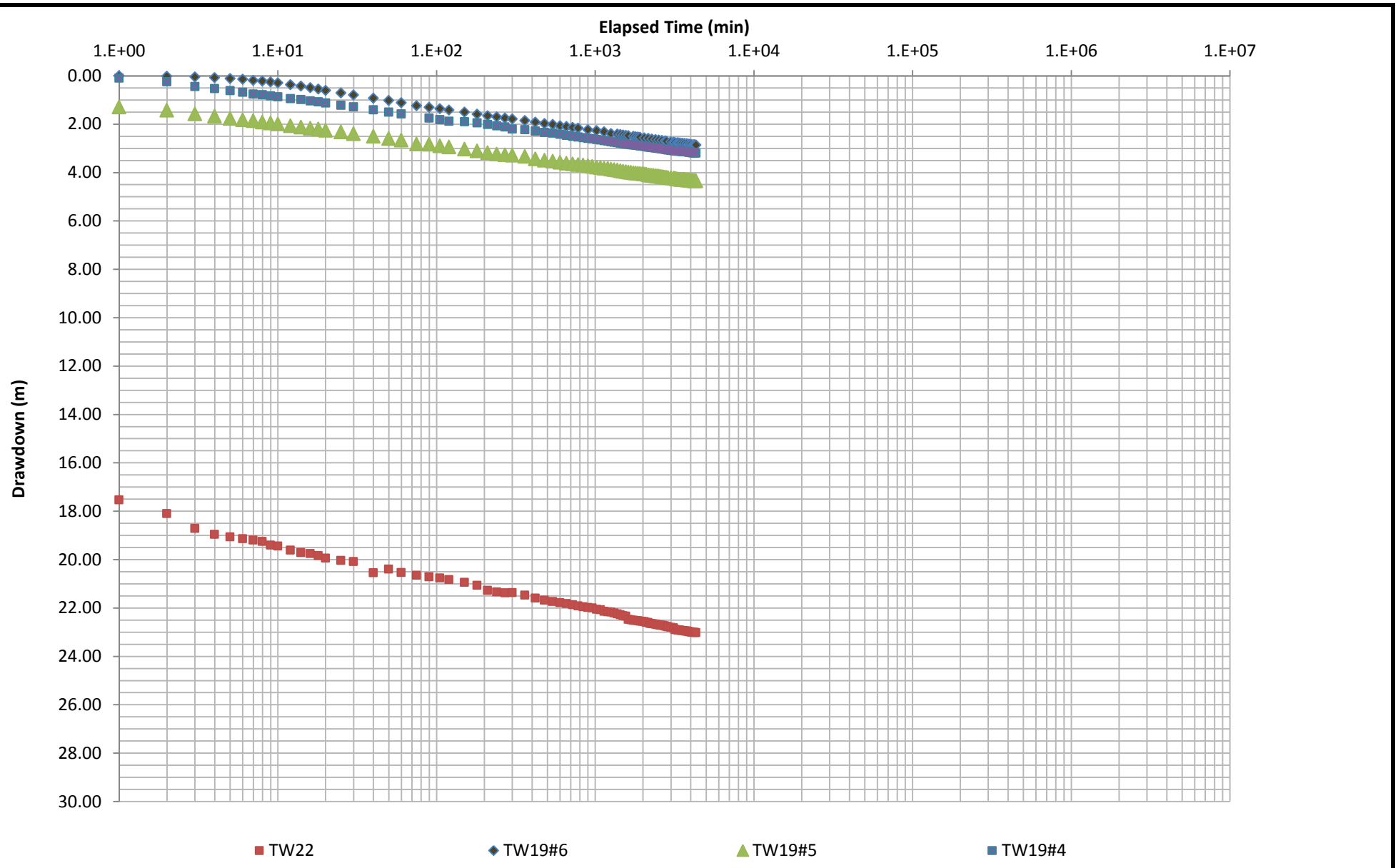
SCALE	AS SHOWN
DATE	2014-07-08
CAD	JPR
CHECK REVIEW	
FILE No.	1311700040BASVE22.dwg
PROJECT No.	13-1170-0040
REV.	
FIGURE	B-4



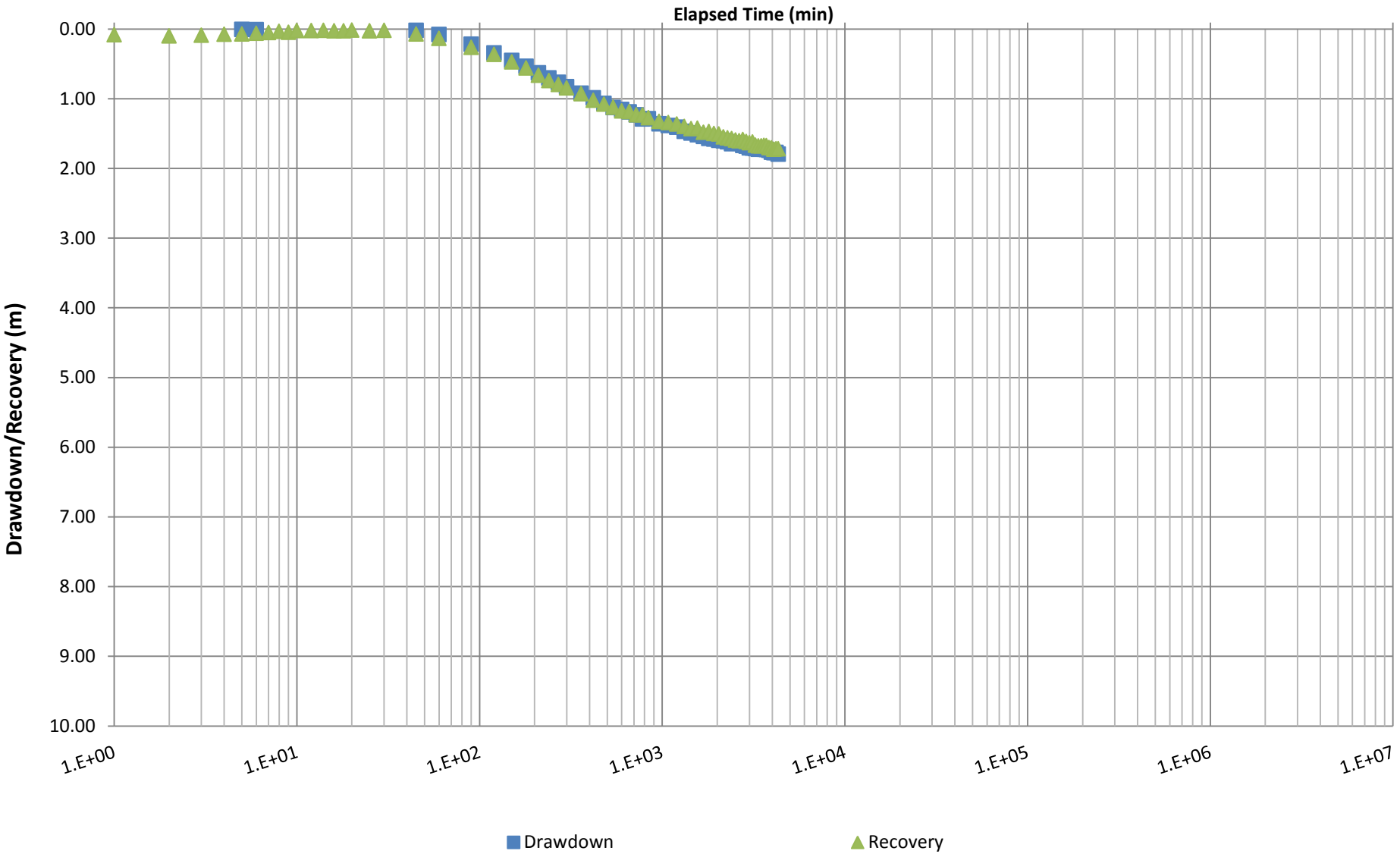
Test Date:	April 15, 2014	Golder Associates	SCALE:	NTS	**Testing of TW22** **Record of Observation Wells**
Pumping Rate:	36.5 L/s		DATE:	29-Oct-14	
			CAD:	JPR	
		FILE No. 1311700040TRANS	CHECK:		MIDHURST WATER SUPPLY CONSTRUCTION & TESTING of TW22
		PROJECT No. 13-1170-0040	REVIEW:		FIGURE No. B-5



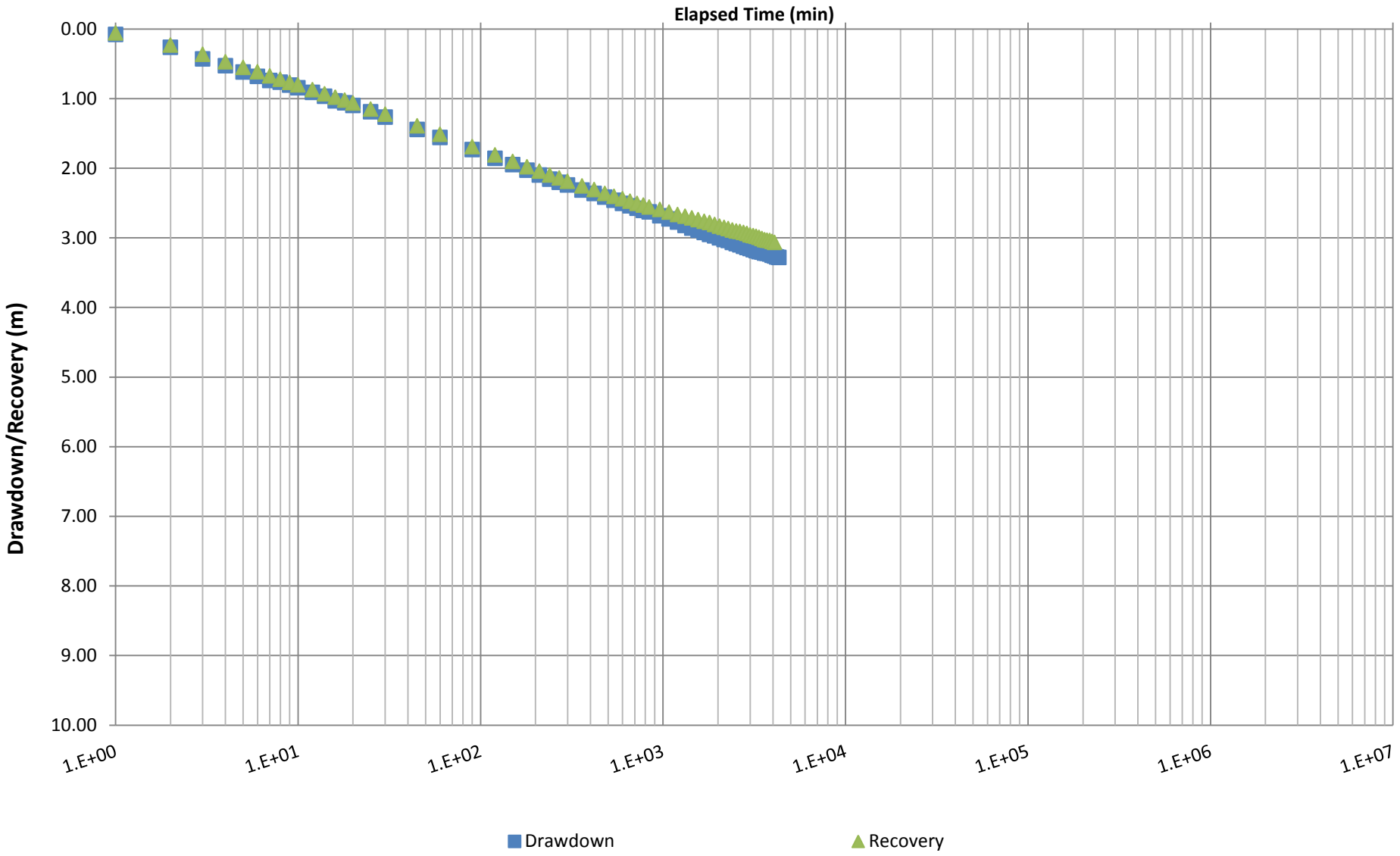
Test Date:	April 15, 2014	Golder Associates	SCALE:	NTS	**Testing of TW22** **Record of Observation Wells**
Pumping Rate:	36.5 L/s		DATE:	26-Sep-14	
			CAD:	ALB	
		FILE No. 1311700040TRANS	CHECK:		MIDHURST WATER SUPPLY CONSTRUCTION & TESTING of TW22
		PROJECT No. 13-1170-0040	REVIEW:		FIGURE No. B-6



Test Date:	15-April-2014	Golder Associates	SCALE:	NTS	Pumping Test Hydrograph Record of TW22 and Aquifer A3/A4 Observation Wells
Pumping Rates L/s:	36.5		DATE:	30-Oct-14	
			CAD:	ALB	
TW22 Static Level (mbmp):	12.16	FILE No. 1311700040	CHECK:		MIDHURST WATER SUPPLY CONSTRUCTION & TESTING of TW22
TW22 Pumping Level (mbmp):	35.19	PROJECT No. 1311700040	REVIEW:		FIGURE No. B-7



Test Date:	April 15, 2014	Golder Associates	SCALE:	NTS	**Pumping Test Hydrograph Record of OW19#3**
Pumping Rate:	36.5 L/s		DATE:	30-Oct-14	
Distance from TW22:	16.6 m		CAD:	ALB	
Static Water Level (mbmp):	10.30	FILE No. 1311700040TRANS	CHECK:		MIDHURST WATER SUPPLY CONSTRUCTION & TESTING of TW22
Pumping Water Level (mbmp):	12.09	PROJECT No. 13-1170-0040	REVIEW:		FIGURE No. B-8



Test Date:	April 15, 2014
Pumping Rate:	36.5 L/s
Distance from TW22:	19.1 m
Static Water Level (mbmp):	11.43
Pumping Water Level (mbmp):	14.71

Golder Associates

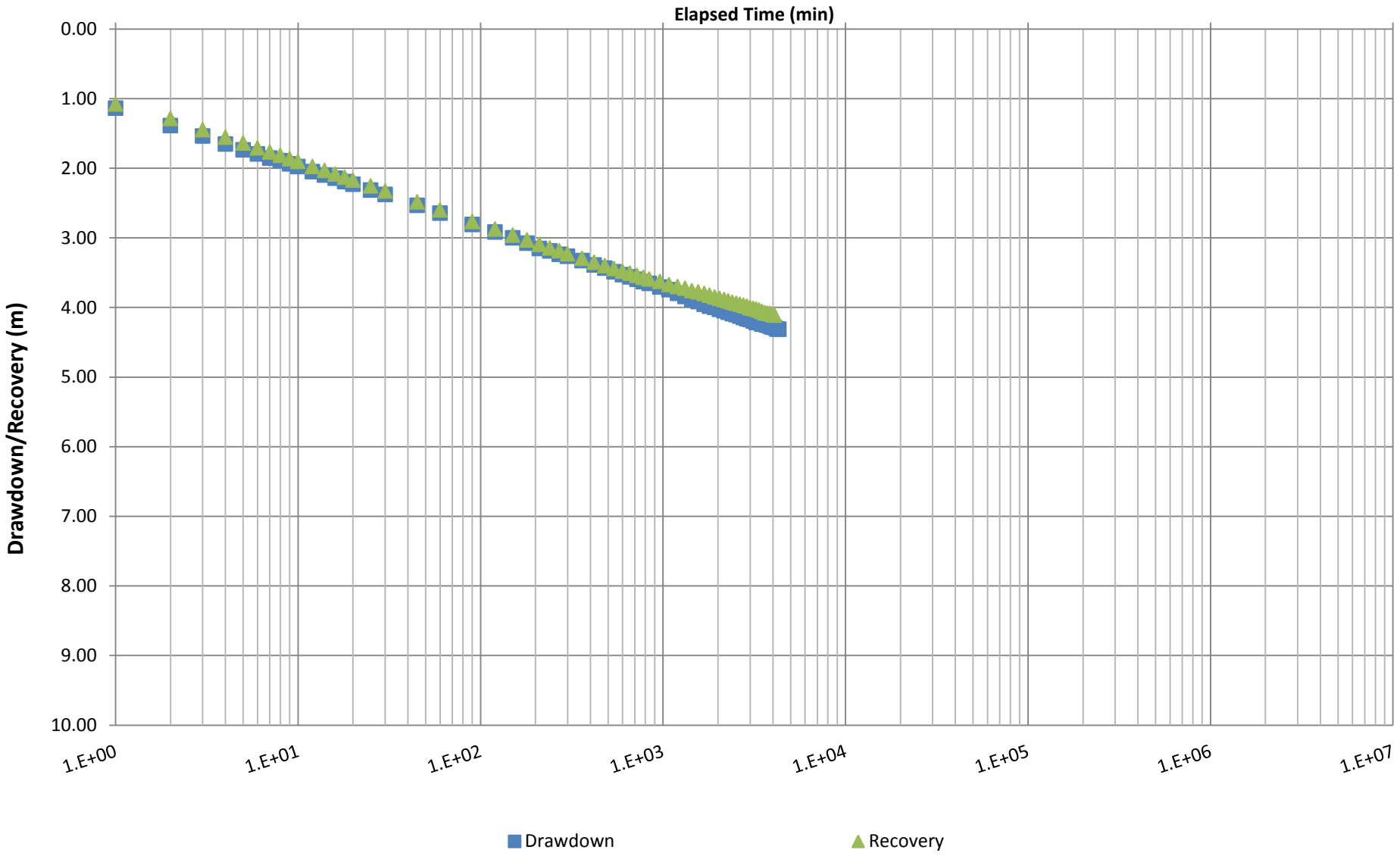
FILE No.	1311700040TRANS
PROJECT No.	13-1170-0040

SCALE:	NTS
DATE:	30-Oct-14
CAD:	ALB
CHECK:	
REVIEW:	

Pumping Test Hydrograph
Record of OW19#4

MIDHURST WATER SUPPLY
CONSTRUCTION & TESTING of TW22

FIGURE No.
B-9



Test Date:	April 15, 2014
Pumping Rate:	36.5 L/s
Distance from TW22:	19.1 m
Static Water Level (mbmp):	11.53
Pumping Water Level (mbmp):	15.85

Golder Associates

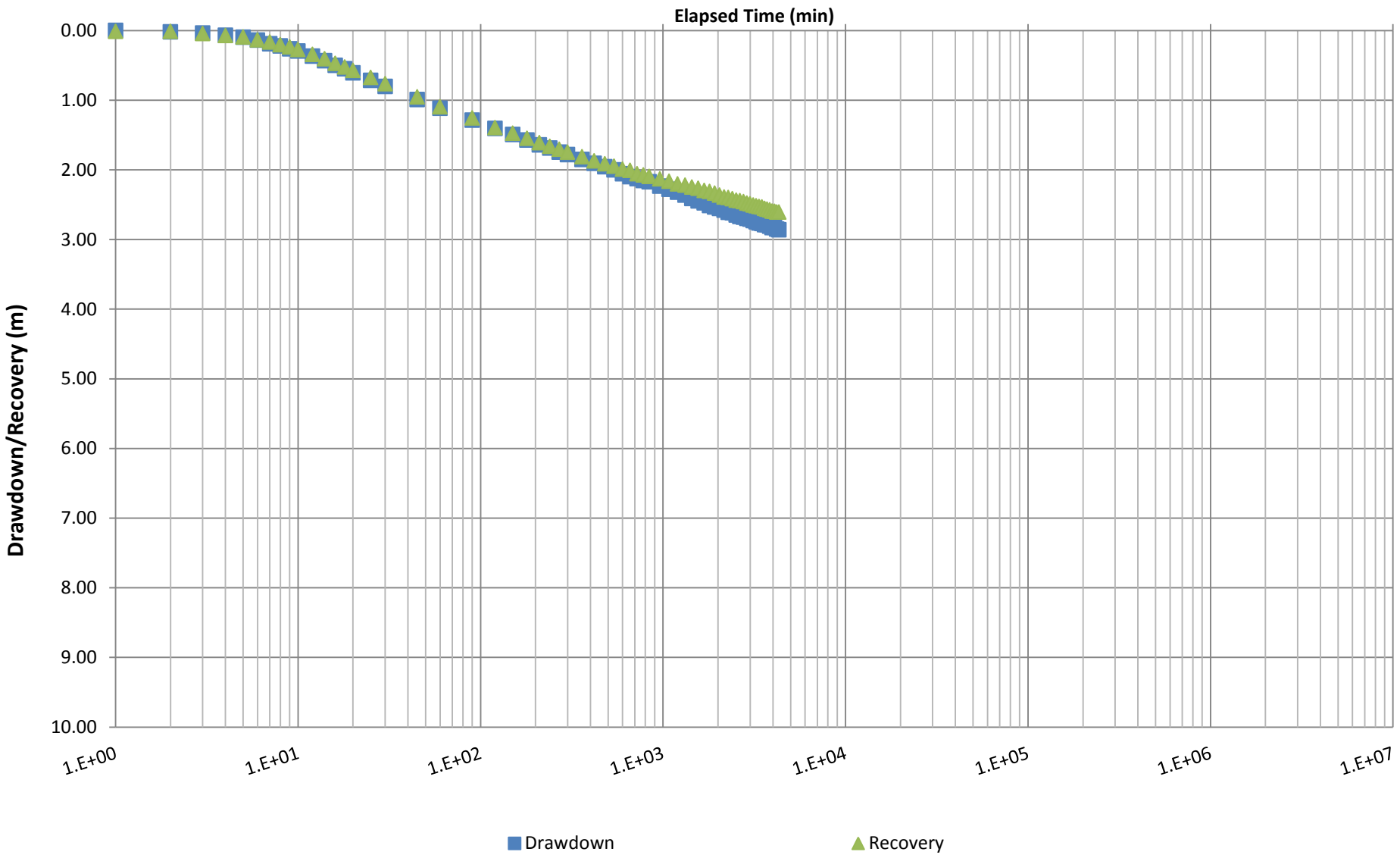
FILE No.	1311700040TRANS
PROJECT No.	13-1170-0040

SCALE:	NTS
DATE:	30-Oct-14
CAD:	ALB
CHECK:	
REVIEW:	

Pumping Test Hydrograph
Record of OW19#5

MIDHURST WATER SUPPLY
CONSTRUCTION & TESTING of TW22

FIGURE No.
B-10



Test Date:	April 15, 2014
Pumping Rate:	36.5 L/s
Distance from TW22:	90 m
Static Water Level (mbmp):	15.14
Pumping Water Level (mbmp):	18.01

Golder Associates

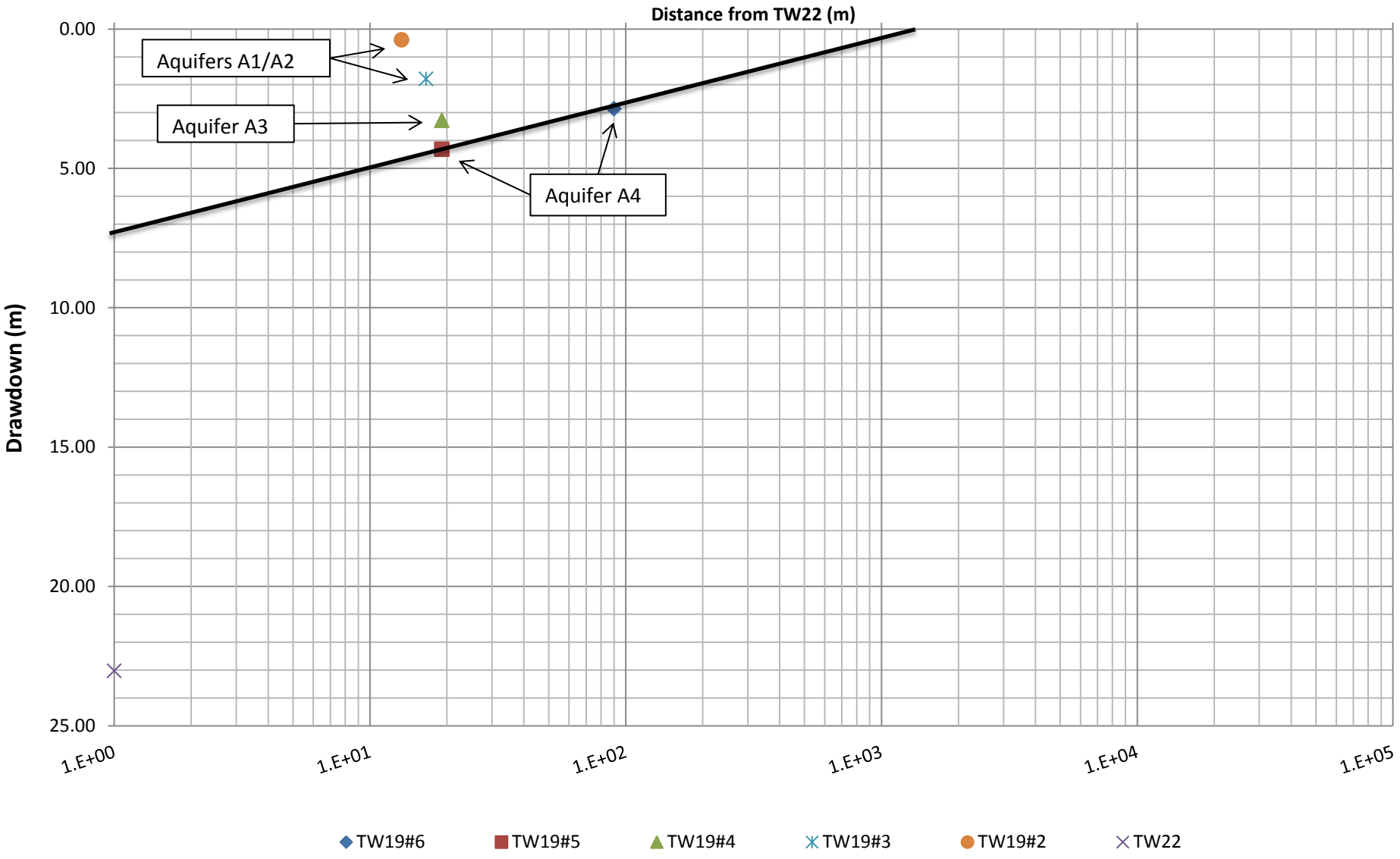
FILE No.	1311700040TRANS
PROJECT No.	13-1170-0040

SCALE:	NTS
DATE:	30-Oct-14
CAD:	ALB
CHECK:	
REVIEW:	

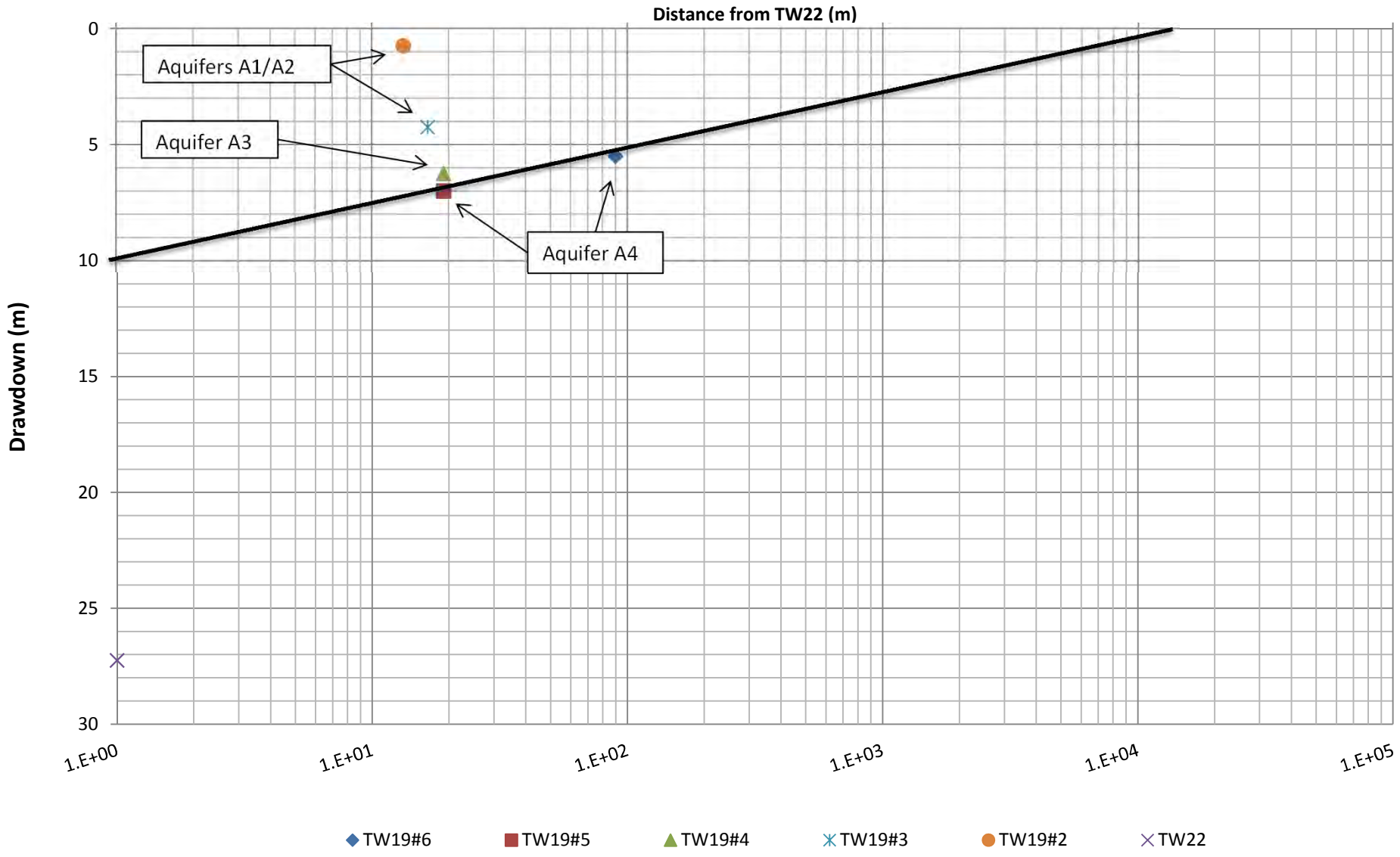
Pumping Test Hydrograph
Record of OW19#6

MIDHURST WATER SUPPLY
CONSTRUCTION & TESTING of TW22

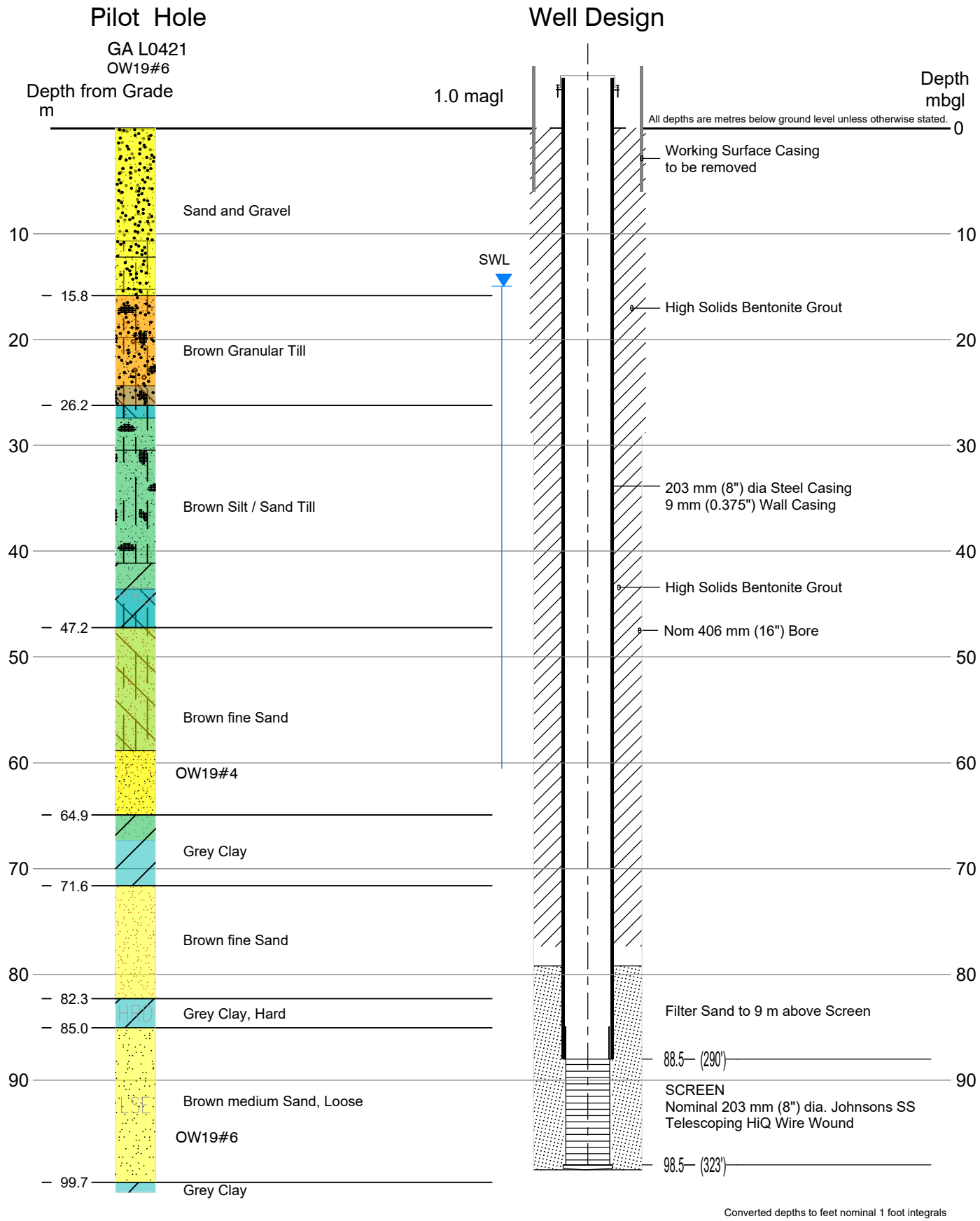
FIGURE No.
B-11



Test Date: April 15, 2014	Golder Associates	SCALE: NTS	**Test Data Drawdown vs Distance Interference From TW22**
Pumping Rate: 36.5 L/s		DATE: 28-Oct-14	
		CAD: ALB	
	FILE No. 1311700040TRANS	CHECK:	MIDHURST WATER SUPPLY CONSTRUCTION & TESTING of TW22 — FIGURE No. B-12
	PROJECT No. 13-1170-0040	REVIEW:	



Test Date: April 15, 2014	Golder Associates	SCALE: NTS	**20- Year Drawdown vs Distance Interference From TW22**	
Pumping Rate: 36.5 L/s		DATE: 20/May/15		
		CAD: ALB		
	FILE No. 1311700040TRANS	CHECK:	MIDHURST WATER SUPPLY	FIGURE No.
	PROJECT No. 13-1170-0040	REVIEW:	CONSTRUCTION & TESTING of TW22	B-13



PLOT DATE: May 21, 2015
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-CB-\1311700040CBLOGS.dwg: [Figure B-14]

Golder Associates
Barrie, Ontario, Canada

FILE No.	1311700040CBLOGS.dwg
PROJECT No.	13-1170-0040
REV.	
SCALE	AS SHOWN
DATE	2015-05-21
DESIGN	
CAD	JPR
CHECK	
REVIEW	

TITLE

PROPOSED TEST WELL TW19 SITE

TOWNSHIP OF SPRINGWATER
MIDHURST WATER SUPPLY INVESTIGATIONS

FIGURE
B-14

Tabulated Levels for TW22

Pump On:	15-Apr-2014 11:30	Static Level:	12.16
Pump Off:	18-Apr-2014 11:30	Pumping Level:	35.19
Pumping Well:	**TW22**	Drawdown:	23.03
Distance from Pumping Well:	13.3 m		

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
15-Apr-2014 11:31	1	29.70	17.54	18-Apr-2014 11:30	0	35.19	0.00
15-Apr-2014 11:32	2	30.27	18.11	18-Apr-2014 11:31	1	16.50	18.69
15-Apr-2014 11:33	3	30.88	18.72	18-Apr-2014 11:32	2	16.13	19.06
15-Apr-2014 11:34	4	31.13	18.97	18-Apr-2014 11:33	3	15.85	19.34
15-Apr-2014 11:35	5	31.23	19.07	18-Apr-2014 11:34	4	15.69	19.50
15-Apr-2014 11:36	6	31.31	19.15	18-Apr-2014 11:35	5	15.55	19.64
15-Apr-2014 11:37	7	31.36	19.20	18-Apr-2014 11:36	6	15.44	19.75
15-Apr-2014 11:38	8	31.42	19.26	18-Apr-2014 11:37	7	15.34	19.85
15-Apr-2014 11:39	9	31.57	19.41	18-Apr-2014 11:38	8	15.26	19.93
15-Apr-2014 11:40	10	31.61	19.45	18-Apr-2014 11:39	9	15.20	19.99
15-Apr-2014 11:42	12	31.78	19.62	18-Apr-2014 11:40	10	15.15	20.04
15-Apr-2014 11:44	14	31.88	19.72	18-Apr-2014 11:42	12	15.03	20.16
15-Apr-2014 11:46	16	31.92	19.76	18-Apr-2014 11:44	14	14.96	20.23
15-Apr-2014 11:48	18	32.00	19.84	18-Apr-2014 11:46	16	14.85	20.34
15-Apr-2014 11:50	20	32.11	19.95	18-Apr-2014 11:48	18	14.81	20.38
15-Apr-2014 11:55	25	32.20	20.04	18-Apr-2014 11:50	20	14.77	20.42
15-Apr-2014 12:00	30	32.25	20.09	18-Apr-2014 11:55	25	14.65	20.54
15-Apr-2014 12:10	40	32.71	20.55	18-Apr-2014 12:00	30	14.56	20.63
15-Apr-2014 12:20	50	32.56	20.40	18-Apr-2014 12:10	40	14.42	20.77
15-Apr-2014 12:30	60	32.70	20.54	18-Apr-2014 12:20	50	14.27	20.92
15-Apr-2014 12:45	75	32.82	20.66	18-Apr-2014 12:30	60	14.26	20.93
15-Apr-2014 13:00	90	32.88	20.72	18-Apr-2014 12:45	75	14.12	21.07
15-Apr-2014 13:15	105	32.93	20.77				
15-Apr-2014 13:30	120	33.00	20.84				
15-Apr-2014 14:00	150	33.11	20.95				
15-Apr-2014 14:30	180	33.23	21.07				
15-Apr-2014 15:00	210	33.44	21.28				
15-Apr-2014 15:30	240	33.51	21.35				
15-Apr-2014 16:00	270	33.54	21.38				
15-Apr-2014 16:30	300	33.53	21.37				
15-Apr-2014 17:30	360	33.64	21.48				
15-Apr-2014 18:30	420	33.76	21.60				
15-Apr-2014 19:30	480	33.85	21.69				
15-Apr-2014 20:30	540	33.90	21.74				
15-Apr-2014 21:30	600	33.95	21.79				
15-Apr-2014 22:30	660	33.99	21.83				
15-Apr-2014 23:30	720	34.03	21.87				
16-Apr-2014 00:30	780	34.08	21.92				
16-Apr-2014 01:30	840	34.12	21.96				
16-Apr-2014 02:30	900	34.15	21.99				
16-Apr-2014 03:30	960	34.17	22.01				
16-Apr-2014 04:30	1020	34.22	22.06				
16-Apr-2014 05:30	1080	34.24	22.08				
16-Apr-2014 06:30	1140	34.31	22.15				
16-Apr-2014 07:30	1200	34.33	22.17				
16-Apr-2014 08:30	1260	34.34	22.18				
16-Apr-2014 09:30	1320	34.37	22.21				
16-Apr-2014 10:30	1380	34.41	22.25				
16-Apr-2014 11:30	1440	34.45	22.29				
16-Apr-2014 12:30	1500	34.49	22.33				
16-Apr-2014 13:30	1560	34.51	22.35				
16-Apr-2014 14:30	1620	34.64	22.48				
16-Apr-2014 15:30	1680	34.66	22.50				
16-Apr-2014 16:30	1740	34.68	22.52				
16-Apr-2014 17:30	1800	34.69	22.53				
16-Apr-2014 18:30	1860	34.70	22.54				
16-Apr-2014 19:30	1920	34.71	22.55				
16-Apr-2014 20:30	1980	34.72	22.56				
16-Apr-2014 21:30	2040	34.73	22.57				
16-Apr-2014 22:30	2100	34.76	22.60				
16-Apr-2014 23:30	2160	34.77	22.61				
17-Apr-2014 00:30	2220	34.81	22.65				
17-Apr-2014 01:30	2280	34.82	22.66				
17-Apr-2014 02:30	2340	34.83	22.67				
17-Apr-2014 03:30	2400	34.84	22.68				
17-Apr-2014 04:30	2460	34.86	22.70				
17-Apr-2014 05:30	2520	34.87	22.71				
17-Apr-2014 06:30	2580	34.88	22.72				
17-Apr-2014 07:30	2640	34.88	22.72				
17-Apr-2014 08:30	2700	34.89	22.73				

Tabulated Levels for TW22

Pump On:	15-Apr-2014 11:30	Static Level:	12.16
Pump Off:	18-Apr-2014 11:30	Pumping Level:	35.19
Pumping Well:	**TW22**	Drawdown:	23.03
Distance from Pumping Well:	13.3 m		

Date:Time dd-mmm-yyyy hh:mm	Elapsed (min)	WL m	DD m	Date:Time dd-mmm-yyyy hh:mm	Elapsed (min)	WL m	RC m
17-Apr-2014 09:30	2760	34.91	22.75				
17-Apr-2014 10:30	2820	34.93	22.77				
17-Apr-2014 11:30	2880	34.95	22.79				
17-Apr-2014 13:30	3000	34.97	22.81				
17-Apr-2014 15:30	3120	34.99	22.83				
17-Apr-2014 16:30	3180	35.06	22.90				
17-Apr-2014 17:30	3240	35.06	22.90				
17-Apr-2014 18:30	3300	35.07	22.91				
17-Apr-2014 19:30	3360	35.08	22.92				
17-Apr-2014 20:30	3420	35.08	22.92				
17-Apr-2014 21:30	3480	35.10	22.94				
17-Apr-2014 22:30	3540	35.10	22.94				
17-Apr-2014 23:30	3600	35.10	22.94				
18-Apr-2014 00:30	3660	35.11	22.95				
18-Apr-2014 01:30	3720	35.13	22.97				
18-Apr-2014 02:30	3780	35.12	22.96				
18-Apr-2014 03:30	3840	35.13	22.97				
18-Apr-2014 04:30	3900	35.15	22.99				
18-Apr-2014 05:30	3960	35.16	23.00				
18-Apr-2014 06:30	4020	35.16	23.00				
18-Apr-2014 07:30	4080	35.18	23.02				
18-Apr-2014 08:30	4140	35.18	23.02				
18-Apr-2014 09:30	4200	35.18	23.02				
18-Apr-2014 10:30	4260	35.19	23.03				
18-Apr-2014 11:30	4320	35.19	23.03				

Tabulated Levels for Ow19#1

Pump On:	15-Apr-2014 11:30	Static Level:	8.20
Pump Off:	18-Apr-2014 11:30	Pumping Level:	8.21
Pumping Well:	**TW22**	Drawdown:	0.00
Distance from Pumping Well:	13.3 m		

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
15-Apr-2014 11:31	1	8.17	-0.04	18-Apr-2014 11:31	1	8.22	-0.01
15-Apr-2014 11:32	2	8.14	-0.06	18-Apr-2014 11:32	2	8.22	-0.01
15-Apr-2014 11:33	3	8.14	-0.06	18-Apr-2014 11:33	3	8.26	-0.06
15-Apr-2014 11:34	4	8.15	-0.05	18-Apr-2014 11:34	4	8.27	-0.06
15-Apr-2014 11:35	5	8.14	-0.07	18-Apr-2014 11:35	5	8.27	-0.06
15-Apr-2014 11:36	6	8.15	-0.05	18-Apr-2014 11:36	6	8.26	-0.06
15-Apr-2014 11:37	7	8.15	-0.06	18-Apr-2014 11:37	7	8.26	-0.05
15-Apr-2014 11:38	8	8.14	-0.06	18-Apr-2014 11:38	8	8.26	-0.05
15-Apr-2014 11:39	9	8.16	-0.04	18-Apr-2014 11:39	9	8.26	-0.05
15-Apr-2014 11:40	10	8.16	-0.05	18-Apr-2014 11:40	10	8.26	-0.05
15-Apr-2014 11:42	12	8.15	-0.05	18-Apr-2014 11:42	12	8.26	-0.05
15-Apr-2014 11:44	14	8.16	-0.05	18-Apr-2014 11:44	14	8.25	-0.04
15-Apr-2014 11:46	16	8.16	-0.05	18-Apr-2014 11:46	16	8.25	-0.04
15-Apr-2014 11:48	18	8.16	-0.05	18-Apr-2014 11:48	18	8.24	-0.04
15-Apr-2014 11:50	20	8.16	-0.05	18-Apr-2014 11:50	20	8.24	-0.04
15-Apr-2014 11:55	25	8.17	-0.04	18-Apr-2014 11:55	25	8.25	-0.04
15-Apr-2014 12:00	30	8.17	-0.03	18-Apr-2014 12:00	30	8.24	-0.04
15-Apr-2014 12:15	45	8.18	-0.03	18-Apr-2014 12:15	45	8.23	-0.03
15-Apr-2014 12:30	60	8.18	-0.02	18-Apr-2014 12:30	60	8.22	-0.01
15-Apr-2014 13:00	90	8.22	0.02	18-Apr-2014 13:00	90	8.21	0.00
15-Apr-2014 13:30	120	8.21	0.01	18-Apr-2014 13:30	120	8.19	0.02
15-Apr-2014 14:00	150	8.23	0.03	18-Apr-2014 14:00	150	8.18	0.03
15-Apr-2014 14:30	180	8.24	0.04	18-Apr-2014 14:30	180	8.17	0.04
15-Apr-2014 15:00	210	8.25	0.04	18-Apr-2014 15:00	210	8.17	0.04
15-Apr-2014 15:30	240	8.28	0.07	18-Apr-2014 15:30	240	8.16	0.05
15-Apr-2014 16:00	270	8.27	0.07	18-Apr-2014 16:00	270	8.14	0.06
15-Apr-2014 16:30	300	8.27	0.06	18-Apr-2014 16:30	300	8.13	0.07
15-Apr-2014 17:30	360	8.29	0.09	18-Apr-2014 17:30	360	8.12	0.08
15-Apr-2014 18:30	420	8.29	0.08	18-Apr-2014 18:30	420	8.13	0.08
15-Apr-2014 19:30	480	8.30	0.10	18-Apr-2014 19:30	480	8.11	0.10
15-Apr-2014 20:30	540	8.31	0.11	18-Apr-2014 20:30	540	8.11	0.10
15-Apr-2014 21:30	600	8.32	0.12	18-Apr-2014 21:30	600	8.11	0.10
15-Apr-2014 22:30	660	8.33	0.13	18-Apr-2014 22:30	660	8.09	0.12
15-Apr-2014 23:30	720	8.33	0.12	18-Apr-2014 23:30	720	8.09	0.11
16-Apr-2014 00:30	780	8.33	0.12	19-Apr-2014 00:30	780	8.08	0.12
16-Apr-2014 01:30	840	8.33	0.13	19-Apr-2014 01:30	840	8.09	0.11
16-Apr-2014 03:30	960	8.33	0.12	19-Apr-2014 03:30	960	8.07	0.13
16-Apr-2014 05:30	1080	8.33	0.13	19-Apr-2014 05:30	1080	8.07	0.14
16-Apr-2014 07:30	1200	8.36	0.15	19-Apr-2014 07:30	1200	8.08	0.13
16-Apr-2014 09:30	1320	8.37	0.16	19-Apr-2014 09:30	1320	8.08	0.13
15-Apr-2014 11:30	1440	8.20	0.00	18-Apr-2014 11:30	1440	8.21	0.00
15-Apr-2014 13:30	1560	8.21	0.01	18-Apr-2014 13:30	1560	8.19	0.02
15-Apr-2014 15:30	1680	8.28	0.07	18-Apr-2014 15:30	1680	8.16	0.05
15-Apr-2014 17:30	1800	8.29	0.09	18-Apr-2014 17:30	1800	8.12	0.08
15-Apr-2014 19:30	1920	8.30	0.10	18-Apr-2014 19:30	1920	8.11	0.10
15-Apr-2014 21:30	2040	8.32	0.12	18-Apr-2014 21:30	2040	8.11	0.10
15-Apr-2014 23:30	2160	8.33	0.12	18-Apr-2014 23:30	2160	8.09	0.11
16-Apr-2014 01:30	2280	8.33	0.13	19-Apr-2014 01:30	2280	8.09	0.11
16-Apr-2014 03:30	2400	8.33	0.12	19-Apr-2014 03:30	2400	8.07	0.13
16-Apr-2014 05:30	2520	8.33	0.13	19-Apr-2014 05:30	2520	8.07	0.14
16-Apr-2014 07:30	2640	8.36	0.15	19-Apr-2014 07:30	2640	8.08	0.13
16-Apr-2014 09:30	2760	8.37	0.16	19-Apr-2014 09:30	2760	8.08	0.13
15-Apr-2014 11:30	2880	8.20	0.00	18-Apr-2014 11:30	2880	8.21	0.00
15-Apr-2014 13:30	3000	8.21	0.01	18-Apr-2014 13:30	3000	8.19	0.02
15-Apr-2014 15:30	3120	8.28	0.07	18-Apr-2014 15:30	3120	8.16	0.05
15-Apr-2014 17:30	3240	8.29	0.09	18-Apr-2014 17:30	3240	8.12	0.08
15-Apr-2014 19:30	3360	8.30	0.10	18-Apr-2014 19:30	3360	8.11	0.10
15-Apr-2014 21:30	3480	8.32	0.12	18-Apr-2014 21:30	3480	8.11	0.10
15-Apr-2014 23:30	3600	8.33	0.12	18-Apr-2014 23:30	3600	8.09	0.11
16-Apr-2014 01:30	3720	8.33	0.13	19-Apr-2014 01:30	3720	8.09	0.11
16-Apr-2014 03:30	3840	8.33	0.12	19-Apr-2014 03:30	3840	8.07	0.13
16-Apr-2014 05:30	3960	8.33	0.13	19-Apr-2014 05:30	3960	8.07	0.14
16-Apr-2014 07:30	4080	8.36	0.15	19-Apr-2014 07:30	4080	8.08	0.13
16-Apr-2014 09:30	4200	8.37	0.16	19-Apr-2014 09:30	4200	8.08	0.13
15-Apr-2014 11:30	4320	8.20	0.00	18-Apr-2014 11:30	4320	8.21	0.00

Tabulated Levels for Ow19#2

Pump On:	15-Apr-2014 11:30	Static Level:	8.41
Pump Off:	18-Apr-2014 11:30	Pumping Level:	8.8
Pumping Well:	**TW22**	Drawdown:	0.39
Distance from Pumping Well:	13.3 m	20yr DD:	0.75

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
15-Apr-2014 11:31	1	8.42	0.01	18-Apr-2014 11:31	1	8.78	0.02
15-Apr-2014 11:32	2	8.40	-0.01	18-Apr-2014 11:32	2	8.78	0.02
15-Apr-2014 11:33	3	8.40	-0.01	18-Apr-2014 11:33	3	8.80	0.00
15-Apr-2014 11:34	4	8.39	-0.02	18-Apr-2014 11:34	4	8.80	0.00
15-Apr-2014 11:35	5	8.39	-0.02	18-Apr-2014 11:35	5	8.80	0.00
15-Apr-2014 11:36	6	8.38	-0.03	18-Apr-2014 11:36	6	8.80	0.00
15-Apr-2014 11:37	7	8.39	-0.02	18-Apr-2014 11:37	7	8.81	-0.01
15-Apr-2014 11:38	8	8.38	-0.03	18-Apr-2014 11:38	8	8.81	-0.01
15-Apr-2014 11:39	9	8.38	-0.03	18-Apr-2014 11:39	9	8.81	-0.01
15-Apr-2014 11:40	10	8.38	-0.03	18-Apr-2014 11:40	10	8.81	-0.01
15-Apr-2014 11:42	12	8.38	-0.03	18-Apr-2014 11:42	12	8.81	-0.01
15-Apr-2014 11:44	14	8.39	-0.02	18-Apr-2014 11:44	14	8.81	0.00
15-Apr-2014 11:46	16	8.39	-0.02	18-Apr-2014 11:46	16	8.81	-0.01
15-Apr-2014 11:48	18	8.39	-0.02	18-Apr-2014 11:48	18	8.81	-0.01
15-Apr-2014 11:50	20	8.40	-0.01	18-Apr-2014 11:50	20	8.80	0.00
15-Apr-2014 11:55	25	8.41	0.00	18-Apr-2014 11:55	25	8.79	0.01
15-Apr-2014 12:00	30	8.41	0.00	18-Apr-2014 12:00	30	8.79	0.01
15-Apr-2014 12:15	45	8.43	0.02	18-Apr-2014 12:15	45	8.77	0.03
15-Apr-2014 12:30	60	8.44	0.03	18-Apr-2014 12:30	60	8.74	0.06
15-Apr-2014 13:00	90	8.49	0.08	18-Apr-2014 13:00	90	8.70	0.10
15-Apr-2014 13:30	120	8.51	0.10	18-Apr-2014 13:30	120	8.67	0.13
15-Apr-2014 14:00	150	8.55	0.14	18-Apr-2014 14:00	150	8.66	0.14
15-Apr-2014 14:30	180	8.56	0.15	18-Apr-2014 14:30	180	8.63	0.18
15-Apr-2014 15:00	210	8.58	0.16	18-Apr-2014 15:00	210	8.60	0.20
15-Apr-2014 15:30	240	8.60	0.19	18-Apr-2014 15:30	240	8.59	0.22
15-Apr-2014 16:00	270	8.62	0.21	18-Apr-2014 16:00	270	8.58	0.22
15-Apr-2014 16:30	300	8.62	0.21	18-Apr-2014 16:30	300	8.38	0.42
15-Apr-2014 17:30	360	8.65	0.24	18-Apr-2014 17:30	360	8.54	0.26
15-Apr-2014 18:30	420	8.66	0.24	18-Apr-2014 18:30	420	8.52	0.28
15-Apr-2014 19:30	480	8.68	0.27	18-Apr-2014 19:30	480	8.50	0.30
15-Apr-2014 20:30	540	8.70	0.29	18-Apr-2014 20:30	540	8.49	0.31
15-Apr-2014 21:30	600	8.72	0.31	18-Apr-2014 21:30	600	8.49	0.31
15-Apr-2014 22:30	660	8.73	0.32	18-Apr-2014 22:30	660	8.49	0.31
15-Apr-2014 23:30	720	8.73	0.32	18-Apr-2014 23:30	720	8.48	0.32
16-Apr-2014 00:30	780	8.75	0.34	19-Apr-2014 00:30	780	8.47	0.33
16-Apr-2014 01:30	840	8.75	0.33	19-Apr-2014 01:30	840	8.46	0.34
16-Apr-2014 03:30	960	8.75	0.34	19-Apr-2014 03:30	960	8.46	0.34
16-Apr-2014 05:30	1080	8.76	0.35	19-Apr-2014 05:30	1080	8.44	0.36
16-Apr-2014 07:30	1200	8.78	0.37	19-Apr-2014 07:30	1200	8.44	0.36
16-Apr-2014 09:30	1320	8.80	0.39	19-Apr-2014 09:30	1320	8.44	0.36
15-Apr-2014 11:30	1440	8.41	0.00	18-Apr-2014 11:30	1440	8.78	0.03
15-Apr-2014 13:30	1560	8.51	0.10	18-Apr-2014 13:30	1560	8.67	0.13
15-Apr-2014 15:30	1680	8.60	0.19	18-Apr-2014 15:30	1680	8.59	0.22
15-Apr-2014 17:30	1800	8.65	0.24	18-Apr-2014 17:30	1800	8.54	0.26
15-Apr-2014 19:30	1920	8.68	0.27	18-Apr-2014 19:30	1920	8.50	0.30
15-Apr-2014 21:30	2040	8.72	0.31	18-Apr-2014 21:30	2040	8.49	0.31
15-Apr-2014 23:30	2160	8.73	0.32	18-Apr-2014 23:30	2160	8.48	0.32
16-Apr-2014 01:30	2280	8.75	0.33	19-Apr-2014 01:30	2280	8.46	0.34
16-Apr-2014 03:30	2400	8.75	0.34	19-Apr-2014 03:30	2400	8.46	0.34
16-Apr-2014 05:30	2520	8.76	0.35	19-Apr-2014 05:30	2520	8.44	0.36
16-Apr-2014 07:30	2640	8.78	0.37	19-Apr-2014 07:30	2640	8.44	0.36
16-Apr-2014 09:30	2760	8.80	0.39	19-Apr-2014 09:30	2760	8.44	0.36
15-Apr-2014 11:30	2880	8.41	0.00	18-Apr-2014 11:30	2880	8.78	0.03
15-Apr-2014 13:30	3000	8.51	0.10	18-Apr-2014 13:30	3000	8.67	0.13
15-Apr-2014 15:30	3120	8.60	0.19	18-Apr-2014 15:30	3120	8.59	0.22
15-Apr-2014 17:30	3240	8.65	0.24	18-Apr-2014 17:30	3240	8.54	0.26
15-Apr-2014 19:30	3360	8.68	0.27	18-Apr-2014 19:30	3360	8.50	0.30
15-Apr-2014 21:30	3480	8.72	0.31	18-Apr-2014 21:30	3480	8.49	0.31
15-Apr-2014 23:30	3600	8.73	0.32	18-Apr-2014 23:30	3600	8.48	0.32
16-Apr-2014 01:30	3720	8.75	0.33	19-Apr-2014 01:30	3720	8.46	0.34
16-Apr-2014 03:30	3840	8.75	0.34	19-Apr-2014 03:30	3840	8.46	0.34
16-Apr-2014 05:30	3960	8.76	0.35	19-Apr-2014 05:30	3960	8.44	0.36
16-Apr-2014 07:30	4080	8.78	0.37	19-Apr-2014 07:30	4080	8.44	0.36
16-Apr-2014 09:30	4200	8.80	0.39	19-Apr-2014 09:30	4200	8.44	0.36
15-Apr-2014 11:30	4320	8.41	0.00	18-Apr-2014 11:30	4320	8.78	0.03

Tabulated Levels for Ow19#3

Pump On:	15-Apr-2014 11:30	Static Level:	10.30
Pump Off:	18-Apr-2014 11:30	Pumping Level:	12.09
Pumping Well:	**TW22**	Drawdown:	1.79
Distance from Pumping Well:	16.6 m	20 yr DD:	4.25

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
15-Apr-2014 11:31	1	10.27	-0.03	18-Apr-2014 11:31	1	12.01	0.08
15-Apr-2014 11:32	2	10.29	-0.01	18-Apr-2014 11:32	2	11.99	0.10
15-Apr-2014 11:33	3	10.27	-0.03	18-Apr-2014 11:33	3	12.00	0.09
15-Apr-2014 11:34	4	10.28	-0.02	18-Apr-2014 11:34	4	12.02	0.07
15-Apr-2014 11:35	5	10.30	0.01	18-Apr-2014 11:35	5	12.02	0.07
15-Apr-2014 11:36	6	10.31	0.01	18-Apr-2014 11:36	6	12.03	0.06
15-Apr-2014 11:37	7	10.29	0.00	18-Apr-2014 11:37	7	12.04	0.05
15-Apr-2014 11:38	8	10.28	-0.02	18-Apr-2014 11:38	8	12.05	0.04
15-Apr-2014 11:39	9	10.28	-0.02	18-Apr-2014 11:39	9	12.04	0.05
15-Apr-2014 11:40	10	10.27	-0.03	18-Apr-2014 11:40	10	12.07	0.02
15-Apr-2014 11:42	12	10.27	-0.03	18-Apr-2014 11:42	12	12.07	0.02
15-Apr-2014 11:44	14	10.28	-0.01	18-Apr-2014 11:44	14	12.07	0.02
15-Apr-2014 11:46	16	10.26	-0.04	18-Apr-2014 11:46	16	12.06	0.03
15-Apr-2014 11:48	18	10.29	-0.01	18-Apr-2014 11:48	18	12.06	0.03
15-Apr-2014 11:50	20	10.25	-0.04	18-Apr-2014 11:50	20	12.07	0.02
15-Apr-2014 11:55	25	10.28	-0.01	18-Apr-2014 11:55	25	12.06	0.03
15-Apr-2014 12:00	30	10.27	-0.03	18-Apr-2014 12:00	30	12.07	0.02
15-Apr-2014 12:15	45	10.32	0.02	18-Apr-2014 12:15	45	12.02	0.07
15-Apr-2014 12:30	60	10.38	0.08	18-Apr-2014 12:30	60	11.96	0.13
15-Apr-2014 13:00	90	10.52	0.22	18-Apr-2014 13:00	90	11.83	0.26
15-Apr-2014 13:30	120	10.64	0.34	18-Apr-2014 13:30	120	11.72	0.37
15-Apr-2014 14:00	150	10.75	0.45	18-Apr-2014 14:00	150	11.62	0.47
15-Apr-2014 14:30	180	10.84	0.54	18-Apr-2014 14:30	180	11.53	0.56
15-Apr-2014 15:00	210	10.93	0.63	18-Apr-2014 15:00	210	11.43	0.66
15-Apr-2014 15:30	240	11.00	0.70	18-Apr-2014 15:30	240	11.35	0.74
15-Apr-2014 16:00	270	11.06	0.77	18-Apr-2014 16:00	270	11.29	0.80
15-Apr-2014 16:30	300	11.13	0.83	18-Apr-2014 16:30	300	11.25	0.84
15-Apr-2014 17:30	360	11.22	0.92	18-Apr-2014 17:30	360	11.16	0.93
15-Apr-2014 18:30	420	11.29	0.99	18-Apr-2014 18:30	420	11.07	1.02
15-Apr-2014 19:30	480	11.37	1.07	18-Apr-2014 19:30	480	11.01	1.08
15-Apr-2014 20:30	540	11.42	1.13	18-Apr-2014 20:30	540	10.97	1.12
15-Apr-2014 21:30	600	11.45	1.15	18-Apr-2014 21:30	600	10.91	1.18
15-Apr-2014 22:30	660	11.49	1.19	18-Apr-2014 22:30	660	10.90	1.19
15-Apr-2014 23:30	720	11.53	1.23	18-Apr-2014 23:30	720	10.86	1.23
16-Apr-2014 00:30	780	11.59	1.29	19-Apr-2014 00:30	780	10.86	1.23
16-Apr-2014 01:30	840	11.59	1.29	19-Apr-2014 01:30	840	10.82	1.27
16-Apr-2014 03:30	960	11.66	1.36	19-Apr-2014 03:30	960	10.77	1.33
16-Apr-2014 05:30	1080	11.68	1.38	19-Apr-2014 05:30	1080	10.75	1.34
16-Apr-2014 07:30	1200	11.71	1.41	19-Apr-2014 07:30	1200	10.73	1.36
16-Apr-2014 09:30	1320	11.77	1.47	19-Apr-2014 09:30	1320	10.69	1.40
16-Apr-2014 11:30	1440	11.79	1.49	19-Apr-2014 11:30	1440	10.66	1.43
16-Apr-2014 13:30	1560	11.81	1.52	19-Apr-2014 13:30	1560	10.67	1.43
16-Apr-2014 15:30	1680	11.84	1.54	19-Apr-2014 15:30	1680	10.61	1.48
16-Apr-2014 17:30	1800	11.87	1.57	19-Apr-2014 17:30	1800	10.62	1.47
16-Apr-2014 19:30	1920	11.88	1.58	19-Apr-2014 19:30	1920	10.59	1.50
16-Apr-2014 21:30	2040	11.90	1.60	19-Apr-2014 21:30	2040	10.58	1.51
16-Apr-2014 23:30	2160	11.90	1.61	19-Apr-2014 23:30	2160	10.54	1.55
17-Apr-2014 01:30	2280	11.92	1.62	20-Apr-2014 01:30	2280	10.53	1.56
17-Apr-2014 03:30	2400	11.94	1.65	20-Apr-2014 03:30	2400	10.52	1.57
17-Apr-2014 05:30	2520	11.94	1.64	20-Apr-2014 05:30	2520	10.50	1.59
17-Apr-2014 07:30	2640	11.94	1.64	20-Apr-2014 07:30	2640	10.49	1.60
17-Apr-2014 09:30	2760	11.97	1.67	20-Apr-2014 09:30	2760	10.50	1.59
17-Apr-2014 11:30	2880	11.98	1.68	20-Apr-2014 11:30	2880	10.47	1.62
17-Apr-2014 13:30	3000	12.00	1.70	20-Apr-2014 13:30	3000	10.46	1.63
17-Apr-2014 15:30	3120	12.01	1.71	20-Apr-2014 15:30	3120	10.47	1.62
17-Apr-2014 17:30	3240	12.01	1.72	20-Apr-2014 17:30	3240	10.42	1.67
17-Apr-2014 19:30	3360	12.03	1.73	20-Apr-2014 19:30	3360	10.41	1.68
17-Apr-2014 21:30	3480	12.01	1.71	20-Apr-2014 21:30	3480	10.41	1.68
17-Apr-2014 23:30	3600	12.03	1.73	20-Apr-2014 23:30	3600	10.42	1.67
18-Apr-2014 01:30	3720	12.03	1.73	21-Apr-2014 01:30	3720	10.42	1.67
18-Apr-2014 03:30	3840	12.04	1.74	21-Apr-2014 03:30	3840	10.39	1.70
18-Apr-2014 05:30	3960	12.07	1.77	21-Apr-2014 05:30	3960	10.38	1.71
18-Apr-2014 07:30	4080	12.07	1.78	21-Apr-2014 07:30	4080	10.36	1.73
18-Apr-2014 09:30	4200	12.07	1.77	21-Apr-2014 09:30	4200	10.37	1.72
18-Apr-2014 11:30	4320	12.10	1.80	21-Apr-2014 11:30	4320	10.37	1.72

Tabulated Levels for Ow19#4

Pump On:	15-Apr-2014 11:30	Static Level:	11.43
Pump Off:	18-Apr-2014 11:30	Pumping Level:	14.71
Pumping Well:	**TW22**	Drawdown:	3.28
Distance from Pumping Well:	19.1 m	20 yr DD:	6.25

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
15-Apr-2014 11:31	1	11.51	0.08	18-Apr-2014 11:31	1	14.65	0.06
15-Apr-2014 11:32	2	11.69	0.26	18-Apr-2014 11:32	2	14.48	0.23
15-Apr-2014 11:33	3	11.86	0.43	18-Apr-2014 11:33	3	14.34	0.37
15-Apr-2014 11:34	4	11.96	0.53	18-Apr-2014 11:34	4	14.24	0.47
15-Apr-2014 11:35	5	12.05	0.62	18-Apr-2014 11:35	5	14.16	0.55
15-Apr-2014 11:36	6	12.11	0.68	18-Apr-2014 11:36	6	14.09	0.62
15-Apr-2014 11:37	7	12.17	0.74	18-Apr-2014 11:37	7	14.03	0.68
15-Apr-2014 11:38	8	12.19	0.76	18-Apr-2014 11:38	8	13.99	0.72
15-Apr-2014 11:39	9	12.24	0.81	18-Apr-2014 11:39	9	13.94	0.77
15-Apr-2014 11:40	10	12.27	0.85	18-Apr-2014 11:40	10	13.91	0.80
15-Apr-2014 11:42	12	12.34	0.91	18-Apr-2014 11:42	12	13.84	0.87
15-Apr-2014 11:44	14	12.39	0.97	18-Apr-2014 11:44	14	13.78	0.93
15-Apr-2014 11:46	16	12.46	1.04	18-Apr-2014 11:46	16	13.73	0.98
15-Apr-2014 11:48	18	12.49	1.06	18-Apr-2014 11:48	18	13.69	1.02
15-Apr-2014 11:50	20	12.53	1.10	18-Apr-2014 11:50	20	13.65	1.07
15-Apr-2014 11:55	25	12.62	1.19	18-Apr-2014 11:55	25	13.56	1.15
15-Apr-2014 12:00	30	12.69	1.27	18-Apr-2014 12:00	30	13.48	1.23
15-Apr-2014 12:15	45	12.87	1.45	18-Apr-2014 12:15	45	13.32	1.39
15-Apr-2014 12:30	60	12.99	1.56	18-Apr-2014 12:30	60	13.20	1.52
15-Apr-2014 13:00	90	13.16	1.74	18-Apr-2014 13:00	90	13.02	1.69
15-Apr-2014 13:30	120	13.29	1.86	18-Apr-2014 13:30	120	12.90	1.81
15-Apr-2014 14:00	150	13.38	1.95	18-Apr-2014 14:00	150	12.81	1.90
15-Apr-2014 14:30	180	13.46	2.03	18-Apr-2014 14:30	180	12.73	1.98
15-Apr-2014 15:00	210	13.53	2.10	18-Apr-2014 15:00	210	12.67	2.05
15-Apr-2014 15:30	240	13.58	2.16	18-Apr-2014 15:30	240	12.61	2.10
15-Apr-2014 16:00	270	13.63	2.21	18-Apr-2014 16:00	270	12.57	2.14
15-Apr-2014 16:30	300	13.67	2.24	18-Apr-2014 16:30	300	12.52	2.19
15-Apr-2014 17:30	360	13.74	2.31	18-Apr-2014 17:30	360	12.46	2.26
15-Apr-2014 18:30	420	13.79	2.37	18-Apr-2014 18:30	420	12.40	2.31
15-Apr-2014 19:30	480	13.84	2.42	18-Apr-2014 19:30	480	12.35	2.37
15-Apr-2014 20:30	540	13.89	2.46	18-Apr-2014 20:30	540	12.31	2.41
15-Apr-2014 21:30	600	13.93	2.51	18-Apr-2014 21:30	600	12.27	2.44
15-Apr-2014 22:30	660	13.97	2.54	18-Apr-2014 22:30	660	12.23	2.48
15-Apr-2014 23:30	720	14.00	2.58	18-Apr-2014 23:30	720	12.21	2.51
16-Apr-2014 00:30	780	14.04	2.61	19-Apr-2014 00:30	780	12.18	2.53
16-Apr-2014 01:30	840	14.06	2.63	19-Apr-2014 01:30	840	12.15	2.56
16-Apr-2014 03:30	960	14.11	2.68	19-Apr-2014 03:30	960	12.12	2.59
16-Apr-2014 05:30	1080	14.16	2.73	19-Apr-2014 05:30	1080	12.08	2.63
16-Apr-2014 07:30	1200	14.20	2.77	19-Apr-2014 07:30	1200	12.05	2.67
16-Apr-2014 09:30	1320	14.25	2.82	19-Apr-2014 09:30	1320	12.02	2.69
16-Apr-2014 11:30	1440	14.29	2.86	19-Apr-2014 11:30	1440	12.00	2.72
16-Apr-2014 13:30	1560	14.32	2.89	19-Apr-2014 13:30	1560	11.97	2.74
16-Apr-2014 15:30	1680	14.35	2.92	19-Apr-2014 15:30	1680	11.95	2.76
16-Apr-2014 17:30	1800	14.38	2.95	19-Apr-2014 17:30	1800	11.93	2.78
16-Apr-2014 19:30	1920	14.40	2.97	19-Apr-2014 19:30	1920	11.90	2.81
16-Apr-2014 21:30	2040	14.43	3.00	19-Apr-2014 21:30	2040	11.88	2.83
16-Apr-2014 23:30	2160	14.45	3.02	19-Apr-2014 23:30	2160	11.86	2.85
17-Apr-2014 01:30	2280	14.47	3.04	20-Apr-2014 01:30	2280	11.84	2.87
17-Apr-2014 03:30	2400	14.49	3.07	20-Apr-2014 03:30	2400	11.82	2.89
17-Apr-2014 05:30	2520	14.51	3.08	20-Apr-2014 05:30	2520	11.81	2.90
17-Apr-2014 07:30	2640	14.53	3.10	20-Apr-2014 07:30	2640	11.80	2.91
17-Apr-2014 09:30	2760	14.55	3.12	20-Apr-2014 09:30	2760	11.79	2.92
17-Apr-2014 11:30	2880	14.57	3.14	20-Apr-2014 11:30	2880	11.77	2.94
17-Apr-2014 13:30	3000	14.58	3.15	20-Apr-2014 13:30	3000	11.75	2.96
17-Apr-2014 15:30	3120	14.60	3.17	20-Apr-2014 15:30	3120	11.74	2.97
17-Apr-2014 17:30	3240	14.61	3.18	20-Apr-2014 17:30	3240	11.73	2.98
17-Apr-2014 19:30	3360	14.63	3.20	20-Apr-2014 19:30	3360	11.72	3.00
17-Apr-2014 21:30	3480	14.64	3.21	20-Apr-2014 21:30	3480	11.70	3.01
17-Apr-2014 23:30	3600	14.65	3.22	20-Apr-2014 23:30	3600	11.68	3.03
18-Apr-2014 01:30	3720	14.65	3.22	21-Apr-2014 01:30	3720	11.67	3.04
18-Apr-2014 03:30	3840	14.66	3.23	21-Apr-2014 03:30	3840	11.67	3.04
18-Apr-2014 05:30	3960	14.68	3.25	21-Apr-2014 05:30	3960	11.66	3.05
18-Apr-2014 07:30	4080	14.69	3.26	21-Apr-2014 07:30	4080	11.64	3.07
18-Apr-2014 09:30	4200	14.70	3.28				
18-Apr-2014 11:30	4320	14.71	3.28				

Tabulated Levels for Ow19#5

Pump On:	15-Apr-2014 11:30	Static Level:	11.53
Pump Off:	18-Apr-2014 11:30	Pumping Level:	15.85
Pumping Well:	**TW22**	Drawdown:	4.32
Distance from Pumping Well:	19.1 m	20 yr DD:	7

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
15-Apr-2014 11:31	1	12.67	1.14	18-Apr-2014 11:31	1	14.77	1.08
15-Apr-2014 11:32	2	12.92	1.39	18-Apr-2014 11:32	2	14.56	1.29
15-Apr-2014 11:33	3	13.07	1.54	18-Apr-2014 11:33	3	14.40	1.45
15-Apr-2014 11:34	4	13.18	1.65	18-Apr-2014 11:34	4	14.29	1.56
15-Apr-2014 11:35	5	13.27	1.74	18-Apr-2014 11:35	5	14.21	1.64
15-Apr-2014 11:36	6	13.33	1.80	18-Apr-2014 11:36	6	14.14	1.71
15-Apr-2014 11:37	7	13.39	1.86	18-Apr-2014 11:37	7	14.08	1.77
15-Apr-2014 11:38	8	13.42	1.89	18-Apr-2014 11:38	8	14.03	1.82
15-Apr-2014 11:39	9	13.47	1.94	18-Apr-2014 11:39	9	13.99	1.87
15-Apr-2014 11:40	10	13.51	1.98	18-Apr-2014 11:40	10	13.95	1.91
15-Apr-2014 11:42	12	13.58	2.05	18-Apr-2014 11:42	12	13.87	1.98
15-Apr-2014 11:44	14	13.63	2.10	18-Apr-2014 11:44	14	13.82	2.03
15-Apr-2014 11:46	16	13.68	2.15	18-Apr-2014 11:46	16	13.76	2.09
15-Apr-2014 11:48	18	13.72	2.19	18-Apr-2014 11:48	18	13.72	2.13
15-Apr-2014 11:50	20	13.76	2.23	18-Apr-2014 11:50	20	13.68	2.17
15-Apr-2014 11:55	25	13.85	2.32	18-Apr-2014 11:55	25	13.60	2.26
15-Apr-2014 12:00	30	13.91	2.38	18-Apr-2014 12:00	30	13.52	2.33
15-Apr-2014 12:15	45	14.06	2.53	18-Apr-2014 12:15	45	13.36	2.49
15-Apr-2014 12:30	60	14.18	2.65	18-Apr-2014 12:30	60	13.25	2.60
15-Apr-2014 13:00	90	14.34	2.81	18-Apr-2014 13:00	90	13.08	2.77
15-Apr-2014 13:30	120	14.45	2.92	18-Apr-2014 13:30	120	12.98	2.88
15-Apr-2014 14:00	150	14.53	3.00	18-Apr-2014 14:00	150	12.89	2.96
15-Apr-2014 14:30	180	14.61	3.08	18-Apr-2014 14:30	180	12.82	3.03
15-Apr-2014 15:00	210	14.68	3.15	18-Apr-2014 15:00	210	12.75	3.10
15-Apr-2014 15:30	240	14.72	3.19	18-Apr-2014 15:30	240	12.70	3.15
15-Apr-2014 16:00	270	14.77	3.24	18-Apr-2014 16:00	270	12.66	3.19
15-Apr-2014 16:30	300	14.80	3.27	18-Apr-2014 16:30	300	12.62	3.23
15-Apr-2014 17:30	360	14.86	3.33	18-Apr-2014 17:30	360	12.55	3.30
15-Apr-2014 18:30	420	14.92	3.39	18-Apr-2014 18:30	420	12.50	3.35
15-Apr-2014 19:30	480	14.97	3.44	18-Apr-2014 19:30	480	12.45	3.40
15-Apr-2014 20:30	540	15.02	3.49	18-Apr-2014 20:30	540	12.41	3.44
15-Apr-2014 21:30	600	15.06	3.53	18-Apr-2014 21:30	600	12.37	3.48
15-Apr-2014 22:30	660	15.09	3.56	18-Apr-2014 22:30	660	12.34	3.51
15-Apr-2014 23:30	720	15.13	3.60	18-Apr-2014 23:30	720	12.31	3.54
16-Apr-2014 00:30	780	15.16	3.63	19-Apr-2014 00:30	780	12.28	3.57
16-Apr-2014 01:30	840	15.19	3.66	19-Apr-2014 01:30	840	12.26	3.59
16-Apr-2014 03:30	960	15.24	3.71	19-Apr-2014 03:30	960	12.22	3.63
16-Apr-2014 05:30	1080	15.28	3.75	19-Apr-2014 05:30	1080	12.18	3.67
16-Apr-2014 07:30	1200	15.33	3.80	19-Apr-2014 07:30	1200	12.15	3.70
16-Apr-2014 09:30	1320	15.37	3.84	19-Apr-2014 09:30	1320	12.13	3.73
16-Apr-2014 11:30	1440	15.41	3.88	19-Apr-2014 11:30	1440	12.09	3.76
16-Apr-2014 13:30	1560	15.45	3.92	19-Apr-2014 13:30	1560	12.07	3.78
16-Apr-2014 15:30	1680	15.49	3.96	19-Apr-2014 15:30	1680	12.05	3.80
16-Apr-2014 17:30	1800	15.51	3.98	19-Apr-2014 17:30	1800	12.03	3.83
16-Apr-2014 19:30	1920	15.53	4.00	19-Apr-2014 19:30	1920	12.00	3.85
16-Apr-2014 21:30	2040	15.56	4.03	19-Apr-2014 21:30	2040	11.98	3.87
16-Apr-2014 23:30	2160	15.58	4.05	19-Apr-2014 23:30	2160	11.96	3.89
17-Apr-2014 01:30	2280	15.60	4.07	20-Apr-2014 01:30	2280	11.94	3.91
17-Apr-2014 03:30	2400	15.62	4.09	20-Apr-2014 03:30	2400	11.92	3.93
17-Apr-2014 05:30	2520	15.64	4.11	20-Apr-2014 05:30	2520	11.91	3.94
17-Apr-2014 07:30	2640	15.65	4.12	20-Apr-2014 07:30	2640	11.89	3.96
17-Apr-2014 09:30	2760	15.68	4.15	20-Apr-2014 09:30	2760	11.88	3.97
17-Apr-2014 11:30	2880	15.69	4.16	20-Apr-2014 11:30	2880	11.87	3.98
17-Apr-2014 13:30	3000	15.70	4.17	20-Apr-2014 13:30	3000	11.85	4.00
17-Apr-2014 15:30	3120	15.73	4.20	20-Apr-2014 15:30	3120	11.84	4.01
17-Apr-2014 17:30	3240	15.75	4.22	20-Apr-2014 17:30	3240	11.83	4.02
17-Apr-2014 19:30	3360	15.75	4.22	20-Apr-2014 19:30	3360	11.81	4.04
17-Apr-2014 21:30	3480	15.77	4.24	20-Apr-2014 21:30	3480	11.79	4.06
17-Apr-2014 23:30	3600	15.78	4.25	20-Apr-2014 23:30	3600	11.77	4.08
18-Apr-2014 01:30	3720	15.78	4.25	21-Apr-2014 01:30	3720	11.77	4.08
18-Apr-2014 03:30	3840	15.80	4.27	21-Apr-2014 03:30	3840	11.76	4.09
18-Apr-2014 05:30	3960	15.81	4.28	21-Apr-2014 05:30	3960	11.75	4.10
18-Apr-2014 07:30	4080	15.82	4.29	21-Apr-2014 07:30	4080	11.74	4.11
18-Apr-2014 09:30	4200	15.84	4.31				
18-Apr-2014 11:30	4320	15.84	4.31				

Tabulated Levels for Ow19#6

Pump On:	15-Apr-2014 11:30	Static Level:	15.14
Pump Off:	18-Apr-2014 11:30	Pumping Level:	18.01
Pumping Well:	**TW22**	Drawdown:	2.87
Distance from Pumping Well:	90 m	20 yr DD:	5.5

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
15-Apr-2014 11:31	1	15.14	0.00	18-Apr-2014 11:31	1	18.00	0.02
15-Apr-2014 11:32	2	15.17	0.02	18-Apr-2014 11:32	2	18.00	0.01
15-Apr-2014 11:33	3	15.18	0.04	18-Apr-2014 11:33	3	17.97	0.04
15-Apr-2014 11:34	4	15.21	0.07	18-Apr-2014 11:34	4	17.94	0.07
15-Apr-2014 11:35	5	15.24	0.10	18-Apr-2014 11:35	5	17.92	0.09
15-Apr-2014 11:36	6	15.28	0.14	18-Apr-2014 11:36	6	17.88	0.13
15-Apr-2014 11:37	7	15.33	0.19	18-Apr-2014 11:37	7	17.85	0.16
15-Apr-2014 11:38	8	15.37	0.22	18-Apr-2014 11:38	8	17.81	0.21
15-Apr-2014 11:39	9	15.41	0.27	18-Apr-2014 11:39	9	17.78	0.23
15-Apr-2014 11:40	10	15.44	0.30	18-Apr-2014 11:40	10	17.74	0.28
15-Apr-2014 11:42	12	15.51	0.37	18-Apr-2014 11:42	12	17.67	0.34
15-Apr-2014 11:44	14	15.58	0.44	18-Apr-2014 11:44	14	17.60	0.41
15-Apr-2014 11:46	16	15.64	0.50	18-Apr-2014 11:46	16	17.54	0.47
15-Apr-2014 11:48	18	15.69	0.55	18-Apr-2014 11:48	18	17.49	0.52
15-Apr-2014 11:50	20	15.75	0.61	18-Apr-2014 11:50	20	17.44	0.57
15-Apr-2014 11:55	25	15.86	0.72	18-Apr-2014 11:55	25	17.34	0.67
15-Apr-2014 12:00	30	15.95	0.81	18-Apr-2014 12:00	30	17.25	0.77
15-Apr-2014 12:15	45	16.14	0.99	18-Apr-2014 12:15	45	17.06	0.95
15-Apr-2014 12:30	60	16.26	1.12	18-Apr-2014 12:30	60	16.91	1.10
15-Apr-2014 13:00	90	16.43	1.29	18-Apr-2014 13:00	90	16.75	1.26
15-Apr-2014 13:30	120	16.55	1.41	18-Apr-2014 13:30	120	16.61	1.40
15-Apr-2014 14:00	150	16.64	1.49	18-Apr-2014 14:00	150	16.53	1.48
15-Apr-2014 14:30	180	16.72	1.57	18-Apr-2014 14:30	180	16.46	1.55
15-Apr-2014 15:00	210	16.79	1.64	18-Apr-2014 15:00	210	16.40	1.61
15-Apr-2014 15:30	240	16.83	1.69	18-Apr-2014 15:30	240	16.35	1.67
15-Apr-2014 16:00	270	16.89	1.75	18-Apr-2014 16:00	270	16.31	1.71
15-Apr-2014 16:30	300	16.93	1.78	18-Apr-2014 16:30	300	16.26	1.75
15-Apr-2014 17:30	360	16.99	1.85	18-Apr-2014 17:30	360	16.20	1.82
15-Apr-2014 18:30	420	17.05	1.91	18-Apr-2014 18:30	420	16.14	1.87
15-Apr-2014 19:30	480	17.10	1.96	18-Apr-2014 19:30	480	16.10	1.91
15-Apr-2014 20:30	540	17.15	2.00	18-Apr-2014 20:30	540	16.06	1.95
15-Apr-2014 21:30	600	17.20	2.06	18-Apr-2014 21:30	600	16.02	1.99
15-Apr-2014 22:30	660	17.24	2.10	18-Apr-2014 22:30	660	16.00	2.01
15-Apr-2014 23:30	720	17.27	2.13	18-Apr-2014 23:30	720	15.95	2.06
16-Apr-2014 00:30	780	17.30	2.16	19-Apr-2014 00:30	780	15.94	2.07
16-Apr-2014 01:30	840	17.31	2.17	19-Apr-2014 01:30	840	15.92	2.09
16-Apr-2014 03:30	960	17.38	2.23	19-Apr-2014 03:30	960	15.88	2.13
16-Apr-2014 05:30	1080	17.42	2.28	19-Apr-2014 05:30	1080	15.84	2.17
16-Apr-2014 07:30	1200	17.46	2.32	19-Apr-2014 07:30	1200	15.81	2.20
16-Apr-2014 09:30	1320	17.51	2.36	19-Apr-2014 09:30	1320	15.79	2.22
16-Apr-2014 11:30	1440	17.56	2.41	19-Apr-2014 11:30	1440	15.76	2.25
16-Apr-2014 13:30	1560	17.59	2.45	19-Apr-2014 13:30	1560	15.74	2.27
16-Apr-2014 15:30	1680	17.62	2.48	19-Apr-2014 15:30	1680	15.71	2.30
16-Apr-2014 17:30	1800	17.66	2.51	19-Apr-2014 17:30	1800	15.70	2.31
16-Apr-2014 19:30	1920	17.68	2.53	19-Apr-2014 19:30	1920	15.67	2.34
16-Apr-2014 21:30	2040	17.70	2.56	19-Apr-2014 21:30	2040	15.65	2.36
16-Apr-2014 23:30	2160	17.72	2.58	19-Apr-2014 23:30	2160	15.62	2.39
17-Apr-2014 01:30	2280	17.75	2.61	20-Apr-2014 01:30	2280	15.61	2.40
17-Apr-2014 03:30	2400	17.76	2.62	20-Apr-2014 03:30	2400	15.59	2.42
17-Apr-2014 05:30	2520	17.79	2.65	20-Apr-2014 05:30	2520	15.57	2.44
17-Apr-2014 07:30	2640	17.81	2.67	20-Apr-2014 07:30	2640	15.57	2.44
17-Apr-2014 09:30	2760	17.82	2.68	20-Apr-2014 09:30	2760	15.55	2.46
17-Apr-2014 11:30	2880	17.84	2.70	20-Apr-2014 11:30	2880	15.53	2.48
17-Apr-2014 13:30	3000	17.85	2.71	20-Apr-2014 13:30	3000	15.52	2.49
17-Apr-2014 15:30	3120	17.87	2.73	20-Apr-2014 15:30	3120	15.50	2.51
17-Apr-2014 17:30	3240	17.89	2.75	20-Apr-2014 17:30	3240	15.49	2.52
17-Apr-2014 19:30	3360	17.91	2.76	20-Apr-2014 19:30	3360	15.48	2.53
17-Apr-2014 21:30	3480	17.91	2.77	20-Apr-2014 21:30	3480	15.47	2.54
17-Apr-2014 23:30	3600	17.93	2.79	20-Apr-2014 23:30	3600	15.45	2.56
18-Apr-2014 01:30	3720	17.93	2.79	21-Apr-2014 01:30	3720	15.44	2.57
18-Apr-2014 03:30	3840	17.95	2.81	21-Apr-2014 03:30	3840	15.44	2.58
18-Apr-2014 05:30	3960	17.97	2.83	21-Apr-2014 05:30	3960	15.42	2.59
18-Apr-2014 07:30	4080	17.97	2.83	21-Apr-2014 07:30	4080	15.41	2.60
18-Apr-2014 09:30	4200	18.00	2.85	21-Apr-2014 09:30	4200	15.40	2.61
18-Apr-2014 11:30	4320	18.01	2.86	21-Apr-2014 11:30	4320	15.40	2.61

Tabulated Levels for Ow09-01

Pump On:	15-Apr-2014 11:30	Static Level:	8.21
Pump Off:	18-Apr-2014 11:30	Pumping Level:	6.33
Pumping Well:	**TW22**	Drawdown:	-1.88
Distance from Pumping Well:	m		

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
15-Apr-2014 11:31	1	8.20	0.00	18-Apr-2014 11:31	1	6.33	0.00
15-Apr-2014 11:32	2	8.20	-0.01	18-Apr-2014 11:32	2	6.33	0.00
15-Apr-2014 11:33	3	8.21	0.00	18-Apr-2014 11:33	3	6.33	0.00
15-Apr-2014 11:34	4	8.21	0.00	18-Apr-2014 11:34	4	6.33	0.00
15-Apr-2014 11:35	5	8.20	0.00	18-Apr-2014 11:35	5	6.33	0.00
15-Apr-2014 11:36	6	8.20	0.00	18-Apr-2014 11:36	6	6.33	0.00
15-Apr-2014 11:37	7	8.20	0.00	18-Apr-2014 11:37	7	6.33	0.00
15-Apr-2014 11:38	8	8.20	0.00	18-Apr-2014 11:38	8	6.33	0.00
15-Apr-2014 11:39	9	8.20	0.00	18-Apr-2014 11:39	9	6.33	0.00
15-Apr-2014 11:40	10	8.20	0.00	18-Apr-2014 11:40	10	6.33	0.00
15-Apr-2014 11:42	12	8.21	0.00	18-Apr-2014 11:42	12	6.33	0.00
15-Apr-2014 11:44	14	8.21	0.01	18-Apr-2014 11:44	14	6.32	0.00
15-Apr-2014 11:46	16	8.21	0.00	18-Apr-2014 11:46	16	6.33	0.00
15-Apr-2014 11:48	18	8.21	0.00	18-Apr-2014 11:48	18	6.33	0.00
15-Apr-2014 11:50	20	8.20	0.00	18-Apr-2014 11:50	20	6.33	0.00
15-Apr-2014 11:55	25	8.21	0.00	18-Apr-2014 11:55	25	6.33	0.00
15-Apr-2014 12:00	30	8.21	0.00	18-Apr-2014 12:00	30	6.33	0.00
15-Apr-2014 12:15	45	8.20	0.00	18-Apr-2014 12:15	45	6.33	0.00
15-Apr-2014 12:30	60	8.20	0.00	18-Apr-2014 12:30	60	6.32	0.01
15-Apr-2014 13:00	90	8.21	0.00	18-Apr-2014 13:00	90	6.32	0.01
15-Apr-2014 13:30	120	8.20	0.00	18-Apr-2014 13:30	120	6.32	0.01
15-Apr-2014 14:00	150	8.20	0.00	18-Apr-2014 14:00	150	6.31	0.02
15-Apr-2014 14:30	180	8.20	-0.01	18-Apr-2014 14:30	180	6.31	0.02
15-Apr-2014 15:00	210	8.20	-0.01	18-Apr-2014 15:00	210	6.31	0.02
15-Apr-2014 15:30	240	8.20	0.00	18-Apr-2014 15:30	240	6.30	0.03
15-Apr-2014 16:00	270	8.20	0.00	18-Apr-2014 16:00	270	6.30	0.03
15-Apr-2014 16:30	300	8.20	-0.01	18-Apr-2014 16:30	300	6.29	0.04
15-Apr-2014 17:30	360	8.20	-0.01	18-Apr-2014 17:30	360	6.28	0.05
15-Apr-2014 18:30	420	8.19	-0.02	18-Apr-2014 18:30	420	6.28	0.05
15-Apr-2014 19:30	480	8.19	-0.02	18-Apr-2014 19:30	480	6.27	0.06
15-Apr-2014 20:30	540	8.19	-0.01	18-Apr-2014 20:30	540	6.27	0.06
15-Apr-2014 21:30	600	8.19	-0.02	18-Apr-2014 21:30	600	6.27	0.06
15-Apr-2014 22:30	660	8.19	-0.02	18-Apr-2014 22:30	660	6.26	0.06
15-Apr-2014 23:30	720	8.19	-0.02	18-Apr-2014 23:30	720	6.26	0.07
16-Apr-2014 00:30	780	8.18	-0.02	19-Apr-2014 00:30	780	6.26	0.07
16-Apr-2014 01:30	840	8.18	-0.03	19-Apr-2014 01:30	840	6.25	0.08
16-Apr-2014 03:30	960	8.17	-0.04	19-Apr-2014 03:30	960	6.25	0.08
16-Apr-2014 05:30	1080	8.10	-0.11	19-Apr-2014 05:30	1080	6.24	0.09
16-Apr-2014 07:30	1200	8.00	-0.21	19-Apr-2014 07:30	1200	6.24	0.09
16-Apr-2014 09:30	1320	7.89	-0.32	19-Apr-2014 09:30	1320	6.24	0.09
16-Apr-2014 11:30	1440	7.73	-0.47	19-Apr-2014 11:30	1440	6.23	0.10
16-Apr-2014 13:30	1560	7.48	-0.73	19-Apr-2014 13:30	1560	6.22	0.11
16-Apr-2014 15:30	1680	7.20	-1.00	19-Apr-2014 15:30	1680	6.20	0.13
16-Apr-2014 17:30	1800	7.05	-1.16	19-Apr-2014 17:30	1800	6.18	0.15
16-Apr-2014 19:30	1920	6.93	-1.27	19-Apr-2014 19:30	1920	6.16	0.17
16-Apr-2014 21:30	2040	6.88	-1.32	19-Apr-2014 21:30	2040	6.14	0.19
16-Apr-2014 23:30	2160	6.84	-1.36	19-Apr-2014 23:30	2160	6.13	0.20
17-Apr-2014 01:30	2280	6.80	-1.41	20-Apr-2014 01:30	2280	6.12	0.21
17-Apr-2014 03:30	2400	6.76	-1.45	20-Apr-2014 03:30	2400	6.10	0.23
17-Apr-2014 05:30	2520	6.73	-1.48	20-Apr-2014 05:30	2520	6.09	0.24
17-Apr-2014 07:30	2640	6.70	-1.51	20-Apr-2014 07:30	2640	6.09	0.24
17-Apr-2014 09:30	2760	6.67	-1.54	20-Apr-2014 09:30	2760	6.07	0.26
17-Apr-2014 11:30	2880	6.63	-1.57	20-Apr-2014 11:30	2880	6.06	0.27
17-Apr-2014 13:30	3000	6.58	-1.62	20-Apr-2014 13:30	3000	6.03	0.30
17-Apr-2014 15:30	3120	6.55	-1.66	20-Apr-2014 15:30	3120	6.00	0.33
17-Apr-2014 17:30	3240	6.52	-1.69	20-Apr-2014 17:30	3240	5.98	0.35
17-Apr-2014 19:30	3360	6.49	-1.72	20-Apr-2014 19:30	3360	5.97	0.36
17-Apr-2014 21:30	3480	6.47	-1.74	20-Apr-2014 21:30	3480	5.95	0.38
17-Apr-2014 23:30	3600	6.43	-1.77	20-Apr-2014 23:30	3600	5.94	0.39
18-Apr-2014 01:30	3720	6.41	-1.80	21-Apr-2014 01:30	3720	5.93	0.40
18-Apr-2014 03:30	3840	6.38	-1.83	21-Apr-2014 03:30	3840	5.91	0.41
18-Apr-2014 05:30	3960	6.36	-1.85	21-Apr-2014 05:30	3960	5.90	0.43
18-Apr-2014 07:30	4080	6.35	-1.86	21-Apr-2014 07:30	4080	5.89	0.44
18-Apr-2014 09:30	4200	6.34	-1.86				
18-Apr-2014 11:30	4320	6.33	-1.88				

Tabulated Levels for Ow8I

Pump On:	15-Apr-2014 11:30	Static Level:	44.85
Pump Off:	18-Apr-2014 11:30	Pumping Level:	44.79
Pumping Well:	**TW22**	Drawdown:	-0.06
Distance from Pumping Well:	1250 m		

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
15-Apr-2014 11:31	1	44.85	0.00	18-Apr-2014 11:31	1	44.79	0.00
15-Apr-2014 11:32	2	44.85	0.00	18-Apr-2014 11:32	2	44.79	0.00
15-Apr-2014 11:33	3	44.85	0.00	18-Apr-2014 11:33	3	44.79	0.00
15-Apr-2014 11:34	4	44.85	0.01	18-Apr-2014 11:34	4	44.79	0.00
15-Apr-2014 11:35	5	44.85	0.00	18-Apr-2014 11:35	5	44.79	0.00
15-Apr-2014 11:36	6	44.85	0.00	18-Apr-2014 11:36	6	44.79	0.00
15-Apr-2014 11:37	7	44.85	0.00	18-Apr-2014 11:37	7	44.79	0.00
15-Apr-2014 11:38	8	44.85	0.00	18-Apr-2014 11:38	8	44.79	0.00
15-Apr-2014 11:39	9	44.85	0.01	18-Apr-2014 11:39	9	44.79	0.00
15-Apr-2014 11:40	10	44.86	0.01	18-Apr-2014 11:40	10	44.79	0.00
15-Apr-2014 11:42	12	44.86	0.01	18-Apr-2014 11:42	12	44.79	0.00
15-Apr-2014 11:44	14	44.86	0.01	18-Apr-2014 11:44	14	44.79	0.00
15-Apr-2014 11:46	16	44.85	0.01	18-Apr-2014 11:46	16	44.79	0.00
15-Apr-2014 11:48	18	44.86	0.01	18-Apr-2014 11:48	18	44.79	0.00
15-Apr-2014 11:50	20	44.86	0.01	18-Apr-2014 11:50	20	44.79	0.00
15-Apr-2014 11:55	25	44.86	0.01	18-Apr-2014 11:55	25	44.79	0.00
15-Apr-2014 12:00	30	44.85	0.00	18-Apr-2014 12:00	30	44.79	0.00
15-Apr-2014 12:15	45	44.86	0.01	18-Apr-2014 12:15	45	44.79	0.00
15-Apr-2014 12:30	60	44.85	0.01	18-Apr-2014 12:30	60	44.79	0.00
15-Apr-2014 13:00	90	44.86	0.01	18-Apr-2014 13:00	90	44.79	0.00
15-Apr-2014 13:30	120	44.86	0.01	18-Apr-2014 13:30	120	44.79	0.00
15-Apr-2014 14:00	150	44.86	0.02	18-Apr-2014 14:00	150	44.79	0.00
15-Apr-2014 14:30	180	44.86	0.01	18-Apr-2014 14:30	180	44.79	0.00
15-Apr-2014 15:00	210	44.87	0.02	18-Apr-2014 15:00	210	44.78	0.01
15-Apr-2014 15:30	240	44.88	0.03	18-Apr-2014 15:30	240	44.79	0.00
15-Apr-2014 16:00	270	44.88	0.03	18-Apr-2014 16:00	270	44.78	0.01
15-Apr-2014 16:30	300	44.88	0.03	18-Apr-2014 16:30	300	44.78	0.01
15-Apr-2014 17:30	360	44.88	0.03	18-Apr-2014 17:30	360	44.78	0.01
15-Apr-2014 18:30	420	44.88	0.03	18-Apr-2014 18:30	420	44.78	0.01
15-Apr-2014 19:30	480	44.88	0.03	18-Apr-2014 19:30	480	44.78	0.01
15-Apr-2014 20:30	540	44.89	0.04	18-Apr-2014 20:30	540	44.78	0.01
15-Apr-2014 21:30	600	44.90	0.05	18-Apr-2014 21:30	600	44.78	0.01
15-Apr-2014 22:30	660	44.91	0.06	18-Apr-2014 22:30	660	44.79	0.00
15-Apr-2014 23:30	720	44.91	0.06	18-Apr-2014 23:30	720	44.79	0.00
16-Apr-2014 00:30	780	44.92	0.07	19-Apr-2014 00:30	780	44.79	0.00
16-Apr-2014 01:30	840	44.91	0.07	19-Apr-2014 01:30	840	44.79	0.00
16-Apr-2014 03:30	960	44.92	0.07	19-Apr-2014 03:30	960	44.80	-0.01
16-Apr-2014 05:30	1080	44.92	0.07	19-Apr-2014 05:30	1080	44.80	-0.01
16-Apr-2014 07:30	1200	44.94	0.09	19-Apr-2014 07:30	1200	44.81	-0.02
16-Apr-2014 09:30	1320	44.95	0.10	19-Apr-2014 09:30	1320	44.82	-0.03
16-Apr-2014 11:30	1440	44.96	0.11	19-Apr-2014 11:30	1440	44.82	-0.03
16-Apr-2014 13:30	1560	44.95	0.10	19-Apr-2014 13:30	1560	44.83	-0.04
16-Apr-2014 15:30	1680	44.94	0.09	19-Apr-2014 15:30	1680	44.82	-0.03
16-Apr-2014 17:30	1800	44.93	0.09	19-Apr-2014 17:30	1800	44.81	-0.02
16-Apr-2014 19:30	1920	44.92	0.07	19-Apr-2014 19:30	1920	44.80	-0.01
16-Apr-2014 21:30	2040	44.92	0.07	19-Apr-2014 21:30	2040	44.80	-0.01
16-Apr-2014 23:30	2160	44.92	0.07	19-Apr-2014 23:30	2160	44.79	0.00
17-Apr-2014 01:30	2280	44.91	0.06	20-Apr-2014 01:30	2280	44.79	0.00
17-Apr-2014 03:30	2400	44.90	0.05	20-Apr-2014 03:30	2400	44.78	0.01
17-Apr-2014 05:30	2520	44.89	0.04	20-Apr-2014 05:30	2520	44.78	0.01
17-Apr-2014 07:30	2640	44.89	0.04	20-Apr-2014 07:30	2640	44.78	0.01
17-Apr-2014 09:30	2760	44.89	0.04	20-Apr-2014 09:30	2760	44.77	0.02
17-Apr-2014 11:30	2880	44.88	0.03	20-Apr-2014 11:30	2880	44.77	0.02
17-Apr-2014 13:30	3000	44.86	0.01	20-Apr-2014 13:30	3000	44.76	0.03
17-Apr-2014 15:30	3120	44.85	0.00	20-Apr-2014 15:30	3120	44.74	0.05
17-Apr-2014 17:30	3240	44.83	-0.02	20-Apr-2014 17:30	3240	44.74	0.05
17-Apr-2014 19:30	3360	44.82	-0.03	20-Apr-2014 19:30	3360	44.73	0.06
17-Apr-2014 21:30	3480	44.82	-0.03	20-Apr-2014 21:30	3480	44.72	0.07
17-Apr-2014 23:30	3600	44.81	-0.04	20-Apr-2014 23:30	3600	44.71	0.08
18-Apr-2014 01:30	3720	44.80	-0.05	21-Apr-2014 01:30	3720	44.71	0.08
18-Apr-2014 03:30	3840	44.79	-0.06	21-Apr-2014 03:30	3840	44.70	0.09
18-Apr-2014 05:30	3960	44.78	-0.07	21-Apr-2014 05:30	3960	44.70	0.09
18-Apr-2014 07:30	4080	44.78	-0.07	21-Apr-2014 07:30	4080	44.70	0.09
18-Apr-2014 09:30	4200	44.79	-0.06				
18-Apr-2014 11:30	4320	44.79	-0.06				

Tabulated Levels for Ow8D

Pump On:	15-Apr-2014 11:30	Static Level:	41.92
Pump Off:	18-Apr-2014 11:30	Pumping Level:	41.74
Pumping Well:	**TW22**	Drawdown:	-0.18
Distance from Pumping Well:	1250 m		

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
15-Apr-2014 11:31	1	41.92	0.00	18-Apr-2014 11:31	1	41.74	0.00
15-Apr-2014 11:32	2	41.91	0.00	18-Apr-2014 11:32	2	41.74	0.00
15-Apr-2014 11:33	3	41.92	0.00	18-Apr-2014 11:33	3	41.74	0.00
15-Apr-2014 11:34	4	41.92	0.00	18-Apr-2014 11:34	4	41.74	0.00
15-Apr-2014 11:35	5	41.91	0.00	18-Apr-2014 11:35	5	41.74	0.00
15-Apr-2014 11:36	6	41.91	0.00	18-Apr-2014 11:36	6	41.74	0.00
15-Apr-2014 11:37	7	41.91	0.00	18-Apr-2014 11:37	7	41.74	0.00
15-Apr-2014 11:38	8	41.92	0.00	18-Apr-2014 11:38	8	41.74	0.00
15-Apr-2014 11:39	9	41.92	0.00	18-Apr-2014 11:39	9	41.74	0.00
15-Apr-2014 11:40	10	41.92	0.00	18-Apr-2014 11:40	10	41.74	0.00
15-Apr-2014 11:42	12	41.92	0.00	18-Apr-2014 11:42	12	41.74	0.00
15-Apr-2014 11:44	14	41.92	0.00	18-Apr-2014 11:44	14	41.74	0.00
15-Apr-2014 11:46	16	41.91	0.00	18-Apr-2014 11:46	16	41.74	0.00
15-Apr-2014 11:48	18	41.91	0.00	18-Apr-2014 11:48	18	41.74	0.00
15-Apr-2014 11:50	20	41.91	0.00	18-Apr-2014 11:50	20	41.74	0.00
15-Apr-2014 11:55	25	41.91	0.00	18-Apr-2014 11:55	25	41.75	0.00
15-Apr-2014 12:00	30	41.91	-0.01	18-Apr-2014 12:00	30	41.74	0.00
15-Apr-2014 12:15	45	41.91	-0.01	18-Apr-2014 12:15	45	41.75	0.00
15-Apr-2014 12:30	60	41.91	-0.01	18-Apr-2014 12:30	60	41.74	0.00
15-Apr-2014 13:00	90	41.92	0.00	18-Apr-2014 13:00	90	41.74	0.00
15-Apr-2014 13:30	120	41.91	-0.01	18-Apr-2014 13:30	120	41.74	0.00
15-Apr-2014 14:00	150	41.91	-0.01	18-Apr-2014 14:00	150	41.74	0.00
15-Apr-2014 14:30	180	41.92	0.00	18-Apr-2014 14:30	180	41.74	0.00
15-Apr-2014 15:00	210	41.91	0.00	18-Apr-2014 15:00	210	41.73	0.01
15-Apr-2014 15:30	240	41.91	0.00	18-Apr-2014 15:30	240	41.73	0.01
15-Apr-2014 16:00	270	41.91	-0.01	18-Apr-2014 16:00	270	41.73	0.01
15-Apr-2014 16:30	300	41.91	-0.01	18-Apr-2014 16:30	300	41.72	0.02
15-Apr-2014 17:30	360	41.91	-0.01	18-Apr-2014 17:30	360	41.72	0.02
15-Apr-2014 18:30	420	41.91	-0.01	18-Apr-2014 18:30	420	41.72	0.03
15-Apr-2014 19:30	480	41.90	-0.02	18-Apr-2014 19:30	480	41.71	0.04
15-Apr-2014 20:30	540	41.90	-0.02	18-Apr-2014 20:30	540	41.70	0.04
15-Apr-2014 21:30	600	41.90	-0.01	18-Apr-2014 21:30	600	41.70	0.05
15-Apr-2014 22:30	660	41.91	-0.01	18-Apr-2014 22:30	660	41.70	0.05
15-Apr-2014 23:30	720	41.91	-0.01	18-Apr-2014 23:30	720	41.70	0.04
16-Apr-2014 00:30	780	41.90	-0.02	19-Apr-2014 00:30	780	41.70	0.05
16-Apr-2014 01:30	840	41.90	-0.02	19-Apr-2014 01:30	840	41.69	0.05
16-Apr-2014 03:30	960	41.89	-0.02	19-Apr-2014 03:30	960	41.70	0.04
16-Apr-2014 05:30	1080	41.89	-0.03	19-Apr-2014 05:30	1080	41.69	0.05
16-Apr-2014 07:30	1200	41.89	-0.03	19-Apr-2014 07:30	1200	41.68	0.06
16-Apr-2014 09:30	1320	41.90	-0.02	19-Apr-2014 09:30	1320	41.68	0.06
16-Apr-2014 11:30	1440	41.90	-0.02	19-Apr-2014 11:30	1440	41.69	0.05
16-Apr-2014 13:30	1560	41.90	-0.02	19-Apr-2014 13:30	1560	41.69	0.06
16-Apr-2014 15:30	1680	41.87	-0.04	19-Apr-2014 15:30	1680	41.67	0.07
16-Apr-2014 17:30	1800	41.87	-0.05	19-Apr-2014 17:30	1800	41.66	0.08
16-Apr-2014 19:30	1920	41.86	-0.06	19-Apr-2014 19:30	1920	41.64	0.10
16-Apr-2014 21:30	2040	41.85	-0.06	19-Apr-2014 21:30	2040	41.62	0.12
16-Apr-2014 23:30	2160	41.87	-0.05	19-Apr-2014 23:30	2160	41.61	0.14
17-Apr-2014 01:30	2280	41.86	-0.06	20-Apr-2014 01:30	2280	41.72	0.02
17-Apr-2014 03:30	2400	41.85	-0.06	20-Apr-2014 03:30	2400	41.73	0.01
17-Apr-2014 05:30	2520	41.84	-0.07	20-Apr-2014 05:30	2520	41.72	0.03
17-Apr-2014 07:30	2640	41.84	-0.08	20-Apr-2014 07:30	2640	41.70	0.04
17-Apr-2014 09:30	2760	41.84	-0.08	20-Apr-2014 09:30	2760	41.68	0.06
17-Apr-2014 11:30	2880	41.83	-0.09	20-Apr-2014 11:30	2880	41.67	0.07
17-Apr-2014 13:30	3000	41.82	-0.10	20-Apr-2014 13:30	3000	41.65	0.09
17-Apr-2014 15:30	3120	41.81	-0.11	20-Apr-2014 15:30	3120	41.63	0.11
17-Apr-2014 17:30	3240	41.79	-0.13	20-Apr-2014 17:30	3240	41.62	0.12
17-Apr-2014 19:30	3360	41.78	-0.14	20-Apr-2014 19:30	3360	41.60	0.14
17-Apr-2014 21:30	3480	41.78	-0.14	20-Apr-2014 21:30	3480	41.58	0.16
17-Apr-2014 23:30	3600	41.77	-0.14	20-Apr-2014 23:30	3600	41.59	0.16
18-Apr-2014 01:30	3720	41.76	-0.15	21-Apr-2014 01:30	3720	41.57	0.17
18-Apr-2014 03:30	3840	41.76	-0.16	21-Apr-2014 03:30	3840	41.56	0.18
18-Apr-2014 05:30	3960	41.75	-0.17	21-Apr-2014 05:30	3960	41.55	0.19
18-Apr-2014 07:30	4080	41.74	-0.18	21-Apr-2014 07:30	4080	41.55	0.19
18-Apr-2014 09:30	4200	41.74	-0.17				
18-Apr-2014 11:30	4320	41.74	-0.18				

Tabulated Levels for Ow10D

Pump On:	15-Apr-2014 11:30	Static Level:	36.87
Pump Off:	18-Apr-2014 11:30	Pumping Level:	39.16
Pumping Well:	**TW22**	Drawdown:	2.29
Distance from Pumping Well:	2050 m		

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
15-Apr-2014 11:31	1	36.86	-0.01	18-Apr-2014 11:31	1	39.16	0.00
15-Apr-2014 11:32	2	36.85	-0.02	18-Apr-2014 11:32	2	39.16	0.00
15-Apr-2014 11:33	3	36.84	-0.03	18-Apr-2014 11:33	3	39.16	0.00
15-Apr-2014 11:34	4	36.83	-0.04	18-Apr-2014 11:34	4	39.16	0.00
15-Apr-2014 11:35	5	36.82	-0.05	18-Apr-2014 11:35	5	39.16	0.00
15-Apr-2014 11:36	6	36.81	-0.06	18-Apr-2014 11:36	6	39.16	0.00
15-Apr-2014 11:37	7	36.80	-0.07	18-Apr-2014 11:37	7	39.16	0.00
15-Apr-2014 11:38	8	36.79	-0.08	18-Apr-2014 11:38	8	39.16	0.00
15-Apr-2014 11:39	9	36.79	-0.08	18-Apr-2014 11:39	9	39.16	0.00
15-Apr-2014 11:40	10	36.77	-0.10	18-Apr-2014 11:40	10	39.16	0.00
15-Apr-2014 11:42	12	36.76	-0.11	18-Apr-2014 11:42	12	39.16	0.00
15-Apr-2014 11:44	14	36.74	-0.13	18-Apr-2014 11:44	14	39.15	0.01
15-Apr-2014 11:46	16	36.72	-0.15	18-Apr-2014 11:46	16	39.16	0.00
15-Apr-2014 11:48	18	36.70	-0.17	18-Apr-2014 11:48	18	39.16	0.00
15-Apr-2014 11:50	20	36.68	-0.19	18-Apr-2014 11:50	20	39.16	0.00
15-Apr-2014 11:55	25	36.64	-0.23	18-Apr-2014 11:55	25	39.16	0.00
15-Apr-2014 12:00	30	36.60	-0.27	18-Apr-2014 12:00	30	39.16	0.00
15-Apr-2014 12:15	45	36.47	-0.40	18-Apr-2014 12:15	45	39.16	0.00
15-Apr-2014 12:30	60	36.36	-0.51	18-Apr-2014 12:30	60	39.16	0.00
15-Apr-2014 13:00	90	36.17	-0.70	18-Apr-2014 13:00	90	39.16	0.00
15-Apr-2014 13:30	120	36.31	-0.56	18-Apr-2014 13:30	120	39.16	0.00
15-Apr-2014 14:00	150	36.59	-0.28	18-Apr-2014 14:00	150	39.16	0.00
15-Apr-2014 14:30	180	37.91	1.04	18-Apr-2014 14:30	180	39.16	0.00
15-Apr-2014 15:00	210	39.16	2.29	18-Apr-2014 15:00	210	39.16	0.00
15-Apr-2014 15:30	240	39.16	2.29	18-Apr-2014 15:30	240	39.16	0.00
15-Apr-2014 16:00	270	39.16	2.29	18-Apr-2014 16:00	270	39.16	0.00
15-Apr-2014 16:30	300	39.16	2.29	18-Apr-2014 16:30	300	39.16	0.00
15-Apr-2014 17:30	360	38.31	1.44	18-Apr-2014 17:30	360	39.16	0.00
15-Apr-2014 18:30	420	37.40	0.53	18-Apr-2014 18:30	420	39.16	0.00
15-Apr-2014 19:30	480	37.06	0.19	18-Apr-2014 19:30	480	39.16	0.00
15-Apr-2014 20:30	540	36.86	-0.01	18-Apr-2014 20:30	540	39.16	0.00
15-Apr-2014 21:30	600	38.11	1.24	18-Apr-2014 21:30	600	39.16	0.00
15-Apr-2014 22:30	660	39.16	2.29	18-Apr-2014 22:30	660	39.16	0.00
15-Apr-2014 23:30	720	39.15	2.28	18-Apr-2014 23:30	720	39.16	0.00
16-Apr-2014 00:30	780	39.16	2.29	19-Apr-2014 00:30	780	39.16	0.00
16-Apr-2014 01:30	840	39.15	2.28	19-Apr-2014 01:30	840	39.15	0.01
16-Apr-2014 03:30	960	39.16	2.29	19-Apr-2014 03:30	960	39.16	0.00
16-Apr-2014 05:30	1080	38.92	2.05	19-Apr-2014 05:30	1080	39.16	0.00
16-Apr-2014 07:30	1200	37.50	0.63	19-Apr-2014 07:30	1200	39.15	0.01
16-Apr-2014 09:30	1320	37.13	0.26	19-Apr-2014 09:30	1320	39.16	0.00
16-Apr-2014 11:30	1440	36.91	0.04	19-Apr-2014 11:30	1440	39.16	0.00
16-Apr-2014 13:30	1560	36.79	-0.08	19-Apr-2014 13:30	1560	39.16	0.00
16-Apr-2014 15:30	1680	36.66	-0.21	19-Apr-2014 15:30	1680	39.16	0.00
16-Apr-2014 17:30	1800	36.62	-0.25	19-Apr-2014 17:30	1800	39.16	0.00
16-Apr-2014 19:30	1920	36.59	-0.28	19-Apr-2014 19:30	1920	39.16	0.00
16-Apr-2014 21:30	2040	36.44	-0.43	19-Apr-2014 21:30	2040	39.16	0.00
16-Apr-2014 23:30	2160	36.22	-0.65	19-Apr-2014 23:30	2160	39.16	0.00
17-Apr-2014 01:30	2280	36.05	-0.82	20-Apr-2014 01:30	2280	39.16	0.00
17-Apr-2014 03:30	2400	36.45	-0.42	20-Apr-2014 03:30	2400	39.15	0.01
17-Apr-2014 05:30	2520	39.15	2.28	20-Apr-2014 05:30	2520	39.15	0.01
17-Apr-2014 07:30	2640	39.15	2.28	20-Apr-2014 07:30	2640	39.16	0.00
17-Apr-2014 09:30	2760	39.15	2.28	20-Apr-2014 09:30	2760	39.16	0.00
17-Apr-2014 11:30	2880	39.15	2.28	20-Apr-2014 11:30	2880	39.16	0.00
17-Apr-2014 13:30	3000	39.16	2.29	20-Apr-2014 13:30	3000	39.16	0.00
17-Apr-2014 15:30	3120	39.15	2.29	20-Apr-2014 15:30	3120	39.16	0.00
17-Apr-2014 17:30	3240	39.15	2.28	20-Apr-2014 17:30	3240	39.16	0.00
17-Apr-2014 19:30	3360	39.16	2.29	20-Apr-2014 19:30	3360	39.16	0.00
17-Apr-2014 21:30	3480	39.16	2.29	20-Apr-2014 21:30	3480	39.16	0.00
17-Apr-2014 23:30	3600	39.16	2.29	20-Apr-2014 23:30	3600	39.16	0.00
18-Apr-2014 01:30	3720	39.16	2.29	21-Apr-2014 01:30	3720	39.16	0.00
18-Apr-2014 03:30	3840	39.16	2.29	21-Apr-2014 03:30	3840	39.16	0.00
18-Apr-2014 05:30	3960	39.16	2.29	21-Apr-2014 05:30	3960	39.16	0.00
18-Apr-2014 07:30	4080	39.15	2.29				
18-Apr-2014 09:30	4200	39.16	2.29				
18-Apr-2014 11:30	4320	39.16	2.29				

Table B-2: Water Quality Results

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G32925 **REPORT No. B14-07939**

Report To:

Golder Associates Ltd.
121 Commerce Park Drive, Unit L,
Barrie ON. L4N 8X1 Canada
Attention: Alicia Beynon

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 17-Apr-14
DATE REPORTED: 08-May-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: Snow Valley
P.O. NUMBER: 13-1170-0040
WATERWORKS NO.

			Client I.D.		TW22			
			Sample I.D.		B14-07939-1			
			Date Collected		16-Apr-14			
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Total Coliform	cfu/100mL	1	MOE E3407	17-Apr-14/O	0			
E coli	cfu/100mL	1	MOE E3407	17-Apr-14/O	0			
Background	cfu/100mL	1	MOE E3407	17-Apr-14/O	0			
Hardness (as CaCO3)	mg/L	1	SM 3120	22-Apr-14/O	311			
Alkalinity(CaCO3) to pH4.5	mg/L	5	SM 2320B	21-Apr-14/O	238			
pH @25°C	pH Units		SM 4500H	21-Apr-14/O	7.90			
Colour	TCU	2	SM 2120C	21-Apr-14/O	3			
Turbidity	NTU	0.1	SM 2130	22-Apr-14/O	0.4			
Fluoride	mg/L	0.1	SM4110C	17-Apr-14/O	0.1			
Chloride	mg/L	0.5	SM4110C	17-Apr-14/O	30.2			
Nitrite (N)	mg/L	0.1	SM4110C	17-Apr-14/O	< 0.1			
Nitrate (N)	mg/L	0.1	SM4110C	17-Apr-14/O	7.7			
Nitrate + Nitrite (N)	mg/L	0.1	SM4110C	17-Apr-14/O	7.7			
Sulphate	mg/L	1	SM4110C	17-Apr-14/O	22			
Total Cyanide	mg/L	0.005	SM 4500CN	22-Apr-14/K	< 0.005			
Calcium	mg/L	0.02	SM 3120	22-Apr-14/O	85.9			
Magnesium	mg/L	0.01	SM 3120	22-Apr-14/O	23.4			
Sodium	mg/L	0.2	SM 3120	22-Apr-14/O	9.9			
Potassium	mg/L	0.1	SM 3120	22-Apr-14/O	1.6			
Aluminum	mg/L	0.01	SM 3120	22-Apr-14/O	0.02			
Antimony	mg/L	0.0001	EPA 200.8	22-Apr-14/O	< 0.0001			
Arsenic	mg/L	0.0001	EPA 200.8	22-Apr-14/O	0.0002			
Barium	mg/L	0.001	SM 3120	22-Apr-14/O	0.045			
Boron	mg/L	0.005	SM 3120	22-Apr-14/O	0.007			
Cadmium	mg/L	0.00002	EPA 200.8	22-Apr-14/O	< 0.00002			
Chromium	mg/L	0.002	SM 3120	22-Apr-14/O	< 0.002			



Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

M.D.L. = Method Detection Limit
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

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Table B-2: Water Quality Results

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G32925 **REPORT No. B14-07939**

Report To:

Golder Associates Ltd.
121 Commerce Park Drive, Unit L,
Barrie ON. L4N 8X1 Canada
Attention: Alicia Beynon

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 17-Apr-14
DATE REPORTED: 08-May-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: Snow Valley
P.O. NUMBER: 13-1170-0040
WATERWORKS NO.

			Client I.D.		TW22			
			Sample I.D.		B14-07939-1			
			Date Collected		16-Apr-14			
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Copper	mg/L	0.002	SM 3120	22-Apr-14/O	< 0.002			
Iron	mg/L	0.005	SM 3120	22-Apr-14/O	< 0.005			
Lead	mg/L	0.00002	EPA 200.8	22-Apr-14/O	< 0.00002			
Manganese	mg/L	0.001	SM 3120	22-Apr-14/O	< 0.001			
Mercury	mg/L	0.00002	SM 3112 B	22-Apr-14/O	< 0.00002			
Selenium	mg/L	0.001	EPA 200.8	22-Apr-14/O	< 0.001			
Uranium	mg/L	0.00005	EPA 200.8	22-Apr-14/O	0.00138			
Zinc	mg/L	0.005	SM 3120	22-Apr-14/O	< 0.005			
Ammonia (N)-Total	mg/L	0.01	MOEE 3364	22-Apr-14/O	< 0.01			
Total Kjeldahl Nitrogen	mg/L	0.05	MOEE 3367	25-Apr-14/O	< 0.05			
Organic Nitrogen	mg/L	0.05	MOEE 3367	28-Apr-14/O	< 0.05			
Dissolved Organic Carbon	mg/L	0.2	EPA 415.1	17-Apr-14/O	1.7			
Sulphide	mg/L	0.01	SM4500-S2	21-Apr-14/K	< 0.01			
Methane	L/m3	0.006	NA	23-Apr-14	< 0.006 [2]			
Benzene	µg/L	0.5	EPA 8260	17-Apr-14/O	< 0.5			
Carbon Tetrachloride	µg/L	0.2	EPA 8260	17-Apr-14/O	< 0.2			
Dichlorobenzene,1,2-	µg/L	0.1	EPA 8260	17-Apr-14/O	< 0.1			
Dichlorobenzene,1,4-	µg/L	0.2	EPA 8260	17-Apr-14/O	< 0.2			
Dichloroethane,1,2-	µg/L	0.1	EPA 8260	17-Apr-14/O	< 0.1			
Dichloroethene, 1,1-	µg/L	0.1	EPA 8260	17-Apr-14/O	< 0.1			
Dichloromethane (Methylene Chloride)	µg/L	0.3	EPA 8260	17-Apr-14/O	< 0.3			
Ethylbenzene	µg/L	0.5	EPA 8260	17-Apr-14/O	< 0.5			
Monochlorobenzene (Chlorobenzene)	µg/L	0.2	EPA 8260	17-Apr-14/O	< 0.2			
Tetrachloroethylene	µg/L	0.2	EPA 8260	17-Apr-14/O	< 0.2			
Toluene	µg/L	0.5	EPA 8260	17-Apr-14/O	< 0.5			

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

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CADUCEON ENVIRONMENTAL LABORATORIES
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Final Report

C.O.C.: G32925 **REPORT No. B14-07939**

Report To:

Golder Associates Ltd.
121 Commerce Park Drive, Unit L,
Barrie ON. L4N 8X1 Canada
Attention: Alicia Beynon

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 17-Apr-14
DATE REPORTED: 08-May-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: Snow Valley
P.O. NUMBER: 13-1170-0040
WATERWORKS NO.

			Client I.D.		TW22			
			Sample I.D.		B14-07939-1			
			Date Collected		16-Apr-14			
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Trichloroethylene	µg/L	0.1	EPA 8260	17-Apr-14/O	< 0.1			
Vinyl Chloride	µg/L	0.2	EPA 8260	17-Apr-14/O	< 0.2			
Xylene, m,p-	µg/L	0.4	EPA 8260	17-Apr-14/O	< 0.4			
Xylene, o-	µg/L	0.1	EPA 8260	17-Apr-14/O	< 0.1			
Xylene, m,p,o-	µg/L	0.4	EPA 8260	17-Apr-14/O	< 0.4			
Bromoform	µg/L	0.1	EPA 8260	17-Apr-14/O	< 0.1			
Bromodichloromethane	µg/L	0.1	EPA 8260	17-Apr-14/O	< 0.1			
Dibromochloromethane	µg/L	0.1	EPA 8260	17-Apr-14/O	< 0.1			
Chloroform	µg/L	0.3	EPA 8260	17-Apr-14/O	< 0.3			
Total Trihalomethanes	µg/L	0.3	EPA 8260	17-Apr-14/O	< 0.3			
Alachlor	µg/L	0.3	EPA 8270	24-Apr-14/K	< 0.3			
Aldicarb	µg/L	3	EPA 8270	24-Apr-14/K	< 3			
Aldrin + Dieldrin	µg/L	0.02	EPA 8080	22-Apr-14/K	< 0.02			
Atrazine + Metabolites	µg/L	0.5	Calc.	24-Apr-14/K	< 0.5			
Azinphos-methyl	µg/L	1	EPA 8270	24-Apr-14/K	< 1			
Bendiocarb	µg/L	3	EPA 8270	24-Apr-14/K	< 3			
Benzo(a)pyrene	µg/L	0.005	EPA 8270	24-Apr-14/K	< 0.005			
Bromoxynil	µg/L	0.3	EPA 8270	24-Apr-14/K	< 0.3			
Carbaryl	µg/L	3	EPA 8270	24-Apr-14/K	< 3			
Carbofuran	µg/L	1	EPA 8270	24-Apr-14/K	< 1			
Chlordane (Total)	µg/L	0.04	EPA 8080	22-Apr-14/K	< 0.04			
Chlorpyrifos	µg/L	0.5	EPA 8270	24-Apr-14/K	< 0.5			
Cyanazine	µg/L	0.5	EPA 8270	24-Apr-14/K	< 0.5			
DDT + Metabolites	µg/L	0.01	EPA 8080	22-Apr-14/K	< 0.01			
Diazinon	µg/L	1	EPA 8270	24-Apr-14/K	< 1			
Dicamba	µg/L	5	EPA 8270	24-Apr-14/K	< 5			

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

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Attention: Alicia Beynon

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 17-Apr-14
DATE REPORTED: 08-May-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: Snow Valley
P.O. NUMBER: 13-1170-0040
WATERWORKS NO.

			Client I.D.		TW22			
			Sample I.D.		B14-07939-1			
			Date Collected		16-Apr-14			
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Dichlorophenol, 2,4-	µg/L	0.1	EPA 8270	24-Apr-14/K	< 0.1			
Dichlorophenoxy acetic acid, 2,4- (2,4-D)	µg/L	5	EPA 8270	24-Apr-14/K	< 5			
Diclofop-methyl	µg/L	0.5	EPA 8270	24-Apr-14/K	< 0.5			
Dimethoate	µg/L	1	EPA 8270	24-Apr-14/K	< 1			
Dinoseb	µg/L	0.5	EPA 8270	24-Apr-14/K	< 0.5			
Dioxin & Furan (TEQ)	ppq	1	E.C. 1/RM/19	01-May-14	< 1 [3]			
Diquat	µg/L	5	EPA 549.1	23-Apr-14/K	< 5			
Diuron	µg/L	5	EPA 8270	24-Apr-14/K	< 5			
Lindane (Hexachlorocyclohexane, Gamma)	µg/L	0.1	EPA 8080	22-Apr-14/K	< 0.1			
Glyphosate	µg/L	25	EPA 547	23-Apr-14/K	< 25			
Heptachlor + Heptachlor Epoxide	µg/L	0.1	EPA 8080	22-Apr-14/K	< 0.1			
Malathion	µg/L	5	EPA 8270	24-Apr-14/K	< 5			
Methoxychlor	µg/L	0.1	EPA 8080	22-Apr-14/K	< 0.1			
Metolachlor	µg/L	3	EPA 8270	24-Apr-14/K	< 3			
Metribuzin	µg/L	3	EPA 8270	24-Apr-14/K	< 3			
Microcystin DM	ppb	0.1	NA	24-Apr-14	< 0.1 [1]			
N-Nitrosodimethylamine	µg/L	0.0008	E3209A/SM 6410B	25-Apr-14	< 0.0008 [2]			
NTA	mg/L	0.03	J. Chrom A 690	23-Apr-14	< 0.03 [2]			
Paraquat	µg/L	1	EPA 549.1	23-Apr-14/K	< 1			
Parathion	µg/L	3	EPA 8270	24-Apr-14/K	< 3			
Pentachlorophenol	µg/L	0.1	EPA 8270	24-Apr-14/K	< 0.1			

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

M.D.L. = Method Detection Limit
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

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Final Report

C.O.C.: G32925 **REPORT No. B14-07939**

Report To:

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121 Commerce Park Drive, Unit L,
Barrie ON. L4N 8X1 Canada
Attention: Alicia Beynon

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 17-Apr-14
DATE REPORTED: 08-May-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: Snow Valley
P.O. NUMBER: 13-1170-0040
WATERWORKS NO.

			Client I.D.		TW22			
			Sample I.D.		B14-07939-1			
			Date Collected		16-Apr-14			
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Phorate	µg/L	0.3	EPA 8270	24-Apr-14/K	< 0.3			
Picloram	µg/L	5	EPA 8270	24-Apr-14/K	< 5			
Poly-Chlorinated Biphenyls (PCB's)	µg/L	0.05	EPA 8080	22-Apr-14/K	< 0.05			
Prometryne	µg/L	0.1	EPA 8270	24-Apr-14/K	< 0.1			
Simazine	µg/L	0.5	EPA 8270	24-Apr-14/K	< 0.5			
Temephos	µg/L	10	EPA 8270	24-Apr-14/K	< 10			
Terbufos	µg/L	0.3	EPA 8270	24-Apr-14/K	< 0.3			
Tetrachlorophenol, 2,3,4,6-	µg/L	0.1	EPA 8270	24-Apr-14/K	< 0.1			
Triallate	µg/L	10	EPA 8270	24-Apr-14/K	< 10			
Trichlorophenol 2,4,6-	µg/L	0.1	EPA 8270	24-Apr-14/K	< 0.1			
Trichlorophenoxy acetic acid, 2,4,5-	µg/L	10	EPA 8270	24-Apr-14/K	< 10			
Trifluralin	µg/L	0.5	EPA 8270	24-Apr-14/K	< 0.5			
Anion Sum	meq/L		Calc.	23-Apr-14/O	6.63			
Cation Sum	meq/L		Calc.	23-Apr-14/O	6.68			
% Difference	%		Calc.	23-Apr-14/O	0.382			
Ion Ratio	AS/CS		Calc.	23-Apr-14/O	0.992			
Sodium Adsorption Ratio	-		Calc.	23-Apr-14/O	0.245			
TDS(ion sum calc.)	mg/L		Calc.	23-Apr-14/O	350			
Conductivity (calc.)	µmho/cm		Calc.	23-Apr-14/O	637			
Langelier Index(25°C)	S.I.		Calc.	23-Apr-14/O	0.758			

1 subcontracted to COAL Inc.
2 Subcontracted to SGS Lakefield
3 Subcontracted to Wellington Labs

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

M.D.L. = Method Detection Limit
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

The analytical results reported herein refer to the samples as received. Reproduction of this analytical report in full or in part is prohibited without prior consent from Caduceon Environmental Laboratories.

Table B-2: Water Quality Results

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G32925 **REPORT No. B14-07940**

Report To:

Golder Associates Ltd.
121 Commerce Park Drive, Unit L,
Barrie ON. L4N 8X1 Canada
Attention: Alicia Beynon

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 17-Apr-14
DATE REPORTED: 30-Apr-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: Snow Valley
P.O. NUMBER: 13-1170-0040
WATERWORKS NO.

			Client I.D.		TW22 (1 hr)			
			Sample I.D.		B14-07940-1			
			Date Collected		15-Apr-14			
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Hardness (as CaCO3)	mg/L	1	SM 3120	22-Apr-14/O	313			
Alkalinity(CaCO3) to pH4.5	mg/L	5	SM 2320B	17-Apr-14/O	233			
Conductivity @25°C	µmho/cm	1	SM 2510B	17-Apr-14/O	649			
pH @25°C	pH Units		SM 4500H	17-Apr-14/O	8.11			
Colour	TCU	2	SM 2120C	21-Apr-14/O	2			
Turbidity	NTU	0.1	SM 2130	22-Apr-14/O	2.5			
Calcium	mg/L	0.02	SM 3120	22-Apr-14/O	86.1			
Magnesium	mg/L	0.01	SM 3120	22-Apr-14/O	23.8			
Sodium	mg/L	0.2	SM 3120	22-Apr-14/O	11.8			
Potassium	mg/L	0.1	SM 3120	22-Apr-14/O	2.3			
Copper	mg/L	0.002	SM 3120	22-Apr-14/O	0.003			
Iron	mg/L	0.005	SM 3120	22-Apr-14/O	0.013			
Manganese	mg/L	0.001	SM 3120	22-Apr-14/O	0.003			
Silica	mg/L	0.02	SM 3120	22-Apr-14/O	14.2			
Zinc	mg/L	0.005	SM 3120	22-Apr-14/O	< 0.005			
Ammonia (N)-Total	mg/L	0.01	MOEE 3364	22-Apr-14/O	< 0.01			
Total Kjeldahl Nitrogen	mg/L	0.05	MOEE 3367	25-Apr-14/O	< 0.05			
Organic Nitrogen	mg/L	0.05	MOEE 3367	25-Apr-14/O	< 0.05			
Dissolved Organic Carbon	mg/L	0.2	EPA 415.1	17-Apr-14/O	1.8			
Sulphide	mg/L	0.01	SM4500-S2	21-Apr-14/K	< 0.01			
Phenolics	mg/L	0.001	MOEE 3179	17-Apr-14/O	< 0.001			
Tannins and Lignins	mg/L	0.1	N/A	28-Apr-14	< 0.1 [1]			
Anion Sum	meq/L		Calc.	22-Apr-14/O	6.77			
Cation Sum	meq/L		Calc.	22-Apr-14/O	6.83			
% Difference	%		Calc.	22-Apr-14/O	0.481			
Ion Ratio	AS/CS		Calc.	22-Apr-14/O	0.990			

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

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Table B-2: Water Quality Results

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G32925 **REPORT No. B14-07940**

Report To:

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121 Commerce Park Drive, Unit L,
Barrie ON. L4N 8X1 Canada
Attention: Alicia Beynon

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 17-Apr-14
DATE REPORTED: 30-Apr-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: Snow Valley
P.O. NUMBER: 13-1170-0040
WATERWORKS NO.

			Client I.D.		TW22 (1 hr)			
			Sample I.D.		B14-07940-1			
			Date Collected		15-Apr-14			
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Sodium Adsorption Ratio	-		Calc.	22-Apr-14/O	0.291			
TDS(ion sum calc.)	mg/L		Calc.	22-Apr-14/O	360			
Conductivity (calc.)	µmho/cm		Calc.	22-Apr-14/O	655			
TDS(calc.)/EC(actual)	-		Calc.	22-Apr-14/O	0.554			
EC(calc.)/EC(actual)	-		Calc.	22-Apr-14/O	1.01			
Langelier Index(25°C)	S.I.		Calc.	22-Apr-14/O	0.961			
Fluoride	mg/L	0.1	SM4110C	17-Apr-14/O	0.1			
Nitrite (N)	mg/L	0.1	SM4110C	17-Apr-14/O	< 0.1			
Nitrate (N)	mg/L	0.1	SM4110C	17-Apr-14/O	7.9			
Bromide	mg/L	0.4	SM4110C	17-Apr-14/O	< 0.4			
Chloride	mg/L	0.5	SM4110C	17-Apr-14/O	37.8			
Sulphate	mg/L	1	SM4110C	17-Apr-14/O	22			

1 . subcontracted to Paracel Labs



Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

M.D.L. = Method Detection Limit
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

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Table B-2: Water Quality Results

CENTRAL ONTARIO ANALYTICAL LABORATORY INC.

4260 Burnside Line, R.R. #4
Orillia, ON L3V 6H4
Tel: (705) 326-8285 Fax: (705) 326-9316
www.coalab.ca

Final Certificate of Microbiological Analysis of Drinking Water

Date & Time Received:	Temp. Rec'd. (°C):	Receiver:	Date & Time Incubated:	2014-04-15 15:00
2014-04-15 14:12	8.3	MH	HPC & FS Date & Time Incubated:	

Date Sampled: 2014-04-15

Collected By: K. Easton

Name of Facility: Golder Associates

Drinking Water System (DWS) #

Submitted By: K. Easton

Twp/Town	
Systems Health Unit	SMDHU
Regulation	319/08
Total # of pages sent	1
# of samples sent	1
# of samples received	1

Report To: **Golder Associates Ltd.**

Address: 121 Commerce Park Drive, Unit L, Barrie, ON. L4N 8X1

Telephone: 705 722-4492 Ext: Fax: 705-722-3786

Email Address: patricia_chapple@golder.com

"Live Person" After Hours Contact Name and Tel. No:

Conditions/ Comments Project #: 13-1170-0040 Also send to: John - easton@golder.com Alicia - beynon@golder.com Thanks!

Time Sampled	Sample Identifier	Identification of Collection Site	Water Type	Temp. Of Sample (°C/°F)	Treatment Information				Laboratory Number	Total Coliform		E. coli		Background		HPC		
					U.V.	Other	Total Cl_2 (mg/L)	Free Cl_2 (mg/L)		>/<	CFU/100 ml	>/<	CFU/100 ml	>/<	CFU/100 ml	>/<	CFU/1 ml	
12:00	1	TW22-Well	D						005752		0		0		0			

All samples will be considered DISTRIBUTION samples unless otherwise indicated.

All times are transcribed in the 24-hour clock for upload to the Ministry of the Environment (MOE) and/or Ministry of Health and Long Term Care (MoHLTC).

Analysis performed by qualified analysts. Results relate only to the aliquot submitted. Samples have been analyzed as received. COAL is accredited by SCC and licensed by MOE in these specific microbiological parameters and the following inorganic and physical parameters: pH, turbidity, and alkalinity.

COAL accepts no responsibility for parameters selected, misidentification of samples or incorrect quantity, this is the responsibility of the submitting agency.

For collection and handling procedures visit www.coalab.ca/watersamples.html

Raw = R
Distribution = D
Point of Entry = E

F.S. & Faecal Strep. = Faecal Streptococcus HPC = Heterotrophic Plate Count HPM = Heavy Particulate Matter N/R = Not Received F.S. and HPC require 48 hours of incubation Raw Water Comsumed = RWC

Analysis Date & Time: 2014-04-16 13:30 Enumerated By: GD Audited By: LC Methodology: M/F CFU/100ml

Analysis Date & Time: Enumerated By: Audited By: HPC Methodology: SP CFU/1ml; FS Methodology: M/F CFU/100ml

Transcribed By: HM Authorized & Rechecked By: TJ/JT Copy Released By: CAB, LC

Lab No. Submitting Agency @ Health Unit @ Spills Action Centre (SAC) @ AWQI # By: Date:

Test Methodology and Detection Limit

Total Coliform (Treated)	COAL Endo	Detection Limit	0 - 80	Reportable Limit:	1	Performed by Membrane Filtration	M/F CFU/100 ml
Total Coliform (Untreated)	COAL DC	Detection Limit	0 - 80	Reportable Limit:	1	Performed by Membrane Filtration	M/F CFU/100 ml
E. coli	COAL DC	Detection Limit	0 - 60	Reportable Limit:	1	Performed by Membrane Filtration	M/F CFU/100 ml
Background	COAL Endo	Detection Limit	0 - 200	Indicates Deterioration:	>200	Performed by Membrane Filtration	M/F CFU/100 ml
Background	COAL DC	Detection Limit	0 - 200	Indicates Deterioration:	>200	Performed by Membrane Filtration	M/F CFU/100 ml
HPC	COAL HPC	Detection Limit	10 - 2.00 x 10^3	Indicates Deterioration:	>500	Performed by Spread Plate	SP CFU/1 ml
Faecal Streptococcus	COAL FS	Detection Limit	0 - 80	Reportable Limit:	1	Performed by Membrane Filtration	M/F CFU/100 ml

Approved for use by TJ prior to use.

Table B-2: Water Quality Results

CENTRAL ONTARIO ANALYTICAL LABORATORY INC.

4260 Burnside Line, R.R. #4
Orillia, ON L3V 6H4
Tel: (705) 326-8285 Fax: (705) 326-9316
www.coalab.ca

Final Certificate of Microbiological Analysis of Drinking Water

Date & Time Received:	Temp. Rec'd. (°C):	Receiver:	Date & Time Incubated:	2014-04-16 15:00
2014-04-16 14:40	13.7	AB	HPC & FS Date & Time Incubated:	

Date Sampled: 2014-04-16

Collected By: Alicia Beynon

Name of Facility: Golder Associates

Drinking Water System (DWS) #

Submitted By: Kevin Easton

Twp/Town	
Systems Health Unit	SMDHU
Regulation	319/08
Total # of pages sent	1
# of samples sent	1
# of samples received	1

Report To: **Golder Associates Ltd.**

Address: 121 Commerce Park Drive, Unit L, Barrie, ON. L4N 8X1

Telephone: 705 722-4492 Ext: Fax: 705-722-3786

Email Address: patricia_chapple@golder.com

"Live Person" After Hours Contact Name and Tel. No:

Conditions/ Comments Project #: 13-1170-0040 Please send to: John_easton@golder.com ; Alicia_beynon@golder.com

Time Sampled	Sample Identifier	Identification of Collection Site	Water Type	Temp. Of Sample (°C/°F)	Treatment Information				Laboratory Number	Total Coliform		E. coli		Background		HPC		
					U.V.	Other	Total Cl_2 (mg/L)	Free Cl_2 (mg/L)		>/<	CFU/100 ml	>/<	CFU/100 ml	>/<	CFU/100 ml	>/<	CFU/1 ml	
08:00		TW22	D						005901		0		0		0			

All samples will be considered DISTRIBUTION samples unless otherwise indicated.

All times are transcribed in the 24-hour clock for upload to the Ministry of the Environment (MOE) and/or Ministry of Health and Long Term Care (MoHLTC).

Analysis performed by qualified analysts. Results relate only to the aliquot submitted. Samples have been analyzed as received. COAL is accredited by SCC and licensed by MOE in these specific microbiological parameters and the following inorganic and physical parameters: pH, turbidity, and alkalinity.

COAL accepts no responsibility for parameters selected, misidentification of samples or incorrect quantity, this is the responsibility of the submitting agency.

For collection and handling procedures visit www.coalab.ca/watersamples.html

Raw = R
Distribution = D
Point of Entry = E

F.S. & Faecal Strep. = Faecal Streptococcus HPC = Heterotrophic Plate Count HPM = Heavy Particulate Matter N/R = Not Received F.S. and HPC require 48 hours of incubation Raw Water Comsumed = RWC

Analysis Date & Time: 2014-04-17 13:30 Enumerated By: LC Audited By: AV Methodology: M/F CFU/100ml

Analysis Date & Time: Enumerated By: Audited By: HPC Methodology: SP CFU/1ml; FS Methodology: M/F CFU/100ml

Transcribed By: HM Authorized & Rechecked By: TJ/JT Copy Released By: AB, AV, HM

Lab No. Submitting Agency @ Health Unit @ Spills Action Centre (SAC) @ AWQI # By: Date:

Test Methodology and Detection Limit

Total Coliform (Treated)	COAL Endo	Detection Limit	0 - 80	Reportable Limit:	1	Performed by Membrane Filtration	M/F CFU/100 ml
Total Coliform (Untreated)	COAL DC	Detection Limit	0 - 80	Reportable Limit:	1	Performed by Membrane Filtration	M/F CFU/100 ml
E. coli	COAL DC	Detection Limit	0 - 60	Reportable Limit:	1	Performed by Membrane Filtration	M/F CFU/100 ml
Background	COAL Endo	Detection Limit	0 - 200	Indicates Deterioration:	>200	Performed by Membrane Filtration	M/F CFU/100 ml
Background	COAL DC	Detection Limit	0 - 200	Indicates Deterioration:	>200	Performed by Membrane Filtration	M/F CFU/100 ml
HPC	COAL HPC	Detection Limit	10 - 2.00 x 10^3	Indicates Deterioration:	>500	Performed by Spread Plate	SP CFU/1 ml
Faecal Streptococcus	COAL FS	Detection Limit	0 - 80	Reportable Limit:	1	Performed by Membrane Filtration	M/F CFU/100 ml

Approved for use by TJ prior to use.

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G42871 **REPORT No. B14-26213**

Report To:

Golder Associates Ltd.
121 Commerce Park Drive, Unit L,
Barrie ON. L4N 8X1 Canada
Attention: Alicia Beynon

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 08-Oct-14
DATE REPORTED: 17-Oct-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 1311700040
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		TW22			
			Sample I.D.		B14-26213-1			
			Date Collected		07-Oct-14			
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Hardness (as CaCO3)	mg/L	1	SM 3120	09-Oct-14/O	331			
Alkalinity(CaCO3) to pH4.5	mg/L	5	SM 2320B	09-Oct-14/O	231			
Conductivity @25°C	µmho/cm	1	SM 2510B	09-Oct-14/O	660			
pH @25°C	pH Units		SM 4500H	09-Oct-14/O	8.11			
Fluoride	mg/L	0.1	SM4110C	10-Oct-14/O	< 0.1			
Chloride	mg/L	0.5	SM4110C	10-Oct-14/O	50.3			
Nitrite (N)	mg/L	0.1	SM4110C	10-Oct-14/O	< 0.1			
Nitrate (N)								
Sulphate	mg/L	1	SM4110C	10-Oct-14/O	23			
Calcium	mg/L	0.02	SM 3120	09-Oct-14/O	90.9			
Magnesium	mg/L	0.01	SM 3120	09-Oct-14/O	25.3			
Sodium	mg/L	0.2	SM 3120	09-Oct-14/O	16.5			
Potassium	mg/L	0.1	SM 3120	09-Oct-14/O	1.9			
Iron	mg/L	0.005	SM 3120	09-Oct-14/O	0.027			
Manganese	mg/L	0.001	SM 3120	09-Oct-14/O	0.002			
Ammonia (N)-Total	mg/L	0.01	MOEE 3364	17-Oct-14/O	< 0.01			
Dissolved Organic Carbon	mg/L	0.2	EPA 415.1	14-Oct-14/O	1.7			
Tannins and Lignins	mg/L	0.1	N/A	14-Oct-14	< 0.1 [1]			
Anion Sum	meq/L		Calc.	17-Oct-14/O	7.05			
Cation Sum	meq/L		Calc.	17-Oct-14/O	7.38			
% Difference	%		Calc.	17-Oct-14/O	2.32			
Ion Ratio	AS/CS		Calc.	17-Oct-14/O	0.955			
Sodium Adsorption Ratio	-		Calc.	17-Oct-14/O	0.395			
TDS(ion sum calc.)	mg/L		Calc.	17-Oct-14/O	380			
Conductivity (calc.)	µmho/cm		Calc.	17-Oct-14/O	700			
TDS(calc.)/EC(actual)	-		Calc.	17-Oct-14/O	0.576			
EC(calc.)/EC(actual)	-		Calc.	17-Oct-14/O	1.06			

Table B-2: Water Quality Results

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

M.D.L. = Method Detection Limit
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

The analytical results reported herein refer to the samples as received. Reproduction of this analytical report in full or in part is prohibited without prior consent from Caduceon Environmental Laboratories.

CADUCEON™
ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G42871 **REPORT No. B14-26213**

Report To:

Golder Associates Ltd.
121 Commerce Park Drive, Unit L,
Barrie ON. L4N 8X1 Canada
Attention: Alicia Beynon

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 08-Oct-14
DATE REPORTED: 17-Oct-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 1311700040
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		TW22			
			Sample I.D.		B14-26213-1			
			Date Collected		07-Oct-14			
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Langelier Index(25°C)	S.I.		Calc.	17-Oct-14/O	0.979			

1 subcontracted to Paracel Labs

M.D.L. = Method Detection Limit
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

The analytical results reported herein refer to the samples as received. Reproduction of this analytical report in full or in part is prohibited without prior consent from Caduceon Environmental Laboratories.

Table B-2: Water Quality Results

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: ---

REPORT No. B14-26214

Report To:

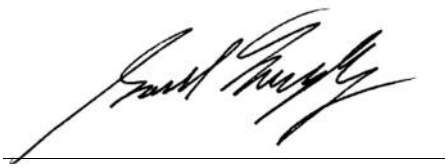
Golder Associates Ltd.
121 Commerce Park Drive, Unit L,
Barrie ON. L4N 8X1 Canada
Attention: Alicia Beynon

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 08-Oct-14
DATE REPORTED: 27-Oct-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 1311700040
P.O. NUMBER: THM Formation
WATERWORKS NO.

	Parameter		Chloroform	Bromodichloromethane	Dibromochloromethane	Bromoform	Total Trihalomethanes
	Units		µg/L	µg/L	µg/L	µg/L	µg/L
	M.D.L.		0.3	0.1	0.1	0.1	0.3
	Reference Method		EPA 8260	EPA 8260	EPA 8260	EPA 8260	EPA 8260
	Date Analyzed/Site		23-Oct-14/O	23-Oct-14/O	23-Oct-14/O	23-Oct-14/O	23-Oct-14/O
Client I.D.	Sample I.D.	Date Collected					
TW22 No Cl added	B14-26214-1	07-Oct-14	< 0.3	< 0.1	< 0.1	< 0.1	< 0.3
TW22 2.0 mg/L	B14-26214-2	07-Oct-14	7.4	4.4	2.5	< 0.1	14.4
TW22 4.0 mg/L	B14-26214-3	07-Oct-14	11.4	5.1	2.4	< 0.1	18.9
TW22 6.0 mg/L	B14-26214-4	07-Oct-14	12.8	5.1	2.2	< 0.1	20.1
TW22 8.0 mg/L	B14-26214-5	07-Oct-14	17.1	6.0	2.3	< 0.1	25.3
TW22 10 mg/L	B14-26214-6	07-Oct-14	17.3	5.7	2.0	< 0.1	25.1
TW22 12.0 mg/L	B14-26214-7	07-Oct-14	18.1	5.6	1.9	< 0.1	25.6
TW22 14.0 mg/L	B14-26214-8	07-Oct-14	19.6	5.8	1.9	< 0.1	27.3
TW22 4.0 mg/L DUP	B14-26214-9	07-Oct-14	11.7	5.4	2.5	< 0.1	19.6
BLK Organuc Free	B14-26214-10	07-Oct-14	1.1	< 0.1	< 0.1	< 0.1	1.1
Organic Free - 2.0 mg/L	B14-26214-11	07-Oct-14	5.5	0.4	< 0.1	< 0.1	5.8
Organic Free - 4.0 mg/L	B14-26214-12	07-Oct-14	2.1	0.3	< 0.1	< 0.1	2.4
Organic Free - 6.0 mg/L	B14-26214-13	07-Oct-14	3.4	0.3	< 0.1	< 0.1	3.7
Organic Free - 8.0 mg/L	B14-26214-14	07-Oct-14	3.7	0.3	< 0.1	< 0.1	4.1
Organic Free - 10.0 mg/L	B14-26214-15	07-Oct-14	4.7	0.3	< 0.1	< 0.1	5.0
Organic Free - 12.0 mg/L	B14-26214-16	07-Oct-14	4.0	0.3	< 0.1	< 0.1	4.3
Organic Free - 14.0 mg/L	B14-26214-17	07-Oct-14	5.4	0.3	< 0.1	< 0.1	5.7
Organic Free - 4.0 mg/mL DUP	B14-26214-18	07-Oct-14	2.9	0.3	< 0.1	< 0.1	3.2



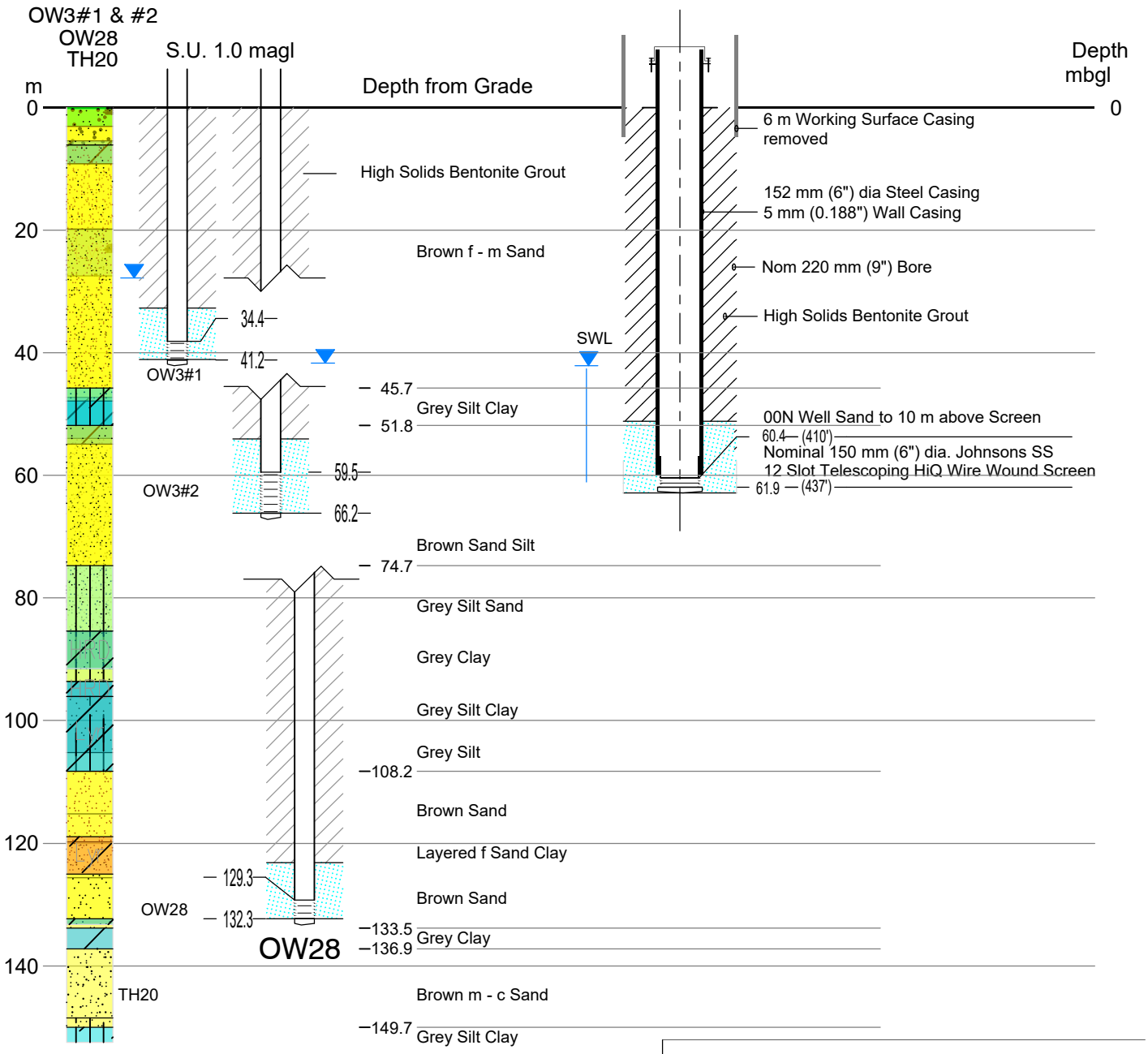
Gord Murphy
Lab Supervisor

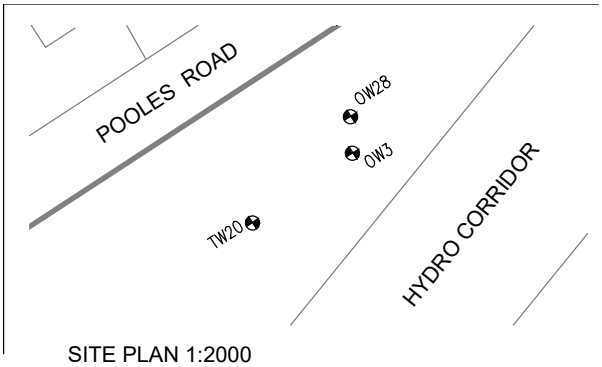
M.D.L. = Method Detection Limit
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

The analytical results reported herein refer to the samples as received. Reproduction of this analytical report in full or in part is prohibited without prior consent from Caduceon Environmental Laboratories.

APPENDIX C

Site 2: Well Construction and Testing Pooles Road





SITE PLAN 1:2000

Notes:

All depths are metres below ground level unless otherwise stated.

Converted depths to feet nominal 1 foot integrals

OW's at distance from Pilot Hole of TW20 are truncated above grade at elevation of Test Well, with depths relative approximate to Site Grade of TW20

Observation Well Screens 51 mm (2") dia. Sch. 40 PVC

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-07-14
DESIGN	
CAD	JPR
CHECK	
REVIEW	

TITLE

AS-BUILT WELL TW20

FILE No. 1311700040CBLOGS.dwg

PROJECT No. 13-1170-0040 REV.

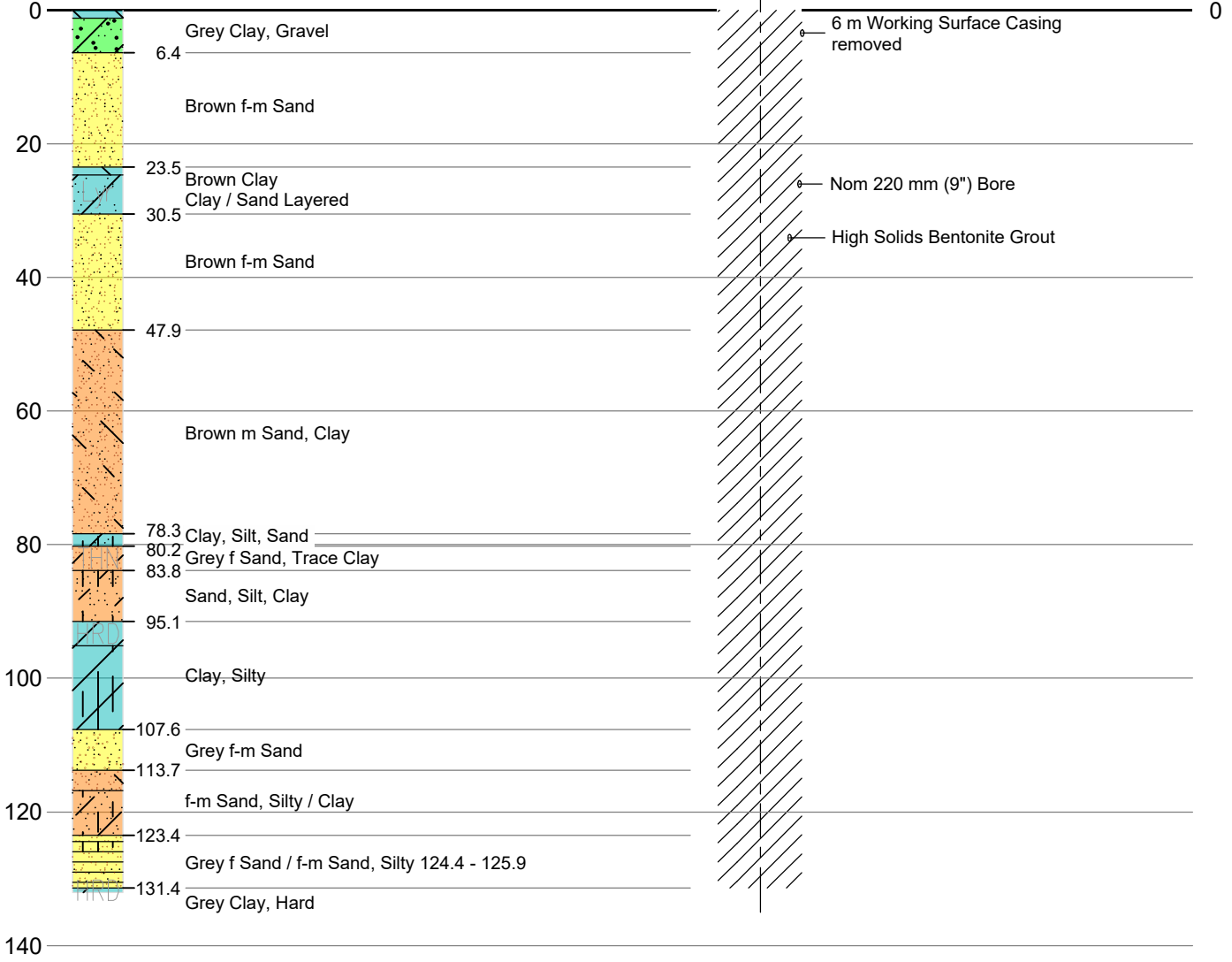
MIDHURST
WATER SUPPLY EXPLORATION

FIGURE **C-1**

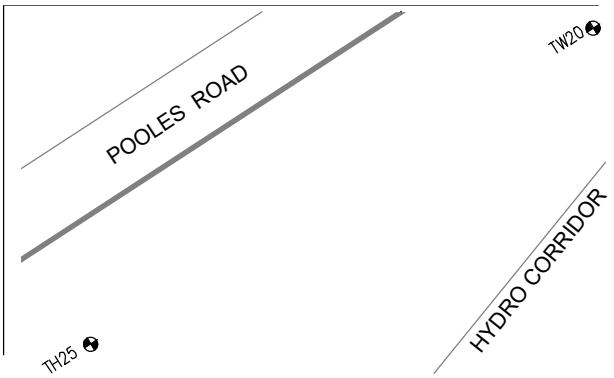
PLOT DATE: August 7, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\CB-\1311700040CBLOGS.dwg: [Figure C-1]

Log

TH25
Abandonment



SITE PLAN 1:2000



Notes:

All depths are metres below ground level unless otherwise stated.

Converted depths to feet nominal 1 foot integrals

Initiated construction of 51 mm PVC, Screen damaged, pulled, and hole abandoned

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-07-14
DESIGN	
CAD	JPR
CHECK	
REVIEW	

TITLE

ABANDONMENT WELL TH25

FILE No. 1311700040CBLOGS.dwg

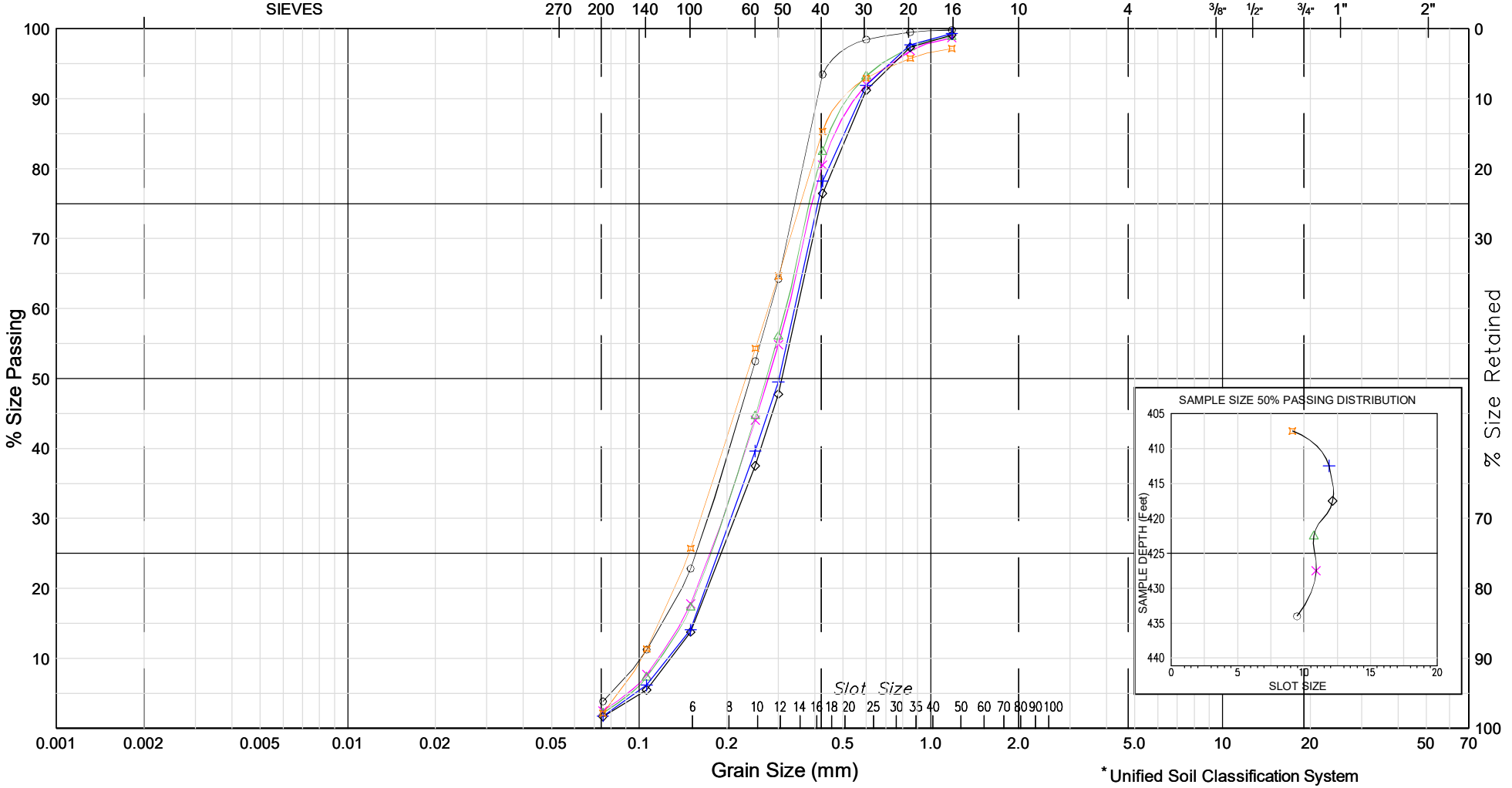
PROJECT No. 13-1170-0040 REV.

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE **C-2**

PLOT DATE: August 7, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\CB-\1311700040CBLOGS.dwg: [Figure C-2]

PLOT DATE: October 1, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-BA-\1311700040BASVE20A.dwg



TW20A 405–410 ft
TW20A 410–415 ft
TW20A 415–420 ft
TW20A 420–425 ft
TW20A 425–430 ft
TW20A 430–438 ft

*Unified Soil Classification System
Clay denoted from MIT Soil Classification

TITLE

GRAIN SIZE ANALYSIS
TW20
WASHED SAMPLES

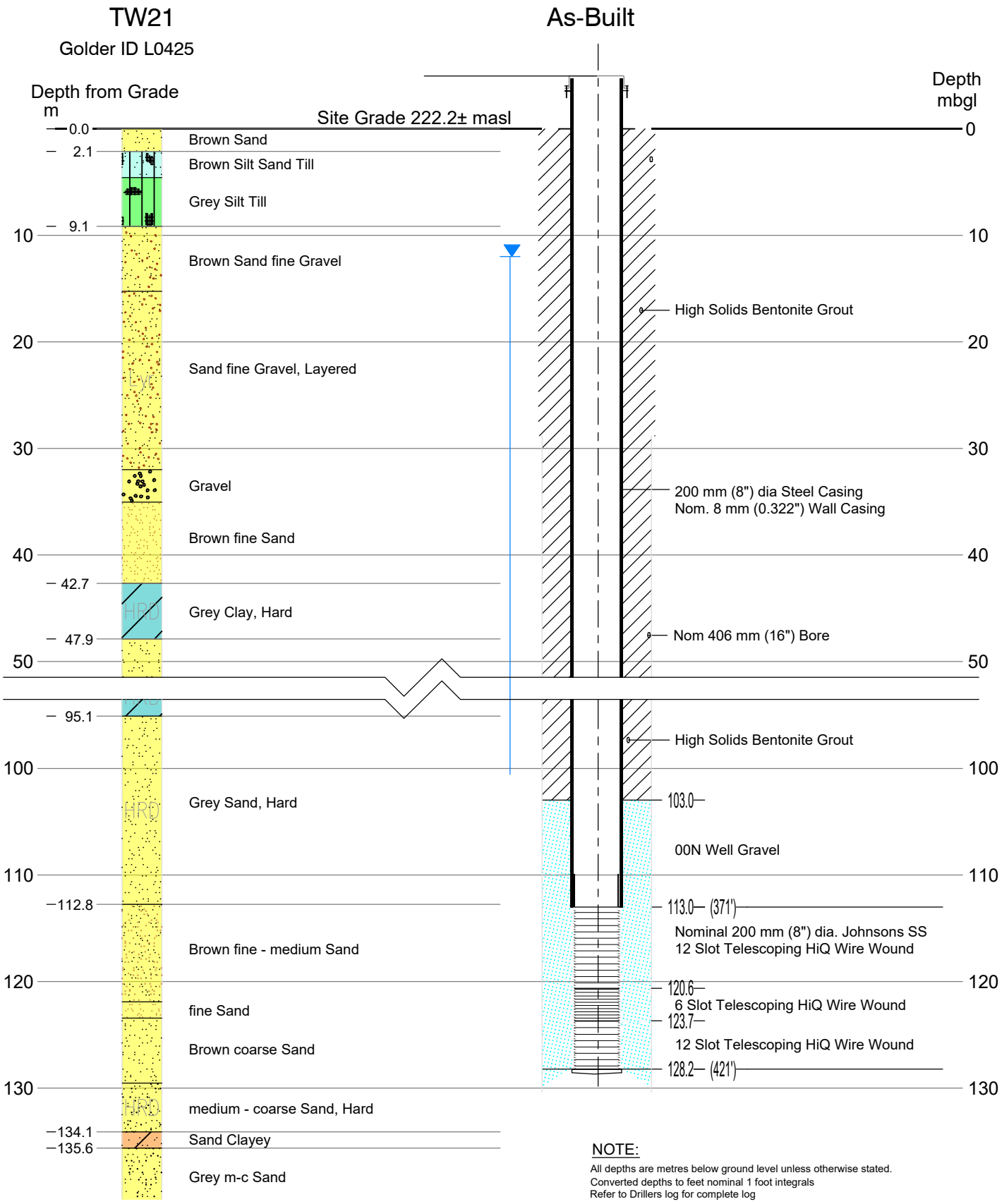
MIDHURST
WATER SUPPLY EXPLORATION

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-02-24
CAD	JPR
CHECK REVIEW	
FILE No.	1311700040BASVE20A.dwg
PROJECT No.	13-1170-0040
REV.	
FIGURE	C-3

APPENDIX D

Site 3: Well Construction and Testing Old Second Road



NOTE:
All depths are metres below ground level unless otherwise stated.
Converted depths to feet nominal 1 foot integrals
Refer to Drillers log for complete log

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-07-08
DESIGN	
CAD	JPR
CHECK	
REVIEW	

FILE No. 1311700040CBLOGS.dwg
PROJECT No. 13-1170-0040 REV.

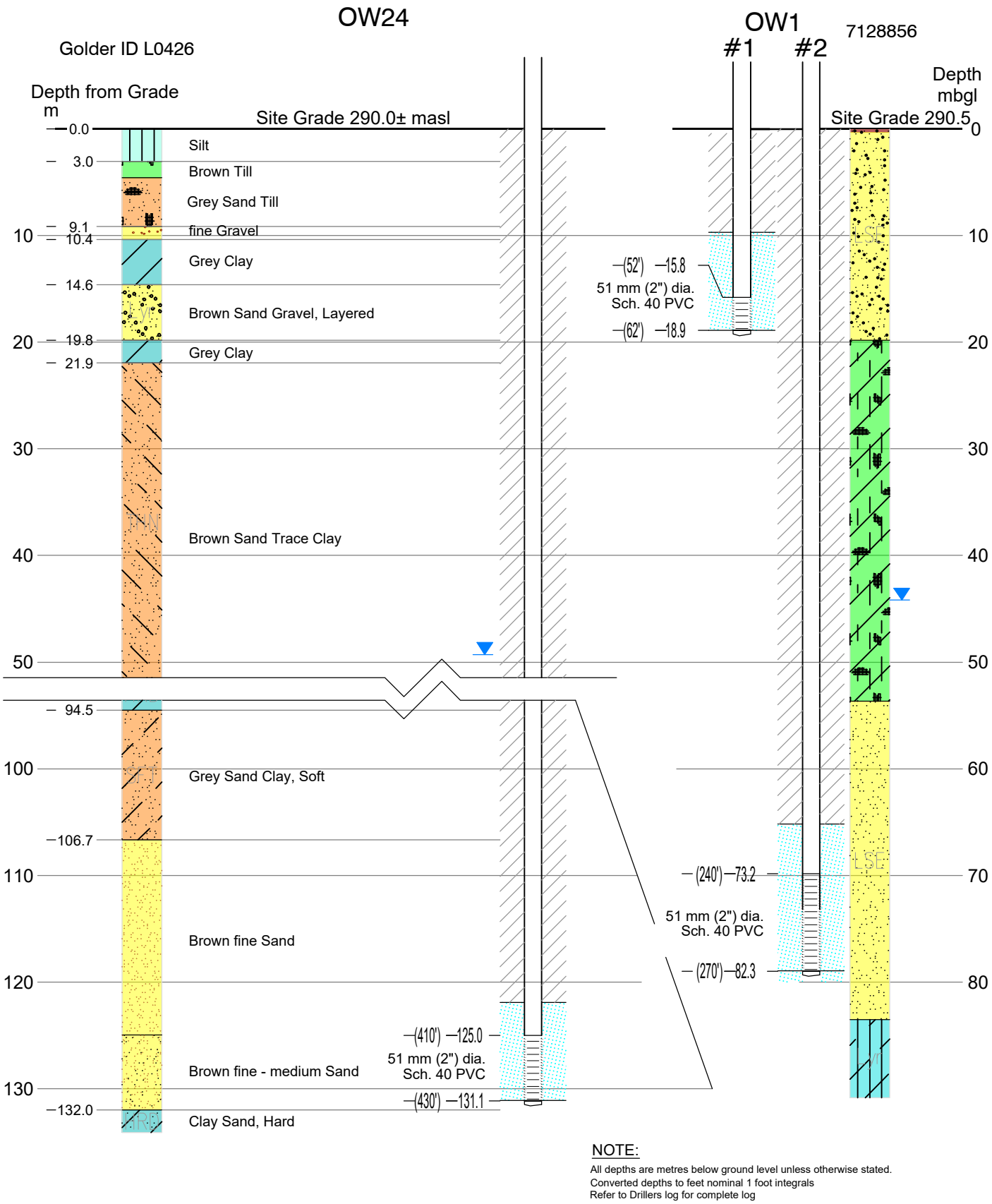
TITLE

PRODUCTION WELL TW21
AS-BUILT

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE
D-1

PLOT DATE: October 30, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-CB-\1311700040CBLOGS.dwg: [Figure D-1]



NOTE:

All depths are metres below ground level unless otherwise stated.
Converted depths to feet nominal 1 foot integrals
Refer to Drillers log for complete log

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-09-26
DESIGN	
CAD	JPR
CHECK	
REVIEW	

TITLE

OBSERVATION WELL OW24
AS-BUILT

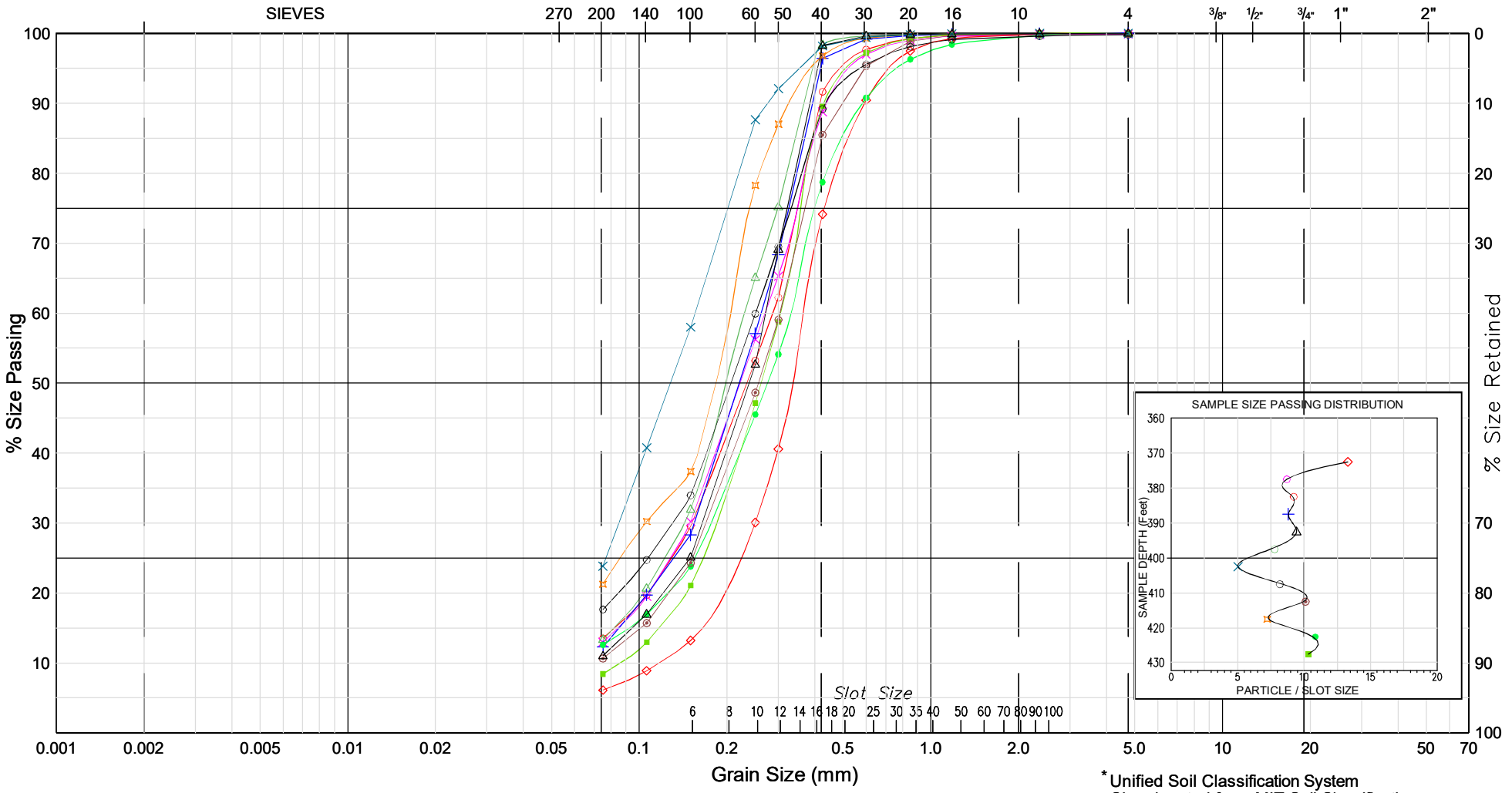
FILE No. 1311700040CBLOGS.dwg		
PROJECT No. 13-1170-0040	REV.	

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE
D-2

PLOT DATE: September 26, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-CB-\1311700040CBLOGS.dwg: [Figure D-2]

PLOT DATE: July 21, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-BA-\1311700040BASVE21.dwg



*Unified Soil Classification System
Clay denoted from MIT Soil Classification

- TW21 370-375 ft
- TW21 375-380 ft
- TW21 380-385 ft
- TW21 385-390 ft
- TW21 390-395 ft
- TW21 395-400 ft
- TW21 420-425 ft
- TW21 425-430 ft
- TW21 410-415 ft
- TW21 400-405 ft
- TW21 405-410 ft
- TW21 415-420 ft

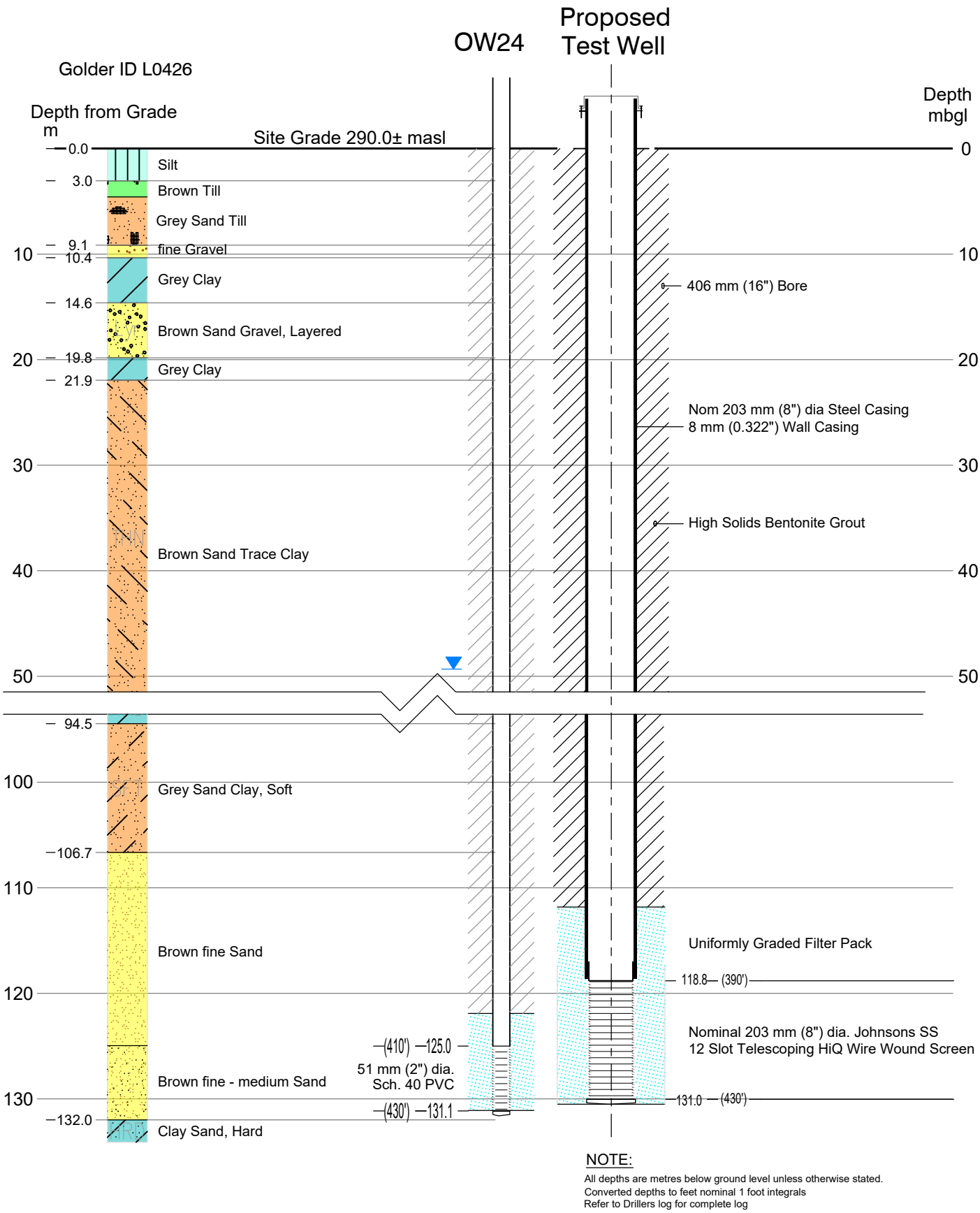
TITLE

GRAIN SIZE ANALYSIS TW21

MIDHURST
WATER SUPPLY EXPLORATION

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-07-21
CAD	JPR
CHECK REVIEW	
FILE No.	1311700040BASVE21.dwg
PROJECT No.	13-1170-0040
REV.	
FIGURE	D-3



NOTE:

All depths are metres below ground level unless otherwise stated.
Converted depths to feet nominal 1 foot integrals
Refer to Drillers log for complete log

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-10-30
DESIGN	
CAD	JPR
CHECK	JAE
REVIEW	

FILE No. 1311700040CBLOGS.dwg
PROJECT No. 13-1170-0040 REV.

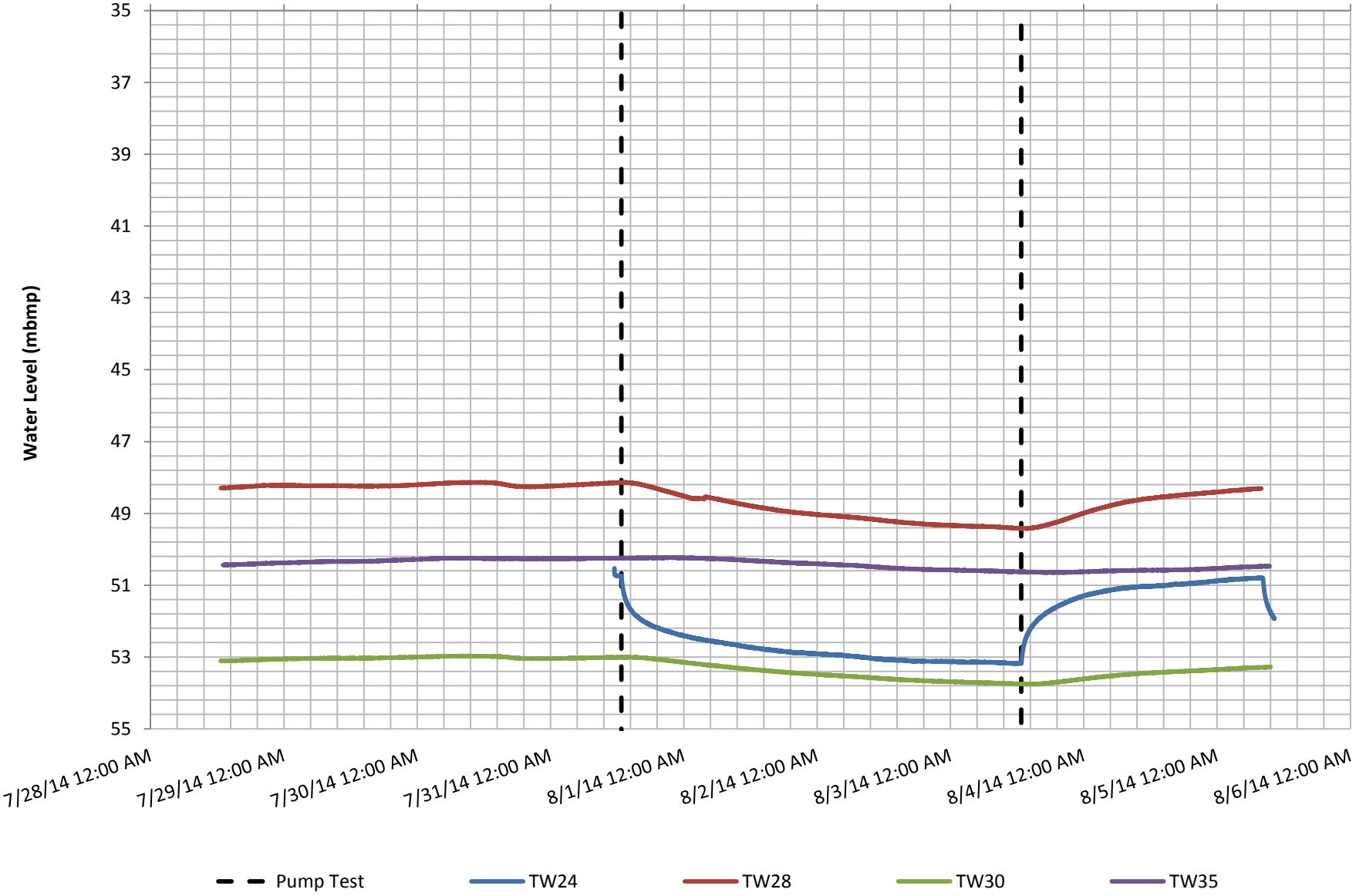
TITLE

TEST WELL OW24 SITE PROPOSED CONSTRUCTION

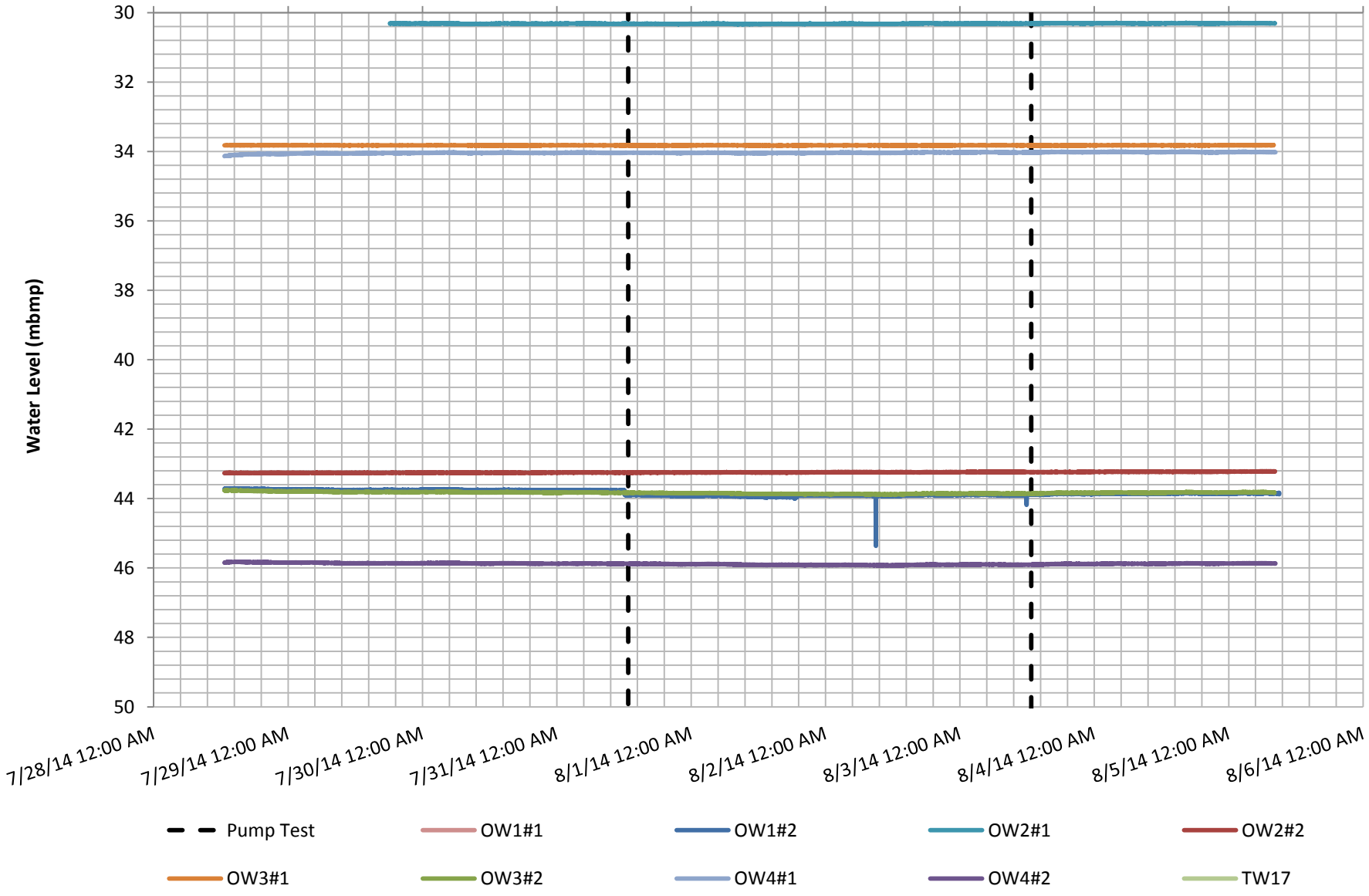
MIDHURST
WATER SUPPLY EXPLORATION

FIGURE **D-4**

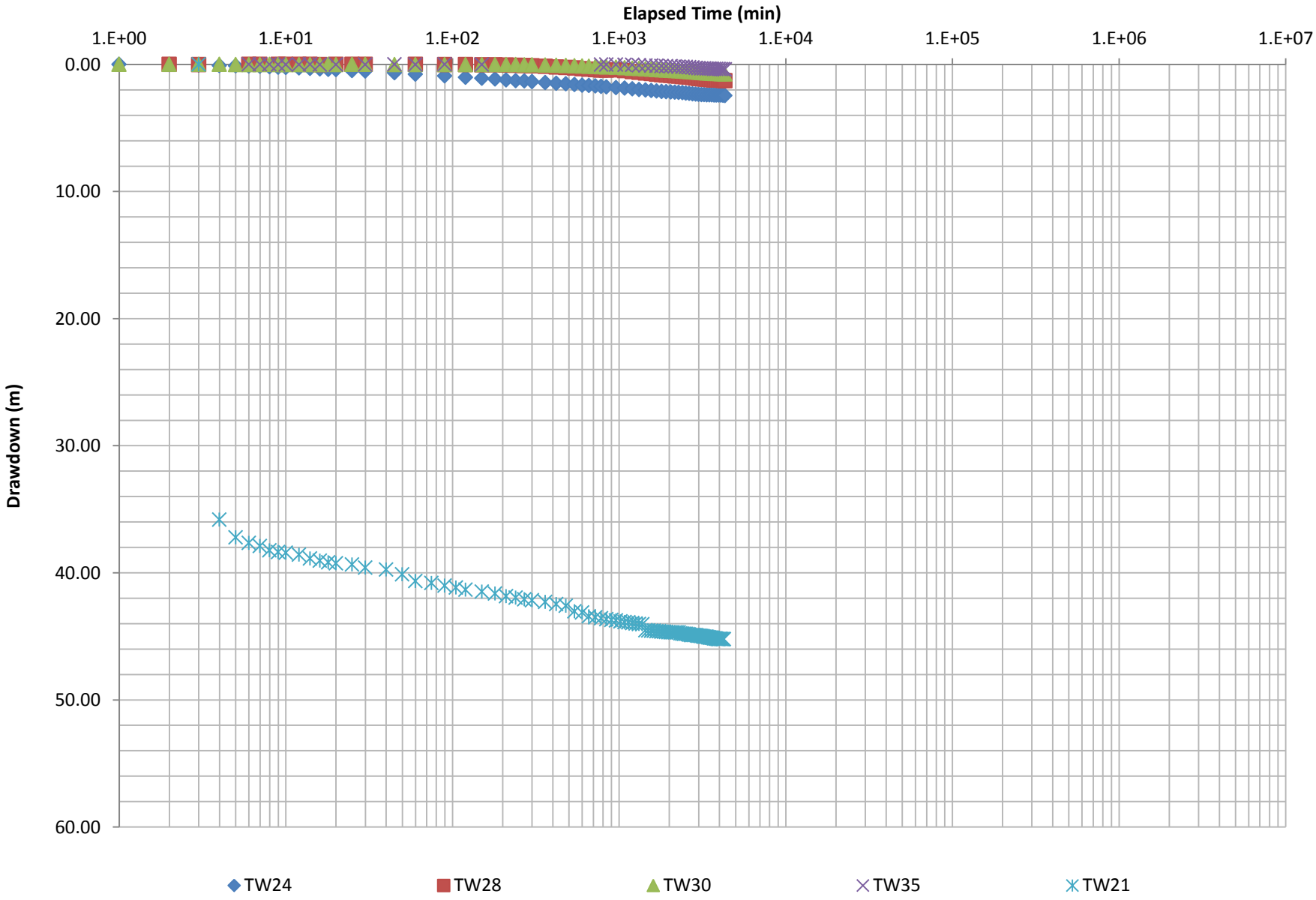
PLOT DATE: October 30, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\CB\1311700040CBLOGS.dwg: [Figure D-4]



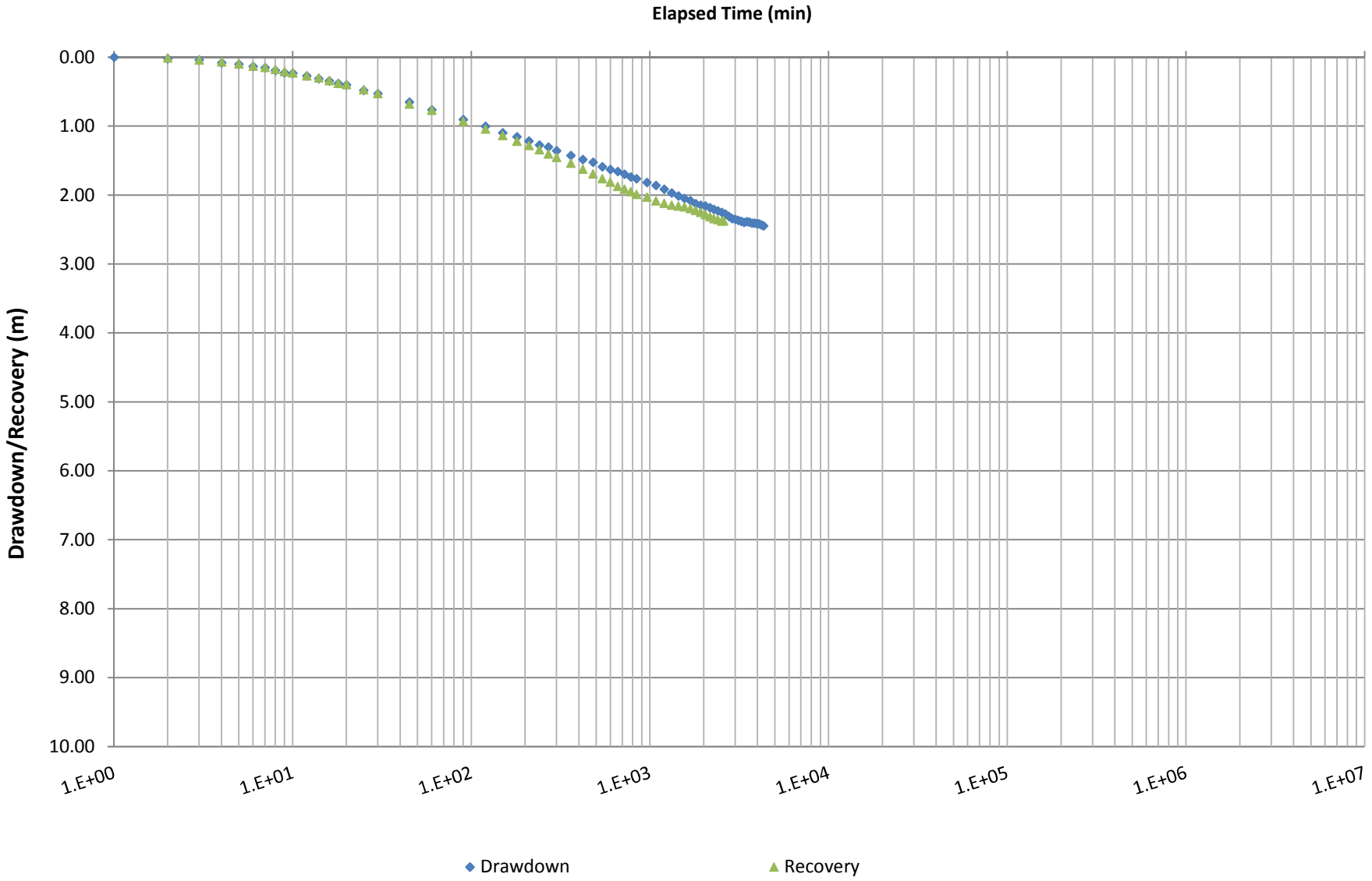
Test Date:	31-Jul-2014	Golder Associates	SCALE:	NTS	**Testing of TW21** **Record of Observation Wells**
Pumping Rates L/s:	27.8		DATE:	29-Oct-14	
			CAD:	ALB	
		FILE No. 1311700040	CHECK:		MIDHURST WATER SUPPLY CONSTRUCTION & TESTING of TW21
		PROJECT No. 1311700040	REVIEW:		FIGURE No. D-5



Test Date:	31-Jul-2014	Golder Associates	SCALE:	NTS	**Testing of TW21** **Record of Observation Wells**
Pumping Rates L/s:	27.8		DATE:	29-Oct-14	
			CAD:	ALB	
		FILE No. 1311700040	CHECK:		MIDHURST WATER SUPPLY CONSTRUCTION & TESTING of TW21
		PROJECT No. 1311700040	REVIEW:		FIGURE No. D-6



Test Date:	31-Jul-2014	Golder Associates	SCALE:	NTS	**Pumping Test Hydrograph Record of TW21 and Aquifer A3 Observation Wells**
Pumping Rates L/s:	27.8		DATE:	30-Oct-14	
TW21 Static Level (mbmp):	49.08		CAD:	ALB	
TW21 Pumping Level (mbmp):	94.31	FILE No. 1311700040	CHECK:		MIDHURST WATER SUPPLY CONSTRUCTION & TESTING of TW21
		PROJECT No. 1311700040	REVIEW:		FIGURE No. D-7



Test Date:	31-Jul-2014
Pumping Rate:	27.8 L/s
Distance from TW21 (m):	155.6
Static Water Level (mbmp):	50.74
Pumping Water Level (mbmp):	53.18

Golder Associates

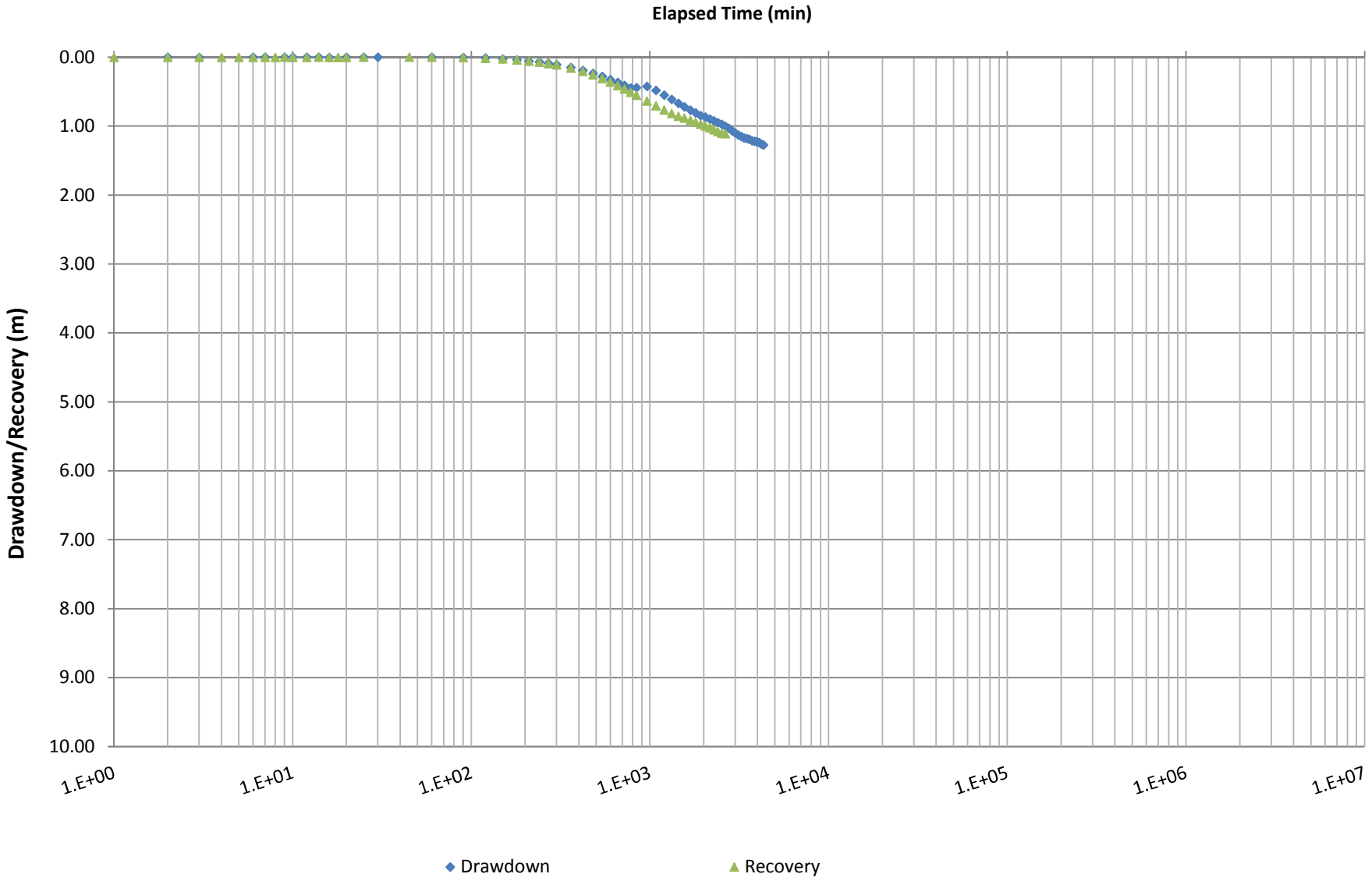
FILE No.	1311700040TRANS
PROJECT No.	13-1170-0040

SCALE:	NTS
DATE:	9/Mar/16
CAD:	ALB
CHECK:	
REVIEW:	

Pumping Test Hydrograph
Record of OW24

MIDHURST WATER SUPPLY
CONSTRUCTION & TESTING of TW21

FIGURE No.
D-8



Test Date:	31-Jul-2014
Pumping Rate:	27.8 L/s
Distance from TW21 (m):	530
Static Water Level (mbmp):	48.14
Pumping Water Level (mbmp):	49.42

Golder Associates

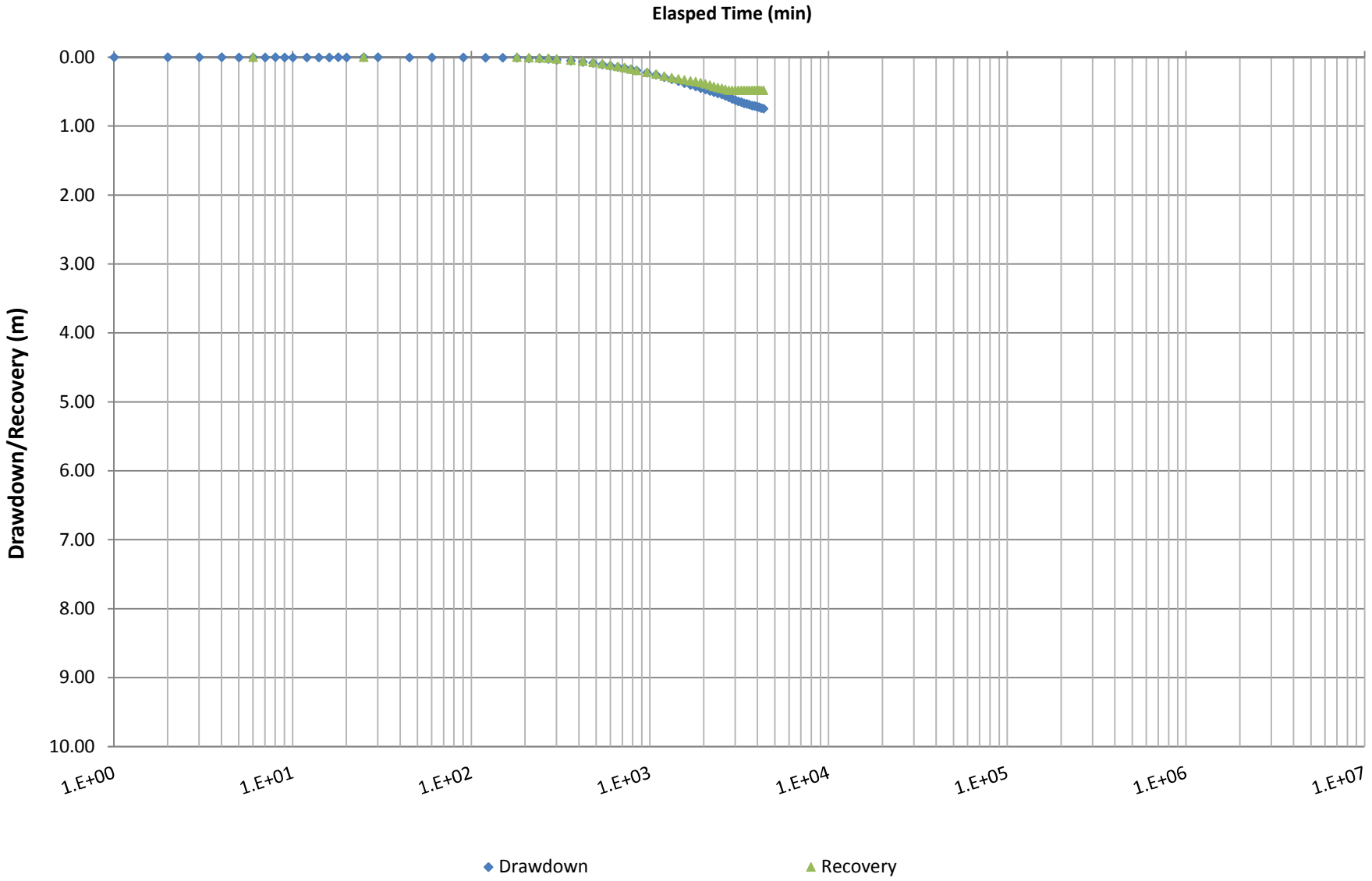
FILE No.	1311700040TRANS
PROJECT No.	13-1170-0040

SCALE:	NTS
DATE:	9/Mar/16
CAD:	ALB
CHECK:	
REVIEW:	

PUMP TEST HYDROGRAPH
OBSERVATION WELL OW28

MIDHURST WATER SUPPLY
TESTING AND CONSTRUCTION

FIGURE No.
D-9



Test Date:	31-Jul-2014
Pumping Rate:	27.8 L/s
Distance from TW21 (m):	1250
Static Water Level (mbmp):	53.01
Pumping Water Level (mbmp):	53.75

Golder Associates

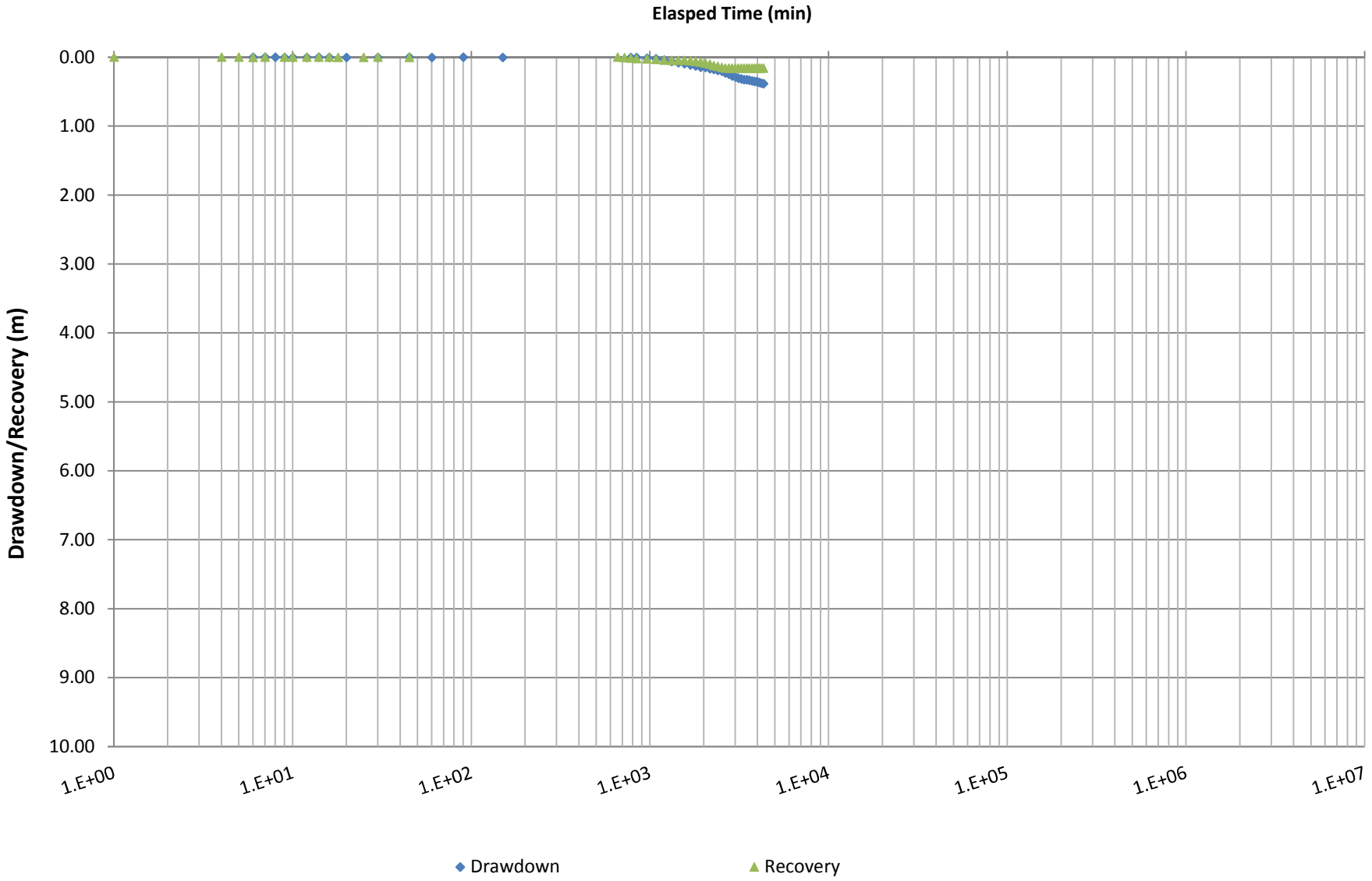
FILE No.	1311700040TRANS
PROJECT No.	13-1170-0040

SCALE:	NTS
DATE:	9/Mar/16
CAD:	ALB
CHECK:	
REVIEW:	

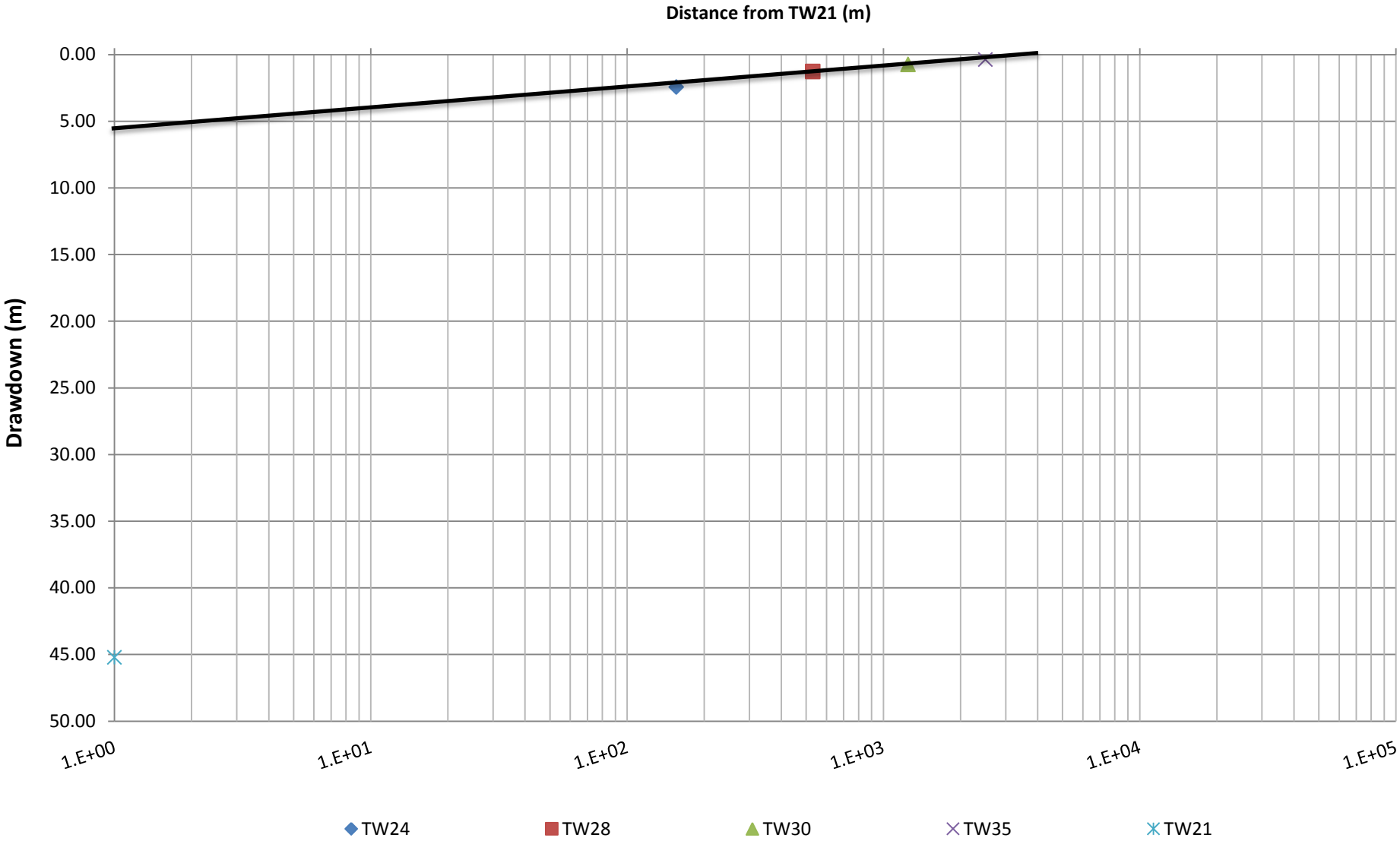
Pumping Test Hydrograph
Record of OW30

MIDHURST WATER SUPPLY
CONSTRUCTION & TESTING of TW21

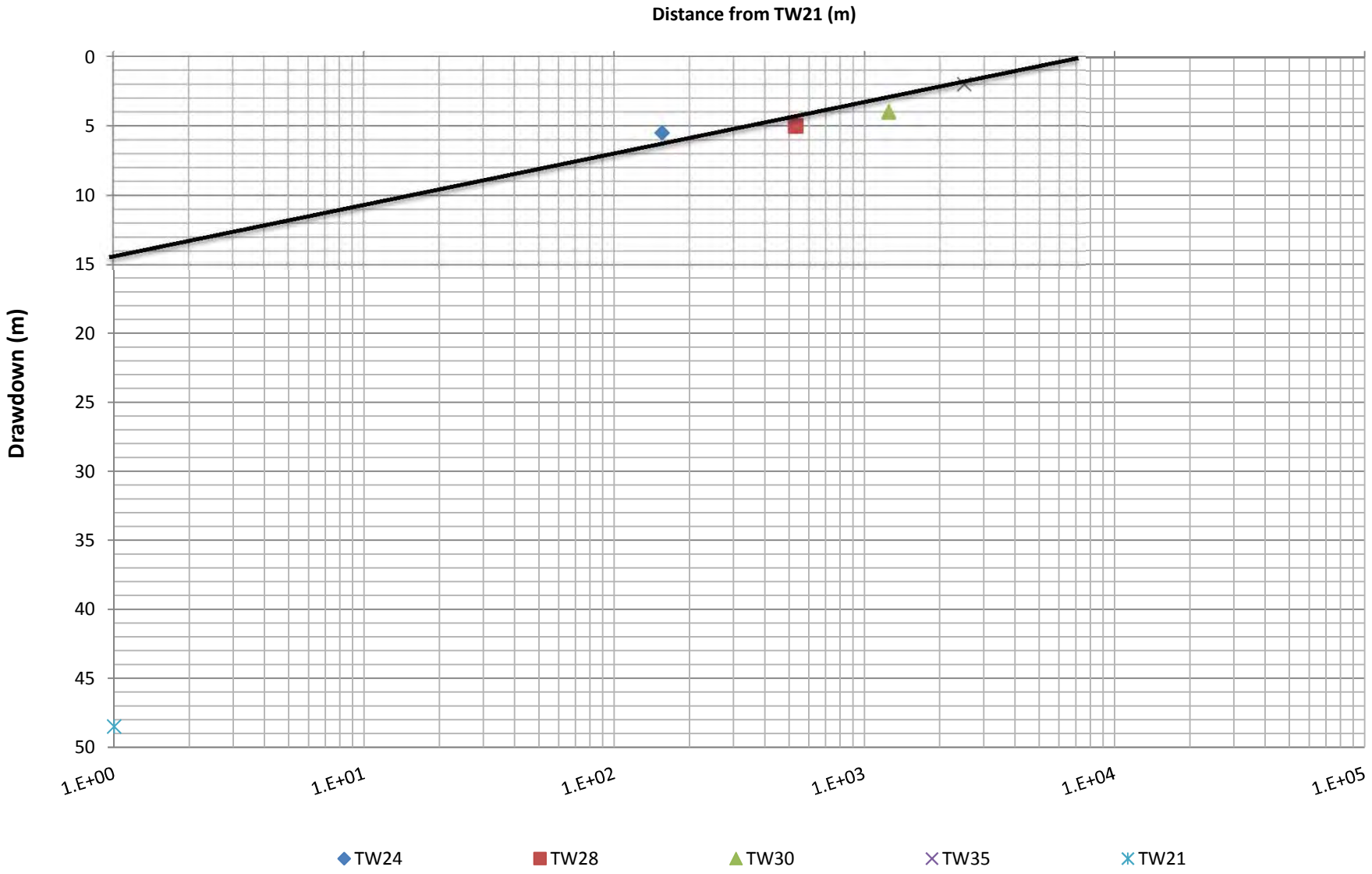
FIGURE No.
D-10



Test Date:	31-Jul-2014	Golder Associates	SCALE:	NTS	**Pumping Test Hydrograph Record of OW35**
Pumping Rate:	27.8 L/s		DATE:	9/Mar/16	
Distance from TW21 (m):	2500		CAD:	ALB	
Static Water Level (mbmp):	50.25	FILE No. 1311700040TRANS	CHECK:		MIDHURST WATER SUPPLY CONSTRUCTION & TESTING of TW21
Pumping Water Level (mbmp):	50.63	PROJECT No. 13-1170-0040	REVIEW:		FIGURE No. D-11



Test Date: July 22, 2014	Golder Associates	SCALE: NTS	Test Data Drawdown vs Distance Interference From TW21	
Pumping Rate: 27.8 L/s		DATE: 29-Oct-14		
		CAD: ALB		
	FILE No. 1311700040TRANS	CHECK:	MIDHURST WATER SUPPLY	FIGURE No.
	PROJECT No. 13-1170-0040	REVIEW:	CONSTRUCTION & TESTIONG of TW21	D-12



Test Date:	July 22, 2014	Golder Associates		SCALE: NTS	20-Year Drawdown vs Distance Interference From TW21
Pumping Rate:	27.8 L/s			DATE: 9/Mar/16	
				CAD: ALB	
		FILE No. 1311700040TRANS		CHECK:	MIDHURST WATER SUPPLY CONSTRUCTION & TESTIONG of TW21
		PROJECT No. 13-1170-0040		REVIEW:	FIGURE No. D-13

Tabulated Levels for TW21

	Pump On:	22-Jul-2014 12:45		Static Level:	49.08
	Pump Off:	24-Jul-2014 12:45		Pumping Level:	94.31
	Pumping Well:	**TW21**		Drawdown:	45.23
	Distance from Pumping Well:	0 m		20 yr DD:	48.5
Date:Time	Elapsed	WL	DD		
dd-mmm-yyyy hh:mm	(min)	m	m		
31-07-2014 12:45	3	49.08	0.00		
24-07-2014 12:48	4	84.89	35.81		
24-07-2014 12:49	5	86.3	37.22		
24-07-2014 12:50	6	86.72	37.64		
24-07-2014 12:51	7	86.98	37.90		
24-07-2014 12:52	8	87.32	38.24		
24-07-2014 12:53	9	87.44	38.36		
24-07-2014 12:54	10	87.5	38.42		
24-07-2014 12:55	12	87.66	38.58		
24-07-2014 12:57	14	87.95	38.87		
24-07-2014 12:59	16	88.12	39.04		
24-07-2014 13:01	18	88.26	39.18		
24-07-2014 13:03	20	88.34	39.26		
24-07-2014 13:05	25	88.43	39.35		
24-07-2014 13:10	30	88.68	39.60		
24-07-2014 13:15	40	88.83	39.75		
24-07-2014 13:25	50	89.2	40.12		
24-07-2014 13:35	60	89.73	40.65		
24-07-2014 13:45	75	89.89	40.81		
24-07-2014 14:00	90	90.09	41.01		
24-07-2014 14:15	105	90.25	41.17		
24-07-2014 14:30	120	90.42	41.34		
24-07-2014 14:45	150	90.56	41.48		
24-07-2014 15:15	180	90.71	41.63		
24-07-2014 15:45	210	90.92	41.84		
24-07-2014 16:15	240	91.03	41.95		
24-07-2014 16:45	270	91.17	42.09		
24-07-2014 17:15	300	91.24	42.16		
24-07-2014 17:45	360	91.37	42.29		
24-07-2014 18:45	420	91.54	42.46		
24-07-2014 19:45	480	91.68	42.60		
24-07-2014 20:45	540	92.11	43.03		
24-07-2014 21:45	600	92.21	43.13		
24-07-2014 22:45	660	92.51	43.43		
24-07-2014 23:45	720	92.59	43.51		
25-07-2014 0:45	780	92.66	43.58		
25-07-2014 1:45	840	92.74	43.66		
25-07-2014 2:45	900	92.79	43.71		
25-07-2014 3:45	960	92.83	43.75		
25-07-2014 4:45	1020	92.9	43.82		
25-07-2014 5:45	1080	92.97	43.89		
25-07-2014 6:45	1140	92.98	43.90		
25-07-2014 7:45	1200	93.03	43.95		
25-07-2014 8:45	1260	93.07	43.99		
25-07-2014 9:45	1320	93.12	44.04		
25-07-2014 10:45	1380	93.14	44.06		
25-07-2014 11:45	1440	93.61	44.53		
25-07-2014 12:45	1500	93.63	44.55		
25-07-2014 13:45	1560	93.65	44.57		
25-07-2014 14:45	1620	93.65	44.57		
25-07-2014 15:45	1680	93.68	44.60		
25-07-2014 16:45	1740	93.68	44.60		
25-07-2014 17:45	1800	93.71	44.63		
25-07-2014 18:45	1860	93.72	44.64		
25-07-2014 19:45	1920	93.74	44.66		
25-07-2014 20:45	1980	93.76	44.68		
25-07-2014 21:45	2040	93.77	44.69		
25-07-2014 22:45	2100	93.78	44.70		
25-07-2014 23:45	2160	93.77	44.69		
26-07-2014 0:45	2220	93.78	44.70		
26-07-2014 1:45	2280	93.78	44.70		
26-07-2014 2:45	2340	93.84	44.76		
26-07-2014 3:45	2400	93.87	44.79		
26-07-2014 4:45	2460	93.88	44.80		
26-07-2014 5:45	2520	93.89	44.81		
26-07-2014 6:45	2580	93.91	44.83		
26-07-2014 7:45	2640	93.95	44.87		
26-07-2014 8:45	2700	93.98	44.90		
26-07-2014 9:45	2760	93.98	44.90		
26-07-2014 10:45	2820	93.99	44.91		
26-07-2014 11:45	2880	93.99	44.91		

Tabulated Levels for TW21

	Pump On:	22-Jul-2014 12:45		Static Level:	49.08
	Pump Off:	24-Jul-2014 12:45		Pumping Level:	94.31
	Pumping Well:	**TW21**		Drawdown:	45.23
	Distance from Pumping Well:	0 m		20 yr DD:	48.5

Date:Time	Elapsed	WL	DD
dd-mmm-yyyy hh:mm	(min)	m	m
26-07-2014 12:45	2940	94.02	44.94
26-07-2014 13:45	3000	94.04	44.96
26-07-2014 14:45	3060	94.04	44.96
26-07-2014 15:45	3120	94.05	44.97
26-07-2014 16:45	3180	94.08	45.00
26-07-2014 17:45	3240	94.12	45.04
26-07-2014 18:45	3300	94.12	45.04
26-07-2014 19:45	3360	94.11	45.03
26-07-2014 20:45	3420	94.16	45.08
26-07-2014 21:45	3480	94.17	45.09
26-07-2014 22:45	3540	94.18	45.10
26-07-2014 23:45	3600	94.19	45.11
27-07-2014 0:45	3660	94.2	45.12
27-07-2014 1:45	3720	94.25	45.17
27-07-2014 2:45	3780	94.25	45.17
27-07-2014 3:45	3840	94.26	45.18
27-07-2014 4:45	3900	94.28	45.20
27-07-2014 5:45	3960	94.3	45.22
27-07-2014 6:45	4020	94.29	45.21
27-07-2014 7:45	4080	94.29	45.21
27-07-2014 8:45	4140	94.3	45.22
27-07-2014 9:45	4200	94.3	45.22
27-07-2014 10:45	4260	94.3	45.22
27-07-2014 11:45	4320	94.31	45.23

Tabulated Levels forTW24

Pump On:	31-Jul-2014 12:45			Static Level:	50.74		
Pump Off:	03-Aug-2014 12:45			Pumping Level:	53.18		
Pumping Well:	**TW21**			Drawdown:	2.45		
Distance from Pumping Well:	155.6 m			20 yr DD:	5.5		
Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
31-Jul-2014 12:46	1	50.74	0.00	03-Aug-2014 12:46	1	53.18	0.00
31-Jul-2014 12:47	2	50.76	0.02	03-Aug-2014 12:47	2	53.17	0.01
31-Jul-2014 12:48	3	50.78	0.04	03-Aug-2014 12:48	3	53.14	0.04
31-Jul-2014 12:49	4	50.82	0.08	03-Aug-2014 12:49	4	53.11	0.07
31-Jul-2014 12:50	5	50.84	0.10	03-Aug-2014 12:50	5	53.08	0.10
31-Jul-2014 12:51	6	50.87	0.13	03-Aug-2014 12:51	6	53.05	0.13
31-Jul-2014 12:52	7	50.89	0.15	03-Aug-2014 12:52	7	53.03	0.15
31-Jul-2014 12:53	8	50.93	0.19	03-Aug-2014 12:53	8	53.00	0.18
31-Jul-2014 12:54	9	50.96	0.22	03-Aug-2014 12:54	9	52.97	0.21
31-Jul-2014 12:55	10	50.97	0.23	03-Aug-2014 12:55	10	52.95	0.23
31-Jul-2014 12:57	12	51.01	0.27	03-Aug-2014 12:57	12	52.91	0.27
31-Jul-2014 12:59	14	51.05	0.31	03-Aug-2014 12:59	14	52.88	0.30
31-Jul-2014 13:01	16	51.08	0.34	03-Aug-2014 13:01	16	52.84	0.34
31-Jul-2014 13:03	18	51.12	0.38	03-Aug-2014 13:03	18	52.80	0.38
31-Jul-2014 13:05	20	51.14	0.40	03-Aug-2014 13:05	20	52.78	0.40
31-Jul-2014 13:10	25	51.22	0.48	03-Aug-2014 13:10	25	52.71	0.47
31-Jul-2014 13:15	30	51.27	0.53	03-Aug-2014 13:15	30	52.65	0.53
31-Jul-2014 13:30	45	51.39	0.65	03-Aug-2014 13:30	45	52.50	0.68
31-Jul-2014 13:45	60	51.50	0.76	03-Aug-2014 13:45	60	52.41	0.77
31-Jul-2014 14:15	90	51.64	0.90	03-Aug-2014 14:15	90	52.25	0.93
31-Jul-2014 14:45	120	51.74	1.00	03-Aug-2014 14:45	120	52.14	1.04
31-Jul-2014 15:15	150	51.83	1.10	03-Aug-2014 15:15	150	52.05	1.14
31-Jul-2014 15:45	180	51.89	1.15	03-Aug-2014 15:45	180	51.96	1.22
31-Jul-2014 16:15	210	51.95	1.22	03-Aug-2014 16:15	210	51.90	1.28
31-Jul-2014 16:45	240	52.01	1.27	03-Aug-2014 16:45	240	51.84	1.34
31-Jul-2014 17:15	270	52.04	1.30	03-Aug-2014 17:15	270	51.78	1.40
31-Jul-2014 17:45	300	52.09	1.36	03-Aug-2014 17:45	300	51.73	1.46
31-Jul-2014 18:45	360	52.16	1.43	03-Aug-2014 18:45	360	51.64	1.54
31-Jul-2014 19:45	420	52.22	1.48	03-Aug-2014 19:45	420	51.56	1.62
31-Jul-2014 20:45	480	52.26	1.52	03-Aug-2014 20:45	480	51.49	1.70
31-Jul-2014 21:45	540	52.32	1.59	03-Aug-2014 21:45	540	51.42	1.76
31-Jul-2014 22:45	600	52.37	1.63	03-Aug-2014 22:45	600	51.37	1.81
31-Jul-2014 23:45	660	52.39	1.66	03-Aug-2014 23:45	660	51.31	1.87
01-Aug-2014 00:45	720	52.43	1.70	04-Aug-2014 00:45	720	51.27	1.92
01-Aug-2014 01:45	780	52.47	1.74	04-Aug-2014 01:45	780	51.23	1.95
01-Aug-2014 02:45	840	52.50	1.76	04-Aug-2014 02:45	840	51.19	1.99
01-Aug-2014 04:45	960	52.55	1.82	04-Aug-2014 04:45	960	51.15	2.03
01-Aug-2014 06:45	1080	52.60	1.86	04-Aug-2014 06:45	1080	51.10	2.09
01-Aug-2014 08:45	1200	52.65	1.92	04-Aug-2014 08:45	1200	51.06	2.12
01-Aug-2014 10:45	1320	52.70	1.97	04-Aug-2014 10:45	1320	51.03	2.15
01-Aug-2014 12:45	1440	52.75	2.01	04-Aug-2014 12:45	1440	51.02	2.16
01-Aug-2014 14:45	1560	52.79	2.05	04-Aug-2014 14:45	1560	51.01	2.17
01-Aug-2014 16:45	1680	52.82	2.08	04-Aug-2014 16:45	1680	50.98	2.20
01-Aug-2014 18:45	1800	52.86	2.12	04-Aug-2014 18:45	1800	50.96	2.22
01-Aug-2014 20:45	1920	52.88	2.15	04-Aug-2014 20:45	1920	50.93	2.25
01-Aug-2014 22:45	2040	52.89	2.16	04-Aug-2014 22:45	2040	50.90	2.28
02-Aug-2014 00:45	2160	52.92	2.18	05-Aug-2014 00:45	2160	50.87	2.31
02-Aug-2014 02:45	2280	52.94	2.21	05-Aug-2014 02:45	2280	50.84	2.34
02-Aug-2014 04:45	2400	52.96	2.23	05-Aug-2014 04:45	2400	50.82	2.36
02-Aug-2014 06:45	2520	52.99	2.25	05-Aug-2014 06:45	2520	50.80	2.38
02-Aug-2014 08:45	2640	53.01	2.28	05-Aug-2014 07:45	2580	50.81	2.37
02-Aug-2014 10:45	2760	53.04	2.31				
02-Aug-2014 12:45	2880	53.08	2.34				
02-Aug-2014 14:45	3000	53.09	2.35				
02-Aug-2014 16:45	3120	53.10	2.37				
02-Aug-2014 18:45	3240	53.12	2.38				
02-Aug-2014 20:45	3360	53.13	2.40				
02-Aug-2014 22:45	3480	53.12	2.38				
03-Aug-2014 00:45	3600	53.13	2.39				
03-Aug-2014 02:45	3720	53.14	2.41				
03-Aug-2014 04:45	3840	53.14	2.41				
03-Aug-2014 06:45	3960	53.15	2.41				
03-Aug-2014 08:45	4080	53.15	2.42				
03-Aug-2014 10:45	4200	53.17	2.43				
03-Aug-2014 12:45	4320	53.18	2.45				

Tabulated Levels for OW1#1

Pump On:	31-Jul-2014 12:45		Static Level:	7.64	
Pump Off:	03-Aug-2014 12:45		Pumping Level:	7.69	
Pumping Well:	**TW21**		Drawdown:	0.05	
Distance from Pumping Well:	200 m				

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
31-Jul-2014 12:46	1	7.64	0.00	03-Aug-2014 12:46	1	7.69	0.00
31-Jul-2014 12:47	2	7.64	0.00	03-Aug-2014 12:47	2	7.69	0.00
31-Jul-2014 12:48	3	7.64	0.00	03-Aug-2014 12:48	3	7.69	0.00
31-Jul-2014 12:49	4	7.64	0.00	03-Aug-2014 12:49	4	7.69	0.00
31-Jul-2014 12:50	5	7.64	0.00	03-Aug-2014 12:50	5	7.69	0.00
31-Jul-2014 12:51	6	7.64	0.00	03-Aug-2014 12:51	6	7.68	0.00
31-Jul-2014 12:52	7	7.64	0.00	03-Aug-2014 12:52	7	7.69	0.00
31-Jul-2014 12:53	8	7.64	0.00	03-Aug-2014 12:53	8	7.69	0.00
31-Jul-2014 12:54	9	7.64	0.00	03-Aug-2014 12:54	9	7.69	0.00
31-Jul-2014 12:55	10	7.64	0.00	03-Aug-2014 12:55	10	7.69	0.00
31-Jul-2014 12:57	12	7.64	0.00	03-Aug-2014 12:57	12	7.68	0.00
31-Jul-2014 12:59	14	7.64	0.00	03-Aug-2014 12:59	14	7.68	0.00
31-Jul-2014 13:01	16	7.64	0.00	03-Aug-2014 13:01	16	7.68	0.00
31-Jul-2014 13:03	18	7.64	0.00	03-Aug-2014 13:03	18	7.68	0.00
31-Jul-2014 13:05	20	7.64	0.00	03-Aug-2014 13:05	20	7.69	0.00
31-Jul-2014 13:10	25	7.64	0.00	03-Aug-2014 13:10	25	7.68	0.00
31-Jul-2014 13:15	30	7.64	0.00	03-Aug-2014 13:15	30	7.68	0.00
31-Jul-2014 13:30	45	7.64	0.00	03-Aug-2014 13:30	45	7.68	0.00
31-Jul-2014 13:45	60	7.64	0.00	03-Aug-2014 13:45	60	7.68	0.00
31-Jul-2014 14:15	90	7.64	0.00	03-Aug-2014 14:15	90	7.68	0.00
31-Jul-2014 14:45	120	7.64	0.00	03-Aug-2014 14:45	120	7.68	0.00
31-Jul-2014 15:15	150	7.64	0.00	03-Aug-2014 15:15	150	7.68	0.01
31-Jul-2014 15:45	180	7.64	0.00	03-Aug-2014 15:45	180	7.68	0.01
31-Jul-2014 16:15	210	7.65	0.01	03-Aug-2014 16:15	210	7.67	0.01
31-Jul-2014 16:45	240	7.64	0.00	03-Aug-2014 16:45	240	7.67	0.01
31-Jul-2014 17:15	270	7.64	0.00	03-Aug-2014 17:15	270	7.67	0.01
31-Jul-2014 17:45	300	7.65	0.01	03-Aug-2014 17:45	300	7.67	0.02
31-Jul-2014 18:45	360	7.65	0.01	03-Aug-2014 18:45	360	7.67	0.02
31-Jul-2014 19:45	420	7.65	0.01	03-Aug-2014 19:45	420	7.67	0.01
31-Jul-2014 20:45	480	7.65	0.01	03-Aug-2014 20:45	480	7.67	0.02
31-Jul-2014 21:45	540	7.66	0.02	03-Aug-2014 21:45	540	7.67	0.01
31-Jul-2014 22:45	600	7.66	0.02	03-Aug-2014 22:45	600	7.67	0.01
31-Jul-2014 23:45	660	7.66	0.02	03-Aug-2014 23:45	660	7.67	0.01
01-Aug-2014 00:45	720	7.65	0.02	04-Aug-2014 00:45	720	7.67	0.02
01-Aug-2014 01:45	780	7.66	0.02	04-Aug-2014 01:45	780	7.66	0.02
01-Aug-2014 02:45	840	7.65	0.01	04-Aug-2014 02:45	840	7.67	0.02
01-Aug-2014 04:45	960	7.65	0.01	04-Aug-2014 04:45	960	7.66	0.02
01-Aug-2014 06:45	1080	7.66	0.02	04-Aug-2014 06:45	1080	7.67	0.02
01-Aug-2014 08:45	1200	7.67	0.03	04-Aug-2014 08:45	1200	7.67	0.02
01-Aug-2014 10:45	1320	7.68	0.04	04-Aug-2014 10:45	1320	7.67	0.02
01-Aug-2014 12:45	1440	7.68	0.04	04-Aug-2014 12:45	1440	7.67	0.02
01-Aug-2014 14:45	1560	7.68	0.04	04-Aug-2014 14:45	1560	7.66	0.02
01-Aug-2014 16:45	1680	7.68	0.04	04-Aug-2014 16:45	1680	7.66	0.03
01-Aug-2014 18:45	1800	7.68	0.04	04-Aug-2014 18:45	1800	7.66	0.02
01-Aug-2014 20:45	1920	7.68	0.04	04-Aug-2014 20:45	1920	7.66	0.02
01-Aug-2014 22:45	2040	7.69	0.05	04-Aug-2014 22:45	2040	7.66	0.02
02-Aug-2014 00:45	2160	7.69	0.05	05-Aug-2014 00:45	2160	7.66	0.02
02-Aug-2014 02:45	2280	7.68	0.05	05-Aug-2014 02:45	2280	7.66	0.03
02-Aug-2014 04:45	2400	7.69	0.05	05-Aug-2014 04:45	2400	7.66	0.03
02-Aug-2014 06:45	2520	7.69	0.05	05-Aug-2014 06:45	2520	7.66	0.03
02-Aug-2014 08:45	2640	7.70	0.06	05-Aug-2014 07:45	2580	7.66	0.02
02-Aug-2014 10:45	2760	7.70	0.06				
02-Aug-2014 12:45	2880	7.70	0.06				
02-Aug-2014 14:45	3000	7.69	0.05				
02-Aug-2014 16:45	3120	7.69	0.05				
02-Aug-2014 18:45	3240	7.68	0.04				
02-Aug-2014 20:45	3360	7.68	0.05				
02-Aug-2014 22:45	3480	7.68	0.04				
03-Aug-2014 00:45	3600	7.68	0.04				
03-Aug-2014 02:45	3720	7.68	0.05				
03-Aug-2014 04:45	3840	7.68	0.04				
03-Aug-2014 06:45	3960	7.68	0.04				
03-Aug-2014 08:45	4080	7.69	0.05				
03-Aug-2014 10:45	4200	7.69	0.05				
03-Aug-2014 12:45	4320	7.69	0.05				

Tabulated Levels for OW1#2

Pump On:	31-Jul-2014 12:45		Static Level:	43.90	
Pump Off:	03-Aug-2014 12:45		Pumping Level:	43.88	
Pumping Well:	**TW21**		Drawdown:	-0.02	
Distance from Pumping Well:	200 m				

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
31-Jul-2014 12:46	1	43.90	0.00	03-Aug-2014 12:46	1	43.88	0.00
31-Jul-2014 12:47	2	43.90	0.00	03-Aug-2014 12:47	2	43.89	-0.01
31-Jul-2014 12:48	3	43.90	-0.01	03-Aug-2014 12:48	3	43.88	0.00
31-Jul-2014 12:49	4	43.90	-0.01	03-Aug-2014 12:49	4	43.89	0.00
31-Jul-2014 12:50	5	43.89	-0.01	03-Aug-2014 12:50	5	43.88	0.00
31-Jul-2014 12:51	6	43.89	-0.01	03-Aug-2014 12:51	6	43.88	0.00
31-Jul-2014 12:52	7	43.89	-0.01	03-Aug-2014 12:52	7	43.88	0.00
31-Jul-2014 12:53	8	43.89	-0.01	03-Aug-2014 12:53	8	43.89	-0.01
31-Jul-2014 12:54	9	43.90	0.00	03-Aug-2014 12:54	9	43.89	-0.01
31-Jul-2014 12:55	10	43.89	-0.01	03-Aug-2014 12:55	10	43.89	0.00
31-Jul-2014 12:57	12	43.89	-0.01	03-Aug-2014 12:57	12	43.89	-0.01
31-Jul-2014 12:59	14	43.90	-0.01	03-Aug-2014 12:59	14	43.89	-0.01
31-Jul-2014 13:01	16	43.90	-0.01	03-Aug-2014 13:01	16	43.88	0.00
31-Jul-2014 13:03	18	43.88	-0.02	03-Aug-2014 13:03	18	43.88	0.00
31-Jul-2014 13:05	20	43.90	-0.01	03-Aug-2014 13:05	20	43.89	-0.01
31-Jul-2014 13:10	25	43.90	-0.01	03-Aug-2014 13:10	25	43.89	-0.01
31-Jul-2014 13:15	30	43.89	-0.01	03-Aug-2014 13:15	30	43.89	-0.01
31-Jul-2014 13:30	45	43.89	-0.01	03-Aug-2014 13:30	45	43.88	0.00
31-Jul-2014 13:45	60	43.90	0.00	03-Aug-2014 13:45	60	43.88	0.00
31-Jul-2014 14:15	90	43.90	0.00	03-Aug-2014 14:15	90	43.88	0.00
31-Jul-2014 14:45	120	43.89	-0.01	03-Aug-2014 14:45	120	43.88	0.00
31-Jul-2014 15:15	150	43.90	0.00	03-Aug-2014 15:15	150	43.88	0.00
31-Jul-2014 15:45	180	43.89	-0.01	03-Aug-2014 15:45	180	43.88	0.01
31-Jul-2014 16:15	210	43.90	-0.01	03-Aug-2014 16:15	210	43.87	0.01
31-Jul-2014 16:45	240	43.90	0.00	03-Aug-2014 16:45	240	43.87	0.02
31-Jul-2014 17:15	270	43.89	-0.01	03-Aug-2014 17:15	270	43.87	0.01
31-Jul-2014 17:45	300	43.89	-0.01	03-Aug-2014 17:45	300	43.87	0.01
31-Jul-2014 18:45	360	43.91	0.01	03-Aug-2014 18:45	360	43.86	0.02
31-Jul-2014 19:45	420	43.91	0.01	03-Aug-2014 19:45	420	43.85	0.03
31-Jul-2014 20:45	480	43.92	0.02	03-Aug-2014 20:45	480	43.87	0.01
31-Jul-2014 21:45	540	43.92	0.02	03-Aug-2014 21:45	540	43.87	0.01
31-Jul-2014 22:45	600	43.93	0.02	03-Aug-2014 22:45	600	43.87	0.01
31-Jul-2014 23:45	660	43.93	0.02	03-Aug-2014 23:45	660	43.87	0.02
01-Aug-2014 00:45	720	43.92	0.02	04-Aug-2014 00:45	720	43.86	0.02
01-Aug-2014 01:45	780	43.92	0.02	04-Aug-2014 01:45	780	43.86	0.02
01-Aug-2014 02:45	840	43.90	0.00	04-Aug-2014 02:45	840	43.86	0.02
01-Aug-2014 04:45	960	43.91	0.01	04-Aug-2014 04:45	960	43.85	0.03
01-Aug-2014 06:45	1080	43.93	0.03	04-Aug-2014 06:45	1080	43.87	0.02
01-Aug-2014 08:45	1200	43.94	0.04	04-Aug-2014 08:45	1200	43.85	0.03
01-Aug-2014 10:45	1320	43.93	0.03	04-Aug-2014 10:45	1320	43.86	0.02
01-Aug-2014 12:45	1440	43.95	0.05	04-Aug-2014 12:45	1440	43.86	0.02
01-Aug-2014 14:45	1560	43.96	0.05	04-Aug-2014 14:45	1560	43.85	0.03
01-Aug-2014 16:45	1680	43.96	0.05	04-Aug-2014 16:45	1680	43.85	0.03
01-Aug-2014 18:45	1800	43.96	0.06	04-Aug-2014 18:45	1800	43.85	0.03
01-Aug-2014 20:45	1920	43.90	0.00	04-Aug-2014 20:45	1920	43.85	0.03
01-Aug-2014 22:45	2040	43.91	0.00	04-Aug-2014 22:45	2040	43.85	0.03
02-Aug-2014 00:45	2160	43.91	0.00	05-Aug-2014 00:45	2160	43.85	0.03
02-Aug-2014 02:45	2280	43.91	0.00	05-Aug-2014 02:45	2280	43.84	0.04
02-Aug-2014 04:45	2400	43.90	0.00	05-Aug-2014 04:45	2400	43.85	0.03
02-Aug-2014 06:45	2520	43.91	0.00	05-Aug-2014 06:45	2520	43.85	0.03
02-Aug-2014 08:45	2640	43.92	0.01	05-Aug-2014 07:45	2580	43.85	0.03
02-Aug-2014 10:45	2760	43.91	0.00				
02-Aug-2014 12:45	2880	43.92	0.02				
02-Aug-2014 14:45	3000	43.91	0.00				
02-Aug-2014 16:45	3120	43.90	0.00				
02-Aug-2014 18:45	3240	43.90	0.00				
02-Aug-2014 20:45	3360	43.90	-0.01				
02-Aug-2014 22:45	3480	43.89	-0.01				
03-Aug-2014 00:45	3600	43.90	0.00				
03-Aug-2014 02:45	3720	43.90	-0.01				
03-Aug-2014 04:45	3840	43.89	-0.01				
03-Aug-2014 06:45	3960	43.89	-0.01				
03-Aug-2014 08:45	4080	43.91	0.01				
03-Aug-2014 10:45	4200	43.91	0.00				
03-Aug-2014 12:45	4320	43.88	-0.02				

Tabulated Levels for OW2#1

Pump On:	31-Jul-2014 12:45			Static Level:	30.32		
Pump Off:	03-Aug-2014 12:45			Pumping Level:	30.31		
Pumping Well:	**TW21**			Drawdown:	-0.01		
Distance from Pumping Well:	490 m			20 yr DD:	5		
Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
31-Jul-2014 12:46	1	30.32	0.00	03-Aug-2014 12:46	1	30.31	0.00
31-Jul-2014 12:47	2	30.32	0.00	03-Aug-2014 12:47	2	30.31	0.00
31-Jul-2014 12:48	3	30.32	0.00	03-Aug-2014 12:48	3	30.31	0.00
31-Jul-2014 12:49	4	30.32	0.00	03-Aug-2014 12:49	4	30.31	0.00
31-Jul-2014 12:50	5	30.32	0.00	03-Aug-2014 12:50	5	30.31	0.00
31-Jul-2014 12:51	6	30.32	0.00	03-Aug-2014 12:51	6	30.32	0.00
31-Jul-2014 12:52	7	30.32	0.00	03-Aug-2014 12:52	7	30.31	0.00
31-Jul-2014 12:53	8	30.32	0.00	03-Aug-2014 12:53	8	30.31	0.00
31-Jul-2014 12:54	9	30.32	0.00	03-Aug-2014 12:54	9	30.31	0.00
31-Jul-2014 12:55	10	30.33	0.01	03-Aug-2014 12:55	10	30.31	0.00
31-Jul-2014 12:57	12	30.32	0.00	03-Aug-2014 12:57	12	30.31	0.00
31-Jul-2014 12:59	14	30.32	0.00	03-Aug-2014 12:59	14	30.31	0.00
31-Jul-2014 13:01	16	30.33	0.00	03-Aug-2014 13:01	16	30.31	0.00
31-Jul-2014 13:03	18	30.32	0.00	03-Aug-2014 13:03	18	30.31	0.00
31-Jul-2014 13:05	20	30.32	0.00	03-Aug-2014 13:05	20	30.31	0.00
31-Jul-2014 13:10	25	30.32	0.00	03-Aug-2014 13:10	25	30.31	0.00
31-Jul-2014 13:15	30	30.32	0.00	03-Aug-2014 13:15	30	30.31	0.00
31-Jul-2014 13:30	45	30.32	0.00	03-Aug-2014 13:30	45	30.31	0.00
31-Jul-2014 13:45	60	30.32	0.00	03-Aug-2014 13:45	60	30.31	0.00
31-Jul-2014 14:15	90	30.32	0.00	03-Aug-2014 14:15	90	30.31	0.00
31-Jul-2014 14:45	120	30.32	0.00	03-Aug-2014 14:45	120	30.31	0.00
31-Jul-2014 15:15	150	30.33	0.00	03-Aug-2014 15:15	150	30.31	0.01
31-Jul-2014 15:45	180	30.32	0.00	03-Aug-2014 15:45	180	30.31	0.01
31-Jul-2014 16:15	210	30.32	0.00	03-Aug-2014 16:15	210	30.30	0.01
31-Jul-2014 16:45	240	30.32	0.00	03-Aug-2014 16:45	240	30.30	0.01
31-Jul-2014 17:15	270	30.32	0.00	03-Aug-2014 17:15	270	30.31	0.01
31-Jul-2014 17:45	300	30.32	0.00	03-Aug-2014 17:45	300	30.31	0.01
31-Jul-2014 18:45	360	30.32	0.00	03-Aug-2014 18:45	360	30.30	0.01
31-Jul-2014 19:45	420	30.33	0.01	03-Aug-2014 19:45	420	30.31	0.01
31-Jul-2014 20:45	480	30.32	0.00	03-Aug-2014 20:45	480	30.31	0.01
31-Jul-2014 21:45	540	30.33	0.01	03-Aug-2014 21:45	540	30.31	0.00
31-Jul-2014 22:45	600	30.33	0.01	03-Aug-2014 22:45	600	30.31	0.01
31-Jul-2014 23:45	660	30.33	0.01	03-Aug-2014 23:45	660	30.32	0.00
01-Aug-2014 00:45	720	30.33	0.00	04-Aug-2014 00:45	720	30.31	0.00
01-Aug-2014 01:45	780	30.32	0.00	04-Aug-2014 01:45	780	30.31	0.01
01-Aug-2014 02:45	840	30.32	0.00	04-Aug-2014 02:45	840	30.31	0.01
01-Aug-2014 04:45	960	30.32	0.00	04-Aug-2014 04:45	960	30.31	0.00
01-Aug-2014 06:45	1080	30.32	0.00	04-Aug-2014 06:45	1080	30.32	0.00
01-Aug-2014 08:45	1200	30.33	0.01	04-Aug-2014 08:45	1200	30.31	0.01
01-Aug-2014 10:45	1320	30.33	0.01	04-Aug-2014 10:45	1320	30.31	0.00
01-Aug-2014 12:45	1440	30.33	0.01	04-Aug-2014 12:45	1440	30.31	0.01
01-Aug-2014 14:45	1560	30.33	0.01	04-Aug-2014 14:45	1560	30.31	0.00
01-Aug-2014 16:45	1680	30.33	0.01	04-Aug-2014 16:45	1680	30.30	0.01
01-Aug-2014 18:45	1800	30.33	0.00	04-Aug-2014 18:45	1800	30.31	0.00
01-Aug-2014 20:45	1920	30.33	0.01	04-Aug-2014 20:45	1920	30.31	0.00
01-Aug-2014 22:45	2040	30.33	0.00	04-Aug-2014 22:45	2040	30.31	0.00
02-Aug-2014 00:45	2160	30.33	0.01	05-Aug-2014 00:45	2160	30.31	0.00
02-Aug-2014 02:45	2280	30.32	0.00	05-Aug-2014 02:45	2280	30.30	0.01
02-Aug-2014 04:45	2400	30.32	0.00	05-Aug-2014 04:45	2400	30.30	0.01
02-Aug-2014 06:45	2520	30.32	0.00	05-Aug-2014 06:45	2520	30.31	0.01
02-Aug-2014 08:45	2640	30.33	0.00	05-Aug-2014 08:45	2640	30.31	0.00
02-Aug-2014 10:45	2760	30.33	0.01				
02-Aug-2014 12:45	2880	30.33	0.01				
02-Aug-2014 14:45	3000	30.32	0.00				
02-Aug-2014 16:45	3120	30.31	-0.01				
02-Aug-2014 18:45	3240	30.31	-0.01				
02-Aug-2014 20:45	3360	30.32	0.00				
02-Aug-2014 22:45	3480	30.32	-0.01				
03-Aug-2014 00:45	3600	30.31	-0.01				
03-Aug-2014 02:45	3720	30.32	0.00				
03-Aug-2014 04:45	3840	30.31	-0.01				
03-Aug-2014 06:45	3960	30.32	-0.01				
03-Aug-2014 08:45	4080	30.32	0.00				
03-Aug-2014 10:45	4200	30.32	0.00				
03-Aug-2014 12:45	4320	30.31	-0.01				

Tabulated Levels for OW2#2

Pump On:	31-Jul-2014 12:45			Static Level:	43.25		
Pump Off:	03-Aug-2014 12:45			Pumping Level:	43.24		
Pumping Well:	**TW21**			Drawdown:	-0.01		
Distance from Pumping Well:	490 m			20 yr DD:	5		
Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
31-Jul-2014 12:46	1	43.25	0.00	03-Aug-2014 12:46	1	43.24	0.00
31-Jul-2014 12:47	2	43.25	0.00	03-Aug-2014 12:47	2	43.24	0.00
31-Jul-2014 12:48	3	43.25	0.00	03-Aug-2014 12:48	3	43.24	0.00
31-Jul-2014 12:49	4	43.25	0.00	03-Aug-2014 12:49	4	43.24	0.00
31-Jul-2014 12:50	5	43.25	0.00	03-Aug-2014 12:50	5	43.24	0.00
31-Jul-2014 12:51	6	43.26	0.00	03-Aug-2014 12:51	6	43.24	0.00
31-Jul-2014 12:52	7	43.25	0.00	03-Aug-2014 12:52	7	43.24	0.00
31-Jul-2014 12:53	8	43.25	0.00	03-Aug-2014 12:53	8	43.24	0.00
31-Jul-2014 12:54	9	43.26	0.01	03-Aug-2014 12:54	9	43.24	0.00
31-Jul-2014 12:55	10	43.25	0.00	03-Aug-2014 12:55	10	43.24	0.00
31-Jul-2014 12:57	12	43.25	0.00	03-Aug-2014 12:57	12	43.24	0.00
31-Jul-2014 12:59	14	43.25	0.00	03-Aug-2014 12:59	14	43.24	0.00
31-Jul-2014 13:01	16	43.26	0.00	03-Aug-2014 13:01	16	43.24	0.00
31-Jul-2014 13:03	18	43.25	0.00	03-Aug-2014 13:03	18	43.24	0.00
31-Jul-2014 13:05	20	43.25	0.00	03-Aug-2014 13:05	20	43.24	0.00
31-Jul-2014 13:10	25	43.25	0.00	03-Aug-2014 13:10	25	43.24	0.00
31-Jul-2014 13:15	30	43.25	0.00	03-Aug-2014 13:15	30	43.24	0.00
31-Jul-2014 13:30	45	43.26	0.00	03-Aug-2014 13:30	45	43.24	0.00
31-Jul-2014 13:45	60	43.25	0.00	03-Aug-2014 13:45	60	43.24	0.00
31-Jul-2014 14:15	90	43.25	0.00	03-Aug-2014 14:15	90	43.24	0.00
31-Jul-2014 14:45	120	43.25	0.00	03-Aug-2014 14:45	120	43.24	0.00
31-Jul-2014 15:15	150	43.25	0.00	03-Aug-2014 15:15	150	43.24	0.00
31-Jul-2014 15:45	180	43.25	0.00	03-Aug-2014 15:45	180	43.24	0.00
31-Jul-2014 16:15	210	43.25	0.00	03-Aug-2014 16:15	210	43.24	0.00
31-Jul-2014 16:45	240	43.25	0.00	03-Aug-2014 16:45	240	43.24	0.00
31-Jul-2014 17:15	270	43.25	0.00	03-Aug-2014 17:15	270	43.23	0.00
31-Jul-2014 17:45	300	43.25	0.00	03-Aug-2014 17:45	300	43.24	0.00
31-Jul-2014 18:45	360	43.25	0.00	03-Aug-2014 18:45	360	43.23	0.00
31-Jul-2014 19:45	420	43.25	0.00	03-Aug-2014 19:45	420	43.24	0.00
31-Jul-2014 20:45	480	43.25	0.00	03-Aug-2014 20:45	480	43.24	0.00
31-Jul-2014 21:45	540	43.25	0.00	03-Aug-2014 21:45	540	43.23	0.00
31-Jul-2014 22:45	600	43.25	0.00	03-Aug-2014 22:45	600	43.23	0.00
31-Jul-2014 23:45	660	43.25	0.00	03-Aug-2014 23:45	660	43.23	0.01
01-Aug-2014 00:45	720	43.25	-0.01	04-Aug-2014 00:45	720	43.23	0.01
01-Aug-2014 01:45	780	43.25	0.00	04-Aug-2014 01:45	780	43.23	0.01
01-Aug-2014 02:45	840	43.25	0.00	04-Aug-2014 02:45	840	43.23	0.01
01-Aug-2014 04:45	960	43.24	-0.01	04-Aug-2014 04:45	960	43.23	0.01
01-Aug-2014 06:45	1080	43.24	-0.01	04-Aug-2014 06:45	1080	43.23	0.01
01-Aug-2014 08:45	1200	43.25	-0.01	04-Aug-2014 08:45	1200	43.23	0.01
01-Aug-2014 10:45	1320	43.25	0.00	04-Aug-2014 10:45	1320	43.23	0.01
01-Aug-2014 12:45	1440	43.25	0.00	04-Aug-2014 12:45	1440	43.23	0.01
01-Aug-2014 14:45	1560	43.25	0.00	04-Aug-2014 14:45	1560	43.23	0.01
01-Aug-2014 16:45	1680	43.25	0.00	04-Aug-2014 16:45	1680	43.23	0.01
01-Aug-2014 18:45	1800	43.25	-0.01	04-Aug-2014 18:45	1800	43.23	0.01
01-Aug-2014 20:45	1920	43.25	0.00	04-Aug-2014 20:45	1920	43.23	0.01
01-Aug-2014 22:45	2040	43.24	-0.01	04-Aug-2014 22:45	2040	43.23	0.01
02-Aug-2014 00:45	2160	43.24	-0.01	05-Aug-2014 00:45	2160	43.22	0.01
02-Aug-2014 02:45	2280	43.24	-0.01	05-Aug-2014 02:45	2280	43.22	0.01
02-Aug-2014 04:45	2400	43.24	-0.01	05-Aug-2014 04:45	2400	43.22	0.02
02-Aug-2014 06:45	2520	43.24	-0.01	05-Aug-2014 06:45	2520	43.22	0.02
02-Aug-2014 08:45	2640	43.24	-0.01	05-Aug-2014 08:45	2640	43.22	0.02
02-Aug-2014 10:45	2760	43.24	-0.01				
02-Aug-2014 12:45	2880	43.24	-0.01				
02-Aug-2014 14:45	3000	43.24	-0.01				
02-Aug-2014 16:45	3120	43.25	-0.01				
02-Aug-2014 18:45	3240	43.24	-0.01				
02-Aug-2014 20:45	3360	43.24	-0.01				
02-Aug-2014 22:45	3480	43.24	-0.01				
03-Aug-2014 00:45	3600	43.24	-0.01				
03-Aug-2014 02:45	3720	43.24	-0.01				
03-Aug-2014 04:45	3840	43.23	-0.02				
03-Aug-2014 06:45	3960	43.23	-0.02				
03-Aug-2014 08:45	4080	43.23	-0.02				
03-Aug-2014 10:45	4200	43.24	-0.02				
03-Aug-2014 12:45	4320	43.24	-0.01				

Tabulated Levels for TW28

Pump On:	31-Jul-2014 12:45			Static Level:	48.14		
Pump Off:	03-Aug-2014 12:45			Pumping Level:	49.42		
Pumping Well:	**TW21**			Drawdown:	1.28		
Distance from Pumping Well:	530 m			20 yr DD:	5		
Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
31-Jul-2014 12:46	1	48.14	0.00	03-Aug-2014 12:46	1	49.42	0.00
31-Jul-2014 12:47	2	48.14	0.00	03-Aug-2014 12:47	2	49.42	0.00
31-Jul-2014 12:48	3	48.15	0.00	03-Aug-2014 12:48	3	49.42	0.00
31-Jul-2014 12:49	4	48.14	0.00	03-Aug-2014 12:49	4	49.42	0.00
31-Jul-2014 12:50	5	48.14	0.00	03-Aug-2014 12:50	5	49.42	0.00
31-Jul-2014 12:51	6	48.14	0.00	03-Aug-2014 12:51	6	49.42	0.00
31-Jul-2014 12:52	7	48.14	0.00	03-Aug-2014 12:52	7	49.42	0.00
31-Jul-2014 12:53	8	48.14	0.00	03-Aug-2014 12:53	8	49.42	0.00
31-Jul-2014 12:54	9	48.14	0.00	03-Aug-2014 12:54	9	49.42	0.00
31-Jul-2014 12:55	10	48.14	0.00	03-Aug-2014 12:55	10	49.42	0.00
31-Jul-2014 12:57	12	48.14	0.00	03-Aug-2014 12:57	12	49.42	0.00
31-Jul-2014 12:59	14	48.14	0.00	03-Aug-2014 12:59	14	49.42	0.00
31-Jul-2014 13:01	16	48.15	0.00	03-Aug-2014 13:01	16	49.42	0.00
31-Jul-2014 13:03	18	48.14	0.00	03-Aug-2014 13:03	18	49.42	0.00
31-Jul-2014 13:05	20	48.14	0.00	03-Aug-2014 13:05	20	49.42	0.00
31-Jul-2014 13:10	25	48.14	0.00	03-Aug-2014 13:10	25	49.42	0.00
31-Jul-2014 13:15	30	48.14	0.00	03-Aug-2014 13:15	30	49.42	0.00
31-Jul-2014 13:30	45	48.14	0.00	03-Aug-2014 13:30	45	49.42	0.00
31-Jul-2014 13:45	60	48.14	0.00	03-Aug-2014 13:45	60	49.42	0.00
31-Jul-2014 14:15	90	48.15	0.00	03-Aug-2014 14:15	90	49.41	0.01
31-Jul-2014 14:45	120	48.15	0.01	03-Aug-2014 14:45	120	49.40	0.02
31-Jul-2014 15:15	150	48.17	0.02	03-Aug-2014 15:15	150	49.39	0.03
31-Jul-2014 15:45	180	48.18	0.04	03-Aug-2014 15:45	180	49.38	0.04
31-Jul-2014 16:15	210	48.20	0.06	03-Aug-2014 16:15	210	49.36	0.06
31-Jul-2014 16:45	240	48.21	0.07	03-Aug-2014 16:45	240	49.35	0.07
31-Jul-2014 17:15	270	48.23	0.09	03-Aug-2014 17:15	270	49.33	0.09
31-Jul-2014 17:45	300	48.25	0.11	03-Aug-2014 17:45	300	49.31	0.11
31-Jul-2014 18:45	360	48.29	0.15	03-Aug-2014 18:45	360	49.26	0.16
31-Jul-2014 19:45	420	48.34	0.19	03-Aug-2014 19:45	420	49.21	0.21
31-Jul-2014 20:45	480	48.38	0.23	03-Aug-2014 20:45	480	49.16	0.26
31-Jul-2014 21:45	540	48.42	0.28	03-Aug-2014 21:45	540	49.11	0.31
31-Jul-2014 22:45	600	48.47	0.32	03-Aug-2014 22:45	600	49.06	0.36
31-Jul-2014 23:45	660	48.51	0.37	03-Aug-2014 23:45	660	49.01	0.41
01-Aug-2014 00:45	720	48.55	0.41	04-Aug-2014 00:45	720	48.96	0.46
01-Aug-2014 01:45	780	48.59	0.45	04-Aug-2014 01:45	780	48.91	0.51
01-Aug-2014 02:45	840	48.59	0.44	04-Aug-2014 02:45	840	48.87	0.55
01-Aug-2014 04:45	960	48.57	0.42	04-Aug-2014 04:45	960	48.78	0.64
01-Aug-2014 06:45	1080	48.62	0.48	04-Aug-2014 06:45	1080	48.71	0.71
01-Aug-2014 08:45	1200	48.69	0.55	04-Aug-2014 08:45	1200	48.65	0.77
01-Aug-2014 10:45	1320	48.76	0.61	04-Aug-2014 10:45	1320	48.60	0.82
01-Aug-2014 12:45	1440	48.81	0.67	04-Aug-2014 12:45	1440	48.56	0.86
01-Aug-2014 14:45	1560	48.86	0.72	04-Aug-2014 14:45	1560	48.54	0.88
01-Aug-2014 16:45	1680	48.91	0.77	04-Aug-2014 16:45	1680	48.50	0.92
01-Aug-2014 18:45	1800	48.95	0.81	04-Aug-2014 18:45	1800	48.48	0.94
01-Aug-2014 20:45	1920	48.99	0.84	04-Aug-2014 20:45	1920	48.45	0.97
01-Aug-2014 22:45	2040	49.01	0.87	04-Aug-2014 22:45	2040	48.42	1.00
02-Aug-2014 00:45	2160	49.04	0.90	05-Aug-2014 00:45	2160	48.40	1.03
02-Aug-2014 02:45	2280	49.07	0.92	05-Aug-2014 02:45	2280	48.37	1.05
02-Aug-2014 04:45	2400	49.09	0.95	05-Aug-2014 04:45	2400	48.34	1.08
02-Aug-2014 06:45	2520	49.12	0.97	05-Aug-2014 06:45	2520	48.32	1.10
02-Aug-2014 08:45	2640	49.15	1.00	05-Aug-2014 08:45	2640	48.31	1.11
02-Aug-2014 10:45	2760	49.18	1.03				
02-Aug-2014 12:45	2880	49.21	1.07				
02-Aug-2014 14:45	3000	49.24	1.10				
02-Aug-2014 16:45	3120	49.27	1.13				
02-Aug-2014 18:45	3240	49.29	1.15				
02-Aug-2014 20:45	3360	49.32	1.17				
02-Aug-2014 22:45	3480	49.32	1.18				
03-Aug-2014 00:45	3600	49.34	1.19				
03-Aug-2014 02:45	3720	49.36	1.21				
03-Aug-2014 04:45	3840	49.36	1.22				
03-Aug-2014 06:45	3960	49.37	1.22				
03-Aug-2014 08:45	4080	49.38	1.24				
03-Aug-2014 10:45	4200	49.40	1.26				
03-Aug-2014 12:45	4320	49.42	1.27				

Tabulated Levels for OW3#1

Pump On:	31-Jul-2014 12:45		Static Level:	33.83	
Pump Off:	03-Aug-2014 12:45		Pumping Level:	33.83	
Pumping Well:	**TW21**		Drawdown:	0.00	
Distance from Pumping Well:	550 m				

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
31-Jul-2014 12:46	1	33.83	0.00	03-Aug-2014 12:46	1	33.83	0.00
31-Jul-2014 12:47	2	33.82	0.00	03-Aug-2014 12:47	2	33.83	0.00
31-Jul-2014 12:48	3	33.82	0.00	03-Aug-2014 12:48	3	33.83	0.00
31-Jul-2014 12:49	4	33.83	0.00	03-Aug-2014 12:49	4	33.83	0.00
31-Jul-2014 12:50	5	33.83	0.00	03-Aug-2014 12:50	5	33.83	0.00
31-Jul-2014 12:51	6	33.83	0.00	03-Aug-2014 12:51	6	33.83	0.00
31-Jul-2014 12:52	7	33.83	0.00	03-Aug-2014 12:52	7	33.83	0.00
31-Jul-2014 12:53	8	33.83	0.00	03-Aug-2014 12:53	8	33.83	0.00
31-Jul-2014 12:54	9	33.83	0.00	03-Aug-2014 12:54	9	33.83	0.00
31-Jul-2014 12:55	10	33.83	0.00	03-Aug-2014 12:55	10	33.83	0.00
31-Jul-2014 12:57	12	33.83	0.00	03-Aug-2014 12:57	12	33.83	0.00
31-Jul-2014 12:59	14	33.83	0.00	03-Aug-2014 12:59	14	33.83	0.00
31-Jul-2014 13:01	16	33.83	0.00	03-Aug-2014 13:01	16	33.83	0.00
31-Jul-2014 13:03	18	33.82	0.00	03-Aug-2014 13:03	18	33.83	0.00
31-Jul-2014 13:05	20	33.83	0.00	03-Aug-2014 13:05	20	33.83	0.00
31-Jul-2014 13:10	25	33.83	0.00	03-Aug-2014 13:10	25	33.83	0.00
31-Jul-2014 13:15	30	33.83	0.00	03-Aug-2014 13:15	30	33.83	0.00
31-Jul-2014 13:30	45	33.83	0.00	03-Aug-2014 13:30	45	33.83	0.00
31-Jul-2014 13:45	60	33.83	0.00	03-Aug-2014 13:45	60	33.83	0.00
31-Jul-2014 14:15	90	33.83	0.00	03-Aug-2014 14:15	90	33.83	0.00
31-Jul-2014 14:45	120	33.83	0.00	03-Aug-2014 14:45	120	33.83	0.00
31-Jul-2014 15:15	150	33.83	0.00	03-Aug-2014 15:15	150	33.83	0.00
31-Jul-2014 15:45	180	33.83	0.00	03-Aug-2014 15:45	180	33.83	0.00
31-Jul-2014 16:15	210	33.83	0.00	03-Aug-2014 16:15	210	33.83	0.00
31-Jul-2014 16:45	240	33.83	0.00	03-Aug-2014 16:45	240	33.83	0.00
31-Jul-2014 17:15	270	33.83	0.00	03-Aug-2014 17:15	270	33.83	0.00
31-Jul-2014 17:45	300	33.83	0.00	03-Aug-2014 17:45	300	33.83	0.00
31-Jul-2014 18:45	360	33.83	0.00	03-Aug-2014 18:45	360	33.82	0.00
31-Jul-2014 19:45	420	33.83	0.00	03-Aug-2014 19:45	420	33.83	0.00
31-Jul-2014 20:45	480	33.83	0.00	03-Aug-2014 20:45	480	33.83	0.00
31-Jul-2014 21:45	540	33.83	0.00	03-Aug-2014 21:45	540	33.83	0.00
31-Jul-2014 22:45	600	33.83	0.00	03-Aug-2014 22:45	600	33.83	0.00
31-Jul-2014 23:45	660	33.83	0.00	03-Aug-2014 23:45	660	33.82	0.00
01-Aug-2014 00:45	720	33.82	0.00	04-Aug-2014 00:45	720	33.83	0.00
01-Aug-2014 01:45	780	33.83	0.00	04-Aug-2014 01:45	780	33.82	0.01
01-Aug-2014 02:45	840	33.82	0.00	04-Aug-2014 02:45	840	33.82	0.00
01-Aug-2014 04:45	960	33.82	0.00	04-Aug-2014 04:45	960	33.82	0.01
01-Aug-2014 06:45	1080	33.82	-0.01	04-Aug-2014 06:45	1080	33.82	0.01
01-Aug-2014 08:45	1200	33.83	0.00	04-Aug-2014 08:45	1200	33.82	0.01
01-Aug-2014 10:45	1320	33.83	0.00	04-Aug-2014 10:45	1320	33.82	0.01
01-Aug-2014 12:45	1440	33.83	0.01	04-Aug-2014 12:45	1440	33.82	0.00
01-Aug-2014 14:45	1560	33.83	0.01	04-Aug-2014 14:45	1560	33.83	0.00
01-Aug-2014 16:45	1680	33.83	0.01	04-Aug-2014 16:45	1680	33.83	0.00
01-Aug-2014 18:45	1800	33.83	0.00	04-Aug-2014 18:45	1800	33.83	0.00
01-Aug-2014 20:45	1920	33.83	0.00	04-Aug-2014 20:45	1920	33.83	0.00
01-Aug-2014 22:45	2040	33.82	0.00	04-Aug-2014 22:45	2040	33.82	0.01
02-Aug-2014 00:45	2160	33.82	0.00	05-Aug-2014 00:45	2160	33.82	0.01
02-Aug-2014 02:45	2280	33.83	0.00	05-Aug-2014 02:45	2280	33.82	0.01
02-Aug-2014 04:45	2400	33.82	0.00	05-Aug-2014 04:45	2400	33.82	0.01
02-Aug-2014 06:45	2520	33.82	0.00	05-Aug-2014 06:45	2520	33.82	0.01
02-Aug-2014 08:45	2640	33.83	0.00	05-Aug-2014 08:45	2640	33.82	0.01
02-Aug-2014 10:45	2760	33.83	0.00				
02-Aug-2014 12:45	2880	33.83	0.00				
02-Aug-2014 14:45	3000	33.83	0.00				
02-Aug-2014 16:45	3120	33.83	0.00				
02-Aug-2014 18:45	3240	33.83	0.00				
02-Aug-2014 20:45	3360	33.83	0.01				
02-Aug-2014 22:45	3480	33.82	0.00				
03-Aug-2014 00:45	3600	33.82	0.00				
03-Aug-2014 02:45	3720	33.83	0.00				
03-Aug-2014 04:45	3840	33.83	0.00				
03-Aug-2014 06:45	3960	33.82	0.00				
03-Aug-2014 08:45	4080	33.82	0.00				
03-Aug-2014 10:45	4200	33.83	0.00				
03-Aug-2014 12:45	4320	33.83	0.00				

Tabulated Levels for OW3#2

Pump On:	31-Jul-2014 12:45		Static Level:	43.83	
Pump Off:	03-Aug-2014 12:45		Pumping Level:	43.86	
Pumping Well:	**TW21**		Drawdown:	0.02	
Distance from Pumping Well:	550 m				

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
31-Jul-2014 12:46	1	43.83	0.00	03-Aug-2014 12:46	1	43.85	0.00
31-Jul-2014 12:47	2	43.83	0.00	03-Aug-2014 12:47	2	43.86	0.00
31-Jul-2014 12:48	3	43.83	0.00	03-Aug-2014 12:48	3	43.86	0.00
31-Jul-2014 12:49	4	43.83	0.00	03-Aug-2014 12:49	4	43.86	0.00
31-Jul-2014 12:50	5	43.83	0.00	03-Aug-2014 12:50	5	43.86	0.00
31-Jul-2014 12:51	6	43.83	0.00	03-Aug-2014 12:51	6	43.85	0.00
31-Jul-2014 12:52	7	43.83	0.00	03-Aug-2014 12:52	7	43.86	0.00
31-Jul-2014 12:53	8	43.83	0.00	03-Aug-2014 12:53	8	43.86	0.00
31-Jul-2014 12:54	9	43.83	0.00	03-Aug-2014 12:54	9	43.85	0.00
31-Jul-2014 12:55	10	43.83	0.00	03-Aug-2014 12:55	10	43.86	0.00
31-Jul-2014 12:57	12	43.83	0.00	03-Aug-2014 12:57	12	43.85	0.00
31-Jul-2014 12:59	14	43.83	0.00	03-Aug-2014 12:59	14	43.85	0.00
31-Jul-2014 13:01	16	43.84	0.01	03-Aug-2014 13:01	16	43.86	0.00
31-Jul-2014 13:03	18	43.83	0.00	03-Aug-2014 13:03	18	43.85	0.00
31-Jul-2014 13:05	20	43.83	0.00	03-Aug-2014 13:05	20	43.85	0.00
31-Jul-2014 13:10	25	43.83	0.00	03-Aug-2014 13:10	25	43.85	0.00
31-Jul-2014 13:15	30	43.83	0.00	03-Aug-2014 13:15	30	43.85	0.00
31-Jul-2014 13:30	45	43.83	0.00	03-Aug-2014 13:30	45	43.85	0.00
31-Jul-2014 13:45	60	43.83	0.00	03-Aug-2014 13:45	60	43.85	0.00
31-Jul-2014 14:15	90	43.83	0.00	03-Aug-2014 14:15	90	43.86	0.00
31-Jul-2014 14:45	120	43.83	0.00	03-Aug-2014 14:45	120	43.85	0.00
31-Jul-2014 15:15	150	43.84	0.00	03-Aug-2014 15:15	150	43.85	0.01
31-Jul-2014 15:45	180	43.83	0.00	03-Aug-2014 15:45	180	43.85	0.01
31-Jul-2014 16:15	210	43.84	0.01	03-Aug-2014 16:15	210	43.84	0.01
31-Jul-2014 16:45	240	43.83	0.00	03-Aug-2014 16:45	240	43.84	0.02
31-Jul-2014 17:15	270	43.83	0.00	03-Aug-2014 17:15	270	43.84	0.02
31-Jul-2014 17:45	300	43.84	0.00	03-Aug-2014 17:45	300	43.84	0.02
31-Jul-2014 18:45	360	43.84	0.00	03-Aug-2014 18:45	360	43.83	0.02
31-Jul-2014 19:45	420	43.84	0.01	03-Aug-2014 19:45	420	43.84	0.02
31-Jul-2014 20:45	480	43.84	0.01	03-Aug-2014 20:45	480	43.84	0.02
31-Jul-2014 21:45	540	43.85	0.01	03-Aug-2014 21:45	540	43.84	0.02
31-Jul-2014 22:45	600	43.85	0.02	03-Aug-2014 22:45	600	43.84	0.02
31-Jul-2014 23:45	660	43.84	0.01	03-Aug-2014 23:45	660	43.84	0.02
01-Aug-2014 00:45	720	43.84	0.01	04-Aug-2014 00:45	720	43.83	0.02
01-Aug-2014 01:45	780	43.85	0.02	04-Aug-2014 01:45	780	43.83	0.02
01-Aug-2014 02:45	840	43.84	0.01	04-Aug-2014 02:45	840	43.83	0.02
01-Aug-2014 04:45	960	43.84	0.01	04-Aug-2014 04:45	960	43.83	0.03
01-Aug-2014 06:45	1080	43.85	0.01	04-Aug-2014 06:45	1080	43.83	0.02
01-Aug-2014 08:45	1200	43.86	0.03	04-Aug-2014 08:45	1200	43.83	0.03
01-Aug-2014 10:45	1320	43.87	0.03	04-Aug-2014 10:45	1320	43.83	0.03
01-Aug-2014 12:45	1440	43.87	0.04	04-Aug-2014 12:45	1440	43.83	0.03
01-Aug-2014 14:45	1560	43.87	0.03	04-Aug-2014 14:45	1560	43.83	0.03
01-Aug-2014 16:45	1680	43.87	0.04	04-Aug-2014 16:45	1680	43.82	0.04
01-Aug-2014 18:45	1800	43.87	0.04	04-Aug-2014 18:45	1800	43.82	0.03
01-Aug-2014 20:45	1920	43.87	0.04	04-Aug-2014 20:45	1920	43.83	0.03
01-Aug-2014 22:45	2040	43.87	0.04	04-Aug-2014 22:45	2040	43.83	0.03
02-Aug-2014 00:45	2160	43.87	0.04	05-Aug-2014 00:45	2160	43.82	0.03
02-Aug-2014 02:45	2280	43.87	0.04	05-Aug-2014 02:45	2280	43.82	0.04
02-Aug-2014 04:45	2400	43.87	0.04	05-Aug-2014 04:45	2400	43.82	0.04
02-Aug-2014 06:45	2520	43.87	0.04	05-Aug-2014 06:45	2520	43.82	0.04
02-Aug-2014 08:45	2640	43.88	0.05	05-Aug-2014 08:45	2640	43.83	0.03
02-Aug-2014 10:45	2760	43.88	0.05				
02-Aug-2014 12:45	2880	43.88	0.05				
02-Aug-2014 14:45	3000	43.87	0.04				
02-Aug-2014 16:45	3120	43.87	0.03				
02-Aug-2014 18:45	3240	43.86	0.03				
02-Aug-2014 20:45	3360	43.86	0.03				
02-Aug-2014 22:45	3480	43.86	0.03				
03-Aug-2014 00:45	3600	43.86	0.02				
03-Aug-2014 02:45	3720	43.86	0.03				
03-Aug-2014 04:45	3840	43.85	0.02				
03-Aug-2014 06:45	3960	43.85	0.02				
03-Aug-2014 08:45	4080	43.86	0.03				
03-Aug-2014 10:45	4200	43.86	0.03				
03-Aug-2014 12:45	4320	43.86	0.02				

Tabulated Levels for TW30

Pump On:	31-Jul-2014 12:45			Static Level:	53.01		
Pump Off:	03-Aug-2014 12:45			Pumping Level:	53.75		
Pumping Well:	**TW21**			Drawdown:	0.74		
Distance from Pumping Well:	1250 m			20 yr DD:	4		
Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
31-Jul-2014 12:46	1	53.01	0.00	03-Aug-2014 12:46	1	53.75	0.00
31-Jul-2014 12:47	2	53.01	0.00	03-Aug-2014 12:47	2	53.75	0.00
31-Jul-2014 12:48	3	53.01	0.00	03-Aug-2014 12:48	3	53.75	0.00
31-Jul-2014 12:49	4	53.01	0.00	03-Aug-2014 12:49	4	53.75	0.00
31-Jul-2014 12:50	5	53.01	0.00	03-Aug-2014 12:50	5	53.75	0.00
31-Jul-2014 12:51	6	53.01	0.00	03-Aug-2014 12:51	6	53.75	0.00
31-Jul-2014 12:52	7	53.01	0.00	03-Aug-2014 12:52	7	53.75	0.00
31-Jul-2014 12:53	8	53.01	0.00	03-Aug-2014 12:53	8	53.75	0.00
31-Jul-2014 12:54	9	53.01	0.00	03-Aug-2014 12:54	9	53.75	0.00
31-Jul-2014 12:55	10	53.01	0.00	03-Aug-2014 12:55	10	53.75	0.00
31-Jul-2014 12:57	12	53.01	0.00	03-Aug-2014 12:57	12	53.75	0.00
31-Jul-2014 12:59	14	53.01	0.00	03-Aug-2014 12:59	14	53.75	0.00
31-Jul-2014 13:01	16	53.01	0.00	03-Aug-2014 13:01	16	53.75	0.00
31-Jul-2014 13:03	18	53.01	0.00	03-Aug-2014 13:03	18	53.75	0.00
31-Jul-2014 13:05	20	53.01	0.00	03-Aug-2014 13:05	20	53.75	0.00
31-Jul-2014 13:10	25	53.01	0.00	03-Aug-2014 13:10	25	53.75	0.00
31-Jul-2014 13:15	30	53.01	0.00	03-Aug-2014 13:15	30	53.75	0.00
31-Jul-2014 13:30	45	53.01	0.01	03-Aug-2014 13:30	45	53.75	0.00
31-Jul-2014 13:45	60	53.01	0.00	03-Aug-2014 13:45	60	53.75	0.00
31-Jul-2014 14:15	90	53.01	0.00	03-Aug-2014 14:15	90	53.76	-0.01
31-Jul-2014 14:45	120	53.01	0.01	03-Aug-2014 14:45	120	53.76	-0.01
31-Jul-2014 15:15	150	53.01	0.01	03-Aug-2014 15:15	150	53.76	-0.01
31-Jul-2014 15:45	180	53.01	0.01	03-Aug-2014 15:45	180	53.75	0.00
31-Jul-2014 16:15	210	53.02	0.02	03-Aug-2014 16:15	210	53.74	0.01
31-Jul-2014 16:45	240	53.02	0.02	03-Aug-2014 16:45	240	53.74	0.01
31-Jul-2014 17:15	270	53.03	0.03	03-Aug-2014 17:15	270	53.73	0.02
31-Jul-2014 17:45	300	53.04	0.04	03-Aug-2014 17:45	300	53.73	0.02
31-Jul-2014 18:45	360	53.06	0.05	03-Aug-2014 18:45	360	53.71	0.04
31-Jul-2014 19:45	420	53.07	0.07	03-Aug-2014 19:45	420	53.69	0.06
31-Jul-2014 20:45	480	53.09	0.08	03-Aug-2014 20:45	480	53.68	0.07
31-Jul-2014 21:45	540	53.11	0.11	03-Aug-2014 21:45	540	53.66	0.09
31-Jul-2014 22:45	600	53.13	0.12	03-Aug-2014 22:45	600	53.64	0.11
31-Jul-2014 23:45	660	53.15	0.14	03-Aug-2014 23:45	660	53.62	0.13
01-Aug-2014 00:45	720	53.16	0.16	04-Aug-2014 00:45	720	53.60	0.15
01-Aug-2014 01:45	780	53.18	0.18	04-Aug-2014 01:45	780	53.58	0.17
01-Aug-2014 02:45	840	53.20	0.19	04-Aug-2014 02:45	840	53.56	0.19
01-Aug-2014 04:45	960	53.23	0.22	04-Aug-2014 04:45	960	53.53	0.22
01-Aug-2014 06:45	1080	53.26	0.25	04-Aug-2014 06:45	1080	53.50	0.25
01-Aug-2014 08:45	1200	53.29	0.29	04-Aug-2014 08:45	1200	53.48	0.27
01-Aug-2014 10:45	1320	53.32	0.32	04-Aug-2014 10:45	1320	53.45	0.30
01-Aug-2014 12:45	1440	53.35	0.35	04-Aug-2014 12:45	1440	53.44	0.31
01-Aug-2014 14:45	1560	53.38	0.38	04-Aug-2014 14:45	1560	53.42	0.33
01-Aug-2014 16:45	1680	53.41	0.40	04-Aug-2014 16:45	1680	53.41	0.34
01-Aug-2014 18:45	1800	53.43	0.42	04-Aug-2014 18:45	1800	53.39	0.36
01-Aug-2014 20:45	1920	53.45	0.45	04-Aug-2014 20:45	1920	53.38	0.37
01-Aug-2014 22:45	2040	53.47	0.47	04-Aug-2014 22:45	2040	53.36	0.39
02-Aug-2014 00:45	2160	53.50	0.49	05-Aug-2014 00:45	2160	53.35	0.41
02-Aug-2014 02:45	2280	53.51	0.51	05-Aug-2014 02:45	2280	53.32	0.43
02-Aug-2014 04:45	2400	53.53	0.52	05-Aug-2014 04:45	2400	53.31	0.44
02-Aug-2014 06:45	2520	53.55	0.54	05-Aug-2014 06:45	2520	53.30	0.45
02-Aug-2014 08:45	2640	53.57	0.56	05-Aug-2014 08:45	2640	53.29	0.46
02-Aug-2014 10:45	2760	53.59	0.58	05-Aug-2014 10:45	2760	53.27	0.48
02-Aug-2014 12:45	2880	53.61	0.61	05-Aug-2014 12:45	2880	53.27	0.48
02-Aug-2014 14:45	3000	53.63	0.62	05-Aug-2014 14:45	3000	53.27	0.48
02-Aug-2014 16:45	3120	53.65	0.64	05-Aug-2014 16:45	3120	53.27	0.48
02-Aug-2014 18:45	3240	53.66	0.65	05-Aug-2014 18:45	3240	53.27	0.48
02-Aug-2014 20:45	3360	53.67	0.67	05-Aug-2014 20:45	3360	53.27	0.48
02-Aug-2014 22:45	3480	53.68	0.68	05-Aug-2014 22:45	3480	53.27	0.48
03-Aug-2014 00:45	3600	53.69	0.69	06-Aug-2014 00:45	3600	53.27	0.48
03-Aug-2014 02:45	3720	53.71	0.70	06-Aug-2014 02:45	3720	53.27	0.48
03-Aug-2014 04:45	3840	53.71	0.71	06-Aug-2014 04:45	3840	53.27	0.48
03-Aug-2014 06:45	3960	53.72	0.72	06-Aug-2014 06:45	3960	53.27	0.48
03-Aug-2014 08:45	4080	53.73	0.72	06-Aug-2014 08:45	4080	53.27	0.48
03-Aug-2014 10:45	4200	53.74	0.74	06-Aug-2014 10:45	4200	53.27	0.48
03-Aug-2014 12:45	4320	53.75	0.74	06-Aug-2014 12:45	4320	53.27	0.48

Tabulated Levels for OW4#1

Pump On:	31-Jul-2014 12:45			Static Level:	34.04		
Pump Off:	03-Aug-2014 12:45			Pumping Level:	34.03		
Pumping Well:	**TW21**			Drawdown:	-0.01		
Distance from Pumping Well:	1250 m			20 yr DD:	4		
Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
31-Jul-2014 12:46	1	34.03	0.00	03-Aug-2014 12:46	1	34.03	0.00
31-Jul-2014 12:47	2	34.04	0.00	03-Aug-2014 12:47	2	34.03	0.00
31-Jul-2014 12:48	3	34.04	0.00	03-Aug-2014 12:48	3	34.03	0.00
31-Jul-2014 12:49	4	34.04	0.00	03-Aug-2014 12:49	4	34.03	0.00
31-Jul-2014 12:50	5	34.04	0.00	03-Aug-2014 12:50	5	34.03	0.00
31-Jul-2014 12:51	6	34.04	0.00	03-Aug-2014 12:51	6	34.02	0.00
31-Jul-2014 12:52	7	34.04	0.00	03-Aug-2014 12:52	7	34.03	0.00
31-Jul-2014 12:53	8	34.04	0.00	03-Aug-2014 12:53	8	34.03	0.00
31-Jul-2014 12:54	9	34.04	0.00	03-Aug-2014 12:54	9	34.03	0.00
31-Jul-2014 12:55	10	34.04	0.00	03-Aug-2014 12:55	10	34.03	0.00
31-Jul-2014 12:57	12	34.04	0.00	03-Aug-2014 12:57	12	34.03	0.00
31-Jul-2014 12:59	14	34.04	0.00	03-Aug-2014 12:59	14	34.03	0.00
31-Jul-2014 13:01	16	34.04	0.00	03-Aug-2014 13:01	16	34.02	0.00
31-Jul-2014 13:03	18	34.04	0.00	03-Aug-2014 13:03	18	34.03	0.00
31-Jul-2014 13:05	20	34.04	0.00	03-Aug-2014 13:05	20	34.03	0.00
31-Jul-2014 13:10	25	34.04	0.00	03-Aug-2014 13:10	25	34.03	0.00
31-Jul-2014 13:15	30	34.04	0.00	03-Aug-2014 13:15	30	34.03	0.00
31-Jul-2014 13:30	45	34.04	0.00	03-Aug-2014 13:30	45	34.02	0.00
31-Jul-2014 13:45	60	34.04	0.00	03-Aug-2014 13:45	60	34.03	0.00
31-Jul-2014 14:15	90	34.04	0.00	03-Aug-2014 14:15	90	34.03	0.00
31-Jul-2014 14:45	120	34.04	0.00	03-Aug-2014 14:45	120	34.02	0.00
31-Jul-2014 15:15	150	34.04	0.00	03-Aug-2014 15:15	150	34.02	0.00
31-Jul-2014 15:45	180	34.04	0.00	03-Aug-2014 15:45	180	34.02	0.01
31-Jul-2014 16:15	210	34.04	0.00	03-Aug-2014 16:15	210	34.02	0.01
31-Jul-2014 16:45	240	34.04	0.00	03-Aug-2014 16:45	240	34.02	0.01
31-Jul-2014 17:15	270	34.04	0.00	03-Aug-2014 17:15	270	34.02	0.01
31-Jul-2014 17:45	300	34.04	0.00	03-Aug-2014 17:45	300	34.02	0.01
31-Jul-2014 18:45	360	34.04	0.00	03-Aug-2014 18:45	360	34.01	0.01
31-Jul-2014 19:45	420	34.04	0.01	03-Aug-2014 19:45	420	34.02	0.01
31-Jul-2014 20:45	480	34.04	0.00	03-Aug-2014 20:45	480	34.02	0.00
31-Jul-2014 21:45	540	34.05	0.01	03-Aug-2014 21:45	540	34.03	0.00
31-Jul-2014 22:45	600	34.05	0.01	03-Aug-2014 22:45	600	34.02	0.01
31-Jul-2014 23:45	660	34.04	0.01	03-Aug-2014 23:45	660	34.02	0.01
01-Aug-2014 00:45	720	34.04	0.01	04-Aug-2014 00:45	720	34.02	0.01
01-Aug-2014 01:45	780	34.04	0.01	04-Aug-2014 01:45	780	34.01	0.02
01-Aug-2014 02:45	840	34.04	0.00	04-Aug-2014 02:45	840	34.02	0.01
01-Aug-2014 04:45	960	34.04	0.00	04-Aug-2014 04:45	960	34.01	0.02
01-Aug-2014 06:45	1080	34.04	0.00	04-Aug-2014 06:45	1080	34.02	0.00
01-Aug-2014 08:45	1200	34.05	0.02	04-Aug-2014 08:45	1200	34.02	0.01
01-Aug-2014 10:45	1320	34.05	0.01	04-Aug-2014 10:45	1320	34.02	0.01
01-Aug-2014 12:45	1440	34.05	0.01	04-Aug-2014 12:45	1440	34.02	0.01
01-Aug-2014 14:45	1560	34.05	0.01	04-Aug-2014 14:45	1560	34.02	0.01
01-Aug-2014 16:45	1680	34.04	0.01	04-Aug-2014 16:45	1680	34.01	0.01
01-Aug-2014 18:45	1800	34.05	0.01	04-Aug-2014 18:45	1800	34.02	0.00
01-Aug-2014 20:45	1920	34.05	0.01	04-Aug-2014 20:45	1920	34.03	0.00
01-Aug-2014 22:45	2040	34.04	0.01	04-Aug-2014 22:45	2040	34.02	0.00
02-Aug-2014 00:45	2160	34.05	0.01	05-Aug-2014 00:45	2160	34.02	0.01
02-Aug-2014 02:45	2280	34.04	0.00	05-Aug-2014 02:45	2280	34.01	0.02
02-Aug-2014 04:45	2400	34.03	0.00	05-Aug-2014 04:45	2400	34.02	0.01
02-Aug-2014 06:45	2520	34.03	0.00	05-Aug-2014 06:45	2520	34.02	0.01
02-Aug-2014 08:45	2640	34.04	0.00	05-Aug-2014 08:45	2640	34.02	0.01
02-Aug-2014 10:45	2760	34.04	0.00	05-Aug-2014 10:45	2760	34.02	0.01
02-Aug-2014 12:45	2880	34.04	0.00	05-Aug-2014 12:45	2880	34.02	0.01
02-Aug-2014 14:45	3000	34.03	0.00	05-Aug-2014 14:45	3000	34.02	0.01
02-Aug-2014 16:45	3120	34.03	-0.01	05-Aug-2014 16:45	3120	34.02	0.01
02-Aug-2014 18:45	3240	34.03	-0.01	05-Aug-2014 18:45	3240	34.02	0.01
02-Aug-2014 20:45	3360	34.03	-0.01	05-Aug-2014 20:45	3360	34.02	0.01
02-Aug-2014 22:45	3480	34.03	-0.01	05-Aug-2014 22:45	3480	34.02	0.01
03-Aug-2014 00:45	3600	34.03	-0.01	06-Aug-2014 00:45	3600	34.02	0.01
03-Aug-2014 02:45	3720	34.03	-0.01	06-Aug-2014 02:45	3720	34.02	0.01
03-Aug-2014 04:45	3840	34.02	-0.02	06-Aug-2014 04:45	3840	34.02	0.01
03-Aug-2014 06:45	3960	34.03	-0.01	06-Aug-2014 06:45	3960	34.02	0.01
03-Aug-2014 08:45	4080	34.03	-0.01	06-Aug-2014 08:45	4080	34.02	0.01
03-Aug-2014 10:45	4200	34.03	-0.01	06-Aug-2014 10:45	4200	34.02	0.01
03-Aug-2014 12:45	4320	34.03	-0.01	06-Aug-2014 12:45	4320	34.02	0.01

Tabulated Levels for OW4#2

Pump On:	31-Jul-2014 12:45			Static Level:	45.88		
Pump Off:	03-Aug-2014 12:45			Pumping Level:	45.90		
Pumping Well:	**TW21**			Drawdown:	0.02		
Distance from Pumping Well:	1250 m			20 yr DD:	4		
Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
31-Jul-2014 12:46	1	45.88	0.00	03-Aug-2014 12:46	1	45.90	0.00
31-Jul-2014 12:47	2	45.88	0.00	03-Aug-2014 12:47	2	45.90	0.00
31-Jul-2014 12:48	3	45.88	0.00	03-Aug-2014 12:48	3	45.90	0.00
31-Jul-2014 12:49	4	45.88	0.00	03-Aug-2014 12:49	4	45.90	0.00
31-Jul-2014 12:50	5	45.88	0.00	03-Aug-2014 12:50	5	45.90	0.00
31-Jul-2014 12:51	6	45.88	0.00	03-Aug-2014 12:51	6	45.90	0.00
31-Jul-2014 12:52	7	45.88	0.00	03-Aug-2014 12:52	7	45.90	0.00
31-Jul-2014 12:53	8	45.88	0.00	03-Aug-2014 12:53	8	45.90	0.00
31-Jul-2014 12:54	9	45.88	0.00	03-Aug-2014 12:54	9	45.90	0.00
31-Jul-2014 12:55	10	45.88	0.00	03-Aug-2014 12:55	10	45.90	0.00
31-Jul-2014 12:57	12	45.88	0.00	03-Aug-2014 12:57	12	45.90	0.00
31-Jul-2014 12:59	14	45.88	0.00	03-Aug-2014 12:59	14	45.90	0.00
31-Jul-2014 13:01	16	45.88	0.01	03-Aug-2014 13:01	16	45.90	0.00
31-Jul-2014 13:03	18	45.88	0.00	03-Aug-2014 13:03	18	45.90	0.00
31-Jul-2014 13:05	20	45.88	0.00	03-Aug-2014 13:05	20	45.90	0.00
31-Jul-2014 13:10	25	45.88	0.00	03-Aug-2014 13:10	25	45.90	0.00
31-Jul-2014 13:15	30	45.88	0.00	03-Aug-2014 13:15	30	45.90	0.00
31-Jul-2014 13:30	45	45.88	0.00	03-Aug-2014 13:30	45	45.90	0.00
31-Jul-2014 13:45	60	45.88	0.00	03-Aug-2014 13:45	60	45.90	0.00
31-Jul-2014 14:15	90	45.88	0.00	03-Aug-2014 14:15	90	45.90	0.00
31-Jul-2014 14:45	120	45.88	0.00	03-Aug-2014 14:45	120	45.90	0.00
31-Jul-2014 15:15	150	45.88	0.00	03-Aug-2014 15:15	150	45.90	0.00
31-Jul-2014 15:45	180	45.88	0.00	03-Aug-2014 15:45	180	45.89	0.01
31-Jul-2014 16:15	210	45.88	0.01	03-Aug-2014 16:15	210	45.89	0.01
31-Jul-2014 16:45	240	45.88	0.00	03-Aug-2014 16:45	240	45.89	0.01
31-Jul-2014 17:15	270	45.88	0.00	03-Aug-2014 17:15	270	45.89	0.02
31-Jul-2014 17:45	300	45.88	0.00	03-Aug-2014 17:45	300	45.89	0.01
31-Jul-2014 18:45	360	45.88	0.00	03-Aug-2014 18:45	360	45.88	0.02
31-Jul-2014 19:45	420	45.89	0.01	03-Aug-2014 19:45	420	45.88	0.02
31-Jul-2014 20:45	480	45.89	0.01	03-Aug-2014 20:45	480	45.89	0.02
31-Jul-2014 21:45	540	45.90	0.02	03-Aug-2014 21:45	540	45.89	0.01
31-Jul-2014 22:45	600	45.90	0.02	03-Aug-2014 22:45	600	45.89	0.02
31-Jul-2014 23:45	660	45.90	0.02	03-Aug-2014 23:45	660	45.89	0.02
01-Aug-2014 00:45	720	45.89	0.01	04-Aug-2014 00:45	720	45.88	0.02
01-Aug-2014 01:45	780	45.89	0.01	04-Aug-2014 01:45	780	45.88	0.02
01-Aug-2014 02:45	840	45.89	0.01	04-Aug-2014 02:45	840	45.88	0.02
01-Aug-2014 04:45	960	45.89	0.01	04-Aug-2014 04:45	960	45.88	0.03
01-Aug-2014 06:45	1080	45.89	0.01	04-Aug-2014 06:45	1080	45.88	0.02
01-Aug-2014 08:45	1200	45.91	0.03	04-Aug-2014 08:45	1200	45.88	0.03
01-Aug-2014 10:45	1320	45.91	0.03	04-Aug-2014 10:45	1320	45.88	0.02
01-Aug-2014 12:45	1440	45.91	0.03	04-Aug-2014 12:45	1440	45.88	0.02
01-Aug-2014 14:45	1560	45.91	0.03	04-Aug-2014 14:45	1560	45.88	0.03
01-Aug-2014 16:45	1680	45.91	0.03	04-Aug-2014 16:45	1680	45.87	0.04
01-Aug-2014 18:45	1800	45.91	0.03	04-Aug-2014 18:45	1800	45.87	0.03
01-Aug-2014 20:45	1920	45.92	0.04	04-Aug-2014 20:45	1920	45.87	0.03
01-Aug-2014 22:45	2040	45.92	0.04	04-Aug-2014 22:45	2040	45.87	0.03
02-Aug-2014 00:45	2160	45.92	0.04	05-Aug-2014 00:45	2160	45.87	0.03
02-Aug-2014 02:45	2280	45.91	0.03	05-Aug-2014 02:45	2280	45.86	0.04
02-Aug-2014 04:45	2400	45.91	0.03	05-Aug-2014 04:45	2400	45.87	0.03
02-Aug-2014 06:45	2520	45.91	0.03	05-Aug-2014 06:45	2520	45.86	0.04
02-Aug-2014 08:45	2640	45.92	0.04	05-Aug-2014 08:45	2640	45.87	0.03
02-Aug-2014 10:45	2760	45.92	0.04	05-Aug-2014 10:45	2760	45.87	0.03
02-Aug-2014 12:45	2880	45.93	0.05	05-Aug-2014 12:45	2880	45.87	0.03
02-Aug-2014 14:45	3000	45.92	0.04	05-Aug-2014 14:45	3000	45.87	0.03
02-Aug-2014 16:45	3120	45.91	0.03	05-Aug-2014 16:45	3120	45.87	0.03
02-Aug-2014 18:45	3240	45.90	0.02	05-Aug-2014 18:45	3240	45.87	0.03
02-Aug-2014 20:45	3360	45.91	0.03	05-Aug-2014 20:45	3360	45.87	0.03
02-Aug-2014 22:45	3480	45.90	0.03	05-Aug-2014 22:45	3480	45.87	0.03
03-Aug-2014 00:45	3600	45.90	0.02	06-Aug-2014 00:45	3600	45.87	0.03
03-Aug-2014 02:45	3720	45.91	0.03	06-Aug-2014 02:45	3720	45.87	0.03
03-Aug-2014 04:45	3840	45.90	0.02	06-Aug-2014 04:45	3840	45.87	0.03
03-Aug-2014 06:45	3960	45.90	0.02	06-Aug-2014 06:45	3960	45.87	0.03
03-Aug-2014 08:45	4080	45.91	0.03	06-Aug-2014 08:45	4080	45.87	0.03
03-Aug-2014 10:45	4200	45.91	0.03	06-Aug-2014 10:45	4200	45.87	0.03
03-Aug-2014 12:45	4320	45.90	0.02	06-Aug-2014 12:45	4320	45.87	0.03

Tabulated Levels for TW35

	Pump On:	31-Jul-2014 12:45			Static Level:	50.25	
	Pump Off:	03-Aug-2014 12:45			Pumping Level:	50.63	
	Pumping Well:	**TW21**			Drawdown	0.38	
	Distance from Pumping Well:	2500 m			20 yr DD:	2	
Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
31-Jul-2014 12:46	1	50.25	0.00	03-Aug-2014 12:46	1	50.63	0.00
31-Jul-2014 12:47	2	50.25	0.00	03-Aug-2014 12:47	2	50.63	0.00
31-Jul-2014 12:48	3	50.24	0.00	03-Aug-2014 12:48	3	50.63	0.00
31-Jul-2014 12:49	4	50.25	0.00	03-Aug-2014 12:49	4	50.63	0.00
31-Jul-2014 12:50	5	50.25	0.00	03-Aug-2014 12:50	5	50.63	0.00
31-Jul-2014 12:51	6	50.25	0.00	03-Aug-2014 12:51	6	50.63	0.00
31-Jul-2014 12:52	7	50.25	0.00	03-Aug-2014 12:52	7	50.63	0.00
31-Jul-2014 12:53	8	50.25	0.00	03-Aug-2014 12:53	8	50.63	0.00
31-Jul-2014 12:54	9	50.25	0.00	03-Aug-2014 12:54	9	50.63	0.00
31-Jul-2014 12:55	10	50.25	0.00	03-Aug-2014 12:55	10	50.63	0.00
31-Jul-2014 12:57	12	50.25	0.00	03-Aug-2014 12:57	12	50.63	0.00
31-Jul-2014 12:59	14	50.25	0.00	03-Aug-2014 12:59	14	50.63	0.00
31-Jul-2014 13:01	16	50.25	0.00	03-Aug-2014 13:01	16	50.63	0.00
31-Jul-2014 13:03	18	50.25	0.00	03-Aug-2014 13:03	18	50.63	0.00
31-Jul-2014 13:05	20	50.25	0.00	03-Aug-2014 13:05	20	50.63	0.00
31-Jul-2014 13:10	25	50.25	0.00	03-Aug-2014 13:10	25	50.63	0.00
31-Jul-2014 13:15	30	50.25	0.00	03-Aug-2014 13:15	30	50.63	0.00
31-Jul-2014 13:30	45	50.25	0.00	03-Aug-2014 13:30	45	50.63	0.00
31-Jul-2014 13:45	60	50.25	0.00	03-Aug-2014 13:45	60	50.63	0.00
31-Jul-2014 14:15	90	50.25	0.00	03-Aug-2014 14:15	90	50.64	-0.01
31-Jul-2014 14:45	120	50.24	0.00	03-Aug-2014 14:45	120	50.64	-0.01
31-Jul-2014 15:15	150	50.25	0.00	03-Aug-2014 15:15	150	50.64	-0.01
31-Jul-2014 15:45	180	50.24	0.00	03-Aug-2014 15:45	180	50.64	-0.01
31-Jul-2014 16:15	210	50.25	0.00	03-Aug-2014 16:15	210	50.64	-0.01
31-Jul-2014 16:45	240	50.24	0.00	03-Aug-2014 16:45	240	50.64	-0.01
31-Jul-2014 17:15	270	50.24	0.00	03-Aug-2014 17:15	270	50.64	-0.01
31-Jul-2014 17:45	300	50.24	-0.01	03-Aug-2014 17:45	300	50.64	-0.01
31-Jul-2014 18:45	360	50.24	-0.01	03-Aug-2014 18:45	360	50.64	-0.01
31-Jul-2014 19:45	420	50.24	-0.01	03-Aug-2014 19:45	420	50.65	-0.02
31-Jul-2014 20:45	480	50.23	-0.01	03-Aug-2014 20:45	480	50.64	-0.01
31-Jul-2014 21:45	540	50.23	-0.01	03-Aug-2014 21:45	540	50.64	-0.01
31-Jul-2014 22:45	600	50.24	-0.01	03-Aug-2014 22:45	600	50.63	0.00
31-Jul-2014 23:45	660	50.24	-0.01	03-Aug-2014 23:45	660	50.63	0.00
01-Aug-2014 00:45	720	50.24	0.00	04-Aug-2014 00:45	720	50.62	0.01
01-Aug-2014 01:45	780	50.25	0.00	04-Aug-2014 01:45	780	50.62	0.02
01-Aug-2014 02:45	840	50.25	0.00	04-Aug-2014 02:45	840	50.61	0.02
01-Aug-2014 04:45	960	50.26	0.01	04-Aug-2014 04:45	960	50.60	0.03
01-Aug-2014 06:45	1080	50.27	0.02	04-Aug-2014 06:45	1080	50.60	0.03
01-Aug-2014 08:45	1200	50.29	0.04	04-Aug-2014 08:45	1200	50.59	0.04
01-Aug-2014 10:45	1320	50.31	0.06	04-Aug-2014 10:45	1320	50.58	0.05
01-Aug-2014 12:45	1440	50.33	0.08	04-Aug-2014 12:45	1440	50.58	0.05
01-Aug-2014 14:45	1560	50.34	0.09	04-Aug-2014 14:45	1560	50.58	0.05
01-Aug-2014 16:45	1680	50.36	0.11	04-Aug-2014 16:45	1680	50.58	0.05
01-Aug-2014 18:45	1800	50.37	0.13	04-Aug-2014 18:45	1800	50.57	0.06
01-Aug-2014 20:45	1920	50.39	0.14	04-Aug-2014 20:45	1920	50.56	0.07
01-Aug-2014 22:45	2040	50.40	0.15	04-Aug-2014 22:45	2040	50.54	0.09
02-Aug-2014 00:45	2160	50.41	0.16	05-Aug-2014 00:45	2160	50.53	0.10
02-Aug-2014 02:45	2280	50.42	0.18	05-Aug-2014 02:45	2280	50.51	0.12
02-Aug-2014 04:45	2400	50.44	0.19	05-Aug-2014 04:45	2400	50.50	0.14
02-Aug-2014 06:45	2520	50.45	0.20	05-Aug-2014 06:45	2520	50.48	0.15
02-Aug-2014 08:45	2640	50.47	0.23	05-Aug-2014 08:45	2640	50.47	0.16
02-Aug-2014 10:45	2760	50.49	0.25	05-Aug-2014 10:45	2760	50.47	0.16
02-Aug-2014 12:45	2880	50.52	0.27	05-Aug-2014 12:45	2880	50.47	0.16
02-Aug-2014 14:45	3000	50.53	0.29	05-Aug-2014 14:45	3000	50.47	0.16
02-Aug-2014 16:45	3120	50.55	0.30	05-Aug-2014 16:45	3120	50.47	0.16
02-Aug-2014 18:45	3240	50.56	0.31	05-Aug-2014 18:45	3240	50.47	0.16
02-Aug-2014 20:45	3360	50.57	0.33	05-Aug-2014 20:45	3360	50.47	0.16
02-Aug-2014 22:45	3480	50.57	0.33	05-Aug-2014 22:45	3480	50.47	0.16
03-Aug-2014 00:45	3600	50.58	0.33	06-Aug-2014 00:45	3600	50.47	0.16
03-Aug-2014 02:45	3720	50.59	0.34	06-Aug-2014 02:45	3720	50.47	0.16
03-Aug-2014 04:45	3840	50.60	0.35	06-Aug-2014 04:45	3840	50.47	0.16
03-Aug-2014 06:45	3960	50.60	0.35	06-Aug-2014 06:45	3960	50.47	0.16
03-Aug-2014 08:45	4080	50.61	0.36	06-Aug-2014 08:45	4080	50.47	0.16
03-Aug-2014 10:45	4200	50.62	0.38	06-Aug-2014 10:45	4200	50.47	0.16
03-Aug-2014 12:45	4320	50.63	0.38	06-Aug-2014 12:45	4320	50.47	0.16

Tabulated Levels for TW17

Pump On:	31-Jul-2014 12:45		Static Level:	4.76	
Pump Off:	03-Aug-2014 12:45		Pumping Level:	4.80	
Pumping Well:	**TW21**		Drawdown	0.04	
Distance from Pumping Well:	4800 m				

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
31-Jul-2014 12:46	1	4.76	0.00	03-Aug-2014 12:46	1	4.80	0.00
31-Jul-2014 12:47	2	4.75	0.00	03-Aug-2014 12:47	2	4.80	0.00
31-Jul-2014 12:48	3	4.76	0.00	03-Aug-2014 12:48	3	4.80	0.00
31-Jul-2014 12:49	4	4.76	0.00	03-Aug-2014 12:49	4	4.80	0.00
31-Jul-2014 12:50	5	4.76	0.00	03-Aug-2014 12:50	5	4.80	0.00
31-Jul-2014 12:51	6	4.76	0.00	03-Aug-2014 12:51	6	4.80	0.00
31-Jul-2014 12:52	7	4.76	0.00	03-Aug-2014 12:52	7	4.80	0.00
31-Jul-2014 12:53	8	4.76	0.00	03-Aug-2014 12:53	8	4.80	0.00
31-Jul-2014 12:54	9	4.76	0.00	03-Aug-2014 12:54	9	4.80	0.00
31-Jul-2014 12:55	10	4.76	0.00	03-Aug-2014 12:55	10	4.80	0.00
31-Jul-2014 12:57	12	4.76	0.00	03-Aug-2014 12:57	12	4.80	0.00
31-Jul-2014 12:59	14	4.76	0.00	03-Aug-2014 12:59	14	4.80	0.00
31-Jul-2014 13:01	16	4.76	0.00	03-Aug-2014 13:01	16	4.80	0.00
31-Jul-2014 13:03	18	4.76	0.00	03-Aug-2014 13:03	18	4.80	0.00
31-Jul-2014 13:05	20	4.76	0.00	03-Aug-2014 13:05	20	4.80	0.00
31-Jul-2014 13:10	25	4.76	0.00	03-Aug-2014 13:10	25	4.80	0.00
31-Jul-2014 13:15	30	4.76	0.00	03-Aug-2014 13:15	30	4.80	0.00
31-Jul-2014 13:30	45	4.76	0.00	03-Aug-2014 13:30	45	4.80	0.00
31-Jul-2014 13:45	60	4.76	0.00	03-Aug-2014 13:45	60	4.80	0.00
31-Jul-2014 14:15	90	4.76	0.00	03-Aug-2014 14:15	90	4.80	0.00
31-Jul-2014 14:45	120	4.76	0.00	03-Aug-2014 14:45	120	4.80	0.00
31-Jul-2014 15:15	150	4.76	0.00	03-Aug-2014 15:15	150	4.80	0.00
31-Jul-2014 15:45	180	4.76	0.00	03-Aug-2014 15:45	180	4.80	0.00
31-Jul-2014 16:15	210	4.76	0.01	03-Aug-2014 16:15	210	4.80	0.00
31-Jul-2014 16:45	240	4.76	0.00	03-Aug-2014 16:45	240	4.80	0.00
31-Jul-2014 17:15	270	4.76	0.00	03-Aug-2014 17:15	270	4.80	0.00
31-Jul-2014 17:45	300	4.76	0.01	03-Aug-2014 17:45	300	4.80	0.00
31-Jul-2014 18:45	360	4.76	0.01	03-Aug-2014 18:45	360	4.80	0.00
31-Jul-2014 19:45	420	4.77	0.01	03-Aug-2014 19:45	420	4.80	0.00
31-Jul-2014 20:45	480	4.77	0.01	03-Aug-2014 20:45	480	4.80	0.00
31-Jul-2014 21:45	540	4.77	0.02	03-Aug-2014 21:45	540	4.80	0.00
31-Jul-2014 22:45	600	4.78	0.02	03-Aug-2014 22:45	600	4.80	0.00
31-Jul-2014 23:45	660	4.77	0.02	03-Aug-2014 23:45	660	4.80	0.00
01-Aug-2014 00:45	720	4.77	0.02	04-Aug-2014 00:45	720	4.80	0.00
01-Aug-2014 01:45	780	4.77	0.02	04-Aug-2014 01:45	780	4.80	0.00
01-Aug-2014 02:45	840	4.77	0.01	04-Aug-2014 02:45	840	4.80	0.00
01-Aug-2014 04:45	960	4.77	0.01	04-Aug-2014 04:45	960	4.80	0.00
01-Aug-2014 06:45	1080	4.78	0.02	04-Aug-2014 06:45	1080	4.80	0.00
01-Aug-2014 08:45	1200	4.79	0.03	04-Aug-2014 08:45	1200	4.80	0.00
01-Aug-2014 10:45	1320	4.79	0.04	04-Aug-2014 10:45	1320	4.80	0.00
01-Aug-2014 12:45	1440	4.80	0.04	04-Aug-2014 12:45	1440	4.80	0.00
01-Aug-2014 14:45	1560	4.80	0.04	04-Aug-2014 14:45	1560	4.80	0.00
01-Aug-2014 16:45	1680	4.80	0.04	04-Aug-2014 16:45	1680	4.80	0.00
01-Aug-2014 18:45	1800	4.80	0.04	04-Aug-2014 18:45	1800	4.80	0.00
01-Aug-2014 20:45	1920	4.80	0.04	04-Aug-2014 20:45	1920	4.80	0.00
01-Aug-2014 22:45	2040	4.80	0.05	04-Aug-2014 22:45	2040	4.80	0.00
02-Aug-2014 00:45	2160	4.81	0.05	05-Aug-2014 00:45	2160	4.80	0.00
02-Aug-2014 02:45	2280	4.80	0.05	05-Aug-2014 02:45	2280	4.80	0.00
02-Aug-2014 04:45	2400	4.80	0.05	05-Aug-2014 04:45	2400	4.80	0.00
02-Aug-2014 06:45	2520	4.81	0.05	05-Aug-2014 06:45	2520	4.80	0.00
02-Aug-2014 08:45	2640	4.81	0.06	05-Aug-2014 08:45	2640	4.80	0.00
02-Aug-2014 10:45	2760	4.81	0.06	05-Aug-2014 10:45	2760	4.80	0.00
02-Aug-2014 12:45	2880	4.82	0.06	05-Aug-2014 12:45	2880	4.80	0.00
02-Aug-2014 14:45	3000	4.81	0.05	05-Aug-2014 14:45	3000	4.80	0.00
02-Aug-2014 16:45	3120	4.80	0.05	05-Aug-2014 16:45	3120	4.80	0.00
02-Aug-2014 18:45	3240	4.80	0.04	05-Aug-2014 18:45	3240	4.80	0.00
02-Aug-2014 20:45	3360	4.80	0.05	05-Aug-2014 20:45	3360	4.80	0.00
02-Aug-2014 22:45	3480	4.80	0.04	05-Aug-2014 22:45	3480	4.80	0.00
03-Aug-2014 00:45	3600	4.80	0.04	06-Aug-2014 00:45	3600	4.80	0.00
03-Aug-2014 02:45	3720	4.80	0.05	06-Aug-2014 02:45	3720	4.80	0.00
03-Aug-2014 04:45	3840	4.79	0.04	06-Aug-2014 04:45	3840	4.80	0.00
03-Aug-2014 06:45	3960	4.80	0.04	06-Aug-2014 06:45	3960	4.80	0.00
03-Aug-2014 08:45	4080	4.80	0.04	06-Aug-2014 08:45	4080	4.80	0.00
03-Aug-2014 10:45	4200	4.80	0.04	06-Aug-2014 10:45	4200	4.80	0.00
03-Aug-2014 12:45	4320	4.80	0.04	06-Aug-2014 12:45	4320	4.80	0.00

Table D-2: Water Quality Results

CADUCEON ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G42357 **REPORT No. B14-19352**

Report To:

Golder Associates Ltd.
121 Commerce Park Drive, Unit L,
Barrie ON. L4N 8X1 Canada
Attention: Alicia Beynon

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 05-Aug-14
DATE REPORTED: 13-Aug-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 1311700040 Ph 2000
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		TW21 - 23h			
			Sample I.D.		B14-19352-1			
			Date Collected		01-Aug-14			
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Hardness (as CaCO3)	mg/L	1	SM 3120	06-Aug-14/O	266			
Alkalinity(CaCO3) to pH4.5	mg/L	5	SM 2320B	05-Aug-14/O	200			
Conductivity @25°C	µmho/cm	1	SM 2510B	05-Aug-14/O	533			
pH @25°C	pH Units		SM 4500H	05-Aug-14/O	7.98			
Fluoride	mg/L	0.1	SM4110C	06-Aug-14/O	< 0.1			
Chloride	mg/L	0.5	SM4110C	06-Aug-14/O	27.9			
Nitrite (N)	mg/L	0.1	SM4110C	06-Aug-14/O	< 0.1			
Nitrate (N)	mg/L	0.1	SM4110C	06-Aug-14/O	3.3			
Bromide	mg/L	0.4	SM4110C	06-Aug-14/O	< 0.4			
Sulphate	mg/L	1	SM4110C	06-Aug-14/O	16			
Calcium	mg/L	0.02	SM 3120	06-Aug-14/O	78.9			
Magnesium	mg/L	0.01	SM 3120	06-Aug-14/O	16.8			
Sodium	mg/L	0.2	SM 3120	06-Aug-14/O	9.6			
Potassium	mg/L	0.1	SM 3120	06-Aug-14/O	1.9			
Iron	mg/L	0.005	SM 3120	06-Aug-14/O	0.024			
Manganese	mg/L	0.001	SM 3120	06-Aug-14/O	0.003			
Ammonia (N)-Total	mg/L	0.01	MOEE 3364	08-Aug-14/O	< 0.01			
Dissolved Organic Carbon	mg/L	0.2	EPA 415.1	08-Aug-14/O	1.2			
Tannins and Lignins	mg/L	0.1	N/A	08-Aug-14	< 0.1 [1]			
Anion Sum	meq/L		Calc.	07-Aug-14/O	5.36			
Cation Sum	meq/L		Calc.	07-Aug-14/O	5.79			
% Difference	%		Calc.	07-Aug-14/O	3.84			
Ion Ratio	AS/CS		Calc.	07-Aug-14/O	0.926			
Sodium Adsorption Ratio	-		Calc.	07-Aug-14/O	0.256			
TDS(ion sum calc.)	mg/L		Calc.	07-Aug-14/O	286			
Conductivity (calc.)	µmho/cm		Calc.	07-Aug-14/O	540			
TDS(calc.)/EC(actual)	-		Calc.	07-Aug-14/O	0.537			
EC(calc.)/EC(actual)	-		Calc.	07-Aug-14/O	1.01			

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

M.D.L. = Method Detection Limit
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

The analytical results reported herein refer to the samples as received. Reproduction of this analytical report in full or in part is prohibited without prior consent from Caduceon Environmental Laboratories.

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G42357 **REPORT No. B14-19352**

Report To:

Golder Associates Ltd.
121 Commerce Park Drive, Unit L,
Barrie ON. L4N 8X1 Canada
Attention: Alicia Beynon

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 05-Aug-14
DATE REPORTED: 13-Aug-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 1311700040 Ph 2000
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		TW21 - 23h			
			Sample I.D.		B14-19352-1			
			Date Collected		01-Aug-14			
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Langelier Index(25°C)	S.I.		Calc.	07-Aug-14/O	0.735			

1 . subcontracted to Paracel Labs

Table D-2: Water Quality Results

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

M.D.L. = Method Detection Limit
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

The analytical results reported herein refer to the samples as received. Reproduction of this analytical report in full or in part is prohibited without prior consent from Caduceon Environmental Laboratories.

Table D-2: Water Quality Results

CADUCEON ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G42358 **REPORT No. B14-19681**

Report To:

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Attention: Alicia Beynon

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2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 06-Aug-14
DATE REPORTED: 05-Sep-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 13-1170-0040
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		TW21-72 hour			
			Sample I.D.		B14-19681-1			
			Date Collected		05-Aug-14			
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Hardness (as CaCO3)	mg/L	1	SM 3120	07-Aug-14/O	274			
Alkalinity(CaCO3) to pH4.5	mg/L	5	SM 2320B	06-Aug-14/O	203			
Bicarbonate(as CaCO3)	mg/L	5	SM 2320B	06-Aug-14/O	203			
Carbonate (as CaCO3)	mg/L	5	SM 2320B	06-Aug-14/O	< 5			
Conductivity @25°C	µmho/cm	1	SM 2510B	07-Aug-14/O	523			
pH @25°C	pH Units		SM 4500H	06-Aug-14/O	7.99			
Colour	TCU	2	SM 2120C	08-Aug-14/O	8			
Turbidity	NTU	0.1	SM 2130	08-Aug-14/O	0.3			
UV transmittance	%		N/A	14-Aug-14	97.1 [3]			
Fluoride	mg/L	0.1	SM4110C	07-Aug-14/O	< 0.1			
Chloride	mg/L	0.5	SM4110C	07-Aug-14/O	28.6			
Nitrite (N)	mg/L	0.1	SM4110C	07-Aug-14/O	< 0.1			
Nitrate (N)	mg/L	0.1	SM4110C	07-Aug-14/O	3.1			
Nitrate + Nitrite (N)	mg/L	0.1	SM4110C	07-Aug-14/O	3.1			
Sulphate	mg/L	1	SM4110C	07-Aug-14/O	17			
Calcium	mg/L	0.02	SM 3120	07-Aug-14/O	81.5			
Magnesium	mg/L	0.01	SM 3120	07-Aug-14/O	17.2			
Sodium	mg/L	0.2	SM 3120	07-Aug-14/O	12.3			
Potassium	mg/L	0.1	SM 3120	07-Aug-14/O	2.2			
Aluminum	mg/L	0.01	SM 3120	07-Aug-14/O	0.02			
Antimony	mg/L	0.0001	EPA 200.8	07-Aug-14/O	0.0002			
Arsenic	mg/L	0.0001	EPA 200.8	07-Aug-14/O	< 0.0001			
Barium	mg/L	0.001	SM 3120	07-Aug-14/O	0.056			
Boron	mg/L	0.005	SM 3120	07-Aug-14/O	< 0.005			
Cadmium	mg/L	0.00002	EPA 200.8	07-Aug-14/O	< 0.00002			
Chromium	mg/L	0.002	SM 3120	07-Aug-14/O	< 0.002			
Copper	mg/L	0.002	SM 3120	07-Aug-14/O	0.003			

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

M.D.L. = Method Detection Limit
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

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CADUCEON™
ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G42358 **REPORT No. B14-19681**

Report To:

Golder Associates Ltd.
121 Commerce Park Drive, Unit L,
Barrie ON. L4N 8X1 Canada
Attention: Alicia Beynon

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 06-Aug-14
DATE REPORTED: 05-Sep-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 13-1170-0040
P.O. NUMBER:
WATERWORKS NO.

	Client I.D.	TW21-72 hour			
	Sample I.D.	B14-19681-1			
	Date Collected	05-Aug-14			

Parameter	Units	M.D.L.	Reference Method	Date/Site Analyzed				
Total Cyanide	mg/L	0.005	SM 4500CN	11-Aug-14/K	< 0.005			
Iron	mg/L	0.005	SM 3120	07-Aug-14/O	0.015			
Iron (Total)	mg/L	0.005	SM 3120	07-Aug-14/O	0.066			
Lead	mg/L	0.00002	EPA 200.8	07-Aug-14/O	< 0.00002			
Manganese	mg/L	0.001	SM 3120	07-Aug-14/O	0.002			
Manganese (Total)	mg/L	0.001	SM 3120	07-Aug-14/O	0.008			
Mercury	mg/L	0.00002	SM 3112 B	11-Aug-14/O	< 0.00002			
Selenium	mg/L	0.001	EPA 200.8	07-Aug-14/O	< 0.001			
Uranium	mg/L	0.00005	EPA 200.8	07-Aug-14/O	0.00435			
Zinc	mg/L	0.005	SM 3120	07-Aug-14/O	0.021			
Ammonia (N)-Total	mg/L	0.01	MOEE 3364	08-Aug-14/O	< 0.01			
Total Kjeldahl Nitrogen	mg/L	0.05	MOEE 3367	14-Aug-14/O	< 0.05			
Organic Nitrogen	mg/L	0.05	MOEE 3367	14-Aug-14/O	< 0.05			
Dissolved Organic Carbon	mg/L	0.2	EPA 415.1	08-Aug-14/O	1.2			
Sulphide	mg/L	0.01	SM4500-S2	11-Aug-14/K	< 0.01			
Anion Sum	meq/L		Calc.	08-Aug-14/O	5.44			
Cation Sum	meq/L		Calc.	08-Aug-14/O	6.41			
% Difference	%		Calc.	08-Aug-14/O	8.22			
Ion Ratio	AS/CS		Calc.	08-Aug-14/O	0.848			
Sodium Adsorption Ratio	-		Calc.	08-Aug-14/O	0.350			
TDS(ion sum calc.)	mg/L		Calc.	08-Aug-14/O	301			
Conductivity (calc.)	µmho/cm		Calc.	08-Aug-14/O	572			
TDS(calc.)/EC(actual)	-		Calc.	08-Aug-14/O	0.575			
EC(calc.)/EC(actual)	-		Calc.	08-Aug-14/O	1.09			
Langelier Index(25°C)	S.I.		Calc.	08-Aug-14/O	0.785			
Methane	L/m3	0.006	EPA 8000	11-Aug-14/O	< 0.006 [3]			
Benzene	µg/L	0.5	EPA 8260	07-Aug-14/O	< 0.5			



Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

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Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 06-Aug-14
DATE REPORTED: 05-Sep-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 13-1170-0040
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		TW21-72 hour			
			Sample I.D.		B14-19681-1			
			Date Collected		05-Aug-14			
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Carbon Tetrachloride	µg/L	0.2	EPA 8260	07-Aug-14/O	< 0.2			
Monochlorobenzene (Chlorobenzene)	µg/L	0.2	EPA 8260	07-Aug-14/O	< 0.2			
Dichlorobenzene,1,2-	µg/L	0.1	EPA 8260	07-Aug-14/O	< 0.1			
Dichlorobenzene,1,4-	µg/L	0.2	EPA 8260	07-Aug-14/O	< 0.2			
Dichloroethane,1,2-	µg/L	0.1	EPA 8260	07-Aug-14/O	< 0.1			
Dichloroethene, 1,1-	µg/L	0.1	EPA 8260	07-Aug-14/O	< 0.1			
Ethylbenzene	µg/L	0.5	EPA 8260	07-Aug-14/O	< 0.5			
Dichloromethane (Methylene Chloride)	µg/L	0.3	EPA 8260	07-Aug-14/O	< 0.3			
Tetrachloroethylene	µg/L	0.2	EPA 8260	07-Aug-14/O	< 0.2			
Toluene	µg/L	0.5	EPA 8260	07-Aug-14/O	< 0.5			
Trichloroethylene	µg/L	0.1	EPA 8260	07-Aug-14/O	< 0.1			
Vinyl Chloride	µg/L	0.2	EPA 8260	07-Aug-14/O	< 0.2			
Xylene, m,p,o-	µg/L	0.4	EPA 8260	07-Aug-14/O	< 0.4			
Bromodichloromethane	µg/L	0.1	EPA 8260	07-Aug-14/O	< 0.1			
Bromoform	µg/L	0.1	EPA 8260	07-Aug-14/O	< 0.1			
Chloroform	µg/L	0.3	EPA 8260	07-Aug-14/O	< 0.3			
Dibromochloromethane	µg/L	0.1	EPA 8260	07-Aug-14/O	< 0.1			
Total Trihalomethanes	µg/L	0.3	EPA 8260	07-Aug-14/O	< 0.3			
Alachlor	µg/L	0.3	EPA 8270	15-Aug-14/K	< 0.3			
Aldicarb	µg/L	3	EPA 8270	15-Aug-14/K	< 3			
Aldrin + Dieldrin	µg/L	0.02	EPA 8080	14-Aug-14/K	< 0.02			
Atrazine + Metabolites	µg/L	0.5	Calc.	15-Aug-14/K	< 0.5			
Azinphos-methyl	µg/L	1	EPA 8270	15-Aug-14/K	< 1			
Bendiocarb	µg/L	3	EPA 8270	15-Aug-14/K	< 3			
Benzo(a)pyrene	µg/L	0.005	EPA 8270	15-Aug-14/K	< 0.005			
Bromoxynil	µg/L	0.3	EPA 8270	15-Aug-14/K	< 0.3			

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

M.D.L. = Method Detection Limit
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

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Table D-2: Water Quality Results

CADUCEON ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

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Attention: Alicia Beynon

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 06-Aug-14
DATE REPORTED: 05-Sep-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 13-1170-0040
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		TW21-72 hour			
			Sample I.D.		B14-19681-1			
			Date Collected		05-Aug-14			
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Carbaryl	µg/L	3	EPA 8270	15-Aug-14/K	< 3			
Carbofuran	µg/L	1	EPA 8270	15-Aug-14/K	< 1			
Chlordane (Total)	µg/L	0.04	EPA 8080	14-Aug-14/K	< 0.04			
Chlorpyrifos	µg/L	0.5	EPA 8270	15-Aug-14/K	< 0.5			
Cyanazine	µg/L	0.5	EPA 8270	15-Aug-14/K	< 0.5			
DDT + Metabolites	µg/L	0.01	EPA 8080	14-Aug-14/K	< 0.01			
Diazinon	µg/L	1	EPA 8270	15-Aug-14/K	< 1			
Dicamba	µg/L	5	EPA 8270	15-Aug-14/K	< 5			
Dichlorophenol, 2,4-	µg/L	0.1	EPA 8270	15-Aug-14/K	< 0.1			
Dichlorophenoxy acetic acid, 2,4- (2,4-D)	µg/L	5	EPA 8270	15-Aug-14/K	< 5			
Diclofop-methyl	µg/L	0.5	EPA 8270	15-Aug-14/K	< 0.5			
Dimethoate	µg/L	1	EPA 8270	15-Aug-14/K	< 1			
Dinoseb	µg/L	0.5	EPA 8270	15-Aug-14/K	< 0.5			
Dioxin & Furan (TEQ)	ppq	0.1	E.C. 1/RM/19	03-Sep-14	< 0.1 [4]			
Diquat	µg/L	5	EPA 549.1	11-Aug-14/K	< 5			
Diuron	µg/L	5	EPA 8270	15-Aug-14/K	< 5			
Glyphosate	µg/L	25	EPA 547	11-Aug-14/K	< 25			
Heptachlor + Heptachlor Epoxide	µg/L	0.1	EPA 8080	14-Aug-14/K	< 0.1			
Lindane (Hexachlorocyclohexane, Gamma)	µg/L	0.1	EPA 8080	14-Aug-14/K	< 0.1			
Malathion	µg/L	5	EPA 8270	15-Aug-14/K	< 5			
Methoxychlor	µg/L	0.1	EPA 8080	14-Aug-14/K	< 0.1			
Metolachlor	µg/L	3	EPA 8270	15-Aug-14/K	< 3			
Metribuzin	µg/L	3	EPA 8270	15-Aug-14/K	< 3			

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

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SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 13-1170-0040
P.O. NUMBER:
WATERWORKS NO.

	Client I.D.	TW21-72 hour			
	Sample I.D.	B14-19681-1			
	Date Collected	05-Aug-14			

Parameter	Units	M.D.L.	Reference Method	Date/Site Analyzed				
NTA	mg/L	0.03	J. Chrom A 690	11-Aug-14	< 0.03	3		
N-Nitrosodimethylamine	µg/L	0.0008	E3209A/SM 6410B	11-Aug-14	< 0.0008	3		
Paraquat	µg/L	1	EPA 549.1	11-Aug-14/K	< 1			
Parathion	µg/L	3	EPA 8270	15-Aug-14/K	< 3			
Pentachlorophenol	µg/L	0.1	EPA 8270	15-Aug-14/K	< 0.1			
Phorate	µg/L	0.3	EPA 8270	15-Aug-14/K	< 0.3			
Picloram	µg/L	5	EPA 8270	15-Aug-14/K	< 5			
Poly-Chlorinated Biphenyls (PCB's)	µg/L	0.05	EPA 8080	14-Aug-14/K	< 0.05			
Prometryne	µg/L	0.1	EPA 8270	15-Aug-14/K	< 0.1			
Simazine	µg/L	0.5	EPA 8270	15-Aug-14/K	< 0.5			
Temephos	µg/L	10	EPA 8270	15-Aug-14/K	< 10			
Terbufos	µg/L	0.3	EPA 8270	15-Aug-14/K	< 0.3			
Tetrachlorophenol, 2,3,4,6-	µg/L	0.1	EPA 8270	15-Aug-14/K	< 0.1			
Triallate	µg/L	10	EPA 8270	15-Aug-14/K	< 10			
Trichlorophenol 2,4,6-	µg/L	0.1	EPA 8270	15-Aug-14/K	< 0.1			
Trichlorophenoxy acetic acid, 2,4,5-	µg/L	10	EPA 8270	15-Aug-14/K	< 10			
Trifluralin	µg/L	0.5	EPA 8270	15-Aug-14/K	< 0.5			
Gross Alpha	Bq/L	0.1	GFPC	21-Aug-14	< 0.1	1		
Gross Beta	Bq/L	0.15	GFPC	21-Aug-14	< 0.15	1		
Tritium	Bq/L	100	LSC	21-Aug-14	< 100	1		
Total Coliform	cfu/100mL	1	MOE E3407	06-Aug-14/O	0			
E coli	cfu/100mL	1	MOE E3407	06-Aug-14/O	0			
Background	cfu/100mL	1	MOE E3407	06-Aug-14/O	76			
Heterotrophic Plate Count	cfu/mL	2	SM 9215C	06-Aug-14/O	< 2			

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

M.D.L. = Method Detection Limit
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

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Table D-2: Water Quality Results

CADUCEON™ ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

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SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 13-1170-0040
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		TW21-72 hour			
			Sample I.D.		B14-19681-1			
			Date Collected		05-Aug-14			
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Microcystin DM	ppb	0.1	NA	11-Aug-14	< 0.1 [2]			

1 Subcontracted to Becquerel Labs
2 subcontracted to COAL Inc.
3 Subcontracted to SGS Lakefield
4 Subcontracted to Wellington Labs

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

M.D.L. = Method Detection Limit
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

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Table D-2: Water Quality Results

CENTRAL ONTARIO ANALYTICAL LABORATORY INC.

4260 Burnside Line, R.R. #4
Orillia, ON L3V 6H4
Tel: (705) 326-8285 Fax: (705) 326-9316
www.coalab.ca

Final Certificate of Microbiological Analysis of Drinking Water

Date & Time Received:	Temp. Rec'd. (°C):	Receiver:	Date & Time Incubated:	2014-08-05 11:30
2014-08-05 11:00	3.1	AB	HPC & FS Date & Time Incubated:	

Date Sampled: 2014-08-05

Collected By: Alicia Beynon

Name of Facility: Golder Associates

Drinking Water System (DWS) #

Submitted By: Alicia Beynon

Twp/Town	
Systems Health Unit	SMDHU
Regulation	N/A
Total # of pages sent	3
# of samples sent	15
# of samples received	15

Report To: **Golder Associates Ltd.**

Address: 121 Commerce Park Drive, Unit L, Barrie, ON. L4N 8X1

Telephone: 705 722-4492 Ext: Fax: 705-722-3786

Email Address: patricia_chapple@golder.com ; Alicia_Beynon@golder.com

"Live Person" After Hours Contact Name and Tel. No:

Conditions/ Comments 13-1170-0040

Time Sampled	Sample Identifier	Identification of Collection Site	Water Type	Temp. Of Sample (°C/°F)	Treatment Information				Laboratory Number	Total Coliform		E. coli		Background		HPC		
					U.V.	Other	Total Cl_2 (mg/L)	Free Cl_2 (mg/L)		>/<	CFU/100 ml	>/<	CFU/100 ml	>/<	CFU/100 ml	>/<	CFU/1 ml	
10:00	TW21	(R)	R						905721		1		0		17			

All samples will be considered DISTRIBUTION samples unless otherwise indicated.

All times are transcribed in the 24-hour clock for upload to the Ministry of the Environment (MOE) and/or Ministry of Health and Long Term Care (MoHLTC).

Analysis performed by qualified analysts. Results relate only to the aliquot submitted. Samples have been analyzed as received. COAL is accredited by SCC and licensed by MOE in these specific microbiological parameters and the following inorganic and physical parameters: pH, turbidity, and alkalinity.

COAL accepts no responsibility for parameters selected, misidentification of samples or incorrect quantity, this is the responsibility of the submitting agency.

For collection and handling procedures visit www.coalab.ca/watersamples.html

Raw = R
Distribution = D
Point of Entry = E
Raw Water Comsumed = RWC

F.S. & Faecal Strep. = Faecal Streptococcus HPC = Hetero HPM = Heavy Particulate Matter N/R = Not Received F.S. and HPC require 48 hours of incubation

Analysis Date & Time: 2014-08-06 11:00 Enumerated By: LJ Audited By: GD Methodology: M/F CFU/100ml

Analysis Date & Time: Enumerated By: Audited By: HPC Methodology: SP CFU/1ml; FS Methodology: M/F CFU/100ml

Transcribed By: HM Authorized & Rechecked By: TJ/JT Copy Released By: AB, CAB, LJ

Lab No. ımitting Agenc Health Unit @ Spills Action Centre (SAC) @ AWQI # By: Date:

Test Methodology and Detection Limit

Total Coliform (Treated)	COAL Endo	0 - 80	Reportable Limit:	1	Performed by Membrane Filtration	M/F CFU/100 ml
Total Coliform (Untreated)	COAL DC	0 - 80	Reportable Limit:	1	Performed by Membrane Filtration	M/F CFU/100 ml
E. coli	COAL DC	0 - 60	Reportable Limit:	1	Performed by Membrane Filtration	M/F CFU/100 ml
Background	COAL Endo	0 - 200	Indicates Deterioration:	>200	Performed by Membrane Filtration	M/F CFU/100 ml
Background	COAL DC	0 - 200	Indicates Deterioration:	>200	Performed by Membrane Filtration	M/F CFU/100 ml
HPC	COAL HPC	10 - 2.00 x 10^3	Indicates Deterioration:	>500	Performed by Spread Plate	SP CFU/1 ml
Faecal Streptococcus	COAL FS	0 - 80	Reportable Limit:	1	Performed by Membrane Filtration	M/F CFU/100 ml

Approved for use by TJ prior to use.

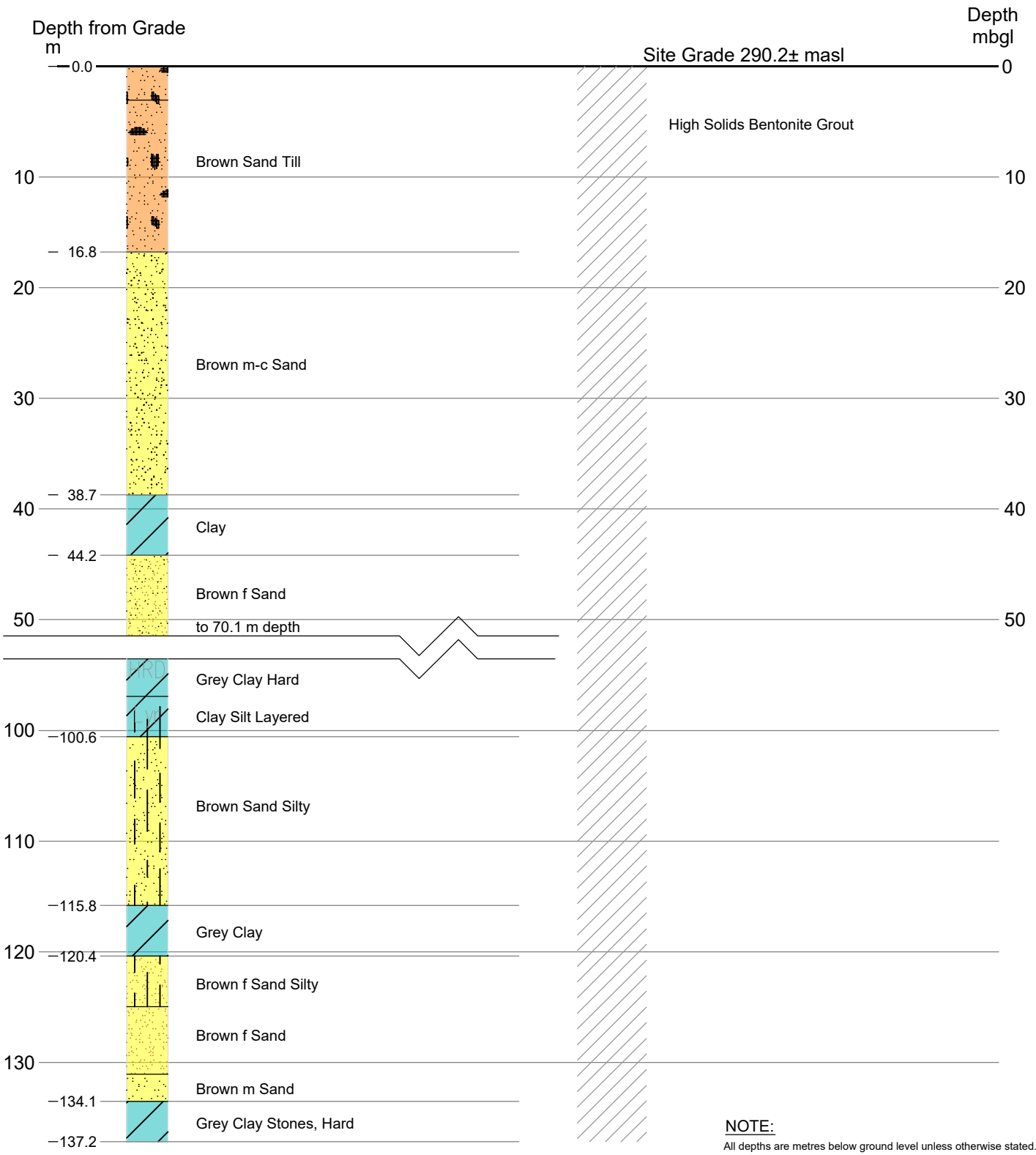
APPENDIX E

Site 4: Well Construction and Testing Doran Road

TH23

Golder ID L0424

Sealed and Abandoned



NOTE:

All depths are metres below ground level unless otherwise stated.
Converted depths to feet nominal 1 foot integrals
Refer to Drillers log for complete log

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-09-25
DESIGN	
CAD	JPR
CHECK	
REVIEW	

TITLE

TEST HOLE TH23
ABANDONED

FILE No. 1311700040CBLOGS.dwg
PROJECT No. 13-1170-0040 REV.

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE **E-1**

PLOT DATE: September 25, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\CB\1311700040CBLOGS.dwg: [Figure E-1]

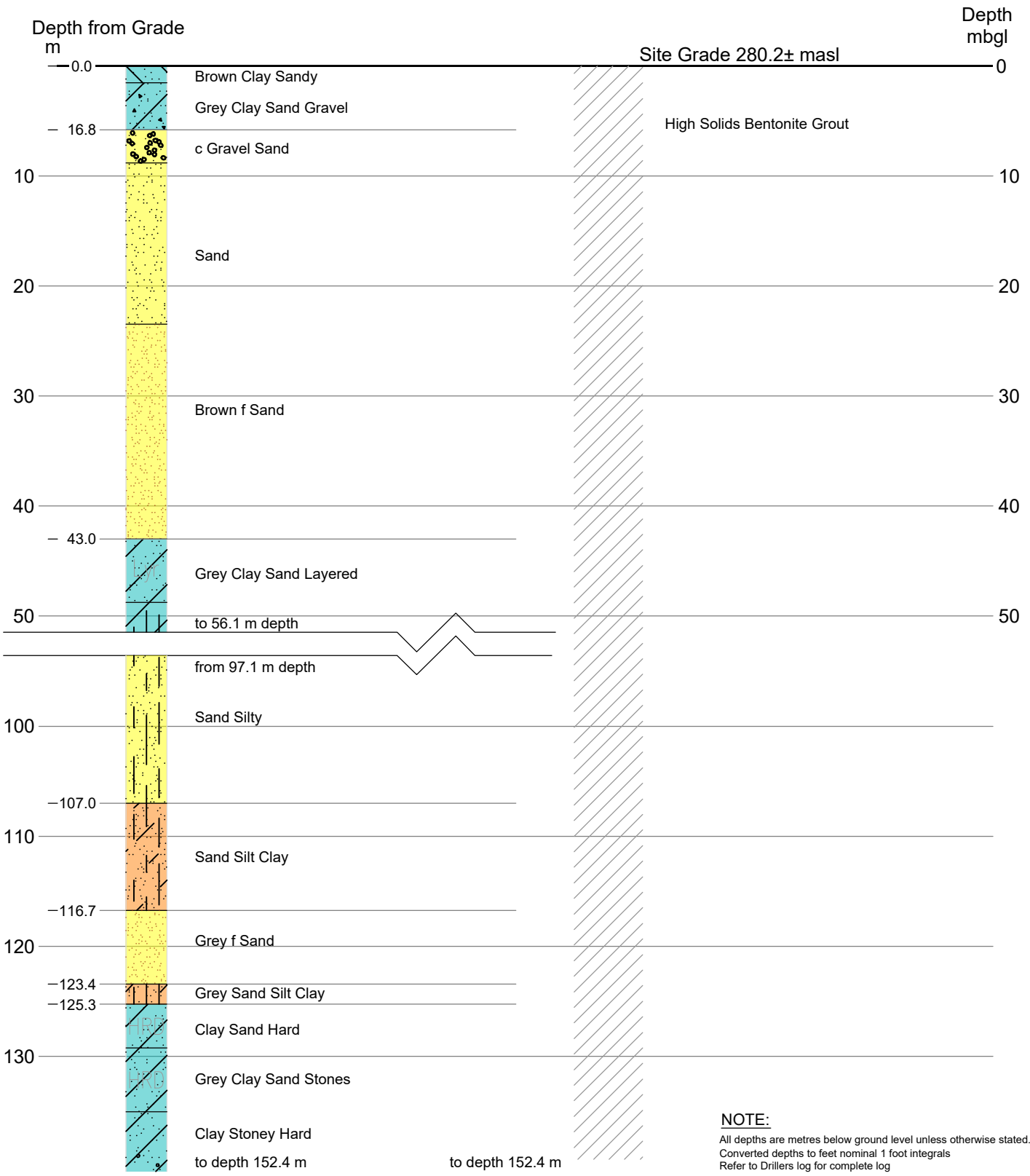
APPENDIX F

Site 5: Well Construction and Testing: Anne Street

TH26

Golder ID L0428

Sealed and Abandoned



NOTE:

All depths are metres below ground level unless otherwise stated.
Converted depths to feet nominal 1 foot integrals
Refer to Drillers log for complete log

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-09-25
DESIGN	
CAD	JPR
CHECK	
REVIEW	

TITLE

TEST HOLE TH26
ABANDONED

FILE No. 1311700040CBLOGS.dwg
PROJECT No. 13-1170-0040 REV.

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE **F-1**

PLOT DATE: September 25, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\CB-\1311700040CBLOGS.dwg: [Figure F-1]

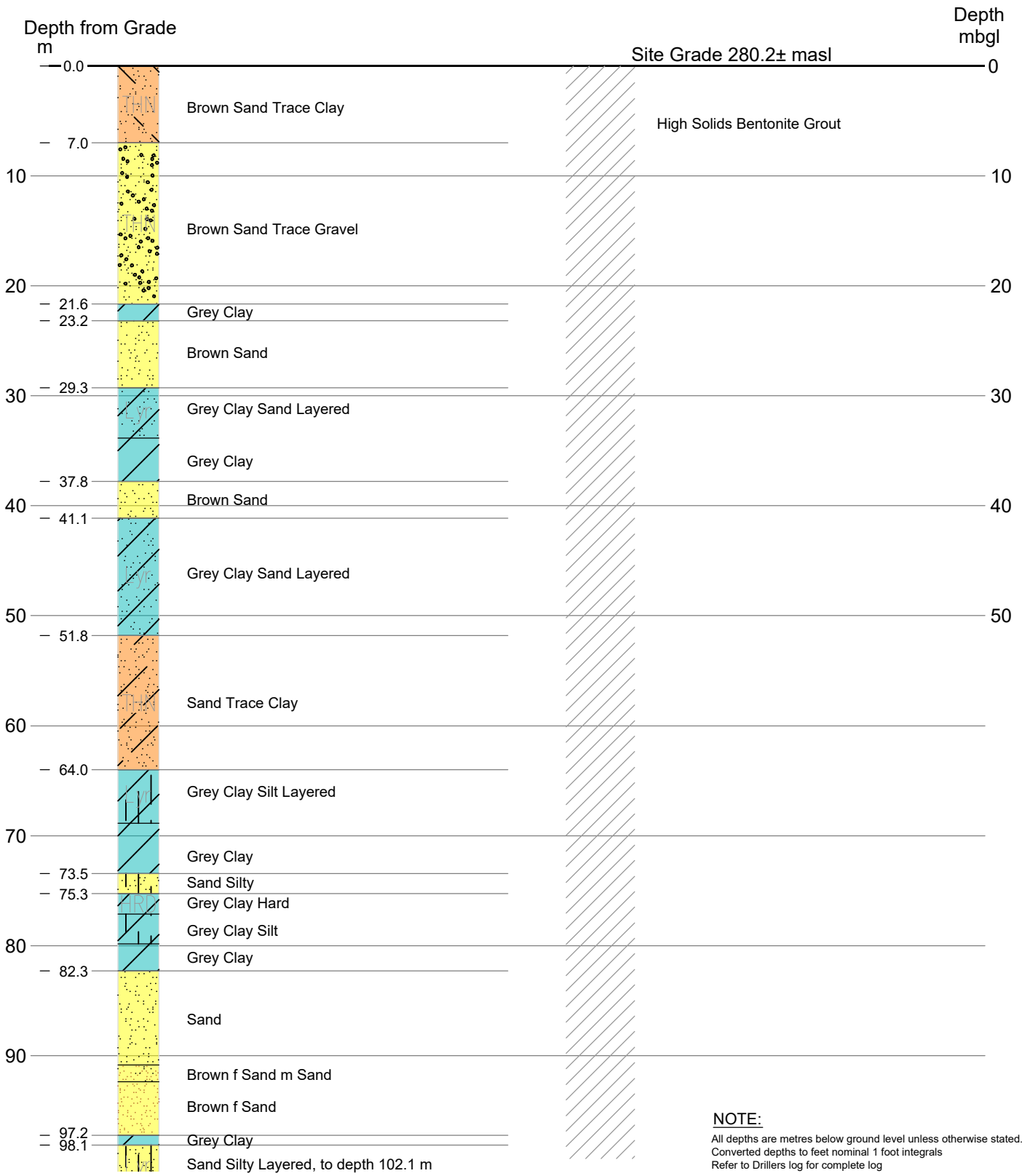
APPENDIX G

Site 6: Well Construction and Testing: Hickling Farm

TH27

Golder ID L0429

Sealed and Abandoned



NOTE:

All depths are metres below ground level unless otherwise stated.
Converted depths to feet nominal 1 foot integrals
Refer to Drillers log for complete log

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-09-25
DESIGN	
CAD	JPR
CHECK	
REVIEW	

TITLE

TEST HOLE TH27 ABANDONED

FILE No. 1311700040CBLOGS.dwg		
PROJECT No. 13-1170-0040	REV.	

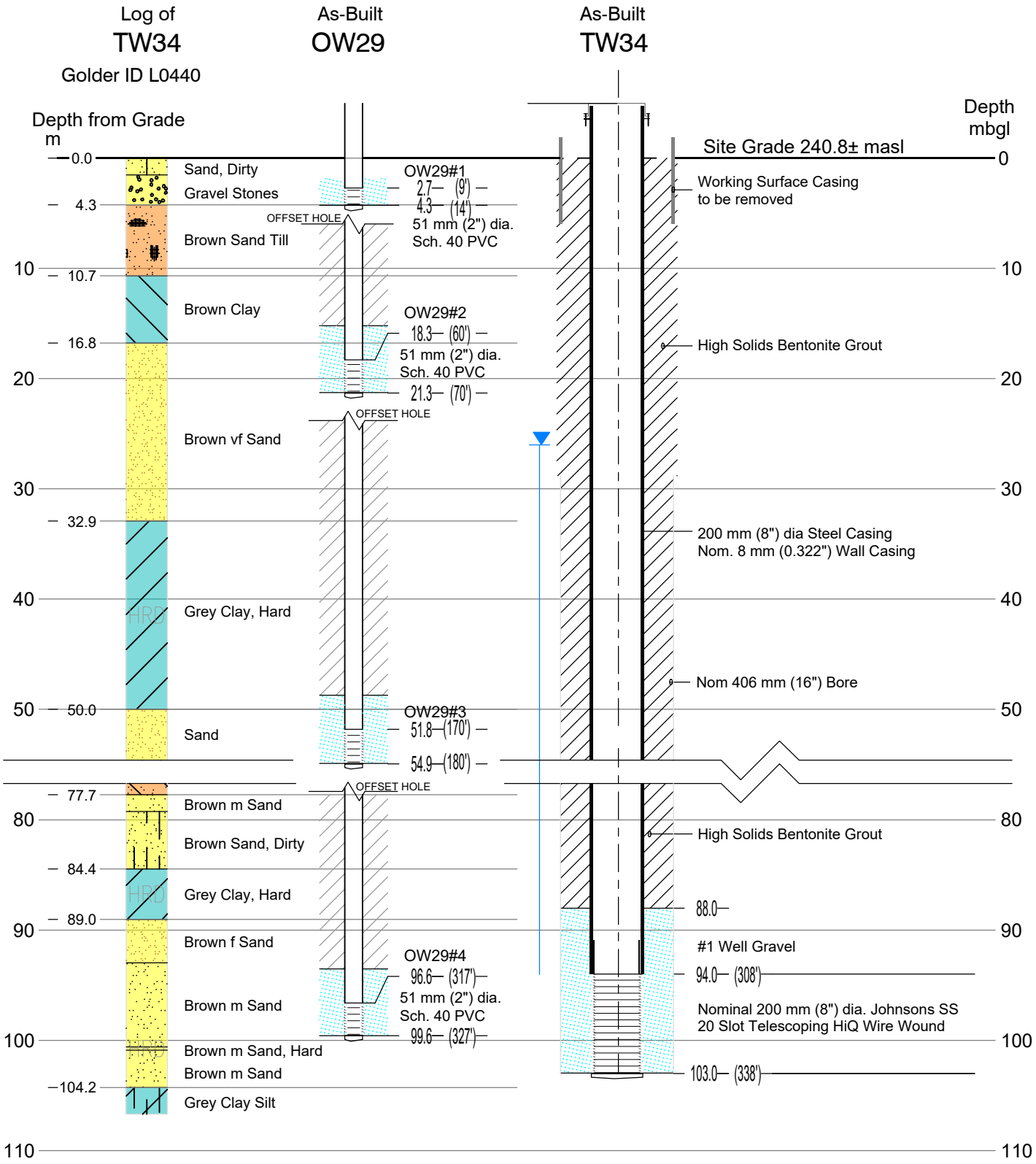
MIDHURST
WATER SUPPLY EXPLORATION

FIGURE **G-1**

PLOT DATE: September 25, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\CB\1311700040CBLOGS.dwg: [Figure G-1]

APPENDIX H

Site 7: Well Construction and Testing: Snow Valley Road (West)



NOTE:

All depths are metres below ground level unless otherwise stated.
Converted depths to feet nominal 1 foot integrals
Refer to Drillers log for complete log
Construction of OW29 is adjusted for difference relative to grade at TW34

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-07-08
DESIGN	
CAD	JPR
CHECK	
REVIEW	

TITLE

PRODUCTION WELL TW34
AS-BUILT

FILE No.	1311700040CBLOGS.dwg
PROJECT No.	13-1170-0040
REV.	

MIDHURST
WATER SUPPLY EXPLORATION

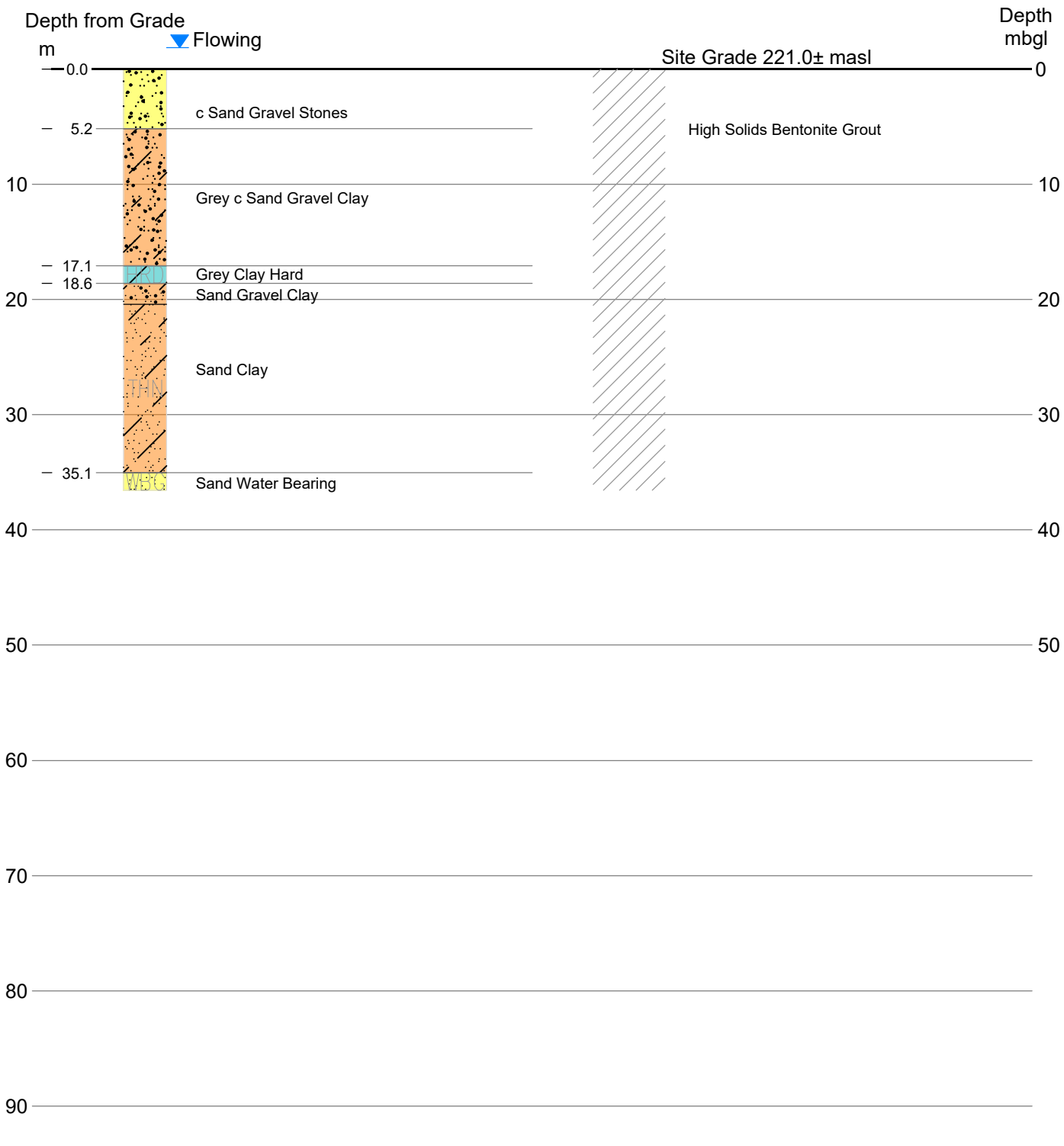
FIGURE
H-1

PLOT DATE: October 30, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-CB-\1311700040CBLOGS.dwg: [Figure H-1]

TH33

Golder ID L0438

Sealed and Abandoned



NOTE:

All depths are metres below ground level unless otherwise stated.
Converted depths to feet nominal 1 foot integrals
Refer to Drillers log for complete log

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-09-25
DESIGN	
CAD	JPR
CHECK	
REVIEW	

TITLE

TEST HOLE TH33
ABANDONED

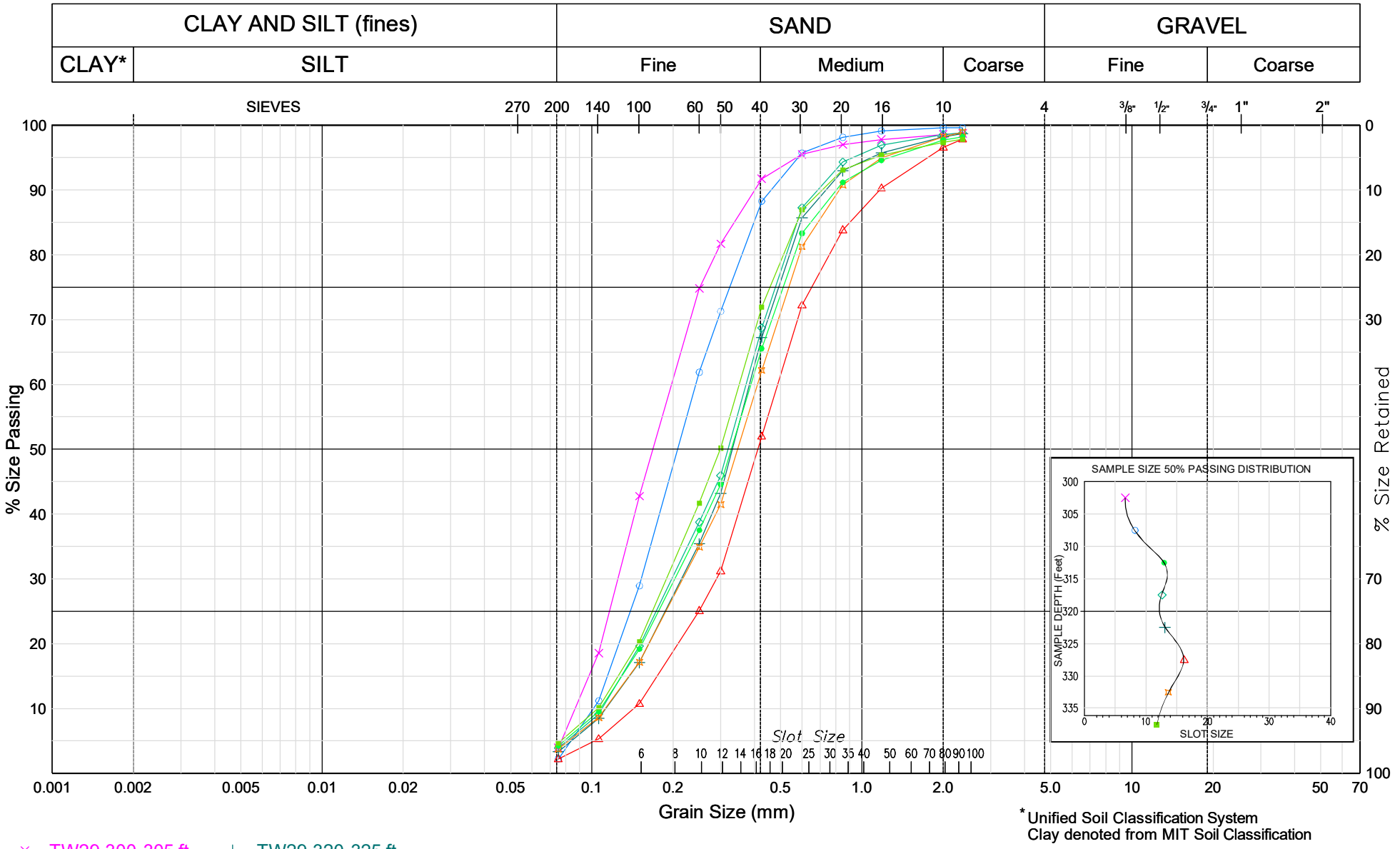
FILE No. 1311700040CBLOGS.dwg
PROJECT No. 13-1170-0040 REV.

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE **H-2**

PLOT DATE: October 30, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\CB\1311700040CBLOGS.dwg: [Figure H-2]

PLOT DATE: October 30, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-BA-\1311700040BASVE29.dwg



*Unified Soil Classification System
Clay denoted from MIT Soil Classification

TITLE

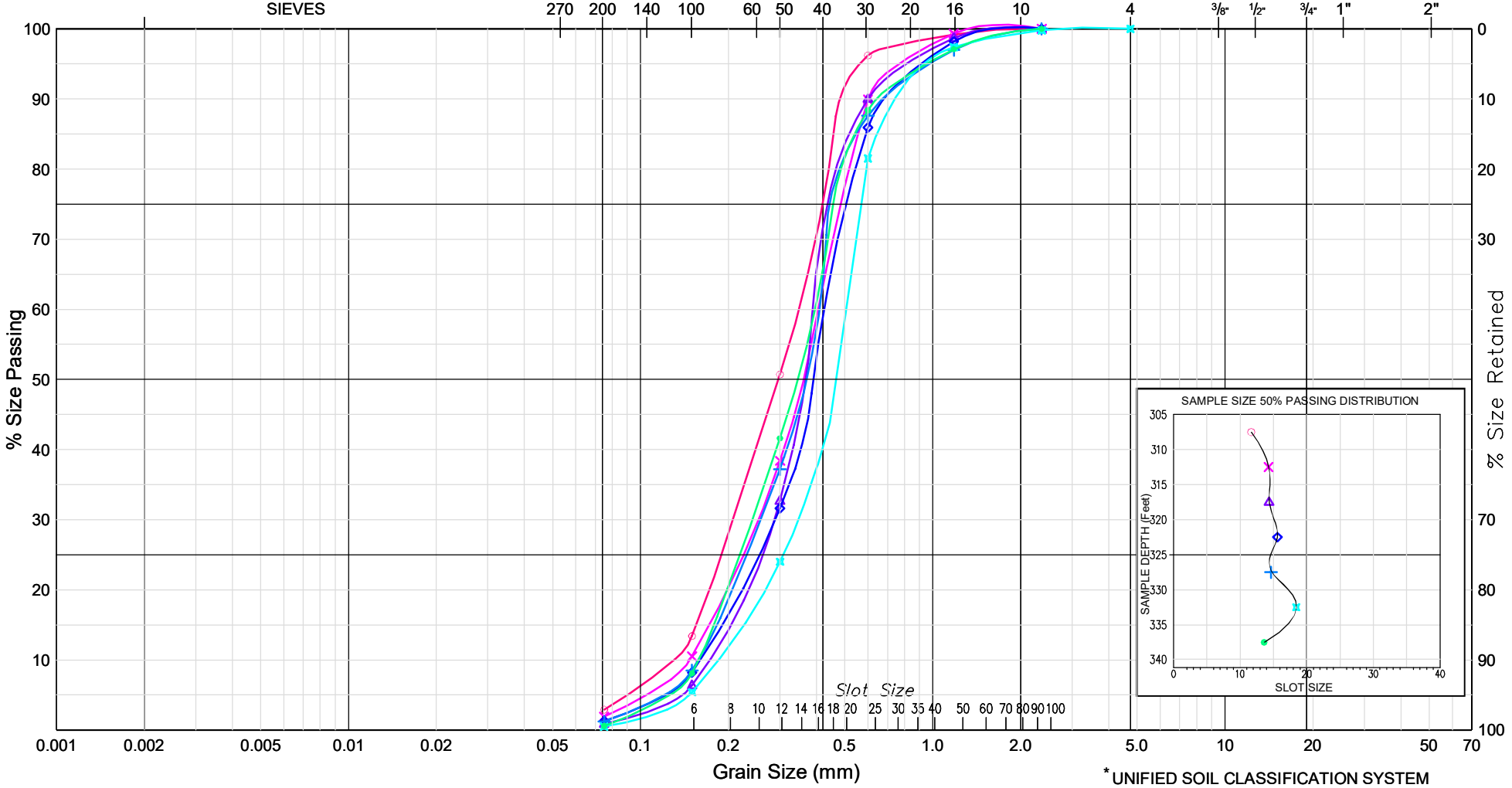
GRAIN SIZE ANALYSIS
OW29

MIDHURST
WATER SUPPLY EXPLORATION

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-04-04
CAD	JPR
CHECK	
REVIEW	
FILE No.	1311700040BASVE29.dwg
PROJECT No.	13-1170-0040
REV.	
FIGURE	H-3

PLOT DATE: October 30, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-BA-\1311700040BASVE34.dwg



LEGEND

- TW34 305-310 ft
- TW34 310-315 ft
- TW34 315-320 ft
- TW34 320-325 ft
- TW34 325-330 ft
- TW34 330-335 ft
- TW34 335-340 ft

*UNIFIED SOIL CLASSIFICATION SYSTEM
CLAY DENOTED FROM MIT SOIL CLASSIFICATION

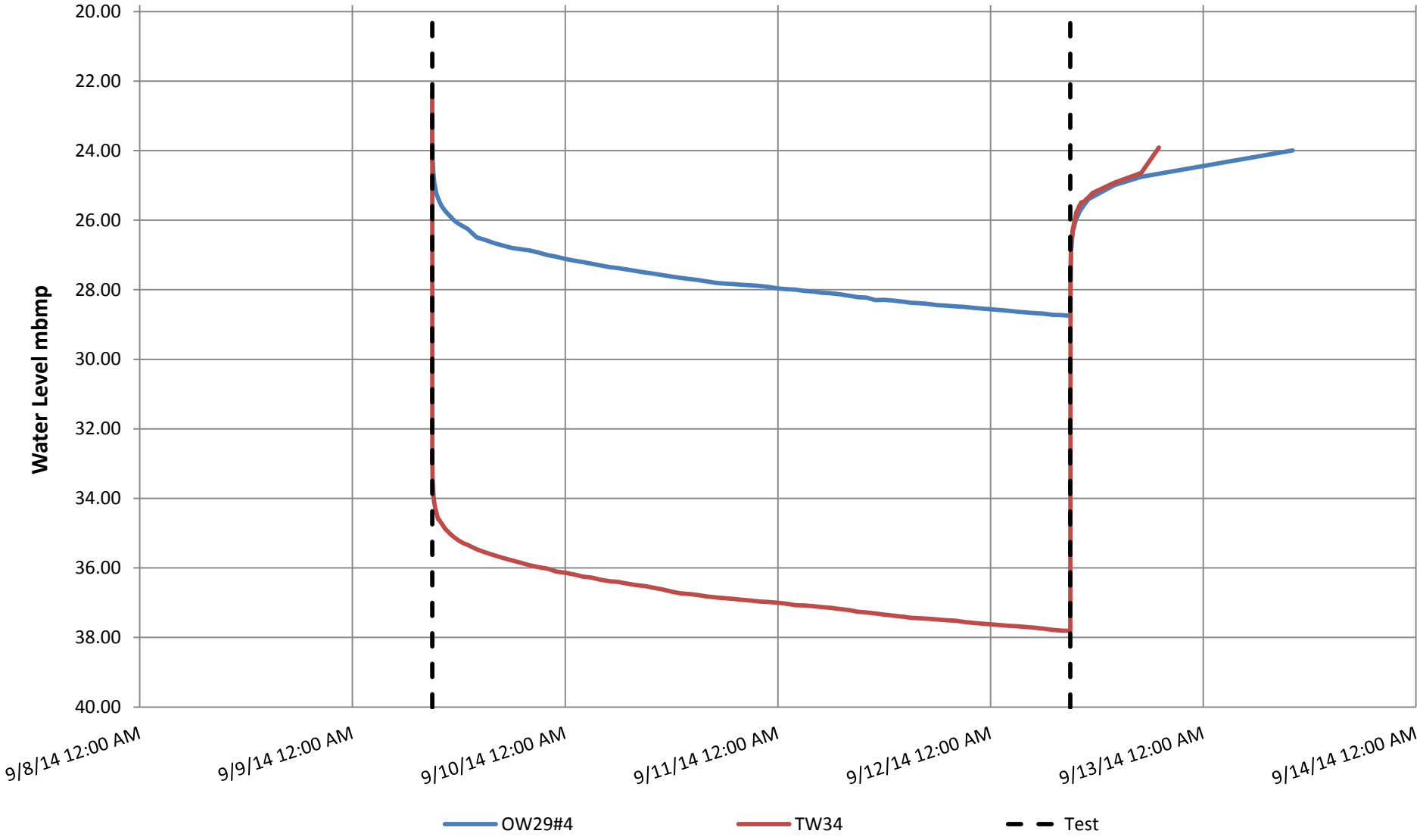
TITLE

GRAIN SIZE ANALYSIS
TW34

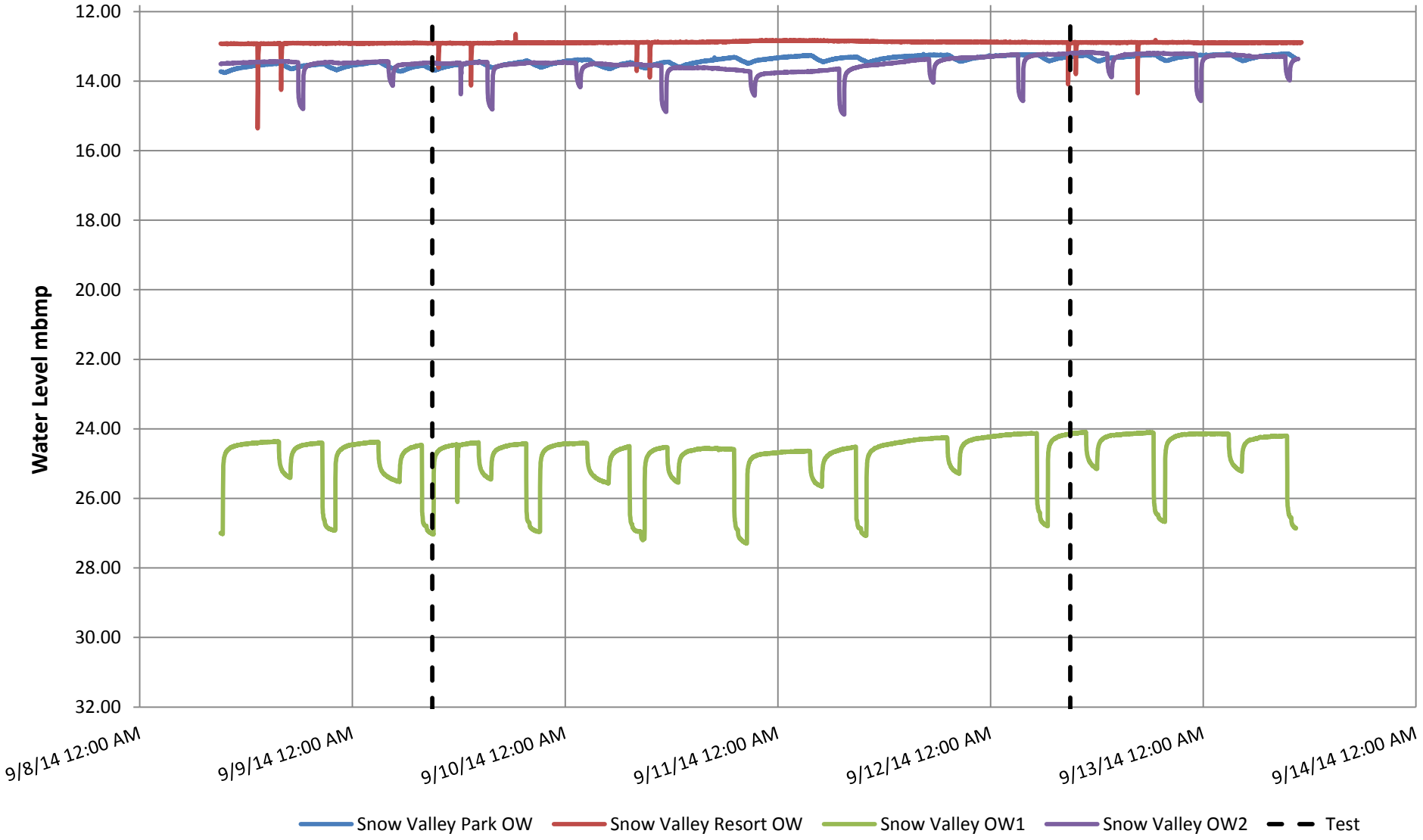
MIDHURST
WATER SUPPLY EXPLORATION

Golder Associates
Barrie, Ontario, Canada

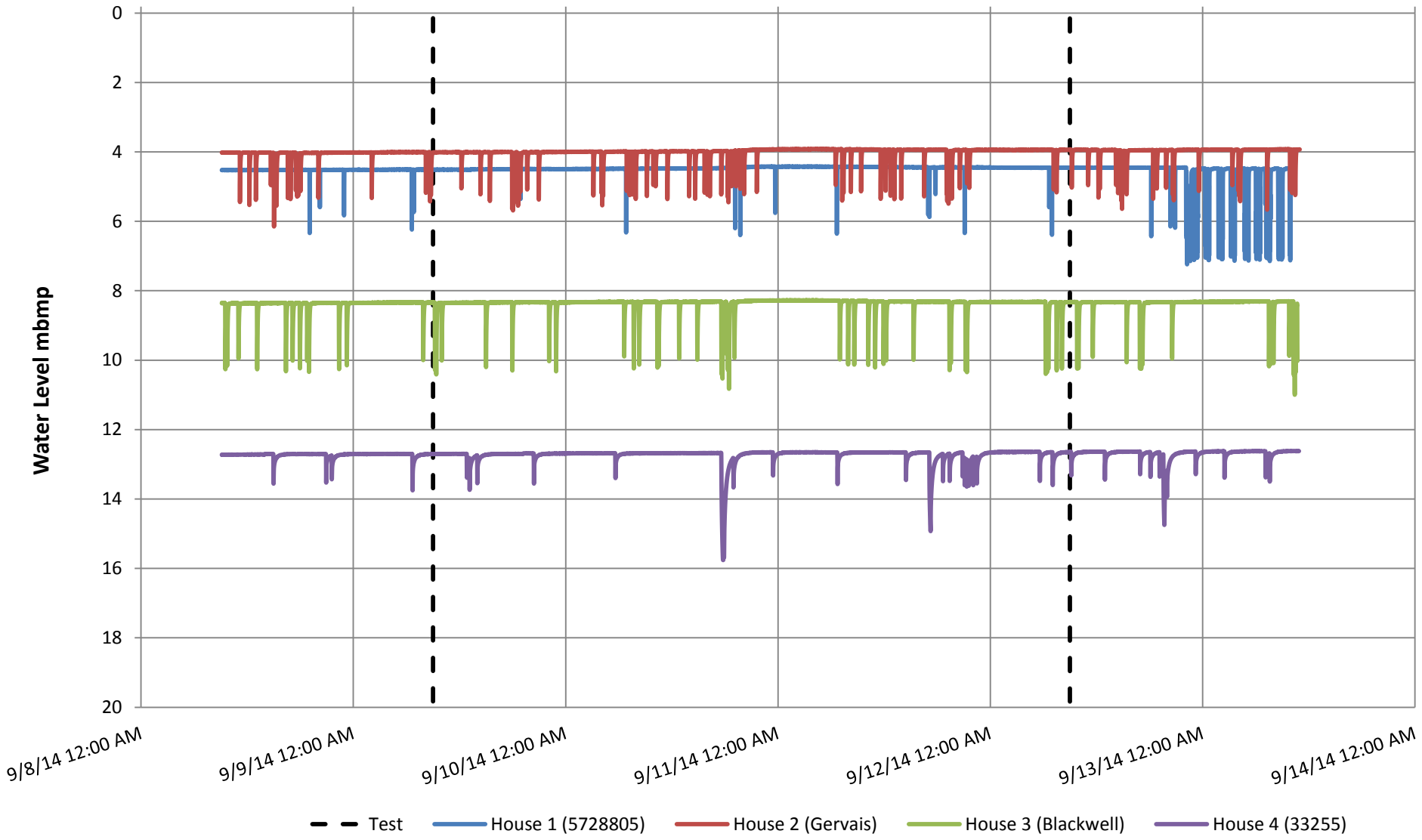
SCALE	AS SHOWN
DATE	2014-10-30
CAD	JPR
CHECK	ALB
REVIEW	JAE
FILE No.	1311700040BASVE34.dwg
PROJECT No.	13-1170-0040
REV.	
FIGURE	H-4



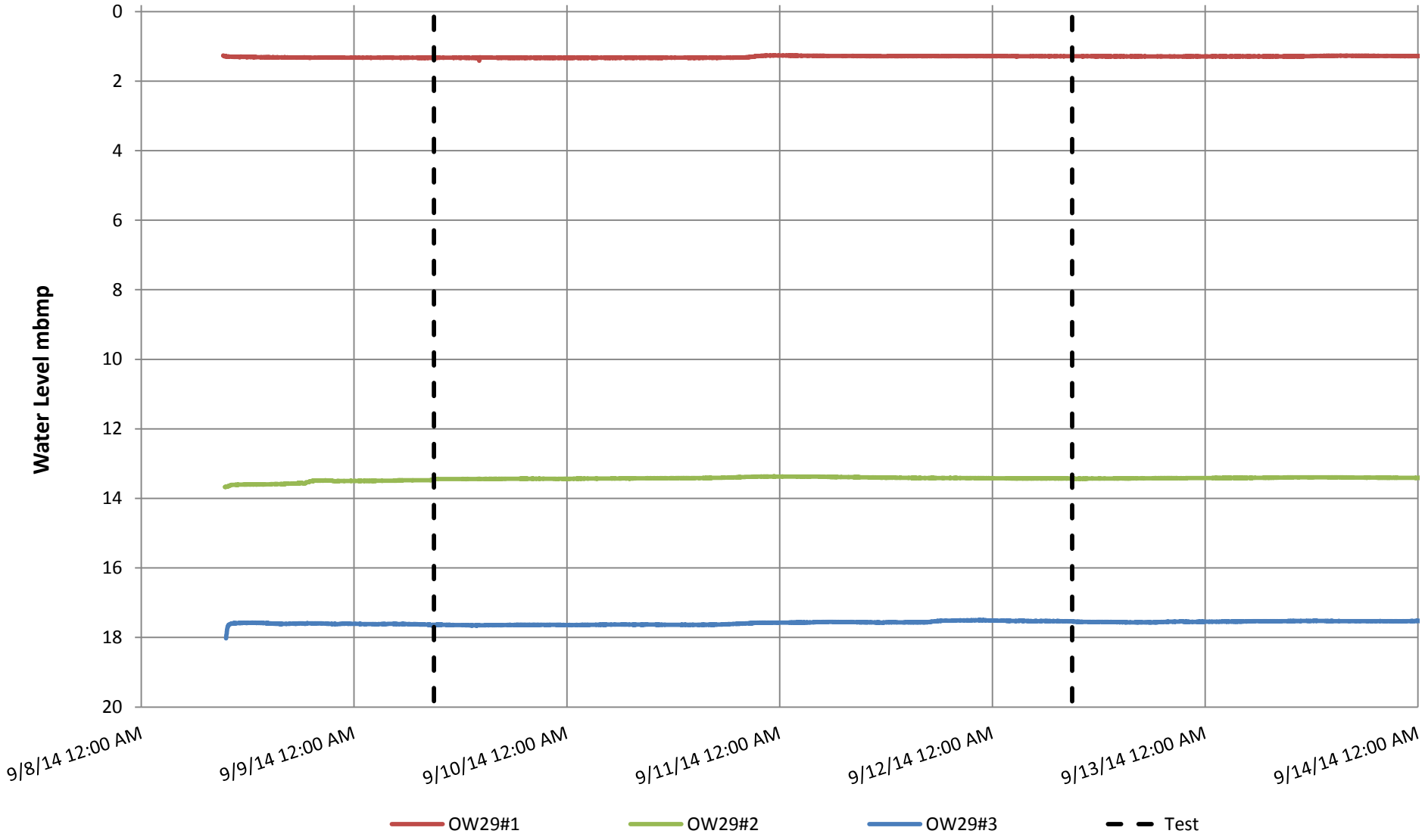
Test Date: September 9, 2014	Golder Associates	SCALE: NTS	**Testing of TW34**	
Pumping Rate: 20 L/s		DATE: 29-Oct-14	**Record of Observation Wells**	
		CAD: ALB		
	FILE No. 1311700040TRANS	CHECK:	MIDHURST WATER SUPPLY	FIGURE No.
	PROJECT No. 13-1170-0040	REVIEW:	CONSTRUCTION & TESTING of TW34	H-5



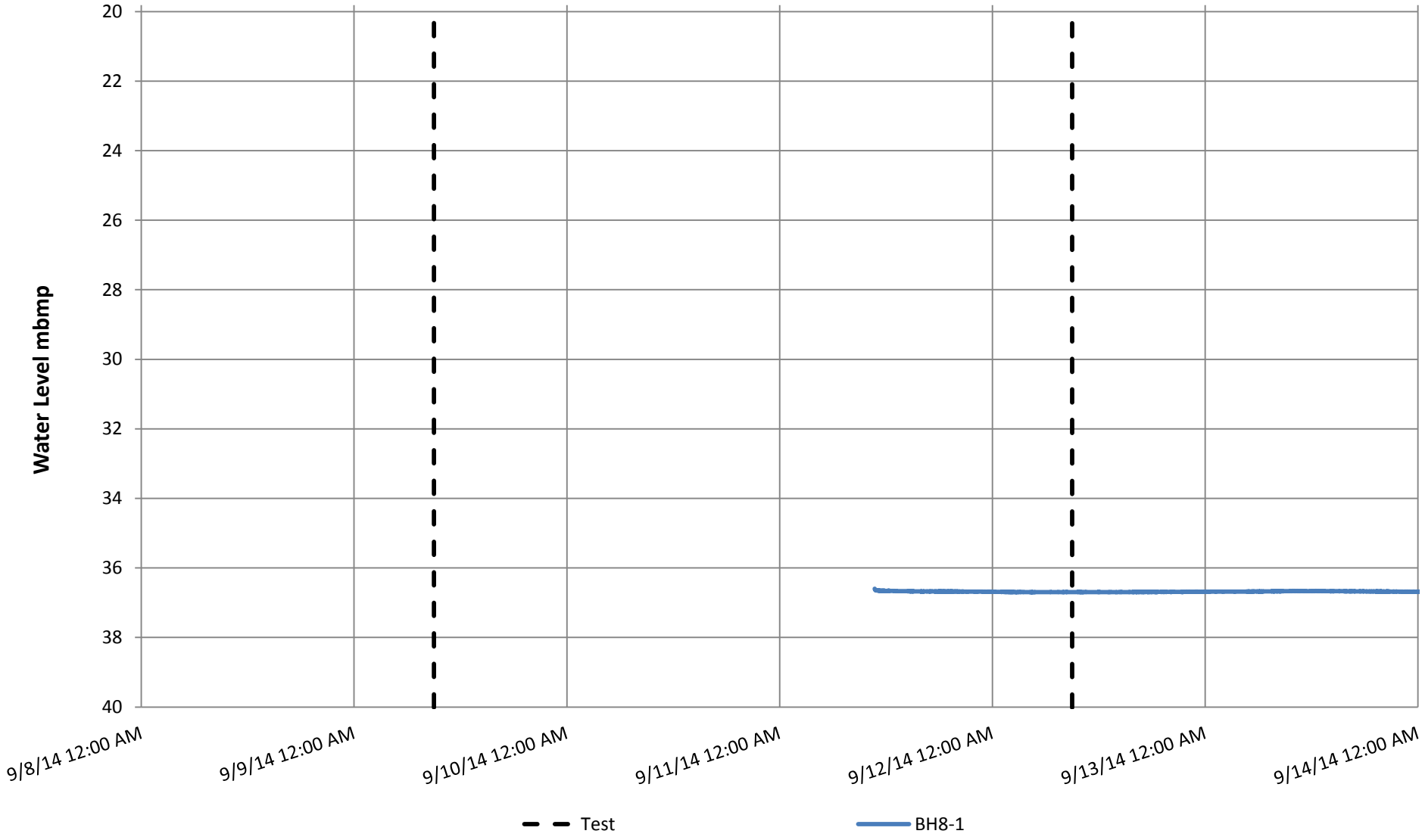
Test Date: September 9, 2014	Golder Associates	SCALE: NTS	**Testing of TW34**	
Pumping Rate: 20 L/s		DATE: 29-Oct-14	**Record of Observation Wells**	
		CAD: ALB		
	FILE No. 1311700040TRANS	CHECK:	MIDHURST WATER SUPPLY	FIGURE No.
	PROJECT No. 13-1170-0040	REVIEW:	CONSTRUCTION & TESTING of TW34	H-6



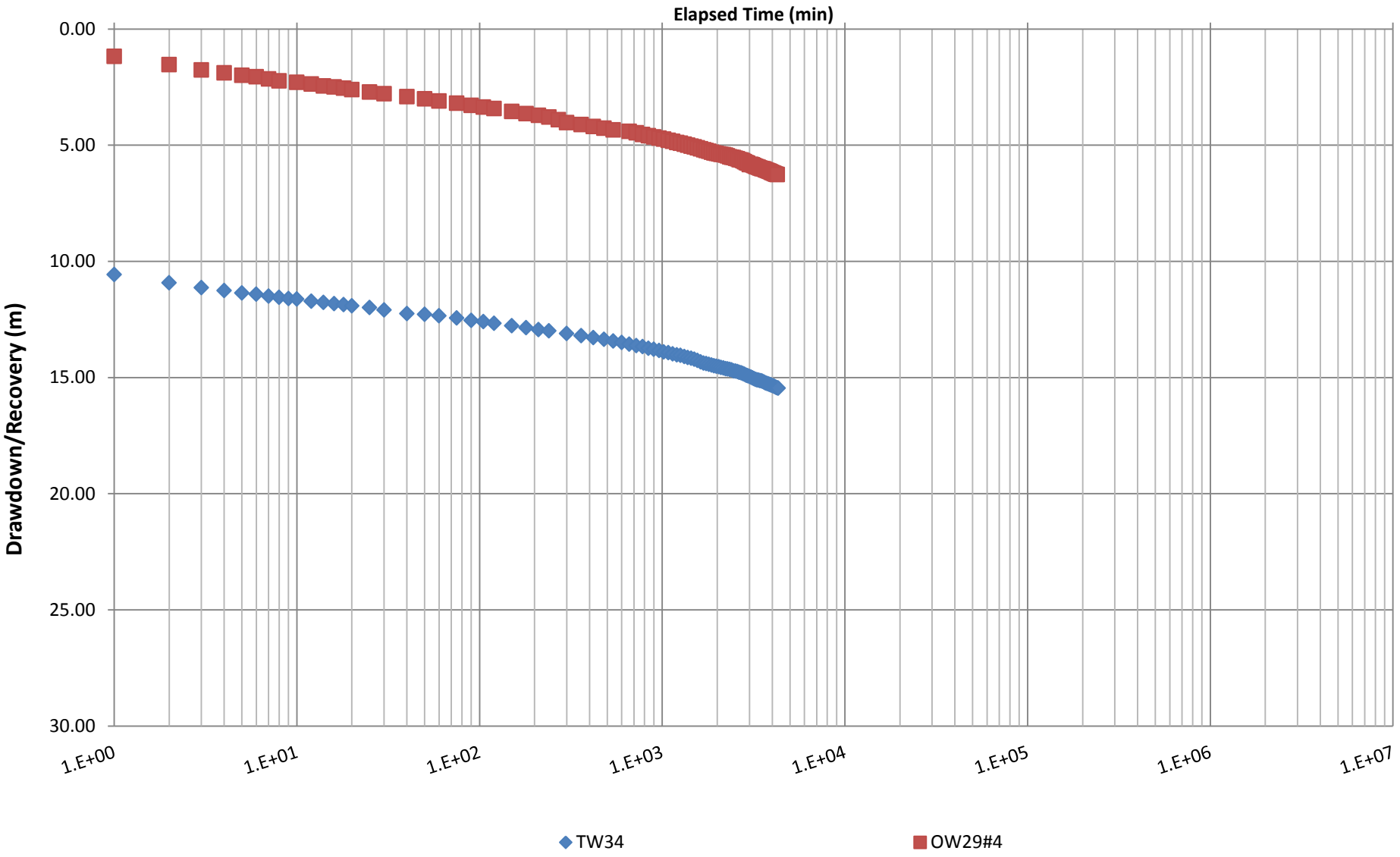
Test Date: September 9, 2014	Golder Associates	SCALE: NTS	**Testing of TW34** **Record of Oberservation Wells**
Pumping Rate: 20 L/s		DATE: 29-Oct-14	
		CAD: ALB	
	FILE No. 1311700040TRANS	CHECK:	MIDHURST WATER SUPPLY CONSTRUCTION & TESTING of TW34 — FIGURE No. H-7
	PROJECT No. 13-1170-0040	REVIEW:	



Test Date: September 9, 2014	Golder Associates	SCALE: NTS	**Testing of TW34**	
Pumping Rate: 20 L/s		DATE: 29-Oct-14	**Record of Observation Wells**	
		CAD: ALB		
	FILE No. 1311700040TRANS	CHECK:	MIDHURST WATER SUPPLY	FIGURE No.
	PROJECT No. 13-1170-0040	REVIEW:	CONSTRUCTION AND TEST of TW34	H-8



Test Date:	September 9, 2014	Golder Associates	SCALE:	NTS	**Testing of TW34** **Record of Observation Well BH8-1**
Pumping Rate:	20 L/s		DATE:	29-Oct-14	
			CAD:	ALB	
Static Water Level (mbmp):	36.6	FILE No. 1311700040TRANS	CHECK:		MIDHURST WATER SUPPLY CONSTRUCTION & TESTING of TW34
		PROJECT No. 13-1170-0040	REVIEW:		FIGURE No. H-9



Test Date:	September 9, 2014	SCALE:	NTS
Pumping Rate:	20 L/s	DATE:	30-Oct-14
TW34 Static Level (mbmp):	22.35	CAD:	ALB
TW34 Pumping Level (mbmp):	37.81	CHECK:	
		REVIEW:	

Golder Associates

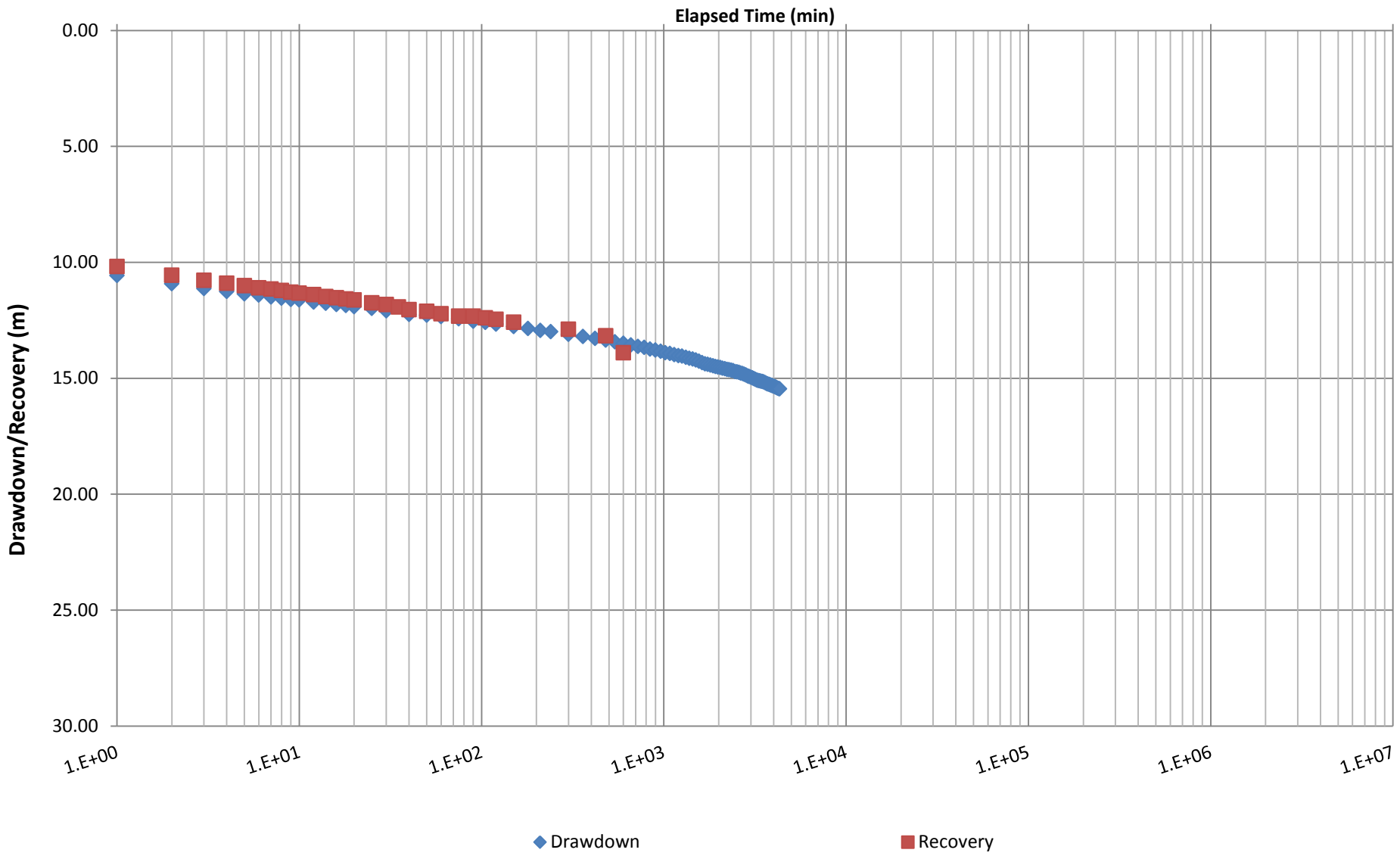
FILE No. 1311700040TRANS

PROJECT No. 13-1170-0040

Pumping Test Hydrograph
Record of OW29#4 and TW34

MIDHURST WATER SUPPLY
CONSTRUCTION & TESTING of TW34

FIGURE No.
H-10



Test Date:	September 9, 2014
Pumping Rate:	20 L/s
Distance from TW34 (m):	0
Static Water Level (mbmp):	22.35
Pumping Water Level (mbmp):	37.81

Golder Associates

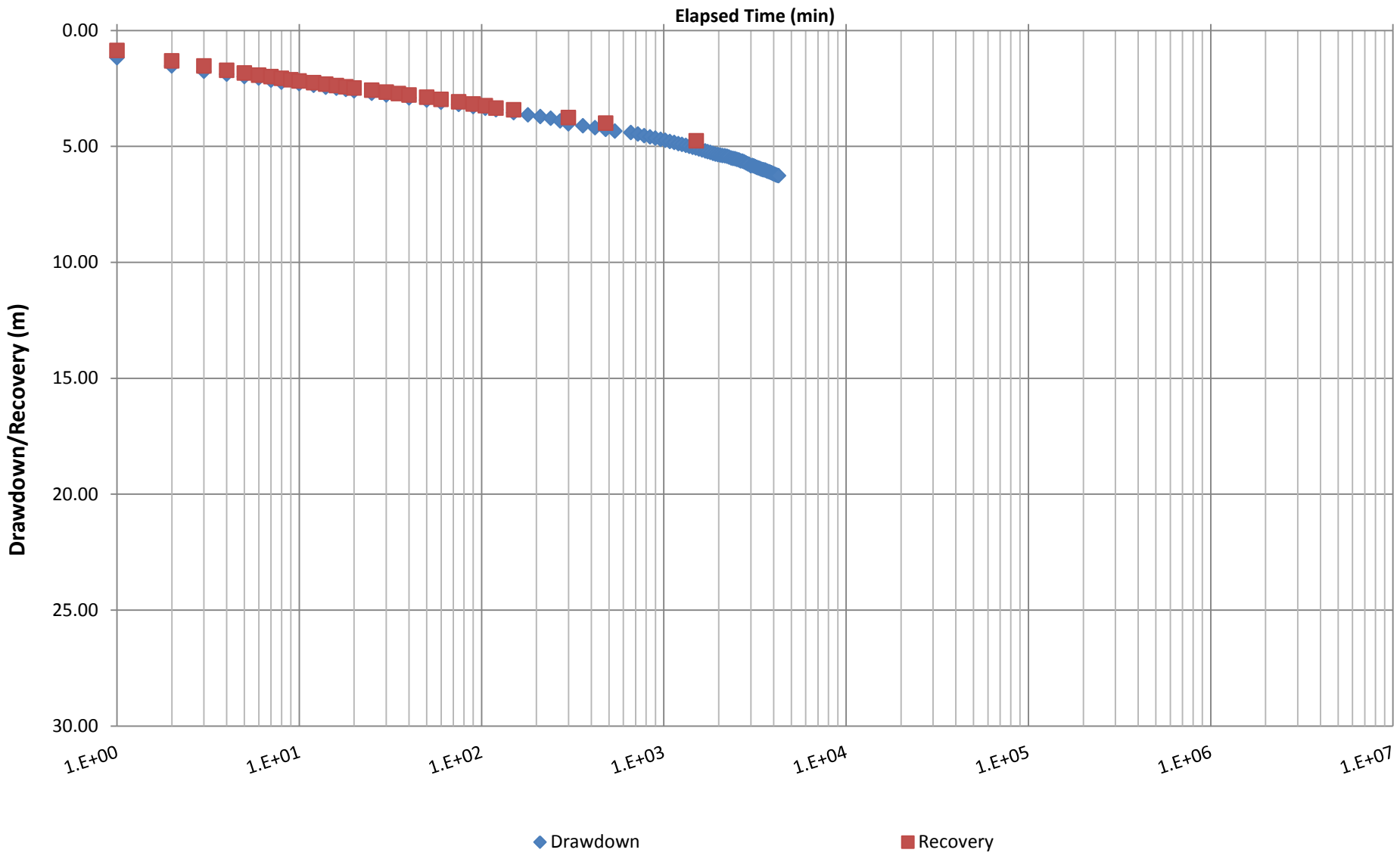
FILE No.	1311700040TRANS
PROJECT No.	13-1170-0040

SCALE:	NTS
DATE:	29-Oct-14
CAD:	ALB
CHECK:	
REVIEW:	

Pumping Test Hydrograph
Record of TW34

MIDHURST WATER SUPPLY
CONSTRUCTION & TESTING of TW34

FIGURE No.
H-11



Test Date:	September 9, 2014
Pumping Rate:	20 L/s
Distance from TW34:	17 m
Static Water Level (mbmp):	22.46
Pumping Water Level (mbmp):	28.75

Golder Associates

FILE No.	1311700040TRANS
PROJECT No.	13-1170-0040

SCALE:	NTS
DATE:	29-Oct-14
CAD:	ALB
CHECK:	
REVIEW:	

Pumping Test Hydrograph
Record of OW29#4

MIDHURST WATER SUPPLY
CONSTRUCTION & TESTING of TW34

FIGURE No.
H-12

Tabulated Levels forTW34

Pump On:	09-Sep-2014 09:00			Static Level:	22.35		
Pump Off:	12-Sep-2014 09:00			Pumping Level:	37.81		
Pumping Well:	**TW34**			DD:	15.46		
Distance from Pumping Well:	0 m			20 Yr DD:	24		
Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
09-Sep-2014 09:00	0	22.35	0.00	12-Sep-2014 09:00	0	37.81	0.00
09-Sep-2014 09:01	1	32.92	10.57	12-Sep-2014 09:00	0.500000002	28.12	9.69
09-Sep-2014 09:02	2	33.28	10.93	12-Sep-2014 09:01	1.000000003	27.63	10.18
09-Sep-2014 09:03	3	33.48	11.13	12-Sep-2014 09:02	1.999999996	27.25	10.56
09-Sep-2014 09:04	4	33.61	11.26	12-Sep-2014 09:03	2.999999999	27.03	10.78
09-Sep-2014 09:05	5	33.71	11.36	12-Sep-2014 09:04	4.000000003	26.91	10.90
09-Sep-2014 09:06	6	33.77	11.42	12-Sep-2014 09:05	4.999999995	26.80	11.01
09-Sep-2014 09:07	7	33.85	11.50	12-Sep-2014 09:06	5.999999999	26.71	11.10
09-Sep-2014 09:08	8	33.90	11.55	12-Sep-2014 09:07	7.000000002	26.65	11.16
09-Sep-2014 09:09	9	33.95	11.60	12-Sep-2014 09:08	8.000000005	26.59	11.22
09-Sep-2014 09:10	10	33.98	11.63	12-Sep-2014 09:09	8.999999998	26.52	11.29
09-Sep-2014 09:12	12	34.07	11.72	12-Sep-2014 09:10	10	26.48	11.33
09-Sep-2014 09:14	14	34.12	11.77	12-Sep-2014 09:12	12	26.42	11.39
09-Sep-2014 09:16	16	34.17	11.82	12-Sep-2014 09:14	14	26.33	11.48
09-Sep-2014 09:18	18	34.22	11.87	12-Sep-2014 09:16	16	26.28	11.53
09-Sep-2014 09:20	20	34.27	11.92	12-Sep-2014 09:18	18	26.23	11.58
09-Sep-2014 09:25	25	34.34	11.99	12-Sep-2014 09:20	20	26.18	11.63
09-Sep-2014 09:30	30	34.44	12.09	12-Sep-2014 09:25	25	26.06	11.75
09-Sep-2014 09:40	40	34.60	12.25	12-Sep-2014 09:30	30	25.99	11.82
09-Sep-2014 09:50	50	34.63	12.28	12-Sep-2014 09:35	35	25.88	11.93
09-Sep-2014 10:00	60	34.70	12.35	12-Sep-2014 09:40	40	25.77	12.04
09-Sep-2014 10:15	75	34.79	12.44	12-Sep-2014 09:50	50	25.69	12.12
09-Sep-2014 10:30	90	34.89	12.54	12-Sep-2014 10:00	60	25.59	12.22
09-Sep-2014 10:45	105	34.95	12.60	12-Sep-2014 10:15	75	25.48	12.33
09-Sep-2014 11:00	120	35.02	12.67	12-Sep-2014 10:30	90	25.48	12.33
09-Sep-2014 11:30	150	35.12	12.77	12-Sep-2014 10:45	105	25.41	12.40
09-Sep-2014 12:00	180	35.21	12.86	12-Sep-2014 11:00	120	25.35	12.46
09-Sep-2014 12:30	210	35.29	12.94	12-Sep-2014 11:30	150	25.22	12.59
09-Sep-2014 13:00	240	35.34	12.99	12-Sep-2014 14:00	300	24.92	12.89
09-Sep-2014 14:00	300	35.46	13.11	12-Sep-2014 17:00	480	24.64	13.17
09-Sep-2014 15:00	360	35.55	13.20	12-Sep-2014 19:00	600	23.91	13.90
09-Sep-2014 16:00	420	35.64	13.29				
09-Sep-2014 17:00	480	35.71	13.36				
09-Sep-2014 18:00	540	35.78	13.43				
09-Sep-2014 19:00	600	35.85	13.50				
09-Sep-2014 20:00	660	35.92	13.57				
09-Sep-2014 21:00	720	35.98	13.63				
09-Sep-2014 22:00	780	36.02	13.67				
09-Sep-2014 23:00	840	36.10	13.75				
10-Sep-2014 00:00	900	36.14	13.79				
10-Sep-2014 01:00	960	36.19	13.84				
10-Sep-2014 02:00	1020	36.25	13.90				
10-Sep-2014 03:00	1080	36.28	13.93				
10-Sep-2014 04:00	1140	36.34	13.99				
10-Sep-2014 05:00	1200	36.38	14.03				
10-Sep-2014 06:00	1260	36.40	14.05				
10-Sep-2014 07:00	1320	36.45	14.10				
10-Sep-2014 08:00	1380	36.49	14.14				
10-Sep-2014 09:00	1440	36.52	14.17				
10-Sep-2014 10:00	1500	36.57	14.22				
10-Sep-2014 11:00	1560	36.62	14.27				
10-Sep-2014 12:00	1620	36.68	14.33				
10-Sep-2014 13:00	1680	36.73	14.38				
10-Sep-2014 14:00	1740	36.75	14.40				
10-Sep-2014 15:00	1800	36.78	14.43				
10-Sep-2014 16:00	1860	36.82	14.47				
10-Sep-2014 17:00	1920	36.85	14.50				
10-Sep-2014 18:00	1980	36.87	14.52				
10-Sep-2014 19:00	2040	36.89	14.54				
10-Sep-2014 20:00	2100	36.92	14.57				
10-Sep-2014 21:00	2160	36.94	14.59				
10-Sep-2014 22:00	2220	36.97	14.62				
10-Sep-2014 23:00	2280	36.98	14.63				
11-Sep-2014 00:00	2340	37.00	14.65				
11-Sep-2014 01:00	2400	37.03	14.68				
11-Sep-2014 02:00	2460	37.07	14.72				
11-Sep-2014 03:00	2520	37.08	14.73				
11-Sep-2014 04:00	2580	37.10	14.75				
11-Sep-2014 05:00	2640	37.13	14.78				
11-Sep-2014 06:00	2700	37.15	14.80				
11-Sep-2014 07:00	2760	37.18	14.83				
11-Sep-2014 08:00	2820	37.21	14.86				
11-Sep-2014 09:00	2880	37.26	14.91				
11-Sep-2014 10:00	2940	37.28	14.93				
11-Sep-2014 11:00	3000	37.31	14.96				
11-Sep-2014 12:00	3060	37.34	14.99				
11-Sep-2014 13:00	3120	37.37	15.02				
11-Sep-2014 14:00	3180	37.40	15.05				
11-Sep-2014 15:00	3240	37.43	15.08				
11-Sep-2014 16:00	3300	37.45	15.10				

11-Sep-2014 17:00	3360	37.46	15.11
11-Sep-2014 18:00	3420	37.48	15.13
11-Sep-2014 19:00	3480	37.50	15.15
11-Sep-2014 20:00	3540	37.52	15.17
11-Sep-2014 21:00	3600	37.55	15.20
11-Sep-2014 22:00	3660	37.58	15.23
11-Sep-2014 23:00	3720	37.60	15.25
12-Sep-2014 00:00	3780	37.62	15.27
12-Sep-2014 01:00	3840	37.64	15.29
12-Sep-2014 02:00	3900	37.66	15.31
12-Sep-2014 03:00	3960	37.68	15.33
12-Sep-2014 04:00	4020	37.70	15.35
12-Sep-2014 05:00	4080	37.72	15.37
12-Sep-2014 06:00	4140	37.75	15.40
12-Sep-2014 07:00	4200	37.78	15.43
12-Sep-2014 08:00	4260	37.80	15.45
12-Sep-2014 09:00	4320	37.81	15.46

Tabulated Levels for Ow29#4

Pump On:	09-Sep-2014 09:00			Static Level:	22.46		
Pump Off:	12-Sep-2014 09:00			Pumping Level:	28.75		
Pumping Well:	**TW34**			DD:	6.29		
Distance from Pumping Well:	17 m			20 Yr DD:	15.5		
Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
09-Sep-2014 09:00	0	22.46	0.00	12-Sep-2014 09:00	0	28.75	0.00
09-Sep-2014 09:01	1	23.64	1.18	12-Sep-2014 09:01	1	27.88	0.87
09-Sep-2014 09:02	2	23.99	1.53	12-Sep-2014 09:02	2	27.44	1.31
09-Sep-2014 09:03	3	24.22	1.76	12-Sep-2014 09:03	3	27.22	1.53
09-Sep-2014 09:04	4	24.35	1.89	12-Sep-2014 09:04	4	27.03	1.72
09-Sep-2014 09:05	5	24.45	1.99	12-Sep-2014 09:05	5	26.91	1.84
09-Sep-2014 09:06	6	24.52	2.06	12-Sep-2014 09:06	6	26.82	1.93
09-Sep-2014 09:07	7	24.61	2.15	12-Sep-2014 09:07	7	26.76	1.99
09-Sep-2014 09:08	8	24.69	2.23	12-Sep-2014 09:08	8	26.68	2.07
09-Sep-2014 09:10	10	24.76	2.30	12-Sep-2014 09:09	9	26.62	2.13
09-Sep-2014 09:12	12	24.83	2.37	12-Sep-2014 09:10	10	26.57	2.18
09-Sep-2014 09:14	14	24.91	2.45	12-Sep-2014 09:12	12	26.50	2.25
09-Sep-2014 09:16	16	24.96	2.50	12-Sep-2014 09:14	14	26.43	2.32
09-Sep-2014 09:18	18	25.01	2.55	12-Sep-2014 09:16	16	26.37	2.38
09-Sep-2014 09:20	20	25.07	2.61	12-Sep-2014 09:18	18	26.32	2.43
09-Sep-2014 09:25	25	25.17	2.71	12-Sep-2014 09:20	20	26.27	2.48
09-Sep-2014 09:30	30	25.25	2.79	12-Sep-2014 09:25	25	26.17	2.58
09-Sep-2014 09:40	40	25.37	2.91	12-Sep-2014 09:30	30	26.09	2.66
09-Sep-2014 09:50	50	25.47	3.01	12-Sep-2014 09:35	35	26.02	2.73
09-Sep-2014 10:00	60	25.56	3.10	12-Sep-2014 09:40	40	25.96	2.79
09-Sep-2014 10:15	75	25.66	3.20	12-Sep-2014 09:50	50	25.87	2.88
09-Sep-2014 10:30	90	25.75	3.29	12-Sep-2014 10:00	60	25.77	2.98
09-Sep-2014 10:45	105	25.82	3.36	12-Sep-2014 10:15	75	25.67	3.08
09-Sep-2014 11:00	120	25.88	3.42	12-Sep-2014 10:30	90	25.58	3.17
09-Sep-2014 11:30	150	26.01	3.55	12-Sep-2014 10:45	105	25.50	3.25
09-Sep-2014 12:00	180	26.10	3.64	12-Sep-2014 11:00	120	25.40	3.35
09-Sep-2014 12:30	210	26.18	3.72	12-Sep-2014 11:30	150	25.33	3.42
09-Sep-2014 13:00	240	26.25	3.79	12-Sep-2014 14:00	300	24.99	3.76
09-Sep-2014 13:30	270	26.37	3.91	12-Sep-2014 17:00	480	24.75	4.00
09-Sep-2014 14:00	300	26.49	4.03	13-Sep-2014 10:05	1505	23.99	4.76
09-Sep-2014 15:00	360	26.57	4.11				
09-Sep-2014 16:00	420	26.66	4.20				
09-Sep-2014 17:00	480	26.73	4.27				
09-Sep-2014 18:00	540	26.80	4.34				
09-Sep-2014 20:00	660	26.87	4.41				
09-Sep-2014 21:00	720	26.93	4.47				
09-Sep-2014 22:00	780	27.00	4.54				
09-Sep-2014 23:00	840	27.05	4.59				
10-Sep-2014 00:00	900	27.11	4.65				
10-Sep-2014 01:00	960	27.16	4.70				
10-Sep-2014 02:00	1020	27.20	4.74				
10-Sep-2014 03:00	1080	27.25	4.79				
10-Sep-2014 04:00	1140	27.30	4.84				
10-Sep-2014 05:00	1200	27.35	4.89				
10-Sep-2014 06:00	1260	27.38	4.92				
10-Sep-2014 07:00	1320	27.42	4.96				
10-Sep-2014 08:00	1380	27.46	5.00				
10-Sep-2014 09:00	1440	27.50	5.04				
10-Sep-2014 10:00	1500	27.54	5.08				
10-Sep-2014 11:00	1560	27.58	5.12				
10-Sep-2014 12:00	1620	27.62	5.16				
10-Sep-2014 13:10	1690	27.66	5.20				
10-Sep-2014 14:00	1740	27.69	5.23				
10-Sep-2014 15:00	1800	27.72	5.26				
10-Sep-2014 16:00	1860	27.76	5.30				
10-Sep-2014 17:00	1920	27.80	5.34				
10-Sep-2014 18:00	1980	27.82	5.36				
10-Sep-2014 19:00	2040	27.84	5.38				
10-Sep-2014 20:00	2100	27.86	5.40				
10-Sep-2014 21:00	2160	27.87	5.41				
10-Sep-2014 22:00	2220	27.89	5.43				
10-Sep-2014 23:00	2280	27.92	5.46				
11-Sep-2014 00:00	2340	27.96	5.50				
11-Sep-2014 01:00	2400	27.98	5.52				
11-Sep-2014 02:00	2460	28.00	5.54				
11-Sep-2014 03:00	2520	28.03	5.57				
11-Sep-2014 04:00	2580	28.05	5.59				
11-Sep-2014 05:00	2640	28.09	5.63				
11-Sep-2014 06:00	2700	28.10	5.64				
11-Sep-2014 07:00	2760	28.13	5.67				
11-Sep-2014 08:00	2820	28.17	5.71				
11-Sep-2014 09:00	2880	28.21	5.75				
11-Sep-2014 10:00	2940	28.23	5.77				
11-Sep-2014 11:00	3000	28.30	5.84				
11-Sep-2014 12:00	3060	28.29	5.83				
11-Sep-2014 13:00	3120	28.31	5.85				
11-Sep-2014 14:00	3180	28.34	5.88				
11-Sep-2014 15:00	3240	28.37	5.91				
11-Sep-2014 16:00	3300	28.39	5.93				
11-Sep-2014 17:00	3360	28.41	5.95				

11-Sep-2014 18:00	3420	28.44	5.98
11-Sep-2014 19:00	3480	28.46	6.00
11-Sep-2014 20:00	3540	28.48	6.02
11-Sep-2014 21:00	3600	28.49	6.03
11-Sep-2014 22:00	3660	28.52	6.06
11-Sep-2014 23:00	3720	28.54	6.08
12-Sep-2014 00:00	3780	28.56	6.10
12-Sep-2014 01:00	3840	28.58	6.12
12-Sep-2014 02:00	3900	28.60	6.14
12-Sep-2014 03:00	3960	28.63	6.17
12-Sep-2014 04:00	4020	28.65	6.19
12-Sep-2014 05:00	4080	28.67	6.21
12-Sep-2014 06:00	4140	28.69	6.23
12-Sep-2014 07:00	4200	28.72	6.26
12-Sep-2014 08:00	4260	28.73	6.27
12-Sep-2014 09:00	4320	28.75	6.29

Tabulated Levels for Ow29#3

	Pump On:	09-Sep-2014 09:00			Static Level:	17.64	
	Pump Off:	12-Sep-2014 09:00			Pumping Level:	17.54	
	Pumping Well:	**TW34**			DD:	-0.10	
	Distance from Pumping Well:	13.64 m					
Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
09-Sep-2014 09:00	0	17.64	0.00	12-Sep-2014 09:00	0	17.54	0.00
09-Sep-2014 09:01	1	17.64	0.00	12-Sep-2014 09:01	1	17.54	0.00
09-Sep-2014 09:02	2	17.64	0.00	12-Sep-2014 09:02	2	17.54	0.00
09-Sep-2014 09:03	3	17.64	0.00	12-Sep-2014 09:03	3	17.54	0.00
09-Sep-2014 09:04	4	17.64	0.00	12-Sep-2014 09:04	4	17.54	-0.01
09-Sep-2014 09:05	5	17.64	0.00	12-Sep-2014 09:05	5	17.54	0.00
09-Sep-2014 09:06	6	17.64	0.00	12-Sep-2014 09:06	6	17.54	0.00
09-Sep-2014 09:07	7	17.64	0.00	12-Sep-2014 09:07	7	17.54	0.00
09-Sep-2014 09:08	8	17.64	0.00	12-Sep-2014 09:08	8	17.54	0.00
09-Sep-2014 09:10	10	17.64	0.00	12-Sep-2014 09:09	9	17.54	0.00
09-Sep-2014 09:12	12	17.64	0.00	12-Sep-2014 09:10	10	17.54	0.00
09-Sep-2014 09:14	14	17.63	0.00	12-Sep-2014 09:12	12	17.54	0.00
09-Sep-2014 09:16	16	17.64	0.00	12-Sep-2014 09:14	14	17.54	-0.01
09-Sep-2014 09:18	18	17.63	-0.01	12-Sep-2014 09:16	16	17.54	-0.01
09-Sep-2014 09:20	20	17.64	0.00	12-Sep-2014 09:18	18	17.54	0.00
09-Sep-2014 09:25	25	17.63	-0.01	12-Sep-2014 09:20	20	17.55	-0.01
09-Sep-2014 09:30	30	17.63	0.00	12-Sep-2014 09:25	25	17.55	-0.01
09-Sep-2014 09:40	40	17.63	0.00	12-Sep-2014 09:30	30	17.55	-0.01
09-Sep-2014 09:50	50	17.63	-0.01	12-Sep-2014 09:35	35	17.55	-0.01
09-Sep-2014 10:00	60	17.63	-0.01	12-Sep-2014 09:40	40	17.55	-0.01
09-Sep-2014 10:15	75	17.63	-0.01	12-Sep-2014 09:50	50	17.55	-0.01
09-Sep-2014 10:30	90	17.64	0.00	12-Sep-2014 10:00	60	17.55	-0.01
09-Sep-2014 10:45	105	17.64	0.00	12-Sep-2014 10:15	75	17.55	-0.01
09-Sep-2014 11:00	120	17.64	0.00	12-Sep-2014 10:30	90	17.55	-0.01
09-Sep-2014 11:30	150	17.64	0.00	12-Sep-2014 10:45	105	17.55	-0.01
09-Sep-2014 12:00	180	17.64	0.00	12-Sep-2014 11:00	120	17.56	-0.02
09-Sep-2014 12:30	210	17.64	0.00	12-Sep-2014 11:30	150	17.56	-0.02
09-Sep-2014 13:00	240	17.65	0.01	12-Sep-2014 14:00	300	17.56	-0.02
09-Sep-2014 13:30	270	17.65	0.01	12-Sep-2014 17:00	480	17.57	-0.03
09-Sep-2014 14:00	300	17.65	0.01	13-Sep-2014 10:05	1505	17.53	0.01
09-Sep-2014 15:00	360	17.65	0.01				
09-Sep-2014 16:00	420	17.65	0.01				
09-Sep-2014 17:00	480	17.64	0.00				
09-Sep-2014 18:00	540	17.64	0.00				
09-Sep-2014 20:00	660	17.64	0.00				
09-Sep-2014 21:00	720	17.64	0.00				
09-Sep-2014 22:00	780	17.64	0.00				
09-Sep-2014 23:00	840	17.64	0.00				
10-Sep-2014 00:00	900	17.64	0.00				
10-Sep-2014 01:00	960	17.64	0.00				
10-Sep-2014 02:00	1020	17.64	0.00				
10-Sep-2014 03:00	1080	17.64	0.00				
10-Sep-2014 04:00	1140	17.63	-0.01				
10-Sep-2014 05:00	1200	17.63	-0.01				
10-Sep-2014 06:00	1260	17.63	-0.01				
10-Sep-2014 07:00	1320	17.63	-0.01				
10-Sep-2014 08:00	1380	17.63	-0.01				
10-Sep-2014 09:00	1440	17.62	-0.02				
10-Sep-2014 10:00	1500	17.63	-0.01				
10-Sep-2014 11:00	1560	17.63	-0.01				
10-Sep-2014 12:00	1620	17.64	0.00				
10-Sep-2014 13:10	1690	17.63	-0.01				
10-Sep-2014 14:00	1740	17.64	0.00				
10-Sep-2014 15:00	1800	17.64	0.00				
10-Sep-2014 16:00	1860	17.63	-0.01				
10-Sep-2014 17:00	1920	17.63	-0.01				
10-Sep-2014 18:00	1980	17.62	-0.02				
10-Sep-2014 19:00	2040	17.61	-0.03				
10-Sep-2014 20:00	2100	17.60	-0.04				
10-Sep-2014 21:00	2160	17.59	-0.05				
10-Sep-2014 22:00	2220	17.57	-0.06				
10-Sep-2014 23:00	2280	17.58	-0.06				
11-Sep-2014 00:00	2340	17.57	-0.07				
11-Sep-2014 01:00	2400	17.57	-0.06				
11-Sep-2014 02:00	2460	17.57	-0.07				
11-Sep-2014 03:00	2520	17.57	-0.07				
11-Sep-2014 04:00	2580	17.56	-0.08				
11-Sep-2014 05:00	2640	17.55	-0.09				
11-Sep-2014 06:00	2700	17.56	-0.08				
11-Sep-2014 07:00	2760	17.56	-0.08				
11-Sep-2014 08:00	2820	17.56	-0.08				
11-Sep-2014 09:00	2880	17.56	-0.08				
11-Sep-2014 10:00	2940	17.57	-0.07				
11-Sep-2014 11:00	3000	17.57	-0.07				
11-Sep-2014 12:00	3060	17.57	-0.07				
11-Sep-2014 13:00	3120	17.56	-0.08				
11-Sep-2014 14:00	3180	17.57	-0.07				
11-Sep-2014 15:00	3240	17.56	-0.07				
11-Sep-2014 16:00	3300	17.56	-0.08				
11-Sep-2014 17:00	3360	17.55	-0.09				

11-Sep-2014 18:00	3420	17.52	-0.12
11-Sep-2014 19:00	3480	17.52	-0.12
11-Sep-2014 20:00	3540	17.51	-0.13
11-Sep-2014 21:00	3600	17.51	-0.13
11-Sep-2014 22:00	3660	17.50	-0.14
11-Sep-2014 23:00	3720	17.50	-0.14
12-Sep-2014 00:00	3780	17.52	-0.12
12-Sep-2014 01:00	3840	17.52	-0.12
12-Sep-2014 02:00	3900	17.52	-0.12
12-Sep-2014 03:00	3960	17.52	-0.12
12-Sep-2014 04:00	4020	17.53	-0.11
12-Sep-2014 05:00	4080	17.53	-0.11
12-Sep-2014 06:00	4140	17.53	-0.11
12-Sep-2014 07:00	4200	17.53	-0.11
12-Sep-2014 08:00	4260	17.53	-0.11
12-Sep-2014 09:00	4320	17.54	-0.10

Tabulated Levels for Ow29#2

Pump On:	09-Sep-2014 09:00		Static Level:	13.46	
Pump Off:	12-Sep-2014 09:00		Pumping Level:	13.42	
Pumping Well:	**TW34**		DD:	-0.03	
Distance from Pumping Well:	13.64 m				

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
09-Sep-2014 09:00	0	13.46	0.00	12-Sep-2014 09:00	0	13.42	0.00
09-Sep-2014 09:01	1	13.45	-0.01	12-Sep-2014 09:01	1	13.42	0.00
09-Sep-2014 09:02	2	13.44	-0.02	12-Sep-2014 09:02	2	13.42	0.00
09-Sep-2014 09:03	3	13.44	-0.02	12-Sep-2014 09:03	3	13.42	0.00
09-Sep-2014 09:04	4	13.44	-0.02	12-Sep-2014 09:04	4	13.43	0.00
09-Sep-2014 09:05	5	13.44	-0.02	12-Sep-2014 09:05	5	13.42	0.00
09-Sep-2014 09:06	6	13.44	-0.02	12-Sep-2014 09:06	6	13.42	0.00
09-Sep-2014 09:07	7	13.44	-0.02	12-Sep-2014 09:07	7	13.42	0.00
09-Sep-2014 09:08	8	13.44	-0.02	12-Sep-2014 09:08	8	13.43	0.00
09-Sep-2014 09:10	10	13.44	-0.01	12-Sep-2014 09:09	9	13.42	0.00
09-Sep-2014 09:12	12	13.44	-0.02	12-Sep-2014 09:10	10	13.43	0.00
09-Sep-2014 09:14	14	13.44	-0.02	12-Sep-2014 09:12	12	13.42	0.00
09-Sep-2014 09:16	16	13.44	-0.02	12-Sep-2014 09:14	14	13.42	0.00
09-Sep-2014 09:18	18	13.44	-0.02	12-Sep-2014 09:16	16	13.43	-0.01
09-Sep-2014 09:20	20	13.44	-0.01	12-Sep-2014 09:18	18	13.44	-0.01
09-Sep-2014 09:25	25	13.44	-0.02	12-Sep-2014 09:20	20	13.44	-0.02
09-Sep-2014 09:30	30	13.44	-0.02	12-Sep-2014 09:25	25	13.44	-0.02
09-Sep-2014 09:40	40	13.44	-0.02	12-Sep-2014 09:30	30	13.44	-0.01
09-Sep-2014 09:50	50	13.44	-0.01	12-Sep-2014 09:35	35	13.44	-0.01
09-Sep-2014 10:00	60	13.44	-0.01	12-Sep-2014 09:40	40	13.43	-0.01
09-Sep-2014 10:15	75	13.44	-0.02	12-Sep-2014 09:50	50	13.43	-0.01
09-Sep-2014 10:30	90	13.44	-0.02	12-Sep-2014 10:00	60	13.43	-0.01
09-Sep-2014 10:45	105	13.44	-0.02	12-Sep-2014 10:15	75	13.44	-0.01
09-Sep-2014 11:00	120	13.44	-0.02	12-Sep-2014 10:30	90	13.43	-0.01
09-Sep-2014 11:30	150	13.45	-0.01	12-Sep-2014 10:45	105	13.43	-0.01
09-Sep-2014 12:00	180	13.44	-0.02	12-Sep-2014 11:00	120	13.43	0.00
09-Sep-2014 12:30	210	13.44	-0.02	12-Sep-2014 11:30	150	13.43	-0.01
09-Sep-2014 13:00	240	13.44	-0.02	12-Sep-2014 14:00	300	13.43	0.00
09-Sep-2014 13:30	270	13.44	-0.02	12-Sep-2014 17:00	480	13.42	0.00
09-Sep-2014 14:00	300	13.44	-0.02	13-Sep-2014 10:05	1505	13.39	0.03
09-Sep-2014 15:00	360	13.44	-0.02				
09-Sep-2014 16:00	420	13.44	-0.02				
09-Sep-2014 17:00	480	13.44	-0.02				
09-Sep-2014 18:00	540	13.44	-0.02				
09-Sep-2014 20:00	660	13.43	-0.03				
09-Sep-2014 21:00	720	13.44	-0.02				
09-Sep-2014 22:00	780	13.44	-0.02				
09-Sep-2014 23:00	840	13.44	-0.02				
10-Sep-2014 00:00	900	13.44	-0.02				
10-Sep-2014 01:00	960	13.43	-0.02				
10-Sep-2014 02:00	1020	13.43	-0.03				
10-Sep-2014 03:00	1080	13.43	-0.03				
10-Sep-2014 04:00	1140	13.43	-0.03				
10-Sep-2014 05:00	1200	13.43	-0.03				
10-Sep-2014 06:00	1260	13.42	-0.03				
10-Sep-2014 07:00	1320	13.42	-0.03				
10-Sep-2014 08:00	1380	13.42	-0.04				
10-Sep-2014 09:00	1440	13.42	-0.04				
10-Sep-2014 10:00	1500	13.42	-0.04				
10-Sep-2014 11:00	1560	13.42	-0.04				
10-Sep-2014 12:00	1620	13.42	-0.04				
10-Sep-2014 13:10	1690	13.42	-0.04				
10-Sep-2014 14:00	1740	13.42	-0.04				
10-Sep-2014 15:00	1800	13.41	-0.04				
10-Sep-2014 16:00	1860	13.41	-0.05				
10-Sep-2014 17:00	1920	13.41	-0.05				
10-Sep-2014 18:00	1980	13.40	-0.06				
10-Sep-2014 19:00	2040	13.39	-0.06				
10-Sep-2014 20:00	2100	13.39	-0.07				
10-Sep-2014 21:00	2160	13.38	-0.08				
10-Sep-2014 22:00	2220	13.37	-0.09				
10-Sep-2014 23:00	2280	13.37	-0.09				
11-Sep-2014 00:00	2340	13.37	-0.09				
11-Sep-2014 01:00	2400	13.38	-0.08				
11-Sep-2014 02:00	2460	13.37	-0.09				
11-Sep-2014 03:00	2520	13.38	-0.08				
11-Sep-2014 04:00	2580	13.38	-0.08				
11-Sep-2014 05:00	2640	13.38	-0.08				
11-Sep-2014 06:00	2700	13.38	-0.07				
11-Sep-2014 07:00	2760	13.39	-0.07				
11-Sep-2014 08:00	2820	13.39	-0.07				
11-Sep-2014 09:00	2880	13.39	-0.07				
11-Sep-2014 10:00	2940	13.40	-0.06				
11-Sep-2014 11:00	3000	13.40	-0.06				
11-Sep-2014 12:00	3060	13.40	-0.05				
11-Sep-2014 13:00	3120	13.41	-0.05				
11-Sep-2014 14:00	3180	13.41	-0.05				
11-Sep-2014 15:00	3240	13.41	-0.05				
11-Sep-2014 16:00	3300	13.41	-0.04				
11-Sep-2014 17:00	3360	13.41	-0.05				

11-Sep-2014 18:00	3420	13.41	-0.05
11-Sep-2014 19:00	3480	13.41	-0.04
11-Sep-2014 20:00	3540	13.41	-0.05
11-Sep-2014 21:00	3600	13.42	-0.04
11-Sep-2014 22:00	3660	13.42	-0.04
11-Sep-2014 23:00	3720	13.42	-0.04
12-Sep-2014 00:00	3780	13.42	-0.04
12-Sep-2014 01:00	3840	13.42	-0.04
12-Sep-2014 02:00	3900	13.43	-0.03
12-Sep-2014 03:00	3960	13.43	-0.03
12-Sep-2014 04:00	4020	13.43	-0.03
12-Sep-2014 05:00	4080	13.43	-0.03
12-Sep-2014 06:00	4140	13.43	-0.03
12-Sep-2014 07:00	4200	13.43	-0.03
12-Sep-2014 08:00	4260	13.43	-0.03
12-Sep-2014 09:00	4320	13.42	-0.03

Tabulated Levels for Ow29#1

Pump On:	09-Sep-2014 09:00			Static Level:	1.33		
Pump Off:	12-Sep-2014 09:00			Pumping Level:	1.28		
Pumping Well:	**TW34**			DD:	-0.05		
Distance from Pumping Well:	15.4 m						
Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
09-Sep-2014 09:00	0	1.33	0.00	12-Sep-2014 09:00	0	1.28	0.00
09-Sep-2014 09:01	1	1.33	0.00	12-Sep-2014 09:01	1	1.28	0.00
09-Sep-2014 09:02	2	1.33	0.00	12-Sep-2014 09:02	2	1.28	0.00
09-Sep-2014 09:03	3	1.33	0.00	12-Sep-2014 09:03	3	1.29	0.00
09-Sep-2014 09:04	4	1.33	0.00	12-Sep-2014 09:04	4	1.29	0.00
09-Sep-2014 09:05	5	1.33	0.00	12-Sep-2014 09:05	5	1.28	0.00
09-Sep-2014 09:06	6	1.33	0.00	12-Sep-2014 09:06	6	1.28	0.00
09-Sep-2014 09:07	7	1.33	0.00	12-Sep-2014 09:07	7	1.28	0.00
09-Sep-2014 09:08	8	1.33	0.00	12-Sep-2014 09:08	8	1.29	0.00
09-Sep-2014 09:10	10	1.33	0.00	12-Sep-2014 09:09	9	1.29	0.00
09-Sep-2014 09:12	12	1.33	0.00	12-Sep-2014 09:10	10	1.28	0.00
09-Sep-2014 09:14	14	1.33	0.00	12-Sep-2014 09:12	12	1.28	0.00
09-Sep-2014 09:16	16	1.33	0.00	12-Sep-2014 09:14	14	1.28	0.00
09-Sep-2014 09:18	18	1.33	0.00	12-Sep-2014 09:16	16	1.29	0.00
09-Sep-2014 09:20	20	1.33	0.00	12-Sep-2014 09:18	18	1.28	0.00
09-Sep-2014 09:25	25	1.33	0.00	12-Sep-2014 09:20	20	1.29	0.00
09-Sep-2014 09:30	30	1.33	0.00	12-Sep-2014 09:25	25	1.29	0.00
09-Sep-2014 09:40	40	1.33	0.00	12-Sep-2014 09:30	30	1.28	0.00
09-Sep-2014 09:50	50	1.33	0.00	12-Sep-2014 09:35	35	1.28	0.00
09-Sep-2014 10:00	60	1.33	0.00	12-Sep-2014 09:40	40	1.29	0.00
09-Sep-2014 10:15	75	1.33	0.00	12-Sep-2014 09:50	50	1.29	0.00
09-Sep-2014 10:30	90	1.33	-0.01	12-Sep-2014 10:00	60	1.29	0.00
09-Sep-2014 10:45	105	1.33	0.00	12-Sep-2014 10:15	75	1.29	0.00
09-Sep-2014 11:00	120	1.33	-0.01	12-Sep-2014 10:30	90	1.28	0.00
09-Sep-2014 11:30	150	1.33	0.00	12-Sep-2014 10:45	105	1.28	0.00
09-Sep-2014 12:00	180	1.33	-0.01	12-Sep-2014 11:00	120	1.28	0.00
09-Sep-2014 12:30	210	1.33	0.00	12-Sep-2014 11:30	150	1.29	0.00
09-Sep-2014 13:00	240	1.33	0.00	12-Sep-2014 14:00	300	1.29	-0.01
09-Sep-2014 13:30	270	1.33	0.00	12-Sep-2014 17:00	480	1.29	-0.01
09-Sep-2014 14:00	300	1.33	0.00	13-Sep-2014 10:05	1505	1.29	0.00
09-Sep-2014 15:00	360	1.32	-0.01				
09-Sep-2014 16:00	420	1.33	0.00				
09-Sep-2014 17:00	480	1.33	0.00				
09-Sep-2014 18:00	540	1.33	0.00				
09-Sep-2014 20:00	660	1.33	-0.01				
09-Sep-2014 21:00	720	1.33	0.00				
09-Sep-2014 22:00	780	1.33	0.00				
09-Sep-2014 23:00	840	1.33	0.00				
10-Sep-2014 00:00	900	1.33	0.00				
10-Sep-2014 01:00	960	1.33	0.00				
10-Sep-2014 02:00	1020	1.33	0.00				
10-Sep-2014 03:00	1080	1.33	0.00				
10-Sep-2014 04:00	1140	1.33	0.00				
10-Sep-2014 05:00	1200	1.33	0.00				
10-Sep-2014 06:00	1260	1.33	0.00				
10-Sep-2014 07:00	1320	1.33	0.00				
10-Sep-2014 08:00	1380	1.33	0.00				
10-Sep-2014 09:00	1440	1.32	-0.01				
10-Sep-2014 10:00	1500	1.33	0.00				
10-Sep-2014 11:00	1560	1.33	0.00				
10-Sep-2014 12:00	1620	1.33	-0.01				
10-Sep-2014 13:10	1690	1.33	0.00				
10-Sep-2014 14:00	1740	1.33	0.00				
10-Sep-2014 15:00	1800	1.33	0.00				
10-Sep-2014 16:00	1860	1.33	0.00				
10-Sep-2014 17:00	1920	1.33	0.00				
10-Sep-2014 18:00	1980	1.33	0.00				
10-Sep-2014 19:00	2040	1.32	-0.01				
10-Sep-2014 20:00	2100	1.32	-0.01				
10-Sep-2014 21:00	2160	1.30	-0.03				
10-Sep-2014 22:00	2220	1.27	-0.06				
10-Sep-2014 23:00	2280	1.26	-0.07				
11-Sep-2014 00:00	2340	1.27	-0.06				
11-Sep-2014 01:00	2400	1.27	-0.06				
11-Sep-2014 02:00	2460	1.27	-0.07				
11-Sep-2014 03:00	2520	1.27	-0.06				
11-Sep-2014 04:00	2580	1.27	-0.06				
11-Sep-2014 05:00	2640	1.27	-0.06				
11-Sep-2014 06:00	2700	1.28	-0.05				
11-Sep-2014 07:00	2760	1.27	-0.06				
11-Sep-2014 08:00	2820	1.28	-0.05				
11-Sep-2014 09:00	2880	1.28	-0.05				
11-Sep-2014 10:00	2940	1.28	-0.05				
11-Sep-2014 11:00	3000	1.28	-0.05				
11-Sep-2014 12:00	3060	1.29	-0.05				
11-Sep-2014 13:00	3120	1.28	-0.05				
11-Sep-2014 14:00	3180	1.28	-0.05				
11-Sep-2014 15:00	3240	1.28	-0.05				
11-Sep-2014 16:00	3300	1.28	-0.05				
11-Sep-2014 17:00	3360	1.28	-0.05				

11-Sep-2014 18:00	3420	1.28	-0.05
11-Sep-2014 19:00	3480	1.28	-0.05
11-Sep-2014 20:00	3540	1.28	-0.05
11-Sep-2014 21:00	3600	1.28	-0.05
11-Sep-2014 22:00	3660	1.28	-0.05
11-Sep-2014 23:00	3720	1.28	-0.05
12-Sep-2014 00:00	3780	1.28	-0.05
12-Sep-2014 01:00	3840	1.28	-0.05
12-Sep-2014 02:00	3900	1.28	-0.05
12-Sep-2014 03:00	3960	1.28	-0.05
12-Sep-2014 04:00	4020	1.29	-0.05
12-Sep-2014 05:00	4080	1.29	-0.05
12-Sep-2014 06:00	4140	1.28	-0.05
12-Sep-2014 07:00	4200	1.28	-0.05
12-Sep-2014 08:00	4260	1.29	-0.04
12-Sep-2014 09:00	4320	1.28	-0.05

Tabulated Levels for House 2

Pump On:	09-Sep-2014 09:00		Static Level:	4.02	
Pump Off:	12-Sep-2014 09:00		Pumping Level:	3.94	
Pumping Well:	**TW34**		DD:	-0.08	
Distance from Pumping Well:	627 m				

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
09-Sep-2014 09:00	0	4.02	0.00	12-Sep-2014 09:00	0	3.94	0.00
09-Sep-2014 09:01	1	4.02	0.00	12-Sep-2014 09:01	1	3.94	0.01
09-Sep-2014 09:02	2	4.02	0.00	12-Sep-2014 09:02	2	3.94	0.00
09-Sep-2014 09:03	3	4.01	0.00	12-Sep-2014 09:03	3	3.94	0.00
09-Sep-2014 09:04	4	4.01	0.00	12-Sep-2014 09:04	4	3.94	0.00
09-Sep-2014 09:05	5	4.02	0.00	12-Sep-2014 09:05	5	3.94	0.00
09-Sep-2014 09:06	6	4.02	0.00	12-Sep-2014 09:06	6	3.94	0.00
09-Sep-2014 09:07	7	4.02	0.00	12-Sep-2014 09:07	7	3.94	0.00
09-Sep-2014 09:08	8	4.01	-0.01	12-Sep-2014 09:08	8	3.94	0.00
09-Sep-2014 09:10	10	4.02	0.00	12-Sep-2014 09:09	9	3.94	0.00
09-Sep-2014 09:12	12	4.01	0.00	12-Sep-2014 09:10	10	3.94	0.00
09-Sep-2014 09:14	14	4.01	-0.01	12-Sep-2014 09:12	12	5.03	-1.09
09-Sep-2014 09:16	16	4.01	0.00	12-Sep-2014 09:14	14	4.42	-0.48
09-Sep-2014 09:18	18	4.01	-0.01	12-Sep-2014 09:16	16	4.16	-0.21
09-Sep-2014 09:20	20	4.01	0.00	12-Sep-2014 09:18	18	4.04	-0.10
09-Sep-2014 09:25	25	4.01	-0.01	12-Sep-2014 09:20	20	3.99	-0.05
09-Sep-2014 09:30	30	4.01	-0.01	12-Sep-2014 09:25	25	3.95	-0.01
09-Sep-2014 09:40	40	4.01	-0.01	12-Sep-2014 09:30	30	3.94	0.00
09-Sep-2014 09:50	50	4.01	-0.01	12-Sep-2014 09:35	35	3.94	0.00
09-Sep-2014 10:00	60	4.01	-0.01	12-Sep-2014 09:40	40	3.94	0.00
09-Sep-2014 10:15	75	4.01	-0.01	12-Sep-2014 09:50	50	3.94	0.00
09-Sep-2014 10:30	90	4.01	-0.01	12-Sep-2014 10:00	60	3.94	0.00
09-Sep-2014 10:45	105	4.01	-0.01	12-Sep-2014 10:15	75	3.94	0.00
09-Sep-2014 11:00	120	4.01	-0.01	12-Sep-2014 10:30	90	3.94	0.00
09-Sep-2014 11:30	150	4.01	-0.01	12-Sep-2014 10:45	105	3.94	0.00
09-Sep-2014 12:00	180	4.01	-0.01	12-Sep-2014 11:00	120	3.94	0.00
09-Sep-2014 12:30	210	4.01	-0.01	12-Sep-2014 11:30	150	3.94	0.00
09-Sep-2014 13:00	240	4.01	-0.01	12-Sep-2014 14:00	300	3.95	0.00
09-Sep-2014 13:30	270	4.01	-0.01	12-Sep-2014 17:00	480	3.95	-0.01
09-Sep-2014 14:00	300	4.01	-0.01	13-Sep-2014 10:05	1505	3.94	0.01
09-Sep-2014 15:00	360	4.01	-0.01				
09-Sep-2014 16:00	420	4.01	-0.01				
09-Sep-2014 17:00	480	4.01	-0.01				
09-Sep-2014 18:00	540	4.48	0.46				
09-Sep-2014 20:00	660	4.01	-0.01				
09-Sep-2014 21:00	720	4.61	0.59				
09-Sep-2014 22:00	780	4.01	-0.01				
09-Sep-2014 23:00	840	4.01	-0.01				
10-Sep-2014 00:00	900	4.00	-0.02				
10-Sep-2014 01:00	960	4.00	-0.02				
10-Sep-2014 02:00	1020	4.00	-0.02				
10-Sep-2014 03:00	1080	4.00	-0.02				
10-Sep-2014 04:00	1140	3.99	-0.03				
10-Sep-2014 05:00	1200	3.99	-0.02				
10-Sep-2014 06:00	1260	3.99	-0.03				
10-Sep-2014 07:00	1320	4.09	0.07				
10-Sep-2014 08:00	1380	4.19	0.17				
10-Sep-2014 09:00	1440	3.99	-0.03				
10-Sep-2014 10:00	1500	4.11	0.10				
10-Sep-2014 11:00	1560	3.99	-0.03				
10-Sep-2014 12:00	1620	3.98	-0.03				
10-Sep-2014 13:10	1690	3.98	-0.03				
10-Sep-2014 14:00	1740	4.42	0.40				
10-Sep-2014 15:00	1800	3.98	-0.04				
10-Sep-2014 16:00	1860	3.98	-0.04				
10-Sep-2014 17:00	1920	3.98	-0.04				
10-Sep-2014 18:00	1980	3.97	-0.05				
10-Sep-2014 19:00	2040	3.97	-0.04				
10-Sep-2014 20:00	2100	3.96	-0.06				
10-Sep-2014 21:00	2160	3.94	-0.08				
10-Sep-2014 22:00	2220	3.93	-0.08				
10-Sep-2014 23:00	2280	3.93	-0.09				
11-Sep-2014 00:00	2340	3.93	-0.09				
11-Sep-2014 01:00	2400	3.93	-0.09				
11-Sep-2014 02:00	2460	3.92	-0.10				
11-Sep-2014 03:00	2520	3.92	-0.10				
11-Sep-2014 04:00	2580	3.92	-0.10				
11-Sep-2014 05:00	2640	3.92	-0.10				
11-Sep-2014 06:00	2700	3.92	-0.10				
11-Sep-2014 07:00	2760	3.92	-0.09				
11-Sep-2014 08:00	2820	3.92	-0.09				
11-Sep-2014 09:00	2880	3.92	-0.09				
11-Sep-2014 10:00	2940	3.93	-0.09				
11-Sep-2014 11:00	3000	3.93	-0.09				
11-Sep-2014 12:00	3060	3.94	-0.08				
11-Sep-2014 13:00	3120	3.94	-0.08				
11-Sep-2014 14:00	3180	4.13	0.12				
11-Sep-2014 15:00	3240	3.94	-0.08				
11-Sep-2014 16:00	3300	3.94	-0.08				
11-Sep-2014 17:00	3360	3.94	-0.08				

11-Sep-2014 18:00	3420	3.94	-0.08
11-Sep-2014 19:00	3480	3.94	-0.08
11-Sep-2014 20:00	3540	3.94	-0.08
11-Sep-2014 21:00	3600	3.95	-0.07
11-Sep-2014 22:00	3660	3.95	-0.07
11-Sep-2014 23:00	3720	3.95	-0.07
12-Sep-2014 00:00	3780	3.94	-0.08
12-Sep-2014 01:00	3840	3.94	-0.08
12-Sep-2014 02:00	3900	3.94	-0.07
12-Sep-2014 03:00	3960	3.94	-0.07
12-Sep-2014 04:00	4020	3.94	-0.07
12-Sep-2014 05:00	4080	3.94	-0.08
12-Sep-2014 06:00	4140	3.94	-0.08
12-Sep-2014 07:00	4200	3.94	-0.08
12-Sep-2014 08:00	4260	3.94	-0.08
12-Sep-2014 09:00	4320	3.94	-0.08

Tabulated Levels for House 3

	Pump On:	09-Sep-2014 09:00			Static Level:	8.34	
	Pump Off:	12-Sep-2014 09:00			Pumping Level:	8.33	
	Pumping Well:	**TW34**			DD:	-0.01	
	Distance from Pumping Well:	655 m					
Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
09-Sep-2014 09:00	0	8.34	0.00	12-Sep-2014 09:00	0	8.33	0.00
09-Sep-2014 09:01	1	8.34	0.00	12-Sep-2014 09:01	1	8.32	0.01
09-Sep-2014 09:02	2	8.34	0.00	12-Sep-2014 09:02	2	8.32	0.00
09-Sep-2014 09:03	3	8.34	0.00	12-Sep-2014 09:03	3	8.32	0.00
09-Sep-2014 09:04	4	8.34	0.00	12-Sep-2014 09:04	4	8.33	0.00
09-Sep-2014 09:05	5	8.34	0.00	12-Sep-2014 09:05	5	8.32	0.00
09-Sep-2014 09:06	6	8.35	0.01	12-Sep-2014 09:06	6	8.32	0.00
09-Sep-2014 09:07	7	8.35	0.01	12-Sep-2014 09:07	7	8.33	0.00
09-Sep-2014 09:08	8	8.34	0.00	12-Sep-2014 09:08	8	8.33	0.00
09-Sep-2014 09:10	10	8.35	0.01	12-Sep-2014 09:09	9	8.33	0.00
09-Sep-2014 09:12	12	8.34	0.00	12-Sep-2014 09:10	10	8.33	0.00
09-Sep-2014 09:14	14	10.28	1.94	12-Sep-2014 09:12	12	8.33	0.00
09-Sep-2014 09:16	16	9.36	1.02	12-Sep-2014 09:14	14	8.33	0.00
09-Sep-2014 09:18	18	8.83	0.49	12-Sep-2014 09:16	16	8.33	0.00
09-Sep-2014 09:20	20	8.58	0.24	12-Sep-2014 09:18	18	8.32	0.00
09-Sep-2014 09:25	25	9.21	0.87	12-Sep-2014 09:20	20	8.33	0.00
09-Sep-2014 09:30	30	8.50	0.16	12-Sep-2014 09:25	25	8.33	0.00
09-Sep-2014 09:40	40	8.36	0.02	12-Sep-2014 09:30	30	8.32	0.00
09-Sep-2014 09:50	50	8.35	0.01	12-Sep-2014 09:35	35	8.32	0.00
09-Sep-2014 10:00	60	9.73	1.39	12-Sep-2014 09:40	40	8.32	0.00
09-Sep-2014 10:15	75	8.36	0.02	12-Sep-2014 09:50	50	9.65	-1.32
09-Sep-2014 10:30	90	8.35	0.01	12-Sep-2014 10:00	60	9.23	-0.90
09-Sep-2014 10:45	105	8.35	0.01	12-Sep-2014 10:15	75	8.35	-0.02
09-Sep-2014 11:00	120	8.35	0.01	12-Sep-2014 10:30	90	8.33	-0.01
09-Sep-2014 11:30	150	8.35	0.01	12-Sep-2014 10:45	105	8.33	0.00
09-Sep-2014 12:00	180	8.34	0.00	12-Sep-2014 11:00	120	8.33	0.00
09-Sep-2014 12:30	210	8.34	0.00	12-Sep-2014 11:30	150	8.33	0.00
09-Sep-2014 13:00	240	8.34	0.00	12-Sep-2014 14:00	300	8.33	0.00
09-Sep-2014 13:30	270	8.34	0.00	12-Sep-2014 17:00	480	8.59	-0.27
09-Sep-2014 14:00	300	8.34	0.00	13-Sep-2014 10:05	1505	8.31	0.01
09-Sep-2014 15:00	360	10.20	1.86				
09-Sep-2014 16:00	420	8.34	0.00				
09-Sep-2014 17:00	480	8.34	0.00				
09-Sep-2014 18:00	540	9.52	1.18				
09-Sep-2014 20:00	660	8.33	-0.01				
09-Sep-2014 21:00	720	8.33	-0.01				
09-Sep-2014 22:00	780	8.34	0.00				
09-Sep-2014 23:00	840	8.67	0.33				
10-Sep-2014 00:00	900	8.34	0.00				
10-Sep-2014 01:00	960	8.33	-0.01				
10-Sep-2014 02:00	1020	8.33	-0.01				
10-Sep-2014 03:00	1080	8.33	-0.01				
10-Sep-2014 04:00	1140	8.33	-0.01				
10-Sep-2014 05:00	1200	8.32	-0.02				
10-Sep-2014 06:00	1260	8.32	-0.02				
10-Sep-2014 07:00	1320	8.32	-0.02				
10-Sep-2014 08:00	1380	8.33	-0.01				
10-Sep-2014 09:00	1440	8.32	-0.02				
10-Sep-2014 10:00	1500	8.32	-0.02				
10-Sep-2014 11:00	1560	8.33	-0.01				
10-Sep-2014 12:00	1620	8.32	-0.02				
10-Sep-2014 13:10	1690	8.32	-0.02				
10-Sep-2014 14:00	1740	8.32	-0.02				
10-Sep-2014 15:00	1800	8.47	0.13				
10-Sep-2014 16:00	1860	8.32	-0.02				
10-Sep-2014 17:00	1920	8.32	-0.03				
10-Sep-2014 18:00	1980	8.33	-0.01				
10-Sep-2014 19:00	2040	8.32	-0.02				
10-Sep-2014 20:00	2100	8.30	-0.04				
10-Sep-2014 21:00	2160	8.30	-0.04				
10-Sep-2014 22:00	2220	8.28	-0.06				
10-Sep-2014 23:00	2280	8.28	-0.06				
11-Sep-2014 00:00	2340	8.28	-0.06				
11-Sep-2014 01:00	2400	8.28	-0.06				
11-Sep-2014 02:00	2460	8.28	-0.06				
11-Sep-2014 03:00	2520	8.28	-0.06				
11-Sep-2014 04:00	2580	8.28	-0.06				
11-Sep-2014 05:00	2640	8.28	-0.06				
11-Sep-2014 06:00	2700	8.28	-0.06				
11-Sep-2014 07:00	2760	9.70	1.36				
11-Sep-2014 08:00	2820	8.64	0.30				
11-Sep-2014 09:00	2880	8.30	-0.04				
11-Sep-2014 10:00	2940	8.30	-0.04				
11-Sep-2014 11:00	3000	9.40	1.06				
11-Sep-2014 12:00	3060	8.68	0.34				
11-Sep-2014 13:00	3120	8.31	-0.03				
11-Sep-2014 14:00	3180	8.32	-0.02				
11-Sep-2014 15:00	3240	8.31	-0.03				
11-Sep-2014 16:00	3300	8.32	-0.02				
11-Sep-2014 17:00	3360	8.32	-0.03				

11-Sep-2014 18:00	3420	8.32	-0.02
11-Sep-2014 19:00	3480	8.32	-0.02
11-Sep-2014 20:00	3540	8.33	-0.02
11-Sep-2014 21:00	3600	8.32	-0.02
11-Sep-2014 22:00	3660	8.33	-0.01
11-Sep-2014 23:00	3720	8.33	-0.01
12-Sep-2014 00:00	3780	8.33	-0.02
12-Sep-2014 01:00	3840	8.32	-0.02
12-Sep-2014 02:00	3900	8.32	-0.02
12-Sep-2014 03:00	3960	8.33	-0.01
12-Sep-2014 04:00	4020	8.33	-0.01
12-Sep-2014 05:00	4080	8.32	-0.02
12-Sep-2014 06:00	4140	8.32	-0.02
12-Sep-2014 07:00	4200	8.33	-0.01
12-Sep-2014 08:00	4260	8.33	-0.01
12-Sep-2014 09:00	4320	8.33	-0.01

Tabulated Levels for House 4

Pump On:	09-Sep-2014 09:00		Static Level:	12.71	
Pump Off:	12-Sep-2014 09:00		Pumping Level:	12.64	
Pumping Well:	**TW34**		DD:	-0.06	
Distance from Pumping Well:	717 m				

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
09-Sep-2014 09:00	0	12.71	0.00	12-Sep-2014 09:00	0	12.64	0.00
09-Sep-2014 09:01	1	12.71	0.00	12-Sep-2014 09:01	1	12.64	0.00
09-Sep-2014 09:02	2	12.70	0.00	12-Sep-2014 09:02	2	12.64	0.00
09-Sep-2014 09:03	3	12.71	0.00	12-Sep-2014 09:03	3	12.64	0.00
09-Sep-2014 09:04	4	12.70	0.00	12-Sep-2014 09:04	4	12.65	0.00
09-Sep-2014 09:05	5	12.71	0.00	12-Sep-2014 09:05	5	12.64	0.00
09-Sep-2014 09:06	6	12.71	0.00	12-Sep-2014 09:06	6	12.64	0.00
09-Sep-2014 09:07	7	12.71	0.00	12-Sep-2014 09:07	7	12.64	0.00
09-Sep-2014 09:08	8	12.71	0.00	12-Sep-2014 09:08	8	13.08	-0.43
09-Sep-2014 09:10	10	12.71	0.00	12-Sep-2014 09:09	9	13.32	-0.68
09-Sep-2014 09:12	12	12.71	0.00	12-Sep-2014 09:10	10	13.03	-0.39
09-Sep-2014 09:14	14	12.71	0.00	12-Sep-2014 09:12	12	12.92	-0.27
09-Sep-2014 09:16	16	12.71	0.00	12-Sep-2014 09:14	14	12.87	-0.23
09-Sep-2014 09:18	18	12.70	0.00	12-Sep-2014 09:16	16	12.83	-0.19
09-Sep-2014 09:20	20	12.71	0.00	12-Sep-2014 09:18	18	12.81	-0.16
09-Sep-2014 09:25	25	12.70	-0.01	12-Sep-2014 09:20	20	12.79	-0.15
09-Sep-2014 09:30	30	12.71	0.00	12-Sep-2014 09:25	25	12.75	-0.11
09-Sep-2014 09:40	40	12.70	0.00	12-Sep-2014 09:30	30	12.72	-0.07
09-Sep-2014 09:50	50	12.70	0.00	12-Sep-2014 09:35	35	12.70	-0.06
09-Sep-2014 10:00	60	12.71	0.00	12-Sep-2014 09:40	40	12.69	-0.05
09-Sep-2014 10:15	75	12.70	-0.01	12-Sep-2014 09:50	50	12.67	-0.03
09-Sep-2014 10:30	90	12.70	0.00	12-Sep-2014 10:00	60	12.66	-0.02
09-Sep-2014 10:45	105	12.70	0.00	12-Sep-2014 10:15	75	12.66	-0.01
09-Sep-2014 11:00	120	12.70	0.00	12-Sep-2014 10:30	90	12.64	0.00
09-Sep-2014 11:30	150	12.70	-0.01	12-Sep-2014 10:45	105	12.64	0.00
09-Sep-2014 12:00	180	12.70	0.00	12-Sep-2014 11:00	120	12.64	0.00
09-Sep-2014 12:30	210	12.70	-0.01	12-Sep-2014 11:30	150	12.64	0.00
09-Sep-2014 13:00	240	12.88	0.18	12-Sep-2014 14:00	300	12.65	-0.01
09-Sep-2014 13:30	270	12.85	0.14	12-Sep-2014 17:00	480	12.90	-0.25
09-Sep-2014 14:00	300	12.74	0.03	13-Sep-2014 10:05	1505	12.62	0.03
09-Sep-2014 15:00	360	12.73	0.02				
09-Sep-2014 16:00	420	12.71	0.00				
09-Sep-2014 17:00	480	12.70	0.00				
09-Sep-2014 18:00	540	12.70	-0.01				
09-Sep-2014 20:00	660	12.69	-0.02				
09-Sep-2014 21:00	720	12.74	0.03				
09-Sep-2014 22:00	780	12.70	-0.01				
09-Sep-2014 23:00	840	12.70	-0.01				
10-Sep-2014 00:00	900	12.69	-0.02				
10-Sep-2014 01:00	960	12.69	-0.02				
10-Sep-2014 02:00	1020	12.68	-0.02				
10-Sep-2014 03:00	1080	12.69	-0.02				
10-Sep-2014 04:00	1140	12.69	-0.02				
10-Sep-2014 05:00	1200	12.68	-0.03				
10-Sep-2014 06:00	1260	12.76	0.05				
10-Sep-2014 07:00	1320	12.69	-0.02				
10-Sep-2014 08:00	1380	12.68	-0.02				
10-Sep-2014 09:00	1440	12.68	-0.03				
10-Sep-2014 10:00	1500	12.68	-0.02				
10-Sep-2014 11:00	1560	12.68	-0.02				
10-Sep-2014 12:00	1620	12.68	-0.03				
10-Sep-2014 13:10	1690	12.68	-0.03				
10-Sep-2014 14:00	1740	12.68	-0.03				
10-Sep-2014 15:00	1800	12.68	-0.03				
10-Sep-2014 16:00	1860	12.68	-0.03				
10-Sep-2014 17:00	1920	12.68	-0.03				
10-Sep-2014 18:00	1980	14.33	1.62				
10-Sep-2014 19:00	2040	13.31	0.60				
10-Sep-2014 20:00	2100	12.71	0.01				
10-Sep-2014 21:00	2160	12.67	-0.04				
10-Sep-2014 22:00	2220	12.66	-0.05				
10-Sep-2014 23:00	2280	12.66	-0.05				
11-Sep-2014 00:00	2340	12.71	0.00				
11-Sep-2014 01:00	2400	12.66	-0.04				
11-Sep-2014 02:00	2460	12.65	-0.06				
11-Sep-2014 03:00	2520	12.65	-0.05				
11-Sep-2014 04:00	2580	12.65	-0.05				
11-Sep-2014 05:00	2640	12.65	-0.05				
11-Sep-2014 06:00	2700	12.66	-0.05				
11-Sep-2014 07:00	2760	12.78	0.07				
11-Sep-2014 08:00	2820	12.67	-0.04				
11-Sep-2014 09:00	2880	12.66	-0.05				
11-Sep-2014 10:00	2940	12.66	-0.04				
11-Sep-2014 11:00	3000	12.66	-0.04				
11-Sep-2014 12:00	3060	12.66	-0.05				
11-Sep-2014 13:00	3120	12.66	-0.05				
11-Sep-2014 14:00	3180	12.66	-0.04				
11-Sep-2014 15:00	3240	12.71	0.01				
11-Sep-2014 16:00	3300	12.67	-0.04				
11-Sep-2014 17:00	3360	12.66	-0.05				

11-Sep-2014 18:00	3420	12.82	0.11
11-Sep-2014 19:00	3480	12.76	0.05
11-Sep-2014 20:00	3540	12.71	0.01
11-Sep-2014 21:00	3600	12.86	0.16
11-Sep-2014 22:00	3660	12.79	0.08
11-Sep-2014 23:00	3720	12.75	0.04
12-Sep-2014 00:00	3780	12.66	-0.04
12-Sep-2014 01:00	3840	12.65	-0.06
12-Sep-2014 02:00	3900	12.65	-0.06
12-Sep-2014 03:00	3960	12.65	-0.06
12-Sep-2014 04:00	4020	12.65	-0.06
12-Sep-2014 05:00	4080	12.64	-0.07
12-Sep-2014 06:00	4140	12.71	0.00
12-Sep-2014 07:00	4200	12.65	-0.05
12-Sep-2014 08:00	4260	12.67	-0.04
12-Sep-2014 09:00	4320	12.64	-0.06

Tabulated Levels for BH8-1

Pump On:	09-Sep-2014 09:00		Static Level:	36.60	
Pump Off:	12-Sep-2014 09:00		Pumping Level:	36.70	
Pumping Well:	**TW34**		DD:	0.09	
Distance from Pumping Well:	771 m				

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
11-Sep-2014 11:00	3000	36.65	0.05	12-Sep-2014 09:00	0	36.70	0.00
11-Sep-2014 12:00	3060	36.66	0.06	12-Sep-2014 09:01	1	36.69	0.00
11-Sep-2014 13:00	3120	36.66	0.06	12-Sep-2014 09:02	2	36.69	0.00
11-Sep-2014 14:00	3180	36.67	0.07	12-Sep-2014 09:03	3	36.69	0.00
11-Sep-2014 15:00	3240	36.68	0.07	12-Sep-2014 09:04	4	36.70	0.00
11-Sep-2014 16:00	3300	36.68	0.08	12-Sep-2014 09:05	5	36.69	0.00
11-Sep-2014 17:00	3360	36.67	0.07	12-Sep-2014 09:06	6	36.70	0.00
11-Sep-2014 18:00	3420	36.68	0.08	12-Sep-2014 09:07	7	36.70	0.00
11-Sep-2014 19:00	3480	36.68	0.08	12-Sep-2014 09:08	8	36.70	0.00
11-Sep-2014 20:00	3540	36.68	0.08	12-Sep-2014 09:09	9	36.70	0.00
11-Sep-2014 21:00	3600	36.68	0.08	12-Sep-2014 09:10	10	36.70	0.00
11-Sep-2014 22:00	3660	36.68	0.08	12-Sep-2014 09:12	12	36.70	0.00
11-Sep-2014 23:00	3720	36.69	0.09	12-Sep-2014 09:14	14	36.70	0.00
12-Sep-2014 00:00	3780	36.68	0.08	12-Sep-2014 09:16	16	36.70	0.00
12-Sep-2014 01:00	3840	36.69	0.09	12-Sep-2014 09:18	18	36.70	0.00
12-Sep-2014 02:00	3900	36.69	0.09	12-Sep-2014 09:20	20	36.70	0.00
12-Sep-2014 03:00	3960	36.69	0.09	12-Sep-2014 09:25	25	36.70	0.00
12-Sep-2014 04:00	4020	36.70	0.10	12-Sep-2014 09:30	30	36.69	0.00
12-Sep-2014 05:00	4080	36.69	0.09	12-Sep-2014 09:35	35	36.69	0.00
12-Sep-2014 06:00	4140	36.69	0.09	12-Sep-2014 09:40	40	36.69	0.00
12-Sep-2014 07:00	4200	36.70	0.09	12-Sep-2014 09:50	50	36.69	0.00
12-Sep-2014 08:00	4260	36.69	0.09	12-Sep-2014 10:00	60	36.69	0.00
12-Sep-2014 09:00	4320	36.70	0.09	12-Sep-2014 10:15	75	36.70	0.00
				12-Sep-2014 10:30	90	36.70	0.00
				12-Sep-2014 10:45	105	36.69	0.00
				12-Sep-2014 11:00	120	36.70	0.00
				12-Sep-2014 11:30	150	36.70	0.00
				12-Sep-2014 14:00	300	36.70	0.00
				12-Sep-2014 17:00	480	36.69	0.01
				13-Sep-2014 10:05	1505	36.66	0.03

Tabulated Levels for SV Resort OW

Pump On:	09-Sep-2014 09:00		Static Level:	12.91	
Pump Off:	12-Sep-2014 09:00		Pumping Level:	12.90	
Pumping Well:	**TW34**		DD:	-0.02	
Distance from Pumping Well:	915 m				

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
09-Sep-2014 09:00	0	12.91	0.00	12-Sep-2014 09:00	0	12.90	0.00
09-Sep-2014 09:01	1	12.91	0.00	12-Sep-2014 09:01	1	12.89	0.00
09-Sep-2014 09:02	2	12.91	-0.01	12-Sep-2014 09:02	2	12.90	0.00
09-Sep-2014 09:03	3	12.91	0.00	12-Sep-2014 09:03	3	12.89	0.00
09-Sep-2014 09:04	4	12.91	0.00	12-Sep-2014 09:04	4	12.89	0.01
09-Sep-2014 09:05	5	12.91	0.00	12-Sep-2014 09:05	5	12.89	0.01
09-Sep-2014 09:06	6	12.92	0.01	12-Sep-2014 09:06	6	12.89	0.00
09-Sep-2014 09:07	7	12.91	0.00	12-Sep-2014 09:07	7	12.89	0.01
09-Sep-2014 09:08	8	12.92	0.00	12-Sep-2014 09:08	8	12.90	-0.01
09-Sep-2014 09:10	10	12.92	0.00	12-Sep-2014 09:09	9	12.89	0.00
09-Sep-2014 09:12	12	12.91	-0.01	12-Sep-2014 09:10	10	12.89	0.00
09-Sep-2014 09:14	14	12.91	0.00	12-Sep-2014 09:12	12	12.89	0.01
09-Sep-2014 09:16	16	12.91	0.00	12-Sep-2014 09:14	14	12.90	0.00
09-Sep-2014 09:18	18	12.90	-0.01	12-Sep-2014 09:16	16	12.89	0.00
09-Sep-2014 09:20	20	12.91	0.00	12-Sep-2014 09:18	18	12.89	0.01
09-Sep-2014 09:25	25	12.90	-0.01	12-Sep-2014 09:20	20	12.89	0.00
09-Sep-2014 09:30	30	12.91	0.00	12-Sep-2014 09:25	25	12.89	0.01
09-Sep-2014 09:40	40	12.90	-0.01	12-Sep-2014 09:30	30	12.89	0.01
09-Sep-2014 09:50	50	12.94	0.03	12-Sep-2014 09:35	35	12.88	0.01
09-Sep-2014 10:00	60	12.91	-0.01	12-Sep-2014 09:40	40	13.15	-0.26
09-Sep-2014 10:15	75	12.91	0.00	12-Sep-2014 09:50	50	12.89	0.00
09-Sep-2014 10:30	90	12.91	0.00	12-Sep-2014 10:00	60	12.89	0.01
09-Sep-2014 10:45	105	12.91	-0.01	12-Sep-2014 10:15	75	12.89	0.01
09-Sep-2014 11:00	120	12.90	-0.02	12-Sep-2014 10:30	90	12.89	0.01
09-Sep-2014 11:30	150	12.91	0.00	12-Sep-2014 10:45	105	12.88	0.01
09-Sep-2014 12:00	180	12.91	0.00	12-Sep-2014 11:00	120	12.89	0.01
09-Sep-2014 12:30	210	12.91	0.00	12-Sep-2014 11:30	150	12.88	0.01
09-Sep-2014 13:00	240	12.91	0.00	12-Sep-2014 14:00	300	12.89	0.01
09-Sep-2014 13:30	270	12.98	0.07	12-Sep-2014 17:00	480	12.89	0.00
09-Sep-2014 14:00	300	12.91	0.00	13-Sep-2014 10:05	1505	12.90	0.00
09-Sep-2014 15:00	360	12.90	-0.01				
09-Sep-2014 16:00	420	12.90	-0.01				
09-Sep-2014 17:00	480	12.90	-0.02				
09-Sep-2014 18:00	540	12.91	0.00				
09-Sep-2014 20:00	660	12.90	-0.02				
09-Sep-2014 21:00	720	12.90	-0.02				
09-Sep-2014 22:00	780	12.90	-0.01				
09-Sep-2014 23:00	840	12.90	-0.01				
10-Sep-2014 00:00	900	12.90	-0.01				
10-Sep-2014 01:00	960	12.90	-0.02				
10-Sep-2014 02:00	1020	12.89	-0.02				
10-Sep-2014 03:00	1080	12.90	-0.02				
10-Sep-2014 04:00	1140	12.89	-0.02				
10-Sep-2014 05:00	1200	12.90	-0.02				
10-Sep-2014 06:00	1260	12.89	-0.03				
10-Sep-2014 07:00	1320	12.89	-0.03				
10-Sep-2014 08:00	1380	12.89	-0.02				
10-Sep-2014 09:00	1440	12.88	-0.03				
10-Sep-2014 10:00	1500	12.89	-0.03				
10-Sep-2014 11:00	1560	12.88	-0.03				
10-Sep-2014 12:00	1620	12.88	-0.03				
10-Sep-2014 13:10	1690	12.88	-0.03				
10-Sep-2014 14:00	1740	12.88	-0.03				
10-Sep-2014 15:00	1800	12.88	-0.03				
10-Sep-2014 16:00	1860	12.87	-0.04				
10-Sep-2014 17:00	1920	12.88	-0.03				
10-Sep-2014 18:00	1980	12.87	-0.04				
10-Sep-2014 19:00	2040	12.85	-0.06				
10-Sep-2014 20:00	2100	12.86	-0.05				
10-Sep-2014 21:00	2160	12.85	-0.06				
10-Sep-2014 22:00	2220	12.84	-0.07				
10-Sep-2014 23:00	2280	12.84	-0.08				
11-Sep-2014 00:00	2340	12.84	-0.08				
11-Sep-2014 01:00	2400	12.84	-0.08				
11-Sep-2014 02:00	2460	12.83	-0.08				
11-Sep-2014 03:00	2520	12.84	-0.07				
11-Sep-2014 04:00	2580	12.83	-0.08				
11-Sep-2014 05:00	2640	12.84	-0.07				
11-Sep-2014 06:00	2700	12.85	-0.07				
11-Sep-2014 07:00	2760	12.85	-0.06				
11-Sep-2014 08:00	2820	12.84	-0.07				
11-Sep-2014 09:00	2880	12.85	-0.06				
11-Sep-2014 10:00	2940	12.86	-0.05				
11-Sep-2014 11:00	3000	12.87	-0.04				
11-Sep-2014 12:00	3060	12.87	-0.05				
11-Sep-2014 13:00	3120	12.87	-0.04				
11-Sep-2014 14:00	3180	12.87	-0.04				
11-Sep-2014 15:00	3240	12.87	-0.04				
11-Sep-2014 16:00	3300	12.88	-0.03				
11-Sep-2014 17:00	3360	12.87	-0.04				

11-Sep-2014 18:00	3420	12.88	-0.03
11-Sep-2014 19:00	3480	12.87	-0.04
11-Sep-2014 20:00	3540	12.87	-0.04
11-Sep-2014 21:00	3600	12.87	-0.04
11-Sep-2014 22:00	3660	12.87	-0.04
11-Sep-2014 23:00	3720	12.88	-0.03
12-Sep-2014 00:00	3780	12.87	-0.04
12-Sep-2014 01:00	3840	12.88	-0.03
12-Sep-2014 02:00	3900	12.89	-0.02
12-Sep-2014 03:00	3960	12.88	-0.03
12-Sep-2014 04:00	4020	12.89	-0.02
12-Sep-2014 05:00	4080	12.89	-0.02
12-Sep-2014 06:00	4140	12.89	-0.03
12-Sep-2014 07:00	4200	12.89	-0.02
12-Sep-2014 08:00	4260	12.89	-0.02
12-Sep-2014 09:00	4320	12.90	-0.02

Tabulated Levels for House 1

Pump On:	09-Sep-2014 09:00		Static Level:	4.51	
Pump Off:	12-Sep-2014 09:00		Pumping Level:	4.45	
Pumping Well:	**TW34**		DD:	-0.06	
Distance from Pumping Well:	926 m				

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
09-Sep-2014 09:00	0	4.51	0.00	12-Sep-2014 09:00	0	4.45	0.00
09-Sep-2014 09:01	1	4.51	0.00	12-Sep-2014 09:01	1	4.45	0.00
09-Sep-2014 09:02	2	4.51	0.00	12-Sep-2014 09:02	2	4.45	0.00
09-Sep-2014 09:03	3	4.51	0.00	12-Sep-2014 09:03	3	4.45	0.00
09-Sep-2014 09:04	4	4.51	0.00	12-Sep-2014 09:04	4	4.46	0.00
09-Sep-2014 09:05	5	4.51	0.00	12-Sep-2014 09:05	5	4.45	0.00
09-Sep-2014 09:06	6	4.51	0.00	12-Sep-2014 09:06	6	4.45	0.00
09-Sep-2014 09:07	7	4.51	0.00	12-Sep-2014 09:07	7	4.45	0.00
09-Sep-2014 09:08	8	4.51	0.00	12-Sep-2014 09:08	8	4.46	-0.01
09-Sep-2014 09:10	10	4.52	0.01	12-Sep-2014 09:09	9	4.46	-0.01
09-Sep-2014 09:12	12	4.51	0.00	12-Sep-2014 09:10	10	4.46	0.00
09-Sep-2014 09:14	14	4.51	0.00	12-Sep-2014 09:12	12	4.45	0.00
09-Sep-2014 09:16	16	4.51	0.00	12-Sep-2014 09:14	14	4.45	0.00
09-Sep-2014 09:18	18	4.51	0.00	12-Sep-2014 09:16	16	4.45	0.00
09-Sep-2014 09:20	20	4.51	0.00	12-Sep-2014 09:18	18	4.45	0.00
09-Sep-2014 09:25	25	4.51	0.00	12-Sep-2014 09:20	20	4.46	-0.01
09-Sep-2014 09:30	30	4.51	0.00	12-Sep-2014 09:25	25	4.46	0.00
09-Sep-2014 09:40	40	4.51	0.00	12-Sep-2014 09:30	30	4.45	0.00
09-Sep-2014 09:50	50	4.51	0.00	12-Sep-2014 09:35	35	4.45	0.00
09-Sep-2014 10:00	60	4.51	0.00	12-Sep-2014 09:40	40	4.45	0.00
09-Sep-2014 10:15	75	4.51	0.00	12-Sep-2014 09:50	50	4.45	0.00
09-Sep-2014 10:30	90	4.51	0.00	12-Sep-2014 10:00	60	4.45	0.00
09-Sep-2014 10:45	105	4.51	0.00	12-Sep-2014 10:15	75	4.46	0.00
09-Sep-2014 11:00	120	4.51	0.00	12-Sep-2014 10:30	90	4.45	0.00
09-Sep-2014 11:30	150	4.51	0.00	12-Sep-2014 10:45	105	4.46	0.00
09-Sep-2014 12:00	180	4.51	0.00	12-Sep-2014 11:00	120	4.45	0.00
09-Sep-2014 12:30	210	4.51	0.00	12-Sep-2014 11:30	150	4.46	-0.01
09-Sep-2014 13:00	240	4.51	0.00	12-Sep-2014 14:00	300	4.46	-0.01
09-Sep-2014 13:30	270	4.50	-0.01	12-Sep-2014 17:00	480	4.46	0.00
09-Sep-2014 14:00	300	4.50	-0.01	13-Sep-2014 10:05	1505	4.50	-0.05
09-Sep-2014 15:00	360	4.50	-0.01				
09-Sep-2014 16:00	420	4.50	-0.01				
09-Sep-2014 17:00	480	4.50	-0.01				
09-Sep-2014 18:00	540	4.50	-0.01				
09-Sep-2014 20:00	660	4.49	-0.02				
09-Sep-2014 21:00	720	4.50	-0.01				
09-Sep-2014 22:00	780	4.49	-0.01				
09-Sep-2014 23:00	840	4.50	-0.01				
10-Sep-2014 00:00	900	4.50	-0.01				
10-Sep-2014 01:00	960	4.49	-0.02				
10-Sep-2014 02:00	1020	4.49	-0.02				
10-Sep-2014 03:00	1080	4.49	-0.01				
10-Sep-2014 04:00	1140	4.49	-0.02				
10-Sep-2014 05:00	1200	4.49	-0.02				
10-Sep-2014 06:00	1260	4.48	-0.03				
10-Sep-2014 07:00	1320	4.49	-0.02				
10-Sep-2014 08:00	1380	4.48	-0.03				
10-Sep-2014 09:00	1440	4.48	-0.03				
10-Sep-2014 10:00	1500	4.48	-0.03				
10-Sep-2014 11:00	1560	4.48	-0.03				
10-Sep-2014 12:00	1620	4.48	-0.03				
10-Sep-2014 13:10	1690	4.48	-0.03				
10-Sep-2014 14:00	1740	4.48	-0.03				
10-Sep-2014 15:00	1800	4.48	-0.03				
10-Sep-2014 16:00	1860	4.47	-0.04				
10-Sep-2014 17:00	1920	4.47	-0.04				
10-Sep-2014 18:00	1980	4.47	-0.04				
10-Sep-2014 19:00	2040	4.45	-0.06				
10-Sep-2014 20:00	2100	4.44	-0.07				
10-Sep-2014 21:00	2160	4.43	-0.08				
10-Sep-2014 22:00	2220	4.43	-0.08				
10-Sep-2014 23:00	2280	4.42	-0.09				
11-Sep-2014 00:00	2340	4.43	-0.08				
11-Sep-2014 01:00	2400	4.43	-0.08				
11-Sep-2014 02:00	2460	4.43	-0.08				
11-Sep-2014 03:00	2520	4.43	-0.08				
11-Sep-2014 04:00	2580	4.42	-0.09				
11-Sep-2014 05:00	2640	4.42	-0.09				
11-Sep-2014 06:00	2700	4.43	-0.08				
11-Sep-2014 07:00	2760	4.43	-0.08				
11-Sep-2014 08:00	2820	4.43	-0.08				
11-Sep-2014 09:00	2880	4.43	-0.08				
11-Sep-2014 10:00	2940	4.43	-0.08				
11-Sep-2014 11:00	3000	4.44	-0.07				
11-Sep-2014 12:00	3060	4.44	-0.07				
11-Sep-2014 13:00	3120	4.44	-0.07				
11-Sep-2014 14:00	3180	4.44	-0.07				
11-Sep-2014 15:00	3240	4.44	-0.06				
11-Sep-2014 16:00	3300	4.45	-0.06				
11-Sep-2014 17:00	3360	4.65	0.15				

11-Sep-2014 18:00	3420	4.45	-0.06
11-Sep-2014 19:00	3480	4.45	-0.06
11-Sep-2014 20:00	3540	4.44	-0.07
11-Sep-2014 21:00	3600	4.45	-0.06
11-Sep-2014 22:00	3660	4.45	-0.06
11-Sep-2014 23:00	3720	4.45	-0.06
12-Sep-2014 00:00	3780	4.45	-0.06
12-Sep-2014 01:00	3840	4.45	-0.06
12-Sep-2014 02:00	3900	4.46	-0.05
12-Sep-2014 03:00	3960	4.45	-0.05
12-Sep-2014 04:00	4020	4.46	-0.05
12-Sep-2014 05:00	4080	4.46	-0.05
12-Sep-2014 06:00	4140	4.46	-0.05
12-Sep-2014 07:00	4200	4.53	0.02
12-Sep-2014 08:00	4260	4.45	-0.05
12-Sep-2014 09:00	4320	4.45	-0.06

Tabulated Levels for SVR OW1

Pump On:	09-Sep-2014 09:00		Static Level:	27.02	
Pump Off:	12-Sep-2014 09:00		Pumping Level:	24.15	
Pumping Well:	**TW34**		DD:	-2.88	
Distance from Pumping Well:	1047 m				

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
09-Sep-2014 09:00	0	27.02	0.00	12-Sep-2014 09:00	0	24.15	0.00
09-Sep-2014 09:01	1	27.02	0.00	12-Sep-2014 09:01	1	24.15	0.00
09-Sep-2014 09:02	2	27.02	0.00	12-Sep-2014 09:02	2	24.15	0.00
09-Sep-2014 09:03	3	27.03	0.01	12-Sep-2014 09:03	3	24.15	0.00
09-Sep-2014 09:04	4	27.03	0.00	12-Sep-2014 09:04	4	24.14	0.01
09-Sep-2014 09:05	5	27.03	0.00	12-Sep-2014 09:05	5	24.15	-0.01
09-Sep-2014 09:06	6	27.03	0.01	12-Sep-2014 09:06	6	24.15	-0.01
09-Sep-2014 09:07	7	27.02	0.00	12-Sep-2014 09:07	7	24.14	0.00
09-Sep-2014 09:08	8	27.03	0.01	12-Sep-2014 09:08	8	24.14	0.00
09-Sep-2014 09:10	10	26.03	-0.99	12-Sep-2014 09:09	9	24.14	0.01
09-Sep-2014 09:12	12	25.09	-1.93	12-Sep-2014 09:10	10	24.14	0.01
09-Sep-2014 09:14	14	24.96	-2.07	12-Sep-2014 09:12	12	24.13	0.01
09-Sep-2014 09:16	16	24.89	-2.14	12-Sep-2014 09:14	14	24.14	0.01
09-Sep-2014 09:18	18	24.85	-2.18	12-Sep-2014 09:16	16	24.13	0.01
09-Sep-2014 09:20	20	24.80	-2.22	12-Sep-2014 09:18	18	24.14	0.01
09-Sep-2014 09:25	25	24.75	-2.28	12-Sep-2014 09:20	20	24.12	0.02
09-Sep-2014 09:30	30	24.70	-2.32	12-Sep-2014 09:25	25	24.13	0.01
09-Sep-2014 09:40	40	24.64	-2.38	12-Sep-2014 09:30	30	24.13	0.02
09-Sep-2014 09:50	50	24.60	-2.43	12-Sep-2014 09:35	35	24.13	0.01
09-Sep-2014 10:00	60	24.58	-2.45	12-Sep-2014 09:40	40	24.12	0.02
09-Sep-2014 10:15	75	24.55	-2.48	12-Sep-2014 09:50	50	24.12	0.03
09-Sep-2014 10:30	90	24.52	-2.50	12-Sep-2014 10:00	60	24.11	0.04
09-Sep-2014 10:45	105	24.51	-2.51	12-Sep-2014 10:15	75	24.10	0.05
09-Sep-2014 11:00	120	24.48	-2.54	12-Sep-2014 10:30	90	24.10	0.05
09-Sep-2014 11:30	150	24.47	-2.56	12-Sep-2014 10:45	105	24.09	0.05
09-Sep-2014 12:00	180	24.51	-2.51	12-Sep-2014 11:00	120	24.85	-0.70
09-Sep-2014 12:30	210	24.45	-2.58	12-Sep-2014 11:30	150	25.05	-0.91
09-Sep-2014 13:00	240	24.43	-2.60	12-Sep-2014 14:00	300	24.18	-0.04
09-Sep-2014 13:30	270	24.41	-2.62	12-Sep-2014 17:00	480	24.12	0.02
09-Sep-2014 14:00	300	24.40	-2.62	13-Sep-2014 10:05	1505	26.77	-2.63
09-Sep-2014 15:00	360	25.35	-1.67				
09-Sep-2014 16:00	420	24.68	-2.35				
09-Sep-2014 17:00	480	24.53	-2.50				
09-Sep-2014 18:00	540	24.46	-2.56				
09-Sep-2014 20:00	660	26.79	-0.23				
09-Sep-2014 21:00	720	26.94	-0.08				
09-Sep-2014 22:00	780	24.56	-2.47				
09-Sep-2014 23:00	840	24.47	-2.56				
10-Sep-2014 00:00	900	24.42	-2.60				
10-Sep-2014 01:00	960	24.43	-2.59				
10-Sep-2014 02:00	1020	24.41	-2.62				
10-Sep-2014 03:00	1080	25.30	-1.72				
10-Sep-2014 04:00	1140	25.49	-1.54				
10-Sep-2014 05:00	1200	25.03	-1.99				
10-Sep-2014 06:00	1260	24.61	-2.41				
10-Sep-2014 07:00	1320	24.53	-2.50				
10-Sep-2014 08:00	1380	26.94	-0.08				
10-Sep-2014 09:00	1440	25.23	-1.79				
10-Sep-2014 10:00	1500	24.62	-2.41				
10-Sep-2014 11:00	1560	24.54	-2.48				
10-Sep-2014 12:00	1620	25.38	-1.64				
10-Sep-2014 13:10	1690	24.78	-2.24				
10-Sep-2014 14:00	1740	24.63	-2.39				
10-Sep-2014 15:00	1800	24.59	-2.44				
10-Sep-2014 16:00	1860	24.56	-2.47				
10-Sep-2014 17:00	1920	24.56	-2.46				
10-Sep-2014 18:00	1980	24.58	-2.45				
10-Sep-2014 19:00	2040	24.60	-2.43				
10-Sep-2014 20:00	2100	27.22	0.19				
10-Sep-2014 21:00	2160	24.86	-2.16				
10-Sep-2014 22:00	2220	24.75	-2.28				
10-Sep-2014 23:00	2280	24.71	-2.31				
11-Sep-2014 00:00	2340	24.68	-2.34				
11-Sep-2014 01:00	2400	24.66	-2.36				
11-Sep-2014 02:00	2460	24.65	-2.37				
11-Sep-2014 03:00	2520	24.65	-2.37				
11-Sep-2014 04:00	2580	25.47	-1.56				
11-Sep-2014 05:00	2640	25.38	-1.64				
11-Sep-2014 06:00	2700	24.70	-2.33				
11-Sep-2014 07:00	2760	24.61	-2.41				
11-Sep-2014 08:00	2820	24.55	-2.47				
11-Sep-2014 09:00	2880	26.78	-0.24				
11-Sep-2014 10:00	2940	26.71	-0.31				
11-Sep-2014 11:00	3000	24.55	-2.48				
11-Sep-2014 12:00	3060	24.47	-2.55				
11-Sep-2014 13:00	3120	24.43	-2.60				
11-Sep-2014 14:00	3180	24.38	-2.64				
11-Sep-2014 15:00	3240	24.34	-2.69				
11-Sep-2014 16:00	3300	24.30	-2.72				
11-Sep-2014 17:00	3360	24.28	-2.74				

11-Sep-2014 18:00	3420	24.27	-2.75
11-Sep-2014 19:00	3480	24.25	-2.78
11-Sep-2014 20:00	3540	25.22	-1.81
11-Sep-2014 21:00	3600	24.43	-2.59
11-Sep-2014 22:00	3660	24.30	-2.72
11-Sep-2014 23:00	3720	24.25	-2.77
12-Sep-2014 00:00	3780	24.23	-2.79
12-Sep-2014 01:00	3840	24.20	-2.83
12-Sep-2014 02:00	3900	24.18	-2.85
12-Sep-2014 03:00	3960	24.15	-2.87
12-Sep-2014 04:00	4020	24.14	-2.88
12-Sep-2014 05:00	4080	24.13	-2.89
12-Sep-2014 06:00	4140	26.73	-0.29
12-Sep-2014 07:00	4200	24.33	-2.70
12-Sep-2014 08:00	4260	24.20	-2.83
12-Sep-2014 09:00	4320	24.15	-2.88

Tabulated Levels for SV Park OW

Pump On:	09-Sep-2014 09:00		Static Level:	13.66	
Pump Off:	12-Sep-2014 09:00		Pumping Level:	13.30	
Pumping Well:	**TW34**		DD:	-0.36	
Distance from Pumping Well:	1564 m				

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
09-Sep-2014 09:00	0	13.66	0.00	12-Sep-2014 09:00	0	13.30	0.00
09-Sep-2014 09:01	1	13.64	-0.02	12-Sep-2014 09:01	1	13.30	0.01
09-Sep-2014 09:02	2	13.65	-0.01	12-Sep-2014 09:02	2	13.30	0.00
09-Sep-2014 09:03	3	13.68	0.02	12-Sep-2014 09:03	3	13.30	0.00
09-Sep-2014 09:04	4	13.67	0.01	12-Sep-2014 09:04	4	13.30	0.00
09-Sep-2014 09:05	5	13.68	0.02	12-Sep-2014 09:05	5	13.30	0.00
09-Sep-2014 09:06	6	13.68	0.02	12-Sep-2014 09:06	6	13.30	0.01
09-Sep-2014 09:07	7	13.68	0.02	12-Sep-2014 09:07	7	13.30	0.01
09-Sep-2014 09:08	8	13.69	0.03	12-Sep-2014 09:08	8	13.30	0.00
09-Sep-2014 09:10	10	13.67	0.01	12-Sep-2014 09:09	9	13.29	0.01
09-Sep-2014 09:12	12	13.68	0.02	12-Sep-2014 09:10	10	13.29	0.01
09-Sep-2014 09:14	14	13.69	0.03	12-Sep-2014 09:12	12	13.29	0.01
09-Sep-2014 09:16	16	13.69	0.03	12-Sep-2014 09:14	14	13.29	0.01
09-Sep-2014 09:18	18	13.69	0.03	12-Sep-2014 09:16	16	13.29	0.01
09-Sep-2014 09:20	20	13.69	0.03	12-Sep-2014 09:18	18	13.28	0.02
09-Sep-2014 09:25	25	13.67	0.01	12-Sep-2014 09:20	20	13.29	0.01
09-Sep-2014 09:30	30	13.68	0.02	12-Sep-2014 09:25	25	13.28	0.02
09-Sep-2014 09:40	40	13.66	0.00	12-Sep-2014 09:30	30	13.28	0.02
09-Sep-2014 09:50	50	13.64	-0.02	12-Sep-2014 09:35	35	13.27	0.03
09-Sep-2014 10:00	60	13.63	-0.03	12-Sep-2014 09:40	40	13.29	0.01
09-Sep-2014 10:15	75	13.60	-0.06	12-Sep-2014 09:50	50	13.28	0.03
09-Sep-2014 10:30	90	13.59	-0.07	12-Sep-2014 10:00	60	13.27	0.04
09-Sep-2014 10:45	105	13.58	-0.08	12-Sep-2014 10:15	75	13.27	0.03
09-Sep-2014 11:00	120	13.56	-0.10	12-Sep-2014 10:30	90	13.26	0.05
09-Sep-2014 11:30	150	13.54	-0.12	12-Sep-2014 10:45	105	13.26	0.04
09-Sep-2014 12:00	180	13.52	-0.14	12-Sep-2014 11:00	120	13.27	0.04
09-Sep-2014 12:30	210	13.51	-0.15	12-Sep-2014 11:30	150	13.35	-0.04
09-Sep-2014 13:00	240	13.49	-0.17	12-Sep-2014 14:00	300	13.33	-0.03
09-Sep-2014 13:30	270	13.46	-0.20	12-Sep-2014 17:00	480	13.25	0.05
09-Sep-2014 14:00	300	13.45	-0.21	13-Sep-2014 10:05	1505	13.30	0.01
09-Sep-2014 15:00	360	13.53	-0.13				
09-Sep-2014 16:00	420	13.61	-0.05				
09-Sep-2014 17:00	480	13.55	-0.11				
09-Sep-2014 18:00	540	13.49	-0.17				
09-Sep-2014 20:00	660	13.44	-0.22				
09-Sep-2014 21:00	720	13.57	-0.09				
09-Sep-2014 22:00	780	13.55	-0.11				
09-Sep-2014 23:00	840	13.49	-0.17				
10-Sep-2014 00:00	900	13.43	-0.23				
10-Sep-2014 01:00	960	13.41	-0.25				
10-Sep-2014 02:00	1020	13.39	-0.27				
10-Sep-2014 03:00	1080	13.45	-0.21				
10-Sep-2014 04:00	1140	13.57	-0.09				
10-Sep-2014 05:00	1200	13.65	-0.01				
10-Sep-2014 06:00	1260	13.55	-0.11				
10-Sep-2014 07:00	1320	13.48	-0.18				
10-Sep-2014 08:00	1380	13.53	-0.13				
10-Sep-2014 09:00	1440	13.62	-0.04				
10-Sep-2014 10:00	1500	13.53	-0.13				
10-Sep-2014 11:00	1560	13.46	-0.20				
10-Sep-2014 12:00	1620	13.50	-0.16				
10-Sep-2014 13:10	1690	13.58	-0.09				
10-Sep-2014 14:00	1740	13.51	-0.15				
10-Sep-2014 15:00	1800	13.46	-0.20				
10-Sep-2014 16:00	1860	13.41	-0.25				
10-Sep-2014 17:00	1920	13.38	-0.28				
10-Sep-2014 18:00	1980	13.35	-0.31				
10-Sep-2014 19:00	2040	13.32	-0.34				
10-Sep-2014 20:00	2100	13.43	-0.23				
10-Sep-2014 21:00	2160	13.47	-0.19				
10-Sep-2014 22:00	2220	13.38	-0.28				
10-Sep-2014 23:00	2280	13.36	-0.30				
11-Sep-2014 00:00	2340	13.34	-0.32				
11-Sep-2014 01:00	2400	13.31	-0.35				
11-Sep-2014 02:00	2460	13.29	-0.37				
11-Sep-2014 03:00	2520	13.27	-0.39				
11-Sep-2014 04:00	2580	13.29	-0.37				
11-Sep-2014 05:00	2640	13.43	-0.23				
11-Sep-2014 06:00	2700	13.38	-0.28				
11-Sep-2014 07:00	2760	13.34	-0.32				
11-Sep-2014 08:00	2820	13.32	-0.34				
11-Sep-2014 09:00	2880	13.32	-0.34				
11-Sep-2014 10:00	2940	13.45	-0.22				
11-Sep-2014 11:00	3000	13.40	-0.26				
11-Sep-2014 12:00	3060	13.36	-0.30				
11-Sep-2014 13:00	3120	13.32	-0.34				
11-Sep-2014 14:00	3180	13.29	-0.37				
11-Sep-2014 15:00	3240	13.28	-0.38				
11-Sep-2014 16:00	3300	13.27	-0.39				
11-Sep-2014 17:00	3360	13.24	-0.42				

11-Sep-2014 18:00	3420	13.25	-0.41
11-Sep-2014 19:00	3480	13.25	-0.41
11-Sep-2014 20:00	3540	13.37	-0.29
11-Sep-2014 21:00	3600	13.42	-0.24
11-Sep-2014 22:00	3660	13.35	-0.31
11-Sep-2014 23:00	3720	13.31	-0.35
12-Sep-2014 00:00	3780	13.29	-0.37
12-Sep-2014 01:00	3840	13.28	-0.38
12-Sep-2014 02:00	3900	13.26	-0.40
12-Sep-2014 03:00	3960	13.25	-0.41
12-Sep-2014 04:00	4020	13.24	-0.42
12-Sep-2014 05:00	4080	13.25	-0.41
12-Sep-2014 06:00	4140	13.35	-0.32
12-Sep-2014 07:00	4200	13.39	-0.27
12-Sep-2014 08:00	4260	13.34	-0.32
12-Sep-2014 09:00	4320	13.30	-0.36

Tabulated Levels for SVR OW2

Pump On:	09-Sep-2014 09:00		Static Level:	13.47	
Pump Off:	12-Sep-2014 09:00		Pumping Level:	13.20	
Pumping Well:	**TW34**		DD:	-0.27	
Distance from Pumping Well:	2213 m				

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
09-Sep-2014 09:00	0	13.47	0.00	12-Sep-2014 09:00	0	13.20	0.00
09-Sep-2014 09:01	1	13.47	0.00	12-Sep-2014 09:01	1	13.21	0.00
09-Sep-2014 09:02	2	13.46	-0.01	12-Sep-2014 09:02	2	13.20	0.00
09-Sep-2014 09:03	3	13.45	-0.02	12-Sep-2014 09:03	3	13.20	0.00
09-Sep-2014 09:04	4	13.47	0.00	12-Sep-2014 09:04	4	13.20	0.00
09-Sep-2014 09:05	5	13.47	0.00	12-Sep-2014 09:05	5	13.20	0.00
09-Sep-2014 09:06	6	13.48	0.00	12-Sep-2014 09:06	6	13.20	0.00
09-Sep-2014 09:07	7	13.48	0.00	12-Sep-2014 09:07	7	13.20	0.00
09-Sep-2014 09:08	8	13.48	0.00	12-Sep-2014 09:08	8	13.20	0.01
09-Sep-2014 09:10	10	13.48	0.00	12-Sep-2014 09:09	9	13.20	0.00
09-Sep-2014 09:12	12	13.48	0.00	12-Sep-2014 09:10	10	13.20	0.00
09-Sep-2014 09:14	14	13.48	0.01	12-Sep-2014 09:12	12	13.20	0.01
09-Sep-2014 09:16	16	13.48	0.00	12-Sep-2014 09:14	14	13.20	0.00
09-Sep-2014 09:18	18	13.48	0.01	12-Sep-2014 09:16	16	13.20	0.01
09-Sep-2014 09:20	20	13.48	0.01	12-Sep-2014 09:18	18	13.20	0.00
09-Sep-2014 09:25	25	13.49	0.01	12-Sep-2014 09:20	20	13.20	0.01
09-Sep-2014 09:30	30	13.49	0.01	12-Sep-2014 09:25	25	13.20	0.01
09-Sep-2014 09:40	40	13.49	0.02	12-Sep-2014 09:30	30	13.20	0.01
09-Sep-2014 09:50	50	13.50	0.02	12-Sep-2014 09:35	35	13.20	0.00
09-Sep-2014 10:00	60	13.49	0.02	12-Sep-2014 09:40	40	13.20	0.01
09-Sep-2014 10:15	75	13.50	0.03	12-Sep-2014 09:50	50	13.19	0.01
09-Sep-2014 10:30	90	13.49	0.02	12-Sep-2014 10:00	60	13.19	0.02
09-Sep-2014 10:45	105	13.49	0.02	12-Sep-2014 10:15	75	13.18	0.02
09-Sep-2014 11:00	120	13.50	0.02	12-Sep-2014 10:30	90	13.18	0.02
09-Sep-2014 11:30	150	13.49	0.01	12-Sep-2014 10:45	105	13.18	0.03
09-Sep-2014 12:00	180	13.48	0.01	12-Sep-2014 11:00	120	13.18	0.03
09-Sep-2014 12:30	210	13.51	0.04	12-Sep-2014 11:30	150	13.18	0.03
09-Sep-2014 13:00	240	13.48	0.01	12-Sep-2014 14:00	300	13.35	-0.15
09-Sep-2014 13:30	270	13.48	0.00	12-Sep-2014 17:00	480	13.21	-0.01
09-Sep-2014 14:00	300	13.46	-0.01	13-Sep-2014 10:05	1505	13.43	-0.23
09-Sep-2014 15:00	360	13.46	-0.02				
09-Sep-2014 16:00	420	13.66	0.18				
09-Sep-2014 17:00	480	13.54	0.07				
09-Sep-2014 18:00	540	13.51	0.04				
09-Sep-2014 20:00	660	13.47	0.00				
09-Sep-2014 21:00	720	13.47	0.00				
09-Sep-2014 22:00	780	13.48	0.01				
09-Sep-2014 23:00	840	13.47	-0.01				
10-Sep-2014 00:00	900	13.46	-0.02				
10-Sep-2014 01:00	960	13.47	0.00				
10-Sep-2014 02:00	1020	13.63	0.16				
10-Sep-2014 03:00	1080	13.51	0.03				
10-Sep-2014 04:00	1140	13.50	0.03				
10-Sep-2014 05:00	1200	13.52	0.05				
10-Sep-2014 06:00	1260	13.54	0.07				
10-Sep-2014 07:00	1320	13.53	0.05				
10-Sep-2014 08:00	1380	13.53	0.05				
10-Sep-2014 09:00	1440	13.55	0.07				
10-Sep-2014 10:00	1500	13.55	0.08				
10-Sep-2014 11:00	1560	14.70	1.23				
10-Sep-2014 12:00	1620	13.64	0.17				
10-Sep-2014 13:10	1690	13.62	0.14				
10-Sep-2014 14:00	1740	13.62	0.15				
10-Sep-2014 15:00	1800	13.61	0.14				
10-Sep-2014 16:00	1860	13.62	0.14				
10-Sep-2014 17:00	1920	13.63	0.16				
10-Sep-2014 18:00	1980	13.66	0.19				
10-Sep-2014 19:00	2040	13.67	0.20				
10-Sep-2014 20:00	2100	13.70	0.22				
10-Sep-2014 21:00	2160	14.18	0.70				
10-Sep-2014 22:00	2220	13.82	0.35				
10-Sep-2014 23:00	2280	13.78	0.31				
11-Sep-2014 00:00	2340	13.75	0.28				
11-Sep-2014 01:00	2400	13.74	0.27				
11-Sep-2014 02:00	2460	13.74	0.27				
11-Sep-2014 03:00	2520	13.73	0.26				
11-Sep-2014 04:00	2580	13.72	0.25				
11-Sep-2014 05:00	2640	13.70	0.23				
11-Sep-2014 06:00	2700	13.67	0.20				
11-Sep-2014 07:00	2760	14.71	1.23				
11-Sep-2014 08:00	2820	13.70	0.23				
11-Sep-2014 09:00	2880	13.60	0.13				
11-Sep-2014 10:00	2940	13.55	0.08				
11-Sep-2014 11:00	3000	13.53	0.05				
11-Sep-2014 12:00	3060	13.50	0.03				
11-Sep-2014 13:00	3120	13.48	0.01				
11-Sep-2014 14:00	3180	13.45	-0.03				
11-Sep-2014 15:00	3240	13.41	-0.06				
11-Sep-2014 16:00	3300	13.39	-0.09				
11-Sep-2014 17:00	3360	13.37	-0.10				

11-Sep-2014 18:00	3420	13.46	-0.01
11-Sep-2014 19:00	3480	13.37	-0.10
11-Sep-2014 20:00	3540	13.34	-0.13
11-Sep-2014 21:00	3600	13.33	-0.15
11-Sep-2014 22:00	3660	13.33	-0.15
11-Sep-2014 23:00	3720	13.31	-0.16
12-Sep-2014 00:00	3780	13.29	-0.18
12-Sep-2014 01:00	3840	13.27	-0.20
12-Sep-2014 02:00	3900	13.25	-0.22
12-Sep-2014 03:00	3960	13.24	-0.24
12-Sep-2014 04:00	4020	13.36	-0.12
12-Sep-2014 05:00	4080	13.26	-0.21
12-Sep-2014 06:00	4140	13.23	-0.25
12-Sep-2014 07:00	4200	13.23	-0.24
12-Sep-2014 08:00	4260	13.22	-0.25
12-Sep-2014 09:00	4320	13.20	-0.27

Table H-2: Water Quality Results

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G26765 **REPORT No. B14-23683**

Report To:

Golder Associates Ltd.
121 Commerce Park Drive, Unit L,
Barrie ON. L4N 8X1 Canada
Attention: Alicia Beynon

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 12-Sep-14
DATE REPORTED: 17-Sep-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 1407634 (McCarthy)
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		TW34 (24 hours)			
			Sample I.D.		B14-23683-1			
			Date Collected		10-Sep-14			
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Hardness (as CaCO3)	mg/L	1	SM 3120	15-Sep-14/O	231			
Alkalinity(CaCO3) to pH4.5	mg/L	5	SM 2320B	15-Sep-14/O	231			
Conductivity @25°C	µmho/cm	1	SM 2510B	15-Sep-14/O	404			
pH @25°C	pH Units		SM 4500H	15-Sep-14/O	8.06			
Fluoride	mg/L	0.1	SM4110C	12-Sep-14/O	0.1			
Bromide	mg/L	0.4	SM4110C	12-Sep-14/O	< 0.4			
Chloride	mg/L	0.5	SM4110C	12-Sep-14/O	1.4			
Nitrite (N)	mg/L	0.1	SM4110C	12-Sep-14/O	< 0.1			
Nitrate (N)	mg/L	0.1	SM4110C	12-Sep-14/O	< 0.1			
Sulphate	mg/L	1	SM4110C	12-Sep-14/O	5			
Calcium	mg/L	0.02	SM 3120	15-Sep-14/O	63.6			
Magnesium	mg/L	0.01	SM 3120	15-Sep-14/O	17.5			
Sodium	mg/L	0.2	SM 3120	15-Sep-14/O	5.2			
Potassium	mg/L	0.1	SM 3120	15-Sep-14/O	2.0			
Iron	mg/L	0.005	SM 3120	15-Sep-14/O	1.45			
Manganese	mg/L	0.001	SM 3120	15-Sep-14/O	0.289			
Ammonia (N)-Total	mg/L	0.01	MOEE 3364	16-Sep-14/O	0.12			
Dissolved Organic Carbon	mg/L	0.2	EPA 415.1	15-Sep-14/O	2.0			
Tannins and Lignins	mg/L	0.1	N/A	15-Sep-14	0.1 [1]			
Anion Sum	meq/L		Calc.	16-Sep-14/O	4.78			
Cation Sum	meq/L		Calc.	16-Sep-14/O	4.99			
% Difference	%		Calc.	16-Sep-14/O	2.15			
Ion Ratio	AS/CS		Calc.	16-Sep-14/O	0.958			
Sodium Adsorption Ratio	-		Calc.	16-Sep-14/O	0.148			
TDS(ion sum calc.)	mg/L		Calc.	16-Sep-14/O	236			
Conductivity (calc.)	µmho/cm		Calc.	16-Sep-14/O	442			
TDS(calc.)/EC(actual)	-		Calc.	16-Sep-14/O	0.584			



M.D.L. = Method Detection Limit
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

The analytical results reported herein refer to the samples as received. Reproduction of this analytical report in full or in part is prohibited without prior consent from Caduceon Environmental Laboratories.

Table H-2: Water Quality Results

CADUCEON™ ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G26765 **REPORT No. B14-23683**

Report To:

Golder Associates Ltd.
121 Commerce Park Drive, Unit L,
Barrie ON. L4N 8X1 Canada
Attention: Alicia Beynon

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 12-Sep-14
DATE REPORTED: 17-Sep-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 1407634 (McCarthy)
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		TW34 (24 hours)			
			Sample I.D.		B14-23683-1			
			Date Collected		10-Sep-14			
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
EC(calc.)/EC(actual)	-		Calc.	16-Sep-14/O	1.09			
Langelier Index(25°C)	S.I.		Calc.	16-Sep-14/O	0.795			

1 . subcontracted to Paracel Labs

M.D.L. = Method Detection Limit
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

The analytical results reported herein refer to the samples as received. Reproduction of this analytical report in full or in part is prohibited without prior consent from Caduceon Environmental Laboratories.

Table H-2: Water Quality Results

CENTRAL ONTARIO ANALYTICAL LABORATORY INC.

4260 Burnside Line, R.R. #4
Orillia, ON L3V 6H4
Tel: (705) 326-8285 Fax: (705) 326-9316
www.coalab.ca

Final Certificate of Microbiological Analysis of Drinking Water

Date & Time Received:	Temp. Rec'd. (°C):	Receiver:	Date & Time Incubated:	2014-09-10 10:30
2014-09-10 09:50	10.4	AB	HPC & FS Date & Time Incubated:	

Date Sampled: 2014-09-09

Collected By: John Easton

Name of Facility: Golder Associates

Drinking Water System (DWS) #

Submitted By: John Easton

Twp/Town	
Systems Health Unit	SMDHU
Regulation	319/08
Total # of pages sent	1
# of samples sent	1
# of samples received	1

Report To: **Golder Associates Ltd.**

Address: 121 Commerce Park Drive, Unit L, Barrie, ON. L4N 8X1

Telephone: 705 722-4492 Ext: Fax: 705-722-3786

Email Address: patricia_chapple@golder.com

"Live Person" After Hours Contact Name and Tel. No:

Conditions/ Comments Test for Total Coliform, E Coli + Background

Time Sampled	Sample Identifier	Identification of Collection Site	Water Type	Temp. Of Sample (°C/°F)	Treatment Information				Laboratory Number	Total Coliform		E. coli		Background		HPC		
					U.V.	Other	Total Cl_2 (mg/L)	Free Cl_2 (mg/L)		>/<	CFU/100 ml	>/<	CFU/100 ml	>/<	CFU/100 ml	>/<	CFU/1 ml	
09:30	TW34	Raw 13-1170-0040 ph 2000	R						906926		0		0		2			

All samples will be considered DISTRIBUTION samples unless otherwise indicated.

All times are transcribed in the 24-hour clock for upload to the Ministry of the Environment (MOE) and/or Ministry of Health and Long Term Care (MoHLTC).

Analysis performed by qualified analysts. Results relate only to the aliquot submitted. Samples have been analyzed as received. COAL is accredited by SCC and licensed by MOE in these specific microbiological parameters and the following inorganic and physical parameters: pH, turbidity, and alkalinity.

COAL accepts no responsibility for parameters selected, misidentification of samples or incorrect quantity, this is the responsibility of the submitting agency.
For collection and handling procedures visit www.coalab.ca/watersamples.html

F.S. & Faecal Strep. = Faecal Streptococcus HPC = Heterotrophic Plate Count HPM = Heavy Particulate Matter N/R = Not Received F.S. and HPC require 48 hours of incubation

Raw = R
Distribution = D
Point of Entry = E
Raw Water Comsumed = RWC

Analysis Date & Time: 2014-09-11 10:00 Enumerated By: LJ Audited By: GD Methodology (COAL Endo - COAL DC): M/F CFU/100ml

Analysis Date & Time: Enumerated By: Audited By: HPC Methodology: SP CFU/1ml; FS Methodology: M/F CFU/100ml

Transcribed By: ST Authorized & Rechecked By: JT/TJ Copy Released By: LJ/CAB

Lab No. Submitting Agency @ Health Unit @ Spills Action Centre (SAC) @ AWQI # By: Date:

Test Methodology and Detection Limit

Total Coliform (Treated)	COAL Endo	Detection Limit	0 - 80	Reportable Limit:	1	Performed by Membrane Filtration	M/F CFU/100 ml
Total Coliform (Untreated)	COAL DC	Detection Limit	0 - 80	Reportable Limit:	1	Performed by Membrane Filtration	M/F CFU/100 ml
E. coli	COAL DC	Detection Limit	0 - 60	Reportable Limit:	1	Performed by Membrane Filtration	M/F CFU/100 ml
Background	COAL Endo	Detection Limit	0 - 200	Indicates Deterioration:	>200	Performed by Membrane Filtration	M/F CFU/100 ml
Background	COAL DC	Detection Limit	0 - 200	Indicates Deterioration:	>200	Performed by Membrane Filtration	M/F CFU/100 ml
HPC	COAL HPC	Detection Limit	10 - 2.00 x 10^3	Indicates Deterioration:	>500	Performed by Spread Plate	SP CFU/1 ml
Faecal Streptococcus	COAL FS	Detection Limit	0 - 80	Reportable Limit:	1	Performed by Membrane Filtration	M/F CFU/100 ml

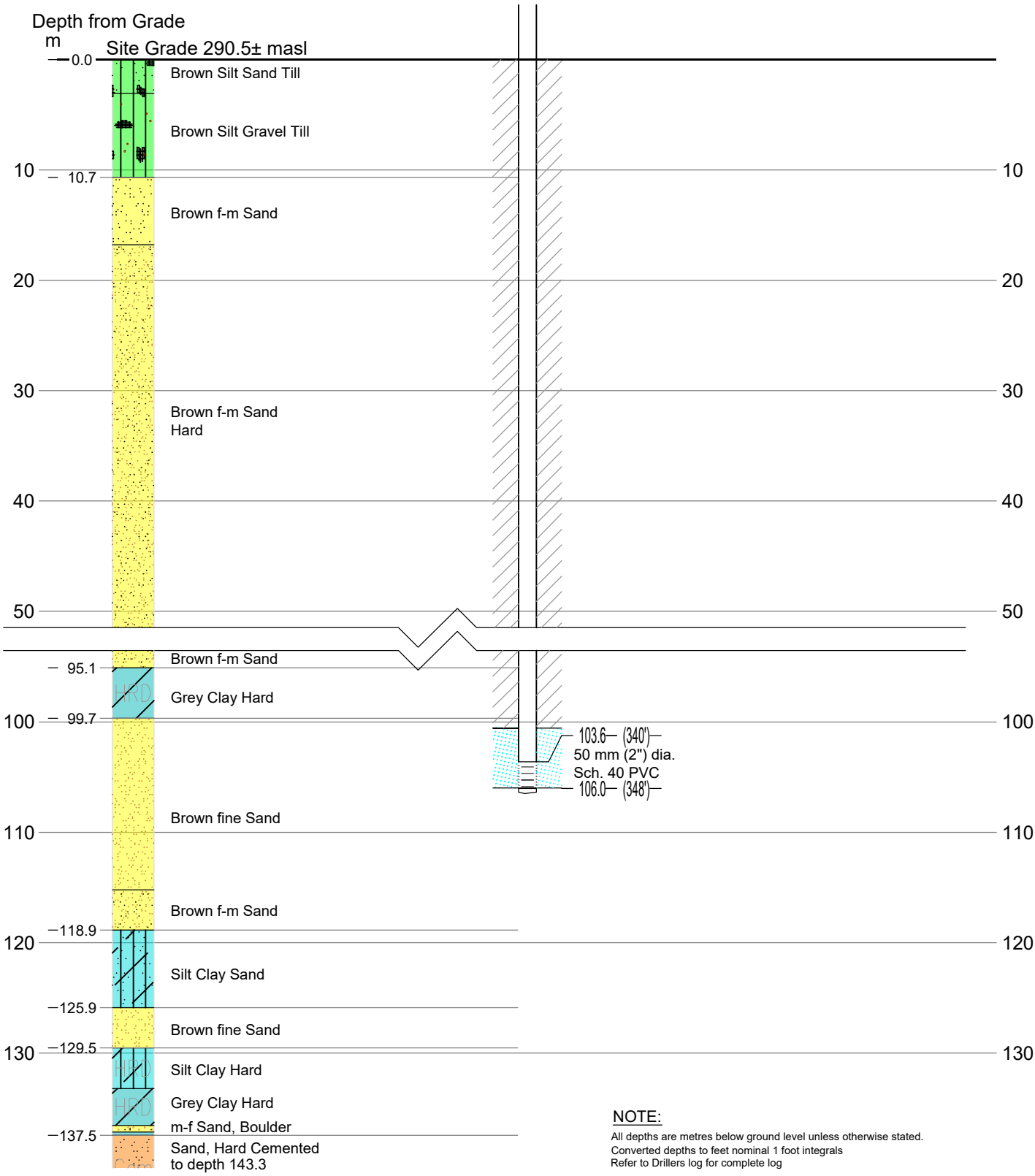
Approved for use by TJ prior to use.

APPENDIX I

Site 8: Well Construction and Testing: Walt Road

OW30

Golder ID L0435



NOTE:

All depths are metres below ground level unless otherwise stated.
Converted depths to feet nominal 1 foot integrals
Refer to Drillers log for complete log

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-10-30
DESIGN	
CAD	JPR
CHECK	
REVIEW	

TITLE

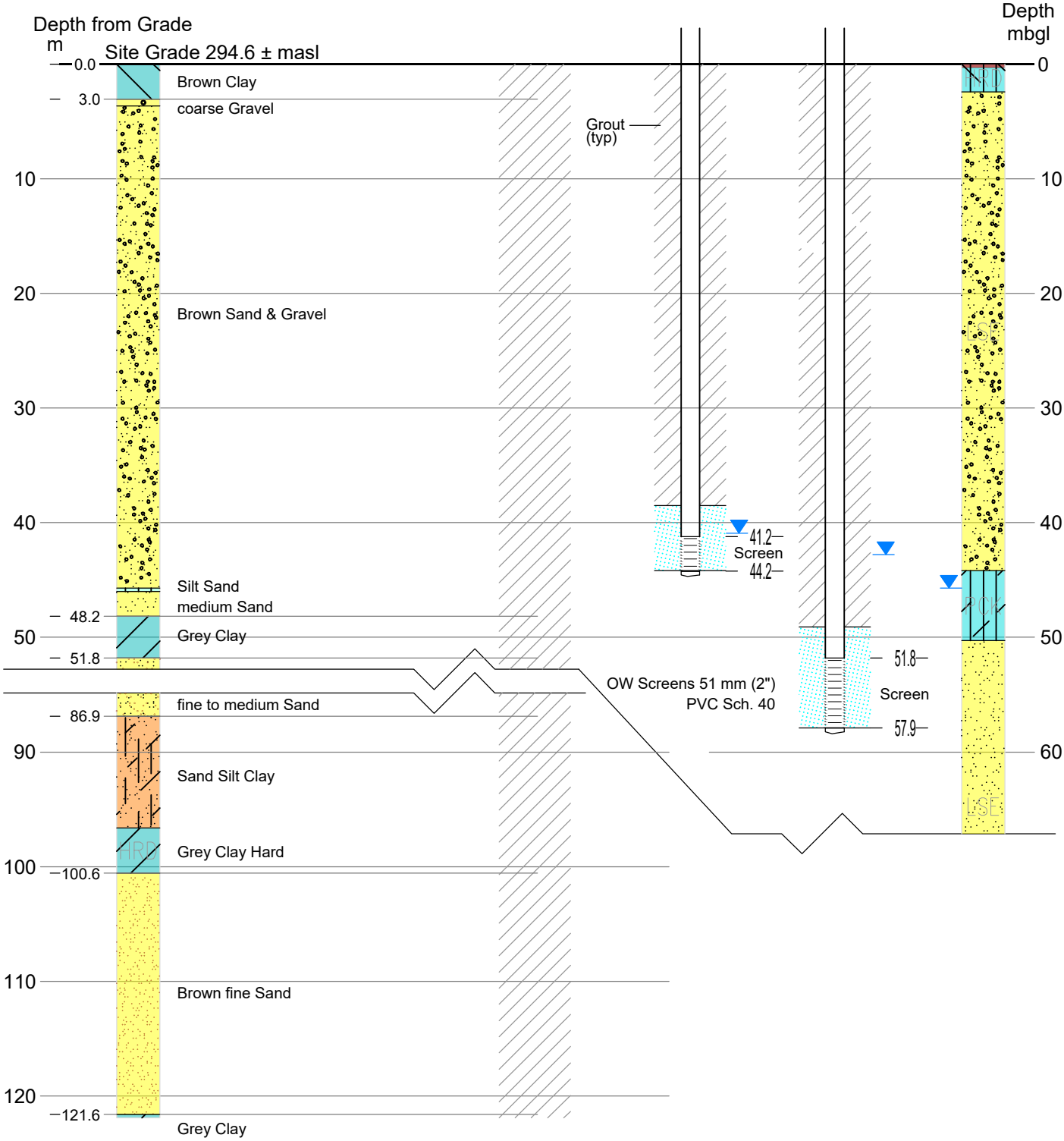
OBSERVATION WELL OW30 AS-BUILT

FILE No. 1311700040CBLOGS.dwg		
PROJECT No. 13-1170-0040	REV.	

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE
I -1

PLOT DATE: October 30, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\CB\1311700040CBLOGS.dwg: [Figure I-1]



NOTE:

All depths are metres below ground level unless otherwise stated.
Converted depths to feet nominal 1 foot integrals
Refer to Drillers log for complete log

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-07-08
DESIGN	
CAD	JPR
CHECK	
REVIEW	

TITLE

TEST HOLE TH31
CONSTRUCTION & ABANDONMENT

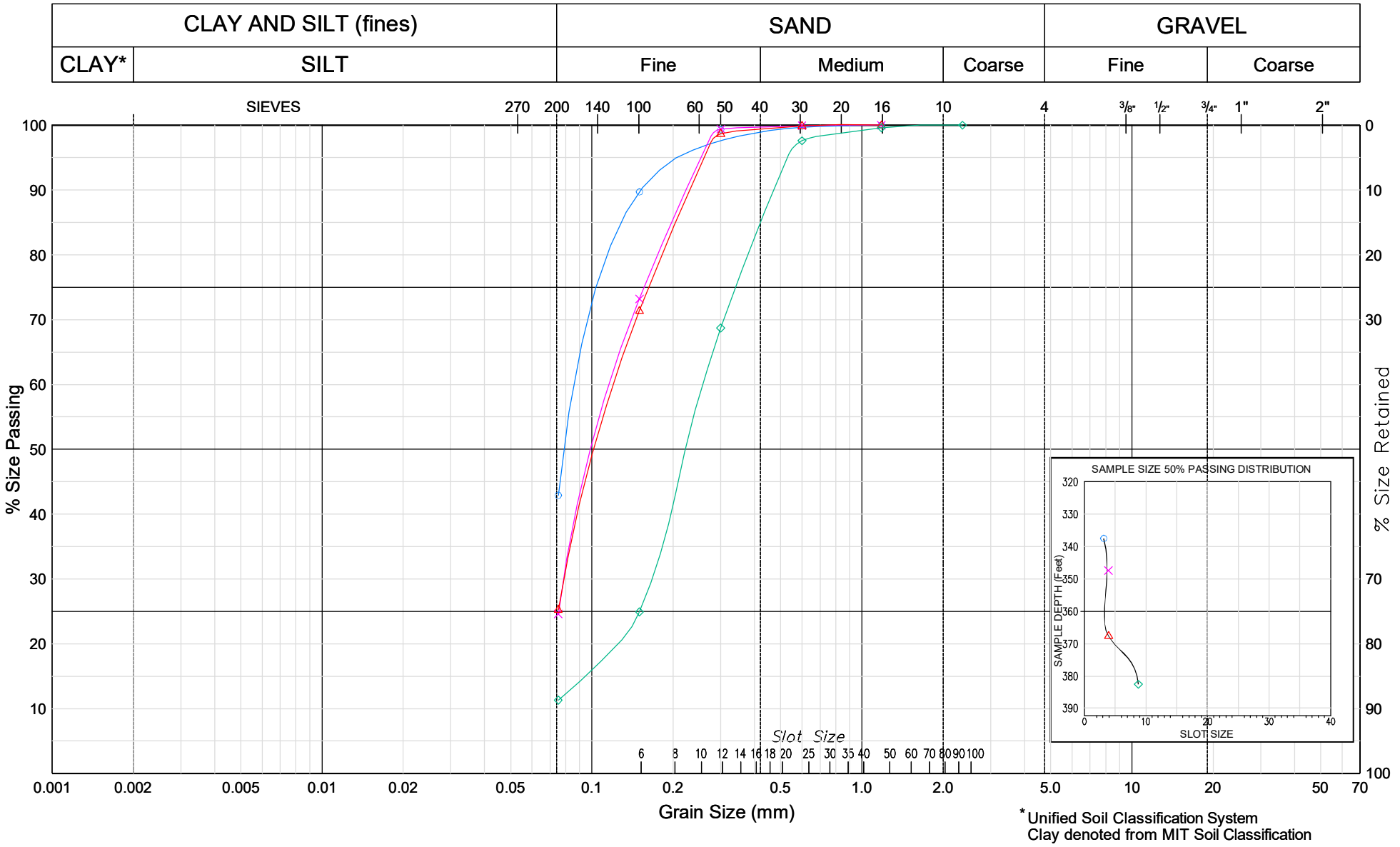
FILE No. 1311700040CBLOGS.dwg		
PROJECT No. 13-1170-0040	REV.	

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE
I-2

PLOT DATE: October 30, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\CB-\1311700040CBLOGS.dwg: [Figure I-2]

PLOT DATE: October 30, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-BA-\1311700040BASVE30.dwg



*Unified Soil Classification System
Clay denoted from MIT Soil Classification

TITLE

GRAIN SIZE ANALYSIS
OW30

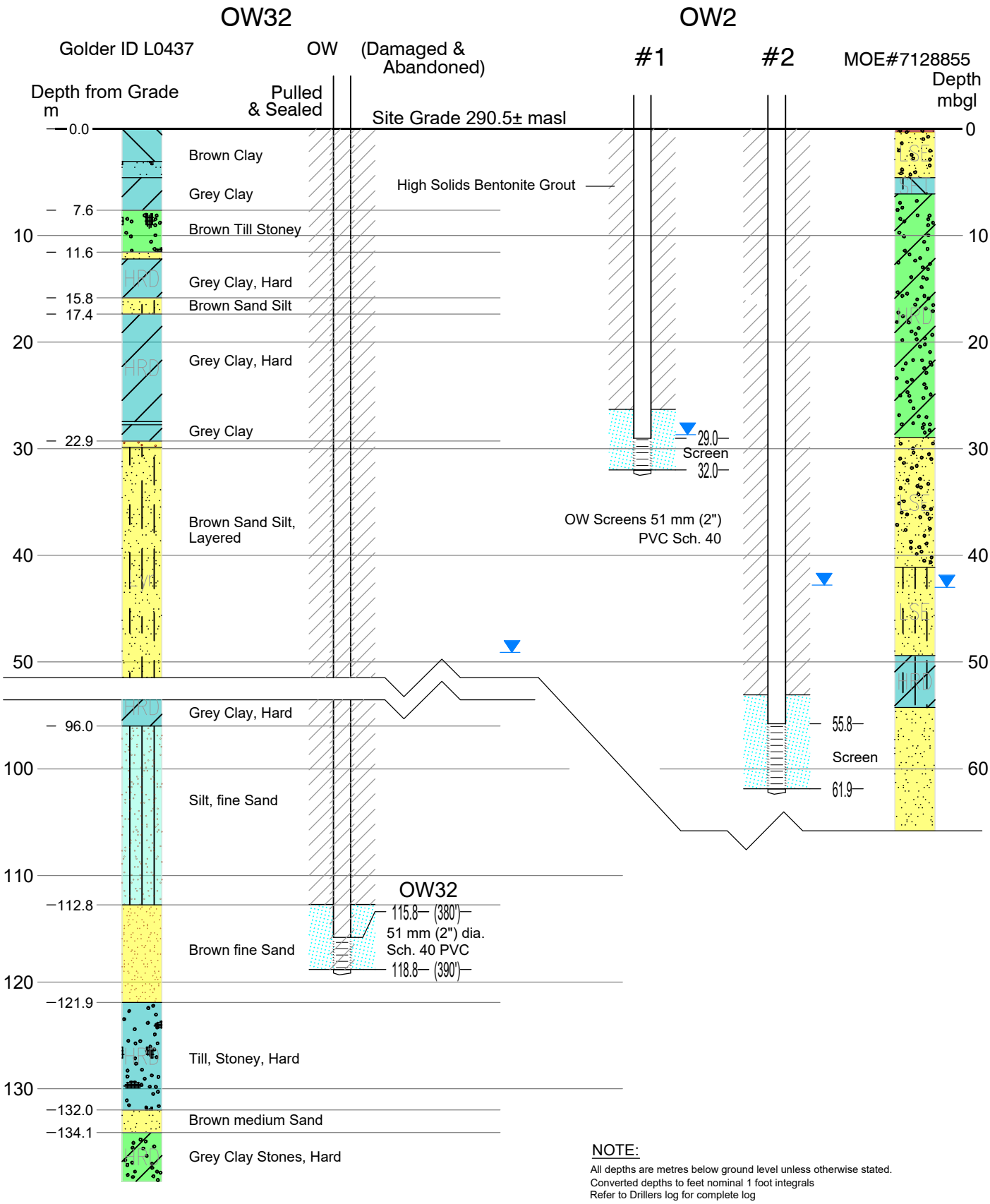
MIDHURST
WATER SUPPLY EXPLORATION

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-04-04
CAD	JPR
CHECK REVIEW	
FILE No.	1311700040BASVE30.dwg
PROJECT No.	13-1170-0040
REV.	
FIGURE	I-3

APPENDIX J

Site 9: Well Construction and Testing: Coutts Site



NOTE:

All depths are metres below ground level unless otherwise stated.
Converted depths to feet nominal 1 foot integrals
Refer to Drillers log for complete log

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-07-08
DESIGN	
CAD	JPR
CHECK	
REVIEW	

TITLE

OBSERVATION WELL OW32 AS-BUILT

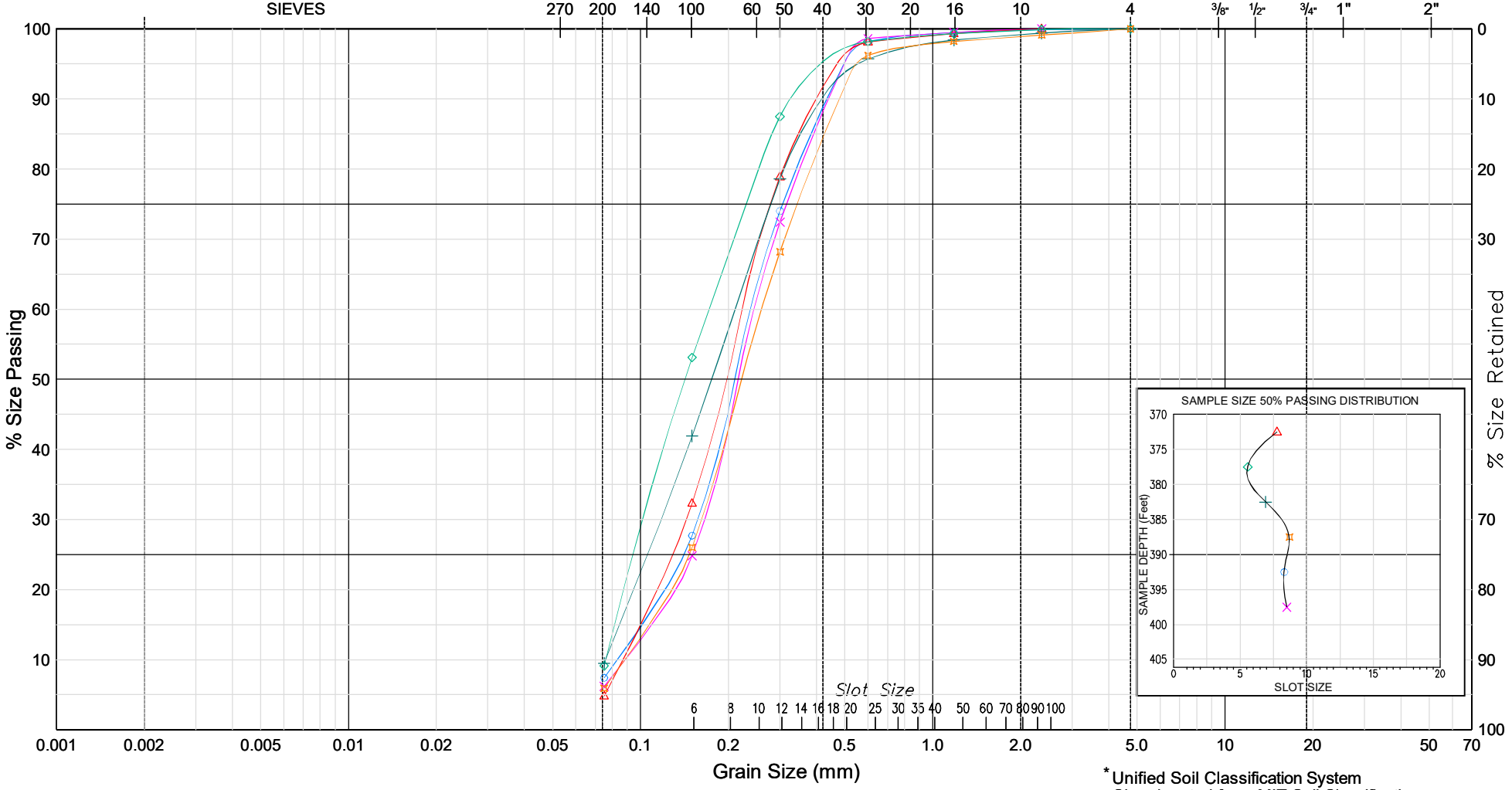
FILE No. 1311700040CBLOGS.dwg		
PROJECT No. 13-1170-0040	REV.	

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE
J -1

PLOT DATE: March 10, 2016
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-CB-\1311700040CBLOGS.dwg: [Figure J-1]

PLOT DATE: October 30, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-BA-\1311700040BASVE32.dwg



△ TW32 370-375 ft
◇ TW32 375-380 ft
+ TW32 380-385 ft
⌑ TW32 385-390 ft
○ TW32 390-395 ft
× TW32 395-400 ft

*Unified Soil Classification System
Clay denoted from MIT Soil Classification

TITLE

GRAIN SIZE ANALYSIS
OW32

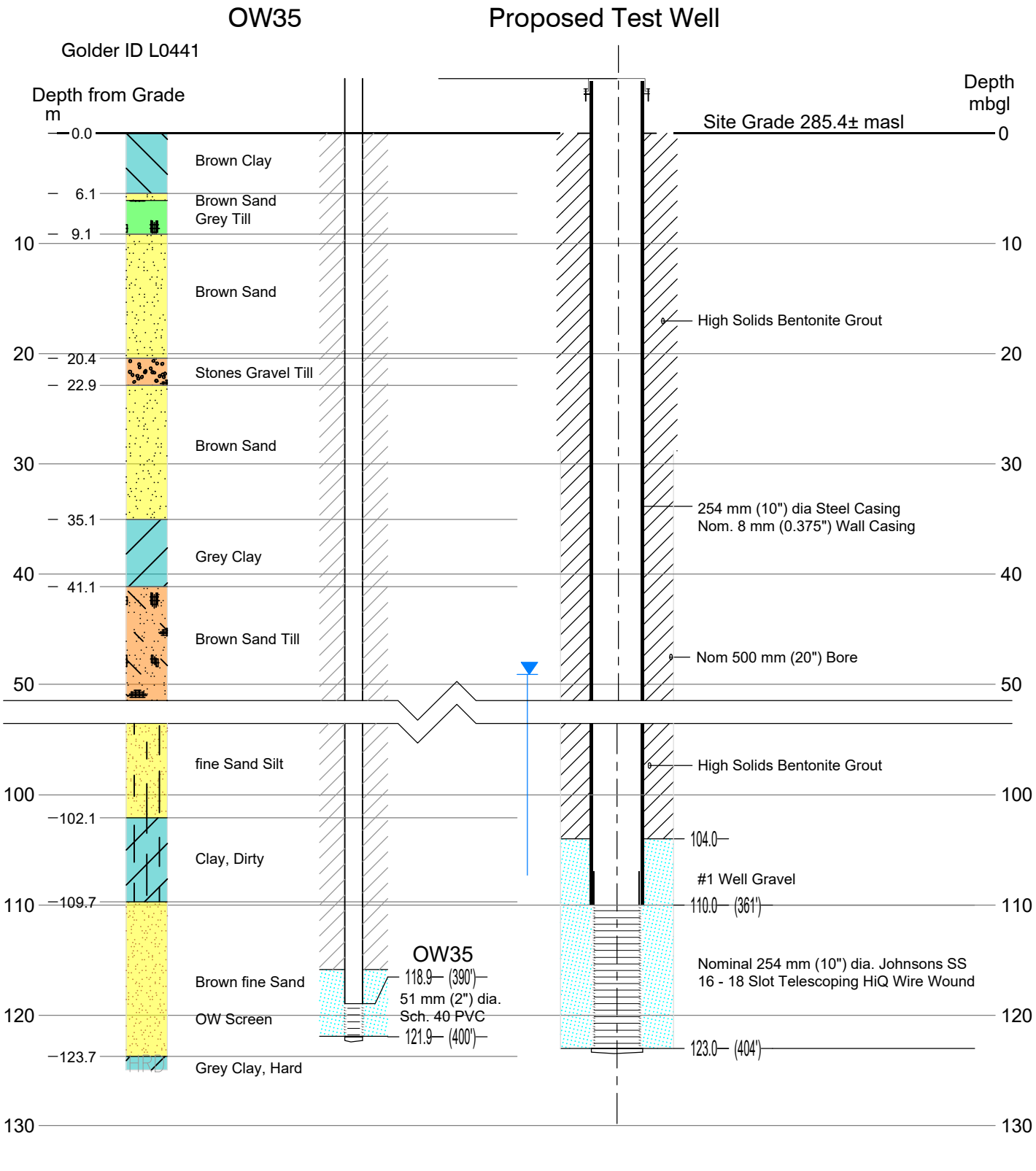
MIDHURST
WATER SUPPLY EXPLORATION

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-04-04
CAD	JPR
CHECK REVIEW	
FILE No.	1311700040BASVE32.dwg
PROJECT No.	13-1170-0040
REV.	
FIGURE	J-2

APPENDIX K

Site 10: Well Construction and Testing: Alliance Site



NOTE:

All depths are metres below ground level unless otherwise stated.
Converted depths to feet nominal 1 foot integrals
Refer to Drillers log for complete log

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-07-08
DESIGN	
CAD	JPR
CHECK	
REVIEW	

TITLE

PRODUCTION WELL OW35 SITE
PROPOSED CONSTRUCTION

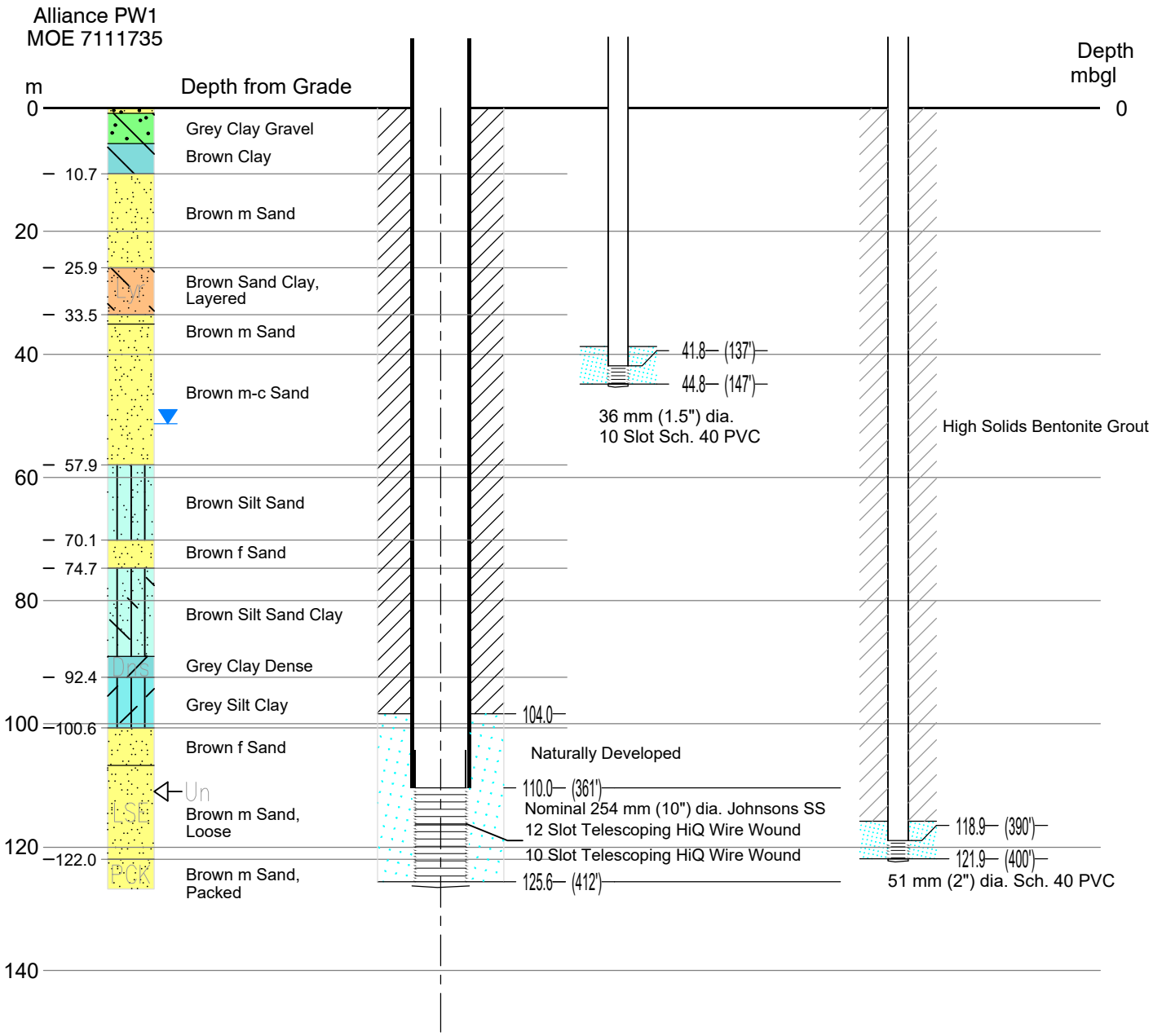
FILE No.	1311700040CBLOGS.dwg
PROJECT No.	13-1170-0040
REV.	

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE
K-1

PLOT DATE: October 30, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\CB\1311700040CBLOGS.dwg: [Figure K-1]

ALLIANCE WELL TH3 OW35



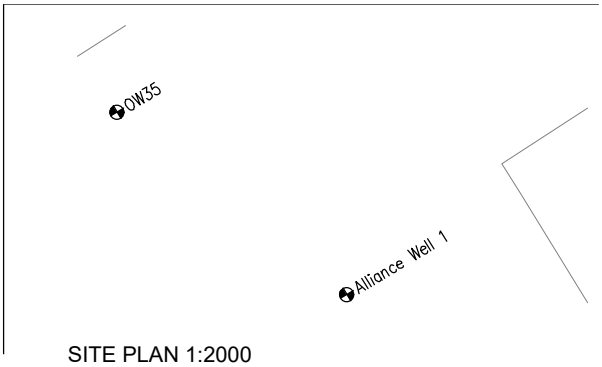
Notes:

All depths are metres below ground level unless otherwise stated.

Converted depths to feet nominal 1 foot integrals

OW's at distance from Pilot Hole of TW20 are truncated above grade at elevation of Test Well, with depths relative approximate to Site Grade of TW20

Observation Well Screens 51 mm (2") dia. Sch. 40 PVC



SITE PLAN 1:2000

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-07-14
DESIGN	
CAD	JPR
CHECK	
REVIEW	

TITLE

AS-BUILT ALLIANCE PW1

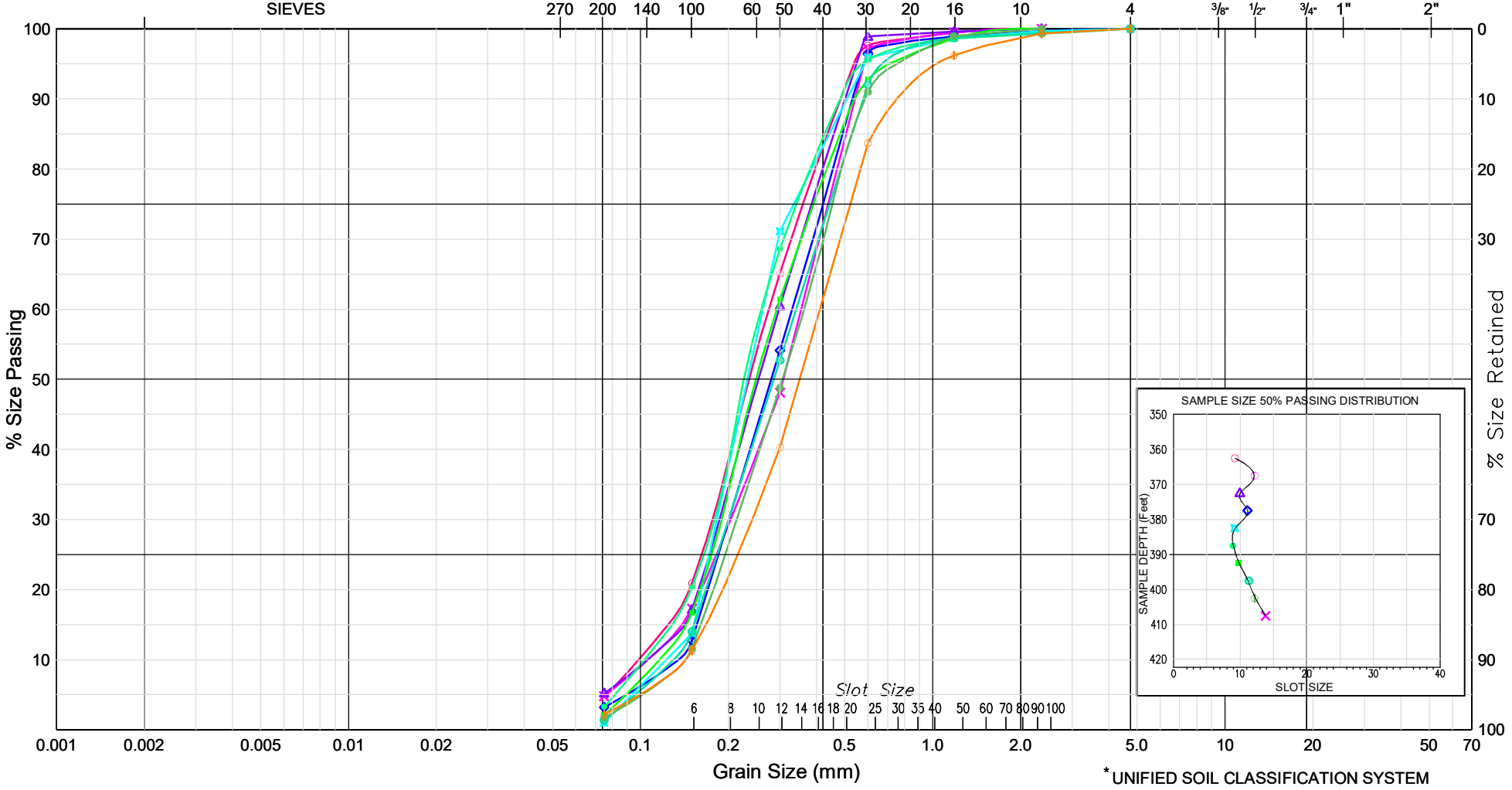
FILE No. 1311700040CBLOGS.dwg
PROJECT No. 13-1170-0040 REV.

MIDHURST
WATER SUPPLY EXPLORATION

FIGURE
K-2

PLOT DATE: October 30, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\CB\1311700040CBLOGS.dwg: [Figure K-2]

PLOT DATE: October 30, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-BA-\1311700040BASVE35.dwg



*UNIFIED SOIL CLASSIFICATION SYSTEM
CLAY DENOTED FROM MIT SOIL CLASSIFICATION

LEGEND

- TW35 360-365'
- TW35 365-370'
- TW35 370-375'
- TW35 375-380'
- TW35 380-385'
- TW35 385-390'
- TW35 390-395'
- TW35 395-400'
- TW35 400-405'
- TW35 405-410'

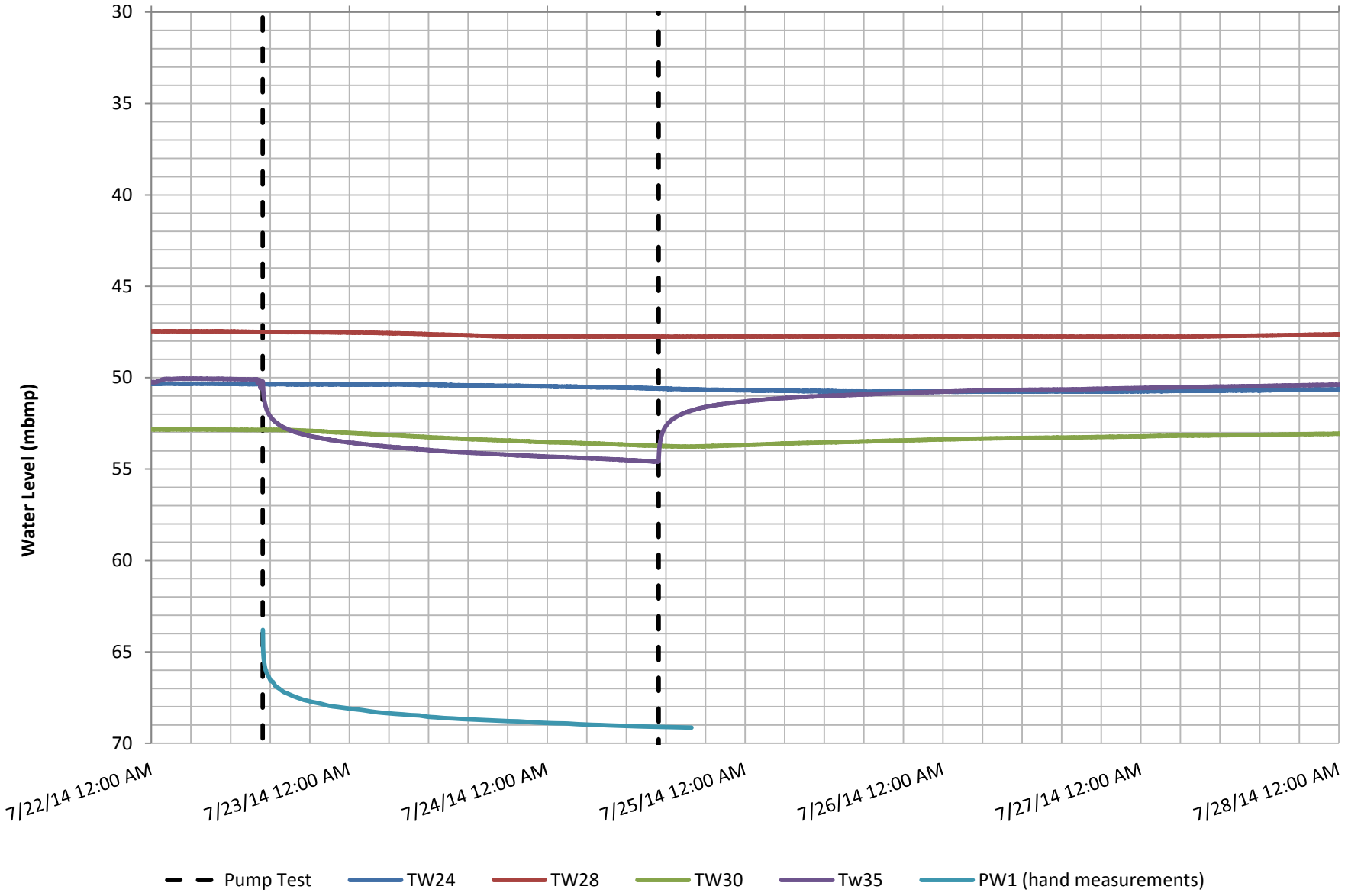
TITLE

GRAIN SIZE ANALYSIS
OW35

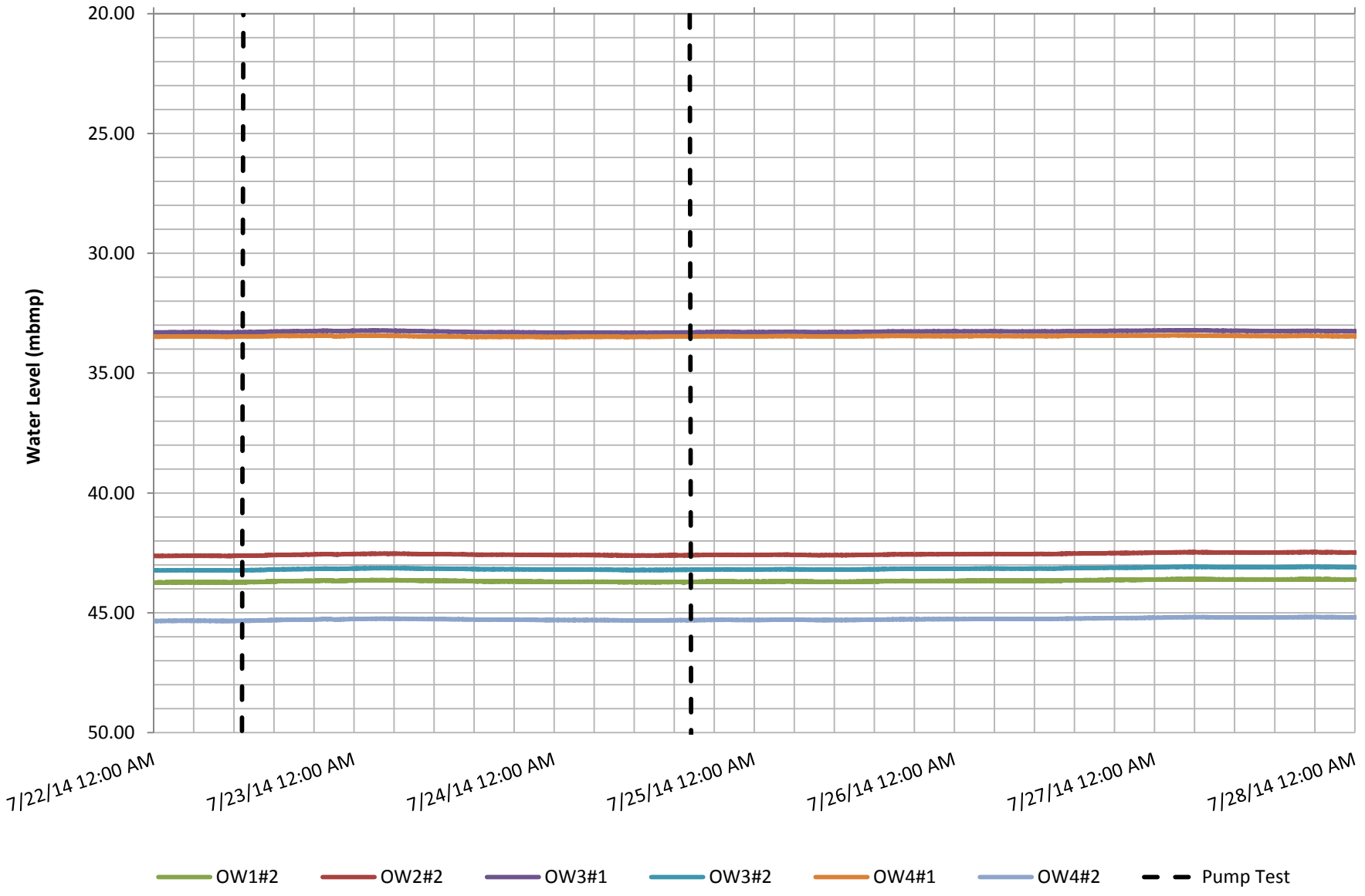
MIDHURST
WATER SUPPLY EXPLORATION

Golder Associates
Barrie, Ontario, Canada

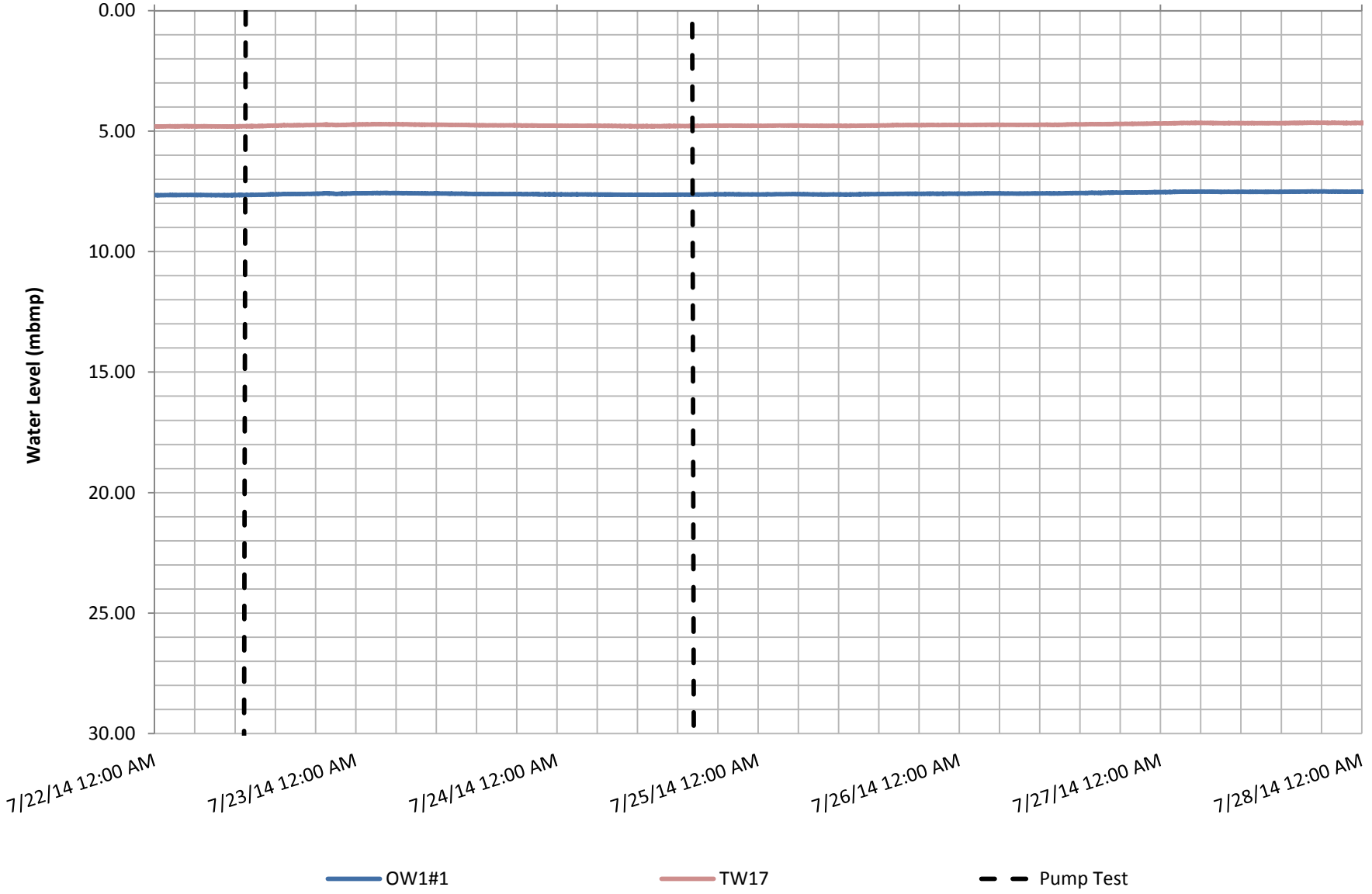
SCALE	AS SHOWN
DATE	2014-10-30
CAD	JPR
CHECK	ALB
REVIEW	JAE
FILE No.	1311700040BASVE35.dwg
PROJECT No.	13-1170-0040
REV.	
FIGURE	K-3



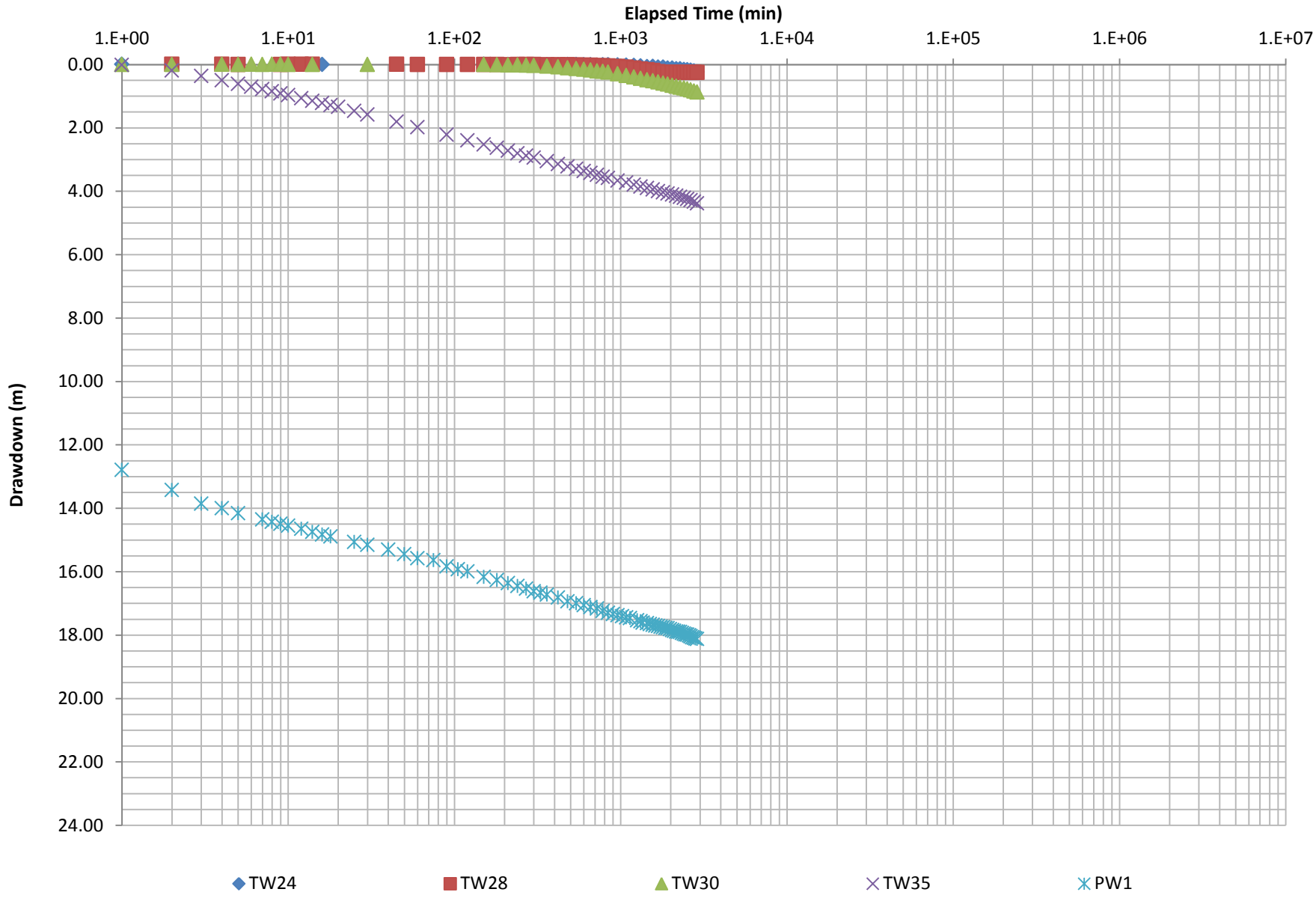
Test Date:	22-Jul-14	Golder Associates	SCALE:	NTS	**Testing of PW1** **Record of Observation Wells**
Pumping Rates L/s:	45		DATE:	29-Oct-14	
			CAD:	ALB	
		FILE No. 1311700040	CHECK:		MIDHURST WATER SUPPLY CONSTRUCTION & TESTING of PW1
		PROJECT No. 1311700040	REVIEW:		FIGURE No. K-4



Test Date:	22-Jul-14	Golder Associates	SCALE:	NTS	**Testing of PW1** **Record of Observation Wells**
Pumping Rates L/s:	45		DATE:	29-Oct-14	
			CAD:	ALB	
		FILE No. 1311700040	CHECK:		MIDHURST WATER SUPPLY CONSTRUCTION & TESTING of PW1
		PROJECT No. 1311700040	REVIEW:		FIGURE No. K-5



Test Date:	22-Jul-14	Golder Associates	SCALE:	NTS	**Testing of PW1** **Record of Observation Wells**
Pumping Rates L/s:	45		DATE:	29-Oct-14	
			CAD:	ALB	
		FILE No. 1311700040	CHECK:		MIDHURST WATER SUPPLY CONSTRUCTION & TESTING of PW1
		PROJECT No. 1311700040	REVIEW:		FIGURE No. K-6



Test Date:	22-Jul-2014
Pumping Rates L/s:	45
PW1 Static Level (mbmp):	51.01
PW1 Pumping Level (mbmp):	69.14

Golder Associates

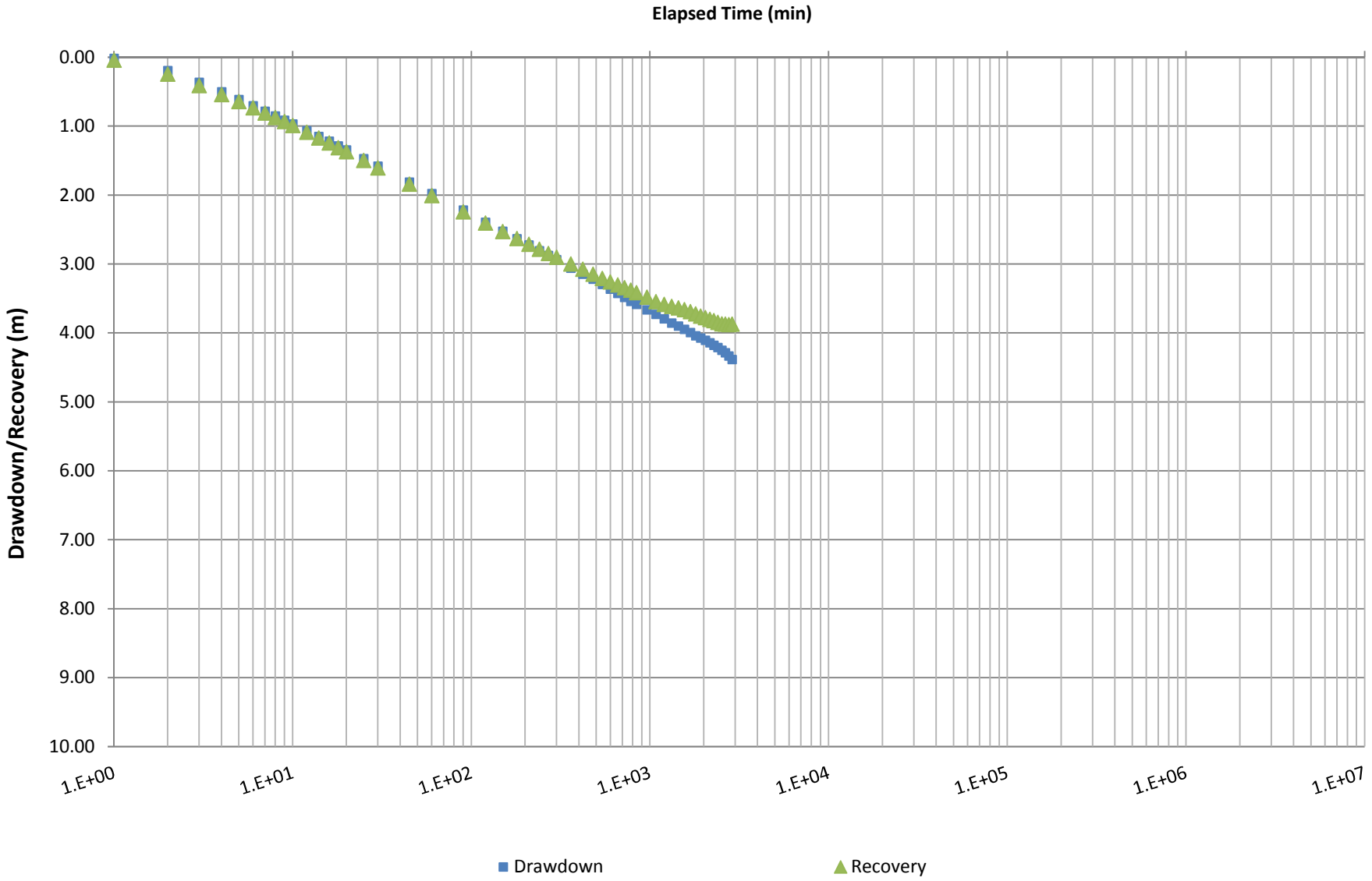
FILE No.	1311700040
PROJECT No.	1311700040

SCALE:	NTS
DATE:	30-Oct-14
CAD:	ALB
CHECK:	
REVIEW:	

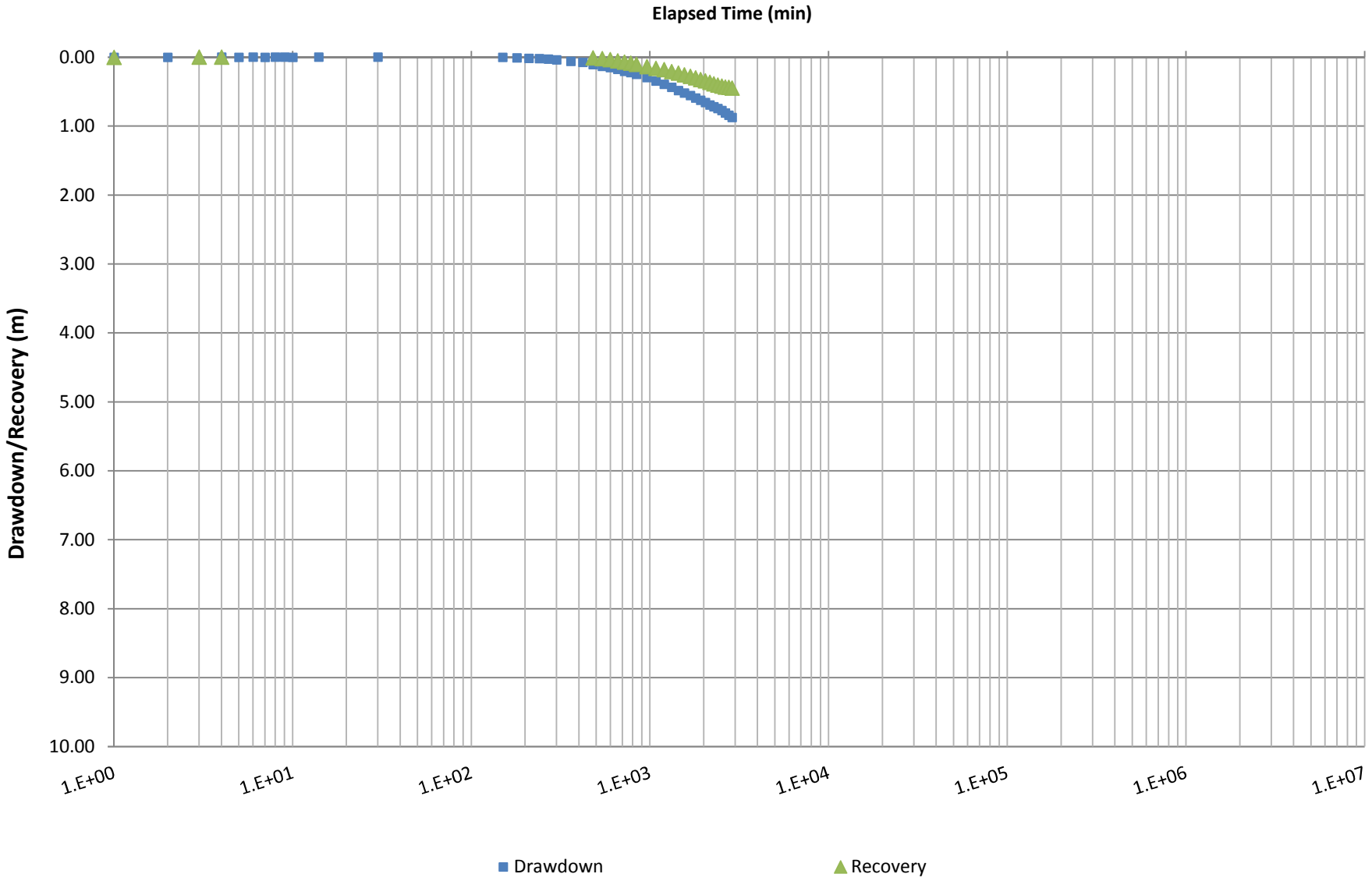
Pumping Test Hydrograph
Record of PW1 and
Aquifer A3 Observation Wells

MIDHURST WATER SUPPLY
CONSTRUCTION & TESTING of PW1

FIGURE No.
K-7



Test Date:	July 22, 2014	Golder Associates	SCALE:	NTS	**Pumping Test Hydrograph Record of OW35**
Pumping Rate:	45 L/s		DATE:	9/Mar/16	
Distance from PW1 (m):	79		CAD:	ALB	
Static Water Level (mbmp):	50.12	FILE No. 1311700040TRANS	CHECK:		MIDHURST WATER SUPPLY CONSTRUCTION & TESTING of PW1
Pumping Water Level (mbmp):	54.5	PROJECT No. 13-1170-0040	REVIEW:		FIGURE No. K-8



Test Date:	July 22, 2014
Pumping Rate:	45 L/s
Distance from PW1 (m):	1500
Static Water Level (mbmp):	52.86
Pumping Water Level (mbmp):	53.73

Golder Associates

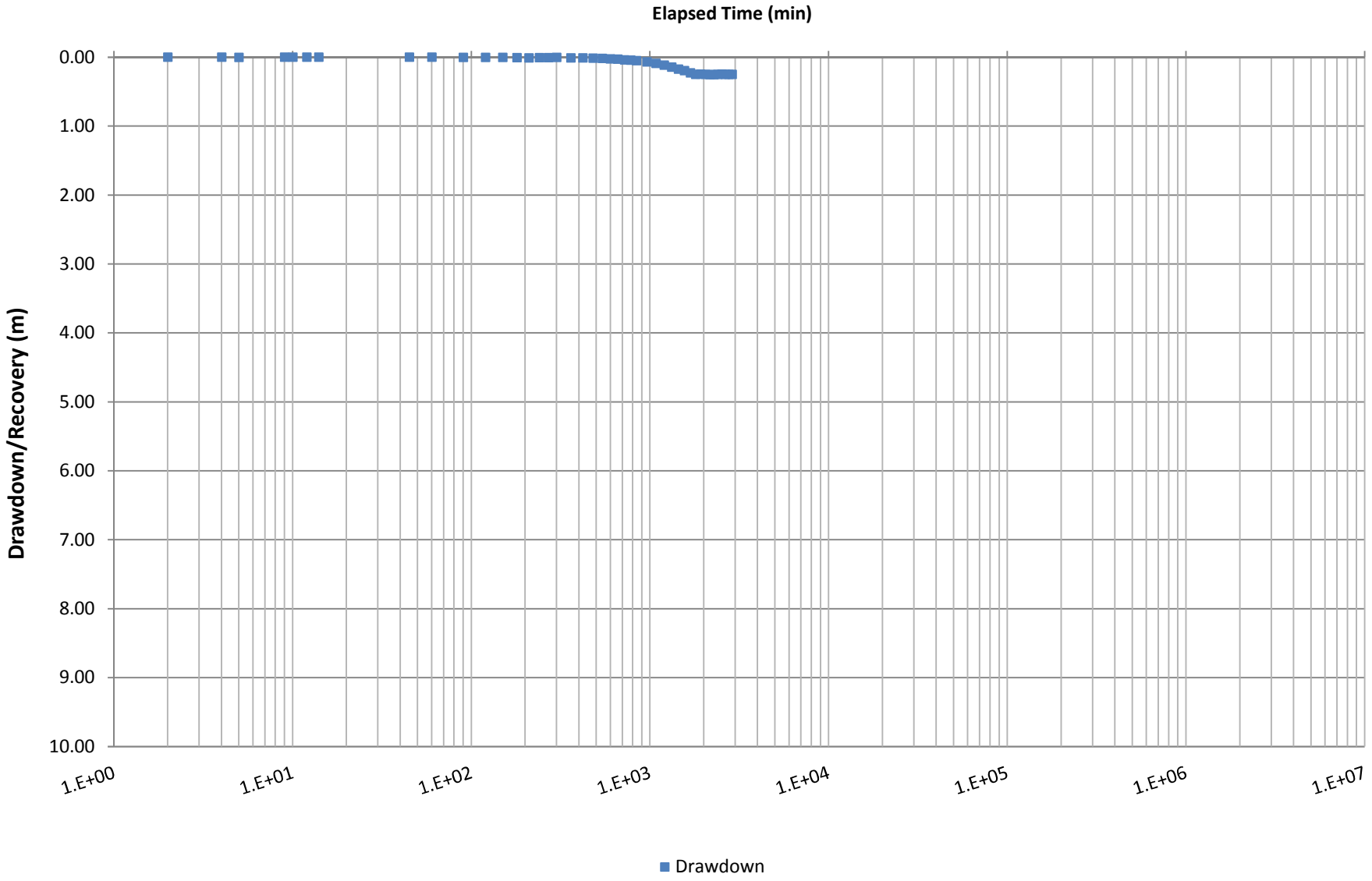
FILE No.	1311700040TRANS
PROJECT No.	13-1170-0040

SCALE:	NTS
DATE:	9/Mar/16
CAD:	ALB
CHECK:	
REVIEW:	

Pumping Test Hydrograph
Record of OW30

MIDHURST WATER SUPPLY
CONSTRUCTION & TESTING of PW1

FIGURE No.
K-9



Test Date:	July 22, 2014
Pumping Rate:	45 L/s
Distance from PW1 (m):	2000
Static Water Level (mbmp):	47.50
Pumping Water Level (mbmp):	47.75

Golder Associates

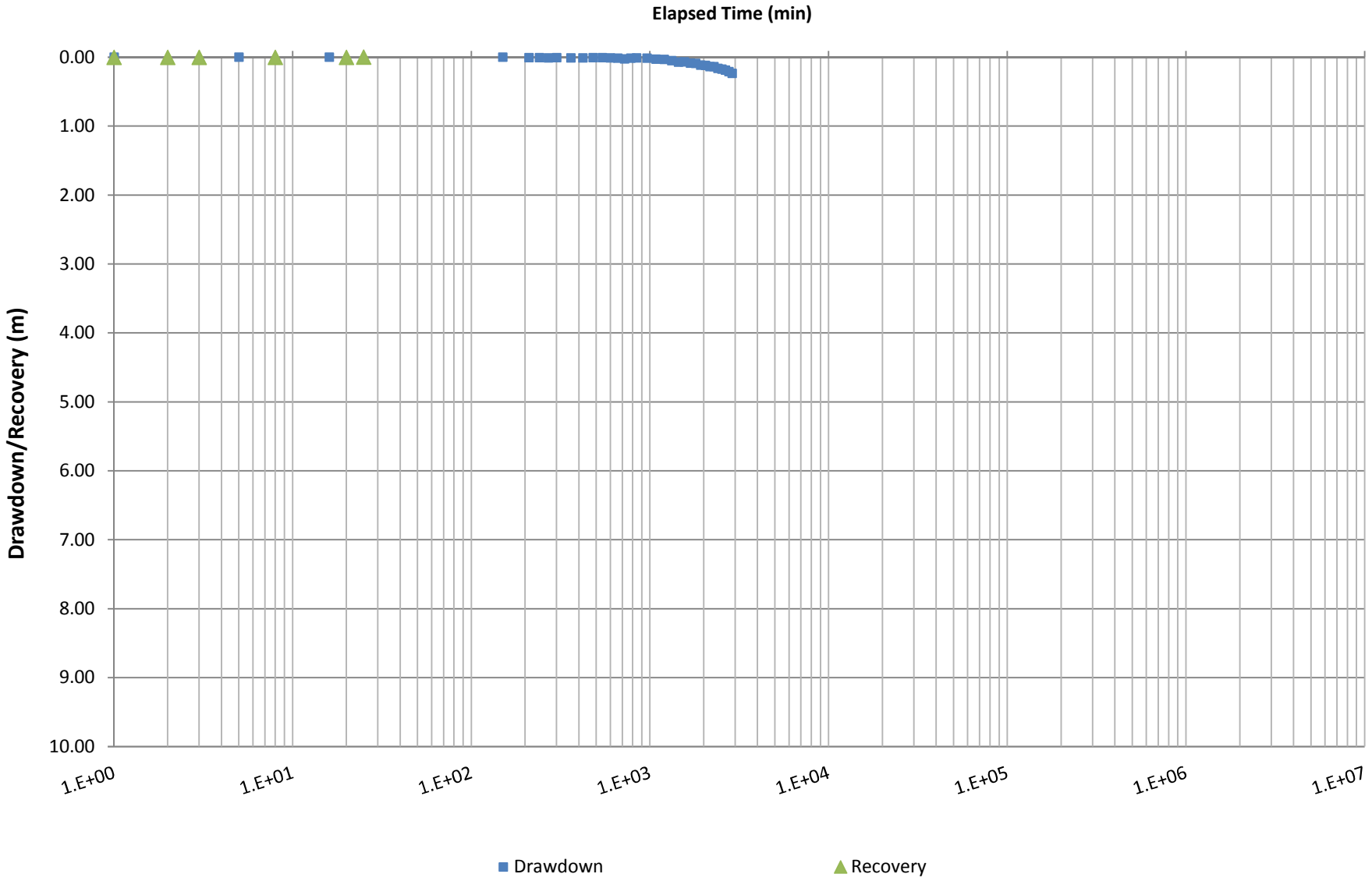
FILE No.	1311700040TRANS
PROJECT No.	13-1170-0040

SCALE:	NTS
DATE:	9/Mar/16
CAD:	ALB
CHECK:	
REVIEW:	

Pumping Test Hydrograph
Record of OW28

MIDHURST WATER SUPPLY
CONSTRUCTION & TESTING of PW1

FIGURE No.
K-10



Test Date:	July 22, 2014
Pumping Rate:	45 L/s
Distance from PW1 (m):	2400
Static Water Level (mbmp):	50.35
Pumping Water Level (mbmp):	50.59

Golder Associates

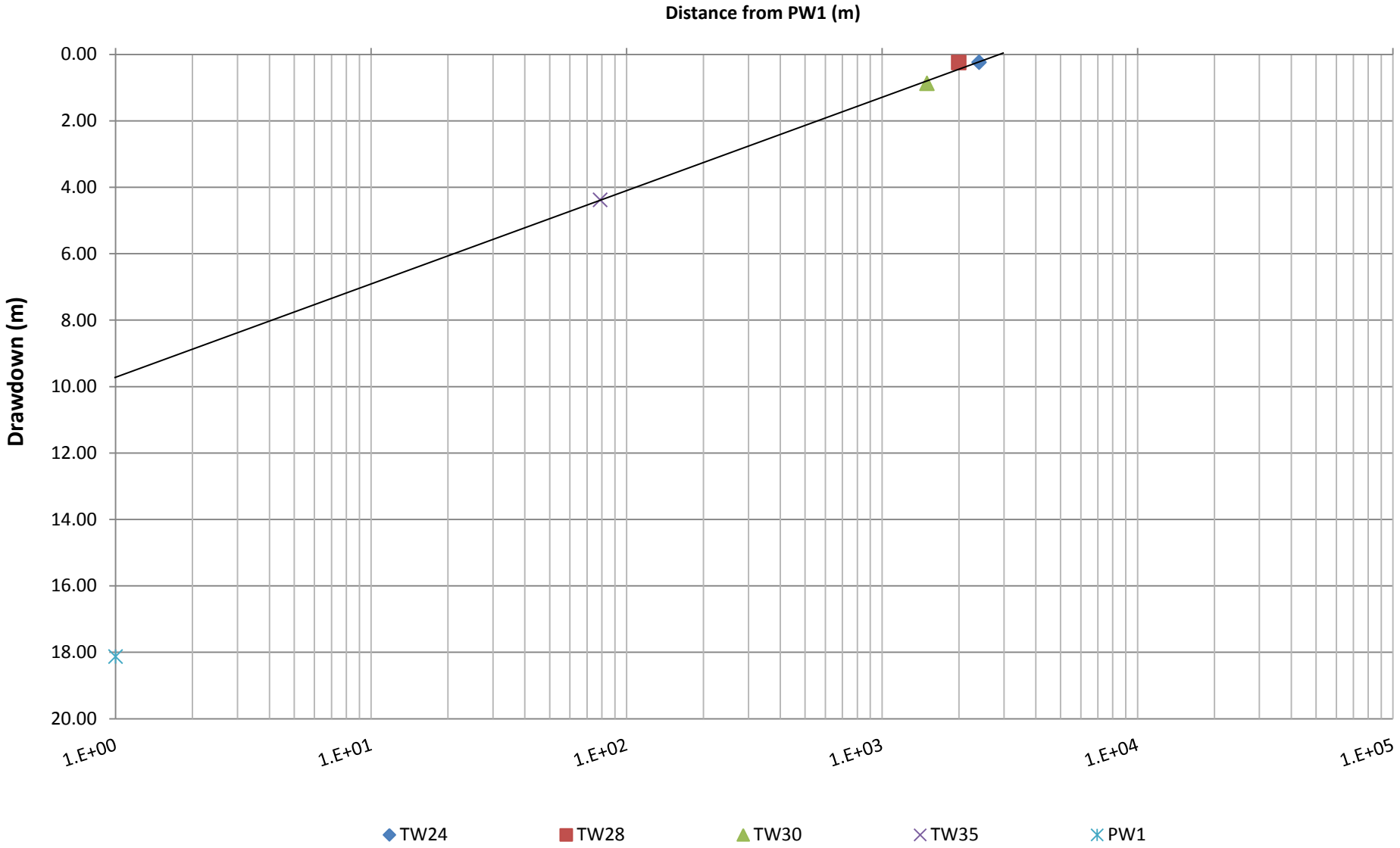
FILE No.	1311700040TRANS
PROJECT No.	13-1170-0040

SCALE:	NTS
DATE:	9/Mar/16
CAD:	ALB
CHECK:	
REVIEW:	

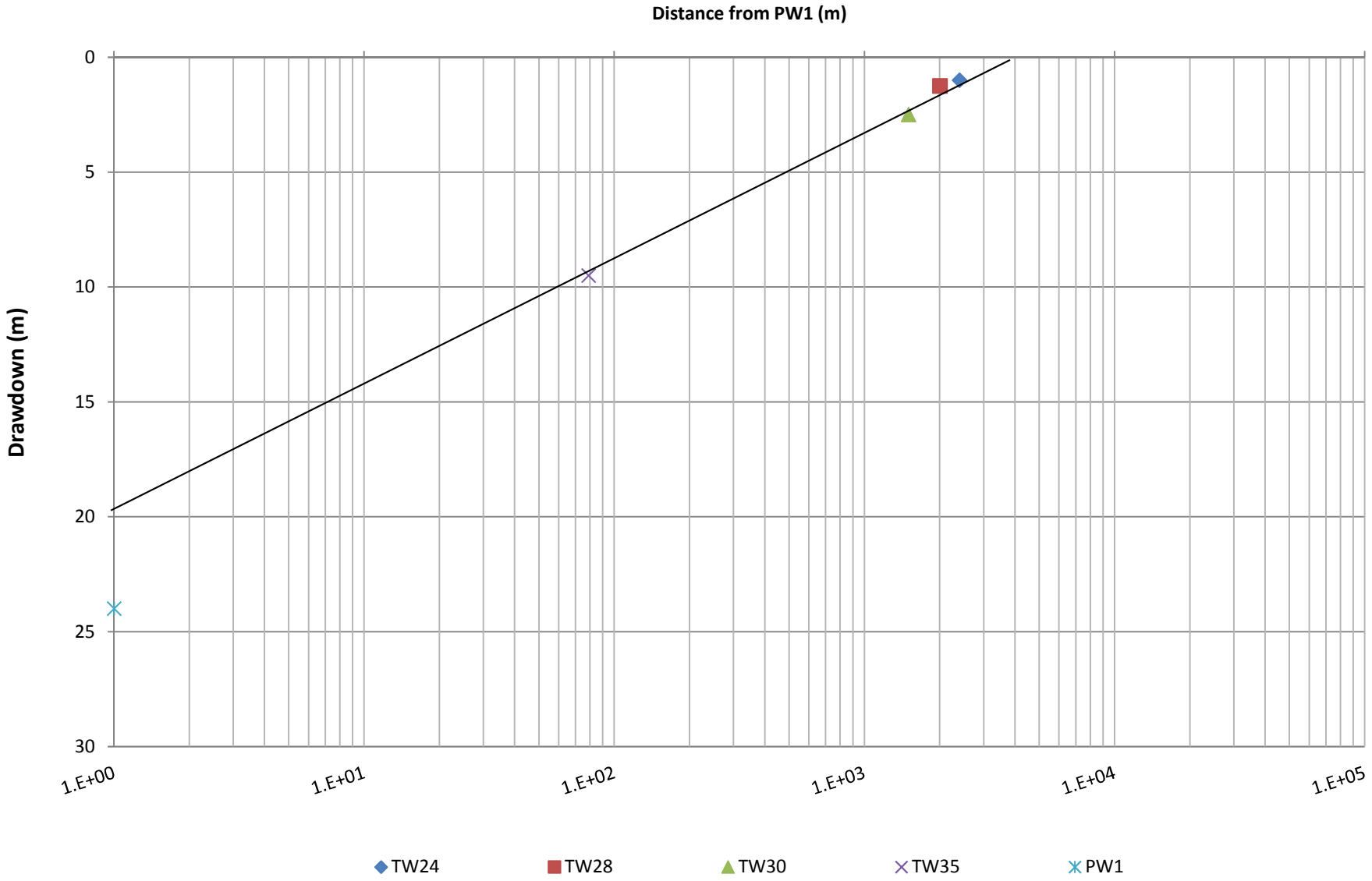
Pumping Test Hydrograph
Record of OW24

MIDHURST WATER SUPPLY
CONSTRUCTION & TESTING of PW1

FIGURE No.
K-11



Test Date: July 22, 2014	Golder Associates	SCALE: NTS	**Test Data Drawdown vs Distance Interference From PW1**	
Pumping Rate: 45 L/s		DATE: 30-Oct-14		
		CAD: ALB		
	FILE No. 1311700040TRANS	CHECK:	MIDHURST WATER SUPPLY CONSTRUCTION & TESTING of PW1	FIGURE No. K-12
	PROJECT No. 13-1170-0040	REVIEW:		



Test Date: July 22, 2014	Golder Associates	SCALE: NTS	**20- Year Drawdown vs Distance Interference From PW1**
Pumping Rate: 45 L/s		DATE: 9/Mar/16	
		CAD: ALB	
	FILE No. 1311700040TRANS	CHECK:	MIDHURST WATER SUPPLY CONSTRUCTION & TESTING of PW1 — FIGURE No. K-13
	PROJECT No. 13-1170-0040	REVIEW:	

Tabulated Levels for PW1

Pump On:	22-Jul-2014 13:30	Static Level:	51.01
Pump Off:	24-Jul-2014 13:30	Pumping Level:	69.14
Pumping Well:	**PW1**	DD:	18.13
Distance from Pumping Well:	0.1 m	20 yr DD:	24

Date:Time	Elapsed	WL	DD
dd-mmm-yyyy hh:mm	(min)	m	m
22-07-2014 13:31	1.00	63.80	12.79
22-07-2014 13:32	2.00	64.44	13.43
22-07-2014 13:33	3	64.87	13.86
22-07-2014 13:34	4	65.01	14.00
22-07-2014 13:35	5	65.17	14.16
22-07-2014 13:37	7	65.37	14.36
22-07-2014 13:38	8	65.44	14.43
22-07-2014 13:39	9	65.50	14.49
22-07-2014 13:40	10	65.56	14.55
22-07-2014 13:42	12	65.66	14.65
22-07-2014 13:44	14	65.76	14.75
22-07-2014 13:46	16	65.84	14.83
22-07-2014 13:48	18	65.90	14.89
22-07-2014 13:55	25	66.08	15.07
22-07-2014 14:00	30	66.17	15.16
22-07-2014 14:10	40	66.32	15.31
22-07-2014 14:20	50	66.46	15.45
22-07-2014 14:30	60	66.59	15.58
22-07-2014 14:45	75	66.65	15.64
22-07-2014 15:00	90	66.85	15.84
22-07-2014 15:15	105	66.94	15.93
22-07-2014 15:30	120	67.01	16.00
22-07-2014 16:00	150	67.18	16.17
22-07-2014 16:30	180	67.28	16.27
22-07-2014 17:00	210	67.38	16.37
22-07-2014 17:30	240	67.47	16.46
22-07-2014 18:00	270	67.55	16.54
22-07-2014 18:30	300	67.63	16.62
22-07-2014 19:00	330	67.68	16.67
22-07-2014 19:30	360	67.74	16.73
22-07-2014 20:30	420	67.83	16.82
22-07-2014 21:30	480	67.95	16.94
22-07-2014 22:30	540	68.01	17.00
22-07-2014 23:30	600	68.07	17.06
23-07-2014 00:30	660	68.13	17.12
23-07-2014 01:30	720	68.18	17.17
23-07-2014 02:30	780	68.25	17.24
23-07-2014 03:30	840	68.31	17.30
23-07-2014 04:30	900	68.35	17.34
23-07-2014 05:30	960	68.39	17.38
23-07-2014 06:30	1020	68.42	17.41
23-07-2014 07:30	1080	68.46	17.45
23-07-2014 08:30	1140	68.48	17.47
23-07-2014 09:30	1260	68.55	17.54
23-07-2014 10:30	1320	68.58	17.57
23-07-2014 11:30	1360	68.62	17.61
23-07-2014 12:30	1440	68.64	17.63
23-07-2014 13:30	1500	68.67	17.66
23-07-2014 14:30	1560	68.69	17.68
23-07-2014 15:30	1620	68.71	17.70
23-07-2014 16:30	1680	68.73	17.72
23-07-2014 17:30	1740	68.75	17.74
23-07-2014 18:30	1800	68.77	17.76
23-07-2014 19:30	1860	68.79	17.78
23-07-2014 20:30	1920	68.8	17.79

Tabulated Levels for PW1

Pump On:	22-Jul-2014 13:30	Static Level:	51.01
Pump Off:	24-Jul-2014 13:30	Pumping Level:	69.14
Pumping Well:	**PW1**	DD:	18.13
Distance from Pumping Well:	0.1 m	20 yr DD:	24

Date:Time	Elapsed	WL	DD
dd-mmm-yyyy hh:mm	(min)	m	m
23-07-2014 21:30	1980	68.83	17.82
23-07-2014 22:30	2040	68.86	17.85
23-07-2014 23:30	2100	68.88	17.87
24-07-2014 00:30	2160	68.9	17.89
24-07-2014 01:30	2220	68.91	17.90
24-07-2014 02:30	2280	68.92	17.91
24-07-2014 03:30	2340	68.95	17.94
24-07-2014 04:30	2400	68.97	17.96
24-07-2014 05:30	2460	68.99	17.98
24-07-2014 06:30	2520	69	17.99
24-07-2014 07:30	2580	69.02	18.01
24-07-2014 09:30	2640	69.05	18.04
24-07-2014 11:30	2700	69.08	18.07
24-07-2014 13:30	2760	69.10	18.09
24-07-2014 15:30	2820	69.12	18.11
24-07-2014 17:30	2880	69.14	18.13

Tabulated Levels for TW35

Pump On:	22-Jul-2014 13:30	Static Level:	50.12
Pump Off:	24-Jul-2014 13:30	Pumping Level:	54.5
Pumping Well:	**PW1**	DD:	4.39
Distance from Pumping Well:	79 m	20 yr DD:	9.5

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
22-Jul-2014 13:31	1	50.13	0.02	24-Jul-2014 13:31	1	54.46	0.04
22-Jul-2014 13:32	2	50.31	0.20	24-Jul-2014 13:32	2	54.26	0.25
22-Jul-2014 13:33	3	50.48	0.37	24-Jul-2014 13:33	3	54.09	0.41
22-Jul-2014 13:34	4	50.62	0.50	24-Jul-2014 13:34	4	53.96	0.54
22-Jul-2014 13:35	5	50.73	0.62	24-Jul-2014 13:35	5	53.86	0.64
22-Jul-2014 13:36	6	50.82	0.71	24-Jul-2014 13:36	6	53.77	0.73
22-Jul-2014 13:37	7	50.90	0.79	24-Jul-2014 13:37	7	53.69	0.81
22-Jul-2014 13:38	8	50.97	0.85	24-Jul-2014 13:38	8	53.62	0.88
22-Jul-2014 13:39	9	51.03	0.92	24-Jul-2014 13:39	9	53.57	0.94
22-Jul-2014 13:40	10	51.08	0.97	24-Jul-2014 13:40	10	53.51	0.99
22-Jul-2014 13:42	12	51.18	1.07	24-Jul-2014 13:42	12	53.41	1.09
22-Jul-2014 13:44	14	51.27	1.15	24-Jul-2014 13:44	14	53.33	1.17
22-Jul-2014 13:46	16	51.34	1.22	24-Jul-2014 13:46	16	53.26	1.24
22-Jul-2014 13:48	18	51.40	1.29	24-Jul-2014 13:48	18	53.19	1.31
22-Jul-2014 13:50	20	51.46	1.35	24-Jul-2014 13:50	20	53.13	1.37
22-Jul-2014 13:55	25	51.59	1.47	24-Jul-2014 13:55	25	53.00	1.50
22-Jul-2014 14:00	30	51.70	1.58	24-Jul-2014 14:00	30	52.89	1.61
22-Jul-2014 14:15	45	51.93	1.81	24-Jul-2014 14:15	45	52.66	1.84
22-Jul-2014 14:30	60	52.10	1.98	24-Jul-2014 14:30	60	52.49	2.01
22-Jul-2014 15:00	90	52.33	2.22	24-Jul-2014 15:00	90	52.26	2.24
22-Jul-2014 15:30	120	52.51	2.40	24-Jul-2014 15:30	120	52.09	2.41
22-Jul-2014 16:00	150	52.64	2.53	24-Jul-2014 16:00	150	51.97	2.53
22-Jul-2014 16:30	180	52.75	2.63	24-Jul-2014 16:30	180	51.87	2.63
22-Jul-2014 17:00	210	52.84	2.73	24-Jul-2014 17:00	210	51.79	2.72
22-Jul-2014 17:30	240	52.92	2.81	24-Jul-2014 17:30	240	51.71	2.79
22-Jul-2014 18:00	270	52.99	2.88	24-Jul-2014 18:00	270	51.65	2.85
22-Jul-2014 18:30	300	53.06	2.94	24-Jul-2014 18:30	300	51.60	2.90
22-Jul-2014 19:30	360	53.18	3.06	24-Jul-2014 19:30	360	51.50	3.00
22-Jul-2014 20:30	420	53.26	3.15	24-Jul-2014 20:30	420	51.42	3.08
22-Jul-2014 21:30	480	53.34	3.22	24-Jul-2014 21:30	480	51.35	3.15
22-Jul-2014 22:30	540	53.41	3.30	24-Jul-2014 22:30	540	51.29	3.21
22-Jul-2014 23:30	600	53.48	3.36	24-Jul-2014 23:30	600	51.24	3.26
23-Jul-2014 00:30	660	53.54	3.43	25-Jul-2014 00:30	660	51.20	3.31
23-Jul-2014 01:30	720	53.60	3.49	25-Jul-2014 01:30	720	51.16	3.35
23-Jul-2014 02:30	780	53.66	3.54	25-Jul-2014 02:30	780	51.12	3.38
23-Jul-2014 03:30	840	53.70	3.59	25-Jul-2014 03:30	840	51.08	3.42
23-Jul-2014 05:30	960	53.78	3.67	25-Jul-2014 05:30	960	51.02	3.48
23-Jul-2014 07:30	1080	53.85	3.73	25-Jul-2014 07:30	1080	50.95	3.55
23-Jul-2014 09:30	1200	53.91	3.80	25-Jul-2014 09:30	1200	50.91	3.59
23-Jul-2014 11:30	1320	53.97	3.86	25-Jul-2014 11:30	1320	50.89	3.62
23-Jul-2014 13:30	1440	54.02	3.90	25-Jul-2014 13:30	1440	50.86	3.64
23-Jul-2014 15:30	1560	54.07	3.95	25-Jul-2014 15:30	1560	50.84	3.66
23-Jul-2014 17:30	1680	54.11	4.00	25-Jul-2014 17:30	1680	50.81	3.69
23-Jul-2014 19:30	1800	54.16	4.04	25-Jul-2014 19:30	1800	50.78	3.72
23-Jul-2014 21:30	1920	54.19	4.07	25-Jul-2014 21:30	1920	50.75	3.76
23-Jul-2014 23:30	2040	54.22	4.11	25-Jul-2014 23:30	2040	50.72	3.78
24-Jul-2014 01:30	2160	54.26	4.14	26-Jul-2014 01:30	2160	50.70	3.80
24-Jul-2014 03:30	2280	54.29	4.18	26-Jul-2014 03:30	2280	50.68	3.82
24-Jul-2014 05:30	2400	54.33	4.21	26-Jul-2014 05:30	2400	50.65	3.85
24-Jul-2014 07:30	2520	54.37	4.25	26-Jul-2014 07:30	2520	50.63	3.87
24-Jul-2014 09:30	2640	54.40	4.29	26-Jul-2014 09:30	2640	50.63	3.87
24-Jul-2014 11:30	2760	54.45	4.33	26-Jul-2014 11:30	2760	50.62	3.88
24-Jul-2014 13:30	2880	54.50	4.39	26-Jul-2014 13:30	2880	50.63	3.87

Tabulated Levels forTW24

Pump On:	22-Jul-2014 13:30	Static Level:	50.35
Pump Off:	24-Jul-2014 13:30	Pumping Level:	50.59
Pumping Well:	**PW1**	DD:	0.24
Distance from Pumping Well:	2400 m	20 yr DD:	1

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
22-Jul-2014 13:31	1	50.35	0.00	24-Jul-2014 13:31	1	50.59	0.01
22-Jul-2014 13:32	2	50.34	-0.01	24-Jul-2014 13:32	2	50.59	0.00
22-Jul-2014 13:33	3	50.35	0.00	24-Jul-2014 13:33	3	50.59	0.00
22-Jul-2014 13:34	4	50.35	0.00	24-Jul-2014 13:34	4	50.60	-0.01
22-Jul-2014 13:35	5	50.35	0.00	24-Jul-2014 13:35	5	50.61	-0.02
22-Jul-2014 13:36	6	50.35	0.00	24-Jul-2014 13:36	6	50.60	-0.01
22-Jul-2014 13:37	7	50.35	0.00	24-Jul-2014 13:37	7	50.60	-0.01
22-Jul-2014 13:38	8	50.35	0.00	24-Jul-2014 13:38	8	50.59	0.00
22-Jul-2014 13:39	9	50.35	0.00	24-Jul-2014 13:39	9	50.60	-0.01
22-Jul-2014 13:40	10	50.35	0.00	24-Jul-2014 13:40	10	50.60	-0.01
22-Jul-2014 13:42	12	50.35	-0.01	24-Jul-2014 13:42	12	50.61	-0.02
22-Jul-2014 13:44	14	50.35	0.00	24-Jul-2014 13:44	14	50.60	-0.01
22-Jul-2014 13:46	16	50.35	0.00	24-Jul-2014 13:46	16	50.60	0.00
22-Jul-2014 13:48	18	50.34	-0.01	24-Jul-2014 13:48	18	50.60	-0.01
22-Jul-2014 13:50	20	50.34	-0.01	24-Jul-2014 13:50	20	50.59	0.00
22-Jul-2014 13:55	25	50.33	-0.02	24-Jul-2014 13:55	25	50.59	0.00
22-Jul-2014 14:00	30	50.34	-0.01	24-Jul-2014 14:00	30	50.60	-0.01
22-Jul-2014 14:15	45	50.35	0.00	24-Jul-2014 14:15	45	50.60	-0.01
22-Jul-2014 14:30	60	50.35	0.00	24-Jul-2014 14:30	60	50.61	-0.02
22-Jul-2014 15:00	90	50.35	-0.01	24-Jul-2014 15:00	90	50.62	-0.02
22-Jul-2014 15:30	120	50.35	0.00	24-Jul-2014 15:30	120	50.62	-0.02
22-Jul-2014 16:00	150	50.35	0.00	24-Jul-2014 16:00	150	50.61	-0.02
22-Jul-2014 16:30	180	50.35	0.00	24-Jul-2014 16:30	180	50.64	-0.04
22-Jul-2014 17:00	210	50.36	0.01	24-Jul-2014 17:00	210	50.63	-0.04
22-Jul-2014 17:30	240	50.36	0.01	24-Jul-2014 17:30	240	50.64	-0.05
22-Jul-2014 18:00	270	50.36	0.01	24-Jul-2014 18:00	270	50.65	-0.06
22-Jul-2014 18:30	300	50.36	0.01	24-Jul-2014 18:30	300	50.65	-0.06
22-Jul-2014 19:30	360	50.36	0.01	24-Jul-2014 19:30	360	50.66	-0.07
22-Jul-2014 20:30	420	50.36	0.01	24-Jul-2014 20:30	420	50.66	-0.07
22-Jul-2014 21:30	480	50.36	0.01	24-Jul-2014 21:30	480	50.67	-0.08
22-Jul-2014 22:30	540	50.36	0.01	24-Jul-2014 22:30	540	50.68	-0.09
22-Jul-2014 23:30	600	50.36	0.01	24-Jul-2014 23:30	600	50.69	-0.10
23-Jul-2014 00:30	660	50.37	0.01	25-Jul-2014 00:30	660	50.69	-0.10
23-Jul-2014 01:30	720	50.38	0.02	25-Jul-2014 01:30	720	50.70	-0.11
23-Jul-2014 02:30	780	50.37	0.02	25-Jul-2014 02:30	780	50.71	-0.12
23-Jul-2014 03:30	840	50.36	0.01	25-Jul-2014 03:30	840	50.71	-0.11
23-Jul-2014 05:30	960	50.37	0.02	25-Jul-2014 05:30	960	50.71	-0.12
23-Jul-2014 07:30	1080	50.38	0.03	25-Jul-2014 07:30	1080	50.74	-0.15
23-Jul-2014 09:30	1200	50.38	0.03	25-Jul-2014 09:30	1200	50.74	-0.15
23-Jul-2014 11:30	1320	50.40	0.05	25-Jul-2014 11:30	1320	50.75	-0.15
23-Jul-2014 13:30	1440	50.42	0.07	25-Jul-2014 13:30	1440	50.75	-0.16
23-Jul-2014 15:30	1560	50.42	0.07	25-Jul-2014 15:30	1560	50.76	-0.16
23-Jul-2014 17:30	1680	50.44	0.09	25-Jul-2014 17:30	1680	50.76	-0.17
23-Jul-2014 19:30	1800	50.44	0.09	25-Jul-2014 19:30	1800	50.76	-0.17
23-Jul-2014 21:30	1920	50.47	0.12	25-Jul-2014 21:30	1920	50.77	-0.17
23-Jul-2014 23:30	2040	50.47	0.12	25-Jul-2014 23:30	2040	50.77	-0.18
24-Jul-2014 01:30	2160	50.49	0.14	26-Jul-2014 01:30	2160	50.76	-0.17
24-Jul-2014 03:30	2280	50.49	0.14	26-Jul-2014 03:30	2280	50.75	-0.16
24-Jul-2014 05:30	2400	50.51	0.16	26-Jul-2014 05:30	2400	50.76	-0.17
24-Jul-2014 07:30	2520	50.53	0.17	26-Jul-2014 07:30	2520	50.76	-0.17
24-Jul-2014 09:30	2640	50.54	0.19	26-Jul-2014 09:30	2640	50.74	-0.15
24-Jul-2014 11:30	2760	50.56	0.21	26-Jul-2014 11:30	2760	50.74	-0.15
24-Jul-2014 13:30	2880	50.59	0.24	26-Jul-2014 13:30	2880	50.75	-0.16

Tabulated Levels for TW28

Pump On:	22-Jul-2014 13:30	Static Level:	47.50
Pump Off:	24-Jul-2014 13:30	Pumping Level:	47.75
Pumping Well:	**PW1**	DD:	0.25
Distance from Pumping Well:	2000 m	20 yr DD:	1.25

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
22-Jul-2014 13:31	1	47.50	0.00	24-Jul-2014 13:31	1	47.75	0.00
22-Jul-2014 13:32	2	47.50	0.00	24-Jul-2014 13:32	2	47.75	0.00
22-Jul-2014 13:33	3	47.50	0.00	24-Jul-2014 13:33	3	47.75	0.00
22-Jul-2014 13:34	4	47.50	0.00	24-Jul-2014 13:34	4	47.75	0.00
22-Jul-2014 13:35	5	47.50	0.00	24-Jul-2014 13:35	5	47.75	0.00
22-Jul-2014 13:36	6	47.50	0.00	24-Jul-2014 13:36	6	47.75	0.00
22-Jul-2014 13:37	7	47.50	0.00	24-Jul-2014 13:37	7	47.76	-0.01
22-Jul-2014 13:38	8	47.50	0.00	24-Jul-2014 13:38	8	47.75	0.00
22-Jul-2014 13:39	9	47.50	0.00	24-Jul-2014 13:39	9	47.75	0.00
22-Jul-2014 13:40	10	47.50	0.00	24-Jul-2014 13:40	10	47.75	0.00
22-Jul-2014 13:42	12	47.50	0.00	24-Jul-2014 13:42	12	47.75	0.00
22-Jul-2014 13:44	14	47.50	0.00	24-Jul-2014 13:44	14	47.75	0.00
22-Jul-2014 13:46	16	47.50	0.00	24-Jul-2014 13:46	16	47.75	0.00
22-Jul-2014 13:48	18	47.50	0.00	24-Jul-2014 13:48	18	47.76	-0.01
22-Jul-2014 13:50	20	47.50	0.00	24-Jul-2014 13:50	20	47.76	-0.01
22-Jul-2014 13:55	25	47.50	0.00	24-Jul-2014 13:55	25	47.76	-0.01
22-Jul-2014 14:00	30	47.50	0.00	24-Jul-2014 14:00	30	47.75	0.00
22-Jul-2014 14:15	45	47.50	0.00	24-Jul-2014 14:15	45	47.75	0.00
22-Jul-2014 14:30	60	47.50	0.00	24-Jul-2014 14:30	60	47.76	-0.01
22-Jul-2014 15:00	90	47.50	0.00	24-Jul-2014 15:00	90	47.75	0.00
22-Jul-2014 15:30	120	47.50	0.00	24-Jul-2014 15:30	120	47.75	0.00
22-Jul-2014 16:00	150	47.50	0.00	24-Jul-2014 16:00	150	47.75	0.00
22-Jul-2014 16:30	180	47.51	0.01	24-Jul-2014 16:30	180	47.75	0.00
22-Jul-2014 17:00	210	47.51	0.01	24-Jul-2014 17:00	210	47.76	-0.01
22-Jul-2014 17:30	240	47.51	0.01	24-Jul-2014 17:30	240	47.75	0.00
22-Jul-2014 18:00	270	47.51	0.01	24-Jul-2014 18:00	270	47.76	-0.01
22-Jul-2014 18:30	300	47.51	0.01	24-Jul-2014 18:30	300	47.75	0.00
22-Jul-2014 19:30	360	47.51	0.01	24-Jul-2014 19:30	360	47.75	0.00
22-Jul-2014 20:30	420	47.51	0.01	24-Jul-2014 20:30	420	47.75	0.00
22-Jul-2014 21:30	480	47.51	0.01	24-Jul-2014 21:30	480	47.75	0.00
22-Jul-2014 22:30	540	47.52	0.02	24-Jul-2014 22:30	540	47.75	0.00
22-Jul-2014 23:30	600	47.52	0.02	24-Jul-2014 23:30	600	47.75	0.00
23-Jul-2014 00:30	660	47.53	0.03	25-Jul-2014 00:30	660	47.75	0.00
23-Jul-2014 01:30	720	47.54	0.04	25-Jul-2014 01:30	720	47.75	0.00
23-Jul-2014 02:30	780	47.54	0.04	25-Jul-2014 02:30	780	47.75	0.00
23-Jul-2014 03:30	840	47.55	0.05	25-Jul-2014 03:30	840	47.75	0.00
23-Jul-2014 05:30	960	47.57	0.07	25-Jul-2014 05:30	960	47.75	0.00
23-Jul-2014 07:30	1080	47.59	0.09	25-Jul-2014 07:30	1080	47.75	0.00
23-Jul-2014 09:30	1200	47.62	0.12	25-Jul-2014 09:30	1200	47.75	0.00
23-Jul-2014 11:30	1320	47.65	0.15	25-Jul-2014 11:30	1320	47.75	0.00
23-Jul-2014 13:30	1440	47.67	0.17	25-Jul-2014 13:30	1440	47.75	0.00
23-Jul-2014 15:30	1560	47.70	0.20	25-Jul-2014 15:30	1560	47.75	0.00
23-Jul-2014 17:30	1680	47.73	0.23	25-Jul-2014 17:30	1680	47.75	0.00
23-Jul-2014 19:30	1800	47.75	0.25	25-Jul-2014 19:30	1800	47.75	0.00
23-Jul-2014 21:30	1920	47.75	0.25	25-Jul-2014 21:30	1920	47.75	0.00
23-Jul-2014 23:30	2040	47.75	0.25	25-Jul-2014 23:30	2040	47.75	0.00
24-Jul-2014 01:30	2160	47.75	0.25	26-Jul-2014 01:30	2160	47.75	0.00
24-Jul-2014 03:30	2280	47.75	0.25	26-Jul-2014 03:30	2280	47.75	0.00
24-Jul-2014 05:30	2400	47.75	0.25	26-Jul-2014 05:30	2400	47.75	0.00
24-Jul-2014 07:30	2520	47.75	0.25	26-Jul-2014 07:30	2520	47.75	0.00
24-Jul-2014 09:30	2640	47.75	0.25	26-Jul-2014 09:30	2640	47.75	0.00
24-Jul-2014 11:30	2760	47.75	0.25	26-Jul-2014 11:30	2760	47.75	0.00
24-Jul-2014 13:30	2880	47.75	0.25	26-Jul-2014 13:30	2880	47.75	0.00

Tabulated Levels for TW30

Pump On:	22-Jul-2014 13:30	Static Level:	52.86
Pump Off:	24-Jul-2014 13:30	Pumping Level:	53.73
Pumping Well:	**PW1**	DD:	0.87
Distance from Pumping Well:	1500 m	20 yr DD:	2.5

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
22-Jul-2014 13:31	1	52.86	0.00	24-Jul-2014 13:31	1	53.73	0.00
22-Jul-2014 13:32	2	52.86	0.00	24-Jul-2014 13:32	2	53.73	0.00
22-Jul-2014 13:33	3	52.85	0.00	24-Jul-2014 13:33	3	53.73	0.00
22-Jul-2014 13:34	4	52.86	0.00	24-Jul-2014 13:34	4	53.73	0.00
22-Jul-2014 13:35	5	52.86	0.00	24-Jul-2014 13:35	5	53.73	0.00
22-Jul-2014 13:36	6	52.86	0.00	24-Jul-2014 13:36	6	53.73	0.00
22-Jul-2014 13:37	7	52.86	0.00	24-Jul-2014 13:37	7	53.73	0.00
22-Jul-2014 13:38	8	52.86	0.00	24-Jul-2014 13:38	8	53.73	0.00
22-Jul-2014 13:39	9	52.86	0.00	24-Jul-2014 13:39	9	53.73	0.00
22-Jul-2014 13:40	10	52.86	0.00	24-Jul-2014 13:40	10	53.73	0.00
22-Jul-2014 13:42	12	52.86	0.00	24-Jul-2014 13:42	12	53.73	0.00
22-Jul-2014 13:44	14	52.86	0.00	24-Jul-2014 13:44	14	53.73	0.00
22-Jul-2014 13:46	16	52.85	0.00	24-Jul-2014 13:46	16	53.73	0.00
22-Jul-2014 13:48	18	52.85	0.00	24-Jul-2014 13:48	18	53.74	-0.01
22-Jul-2014 13:50	20	52.85	0.00	24-Jul-2014 13:50	20	53.74	-0.01
22-Jul-2014 13:55	25	52.85	0.00	24-Jul-2014 13:55	25	53.74	-0.01
22-Jul-2014 14:00	30	52.86	0.00	24-Jul-2014 14:00	30	53.74	-0.01
22-Jul-2014 14:15	45	52.85	0.00	24-Jul-2014 14:15	45	53.74	-0.01
22-Jul-2014 14:30	60	52.85	0.00	24-Jul-2014 14:30	60	53.75	-0.02
22-Jul-2014 15:00	90	52.86	0.00	24-Jul-2014 15:00	90	53.75	-0.02
22-Jul-2014 15:30	120	52.86	0.00	24-Jul-2014 15:30	120	53.76	-0.03
22-Jul-2014 16:00	150	52.86	0.00	24-Jul-2014 16:00	150	53.76	-0.03
22-Jul-2014 16:30	180	52.87	0.01	24-Jul-2014 16:30	180	53.77	-0.04
22-Jul-2014 17:00	210	52.87	0.02	24-Jul-2014 17:00	210	53.77	-0.04
22-Jul-2014 17:30	240	52.88	0.02	24-Jul-2014 17:30	240	53.76	-0.03
22-Jul-2014 18:00	270	52.89	0.03	24-Jul-2014 18:00	270	53.76	-0.03
22-Jul-2014 18:30	300	52.89	0.04	24-Jul-2014 18:30	300	53.76	-0.03
22-Jul-2014 19:30	360	52.92	0.06	24-Jul-2014 19:30	360	53.75	-0.02
22-Jul-2014 20:30	420	52.93	0.08	24-Jul-2014 20:30	420	53.73	0.00
22-Jul-2014 21:30	480	52.97	0.11	24-Jul-2014 21:30	480	53.72	0.01
22-Jul-2014 22:30	540	52.99	0.13	24-Jul-2014 22:30	540	53.71	0.02
22-Jul-2014 23:30	600	53.01	0.15	24-Jul-2014 23:30	600	53.69	0.04
23-Jul-2014 00:30	660	53.03	0.18	25-Jul-2014 00:30	660	53.68	0.05
23-Jul-2014 01:30	720	53.06	0.20	25-Jul-2014 01:30	720	53.66	0.07
23-Jul-2014 02:30	780	53.08	0.23	25-Jul-2014 02:30	780	53.64	0.09
23-Jul-2014 03:30	840	53.10	0.25	25-Jul-2014 03:30	840	53.63	0.10
23-Jul-2014 05:30	960	53.15	0.30	25-Jul-2014 05:30	960	53.59	0.14
23-Jul-2014 07:30	1080	53.21	0.35	25-Jul-2014 07:30	1080	53.57	0.16
23-Jul-2014 09:30	1200	53.25	0.39	25-Jul-2014 09:30	1200	53.55	0.18
23-Jul-2014 11:30	1320	53.30	0.44	25-Jul-2014 11:30	1320	53.52	0.21
23-Jul-2014 13:30	1440	53.34	0.49	25-Jul-2014 13:30	1440	53.50	0.23
23-Jul-2014 15:30	1560	53.38	0.52	25-Jul-2014 15:30	1560	53.47	0.26
23-Jul-2014 17:30	1680	53.41	0.56	25-Jul-2014 17:30	1680	53.45	0.28
23-Jul-2014 19:30	1800	53.45	0.59	25-Jul-2014 19:30	1800	53.43	0.30
23-Jul-2014 21:30	1920	53.48	0.63	25-Jul-2014 21:30	1920	53.40	0.33
23-Jul-2014 23:30	2040	53.51	0.66	25-Jul-2014 23:30	2040	53.39	0.34
24-Jul-2014 01:30	2160	53.55	0.69	26-Jul-2014 01:30	2160	53.37	0.36
24-Jul-2014 03:30	2280	53.58	0.72	26-Jul-2014 03:30	2280	53.34	0.39
24-Jul-2014 05:30	2400	53.60	0.75	26-Jul-2014 05:30	2400	53.33	0.40
24-Jul-2014 07:30	2520	53.63	0.78	26-Jul-2014 07:30	2520	53.31	0.42
24-Jul-2014 09:30	2640	53.67	0.81	26-Jul-2014 09:30	2640	53.30	0.44
24-Jul-2014 11:30	2760	53.70	0.84	26-Jul-2014 11:30	2760	53.29	0.44
24-Jul-2014 13:30	2880	53.73	0.87	26-Jul-2014 13:30	2880	53.28	0.45

Tabulated Levels for OW1#1

Pump On:	22-Jul-2014 13:30	Static Level:	7.62
Pump Off:	24-Jul-2014 13:30	Pumping Level:	7.64
Pumping Well:	**PW1**	DD:	0.02
Distance from Pumping Well:	2750 m		

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
22-Jul-2014 13:31	1	7.62	0.00	24-Jul-2014 13:31	1	7.64	0.00
22-Jul-2014 13:32	2	7.62	0.00	24-Jul-2014 13:32	2	7.63	0.00
22-Jul-2014 13:33	3	7.62	0.00	24-Jul-2014 13:33	3	7.63	0.00
22-Jul-2014 13:34	4	7.62	0.00	24-Jul-2014 13:34	4	7.64	0.00
22-Jul-2014 13:35	5	7.63	0.00	24-Jul-2014 13:35	5	7.63	0.00
22-Jul-2014 13:36	6	7.62	0.00	24-Jul-2014 13:36	6	7.64	0.00
22-Jul-2014 13:37	7	7.62	0.00	24-Jul-2014 13:37	7	7.63	0.00
22-Jul-2014 13:38	8	7.63	0.00	24-Jul-2014 13:38	8	7.64	0.00
22-Jul-2014 13:39	9	7.62	0.00	24-Jul-2014 13:39	9	7.63	0.00
22-Jul-2014 13:40	10	7.62	0.00	24-Jul-2014 13:40	10	7.63	0.00
22-Jul-2014 13:42	12	7.62	0.00	24-Jul-2014 13:42	12	7.63	0.00
22-Jul-2014 13:44	14	7.62	0.00	24-Jul-2014 13:44	14	7.63	0.00
22-Jul-2014 13:46	16	7.62	0.00	24-Jul-2014 13:46	16	7.64	0.00
22-Jul-2014 13:48	18	7.62	0.00	24-Jul-2014 13:48	18	7.63	0.00
22-Jul-2014 13:50	20	7.62	0.00	24-Jul-2014 13:50	20	7.63	0.00
22-Jul-2014 13:55	25	7.62	0.00	24-Jul-2014 13:55	25	7.63	0.00
22-Jul-2014 14:00	30	7.62	0.00	24-Jul-2014 14:00	30	7.64	0.00
22-Jul-2014 14:15	45	7.62	0.00	24-Jul-2014 14:15	45	7.63	0.00
22-Jul-2014 14:30	60	7.62	-0.01	24-Jul-2014 14:30	60	7.63	0.00
22-Jul-2014 15:00	90	7.61	-0.01	24-Jul-2014 15:00	90	7.63	0.00
22-Jul-2014 15:30	120	7.61	-0.01	24-Jul-2014 15:30	120	7.63	0.01
22-Jul-2014 16:00	150	7.61	-0.01	24-Jul-2014 16:00	150	7.63	0.00
22-Jul-2014 16:30	180	7.61	-0.01	24-Jul-2014 16:30	180	7.63	0.01
22-Jul-2014 17:00	210	7.61	-0.01	24-Jul-2014 17:00	210	7.63	0.01
22-Jul-2014 17:30	240	7.60	-0.02	24-Jul-2014 17:30	240	7.63	0.01
22-Jul-2014 18:00	270	7.60	-0.02	24-Jul-2014 18:00	270	7.62	0.02
22-Jul-2014 18:30	300	7.60	-0.03	24-Jul-2014 18:30	300	7.62	0.01
22-Jul-2014 19:30	360	7.59	-0.03	24-Jul-2014 19:30	360	7.62	0.02
22-Jul-2014 20:30	420	7.59	-0.03	24-Jul-2014 20:30	420	7.62	0.02
22-Jul-2014 21:30	480	7.60	-0.02	24-Jul-2014 21:30	480	7.63	0.01
22-Jul-2014 22:30	540	7.58	-0.04	24-Jul-2014 22:30	540	7.63	0.01
22-Jul-2014 23:30	600	7.58	-0.04	24-Jul-2014 23:30	600	7.63	0.01
23-Jul-2014 00:30	660	7.57	-0.05	25-Jul-2014 00:30	660	7.62	0.01
23-Jul-2014 01:30	720	7.57	-0.05	25-Jul-2014 01:30	720	7.62	0.02
23-Jul-2014 02:30	780	7.57	-0.06	25-Jul-2014 02:30	780	7.62	0.02
23-Jul-2014 03:30	840	7.57	-0.05	25-Jul-2014 03:30	840	7.61	0.02
23-Jul-2014 05:30	960	7.57	-0.05	25-Jul-2014 05:30	960	7.62	0.02
23-Jul-2014 07:30	1080	7.59	-0.04	25-Jul-2014 07:30	1080	7.63	0.01
23-Jul-2014 09:30	1200	7.58	-0.04	25-Jul-2014 09:30	1200	7.63	0.01
23-Jul-2014 11:30	1320	7.59	-0.03	25-Jul-2014 11:30	1320	7.62	0.01
23-Jul-2014 13:30	1440	7.60	-0.02	25-Jul-2014 13:30	1440	7.62	0.02
23-Jul-2014 15:30	1560	7.61	-0.01	25-Jul-2014 15:30	1560	7.60	0.03
23-Jul-2014 17:30	1680	7.61	-0.01	25-Jul-2014 17:30	1680	7.60	0.04
23-Jul-2014 19:30	1800	7.61	-0.01	25-Jul-2014 19:30	1800	7.60	0.04
23-Jul-2014 21:30	1920	7.62	0.00	25-Jul-2014 21:30	1920	7.60	0.04
23-Jul-2014 23:30	2040	7.63	0.00	25-Jul-2014 23:30	2040	7.59	0.04
24-Jul-2014 01:30	2160	7.63	0.00	26-Jul-2014 01:30	2160	7.59	0.05
24-Jul-2014 03:30	2280	7.63	0.01	26-Jul-2014 03:30	2280	7.58	0.06
24-Jul-2014 05:30	2400	7.63	0.01	26-Jul-2014 05:30	2400	7.59	0.05
24-Jul-2014 07:30	2520	7.64	0.02	26-Jul-2014 07:30	2520	7.59	0.05
24-Jul-2014 09:30	2640	7.64	0.02	26-Jul-2014 09:30	2640	7.58	0.06
24-Jul-2014 11:30	2760	7.64	0.02	26-Jul-2014 11:30	2760	7.58	0.06
24-Jul-2014 13:30	2880	7.64	0.02	26-Jul-2014 13:30	2880	7.57	0.07

Tabulated Levels for OW1#2

Pump On:	22-Jul-2014 13:30	Static Level:	43.70
Pump Off:	24-Jul-2014 13:30	Pumping Level:	43.72
Pumping Well:	**PW1**	DD:	0.03
Distance from Pumping Well:	2750 m		

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
22-Jul-2014 13:31	1	43.70	0.00	24-Jul-2014 13:31	1	43.72	0.01
22-Jul-2014 13:32	2	43.70	0.00	24-Jul-2014 13:32	2	43.72	0.00
22-Jul-2014 13:33	3	43.69	0.00	24-Jul-2014 13:33	3	43.72	0.00
22-Jul-2014 13:34	4	43.70	0.01	24-Jul-2014 13:34	4	43.72	0.01
22-Jul-2014 13:35	5	43.70	0.00	24-Jul-2014 13:35	5	43.71	0.01
22-Jul-2014 13:36	6	43.70	0.00	24-Jul-2014 13:36	6	43.72	0.00
22-Jul-2014 13:37	7	43.70	0.00	24-Jul-2014 13:37	7	43.73	-0.01
22-Jul-2014 13:38	8	43.70	0.01	24-Jul-2014 13:38	8	43.73	0.00
22-Jul-2014 13:39	9	43.70	0.01	24-Jul-2014 13:39	9	43.73	0.00
22-Jul-2014 13:40	10	43.71	0.01	24-Jul-2014 13:40	10	43.72	0.00
22-Jul-2014 13:42	12	43.70	0.00	24-Jul-2014 13:42	12	43.72	0.00
22-Jul-2014 13:44	14	43.70	0.01	24-Jul-2014 13:44	14	43.72	0.01
22-Jul-2014 13:46	16	43.70	0.00	24-Jul-2014 13:46	16	43.73	-0.01
22-Jul-2014 13:48	18	43.70	0.00	24-Jul-2014 13:48	18	43.72	0.01
22-Jul-2014 13:50	20	43.70	0.01	24-Jul-2014 13:50	20	43.72	0.00
22-Jul-2014 13:55	25	43.70	0.00	24-Jul-2014 13:55	25	43.72	0.00
22-Jul-2014 14:00	30	43.69	-0.01	24-Jul-2014 14:00	30	43.72	0.00
22-Jul-2014 14:15	45	43.69	0.00	24-Jul-2014 14:15	45	43.71	0.01
22-Jul-2014 14:30	60	43.69	0.00	24-Jul-2014 14:30	60	43.72	0.00
22-Jul-2014 15:00	90	43.68	-0.02	24-Jul-2014 15:00	90	43.72	0.01
22-Jul-2014 15:30	120	43.68	-0.01	24-Jul-2014 15:30	120	43.76	-0.04
22-Jul-2014 16:00	150	43.68	-0.01	24-Jul-2014 16:00	150	43.71	0.01
22-Jul-2014 16:30	180	43.69	-0.01	24-Jul-2014 16:30	180	43.72	0.01
22-Jul-2014 17:00	210	43.68	-0.02	24-Jul-2014 17:00	210	43.71	0.01
22-Jul-2014 17:30	240	43.68	-0.01	24-Jul-2014 17:30	240	43.70	0.02
22-Jul-2014 18:00	270	43.68	-0.02	24-Jul-2014 18:00	270	43.72	0.01
22-Jul-2014 18:30	300	43.68	-0.02	24-Jul-2014 18:30	300	43.70	0.02
22-Jul-2014 19:30	360	43.67	-0.03	24-Jul-2014 19:30	360	43.70	0.03
22-Jul-2014 20:30	420	43.64	-0.06	24-Jul-2014 20:30	420	43.70	0.02
22-Jul-2014 21:30	480	43.67	-0.03	24-Jul-2014 21:30	480	43.70	0.02
22-Jul-2014 22:30	540	43.66	-0.04	24-Jul-2014 22:30	540	43.72	0.01
22-Jul-2014 23:30	600	43.65	-0.05	24-Jul-2014 23:30	600	43.71	0.01
23-Jul-2014 00:30	660	43.65	-0.04	25-Jul-2014 00:30	660	43.70	0.02
23-Jul-2014 01:30	720	43.64	-0.06	25-Jul-2014 01:30	720	43.71	0.02
23-Jul-2014 02:30	780	43.64	-0.06	25-Jul-2014 02:30	780	43.70	0.02
23-Jul-2014 03:30	840	43.64	-0.05	25-Jul-2014 03:30	840	43.70	0.03
23-Jul-2014 05:30	960	43.64	-0.06	25-Jul-2014 05:30	960	43.69	0.03
23-Jul-2014 07:30	1080	43.67	-0.03	25-Jul-2014 07:30	1080	43.71	0.01
23-Jul-2014 09:30	1200	43.66	-0.04	25-Jul-2014 09:30	1200	43.71	0.02
23-Jul-2014 11:30	1320	43.67	-0.03	25-Jul-2014 11:30	1320	43.71	0.02
23-Jul-2014 13:30	1440	43.68	-0.02	25-Jul-2014 13:30	1440	43.70	0.03
23-Jul-2014 15:30	1560	43.69	-0.01	25-Jul-2014 15:30	1560	43.69	0.04
23-Jul-2014 17:30	1680	43.69	0.00	25-Jul-2014 17:30	1680	43.68	0.04
23-Jul-2014 19:30	1800	43.70	0.00	25-Jul-2014 19:30	1800	43.68	0.04
23-Jul-2014 21:30	1920	43.70	0.00	25-Jul-2014 21:30	1920	43.68	0.05
23-Jul-2014 23:30	2040	43.70	0.00	25-Jul-2014 23:30	2040	43.67	0.05
24-Jul-2014 01:30	2160	43.71	0.01	26-Jul-2014 01:30	2160	43.67	0.05
24-Jul-2014 03:30	2280	43.72	0.02	26-Jul-2014 03:30	2280	43.67	0.05
24-Jul-2014 05:30	2400	43.71	0.01	26-Jul-2014 05:30	2400	43.67	0.05
24-Jul-2014 07:30	2520	43.72	0.02	26-Jul-2014 07:30	2520	43.66	0.06
24-Jul-2014 09:30	2640	43.72	0.03	26-Jul-2014 09:30	2640	43.67	0.06
24-Jul-2014 11:30	2760	43.72	0.02	26-Jul-2014 11:30	2760	43.66	0.06
24-Jul-2014 13:30	2880	43.72	0.03	26-Jul-2014 13:30	2880	43.65	0.07

Tabulated Levels for OW2#2

Pump On:	22-Jul-2014 13:30	Static Level:	42.60
Pump Off:	24-Jul-2014 13:30	Pumping Level:	42.60
Pumping Well:	**PW1**	DD:	0.00
Distance from Pumping Well:	2200 m		

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
22-Jul-2014 13:31	1	42.60	0.00	24-Jul-2014 13:31	1	42.60	0.00
22-Jul-2014 13:32	2	42.60	0.00	24-Jul-2014 13:32	2	42.60	0.00
22-Jul-2014 13:33	3	42.60	0.00	24-Jul-2014 13:33	3	42.60	0.00
22-Jul-2014 13:34	4	42.60	0.00	24-Jul-2014 13:34	4	42.60	0.00
22-Jul-2014 13:35	5	42.60	0.00	24-Jul-2014 13:35	5	42.61	0.00
22-Jul-2014 13:36	6	42.60	-0.01	24-Jul-2014 13:36	6	42.61	0.00
22-Jul-2014 13:37	7	42.60	0.00	24-Jul-2014 13:37	7	42.61	0.00
22-Jul-2014 13:38	8	42.60	0.00	24-Jul-2014 13:38	8	42.60	0.00
22-Jul-2014 13:39	9	42.60	0.00	24-Jul-2014 13:39	9	42.60	0.00
22-Jul-2014 13:40	10	42.60	0.00	24-Jul-2014 13:40	10	42.60	0.00
22-Jul-2014 13:42	12	42.60	-0.01	24-Jul-2014 13:42	12	42.60	0.00
22-Jul-2014 13:44	14	42.60	0.00	24-Jul-2014 13:44	14	42.60	0.00
22-Jul-2014 13:46	16	42.60	-0.01	24-Jul-2014 13:46	16	42.60	0.01
22-Jul-2014 13:48	18	42.59	-0.01	24-Jul-2014 13:48	18	42.60	0.00
22-Jul-2014 13:50	20	42.59	-0.01	24-Jul-2014 13:50	20	42.60	0.00
22-Jul-2014 13:55	25	42.59	-0.01	24-Jul-2014 13:55	25	42.61	0.00
22-Jul-2014 14:00	30	42.60	-0.01	24-Jul-2014 14:00	30	42.61	0.00
22-Jul-2014 14:15	45	42.59	-0.01	24-Jul-2014 14:15	45	42.60	0.00
22-Jul-2014 14:30	60	42.59	-0.01	24-Jul-2014 14:30	60	42.60	0.00
22-Jul-2014 15:00	90	42.59	-0.01	24-Jul-2014 15:00	90	42.60	0.00
22-Jul-2014 15:30	120	42.58	-0.02	24-Jul-2014 15:30	120	42.60	0.00
22-Jul-2014 16:00	150	42.59	-0.02	24-Jul-2014 16:00	150	42.60	0.00
22-Jul-2014 16:30	180	42.58	-0.02	24-Jul-2014 16:30	180	42.60	0.00
22-Jul-2014 17:00	210	42.58	-0.02	24-Jul-2014 17:00	210	42.60	0.00
22-Jul-2014 17:30	240	42.58	-0.03	24-Jul-2014 17:30	240	42.59	0.01
22-Jul-2014 18:00	270	42.58	-0.02	24-Jul-2014 18:00	270	42.60	0.01
22-Jul-2014 18:30	300	42.57	-0.03	24-Jul-2014 18:30	300	42.59	0.02
22-Jul-2014 19:30	360	42.56	-0.04	24-Jul-2014 19:30	360	42.58	0.02
22-Jul-2014 20:30	420	42.55	-0.05	24-Jul-2014 20:30	420	42.58	0.02
22-Jul-2014 21:30	480	42.56	-0.04	24-Jul-2014 21:30	480	42.59	0.02
22-Jul-2014 22:30	540	42.56	-0.04	24-Jul-2014 22:30	540	42.59	0.02
22-Jul-2014 23:30	600	42.56	-0.05	24-Jul-2014 23:30	600	42.59	0.02
23-Jul-2014 00:30	660	42.54	-0.06	25-Jul-2014 00:30	660	42.59	0.02
23-Jul-2014 01:30	720	42.54	-0.06	25-Jul-2014 01:30	720	42.58	0.02
23-Jul-2014 02:30	780	42.54	-0.07	25-Jul-2014 02:30	780	42.58	0.02
23-Jul-2014 03:30	840	42.53	-0.07	25-Jul-2014 03:30	840	42.58	0.03
23-Jul-2014 05:30	960	42.54	-0.07	25-Jul-2014 05:30	960	42.58	0.02
23-Jul-2014 07:30	1080	42.55	-0.06	25-Jul-2014 07:30	1080	42.60	0.00
23-Jul-2014 09:30	1200	42.55	-0.05	25-Jul-2014 09:30	1200	42.60	0.01
23-Jul-2014 11:30	1320	42.56	-0.05	25-Jul-2014 11:30	1320	42.59	0.01
23-Jul-2014 13:30	1440	42.57	-0.03	25-Jul-2014 13:30	1440	42.58	0.02
23-Jul-2014 15:30	1560	42.58	-0.03	25-Jul-2014 15:30	1560	42.57	0.03
23-Jul-2014 17:30	1680	42.58	-0.03	25-Jul-2014 17:30	1680	42.57	0.04
23-Jul-2014 19:30	1800	42.58	-0.02	25-Jul-2014 19:30	1800	42.56	0.04
23-Jul-2014 21:30	1920	42.58	-0.02	25-Jul-2014 21:30	1920	42.56	0.04
23-Jul-2014 23:30	2040	42.59	-0.01	25-Jul-2014 23:30	2040	42.56	0.04
24-Jul-2014 01:30	2160	42.60	-0.01	26-Jul-2014 01:30	2160	42.56	0.05
24-Jul-2014 03:30	2280	42.60	-0.01	26-Jul-2014 03:30	2280	42.55	0.06
24-Jul-2014 05:30	2400	42.60	-0.01	26-Jul-2014 05:30	2400	42.55	0.05
24-Jul-2014 07:30	2520	42.60	0.00	26-Jul-2014 07:30	2520	42.56	0.05
24-Jul-2014 09:30	2640	42.61	0.00	26-Jul-2014 09:30	2640	42.55	0.05
24-Jul-2014 11:30	2760	42.61	0.00	26-Jul-2014 11:30	2760	42.55	0.05
24-Jul-2014 13:30	2880	42.60	0.00	26-Jul-2014 13:30	2880	42.53	0.07

Tabulated Levels for OW3#1

Pump On:	22-Jul-2014 13:30	Static Level:	33.28
Pump Off:	24-Jul-2014 13:30	Pumping Level:	33.31
Pumping Well:	**PW1**	DD:	0.03
Distance from Pumping Well:	2050 m		

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
22-Jul-2014 13:31	1	33.28	0.00	24-Jul-2014 13:31	1	33.30	0.00
22-Jul-2014 13:32	2	33.28	0.00	24-Jul-2014 13:32	2	33.31	0.00
22-Jul-2014 13:33	3	33.27	-0.01	24-Jul-2014 13:33	3	33.31	0.00
22-Jul-2014 13:34	4	33.28	0.00	24-Jul-2014 13:34	4	33.31	0.00
22-Jul-2014 13:35	5	33.28	0.00	24-Jul-2014 13:35	5	33.31	0.00
22-Jul-2014 13:36	6	33.27	0.00	24-Jul-2014 13:36	6	33.31	0.00
22-Jul-2014 13:37	7	33.28	0.00	24-Jul-2014 13:37	7	33.31	0.00
22-Jul-2014 13:38	8	33.27	-0.01	24-Jul-2014 13:38	8	33.31	0.00
22-Jul-2014 13:39	9	33.27	0.00	24-Jul-2014 13:39	9	33.31	0.00
22-Jul-2014 13:40	10	33.27	0.00	24-Jul-2014 13:40	10	33.31	0.00
22-Jul-2014 13:42	12	33.27	-0.01	24-Jul-2014 13:42	12	33.31	0.00
22-Jul-2014 13:44	14	33.27	0.00	24-Jul-2014 13:44	14	33.30	0.00
22-Jul-2014 13:46	16	33.27	-0.01	24-Jul-2014 13:46	16	33.31	0.00
22-Jul-2014 13:48	18	33.27	-0.01	24-Jul-2014 13:48	18	33.30	0.00
22-Jul-2014 13:50	20	33.27	-0.01	24-Jul-2014 13:50	20	33.31	0.00
22-Jul-2014 13:55	25	33.27	-0.01	24-Jul-2014 13:55	25	33.31	0.00
22-Jul-2014 14:00	30	33.27	-0.01	24-Jul-2014 14:00	30	33.31	0.00
22-Jul-2014 14:15	45	33.26	-0.01	24-Jul-2014 14:15	45	33.30	0.00
22-Jul-2014 14:30	60	33.26	-0.02	24-Jul-2014 14:30	60	33.31	0.00
22-Jul-2014 15:00	90	33.26	-0.02	24-Jul-2014 15:00	90	33.30	0.01
22-Jul-2014 15:30	120	33.26	-0.02	24-Jul-2014 15:30	120	33.30	0.01
22-Jul-2014 16:00	150	33.25	-0.02	24-Jul-2014 16:00	150	33.30	0.01
22-Jul-2014 16:30	180	33.26	-0.02	24-Jul-2014 16:30	180	33.30	0.00
22-Jul-2014 17:00	210	33.25	-0.02	24-Jul-2014 17:00	210	33.30	0.01
22-Jul-2014 17:30	240	33.25	-0.03	24-Jul-2014 17:30	240	33.29	0.01
22-Jul-2014 18:00	270	33.25	-0.03	24-Jul-2014 18:00	270	33.29	0.01
22-Jul-2014 18:30	300	33.24	-0.03	24-Jul-2014 18:30	300	33.29	0.02
22-Jul-2014 19:30	360	33.24	-0.04	24-Jul-2014 19:30	360	33.28	0.02
22-Jul-2014 20:30	420	33.23	-0.05	24-Jul-2014 20:30	420	33.28	0.02
22-Jul-2014 21:30	480	33.24	-0.04	24-Jul-2014 21:30	480	33.28	0.02
22-Jul-2014 22:30	540	33.24	-0.04	24-Jul-2014 22:30	540	33.29	0.01
22-Jul-2014 23:30	600	33.24	-0.04	24-Jul-2014 23:30	600	33.29	0.02
23-Jul-2014 00:30	660	33.23	-0.05	25-Jul-2014 00:30	660	33.29	0.02
23-Jul-2014 01:30	720	33.23	-0.04	25-Jul-2014 01:30	720	33.29	0.02
23-Jul-2014 02:30	780	33.23	-0.05	25-Jul-2014 02:30	780	33.28	0.03
23-Jul-2014 03:30	840	33.22	-0.05	25-Jul-2014 03:30	840	33.28	0.03
23-Jul-2014 05:30	960	33.23	-0.05	25-Jul-2014 05:30	960	33.28	0.03
23-Jul-2014 07:30	1080	33.25	-0.03	25-Jul-2014 07:30	1080	33.29	0.01
23-Jul-2014 09:30	1200	33.26	-0.02	25-Jul-2014 09:30	1200	33.29	0.02
23-Jul-2014 11:30	1320	33.27	-0.01	25-Jul-2014 11:30	1320	33.29	0.02
23-Jul-2014 13:30	1440	33.28	0.00	25-Jul-2014 13:30	1440	33.28	0.03
23-Jul-2014 15:30	1560	33.29	0.01	25-Jul-2014 15:30	1560	33.27	0.04
23-Jul-2014 17:30	1680	33.29	0.01	25-Jul-2014 17:30	1680	33.26	0.04
23-Jul-2014 19:30	1800	33.29	0.02	25-Jul-2014 19:30	1800	33.26	0.04
23-Jul-2014 21:30	1920	33.30	0.02	25-Jul-2014 21:30	1920	33.26	0.05
23-Jul-2014 23:30	2040	33.30	0.03	25-Jul-2014 23:30	2040	33.26	0.05
24-Jul-2014 01:30	2160	33.31	0.03	26-Jul-2014 01:30	2160	33.26	0.05
24-Jul-2014 03:30	2280	33.31	0.03	26-Jul-2014 03:30	2280	33.25	0.05
24-Jul-2014 05:30	2400	33.31	0.03	26-Jul-2014 05:30	2400	33.26	0.05
24-Jul-2014 07:30	2520	33.31	0.03	26-Jul-2014 07:30	2520	33.26	0.04
24-Jul-2014 09:30	2640	33.31	0.04	26-Jul-2014 09:30	2640	33.26	0.05
24-Jul-2014 11:30	2760	33.31	0.04	26-Jul-2014 11:30	2760	33.26	0.05
24-Jul-2014 13:30	2880	33.31	0.03	26-Jul-2014 13:30	2880	33.25	0.06

Tabulated Levels for OW3#2

Pump On:	22-Jul-2014 13:30	Static Level:	43.21
Pump Off:	24-Jul-2014 13:30	Pumping Level:	43.21
Pumping Well:	**PW1**	DD:	0.00
Distance from Pumping Well:	2050 m		

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
22-Jul-2014 13:31	1	43.21	0.00	24-Jul-2014 13:31	1	43.21	0.00
22-Jul-2014 13:32	2	43.21	0.00	24-Jul-2014 13:32	2	43.21	0.00
22-Jul-2014 13:33	3	43.20	0.00	24-Jul-2014 13:33	3	43.21	0.01
22-Jul-2014 13:34	4	43.21	0.00	24-Jul-2014 13:34	4	43.21	0.00
22-Jul-2014 13:35	5	43.21	0.00	24-Jul-2014 13:35	5	43.21	0.00
22-Jul-2014 13:36	6	43.20	0.00	24-Jul-2014 13:36	6	43.21	0.00
22-Jul-2014 13:37	7	43.20	0.00	24-Jul-2014 13:37	7	43.21	0.00
22-Jul-2014 13:38	8	43.20	0.00	24-Jul-2014 13:38	8	43.21	0.00
22-Jul-2014 13:39	9	43.20	-0.01	24-Jul-2014 13:39	9	43.21	0.00
22-Jul-2014 13:40	10	43.21	0.00	24-Jul-2014 13:40	10	43.21	0.00
22-Jul-2014 13:42	12	43.20	-0.01	24-Jul-2014 13:42	12	43.21	0.00
22-Jul-2014 13:44	14	43.20	-0.01	24-Jul-2014 13:44	14	43.21	0.00
22-Jul-2014 13:46	16	43.20	-0.01	24-Jul-2014 13:46	16	43.21	0.01
22-Jul-2014 13:48	18	43.20	-0.01	24-Jul-2014 13:48	18	43.21	0.00
22-Jul-2014 13:50	20	43.20	-0.01	24-Jul-2014 13:50	20	43.21	0.00
22-Jul-2014 13:55	25	43.20	-0.01	24-Jul-2014 13:55	25	43.21	0.00
22-Jul-2014 14:00	30	43.20	-0.01	24-Jul-2014 14:00	30	43.21	0.00
22-Jul-2014 14:15	45	43.20	-0.01	24-Jul-2014 14:15	45	43.21	0.00
22-Jul-2014 14:30	60	43.20	-0.01	24-Jul-2014 14:30	60	43.21	0.00
22-Jul-2014 15:00	90	43.19	-0.02	24-Jul-2014 15:00	90	43.21	0.01
22-Jul-2014 15:30	120	43.19	-0.02	24-Jul-2014 15:30	120	43.21	0.01
22-Jul-2014 16:00	150	43.19	-0.02	24-Jul-2014 16:00	150	43.20	0.01
22-Jul-2014 16:30	180	43.18	-0.02	24-Jul-2014 16:30	180	43.21	0.00
22-Jul-2014 17:00	210	43.18	-0.03	24-Jul-2014 17:00	210	43.20	0.01
22-Jul-2014 17:30	240	43.18	-0.03	24-Jul-2014 17:30	240	43.20	0.01
22-Jul-2014 18:00	270	43.18	-0.03	24-Jul-2014 18:00	270	43.20	0.01
22-Jul-2014 18:30	300	43.17	-0.03	24-Jul-2014 18:30	300	43.19	0.02
22-Jul-2014 19:30	360	43.17	-0.04	24-Jul-2014 19:30	360	43.19	0.02
22-Jul-2014 20:30	420	43.16	-0.05	24-Jul-2014 20:30	420	43.19	0.02
22-Jul-2014 21:30	480	43.17	-0.04	24-Jul-2014 21:30	480	43.19	0.02
22-Jul-2014 22:30	540	43.16	-0.04	24-Jul-2014 22:30	540	43.20	0.01
22-Jul-2014 23:30	600	43.16	-0.05	24-Jul-2014 23:30	600	43.20	0.01
23-Jul-2014 00:30	660	43.15	-0.06	25-Jul-2014 00:30	660	43.20	0.01
23-Jul-2014 01:30	720	43.15	-0.06	25-Jul-2014 01:30	720	43.19	0.02
23-Jul-2014 02:30	780	43.14	-0.07	25-Jul-2014 02:30	780	43.19	0.02
23-Jul-2014 03:30	840	43.14	-0.07	25-Jul-2014 03:30	840	43.19	0.03
23-Jul-2014 05:30	960	43.14	-0.07	25-Jul-2014 05:30	960	43.19	0.02
23-Jul-2014 07:30	1080	43.15	-0.05	25-Jul-2014 07:30	1080	43.20	0.02
23-Jul-2014 09:30	1200	43.16	-0.05	25-Jul-2014 09:30	1200	43.20	0.01
23-Jul-2014 11:30	1320	43.16	-0.04	25-Jul-2014 11:30	1320	43.20	0.02
23-Jul-2014 13:30	1440	43.17	-0.03	25-Jul-2014 13:30	1440	43.19	0.03
23-Jul-2014 15:30	1560	43.18	-0.03	25-Jul-2014 15:30	1560	43.18	0.03
23-Jul-2014 17:30	1680	43.18	-0.02	25-Jul-2014 17:30	1680	43.17	0.04
23-Jul-2014 19:30	1800	43.19	-0.02	25-Jul-2014 19:30	1800	43.17	0.04
23-Jul-2014 21:30	1920	43.19	-0.02	25-Jul-2014 21:30	1920	43.16	0.05
23-Jul-2014 23:30	2040	43.20	-0.01	25-Jul-2014 23:30	2040	43.16	0.05
24-Jul-2014 01:30	2160	43.20	0.00	26-Jul-2014 01:30	2160	43.16	0.05
24-Jul-2014 03:30	2280	43.20	0.00	26-Jul-2014 03:30	2280	43.16	0.06
24-Jul-2014 05:30	2400	43.21	0.00	26-Jul-2014 05:30	2400	43.16	0.05
24-Jul-2014 07:30	2520	43.21	0.00	26-Jul-2014 07:30	2520	43.16	0.05
24-Jul-2014 09:30	2640	43.21	0.00	26-Jul-2014 09:30	2640	43.15	0.06
24-Jul-2014 11:30	2760	43.22	0.01	26-Jul-2014 11:30	2760	43.16	0.06
24-Jul-2014 13:30	2880	43.21	0.00	26-Jul-2014 13:30	2880	43.14	0.07

Tabulated Levels for OW4#1

Pump On:	22-Jul-2014 13:30	Static Level:	33.46
Pump Off:	24-Jul-2014 13:30	Pumping Level:	33.48
Pumping Well:	**PW1**	DD:	0.02
Distance from Pumping Well:	1500 m		

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
22-Jul-2014 13:31	1	33.46	0.00	24-Jul-2014 13:31	1	33.47	0.00
22-Jul-2014 13:32	2	33.46	0.00	24-Jul-2014 13:32	2	33.48	0.00
22-Jul-2014 13:33	3	33.46	0.00	24-Jul-2014 13:33	3	33.48	0.00
22-Jul-2014 13:34	4	33.46	0.00	24-Jul-2014 13:34	4	33.47	0.00
22-Jul-2014 13:35	5	33.46	0.00	24-Jul-2014 13:35	5	33.48	0.00
22-Jul-2014 13:36	6	33.45	-0.01	24-Jul-2014 13:36	6	33.48	0.00
22-Jul-2014 13:37	7	33.46	0.00	24-Jul-2014 13:37	7	33.48	0.00
22-Jul-2014 13:38	8	33.45	-0.01	24-Jul-2014 13:38	8	33.48	0.00
22-Jul-2014 13:39	9	33.46	0.00	24-Jul-2014 13:39	9	33.48	0.00
22-Jul-2014 13:40	10	33.46	0.00	24-Jul-2014 13:40	10	33.48	0.00
22-Jul-2014 13:42	12	33.45	0.00	24-Jul-2014 13:42	12	33.47	0.00
22-Jul-2014 13:44	14	33.46	0.00	24-Jul-2014 13:44	14	33.47	0.00
22-Jul-2014 13:46	16	33.46	0.00	24-Jul-2014 13:46	16	33.47	0.00
22-Jul-2014 13:48	18	33.45	-0.01	24-Jul-2014 13:48	18	33.47	0.01
22-Jul-2014 13:50	20	33.45	-0.01	24-Jul-2014 13:50	20	33.48	0.00
22-Jul-2014 13:55	25	33.45	-0.01	24-Jul-2014 13:55	25	33.48	0.00
22-Jul-2014 14:00	30	33.45	-0.01	24-Jul-2014 14:00	30	33.48	0.00
22-Jul-2014 14:15	45	33.45	-0.01	24-Jul-2014 14:15	45	33.47	0.00
22-Jul-2014 14:30	60	33.45	-0.01	24-Jul-2014 14:30	60	33.48	0.00
22-Jul-2014 15:00	90	33.45	-0.01	24-Jul-2014 15:00	90	33.47	0.01
22-Jul-2014 15:30	120	33.44	-0.02	24-Jul-2014 15:30	120	33.47	0.00
22-Jul-2014 16:00	150	33.45	-0.01	24-Jul-2014 16:00	150	33.47	0.00
22-Jul-2014 16:30	180	33.45	-0.01	24-Jul-2014 16:30	180	33.47	0.00
22-Jul-2014 17:00	210	33.45	-0.01	24-Jul-2014 17:00	210	33.47	0.00
22-Jul-2014 17:30	240	33.45	-0.01	24-Jul-2014 17:30	240	33.47	0.01
22-Jul-2014 18:00	270	33.45	-0.01	24-Jul-2014 18:00	270	33.47	0.01
22-Jul-2014 18:30	300	33.44	-0.02	24-Jul-2014 18:30	300	33.46	0.01
22-Jul-2014 19:30	360	33.44	-0.02	24-Jul-2014 19:30	360	33.46	0.02
22-Jul-2014 20:30	420	33.43	-0.02	24-Jul-2014 20:30	420	33.46	0.02
22-Jul-2014 21:30	480	33.45	-0.01	24-Jul-2014 21:30	480	33.46	0.01
22-Jul-2014 22:30	540	33.45	-0.01	24-Jul-2014 22:30	540	33.47	0.01
22-Jul-2014 23:30	600	33.45	-0.01	24-Jul-2014 23:30	600	33.47	0.01
23-Jul-2014 00:30	660	33.44	-0.02	25-Jul-2014 00:30	660	33.47	0.00
23-Jul-2014 01:30	720	33.44	-0.02	25-Jul-2014 01:30	720	33.46	0.01
23-Jul-2014 02:30	780	33.44	-0.02	25-Jul-2014 02:30	780	33.46	0.02
23-Jul-2014 03:30	840	33.44	-0.02	25-Jul-2014 03:30	840	33.46	0.02
23-Jul-2014 05:30	960	33.45	-0.01	25-Jul-2014 05:30	960	33.46	0.02
23-Jul-2014 07:30	1080	33.46	0.00	25-Jul-2014 07:30	1080	33.47	0.01
23-Jul-2014 09:30	1200	33.47	0.01	25-Jul-2014 09:30	1200	33.47	0.00
23-Jul-2014 11:30	1320	33.48	0.02	25-Jul-2014 11:30	1320	33.47	0.01
23-Jul-2014 13:30	1440	33.48	0.02	25-Jul-2014 13:30	1440	33.46	0.02
23-Jul-2014 15:30	1560	33.49	0.03	25-Jul-2014 15:30	1560	33.45	0.03
23-Jul-2014 17:30	1680	33.49	0.03	25-Jul-2014 17:30	1680	33.45	0.03
23-Jul-2014 19:30	1800	33.48	0.02	25-Jul-2014 19:30	1800	33.45	0.02
23-Jul-2014 21:30	1920	33.48	0.02	25-Jul-2014 21:30	1920	33.45	0.02
23-Jul-2014 23:30	2040	33.49	0.03	25-Jul-2014 23:30	2040	33.45	0.02
24-Jul-2014 01:30	2160	33.49	0.03	26-Jul-2014 01:30	2160	33.46	0.02
24-Jul-2014 03:30	2280	33.49	0.03	26-Jul-2014 03:30	2280	33.45	0.03
24-Jul-2014 05:30	2400	33.48	0.03	26-Jul-2014 05:30	2400	33.46	0.02
24-Jul-2014 07:30	2520	33.48	0.02	26-Jul-2014 07:30	2520	33.46	0.02
24-Jul-2014 09:30	2640	33.48	0.02	26-Jul-2014 09:30	2640	33.45	0.02
24-Jul-2014 11:30	2760	33.48	0.02	26-Jul-2014 11:30	2760	33.46	0.02
24-Jul-2014 13:30	2880	33.48	0.02	26-Jul-2014 13:30	2880	33.45	0.03

Tabulated Levels for OW4#2

Pump On:	22-Jul-2014 13:30	Static Level:	45.32
Pump Off:	24-Jul-2014 13:30	Pumping Level:	45.32
Pumping Well:	**PW1**	DD:	0.00
Distance from Pumping Well:	1500 m		

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
22-Jul-2014 13:31	1	45.32	0.00	24-Jul-2014 13:31	1	45.31	0.00
22-Jul-2014 13:32	2	45.32	0.00	24-Jul-2014 13:32	2	45.32	0.00
22-Jul-2014 13:33	3	45.32	0.00	24-Jul-2014 13:33	3	45.31	0.00
22-Jul-2014 13:34	4	45.32	0.00	24-Jul-2014 13:34	4	45.31	0.00
22-Jul-2014 13:35	5	45.32	0.00	24-Jul-2014 13:35	5	45.32	0.00
22-Jul-2014 13:36	6	45.32	0.00	24-Jul-2014 13:36	6	45.32	0.00
22-Jul-2014 13:37	7	45.32	0.00	24-Jul-2014 13:37	7	45.32	0.00
22-Jul-2014 13:38	8	45.32	0.00	24-Jul-2014 13:38	8	45.32	0.00
22-Jul-2014 13:39	9	45.32	0.00	24-Jul-2014 13:39	9	45.32	0.00
22-Jul-2014 13:40	10	45.32	0.00	24-Jul-2014 13:40	10	45.32	0.00
22-Jul-2014 13:42	12	45.31	-0.01	24-Jul-2014 13:42	12	45.31	0.00
22-Jul-2014 13:44	14	45.32	-0.01	24-Jul-2014 13:44	14	45.31	0.00
22-Jul-2014 13:46	16	45.31	-0.01	24-Jul-2014 13:46	16	45.31	0.01
22-Jul-2014 13:48	18	45.31	-0.01	24-Jul-2014 13:48	18	45.31	0.00
22-Jul-2014 13:50	20	45.31	-0.01	24-Jul-2014 13:50	20	45.32	0.00
22-Jul-2014 13:55	25	45.31	-0.01	24-Jul-2014 13:55	25	45.32	0.00
22-Jul-2014 14:00	30	45.31	-0.01	24-Jul-2014 14:00	30	45.31	0.00
22-Jul-2014 14:15	45	45.31	-0.01	24-Jul-2014 14:15	45	45.32	0.00
22-Jul-2014 14:30	60	45.31	-0.01	24-Jul-2014 14:30	60	45.32	0.00
22-Jul-2014 15:00	90	45.30	-0.02	24-Jul-2014 15:00	90	45.31	0.01
22-Jul-2014 15:30	120	45.30	-0.02	24-Jul-2014 15:30	120	45.31	0.01
22-Jul-2014 16:00	150	45.30	-0.02	24-Jul-2014 16:00	150	45.31	0.00
22-Jul-2014 16:30	180	45.29	-0.03	24-Jul-2014 16:30	180	45.31	0.00
22-Jul-2014 17:00	210	45.30	-0.02	24-Jul-2014 17:00	210	45.31	0.01
22-Jul-2014 17:30	240	45.29	-0.03	24-Jul-2014 17:30	240	45.31	0.01
22-Jul-2014 18:00	270	45.29	-0.03	24-Jul-2014 18:00	270	45.31	0.01
22-Jul-2014 18:30	300	45.28	-0.04	24-Jul-2014 18:30	300	45.30	0.02
22-Jul-2014 19:30	360	45.28	-0.04	24-Jul-2014 19:30	360	45.30	0.02
22-Jul-2014 20:30	420	45.27	-0.05	24-Jul-2014 20:30	420	45.30	0.02
22-Jul-2014 21:30	480	45.28	-0.04	24-Jul-2014 21:30	480	45.30	0.02
22-Jul-2014 22:30	540	45.27	-0.05	24-Jul-2014 22:30	540	45.30	0.01
22-Jul-2014 23:30	600	45.27	-0.05	24-Jul-2014 23:30	600	45.30	0.01
23-Jul-2014 00:30	660	45.26	-0.06	25-Jul-2014 00:30	660	45.31	0.01
23-Jul-2014 01:30	720	45.26	-0.06	25-Jul-2014 01:30	720	45.30	0.02
23-Jul-2014 02:30	780	45.25	-0.07	25-Jul-2014 02:30	780	45.30	0.02
23-Jul-2014 03:30	840	45.25	-0.07	25-Jul-2014 03:30	840	45.29	0.03
23-Jul-2014 05:30	960	45.25	-0.07	25-Jul-2014 05:30	960	45.29	0.02
23-Jul-2014 07:30	1080	45.26	-0.06	25-Jul-2014 07:30	1080	45.30	0.01
23-Jul-2014 09:30	1200	45.27	-0.05	25-Jul-2014 09:30	1200	45.31	0.01
23-Jul-2014 11:30	1320	45.27	-0.05	25-Jul-2014 11:30	1320	45.30	0.01
23-Jul-2014 13:30	1440	45.28	-0.04	25-Jul-2014 13:30	1440	45.29	0.02
23-Jul-2014 15:30	1560	45.29	-0.03	25-Jul-2014 15:30	1560	45.28	0.03
23-Jul-2014 17:30	1680	45.29	-0.03	25-Jul-2014 17:30	1680	45.28	0.04
23-Jul-2014 19:30	1800	45.29	-0.03	25-Jul-2014 19:30	1800	45.28	0.04
23-Jul-2014 21:30	1920	45.30	-0.02	25-Jul-2014 21:30	1920	45.27	0.05
23-Jul-2014 23:30	2040	45.30	-0.02	25-Jul-2014 23:30	2040	45.27	0.04
24-Jul-2014 01:30	2160	45.31	-0.01	26-Jul-2014 01:30	2160	45.27	0.05
24-Jul-2014 03:30	2280	45.31	-0.01	26-Jul-2014 03:30	2280	45.26	0.06
24-Jul-2014 05:30	2400	45.31	-0.01	26-Jul-2014 05:30	2400	45.26	0.05
24-Jul-2014 07:30	2520	45.31	-0.01	26-Jul-2014 07:30	2520	45.27	0.05
24-Jul-2014 09:30	2640	45.32	0.00	26-Jul-2014 09:30	2640	45.26	0.06
24-Jul-2014 11:30	2760	45.32	0.00	26-Jul-2014 11:30	2760	45.26	0.06
24-Jul-2014 13:30	2880	45.32	0.00	26-Jul-2014 13:30	2880	45.25	0.07

Tabulated Levels for TW17

Pump On:	22-Jul-2014 13:30	Static Level:	4.78
Pump Off:	24-Jul-2014 13:30	Pumping Level:	4.79
Pumping Well:	**PW1**	DD:	0.01
Distance from Pumping Well:	2300 m		

Date:Time	Elapsed	WL	DD	Date:Time	Elapsed	WL	RC
dd-mmm-yyyy hh:mm	(min)	m	m	dd-mmm-yyyy hh:mm	(min)	m	m
22-Jul-2014 13:31	1	4.78	0.00	24-Jul-2014 13:31	1	4.78	0.00
22-Jul-2014 13:32	2	4.78	0.00	24-Jul-2014 13:32	2	4.79	0.00
22-Jul-2014 13:33	3	4.77	0.00	24-Jul-2014 13:33	3	4.79	0.00
22-Jul-2014 13:34	4	4.77	0.00	24-Jul-2014 13:34	4	4.79	0.00
22-Jul-2014 13:35	5	4.78	0.00	24-Jul-2014 13:35	5	4.79	0.00
22-Jul-2014 13:36	6	4.77	0.00	24-Jul-2014 13:36	6	4.79	0.00
22-Jul-2014 13:37	7	4.77	0.00	24-Jul-2014 13:37	7	4.79	0.00
22-Jul-2014 13:38	8	4.77	0.00	24-Jul-2014 13:38	8	4.79	0.00
22-Jul-2014 13:39	9	4.77	0.00	24-Jul-2014 13:39	9	4.79	0.00
22-Jul-2014 13:40	10	4.77	0.00	24-Jul-2014 13:40	10	4.79	0.00
22-Jul-2014 13:42	12	4.77	-0.01	24-Jul-2014 13:42	12	4.79	0.00
22-Jul-2014 13:44	14	4.77	0.00	24-Jul-2014 13:44	14	4.79	0.00
22-Jul-2014 13:46	16	4.77	-0.01	24-Jul-2014 13:46	16	4.78	0.00
22-Jul-2014 13:48	18	4.77	-0.01	24-Jul-2014 13:48	18	4.79	0.00
22-Jul-2014 13:50	20	4.77	-0.01	24-Jul-2014 13:50	20	4.79	0.00
22-Jul-2014 13:55	25	4.77	-0.01	24-Jul-2014 13:55	25	4.79	0.00
22-Jul-2014 14:00	30	4.77	-0.01	24-Jul-2014 14:00	30	4.79	0.00
22-Jul-2014 14:15	45	4.76	-0.01	24-Jul-2014 14:15	45	4.79	0.00
22-Jul-2014 14:30	60	4.76	-0.01	24-Jul-2014 14:30	60	4.79	0.00
22-Jul-2014 15:00	90	4.76	-0.01	24-Jul-2014 15:00	90	4.78	0.00
22-Jul-2014 15:30	120	4.76	-0.02	24-Jul-2014 15:30	120	4.78	0.00
22-Jul-2014 16:00	150	4.76	-0.02	24-Jul-2014 16:00	150	4.78	0.00
22-Jul-2014 16:30	180	4.76	-0.02	24-Jul-2014 16:30	180	4.78	0.00
22-Jul-2014 17:00	210	4.76	-0.02	24-Jul-2014 17:00	210	4.78	0.01
22-Jul-2014 17:30	240	4.75	-0.02	24-Jul-2014 17:30	240	4.78	0.01
22-Jul-2014 18:00	270	4.75	-0.03	24-Jul-2014 18:00	270	4.78	0.01
22-Jul-2014 18:30	300	4.75	-0.03	24-Jul-2014 18:30	300	4.77	0.02
22-Jul-2014 19:30	360	4.74	-0.04	24-Jul-2014 19:30	360	4.77	0.02
22-Jul-2014 20:30	420	4.73	-0.05	24-Jul-2014 20:30	420	4.77	0.02
22-Jul-2014 21:30	480	4.74	-0.03	24-Jul-2014 21:30	480	4.77	0.02
22-Jul-2014 22:30	540	4.74	-0.04	24-Jul-2014 22:30	540	4.78	0.01
22-Jul-2014 23:30	600	4.73	-0.05	24-Jul-2014 23:30	600	4.78	0.01
23-Jul-2014 00:30	660	4.72	-0.06	25-Jul-2014 00:30	660	4.78	0.01
23-Jul-2014 01:30	720	4.72	-0.06	25-Jul-2014 01:30	720	4.77	0.02
23-Jul-2014 02:30	780	4.71	-0.06	25-Jul-2014 02:30	780	4.77	0.02
23-Jul-2014 03:30	840	4.71	-0.07	25-Jul-2014 03:30	840	4.77	0.02
23-Jul-2014 05:30	960	4.71	-0.06	25-Jul-2014 05:30	960	4.77	0.02
23-Jul-2014 07:30	1080	4.73	-0.05	25-Jul-2014 07:30	1080	4.78	0.01
23-Jul-2014 09:30	1200	4.73	-0.05	25-Jul-2014 09:30	1200	4.78	0.01
23-Jul-2014 11:30	1320	4.74	-0.04	25-Jul-2014 11:30	1320	4.78	0.01
23-Jul-2014 13:30	1440	4.75	-0.03	25-Jul-2014 13:30	1440	4.77	0.02
23-Jul-2014 15:30	1560	4.76	-0.02	25-Jul-2014 15:30	1560	4.76	0.03
23-Jul-2014 17:30	1680	4.76	-0.02	25-Jul-2014 17:30	1680	4.75	0.04
23-Jul-2014 19:30	1800	4.76	-0.02	25-Jul-2014 19:30	1800	4.75	0.04
23-Jul-2014 21:30	1920	4.76	-0.01	25-Jul-2014 21:30	1920	4.74	0.04
23-Jul-2014 23:30	2040	4.77	-0.01	25-Jul-2014 23:30	2040	4.74	0.04
24-Jul-2014 01:30	2160	4.78	0.00	26-Jul-2014 01:30	2160	4.74	0.05
24-Jul-2014 03:30	2280	4.78	0.00	26-Jul-2014 03:30	2280	4.73	0.05
24-Jul-2014 05:30	2400	4.78	0.00	26-Jul-2014 05:30	2400	4.74	0.05
24-Jul-2014 07:30	2520	4.78	0.01	26-Jul-2014 07:30	2520	4.74	0.05
24-Jul-2014 09:30	2640	4.79	0.01	26-Jul-2014 09:30	2640	4.73	0.06
24-Jul-2014 11:30	2760	4.79	0.02	26-Jul-2014 11:30	2760	4.73	0.05
24-Jul-2014 13:30	2880	4.79	0.01	26-Jul-2014 13:30	2880	4.72	0.07

Table K-2: Water Quality Results

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: DW 60428 **REPORT No. B14-18587**

Report To:

Golder Associates Ltd.
121 Commerce Park Drive, Unit L,
Barrie ON. L4N 8X1 Canada
Attention: John Easton

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 25-Jul-14
DATE REPORTED: 11-Aug-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 13-1170-0040
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		PW1	PW1 - Total		
			Sample I.D.		B14-18587-1	B14-18587-2		
			Date Collected		24-Jul-14	24-Jul-14		
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Hardness (as CaCO3)	mg/L	1	SM 3120	28-Jul-14/O	208			
Hardness (as CaCO3)	mg/L	1	SM 3120	28-Jul-14/O		217		
Alkalinity(CaCO3) to pH4.5	mg/L	5	SM 2320B	25-Jul-14/O	201			
Conductivity @25°C	µmho/cm	1	SM 2510B	25-Jul-14/O	422			
pH @25°C	pH Units		SM 4500H	25-Jul-14/O	8.06			
Colour	TCU	2	SM 2120C	29-Jul-14/O	4			
Turbidity	NTU	0.1	SM 2130	25-Jul-14/O	1.4			
UV transmittance	%		N/A	31-Jul-14	92.0 [2]			
Fluoride	mg/L	0.1	SM4110C	25-Jul-14/O	0.2			
Chloride	mg/L	0.5	SM4110C	25-Jul-14/O	2.1			
Nitrite (N)	mg/L	0.1	SM4110C	25-Jul-14/O	< 0.1			
Nitrate (N)	mg/L	0.1	SM4110C	25-Jul-14/O	< 0.1			
Sulphate	mg/L	1	SM4110C	25-Jul-14/O	14			
Calcium	mg/L	0.02	SM 3120	28-Jul-14/O	55.0			
Calcium	mg/L	0.02	SM 3120	28-Jul-14/O		57.6		
Magnesium	mg/L	0.01	SM 3120	28-Jul-14/O	17.1			
Magnesium	mg/L	0.01	SM 3120	28-Jul-14/O		17.7		
Sodium	mg/L	0.2	SM 3120	28-Jul-14/O	5.2			
Sodium	mg/L	0.2	SM 3120	28-Jul-14/O		5.5		
Potassium	mg/L	0.1	SM 3120	28-Jul-14/O	1.6			
Potassium	mg/L	0.1	SM 3120	28-Jul-14/O		1.7		
Copper	mg/L	0.002	SM 3120	28-Jul-14/O	< 0.002			
Copper	mg/L	0.002	SM 3120	28-Jul-14/O		< 0.002		
Iron	mg/L	0.005	SM 3120	28-Jul-14/O	0.298			
Iron	mg/L	0.005	SM 3120	28-Jul-14/O		0.383		
Manganese	mg/L	0.001	SM 3120	28-Jul-14/O	0.074			
Manganese	mg/L	0.001	SM 3120	28-Jul-14/O		0.078		
Silica	mg/L	0.02	SM 3120	28-Jul-14/O	14.1			



Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

M.D.L. = Method Detection Limit
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

The analytical results reported herein refer to the samples as received. Reproduction of this analytical report in full or in part is prohibited without prior consent from Caduceon Environmental Laboratories.

Table K-2: Water Quality Results

CADUCEON ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: DW 60428 **REPORT No. B14-18587**

Report To:

Golder Associates Ltd.
121 Commerce Park Drive, Unit L,
Barrie ON. L4N 8X1 Canada
Attention: John Easton

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 25-Jul-14
DATE REPORTED: 11-Aug-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 13-1170-0040
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		PW1	PW1 - Total		
			Sample I.D.		B14-18587-1	B14-18587-2		
			Date Collected		24-Jul-14	24-Jul-14		
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Silica	mg/L	0.02	SM 3120	28-Jul-14/O		14.5		
Zinc	mg/L	0.005	SM 3120	28-Jul-14/O	< 0.005			
Zinc	mg/L	0.005	SM 3120	28-Jul-14/O		0.006		
Ammonia (N)-Total	mg/L	0.01	MOEE 3364	28-Jul-14/O	0.22			
Total Kjeldahl Nitrogen	mg/L	0.05	MOEE 3367	05-Aug-14/O	0.23			
Organic Nitrogen	mg/L	0.05	MOEE 3367	05-Aug-14/O	< 0.05			
Dissolved Organic Carbon	mg/L	0.2	EPA 415.1	25-Jul-14/O	1.2			
Sulphide	mg/L	0.01	SM4500-S2	28-Jul-14/K	0.02			
Phenolics	mg/L	0.001	MOEE 3179	28-Jul-14/O	< 0.001			
Tannins and Lignins	mg/L	0.1	N/A	30-Jul-14	< 0.1 [1]			
Total Coliform	cfu/100mL	1	MOE E3371	25-Jul-14/O	0			
E coli	cfu/100mL	1	MOE E3371	25-Jul-14/O	0			
Background	cfu/100mL	1	MOE E3371	25-Jul-14/O	4			
Anion Sum	meq/L		Calc.	28-Jul-14/O	4.37			
Cation Sum	meq/L		Calc.	28-Jul-14/O	4.44			
% Difference	%		Calc.	28-Jul-14/O	0.803			
Ion Ratio	AS/CS		Calc.	28-Jul-14/O	0.984			
Sodium Adsorption Ratio	-		Calc.	28-Jul-14/O	0.156			
TDS(ion sum calc.)	mg/L		Calc.	28-Jul-14/O	216			
Conductivity (calc.)	µmho/cm		Calc.	28-Jul-14/O	407			
TDS(calc.)/EC(actual)	-		Calc.	28-Jul-14/O	0.512			
EC(calc.)/EC(actual)	-		Calc.	28-Jul-14/O	0.964			
Langelier Index(25°C)	S.I.		Calc.	28-Jul-14/O	0.670			

1 subcontracted to Paracel Labs
2 Subcontracted to SGS Lakefield



Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

M.D.L. = Method Detection Limit
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

The analytical results reported herein refer to the samples as received. Reproduction of this analytical report in full or in part is prohibited without prior consent from Caduceon Environmental Laboratories.

APPENDIX L

Observation Well Water Quality Results

		Aquifer	Hardness	Alkalinity	Cond	pH	F	Cl	NO_2	NO_3	SO_2	Ca	Mg	Na	K	Fe	Mn	NH_3	DOC	Tannins and Lignins	Anion Sum	Cation Sum	TDS
Units		--	mg/L	mg/L	µmho/cm		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/L	meq/L	mg/L
ODWS Limits		--	80-100	30-500	--	6.5-8.5	1.5	250	1	10	500	--	--	200	--	0.3	0.05	--	5	--	--	--	500
OW19#1	23-May-14	A1	382	170	930	7.98	0.1	173	< 0.1	5.3	15	101	31.4	38.9	1.7	< 0.005	< 0.001	< 0.01	1.1	0.5	8.98	9.37	487
OW19#2	23-May-14	A1	422	233	2070	8.01	0.1	530	< 0.1	3.9	26	117	31.6	275	2.6	< 0.005	0.008	< 0.01	1.2	0.5	20.4	20.5	1140
OW3#1	28-May-14	A1	357	293	612	8.01	0.1	5.9	< 0.1	5	10	121	13.4	5.2	1	< 0.005	< 0.001	< 0.01	2.1	< 0.1	6.6	7.38	355
OW1#1	30-May-14	A1	387	274	728	7.95	< 0.1	9.2	< 0.1	24.3	20	116	23.6	5	0.9	< 0.005	< 0.001	< 0.01	2.2	< 0.1	7.89	7.96	0.613
OW4#1	30-May-14	A1	228	204	419	8.06	0.1	6.2	< 0.1	1	8	77.3	8.32	3.7	1.2	< 0.005	< 0.001	< 0.01	1.5	0.1	4.5	4.73	0.554
Hickling House	30-May-14	A1	364	295	681	7.98	0.2	8.9	< 0.1	13.6	15	119	16.4	5.9	1.6	< 0.005	< 0.001	< 0.01	1.8	< 0.1	7.43	7.57	0.593
OW3#2	28-May-14	A2	287	216	509	8.08	< 0.1	8	< 0.1	6.5	15	95.3	11.8	3	1.6	< 0.005	< 0.001	< 0.01	1.9	< 0.1	5.31	5.9	293
OW4#2	30-May-14	A2	237	208	429	8.09	0.2	4.7	< 0.1	0.6	16	76.5	11.2	3.4	1.5	< 0.005	0.004	< 0.01	1.4	0.2	4.66	4.93	0.561
OW19#4	30-May-14	A3	304	197	1320	7.97	0.2	278	< 0.1	0.6	37	80	25.4	147	1.8	< 0.005	0.119	0.28	2.1	1.2	12.6	12.5	0.523
OW19#5	30-May-14	A3	384	214	1010	7.95	0.2	173	< 0.1	7.1	23	104	30.4	48.7	2.2	< 0.005	0.025	< 0.01	1.3	0.7	10.2	9.84	0.537
OW8I	28-May-14	A3	211	169	372	8.17	0.2	3.2	< 0.1	< 0.1	30	64.5	12.1	4	1.8	0.182	0.018	< 0.01	1.5	0.6	4.1	4.45	217
TW30	4-Jun-14	A3/A4	121	174	321	8.24	0.3	2.1	< 0.1	0.7	7	30.4	10.9	25.7	2.1	< 0.005	0.028	0.56	1.8	0.3	3.74	3.63	0.582
TW21	1-Aug-14	A3/A4	266	200	533	7.98	<0.1	27.9	<0.1	3.3	16	78.9	16.8	9.6	1.9	0.024	0.003	<0.01	1.2	<0.1	5.36	5.79	286
TW22	16-Apr-14	A4	311	238	637	7.90	0.1	30.2	< 0.1	7.7	22	85.9	23.4	9.9	1.6	< 0.005	< 0.001	< 0.01	1.7		6.63	6.68	350
TW29	23-May-14	A4	181	215	354	8.18	0.2	3	0.3	0.1	13	48.8	14.5	32.4	1.4	0.057	0.153	0.29	1.6	1.5	4.67	5.08	243
OW8D	4-Jun-14	A4	233	182	406	8.05	0.2	4.3	< 0.1	1.4	36	70.9	13.7	4	1.9	0.142	0.005	< 0.01	1.3	< 0.1	4.61	4.89	0.607
PW1	24-Jul-14	A4	208	201	422	8.06	0.2	2.1	< 0.1	0.1	14	55	17.1	5.5	1.7	0.383	0.074	0.22	1.2	<0.1	4.37	4.44	216

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G36548 **REPORT No. B14-11736**

Report To:

Golder Associates Ltd.
121 Commerce Park Drive, Unit L,
Barrie ON. L4N 8X1 Canada
Attention: Alicia Beynon

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 24-May-14
DATE REPORTED: 09-Jun-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 13-1170-0040
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		TW19#1	TW19#2	TW29	
			Sample I.D.		B14-11736-1	B14-11736-2	B14-11736-3	
			Date Collected		23-May-14	23-May-14	23-May-14	
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Hardness (as CaCO3)	mg/L	1	SM 3120	27-May-14/O	382	422	181	
Alkalinity(CaCO3) to pH4.5	mg/L	5	SM 2320B	27-May-14/O	170	233	215	
Conductivity @25°C	µmho/cm	1	SM 2510B	27-May-14/O	930	2070	354	
pH @25°C	pH Units		SM 4500H	27-May-14/O	7.98	8.01	8.18	
Fluoride	mg/L	0.1	SM4110C	27-May-14/O	0.1	0.1	0.2	
Chloride	mg/L	0.5	SM4110C	27-May-14/O	173	530	3.0	
Nitrite (N)	mg/L	0.1	SM4110C	27-May-14/O	< 0.1	< 0.1	0.3	
Nitrate (N)	mg/L	0.1	SM4110C	27-May-14/O	5.3	3.9	0.1	
Sulphate	mg/L	1	SM4110C	27-May-14/O	15	26	13	
Calcium	mg/L	0.02	SM 3120	27-May-14/O	101	117	48.8	
Magnesium	mg/L	0.01	SM 3120	27-May-14/O	31.4	31.6	14.5	
Sodium	mg/L	0.2	SM 3120	27-May-14/O	38.9	275	32.4	
Potassium	mg/L	0.1	SM 3120	27-May-14/O	1.7	2.6	1.4	
Iron	mg/L	0.005	SM 3120	27-May-14/O	< 0.005	< 0.005	0.057	
Manganese	mg/L	0.001	SM 3120	27-May-14/O	< 0.001	0.008	0.153	
Ammonia (N)-Total	mg/L	0.01	MOEE 3364	09-Jun-14/O	< 0.01	< 0.01	0.29	
Dissolved Organic Carbon	mg/L	0.2	EPA 415.1	29-May-14/O	1.1	1.2	1.6	
Tannins and Lignins	mg/L	0.1	N/A	27-May-14	0.5 [1]	0.5 [1]	1.5 [1]	
Anion Sum	meq/L		Calc.	28-May-14/O	8.98	20.4	4.67	
Cation Sum	meq/L		Calc.	28-May-14/O	9.37	20.5	5.08	
% Difference	%		Calc.	28-May-14/O	2.14	0.125	4.16	
Ion Ratio	AS/CS		Calc.	28-May-14/O	0.958	0.998	0.920	
Sodium Adsorption Ratio	-		Calc.	28-May-14/O	0.866	5.83	1.05	
TDS(ion sum calc.)	mg/L		Calc.	28-May-14/O	487	1140	243	
Conductivity (calc.)	µmho/cm		Calc.	28-May-14/O	952	2090	445	
TDS(calc.)/EC(actual)	-		Calc.	28-May-14/O	0.524	0.551	0.687	
EC(calc.)/EC(actual)	-		Calc.	28-May-14/O	1.02	1.01	1.26	

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

M.D.L. = Method Detection Limit
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

The analytical results reported herein refer to the samples as received. Reproduction of this analytical report in full or in part is prohibited without prior consent from Caduceon Environmental Laboratories.

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G36555 **REPORT No. B14-12274**

Report To:

Golder Associates Ltd.
121 Commerce Park Drive, Unit L,
Barrie ON. L4N 8X1 Canada
Attention: Alicia Beynon

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 29-May-14
DATE REPORTED: 12-Jun-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 13-1170-0040
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		OW81	OW3#1	OW3#2	
			Sample I.D.		B14-12274-1	B14-12274-2	B14-12274-3	
			Date Collected		28-May-14	28-May-14	28-May-14	
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Hardness (as CaCO3)	mg/L	1	SM 3120	03-Jun-14/O	211	357	287	
Alkalinity(CaCO3) to pH4.5	mg/L	5	SM 2320B	30-May-14/O	169	293	216	
Conductivity @25°C	µmho/cm	1	SM 2510B	30-May-14/O	372	612	509	
pH @25°C	pH Units		SM 4500H	30-May-14/O	8.17	8.01	8.08	
Fluoride	mg/L	0.1	SM4110C	30-May-14/O	0.2	0.1	< 0.1	
Chloride	mg/L	0.5	SM4110C	30-May-14/O	3.2	5.9	8.0	
Nitrite (N)	mg/L	0.1	SM4110C	30-May-14/O	< 0.1	< 0.1	< 0.1	
Nitrate (N)	mg/L	0.1	SM4110C	30-May-14/O	< 0.1	5.0	6.5	
Sulphate	mg/L	1	SM4110C	30-May-14/O	30	10	15	
Calcium	mg/L	0.02	SM 3120	03-Jun-14/O	64.5	121	95.3	
Magnesium	mg/L	0.01	SM 3120	03-Jun-14/O	12.1	13.4	11.8	
Sodium	mg/L	0.2	SM 3120	03-Jun-14/O	4.0	5.2	3.0	
Potassium	mg/L	0.1	SM 3120	03-Jun-14/O	1.8	1.0	1.6	
Iron	mg/L	0.005	SM 3120	03-Jun-14/O	0.182	< 0.005	< 0.005	
Manganese	mg/L	0.001	SM 3120	03-Jun-14/O	0.018	< 0.001	< 0.001	
Ammonia (N)-Total	mg/L	0.01	MOEE 3364	11-Jun-14/O	< 0.01	< 0.01	< 0.01	
Dissolved Organic Carbon	mg/L	0.2	EPA 415.1	02-Jun-14/O	1.5	2.1	1.9	
Tannins and Lignins	mg/L	0.1	N/A	30-May-14	0.6 [1]	< 0.1 [1]	< 0.1 [1]	
Anion Sum	meq/L		Calc.	02-Jun-14/O	4.10	6.60	5.31	
Cation Sum	meq/L		Calc.	02-Jun-14/O	4.45	7.38	5.90	
% Difference	%		Calc.	02-Jun-14/O	4.03	5.53	5.20	
Ion Ratio	AS/CS		Calc.	02-Jun-14/O	0.923	0.895	0.901	
Sodium Adsorption Ratio	-		Calc.	02-Jun-14/O	0.119	0.119	0.0773	
TDS(ion sum calc.)	mg/L		Calc.	02-Jun-14/O	217	355	293	
Conductivity (calc.)	µmho/cm		Calc.	02-Jun-14/O	408	645	536	
TDS(calc.)/EC(actual)	-		Calc.	02-Jun-14/O	0.584	0.579	0.576	
EC(calc.)/EC(actual)	-		Calc.	02-Jun-14/O	1.10	1.05	1.05	

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

M.D.L. = Method Detection Limit
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

The analytical results reported herein refer to the samples as received. Reproduction of this analytical report in full or in part is prohibited without prior consent from Caduceon Environmental Laboratories.

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G36555 **REPORT No. B14-12274**

Report To:

Golder Associates Ltd.
121 Commerce Park Drive, Unit L,
Barrie ON. L4N 8X1 Canada
Attention: Alicia Beynon

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 29-May-14
DATE REPORTED: 12-Jun-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 13-1170-0040
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		OW81	OW3#1	OW3#2	
			Sample I.D.		B14-12274-1	B14-12274-2	B14-12274-3	
			Date Collected		28-May-14	28-May-14	28-May-14	
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Langelier Index(25°C)	S.I.		Calc.	02-Jun-14/O	0.776	1.11	0.950	

1 subcontracted to Paracel Labs

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

M.D.L. = Method Detection Limit
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

The analytical results reported herein refer to the samples as received. Reproduction of this analytical report in full or in part is prohibited without prior consent from Caduceon Environmental Laboratories.

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G36257 **REPORT No. B14-12522**

Report To:

Golder Associates Ltd.
121 Commerce Park Drive, Unit L,
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Attention: Alicia Beynon

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 02-Jun-14
DATE REPORTED: 17-Jun-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 13-1170-0040
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		OW19#4	OW19#5	OW1#1	House
			Sample I.D.		B14-12522-1	B14-12522-2	B14-12522-3	B14-12522-4
			Date Collected		30-May-14	30-May-14	30-May-14	30-May-14
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Hardness (as CaCO3)	mg/L	1	SM 3120	03-Jun-14/O	304	384	387	364
Alkalinity(CaCO3) to pH4.5	mg/L	5	SM 2320B	05-Jun-14/O	197	214	274	295
Conductivity @25°C	µmho/cm	1	SM 2510B	03-Jun-14/O	1320	1010	728	681
pH @25°C	pH Units		SM 4500H	05-Jun-14/O	7.97	7.95	7.95	7.98
Fluoride	mg/L	0.1	SM4110C	04-Jun-14/O	0.2	0.2	< 0.1	0.2
Chloride	mg/L	0.5	SM4110C	04-Jun-14/O	278	173	9.2	8.9
Nitrite (N)	mg/L	0.1	SM4110C	04-Jun-14/O	< 0.1	< 0.1	< 0.1	< 0.1
Nitrate (N)	mg/L	0.1	SM4110C	04-Jun-14/O	0.6	7.1	24.3	13.6
Sulphate	mg/L	1	SM4110C	04-Jun-14/O	37	23	20	15
Calcium	mg/L	0.02	SM 3120	03-Jun-14/O	80.0	104	116	119
Magnesium	mg/L	0.01	SM 3120	03-Jun-14/O	25.4	30.4	23.6	16.4
Sodium	mg/L	0.2	SM 3120	03-Jun-14/O	147	48.7	5.0	5.9
Potassium	mg/L	0.1	SM 3120	03-Jun-14/O	1.8	2.2	0.9	1.6
Iron	mg/L	0.005	SM 3120	03-Jun-14/O	< 0.005	< 0.005	< 0.005	< 0.005
Manganese	mg/L	0.001	SM 3120	03-Jun-14/O	0.119	0.025	< 0.001	< 0.001
Ammonia (N)-Total	mg/L	0.01	MOEE 3364	17-Jun-14/O	0.28	< 0.01	< 0.01	< 0.01
Dissolved Organic Carbon	mg/L	0.2	EPA 415.1	03-Jun-14/O	2.1	1.3	2.2	1.8
Tannins and Lignins	mg/L	0.1	N/A	05-Jun-14	1.2 [1]	0.7 [1]	< 0.1 [1]	< 0.1 [1]
Anion Sum	meq/L		Calc.	06-Jun-14/O	12.6	10.2	7.89	7.43
Cation Sum	meq/L		Calc.	06-Jun-14/O	12.5	9.84	7.96	7.57
% Difference	%		Calc.	06-Jun-14/O	0.401	1.59	0.461	0.973
Ion Ratio	AS/CS		Calc.	06-Jun-14/O	1.01	1.03	0.991	0.981
Sodium Adsorption Ratio	-		Calc.	06-Jun-14/O	3.66	1.08	0.110	0.136
TDS(ion sum calc.)	mg/L		Calc.	06-Jun-14/O	690	541	447	404
Conductivity (calc.)	µmho/cm		Calc.	06-Jun-14/O	1290	1020	754	702
TDS(calc.)/EC(actual)	-		Calc.	06-Jun-14/O	0.523	0.537	0.613	0.593
EC(calc.)/EC(actual)	-		Calc.	06-Jun-14/O	0.980	1.01	1.04	1.03

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

M.D.L. = Method Detection Limit
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G36257 **REPORT No. B14-12522**

Report To:

Golder Associates Ltd.
121 Commerce Park Drive, Unit L,
Barrie ON. L4N 8X1 Canada
Attention: Alicia Beynon

Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 02-Jun-14
DATE REPORTED: 17-Jun-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 13-1170-0040
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		OW19#4	OW19#5	OW1#1	House
			Sample I.D.		B14-12522-1	B14-12522-2	B14-12522-3	B14-12522-4
			Date Collected		30-May-14	30-May-14	30-May-14	30-May-14
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Langelier Index(25°C)	S.I.		Calc.	06-Jun-14/O	0.684	0.824	0.989	1.06

1 subcontracted to Paracel Labs

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

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DATE RECEIVED: 02-Jun-14
DATE REPORTED: 17-Jun-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 13-1170-0040
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		OW4#1	OW4#2		
			Sample I.D.		B14-12522-5	B14-12522-6		
			Date Collected		30-May-14	30-May-14		
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Hardness (as CaCO3)	mg/L	1	SM 3120	03-Jun-14/O	228	237		
Alkalinity(CaCO3) to pH4.5	mg/L	5	SM 2320B	05-Jun-14/O	204	208		
Conductivity @25°C	µmho/cm	1	SM 2510B	03-Jun-14/O	419	429		
pH @25°C	pH Units		SM 4500H	05-Jun-14/O	8.06	8.09		
Fluoride	mg/L	0.1	SM4110C	04-Jun-14/O	0.1	0.2		
Chloride	mg/L	0.5	SM4110C	04-Jun-14/O	6.2	4.7		
Nitrite (N)	mg/L	0.1	SM4110C	04-Jun-14/O	< 0.1	< 0.1		
Nitrate (N)	mg/L	0.1	SM4110C	04-Jun-14/O	1.0	0.6		
Sulphate	mg/L	1	SM4110C	04-Jun-14/O	8	16		
Calcium	mg/L	0.02	SM 3120	03-Jun-14/O	77.3	76.5		
Magnesium	mg/L	0.01	SM 3120	03-Jun-14/O	8.32	11.2		
Sodium	mg/L	0.2	SM 3120	03-Jun-14/O	3.7	3.4		
Potassium	mg/L	0.1	SM 3120	03-Jun-14/O	1.2	1.5		
Iron	mg/L	0.005	SM 3120	03-Jun-14/O	< 0.005	< 0.005		
Manganese	mg/L	0.001	SM 3120	03-Jun-14/O	< 0.001	0.004		
Ammonia (N)-Total	mg/L	0.01	MOEE 3364	17-Jun-14/O	< 0.01	< 0.01		
Dissolved Organic Carbon	mg/L	0.2	EPA 415.1	03-Jun-14/O	1.5	1.4		
Tannins and Lignins	mg/L	0.1	N/A	05-Jun-14	0.1 [1]	0.2 [1]		
Anion Sum	meq/L		Calc.	06-Jun-14/O	4.50	4.66		
Cation Sum	meq/L		Calc.	06-Jun-14/O	4.73	4.93		
% Difference	%		Calc.	06-Jun-14/O	2.51	2.78		
Ion Ratio	AS/CS		Calc.	06-Jun-14/O	0.951	0.946		
Sodium Adsorption Ratio	-		Calc.	06-Jun-14/O	0.106	0.0971		
TDS(ion sum calc.)	mg/L		Calc.	06-Jun-14/O	232	241		
Conductivity (calc.)	µmho/cm		Calc.	06-Jun-14/O	435	450		
TDS(calc.)/EC(actual)	-		Calc.	06-Jun-14/O	0.554	0.561		
EC(calc.)/EC(actual)	-		Calc.	06-Jun-14/O	1.04	1.05		

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Golder Associates Ltd.
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Caduceon Environmental Laboratories
2378 Holly Lane
Ottawa Ontario K1V 7P1
Tel: 613-526-0123
Fax: 613-526-1244

DATE RECEIVED: 02-Jun-14
DATE REPORTED: 17-Jun-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 13-1170-0040
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		OW4#1	OW4#2		
			Sample I.D.		B14-12522-5	B14-12522-6		
			Date Collected		30-May-14	30-May-14		
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Langelier Index(25°C)	S.I.		Calc.	06-Jun-14/O	0.825	0.858		

1 subcontracted to Paracel Labs

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Preliminary Report

C.O.C.: ---

REPORT No. B14-13031

Report To:

Golder Associates Ltd.
121 Commerce Park Drive, Unit L,
Barrie ON. L4N 8X1 Canada
Attention: Alicia Beynon

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2378 Holly Lane
Ottawa Ontario K1V 7P1
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DATE RECEIVED: 05-Jun-14
DATE REPORTED: 05-Jun-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 13-1170-0040
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		TW30	OW24	OW8D	
			Sample I.D.		B14-13031-1	B14-13031-2	B14-13031-3	
			Date Collected		04-Jun-14	04-Jun-14	04-Jun-14	
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				
Hardness (as CaCO3)	mg/L		SM 3120	/				
Alkalinity(CaCO3) to pH4.5	mg/L		SM 2320B	/				
Conductivity @25°C	µmho/cm		SM 2510B	/				
pH @25°C	pH Units		SM 4500H	/				
Fluoride	mg/L	0.1	SM4110C	05-Jun-14/O	0.3			
Chloride	mg/L	0.5	SM4110C	05-Jun-14/O	2.1			
Nitrite (N)	mg/L	0.1	SM4110C	05-Jun-14/O	< 0.1			
Nitrate (N)	mg/L	0.1	SM4110C	05-Jun-14/O	0.7			
Sulphate	mg/L	1	SM4110C	05-Jun-14/O	7			
Calcium	mg/L		SM 3120	/				
Magnesium	mg/L		SM 3120	/				
Sodium	mg/L		SM 3120	/				
Potassium	mg/L		SM 3120	/				
Iron	mg/L		SM 3120	/				
Manganese	mg/L		SM 3120	/				
Ammonia (N)-Total	mg/L		MOEE 3364	/				
Dissolved Organic Carbon	mg/L		EPA 415.1	/				
Tannins and Lignins	mg/L		N/A	/				
Anion Sum	meq/L		Calc.	/				
Cation Sum	meq/L		Calc.	/				
% Difference	%		Calc.	/				
Ion Ratio	AS/CS		Calc.	/				
Sodium Adsorption Ratio	-		Calc.	/				
TDS(ion sum calc.)	mg/L		Calc.	/				
Conductivity (calc.)	µmho/cm		Calc.	/				
TDS(calc.)/EC(actual)	-		Calc.	/				
EC(calc.)/EC(actual)	-		Calc.	/				
Langelier Index(25°C)	S.I.		Calc.	/				

Greg Clarkin , BSc., C. Chem
Lab Manager - Ottawa District

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Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

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DATE RECEIVED: 05-Jun-14
DATE REPORTED: 05-Jun-14
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 13-1170-0040
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		TW30	OW24	OW8D	
			Sample I.D.		B14-13031-1	B14-13031-2	B14-13031-3	
			Date Collected		04-Jun-14	04-Jun-14	04-Jun-14	
Parameter	**Units**	**M.D.L.**	**Reference Method**	**Date/Site Analyzed**				

M.D.L. = Method Detection Limit
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill

Greg Clarkin , BSc., C. Chem
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APPENDIX M

Groundwater Flow Modelling

May 2018

MIDHURST, ONTARIO
REPORT ON CARSON AND DORAN NEIGHBOURHOODS PROPOSED WATER SUPPLY GROUNDWATER MODELLING

Submitted to:
The Township of Springwater c/o Ainley & Associates
2231 Nursery Road
Minesing ON L0L 1Y2



Report Number: 13-1170-0040 (4000)

REPORT

Golder Associates

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1.0 INTRODUCTION

Midhurst is a residential community located in Springwater Township, Ontario (Figure 1). The community has a population of about 3,100 people. The Midhurst Landowner's Group proposes to develop the Carson and Doran Neighbourhoods (Neighbourhoods) subdivisions north and south of the existing Midhurst residential area. The Neighbourhoods will be primarily residential and provide approximately 8,000 new dwellings for an estimated 29,000 additional people as specified in the Phase 1 and 2 Class Environmental Assessment (Ainley Group, 2009).

This report describes groundwater modelling undertaken to estimate the hydrogeological effects of the Neighbourhoods groundwater supply well pumping. The modelling is part of a larger hydrogeological study to be submitted as part of Phases 3 and 4 of the Midhurst Secondary Plan Class Environmental Assessment.

Modelling is conducted using the existing three-dimensional (3D) Kempenfelt Bay FEFLOW model with refinements in Midhurst and surrounding Willow Creek watershed areas. The use of regional scale models such as the Kempenfelt Bay FEFLOW model to assess groundwater impacts is an industry-accepted and commonly used approach in large water resource studies in Ontario. Groundwater models are an identified Source Water Protection assessment tool in the Ministry of Environment and Climate Change (MOECC) Technical Rules under the Clean Water Act. In addition, the original Kempenfelt Bay model formed the hydrogeologic basis of the City of Barrie Tier 3 Water Budget and Local Area Risk Assessment (AquaResource, 2013). The model was used to estimate impacts as a result of Barrie municipal well pumping and was a supporting tool for the MOECCs 2015 approval of the South Georgian Bay Lake Simcoe Source Protection Plan.

1.1 Scope of Work

The modelling scope of work involves two scenarios: 1) Existing Conditions; and 2) Future Conditions.

Existing Conditions

- Update model parameters in accordance with recent field activities including test well drilling and pumping tests; and
- Calibrate the model to transient (monthly) baseflow estimates along Willow Creek. "Baseflow" is the portion of stream flow supplied by groundwater discharge.

The Existing Conditions model forms the baseline for assessing the effects of Future Conditions pumping.

Future Conditions

- Input Future Conditions proposed wells and pumping rates;
- Estimate aquifer drawdown and potential well interference as a result of the additional water taking;
- Estimate monthly flow reductions at Willow Creek as a result of the additional water taking;
- Delineate capture zones for both existing Midhurst area wells and Carson and Doran Neighbourhood wells; and
- Assess the capture zones in the context of Aquifer Vulnerability Index (AVI).

The Future Conditions model considers the Carson and Doran Neighbourhoods at full build out. Note that this assessment also considers future takings at the City of Barrie municipal water supply system.

This report describes municipal supply pumping, original model construction, subsequent model updates, calibration, and future conditions assessment results.

2.0 MUNICIPAL WATER SUPPLY PUMPING

This section discusses municipal water supply well information as it pertains to the modelling. A summary of the pumping wells in the model and their rates for Existing and Future Conditions is provided in Table 1. In some instances proximate wells are grouped as a single "sink" in the model and share a combined rate.

2.1 Existing Conditions

Midhurst is entirely dependent on groundwater for its water supply. The community is currently serviced by eight wells in two wellfields (Figure 1):

1) Midhurst wellfield, consisting of Wells 1 and 4 (Greenpine wellfield), Wells 2 and 3 (Idlewood Drive wellfield) and Carson Road Well 4; and
2) Paddy Dunn's Circle wellfield, comprised of Wells 1, 2 and 3.

Water consumption ranges from about 880 m^3/d to 1,900 m^3/d (based on monthly data), with an average taking of 1,300 m^3/d during the course of a year (Figure 2). As is typical with municipal water supplies, the highest demand occurs during the summer months of June through August, where water demand is an average of 1.8 times greater than the remainder of the year. The varying demand shown in Figure 2 is simulated during transient calibration to baseflows in the Existing Conditions model.

Additional water takings occur around Midhurst, the most notable of these being the relatively large City of Barrie system. The City of Barrie Tier Three study (AquaResource, 2013) indicates that the total water taking at City of Barrie during 2010 was an average of 40,208 m^3/d. A 2012 water taking estimate, which accounts for the surface water plant being put online, is also listed in the study and predicts a lesser average groundwater demand of 32,465 m^3/d (although the actual rate may reach over 40,000 m^3/d during some months). For this analysis, the 2010 rates were used to reflect Existing Conditions as: 1) they better correlate with the surface water flow measurement period available for this study (the latest flow measurements are up to 2010); and 2) drawdown and baseflow impacts described in the Barrie Tier Three study were based on the 2010 condition as baseline; utilizing the same pumping regime allows comparison between the two studies, particularly with respect to Safe Additional Available Drawdown (SAAD). In addition, the 2010 rates provides a more conservative basis for assessing absolute impact as the lesser 2012 rates would allow for increased groundwater elevations and greater baseflows as a baseline.

For the smaller Snow Valley, Minesing and other systems, the Existing Conditions model uses the recent (circa 2009 to 2010) average water demands as listed in the Tier Three study (AquaResource, 2013).

2.2 Future Conditions

Approximately nine new water supply wells are proposed to supply the Carson and Doran Neighbourhoods (see TW-series and PW-series shown on Figure 1).

For Carson and Doran Neighbourhoods the planned maximum water taking is 221 L/s or approximately 19,094 m^3/d. This rate, if reached, would most likely occur during the June to August period. A pro-rating approach based on Existing Conditions demand ratios allows forecast of Future Conditions water takings for the remaining months of the year (Figure 3). The average water taking is thus anticipated to be approximately 13,134 m^3/d or 152 L/s.

Existing Midhurst and Paddy Dunn's Circle communities are currently near full build-out; as such, their Future Conditions pumping rates are assumed to continue as per Existing Conditions (Figure 2).

The City of Barrie Tier Three study provides an "Existing Plus Committed Plus Planned Demand" for the year 2031. These rates are used for City of Barrie wells in the Future Conditions modelling.

For the remainder of wells in the model, the Future Conditions rates continue as per recent average water demand (AquaResource, 2013).

3.0 MODEL BACKGROUND

The Kempenfelt Bay FEFLOW model was originally constructed in the early 2000s in support of the South Simcoe Groundwater Study. The model provides a computer-based, mathematical representation of the hydrogeologic system as understood through available physiographic mapping, borehole logs, well water levels, aquifer testing results, stream flow measurements and other field observations. A primary objective of the original model was the development of Wellhead Protection Areas (WHPAs) for South Simcoe municipal wells.

The model domain is regional in scale, encompassing an area of 746 km^2 (Figure 1). The Willow Creek watershed, wherein the proposed developments are located, lies almost entirely (>90%) within the model domain and comprises an area of 228 km^2.

An important feature of interest in the model is Willow Creek itself, which flows roughly centrally through the model domain from its source in the Oro uplands to its ultimate discharge location in the Minesing Swamp (Figure 1). The Creek demarcates topographic minima within the subwatershed and flows through granular soils for the majority of its length. As a result, Willow Creek is conceptualized and modelled as a major groundwater discharge zone along its entire reach (as opposed to discrete areas of upwelling).

Table 2 provides a summary of model attributes whereas Figure 4 illustrates an example model cross-section through the Midhurst area (see Figure 1 for plan view location of section).

This report focuses on model updates pertaining to the Midhurst area and encompassing the Willow Creek watershed. For a detailed description of the Midhurst area hydrogeology and prior model development the reader is referred to the following reports:

- *South Simcoe Municipal Groundwater Study* (Golder, WHI and Ainley, 2004);
- *South Simcoe Groundwater Study WHPA – Appendix E, City of Barrie* (Golder and WHI, 2004[1]);
- *South Simcoe Groundwater Study WHPA – Appendix L, Township of Springwater* (Golder and WHI, 2004[2]); and
- *Report On: Hydrogeological Study, Midhurst Water Supply Exploration Program Supporting Document, Midhurst Class EA, Township of Springwater, Ontario* (Golder, 2008).

In addition, the original Kempenfelt Bay model formed the hydrogeologic basis of the City of Barrie Tier 3 Water Budget and Local Area Risk Assessment (AquaResource, 2013). The model was used to estimate impacts as a result of Barrie municipal well pumping and was a supporting tool for the MOECCs 2015 approval of the South Georgian Bay Lake Simcoe Source Protection Plan.

4.0 MODEL UPDATES

Results of Golder's recent Midhurst-area water supply investigation guide the model updates described herein. The drilling and installation of 20 test wells and 13 observation well nests (21 observation wells total) has been completed. Subsequently, five aquifer tests (two in A3 and three in A4) have been conducted. The field study results and analysis allow for local-scale refinement of model parameters in the Midhurst area as follows:

- **Mesh Refinement:** The model mesh density is gradually increased around the new test wells to element dimensions of about 10 m to 15 m in order to better capture local-scale effects due to pumping.
- **Geologic Layering:** A review of borehole logs relative to model layering indicates that the field data is in good agreement with the pre-existing model elevations for deeper units A3, C3 and A4, with most unit "pick" elevations being within +/- 5 m of their model counterpart. No updates are deemed necessary for these layers. However, some minor updates to UC, A1, C1 and A2 are warranted in localized areas of Midhurst (Figure 5).
- **Hydraulic Conductivity:** Recent aquifer testing provides additional estimates of transmissivity for A3 and A4. This data is compared to the existing Midhurst and nearby Snow Valley pumping test results to determine a revised "average" for a sub-regional area encapsulating Midhurst (Figure 5).
  - **Aquifer A3:** The hydraulic conductivity of A3 is increased slightly from 2.3E-4 m/s to 3E-4 m/s.
  - **Aquifer A4:** Prior to the recent testing there were no local estimates of hydraulic conductivity for A4, hence the original value was assigned based on regional estimates. However, aquifer testing indicates that in Midhurst aquifer A4 is more transmissive than previously assumed and the hydraulic conductivity is increased from 6E-5 m/s to 3E-4 m/s.
- **Connection to Surface Water:** Aquifer testing did not reveal the potential for hydraulic connection between the pumping in deep Aquifers A3/A4 and surface water features. Water levels in Aquifer A1 did not decrease and gradients were not reversed as a result of the 72-hour pumping tests. This observation was considered when reviewing the modelled long-term impact of pumping at full build-out. Based on the field testing results, it was anticipated that any simulated potential impacts to surface water features from the deep pumping would take months or even years to propagate (this was later confirmed during the Future Conditions Assessment – Section 6.2).

5.0 MODEL CALIBRATION

The original (2004) Kempenfelt Bay model was calibrated to steady-state conditions. As such, the modelled stream baseflows reflected average yearly conditions. This was a reasonable approach as the goal of the 2004 modelling was to delineate WHPAs for wells screened in deep, confined aquifers; as such the behaviour of surficial aquifers and groundwater / surface water interaction was not a central focus.

For this current assessment it is important to more accurately depict seasonal stream flow fluctuations in order to understand how additional pumping may affect baseflow throughout the year. This is especially the case during the summer months when the dual effect of increased groundwater demand and decreased surface water discharge may accentuate baseflow losses.

As a result, the Existing Conditions model is calibrated in transient mode to Willow Creek monthly baseflow. In addition to improving the understanding of groundwater / surface water interaction in the Midhurst area, the transiently calibrated model serves as the "base case" to assess future effects due to increased pumping.

5.1 Calibration Dataset

The primary source of data for the calibration is continuous flow records for Water Survey of Canada (WSC) flow stations 02ED009, 02ED010, and 02ED032 (Environment Canada, 2012). All three stations are located on Willow Creek (Figure 1). These stations have varying period of records, with the most recent data being collected during 2010 at 02ED032 (Willow Creek at Matheson Creek).

The estimated watershed surplus, total measured stream flow and baseflow for each station is shown on Figure 6. The computer-based BFLOW algorithm (Arnold et al., 1995) is used to separate the baseflow (i.e., groundwater) portion of the total measured stream flow. The monthly baseflow estimates provide the targets for the transient model calibration.

5.2 Parameter Adjustment

Model parameters are refined in the areas of: 1) recharge rates; 2) surficial hydraulic conductivity assignments; 3) constant head constraints; and 4) storage parameters.

5.2.1 Recharge Rates

The 2004 model simulated average Willow Creek baseflow (110,000 m^3/d) is lower than the field-estimated average (156,000 m^3/d) at station 02ED032. This model under-prediction is in part due to the original calibration dataset being limited to low flows during summer, which would tend to bias baseflows to the low end of the measured range. Recharge rates in the original model range from 125 mm/yr to 230 mm/yr (see Figure 4.4 of Golder and WHI, 2004[1]); considerably lower than rates published in the more recent Barrie Tier Three study, which shows large areas of Willow Creek watershed with recharge in the 300 mm/yr to 600 mm/yr range (AquaResource, 2012).

Recharge rates are increased and a new recharge distribution is established to more accurately simulate measured baseflows (Figure 7). The revised distribution is refined through a concurrent review of surficial soil permeability and baseflow measurements at the three WSC stations. A satisfactory yearly average condition is first obtained; then, for monthly inputs, the yearly average recharge rate is pro-rated according to monthly surplus at the Barrie Water Pollution Control Centre (Environment Canada Climate Services, 2012) to approximate seasonal variation (Figure 7).

5.2.2 Hydraulic Conductivity

In tandem with increasing recharge rates, the surficial materials / hydraulic conductivity assignments (Layers 1 through 3) are reviewed. It is found that, in the original model, the surficial material within 500 m of Willow Creek from Little Lake westward to Minesing is typically assigned a hydraulic conductivity reflective of silty or clayey materials, whereas the majority (over 80%) of MOE WWIS logs indicate sand and/or gravel material at surface to

a depth of 3 m or greater. Thus the UC/A1 hydraulic conductivity within +/- 500 m along Willow Creek is increased locally up to 3E-4 m/s (the regional upper bound hydraulic conductivity for A1).

5.2.3 Constant Head Constraints

The original model has Willow Creek and Matheson Creek constant head nodes as unconstrained. This results in the streams being (potentially) both gaining and losing streams, depending on the surrounding groundwater elevation. In general, and as expected, the streams act primarily as discharge locations. However, in upland areas, streams defined as constant head could artificially sustain the water table at ground surface and recharge the system with unrepresentative volumes of groundwater.

For the current analysis, the Willow Creek and Matheson Creek constant head nodes are constrained to be "discharge only". This is consistent with the Creek's conceptual roles as groundwater discharge zones and improves the calibration to monthly baseflows, particularly at flow station 02ED009, which primarily reflects the upland catchment of Willow Creek.

5.2.4 Storage Parameters

The transient simulation requires input of groundwater system storage parameters. Table 2 lists the specific storage value applied for each hydrostratigraphic unit. The specific storage value of 2E-4/m for A2, A3 and A4 is consistent with aquifer test results. The specific storage value of 1E-4/m for C1, C2, C3 and C4 is an assumed input based on listed values for dense gravel to clayey materials that range from 4.9E-5/m to 2.6E-3/m (Batu, 1998). The specific storage value for UC and A1 (Layers 1 through 3) of 3E-4/m is developed through the calibration process.

An effective porosity of 0.25 is used for capture zone development.

5.3 Calibration Results

5.3.1 Transient Simulations

The final simulated versus field estimated (average) monthly baseflows are compared on Figure 8. The model captures the rise and fall of baseflow in accordance with seasonal climate patterns. Simulated discharge is typically within 10% of observed, indicating a reasonable match.

5.3.2 Steady-State Verification

The updated model is also run in steady-state (long term average conditions) to verify that the groundwater level calibration metrics are still satisfactory by comparing model output to 686 static water levels in the MOE WWIS (Figure 9).

Regional flow patterns (Figure 9) are consistent with past field inferences (see Figure 4.4.1 and Figure 4.4.2 of Golder, WHI, Ainley, 2004). Through the Midhurst area, groundwater flow in the A3 aquifer travels in a southwest direction from the uplands to the northeast, eventually moving in a more westerly direction as the influence of Willow Creek and Minesing Swamp discharge zones propagate to the deeper flow system.

A plot of simulated versus observed water levels and calibration statistics is provided on Figure 9 (see insert). For water levels below the 275 masl range, the model provides a good fit to measured data. Above 275 masl the model tends to underpredict water levels. Most of these higher water levels belong to shallow wells in the uplands northeast of Midhurst. At higher ground elevations (250 m up to 370 m) sub-regional, perched aquifers

(not directly related to aquifer A1) exist that are not explicitly captured in the regional-scale Kempenfelt Bay model and are difficult to calibrate to given the regionally continuous layer structure. However, the coarse representation of these upland areas is not considered an issue as the focus of this assessment is on baseflow changes at Willow Creek (lowland area) and drawdown in deep aquifer units (A3 / A4).

5.4 Calibration Summary

Through the calibration process the recharge rates, hydraulic properties of the geologic units and simulated flow patterns are found to be in satisfactory agreement with available field data. The Existing Conditions calibrated model input values are therefore considered to represent reasonable estimates for use in the assessment of Future Conditions. In particular, the calibrated model is considered sufficiently accurate for its ultimate purpose as an impact assessment tool given that:

- The focus of data collection and model refinement occurs in the area with the most pumping and potential for impact (Midhurst);
- Baseflow is evaluated at three “real world” stream gauges broadly positioned along Willow Creek upstream, adjacent to, and downstream of the proposed pumping;
- A high-degree of correspondence is demonstrated between average measured monthly baseflows and simulated monthly baseflows at these stream gauges during transient calibration.

6.0 FUTURE CONDITIONS ASSESSMENT

An assessment of the proposed Neighbourhoods water taking is undertaken for Future Conditions using the forecasted pumping rates listed in Table 1/Figure 3. The following measures are analyzed:

- Drawdown;
- Well interference; and
- Transient (monthly) changes to Willow Creek baseflow.

The Future Conditions model is simulated for a period of ten years. Note that the overall pattern of water level change in the model (including minimum and maximums) becomes reproducible year over year between five and ten years.

6.1 Drawdown

Figure 10 illustrates the simulated drawdown in Aquifers A1, A2, A3, and A4. The month of August during the tenth year of simulation time is used to illustrate drawdown, as this is related to an extended period of low recharge and high pumping (and thus greater drawdown). The 1 metre (m) drawdown contour is used to illustrate the lateral extent of drawdown.

The following is noted:

Aquifer A1

The drawdown in Aquifer A1 is relatively small (< 2.5 m). The lateral extent of response ranges from less than 1 km to approximately 4.5 km from the proposed development. A distant drawdown response is simulated east to northeast of the Doran area towards Oro-Medonte; this is in part a result of a relatively high transmissivity A1

overlain by low transmissivity (and hence lower recharge) UC material in this area. The greatest amount of vertical drawdown in Aquifer A1 emanates from the TW22 / TW19 area. Drawdown here appears to be accentuated by localized thinning of underlying aquitard units.

Aquifer A2

The drawdown in Aquifer A2 is also small (< 3 m), although the lateral drawdown extents have broadened as influence from the underlying municipal well pumping in A3 becomes more prominent.

Aquifer A3

The greatest drawdown occurs in Aquifer A3, where the majority of municipal pumping occurs. The high transmissivity of Aquifer A3 limits vertical drawdown in spite of high pumping rates; however, this same characteristic allows for a broad regional propagation of lateral drawdown. Drawdown reaches about 10 m at the Doran Neighbourhood whereas 3 m occurs at the Carson Neighbourhood. The zone of influence reaches a maximum extent of approximately 6 km from the proposed developments.

The zone of influence from City of Barrie pumping merges with that at Carson and Doran to produce a regionally continuous drawdown. The superposition results in a maximum drawdown of less than 2 m where the two responses merge.

Aquifer A4

Drawdown in Aquifer A4 is similar in extent to Aquifer A3. This is in part a reflection of the occasional absence or thinning of intermediary confining unit C3 throughout the Midhurst and Barrie areas (in other words, A3 and A4 combine into one aquifer). However, the maximum vertical magnitude of the drawdown is less than that in A3, with a maximum of about 7.5 m occurring at the Carson Neighbourhood. Local to TW34, an isolated 1.5 m of drawdown is simulated; the minor drawdown at this location is in part a result of its relatively low pumping rate.

6.1.1 Municipal Well Interference

Simulated well interference at surrounding municipal systems due to pumping at the Neighbourhoods is minimal and not anticipated to cause issues with well performance. The greatest amount of well interference occurs at the Midhurst and Paddy Dunn's Circle wells; where up to 1.7 m of additional drawdown is simulated. The remaining municipal well systems, including City of Barrie and Snow Valley, experience less than 1 m of additional drawdown as a result of Carson and Doran Neighbourhoods pumping, which is considered negligible from an operational standpoint.

6.1.2 Barrie Municipal Wells Safe Additional Available Drawdown (SAAD)

Safe additional available drawdown (SAAD) is defined as the additional drop in water level within a pumping well that could be sustained and still maintain that well's allocated pumping rate. A SAAD analysis was conducted for the Barrie municipal wells as part of the risk assessment portion of the Barrie Tier Three Study (AquaResource, 2013). The following is noted from that study:

- Under normal, current operating conditions the SAAD for Barrie pumping wells ranges from 17 m to 76 m.
- Under "diminished", current operating conditions – which may temporarily occur due to decreases in well efficiency from clogging of the well screen and aquifer materials – the SAAD for Barrie pumping wells ranges from 5 m (at Well 11) to 71 m. The Barrie well operators usually have sufficient time to temporarily

re-allocate pumping and shut a well down for rehabilitation; hence the SAAD for diminished conditions is not considered a strict limitation but rather a precautionary evaluation.

- The SAAD for the aquifer area adjacent to the wells – or the water level available above the top of the aquifer unit to maintain a confined response to pumping – ranges from 22 m to 56 m.
- Simulated drawdown that might occur under various *future* climate / demand risk assessment scenarios is presented. In each instance, the simulated drawdown still falls within the SAAD limits. Well 11 is the only well that exceeds the SAAD, and only under diminished well conditions. Note that this SAAD exceedance is simulated to occur prior to (or independent of) any additional drawdown imposed by Carson and Doran water takings.

Based on the findings above, the additional < 1 m of drawdown imposed by the Carson and Doran water takings at the City of Barrie municipal wells is considered acceptable and does not significantly add to water quantity risks.

6.2 Willow Creek Baseflow Changes

Figure 11 illustrates the Future Conditions simulated changes to monthly baseflows relative to Existing Conditions at the three Willow Creek flow stations. Also included in the chart is the Future Conditions total demand for the Midhurst area for reference.

The illustrated baseflow changes are a function of recharge and water demand. There is a seven month or longer day delay between pumping increase/decrease and associated baseflow response (see chart on left of Figure 11). Baseflow losses as a percent of Existing Conditions baseflow rates are amplified during summer months when recharge is lower and hence baseflow is minimized (see chart on right of Figure 11).

Geographically, the extent of baseflow losses occurs broadly from upstream of Little Lake downstream to Minesing Swamp; there are no highly localized areas of upwelling that are simulated as being discretely or uniquely impacted. The percentage baseflow loss is under 10% for all flow stations. The largest percent baseflow loss (about 9%) occurs at the Midhurst WSC station 02ED010 towards the end of summer; this is a result of the station's proximity to the source of pumping and the relative size of its catchment. The Willow Creek catchment in its entirety experiences within 3% to 7% baseflow loss depending on the time of year.

For context, the *Water Budget and Water Quantity Risk Assessment Guide* (MNR and MOE, 2011) defines an unacceptable impact to coldwater streams as a circumstance where groundwater discharge is reduced by more than 20% as compared to the average monthly baseflow of the watercourse, specifically the following is stated in this reference:

For coldwater streams, an unacceptable impact is defined by a circumstance where groundwater discharge is reduced by more than 20% as compared to the existing estimated monthly streamflow Qp80 (the flow that is exceeded 80 percent of the time) or the average monthly baseflow of the watercourse or another threshold that has already been defined as a condition in an existing permit. [Note: As described previously the modelling considers average monthly baseflow].

A discussion of the potential effect of these baseflow losses on natural environment receptors in the Willow Creek subwatershed is provided in the Hutchinson Environmental Sciences Report entitled *7Q20 Flow Assessment Update for Willow Creek at Highway 26 (Near Minesing) and Ecological Low Flow Assessment*

(HESL, 2018). HESL concluded that "the predicted flow reductions in Willow Creek and its tributaries associated with the proposed water taking to supply the Midhurst Secondary Plan Area will have no adverse effects on habitat and water temperature in Matheson, Black and Willow Creeks." (HESL, 2018).

About 80% to 90% of the Midhurst area water taking is derived from the Willow Creek watershed. The remaining water taking is mostly sourced from the Nottawasaga River watershed (5% - 10%) or directly from Kempenfelt Bay (5% - 10%).

7.0 CAPTURE ZONES

Capture zones for the existing Midhurst and Paddy Dunn's Circle wells and the future Carson and Doran Neighbourhood wells are determined for the 2-year, 5-year, 10-year and 25-year time-of-travel using backward particle tracking in FEFLOW (Figure 12). Close proximity wells with similar capture zones are enveloped into a single capture zone in some cases. The capture zones are derived using Future Conditions average pumping rates and a steady-state (long-term yearly average) head distribution (Figure 12).

The capture zones reflect 2D projections to ground surface and do not necessarily account for vertical travel time. This conservative approach is frequently used to define capture zones for water supply systems in Ontario. The actual travel time for source water entering the groundwater table to reach the wells may be longer than illustrated as aquifers A3 and A4 are deep units residing beneath lower permeability aquitards.

The capture zones produced in this analysis provide the current best estimate of 2D well capture. After the water supply system design is finalized these capture zones may form the basis for Wellhead Protection Area (WHPA) delineation. At this time an uncertainty analysis may be incorporated into the results in order to provide an additional buffer for wellhead protection purposes.

7.1 Midhurst and Paddy Dunn's Circle Systems

Capture zones for Midhurst and Paddy Dunn's Circle wells are projected from Aquifer A3. The 25-year capture zones for the Midhurst Idlewood Drive and Greenpine wells extend about 3 km in an east to northeasterly direction, eventually bordering on the capture zone for TW21 / TW24. The Carson Road Well 4 and Paddy Dunn's Circle Wells 25-year capture zone travels approximately 3 km in a northeasterly direction.

7.2 Carson Neighbourhood

Capture zones for the Carson Neighbourhood are projected from Aquifer A4. The 25-year capture zone of TW22 extends about 3 km to the east. The 25-year capture zone for TW34 travels about 1 km south towards a groundwater high in the Snow Valley upland area.

7.3 Doran Neighbourhood

Capture zones for the Doran Neighbourhood are projected from Aquifer A3. The capture zones for the Doran Neighbourhood wells are oriented northeast as a result of the regional flow system emanating from the upland areas towards Oro-Medonte. The 25-year capture zone for the Alliance Wells extend approximately 4.5 km while the 25-year capture zone for TW21 / TW24 reaches about 3.5 km in length.

8.0 AQUIFER VULNERABILITY

The Aquifer Vulnerability Index (AVI) is a method for mapping the susceptibility of an aquifer to surficial contaminants. The AVI assigns a score based on two key parameters: 1) the thickness of each geologic unit above the aquifer; and 2) the hydraulic conductivity of each of these units.

An AVI analysis was completed by Golder for the South Georgian Bay Lake Simcoe Source Protection Region (Golder, 2010). A review of the mapping indicates that water supply aquifers A3 and A4 would remain classed as "low vulnerability" in the area of the capture zones described in Section 7. This classification is consistent with drilling observations recorded as part of Golder's recent water supply investigation that indicate substantial thicknesses of clayey materials overlying aquifer A3.

9.0 PERMIT TO TAKE WATER CONSIDERATIONS

All water takings in Ontario exceeding 50 m^3/day are required to obtain a Permit To Take Water (PTTW) from the MOECC. The Neighbourhood's future construction activities and proposed water supply will require PTTWs prior to operation, although the initial water supply permit request may be for significantly less water than reported herein as the subdivision will not be at full build-out. The groundwater model will be an important tool during the permitting review and approval process. In addition, and in consultation with the MOECC, a monitoring program may be instituted to ensure that private water supplies and surface water features are not adversely impacted by the water taking.

10.0 LIMITATIONS

10.1 Use of This Report

This report has been prepared by Golder Associates Ltd. (Golder) for use by The Midhurst Landowner's Group or its agents. The factual information, descriptions, interpretations, comments, results, conclusions and electronic files contained herein are specific to the project described in this report. Information used in this report should be restricted to that specified in the scope of work unless otherwise mutually agreed upon by The Midhurst Landowner's Group and Golder. This report should be read in its entirety as some sections could be falsely interpreted when taken individually or out-of-context. Golder is not responsible for any use of this report and its content by a third party, and/or for its use for purposes other than those intended.

Golder is not responsible for any damages that may result from unpredictable or unknown underground conditions, from erroneous information provided by and/or obtained from sources other than Golder, and from ulterior changes in the site conditions unless Golder has been notified of any occurrence, activity, information or discovery, past or future, susceptible of modifying the underground conditions described herein, and have had the opportunity of revising its interpretations. In addition, Golder is not responsible for any decrease of a property's value or any failure to complete a transaction as a consequence of this report.

10.2 Groundwater Modelling General Limitations

Hydrogeological investigations and groundwater modelling are dynamic and inexact sciences. They are dynamic in the sense that the state of any hydrological system is changing with time and the science is continually developing new techniques to evaluate these systems. They are inexact in the sense that field data provides a fraction of information for the site or model domain; as such a truly complete, comprehensive

characterization of the groundwater system is not possible. Therefore, every groundwater model is, by necessity, a simplification of a reality.

The professional groundwater modelling services described in this report are conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions. The results of previous or simultaneous work provided by sources other than Golder and quoted and/or used herein are considered as having been obtained according to recognized and accepted professional rules and practices, and therefore deemed valid.

The model presented herein provides a predictive scientific tool to evaluate the impacts of specified hydrological stressors on a real groundwater system and to compare various scenarios in support of a decision-making process. The model's accuracy is bound to the normal uncertainty associated to groundwater modelling and no warranty, express or implied, is made.

11.0 CLOSURE

A hydrogeological assessment of the proposed Carson and Doran Neighborhoods groundwater supply system is conducted using the Kempenfelt Bay FEFLOW model. An Existing Conditions model scenario is refined and further calibrated in Midhurst and greater Willow Creek watershed areas in accordance with recent drilling, aquifer testing, and stream flow data. Subsequently, a Future Conditions model simulates anticipated water taking at full build-out. Drawdown, well interference, baseflow changes, capture zones and Aquifer Vulnerability Index (AVI) status are assessed. A summary of the Future Conditions assessment results is provided below:

- The additional Carson and Doran water takings result in drawdowns of up to 10 m in Aquifer A3 in the area of the Doran Neighborhood, with a lateral zone of influence reaching 6 km from the proposed development. Well interference at surrounding municipal systems is minimal (1.5 metres or less) and not anticipated to impact well performance.
- Baseflow reductions at Willow Creek are highest during late summer period. The maximum reduction simulated is about 9% in the Midhurst area. The Willow Creek catchment experiences between about 3% to 7% baseflow loss depending on the time of year.
- Capture zones for the Midhurst and Paddy Dunn's Circle and Carson and Doran Neighbourhood wells are developed by delineating the 2 year, 5 year, 10 year and 25 year capture zones at each well. Most capture zones are directed east to northeast in conformance with regional flow patterns emanating from the Oro-Medonte uplands. The 25-year time of travel zones reach upgradient distances ranging from about 1 km to 4.5 km in length.
- Water supply aquifers A3 and A4 have a "low vulnerability" AVI in the areas of the capture zones.

Report Signature Page

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DAH/JAE/plc

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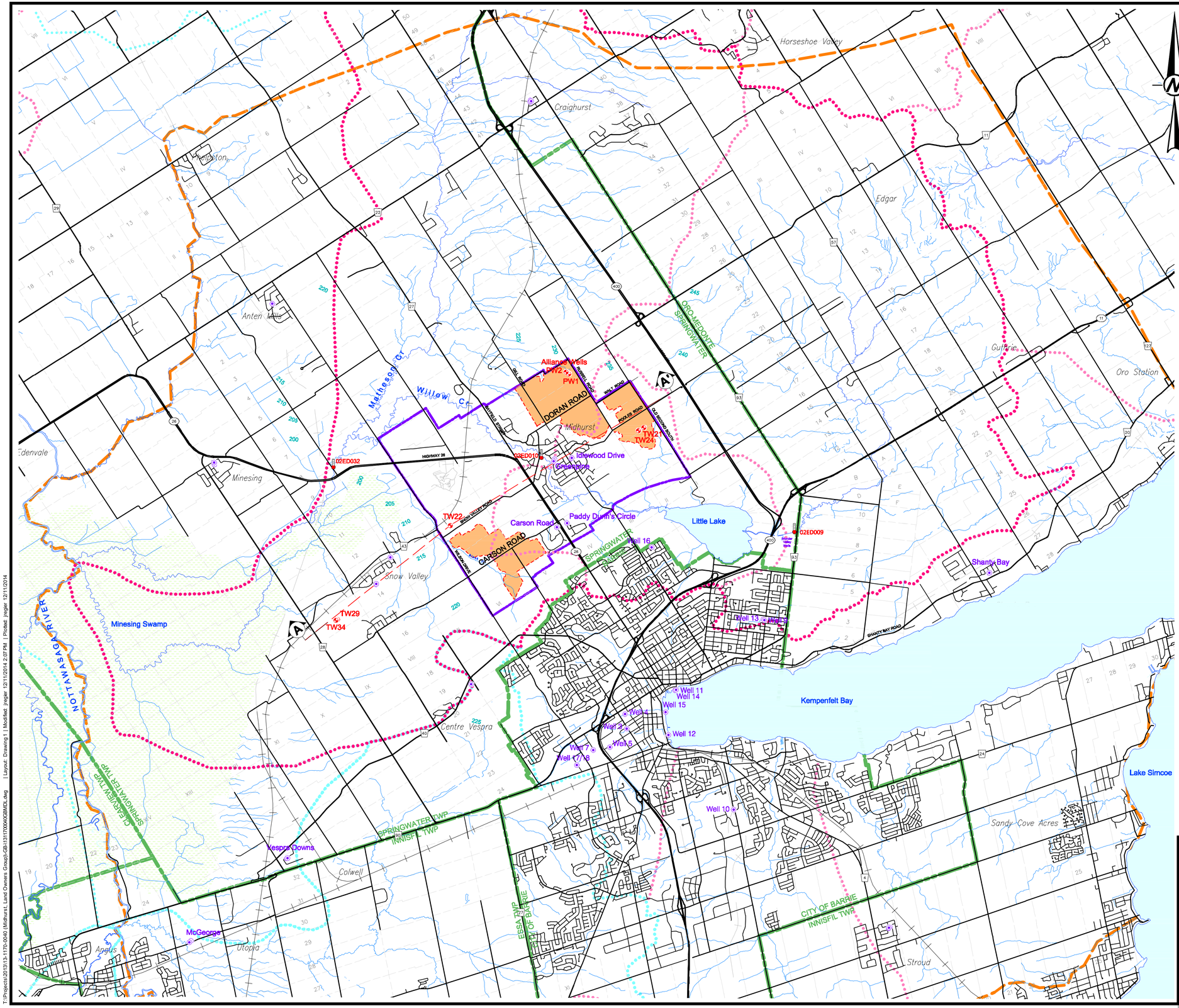
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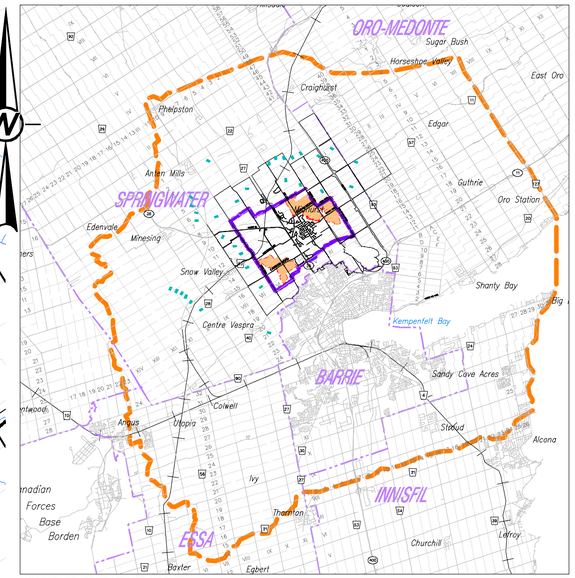
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FIGURES





MODEL EXTENTS KEY PLAN 1:200,000

LEGEND

- Proposed Development
- Midhurst Growth Area Boundary
- Municipal Boundary
- Model Domain
- Willow Creek Watershed Boundary
- Nottawasaga River Watershed Boundary
- Watershed Sub-Basin
- Minesing Wetland Extents (Approximate)
- Existing Municipal / Public Supply Well
- 2014 Municipal Well Test Site
- 02ED009 WSC Flow Station

0 500 1000 2500 5000

SCALE 1:50000 metres

NOTES

1. Base Map from Terenet Mapping 2009
2. Development Plan Geranium Corporation 2013, SCS Consulting
3. Wells are approximate to Survey accuracy, GPS, and or measurement from mapped features.

PROJECT

CARSON AND DORAN NEIGHBOURHOODS GROUNDWATER MODELLING

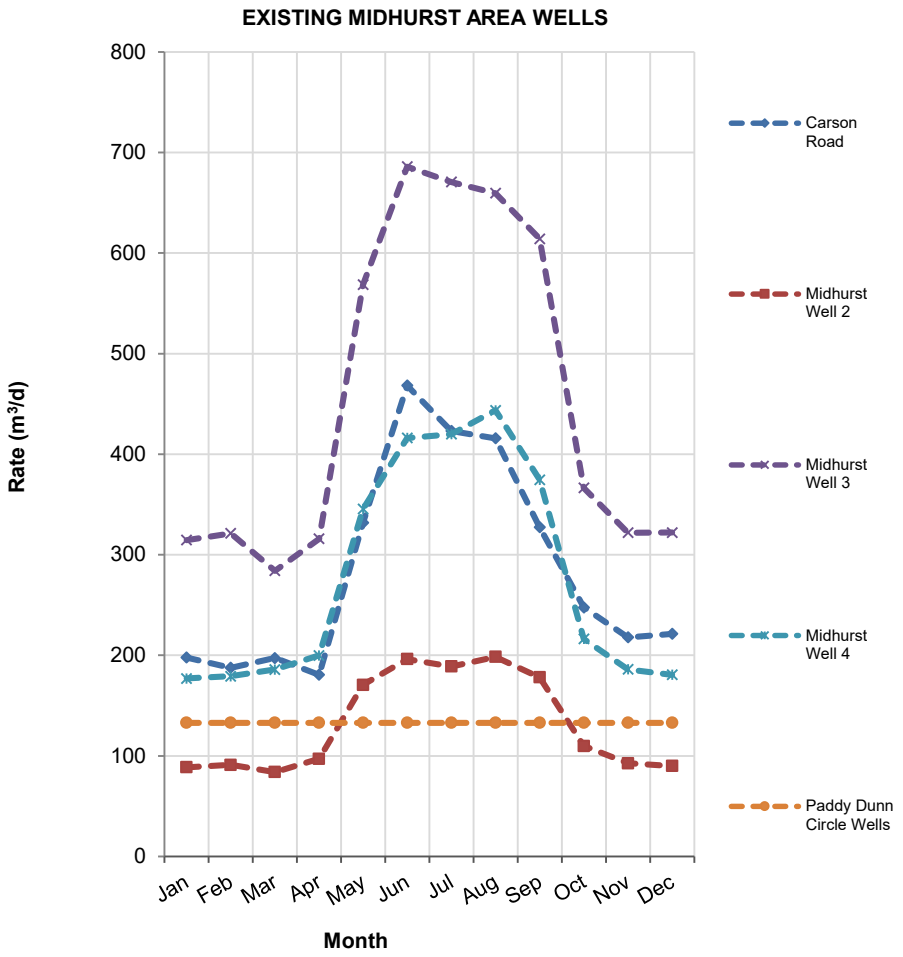
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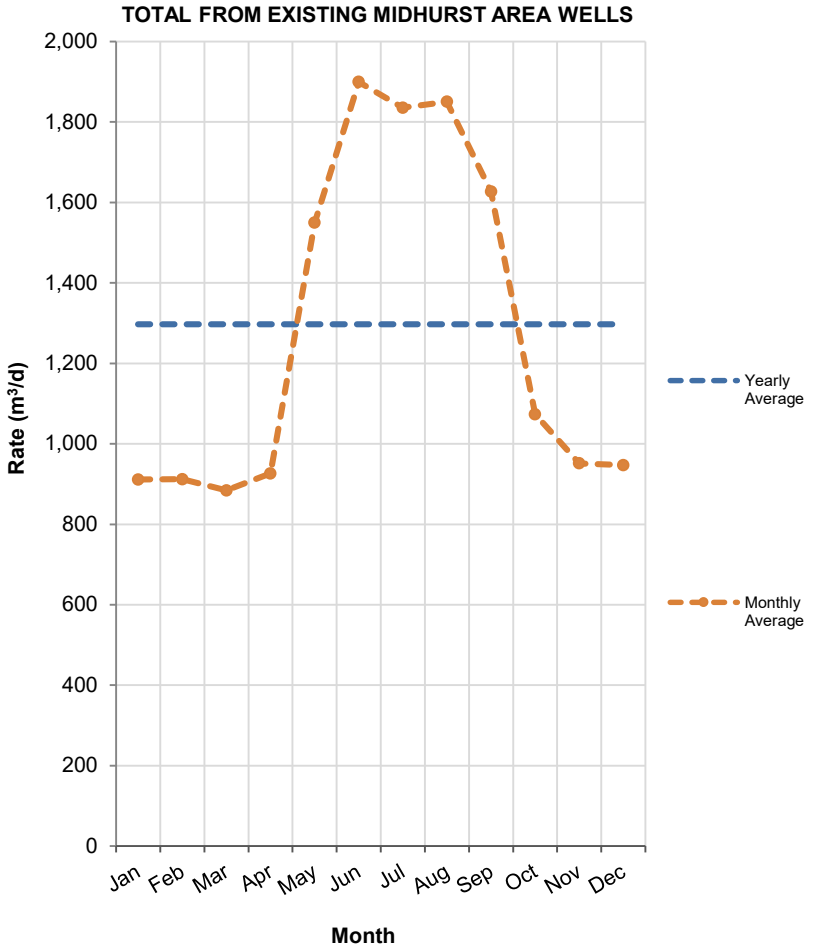
MODEL AREA

Golder Associates

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CHECK				
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NOTE

- *Chart shows 2003 to 2010 monthly averages.*
- *Monthly averages for Paddy Dunn Circle wells not available, average rate for year applied equally every month.*

PROJECT

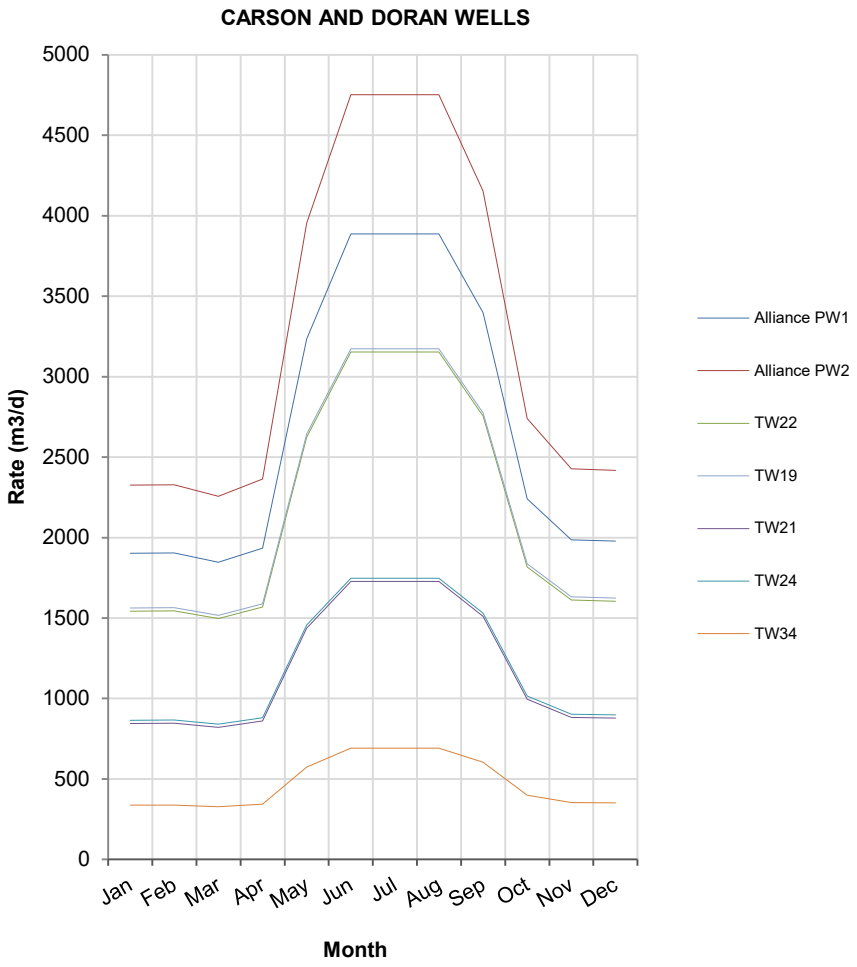
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GROUNDWATER MODELLING

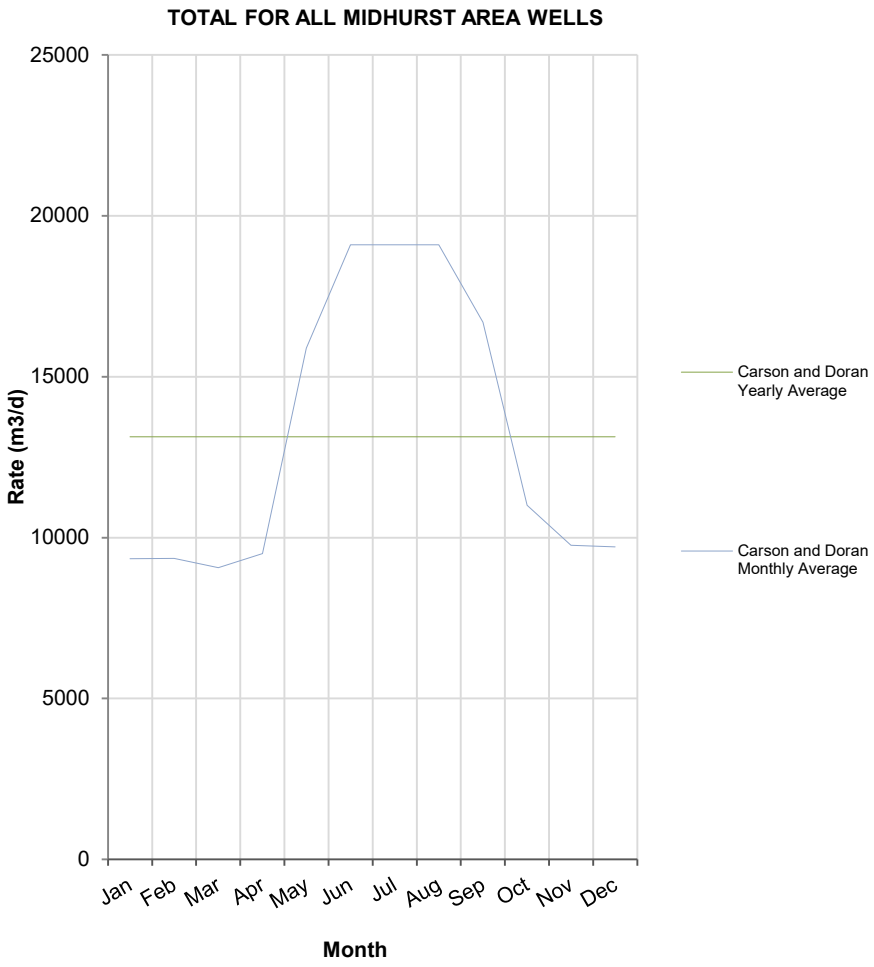
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EXISTING CONDITIONS
MIDHURST AREA PUMPING RATES

Golder Associates

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DESIGN	AM	MAR 2015	REV. 1
CAD	AM	MAR 2015	FIGURE
CHECK			2
REVIEW			





NOTE

- *Projected total monthly demand at Carson and Doran wells calculated by prorating maximum demand (19,095 m^3/d) in accordance with Existing Conditions demand (Figure 2).*
- *Midhurst and Paddy Dunn's Circle rates for Future Conditions (not shown) are assumed to continue as per Existing Conditions (Figure 2).*

PROJECT

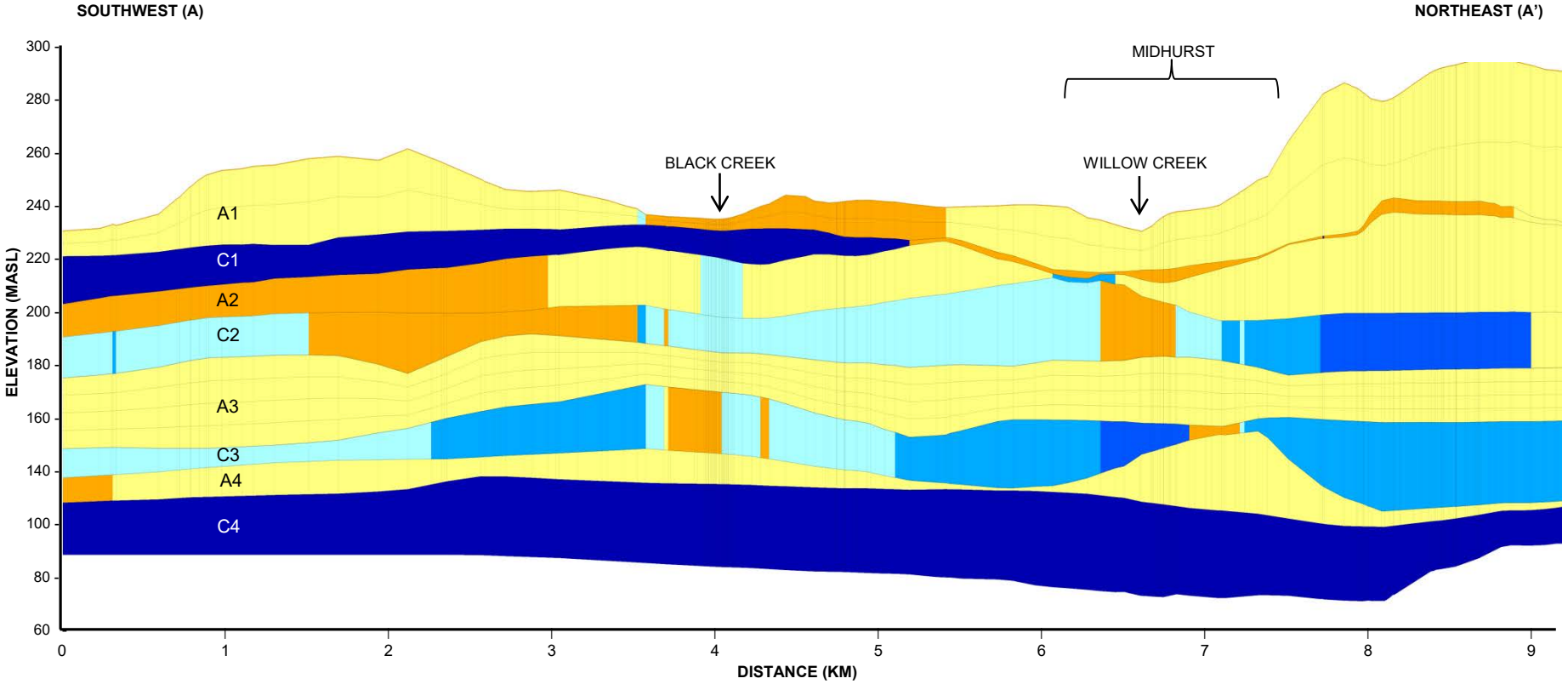
CARSON AND DORAN NEIGHBOURHOODS
GROUNDWATER MODELLING

TITLE

FUTURE CONDITIONS
CARSON AND DORAN PUMPING RATES

Golder Associates

PROJECT No. 13-1170-0040(4000)			SCALE AS SHOWN
DESIGN	AM	NOV 2015	REV. 1
CAD	AM	NOV 2015	FIGURE
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REVIEW			



NOTE:

- *See Figure 1 for plan view location of cross-section.*

LEGEND

HORIZONTAL HYDRAULIC CONDUCTIVITY (K_H) IN M/S:

- K_H >= 1E-4
- 1E-5 < K_H <= 1E-4
- 1E-6 < K_H <= 1E-5
- 1E-7 < K_H <= 1E-6
- 1E-8 < K_H <= 1E-7
- K_H = 1E-8

PROJECT

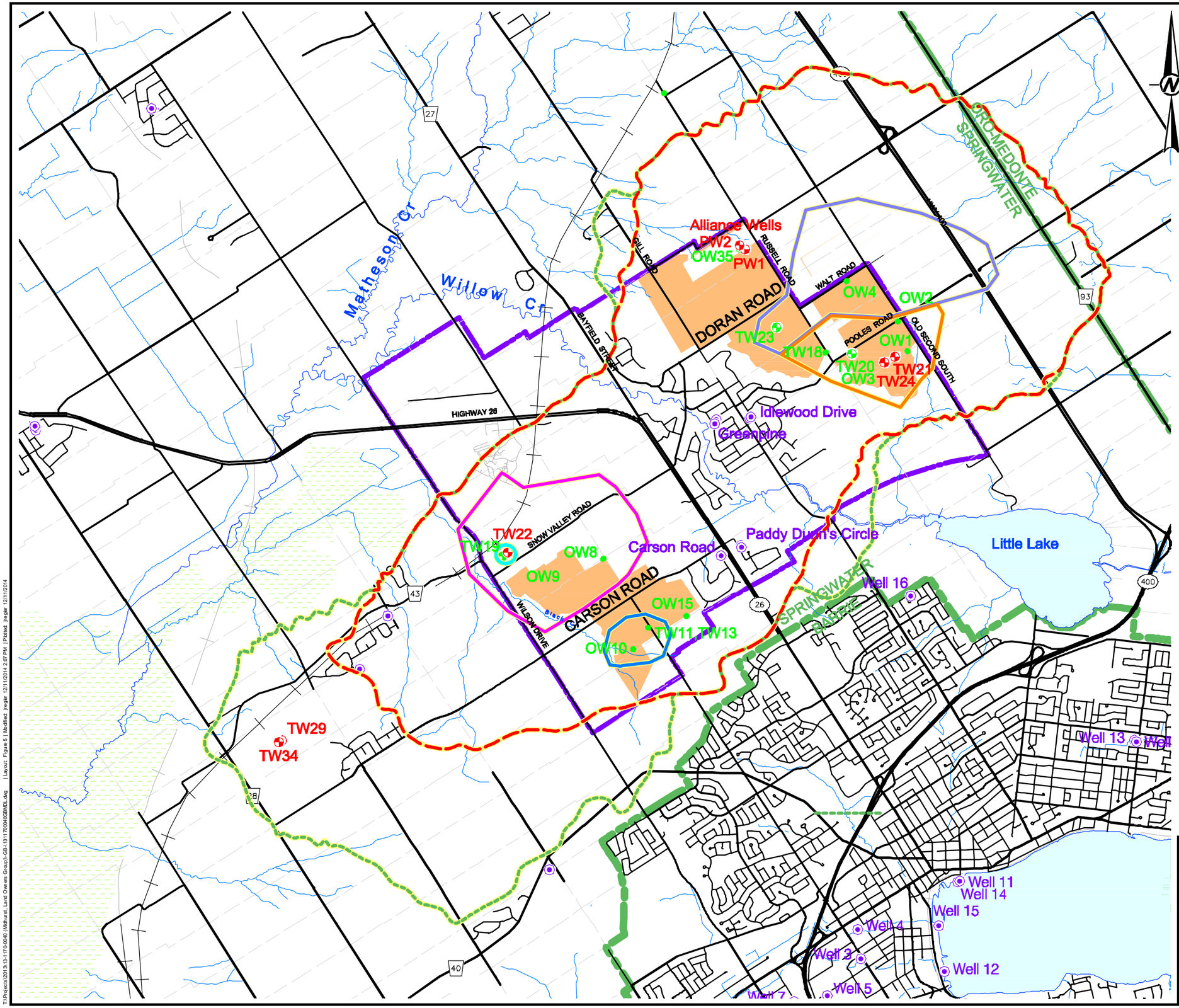
CARSON AND DORAN NEIGHBOURHOODS
GROUNDWATER MODELLING

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MODEL CROSS-SECTION

Golder Associates

PROJECT No. 13-1170-0040(4000)			SCALE AS SHOWN
DESIGN	AM	MAR 2015	REV. 1
CAD	AM	MAR 2015	FIGURE
CHECK			4
REVIEW			



PLAN LEGEND

- Proposed Development
- Midhurst Growth Area Boundary
- Municipal Boundary
- Existing Municipal / Public Supply Well
- Test or Observation Well Site
- Municipal Well Water Supply Test Site

MODEL UPDATE ZONES

- A4 – K increased from 6E-5 m/s to 3E-4 m/s
- A3 – K increased from 2.3E-4 m/s to 3E-4 m/s
- UC (5E-6 m/s) changed to A1 (5E-5 m/s).
  Bottom of A1 raised from about 236 masl to 258 masl towards OW8
- C2 brought up through A2 to C1 (A2 locally thins out)
- Base elevation of A1 lowered from 243 masl to 237 masl
- Bottom of UC raised from ~260 masl to 274 masl.
  Bottom of A1 raised from ~235 masl to 252 masl.
  C1 introduced at 8 m thickness (previously not present)
- Bottom of A1 raised from 233 masl to 241 masl at TW18 to 247 masl TW21.
  C1 introduced at 5 m – 7 m thickness (previously N/P)
  A1 overwrites UC at TW24 and TW21

NOTES:

1. Base Mapping from Terenet Mapping 2009
2. Development Plan Geranium Corporation 2013
3. Wells are approximate to Accuracy of GPS and Measurement from known features.

This figure shows model updates that have been implemented as a result of recent drilling and aquifer testing data (Golder, 2014). For model updates resulting from the calibration refer to Section 5 of this report.

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Plotted 11x17 Landscape

PROJECT

CARSON AND DORAN NEIGHBORHOODS
GROUNDWATER MODELLING

TITLE

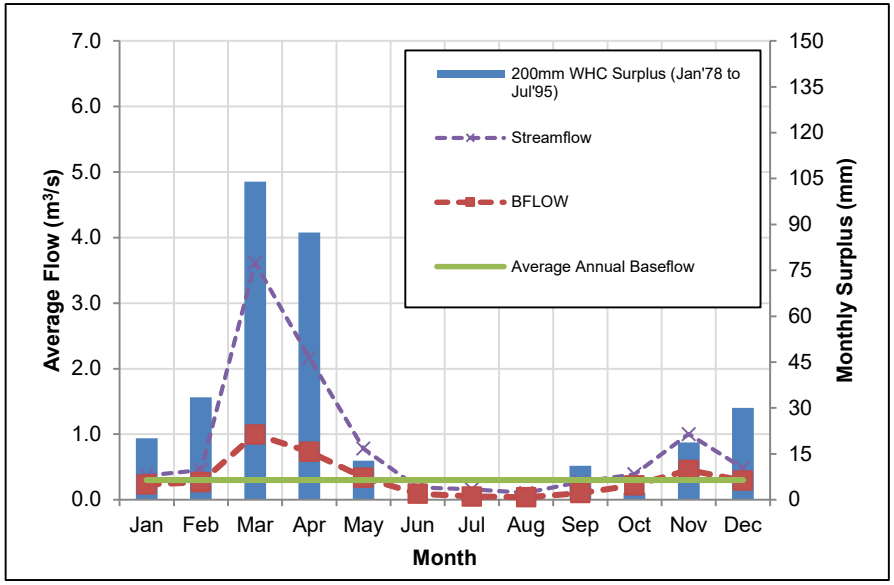
MODEL UPDATE AREAS

Golder Associates

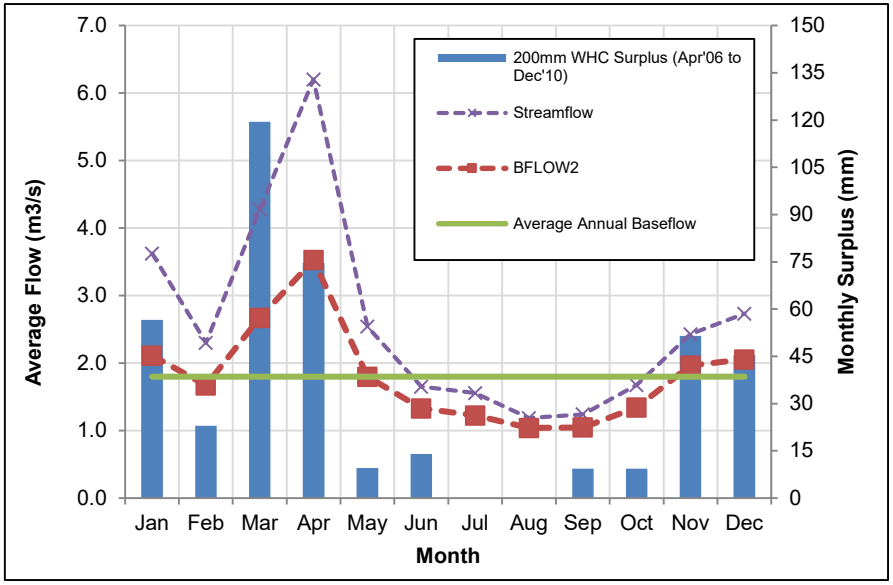
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CHECK				
REVIEW	DH	09 Dec 13		

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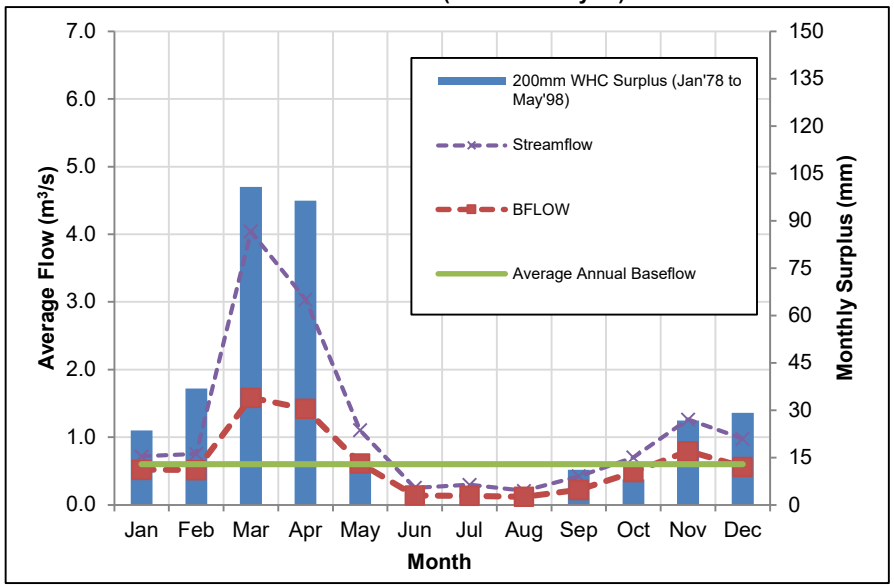
WILLOW CREEK ABOVE LITTLE LAKE (95 km²)
WSC Station 02ED009 (Feb'73 to Jul'95)

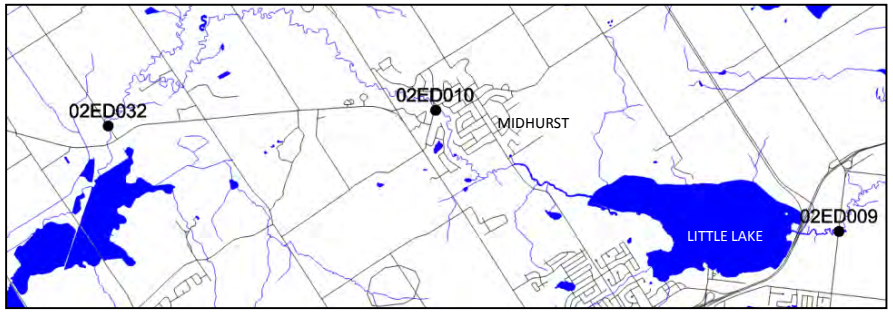


WILLOW CREEK AT MATHESON CREEK (231 km²)
WSC Station 02ED032 (Apr'06 to Dec'10)



WILLOW CREEK AT MIDHURST (127 km²)
WSC Station 02ED010 (Feb'73 to May'98)





PROJECT

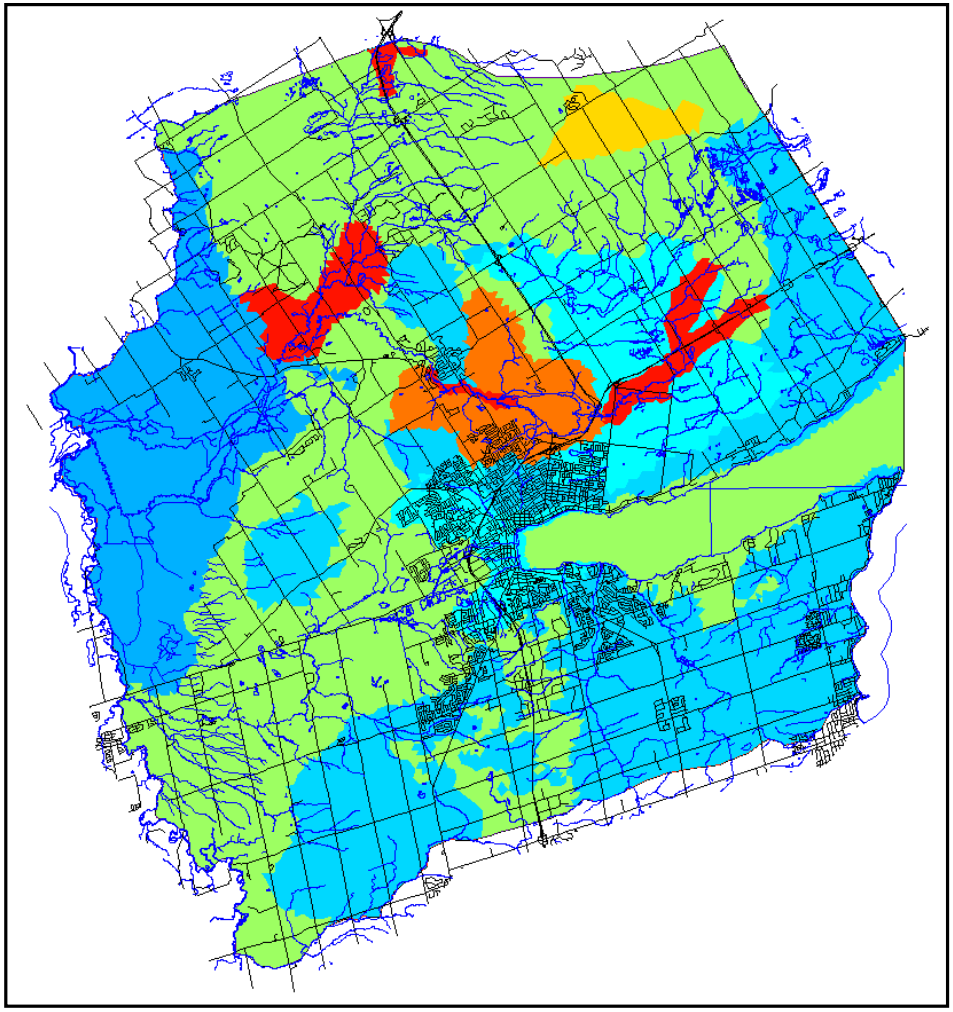
CARSON AND DORAN NEIGHBOURHOODS
GROUNDWATER MODELLING

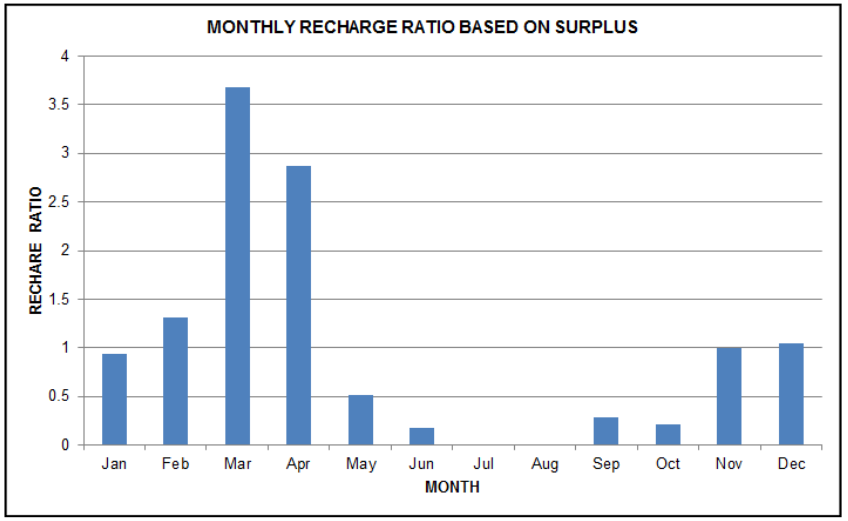
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WILLOW CREEK STREAM FLOW

Golder Associates

PROJECT No. 13-1170-0040(4000)			SCALE AS SHOWN
DESIGN	AM	MAR 2015	REV. 1
CAD	AM	MAR 2015	FIGURE
CHECK			6
REVIEW			





NOTES:

- *In transient simulation the recharge rate at each polygon for each month is determined by multiplying the average recharge rate (see Legend) by the monthly recharge ratio (see above).*
- *Surplus derived from Barrie WPCC monthly averages for period of 1978 – 2012.*

.

LEGEND

AVERAGE RECHARGE RATE (MM/YR):

- 110
- 140
- 170
- 250
- 390
- 450

PROJECT

CARSON AND DORAN NEIGHBOURHOODS
GROUNDWATER MODELLING

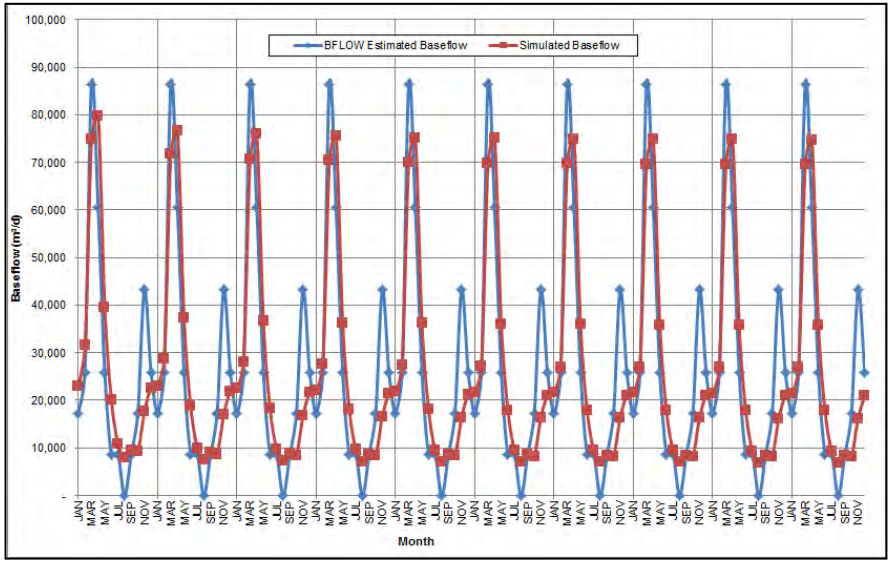
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MODEL RECHARGE DISTRIBUTION

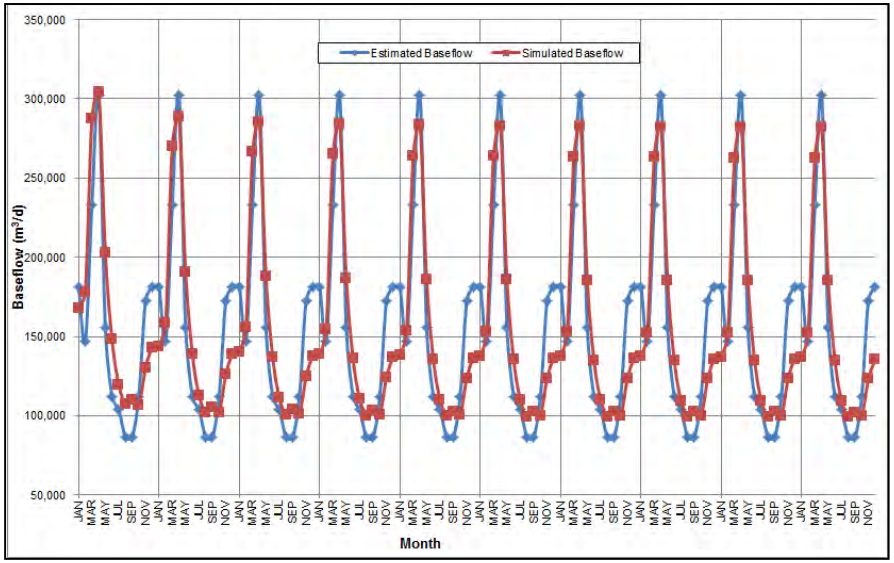
Golder Associates

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CAD	AM	MAR 2015	FIGURE
CHECK			7
REVIEW			

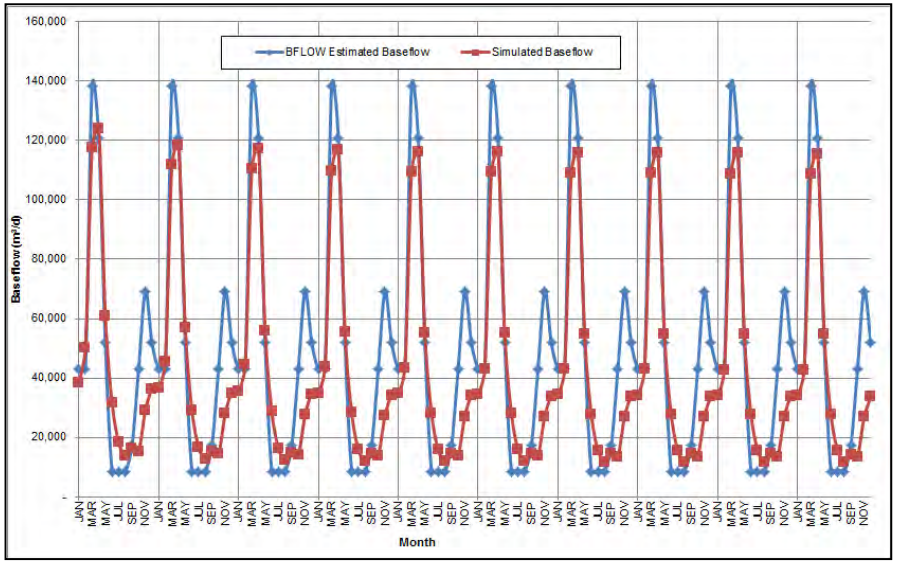
WILLOW ABOVE LITTLE LAKE (95 km²)
WSC Station 02ED009

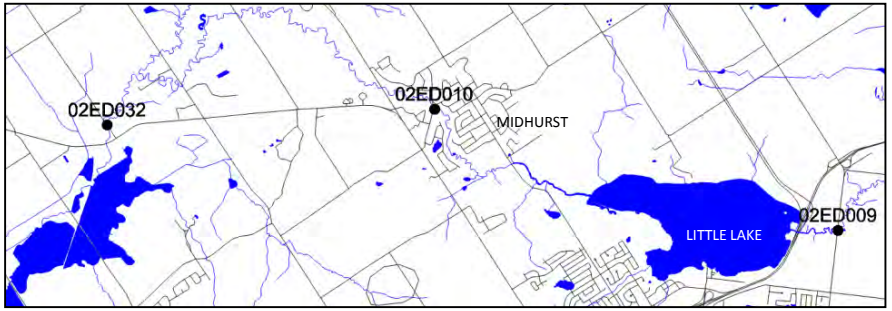


WILLOW AT MATHESON CRK (231 km²)
02ED032 Baseflow Results (Apr'06 to Dec'10)



WILLOW AT MIDHURST (127 km²)
WSC Station 02ED010





PROJECT

CARSON AND DORAN NEIGHBOURHOODS
GROUNDWATER MODELLING

TITLE

EXISTING CONDITIONS
WILLOW CREEK
BASEFLOW CALIBRATION RESULTS

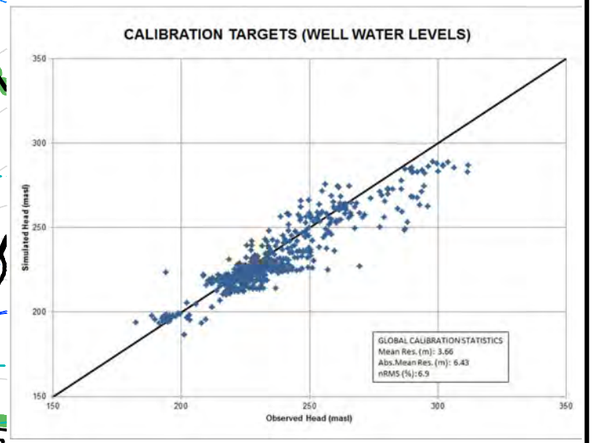
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PROJECT No. 13-1170-0040(4000)			SCALE AS SHOWN
DESIGN	AM	MAR 2015	REV. 1
CAD	AM	MAR 2015	FIGURE
CHECK			8
REVIEW			

Alliance Wells
PW2
PW1
TW21
TW24
TW22
TW19
TW34
Idlewood Drive
Greentree
Carson Road
Paddy Dunn's Circle
Little Lake
Well 16
Well 13
Well 11
Well 14
Well 15
Well 4
Well 3
Well 12
Well 5
Well 7
Kemp
DORAN ROAD
CARSON ROAD
GILL ROAD
RUSSELL ROAD
WALT ROAD
FOOLES ROAD
OLD SECOND SOUTH
BAYFIELD STREET
SNOW VALLEY ROAD
WILSON DRIVE
HIGHWAY 26
Matheson Cr
Willow Cr
Black
ORO-MEDONTE SPRINGWATER
SPRINGWATER
BARRIE
400
27
43
26
93
28
40
220
225
230
235
240
245
215
210
205
200
195
190

PLAN LEGEND

- Proposed Development
- Midhurst Growth Area Boundary
- Municipal Boundary
- Existing Municipal / Public Supply Well
- Municipal Well Test Site
- Existing Model Conditions Aquifer A3 Head Elevations (masl)



NOTES:

1. Base Mapping from Terenet Mapping 2009
2. Development Plan Geranium Corporation 2013
3. Wells are approximate to Accuracy of GPS and Measurement from known features.

This figure shows model updates that have been implemented as a result of recent drilling and aquifer testing data (Golder, 2014). For model updates resulting from the calibration refer to Section 5 of this report.

0 400 1000 2000 4000

SCALE 1:50000 metres

Plotted 11x17 Landscape

PROJECT

CARSON AND DORAN NEIGHBORHOODS
GROUNDWATER MODELLING

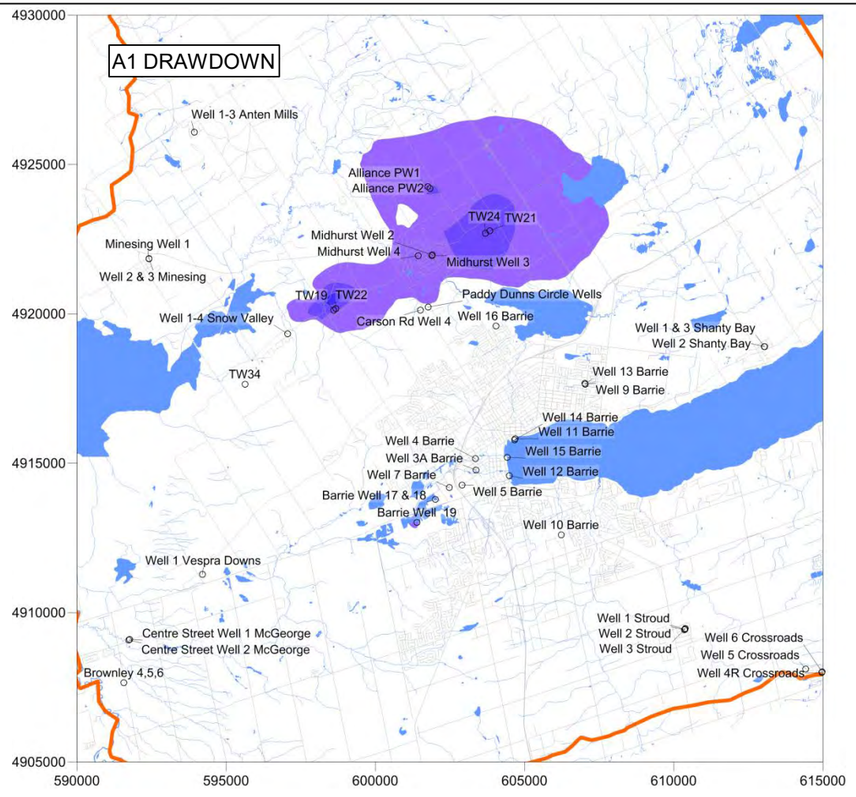
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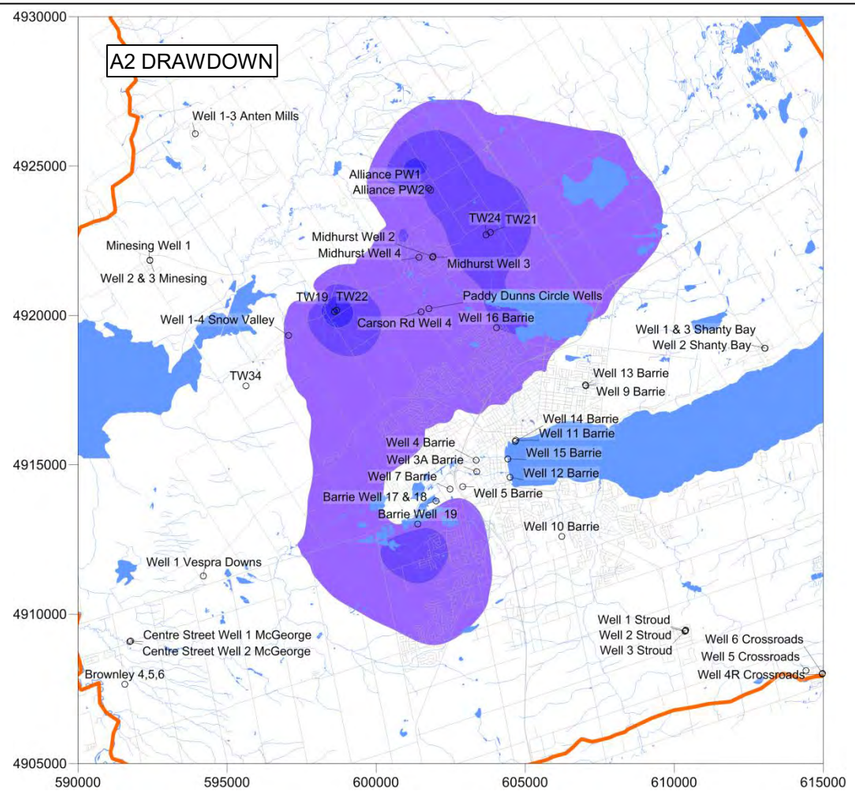
EXISTING CONDITIONS
SIMULATED GROUNDWATER HEAD ELEVATION
AQUIFER A3

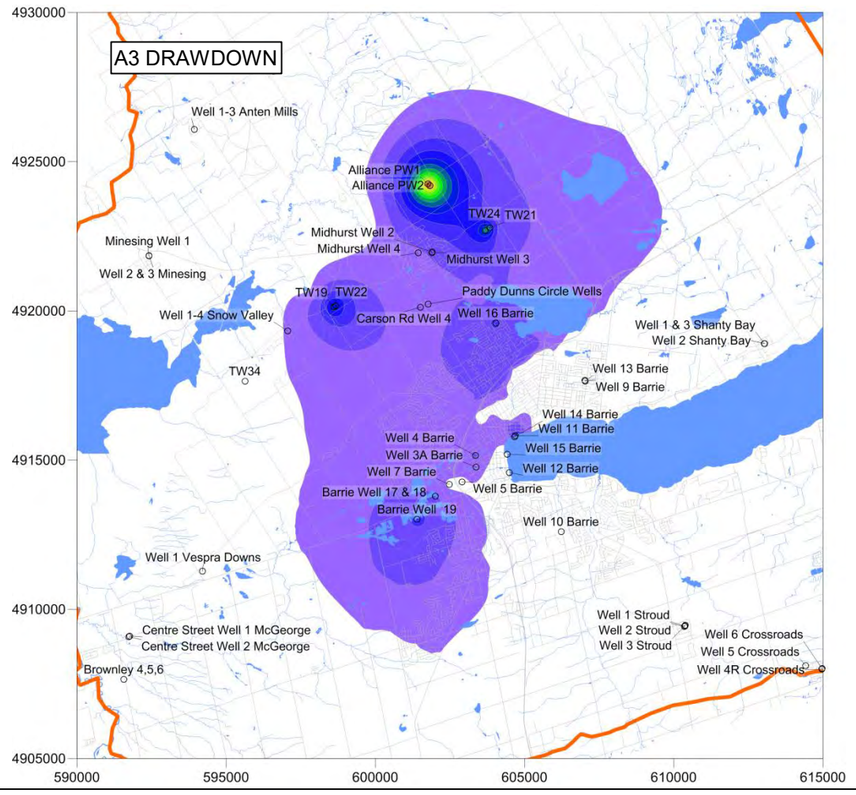
Golder Associates

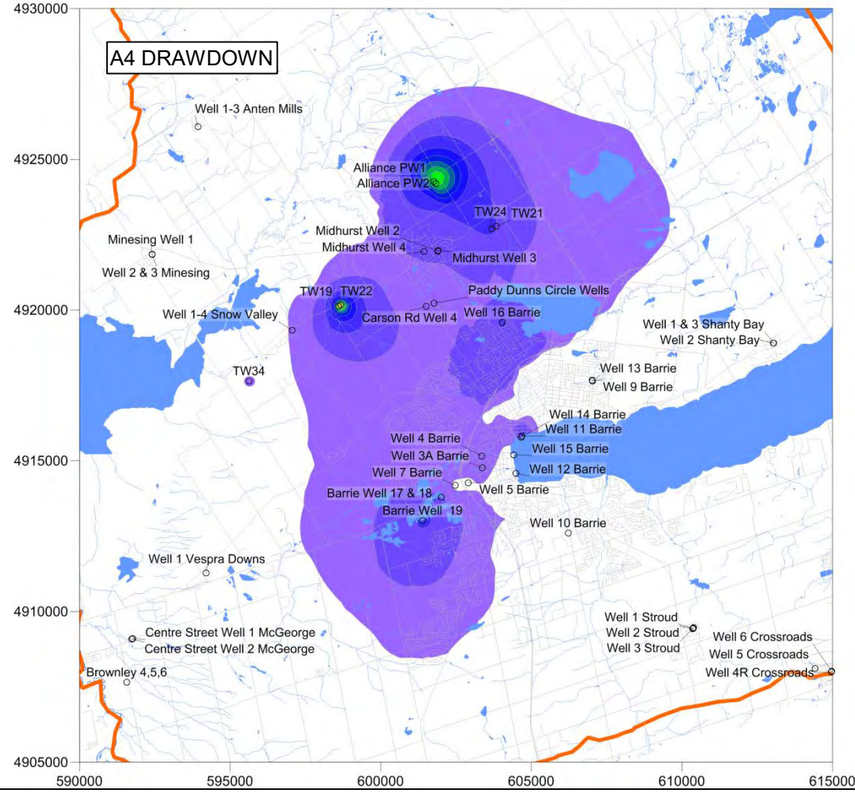
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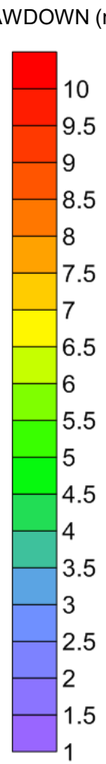
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PROJECT

CARSON AND DORAN NEIGHBOURHOODS GROUNDWATER MODELLING

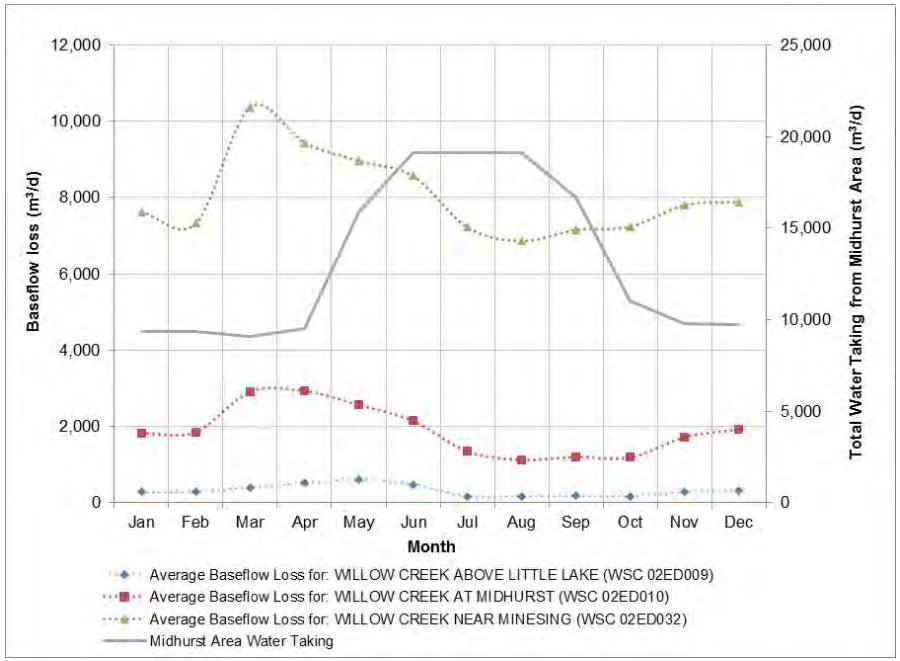
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FUTURE CONDITIONS SIMULATED DRAWDOWN

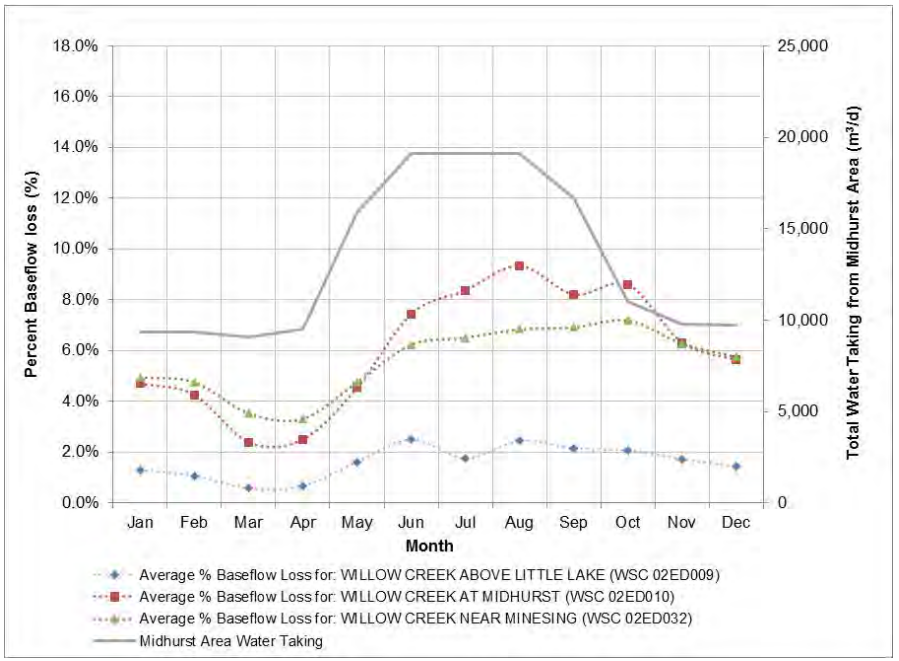
Golder Associates

PROJECT No. 13-1170-0040(4000)			SCALE AS SHOWN
DESIGN	AM	NOV 2015	REV. 1
GIS	AM	NOV 2015	FIGURE
CHECK			**10**
REVIEW			

BASEFLOW LOSS EXPRESSED AS FLOW RATE



BASEFLOW LOSS EXPRESSED AS % OF TOTAL BASEFLOW FOR SUBCATCHMENT



NOTE

- *Monthly rates and percent changes reflect average result for 10-year simulation.*
- *Total Midhurst area pumping includes Carson and Doran Neighbourhoods and Midhurst and Paddy Dunn's Circle municipal well systems.*

PROJECT

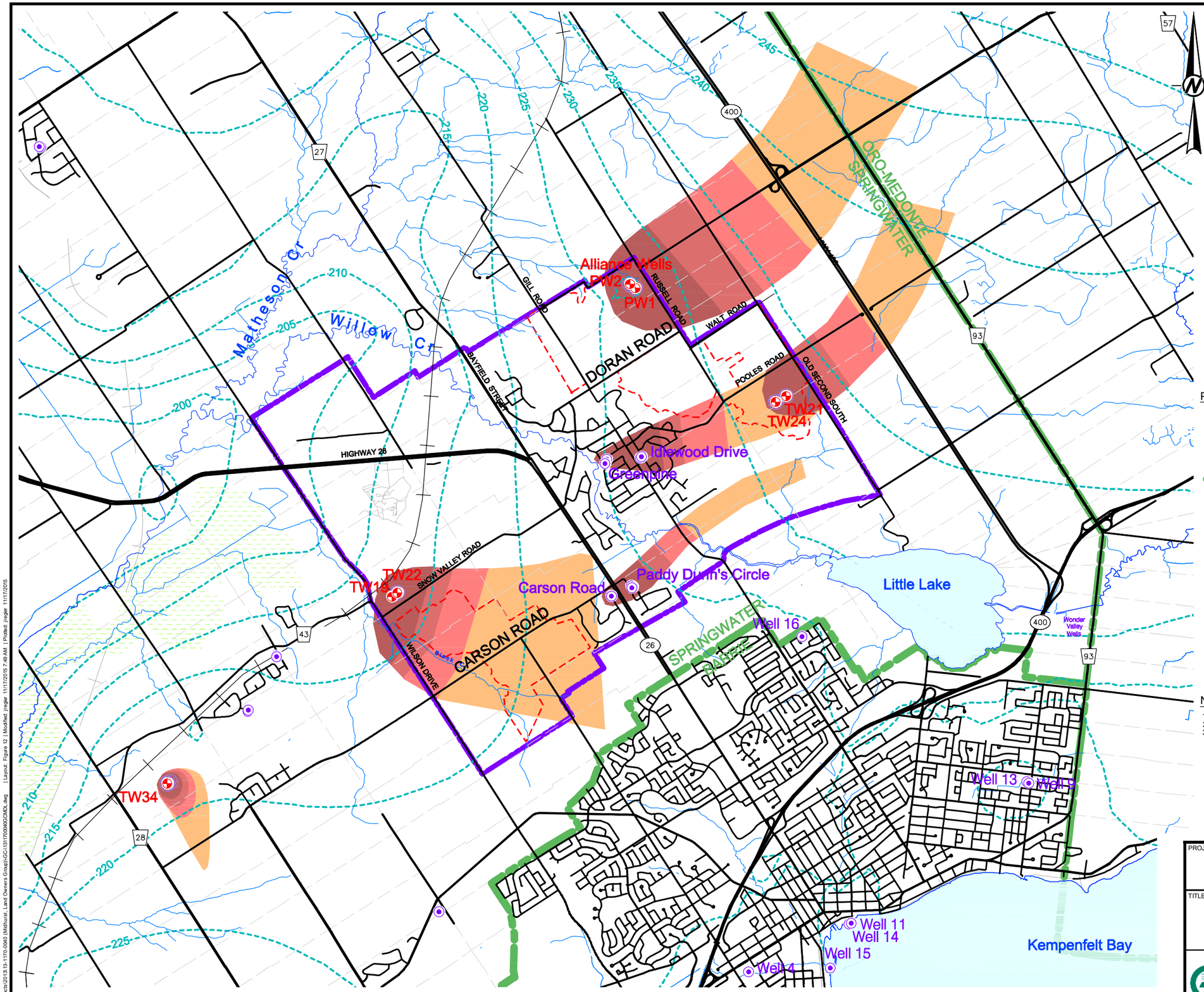
CARSON AND DORAN NEIGHBOURHOODS
GROUNDWATER MODELLING

TITLE

FUTURE CONDITIONS
WILLOW CREEK
SIMULATED BASEFLOW CHANGES

Golder Associates

PROJECT No. 13-1170-0040(4000)			SCALE AS SHOWN
DESIGN	AM	NOV 2015	REV. 1
CAD	AM	NOV 2015	FIGURE
CHECK			11
REVIEW			



PLAN LEGEND

- Proposed Development
- Midhurst Growth Area Boundary
- Municipal Boundary
- Existing Municipal / Public Supply Well
- Municipal Well Test Site

100 m Radius Around Well
Model 2, 5, 10 & 25 Year Time of Travel Capture Zone
Gridded Model A3 Aquifer Equipotentials (masl)

NOTES:

1. Base Mapping from Terenet Mapping 2009
2. Development Plan Geranium Corporation 2013
3. Wells are approximate to Accuracy of GPS and Measurement from known features.

0 400 1000 2000 4000
SCALE 1:50000 metres
Plotted 11x17 Landscape

PROJECT
CARSON AND DORAN NEIGHBORHOODS
GROUNDWATER MODELLING

TITLE
CAPTURE ZONES

Golder Associates

PROJECT No.	13-1170-0040		FILE No.	1311700040GCMDL
DESIGN			SCALE	AS SHOWN
CADD	JPR	11 Nov 15	FIGURE	12
CHECK				
REVIEW				

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TABLES

TABLE 1
Summary of Pumping Wells

Wellfield	Well ID	Easting	Northing	Aquifer	Existing Conditions Rate Range (m^3/d)	Future Conditions Rate Range (m^3/d)
Midhurst[1]	Greenpine Well 1	601,450	4,921,941	A3	0	0
	Greenpine Well 4	601,436	4,921,946	A3	177 - 443	177 - 443
	Idlewood Drive Well 2	601,908	4,921,972	A3	367 - 884	367 - 884
	Idlewood Drive Well 3	601,894	4,921,949	A3		
	Carson Rd Well 4	601,512	4,920,127	A3	180 - 468	180 - 468
Paddy Dunn's Circle[1]	Well 1	601,772	4,920,229	A3	133	133
	Well 2	601,784	4,920,233	A3		
	Well 3	601,764	4,920,253	A3		
Doran[2]	Alliance PW1	601,830	4,924,191	A3	-	1,846 - 3,888
	Alliance PW2	601,759	4,924,262	A3	-	2,256 - 4,752
	TW21	603,827	4,922,777	A3	-	821 - 1,728
	TW24	603,687	4,922,700	A3	-	821 - 1,728
Carson[2]	TW22	598,675	4,920,171	A4	-	1,497 - 3,154
	TW19	598,604	4,920,119	A4	-	1,497 - 3,154
	TW34	595,627	4,917,644	A4	-	328 - 691
Barrie	3A	603,374	4,914,759	A3	2,087	2,898
	4	603,331	4,915,148	A3	0	2,150
	5	602,927	4,914,267	A3	2,619	1,823
	7	603,533	4,913,835	A3	5,409	2,670
	11	604,690	4,915,816	A3	0	3,900
	12	604,499	4,914,593	A3	4,800	2,898
	14	604,661	4,915,782	A3	3,761	1,823
	15	604,412	4,915,199	A3	4,131	2,670
	17	602,045	4,913,788	A3	5,252	7,036
	18	602,047	4,913,781	A3		
	19	601,394	4,913,017	A3	0	4,178
	9	607,042	4,917,649	A3	3,766	4,589
	13	607,016	4,917,670	A3	4,130	3,012
	16	604,037	4,919,591	A3	4,253	5,095
Craighurst	Well 1	600,812	4,931,473	A1	0	0
	Well 2	600,813	4,931,476	A1	11	11
	Well 3	600,812	4,931,480	A2	21	21
Angus	Centre Street (McGeorge) Well 1	591,761	4,909,103	A3	306	306
	Centre Street (McGeorge) Well 2	591,729	4,909,078	A3	283	283
	Brownley Well 4	591,571	4,907,652	A3	0	0
	Brownley Well 5					
	Brownley Well 6					

TABLE 1
Summary of Pumping Wells

Wellfield	Well ID	Easting	Northing	Aquifer	Existing Conditions Rate Range (m^3/d)	Future Conditions Rate Range (m^3/d)
Stroud	Well 1	610,368	4,909,451	A3	166	166
	Well 2 (Standby)	610,358	4,909,422	A3	166	166
	Well 3	610,387	4,909,478	A3	166	166
Vespra Downs	Well 1 - 93	594,204	4,911,276	A3	39	39
	Well 1- 91	594,176	4,911,266	A3	0	0
Minesing	Well 1	592,409	4,921,843	A3	119	119
	Well 2	592,409	4,921,843	A2	119	119
	Well 3	592,377	4,921,822	A2	137	137
Anten Mills	Well 1	593,949	4,926,082	A3	1	1
	Well 2	593,935	4,926,073	A3	120	120
	Well 3	593,928	4,926,081	A3	151	151
Shanty Bay	Well 1	613,031	4,918,903	A3	43	43
	Well 2	613,046	4,918,902	A2	49	49
	Well 3	613,039	4,918,913	A3	55	55
Snow Valley	Well 3	597,054	4,919,329	A3	284	284
	Well 4					
	Well 1					
	Well 2					

1. See Figure 2 for monthly rates at Midhurst.
2. See Figure 3 for monthly rates at Carson and Doran Neighbourhoods wells.

TABLE 2
Summary of Model Construction Details

General Attributes	
Code	FEFLOW
Software	FEFLOW 6.2
Flow Type	Saturated
Simulation	Steady State & Transient
Dimension	Three-Dimensional (3D)

Domain (Figure 1)	
Area	746 km^2
Horizontal Extents	31 km wide x 24 km long
Vertical Extents	400 masl to 89 masl
Top of Model	Ground Surface
Bottom of Model	Bedrock Surface

Mesh Layout	
Element Type	Triangular Prism
Side Length	300 m to 10 m at wells
Total Elements	745,836

Numerical Layer and Hydrostratigraphic Unit Details

Layer	Nominal Unit	Average Recharge (mm/yr)	Description	Thickness (m)	Hydraulic Conductivity (m/s)	Specific Storage (1/m)
1 - 2	UC / A1	100 - 445	Till or Sand / Gravel	0.25 to 70	1E-6 to 3E-4	3E-04
3	A1	-	Sand	0.25 to 70	5E-6 to 3E-4	3E-04
4 - 6	C1	-	Clayey Silt to Clay	0.2 to 77	1E-08	1E-04
7	A2	-	Sand	0.5 to 44	5E-6 to 3E-4	2E-04
8 - 10	C2	-	Sandy Silt Till	0.2 to 65	5E-07	1E-04
11 - 16	A3	-	Sand/ Gravel	0.2 to 71	5E-5 to 1E-3	2E-04
17 - 19	C3	-	Sandy Silt to ClayTil	0.2 to 60	5E-8 to 3E-7	1E-04
20	A4	-	Sand / Gravel	0.5 to 33	5E-5 to 3E-4	2E-04
21	C4	-	Basal Till	0.5 to 37	1E-08	1E-04

Note:

1. Horizontal hydraulic conductivity listed. Vertical hydraulic conductivity is 1/10th horizontal.

TABLE 2
Summary of Model Construction Details

2. Effective porosity of 25% assumed for particle tracking / capture zone development.

Boundary Conditions			
Feature	**Type**	**Constraint**	**Head Value (masl)**
Willow Creek	Constant Head	Discharge only	DEM elevation
Little Lake	Constant Head	-	229
Matheson Creek	Constant Head	Discharge only	DEM elevation
Bear Creek	Constant Head	Discharge only	DEM elevation
Lake Simcoe	Constant Head	-	218.5
Minesing Wetland	Constant Head	-	186
Other Streams	Constant Head	-	DEM elevation
A3/A4 North	Constant Head	-	270
A3/A4 East	Constant Head	-	220
A3/A4 South	Constant Head	-	203 to 187

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Golder Associates

[DHP 00480240]

January 2017

REPORT

SPRINGWATER, ONTARIO

REPORT ON CARSON AND DORAN NEIGHBOURHOODS WATER SUPPLY - MIDHURST SECONDARY PLAN: SUPPLEMENTARY HYDROLOGIC MODELLING

Submitted to:
The Township of Springwater c/o Ainley & Associates
2231 Nursery Road
Minesing ON L0L 1Y2



Report Number: 13-1170-0040 (4000)

Distribution:Distribution:DistributioDistribution:

PDF - The Township of Springwater c/o Ainley & Associates
PDF - Golder Associates Ltd.

Golder Associates

[DHP 00734293 2]

Executive Summary

The Midhurst Landowners' Group proposes to develop their lands within the Carson Road and Doran Road Neighbourhoods in the Midhurst Secondary Plan, in Springwater, Ontario (Figure 1). Nine new water supply wells are proposed to supply the Neighbourhoods. The estimated total maximum water taking is 221 litres per second (L/s) with an expected average annual water taking of approximately 152 L/s. The wells are situated within the Willow Creek watershed and draw water from a deep, regionally extensive confined sand and gravel aquifer.

Previous computer modelling was conducted to assess potential *groundwater* impacts due to water supply pumping at the proposed development (Golder, 2016[1]). A regional-scale FEFLOW groundwater model that included the Willow Creek watershed was employed. Using this prior model as a foundation, an integrated surface water / groundwater model has been developed to estimate the potential *surface water* impacts that may occur as a result of the future pumping. Particular focus is given to Willow Creek and its downstream discharge area the Minesing Wetland. The development and results of this recent integrated surface water / groundwater modelling analysis form the subject of this report.

HydroGeoSphere (HGS) is the computer program used to model the hydrologic system in this study. HGS is a three-dimensional numerical code that can dynamically consider all major components of the hydrologic cycle (Figure 2), including: precipitation, evapotranspiration, snowmelt, overland flow, infiltration, unsaturated zone flow, and saturated groundwater flow. This comprehensive assessment of the major processes in the hydrologic system allows for a robust simulation of streamflow and water level behaviour within the watershed.

Model construction and input parameter assignments are largely developed based on prior field studies and modelling (Golder, 2016[1], Golder, 2016[2], Beckers and Frind, 2001). The HGS model is calibrated to streamflows and water level data. Both long-term (steady-state) and monthly (transient) average conditions are considered. A reasonable match is obtained between simulated results and observed data, indicating that the model is appropriately parameterized and may be used to predict future impacts to the system.

Pre- to Post-Development pumping conditions are simulated and compared. At Willow Creek, an annual average streamflow reduction of 4% or less is estimated with a maximum decline of 6% occuring along certain reaches during summer. At Minesing Wetland, an annual average streamflow reduction of 3% is simulated with a maximum decline of 5% occuring during summer. However, when inflow from the Nottawasaga River upstream of the model domain and discharge from the proposed upstream wastewater treatment plant at Willow Creek and Highway 26 are considered, these losses comprise less than 1% of the wetland's total flow and are thus considered negligible. Simulated surface water level changes in the Minesing Wetland and Snow Valley area show a reduction of approximately 1 millimetre (mm) or less and are thus considered inconsequential.

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1.0 INTRODUCTION

The Midhurst Secondary Plan Area is located in Springwater Township, Ontario (Figure 1). The Midhurst Landowner's Group proposes to develop the Carson and Doran Neighbourhoods (Neighbourhoods) subdivisions (Figure 1). In accordance with the Phase 1 and 2 Class Environmental Assessment (Ainley Group, 2009), a future water supply is being assessed for approximately 8,208 new units (an estimated 28,638 additional people) in these Neighbourhoods. Nine new water supply wells are proposed to supply the Carson and Doran Neighbourhoods (Figure 1). The estimated maximum water taking is 221 L/s with an average water taking of approximately 152 L/s. The wells are situated within the Willow Creek watershed and draw water from a deep, regionally extensive confined sand and gravel aquifer. A new wastewater treatment plant will service the Neighbourhoods; treated effluent from the plant will be discharged into Willow Creek at Highway 26 at an average rate of 143 L/s at full build-out (Black and Veatch, 2016).

Recent computer modelling ultized a regional FEFLOW groundwater model to predict the impacts of the proposed future pumping on the groundwater system (Golder, 2016[1]). This model was used to estimate groundwater drawdown, well interference, baseflow changes and delineate well capture zones in relation to the proposed pumping.

This report describes additional hydrologic modelling undertaken to estimate the effects of the Neighbourhoods supply well pumping on the surface water system within the Willow Creek watershed and Minesing Wetland (Figure 1). The integrated surface water / groundwater computer program HGS is used. This work is an extension of, and companion report to, the aforementioned groundwater modelling (Golder, 2016[1]) and is part of a larger study submitted as part of Phases 3 and 4 of the Midhurst Secondary Plan Class Environmental Assessment (Golder, 2016[2]).

Two modelling scenarios are investigated in this study:

- **Pre-Development:** This scenario represents current conditions; the term 'Pre-Development' means pre-Neighbourhood development. The scenario incorporates coupled surface water/groundwater flow, Kempenfelt Bay and Nottawasaga River surface flow outlet boundary conditions and average monthly water surplus. Both steady-state (annual average) and 10-year transient (monthly) simulations are undertaken. Pre-Development annual average and monthly pumping rates at existing wells are applied for steady-state and transient simulations, respectively (Table 1 and Figure 6). This scenario provides the initial condition for the Post-Development scenario.
- **Post-Development:** This scenario investigates the impact of pumping under Post-Development conditions with the Neighbourhoods at full build-out. The same boundary conditions are applied as the Pre-Development scenario. Both steady-state (annual average) and 10-year transient (monthly) simulations are undertaken. Post-Development annual average and monthly pumping rates at existing and proposed wells are applied for steady-state and transient simulations, respectively (Table 1 and Figure 7). Additional flow inputs from the wastewater treatment plant into Willow Creek are considered external to the model.

Simulated changes to surface water flow rates and water levels at Willow Creek and Minesing Wetland are evaluated from Pre- to Post-Development scenarios and presented herein.

1.1 Scope of Work

The scope of work consists of the following tasks.

1. **Background Data:** Amass and analyze publicly available climate and surface water studies and data for Minesing Wetland and Willow Creek watershed. The groundwater parameterization herein continues to rely on the hydrogeologic data and inputs derived in the recent groundwater investigation (Golder, 2016[2]) and supporting modelling analysis (Golder, 2016[1]). These data include 686 static water levels in the Ministry of Environment and Climate Change Water Well Information System (WWIS) and continuous flow records for Water Survey of Canada (WSC) Willow Creek flow stations 02ED009, 02ED010, and 02ED032 (Environment Canada, 2012 – locations shown on Figure 1). The latter of these stations is immediately upstream of the Minesing Wetland. To our knowledge, there are no flow records immediately downstream of the Minesing Wetland; however, this location is addressed in the model simulations. A previous hydrology study of the Oro Moraine conducted by others (Beckers and Frind, 2001) provides an estimate of the long-term average surplus water distribution over the study area.

2. **Model Construction, Groundwater**: Import the pre-existing FEFLOW model into HGS. This process effectively parameterizes the subsurface domain in HGS. The entire model domain (Figure 1) is incorporated to allow for regional boundary condition assignments and to encapsulate the entirety of pumping withdrawal influence; however, the primary focus of the model effort is Willow Creek and its downstream discharge area the Minesing Wetland.

3. **Model Construction, Surface Water**: Parameterize surface water model inputs in accordance with information obtained in Task 1.

4. **Calibration**: Calibrate the model to surface water and groundwater data obtained in Task 1. The successfully calibrated model forms the Pre-Development, "baseline" current condition.

5. **Predictive Simulation**: Add Neighbourhoods pumping wells at average annual rates (steady-state simulation) and monthly rates (transient simulation) to establish Post-Development surface water effects including flow and water level changes.

1.2 Code Description – HydroGeoSphere

The HGS model (Therrien et al., 2012) is a three-dimensional control volume finite element simulator designed to represent the entire terrestrial portion of the hydrologic cycle (Figure 2). It uses a globally-implicit approach to simultaneously solve the 2D diffusive wave equation and the 3D form of Richards' equation. It also dynamically integrates key components of the hydrologic cycle such as evaporation from bare soil and water bodies; vegetation-dependent transpiration with root uptake; snowmelt and soil freeze/thaw. Features such as macropores, fractures and tile drains can either be incorporated discretely or by using a dual-porosity, dual permeability formulation. The HGS platform uses a Newton iteration to handle nonlinearities in the governing flow equations, a robust and efficient iterative sparse matrix solver, which has been parallelized to utilize high performance computing facilities for addressing large-scale problems.

University researchers and industry professionals have utilized HGS to carry out a variety of modelling projects. One of the first large-scale watershed studies to use the integrated groundwater/surface water flow capabilities of HGS was carried out by Li et al. (2008). HGS was one of several codes considered by the Ontario Ministry of Natural Resources and Forestry for watershed scale, integrated water-budget modelling applications in Ontario (AquaResource, 2011); the code received a favourable review for its strong theoretical basis and advanced formulation. A third-party review of the HGS computer program was published recently by Brunner and Simmons (2012). A list of publications that have utilized HGS can be found at http://www.aquanty.com/recent-publications/.

HGS provides four distinct advantages for this modelling application. First, it can seamlessly and efficiently adopt the pre-existing calibrated FEFLOW groundwater model inputs into its construction, which results in significant time and cost savings when compared to building a numerical model "from scratch". Second, HGS uses a rigorous, mass conservative approach that fully couples surface and variably saturated subsurface flow equations – this method is more robust than other models that rely on a separate (and often numerically unstable) linkage of surface and subsurface modeling codes. Third, including the surface flow equations reduces the complexity of the boundary condition assigned to the top surface of the model – which is now just the observed or net precipitation. This simplifies calibration of streamflows because surplus water, the sole source of water in the model, is based on observed long term average runoff for the catchment area. Therefore, total runoff from the model will always be correct for steady-state conditions, in that it will equal the input (surplus water) as long as there are no other sources in the model domain. Fourth, HGS eliminates the requirement that the location of surface water bodies be defined as part of the top boundary condition – they arise naturally as a consequence of the topography, surface and subsurface characteristics and the applied precipitation.

2.0 CONCEPTUAL HYDROLOGICAL/HYDROGEOLOGICAL MODEL

2.1 General Considerations

HGS incorporates all of the major processes in the hydrologic cycle (Figure 2). In the integrated modelling approach, a surface flow domain consisting of a 2D finite-element mesh is defined coincident with the top of the groundwater flow domain 3D finite-element mesh. Water can move freely between the two domains with the direction of flow determined by the dynamic local hydraulic gradient. Flow in the surface domain is governed by geometry (in this case the surface topography) and the properties of the surface (principally Manning's coefficient of friction). Similarly, flow in the groundwater domain is governed by hydrostratigraphic layer geometry (such as layer thickness and elevation) and soil properties (such as hydraulic conductivity and storage).

When water, in the form of surplus water (precipitation - evapotranspiration), is applied to the surface flow domain, it can either pond and move laterally as surface flow or vertically into the subsurface as infiltration. Whether or not either of these flows occurs depends on factors such as:

- Hydraulic conductivity of the shallow subsurface - e.g., low permeability materials such as clay can inhibit infiltration;
- Depression storage – i.e. a depression must fill with water before lateral surface flow can occur; and

- Hydraulic gradient – e.g., in a discharge area, upwelling groundwater (upward hydraulic gradient) prevents infiltration.

2.2 Specific Considerations

For information on the details of Midhurst area conceptual hydrogeology and prior model development, the reader is referred to the following reports:

- *South Simcoe Municipal Groundwater Study* (Golder, WHI and Ainley, 2004);
- *South Simcoe Groundwater Study WHPA – Appendix E, City of Barrie* (Golder and WHI, 2004[1]);
- *South Simcoe Groundwater Study WHPA – Appendix L, Township of Springwater* (Golder and WHI, 2004[2]); and
- *Report On: Hydrogeological Study, Midhurst Water Supply Exploration Program Supporting Document, Midhurst Class EA, Township of Springwater, Ontario* (Golder, 2008).
- *Report On: Carson and Duran Neighbourhoods Proposed Water Supply Groundwater Modelling* (Golder, 2016[1]). This modelling was part of a larger hydrogeological study submitted as part of Phases 3 and 4 of the Midhurst Secondary Plan Class Environmental Assessment (Golder, 2016[2]). This modelling was conducted based on the existing three-dimensional (3D) Kempenfelt Bay FEFLOW model with refinements in Midhurst and surrounding Willow Creek watershed areas. It is strongly recommended that the reader consult this report given the foundational role it plays in the current work.
- *Report On: Hydrogeological Study, Midhurst Water Supply Exploration Program, Township of Springwater, Ontario* (Golder, 2016[2]). The hydrogeological characterization developed as part of this assessment formed the basis of several updates incorporated into the groundwater model (Golder, 2016[1]).

The HGS model is constructed by importing the existing FEFLOW model (Golder, 2016[1]) into the HGS framework and so it inherits most of the subsurface characteristics of that model including:

- 3D model domain extents and topography;
- Subsurface material distributions and properties (saturated hydraulic conductivity, specific storage, porosity);
- Lateral boundary conditions (no-flow, fixed heads - e.g. at Kempenfelt Bay); and
- Pumping well boundary conditions.

The following data that are not included in the FEFLOW model analysis was required specifically for the HGS model:

- The long-term, average, water surplus (precipitation – evapotranspiration) distribution (Figure 3) is applied to the surface flow domain in the HGS model. The surplus is obtained from Beckers and Frind (2001), and is calculated using 1951–1990 climate normals for 11 meteorological stations. Average annual precipitation estimates ranged from 800 to 930 mm/yr, while average annual evapotranspiration is estimated to be about 500 mm/yr, based on water budget calculations for the Oro Moraine Upland (Dixon Hydrogeology Limited, 1992). Precipitation minus evapotranspiration provides surplus depth; this is water available for overland

flow or infiltration. The total yearly water surplus over the 696 km^2 study area of Beckers and Frind (2001) was 8.53 m^3/s, which will be similar to the HGS modelled value except for a small discrepancy due to the larger HGS model domain.

- Monthly surplus ratios relative to annual surplus (Figure 4) are based on observed monthly surplus water (Golder, 2016[1]). These ratios are used to prorate the average annual water surplus distribution obtained from Beckers and Frind (2001) shown in Figure 3 to produce 12 monthly water surplus distributions.
- Soil retention properties, required for all subsurface materials as the HGS model solves Richard's equation for variably-saturated flow in the subsurface, are also obtained from Beckers and Frind (2001). The authors subdivided their domain into two materials: aquifers and aquitards, for which they supplied soil retention characteristic curves.
- Surface flow characteristics (Manning coefficient of friction or roughness factor): a value of 0.03 s/m$^{1/3}$ is assumed to apply over the entire surface flow domain. Streeter and Wylie (1985) list average values for this parameter and this value falls within the range of what they classify as 'earth' to 'earth, with stones or weeds'.

3.0 MODEL CONSTRUCTION

Constructing the HGS model from the existing FEFLOW model requires the following two basic steps:

1. Import the existing updated FEFLOW groundwater model into HGS and modify the material properties and boundary condition inputs as required; and
2. Define the surface flow domain and surface material properties.

The details of each step as they pertain to the groundwater and surface water domains are discussed separately below.

3.1 Groundwater Domain

3.1.1 Model Area

The HGS model adopts the same area as the FEFLOW model (Figure 1). The total model area is 746 km^2. The Willow Creek watershed, wherein the proposed developments are located, lies almost entirely (>90%) within the model domain and comprises an area of 228 km^2.

3.1.2 Boundary Conditions

HGS utilizes a surplus distribution as the majority source of water to the model (surplus is precipitation minus evapotranspiration). Figure 3 illustrates the steady-state annual average surplus; this distribution was first developed by Beckers and Frind (2001). From the surplus input, the proportion of overland flow versus infiltration is calculated within HGS. For the transient model, monthly surplus is derived by prorating the annual surplus by the monthly recharge ratios shown in Figure 4 (Golder, 2016[1]).

In the FEFLOW model, a large number of constant head nodes are defined on the top of the model domain (see Figure 5), although in some areas along the outer boundary of the model they are carried down into the

subsurface. HGS constant head and critical depth boundary conditions are applied to the top surface of the model domain, in this case specifically to the surface flow domain (Figure 5). In the HGS model, and unlike the prior FEFLOW model, constant head nodes do not need to be defined along potential streams in order to constrain heads, as the surface flow domain acts as a pathway for excess water to flow laterally should ponding occur. Therefore the only area where constant head nodes are defined is along the outer boundary at Kempenfelt Bay, which are assigned a head of 219 masl. Although this boundary could potentially allow water to flow into the model domain, it is located at a downstream point in the flow system so this is unlikely to happen.

The critical depth boundary condition defined at the outlet of the Nottawasaga River is of a type unique to surface flow models; it is not a fixed head or flux boundary, but merely allows water to freely exit the model domain should ponding occur. The resulting surface water elevation is largely controlled by the elevation of the lowest surface domain node along the boundary, which in this case is 179.7 masl.

By default, any other nodes on the outer model boundary, which are not explicitly assigned boundary conditions for either the surface or subsurface domains, act as no-flow boundaries.

3.1.3 Pumping Rates

The model includes existing municipal wells in Midhurst, City of Barrie wells, and other regional water takings as summarized in Table 1. Most wells draw from deep, regionally extensive confined aquifers A3 or A4, including the proposed wells at the Neighbourhoods. In both Pre- and Post-Development scenarios, singular average annual rates are used for steady-state simulations whereas variable monthly rates are used for transient simulations (Figure 6 and Figure 7). The steady-state simulations reflect long-term, average conditions whereas the transient simulations allow for a more refined understanding of the seasonal nature of potential hydrologic impacts.

The Carson and Doran Neighbourhoods maximum taking is modelled at 221 litres per second (L/s) with a modelled average annual water taking of approximately 152 L/s. As is typical with most municipal water takings in Ontario, the greatest consumption occurs during the summer months. For the proposed Midhurst Neighbourhood wells, the permitted maximum is applied for June, July and August with pro-rated rates calculated for the remaining months (Figure 7) based on existing water usage trends in Midhurst (Figure 6).

3.1.4 Material Properties

Hydraulic conductivity and specific storage values for each element are inherited from the FEFLOW model. An X-direction hydraulic conductivity distribution is presented in Figure 8 for illustration.

Porosity values of 0.3 and 0.5 are assumed for aquifer and aquitard elements respectively and are the same as those used in Beckers and Frind (2001).

HGS solves Richard's equation for variably-saturated soil, which requires that soil retention relationships (pressure head versus saturation and saturation versus relative permeability) be defined for all subsurface materials. These relationships are defined for aquifer and aquitard materials by Beckers and Frind (2001) and are adopted for use here. The 3D model domain is first subdivided into zones of aquifer and aquitard materials based on the X-direction hydraulic conductivity (see Figure 9). These two zones are then assigned the appropriate soil retention properties (Figure 10).

3.2 Surface Water Domain

In HGS, the surface water flow domain is defined to be coincident with the top of the 3D subsurface domain (Figure 1), and, in this case, is composed of 2D triangular elements which are the top faces of the 3D subsurface prism elements.

The main parameter that controls flow in the surface domain, besides the surface slope which is inherited from the geometry of the 3D domain top surface (i.e. the topography), is the Manning coefficient of friction. As described earlier, a value of 0.03 $s/m^{1/3}$ is assumed to apply over the entire surface flow domain.

There is an option in HGS, used in the current model, to create unique surface flow nodes that are coincident with the subsurface nodes on the top of the 3D domain. In this case, the surface flow node has a hydraulic head that can be unique from the subsurface node, and a simple relationship has been defined that controls fluid flux between the two nodes as a function of the head gradient between them. This relationship uses a coupling length parameter, representative of a characteristic length separating the two domains, to control fluid flow between the two domains, with larger values inhibiting flow. Initially, a coupling length value of 0.1 m was assumed to apply to the entire surface flow domain. Delfs et. al. (2012) experimented with this value in simulations of field studies of overland flow and stream generation, and found that HGS was insensitive to small changes in coupling length below a value of 0.1 m.

The final surface flow parameter to be assigned is the depression (or rill) storage height. This is the depth of water that must be attained before surface flow will occur. It represents small depressions in the ground surface that cannot be captured in the finite-element mesh defining the surface flow domain, mainly due to element size constraints. Larger values of depression storage height tend to promote infiltration. A value of 2 mm is assigned for the depression storage height for the entire surface flow domain, mainly to prevent numerical instability.

4.0 MODEL CALIBRATION

Model calibration involves adjusting Pre-Development model input parameters within a reasonable range until simulated results satisfactorily correspond to observed data (calibration targets). The principle calibration targets in this study are annual and monthly streamflows and baseflows (the groundwater portion of streamflows) at Willow Creek and measured static groundwater levels (presumed to provide average water levels) throughout the model domain as supplied by the WWIS. Average annual conditions are considered in the steady-state model whereas monthly conditions are considered in the transient model.

A satisfactory calibration within the groundwater domain has been previously achieved in the FEFLOW model (Golder, 2016[1]); the outcome of that endeavour is primarily inherited in the HGS model. As such, the current calibration mainly focuses on surface parameters affecting calibration to flow; nonetheless, comparison to groundwater targets is also undertaken as a check.

4.1 Parameter Adjustment

4.1.1 Surface Topography

The computer-based BFLOW algorithm (Arnold et al., 1995) is used to separate the baseflow (i.e., groundwater) portion of the total measured stream flow at the three WSC stations (Figure 6, Golder 2016[1]). It was found that steady-state baseflow values predicted by HGS at gauge locations give consistently lower values than the

BFLOW annual average. This could in part be due to how HGS handles surplus water in the surface flow domain, where, depending on local conditions, it can either infiltrate (and become groundwater flow and potential baseflow) or flow overland as surface water. If regions of groundwater discharge are widespread, they can prevent infiltration and cause surplus water to flow overland until it eventually reaches a stream. Such water does not contribute to baseflow in HGS but instead reports as overland flow, another portion of total streamflow.

In order to more accurately reflect physical conditions at Willow Creek and also increase baseflow the following adjustments are made:

- Within areas of coarser grid resolution the localized creek channel depression may be obscured in the interpolated digital topography. Hence the elevation of the stream channels upstream of Little Lake are reduced by 2 m in order to lower stream channel and related water table elevation near the streams. The resulting baseflow increase is on the order of 3%.
- The main stream channels comprising Willow and Matheson Creeks are hydraulically corrected so that they slope continuously downstream to reduce ponding. The resulting baseflow increase is approximately 3%.

4.1.2 Surface Flow Parameters

The following surface flow parameters are adjusted during calibration to baseflows:

- The coupling length is reduced by one order of magnitude from 0.1 m to 0.01 m. This enhances fluid exchange between the surface and subsurface domains and result in a 35% increase in baseflow, however, the absolute value of baseflow is still significantly less than that calculated by BFLOW.
- Depression storage height is increased from 2 mm to 2 cm. This had a negligible effect on the simulated HGS baseflow.
- Although not a calibration parameter, the post-processing baseflow calculation approach is also considered. In HGS, baseflows are calculated for a chosen area (m^2) by integrating the positive exchange flux (m/s) to produce a volumetric flux (m^3/s). The exchange flux represents the rate of fluid flow between the surface and subsurface domains, and positive values represent flow from the subsurface to the surface domain (i.e., exfiltration). If baseflow is restricted to groundwater discharging directly to a surface water body, then we must first specify a surface water depth as a cutoff value for determining what is or is not a surface water body. In this case, a relatively small value of surface water cutoff depth of 0.003 m is chosen, which increases the baseflow estimated from HGS.

4.1.3 Snow Valley Area Hydraulic Conductivity

Recent site investigations (Golder, 2010b) indicate that there are numerous seeps and springs along the flanks of the moraine in the Snow Valley area. Figure 11 (right upper image) shows the observed water surface contours in the area.

The lower image in Figure 11 also shows the boundaries of two regions where hydraulic conductivity adjustments are made. In the first region (blue line) the hydraulic conductivity of the upper 3 model layers is decreased to 10^{-7} m/s while in the second region (orange line) the thickness of the C1 aquitard is increased by extending it upwards one model layer.

The combined effect of these two changes is illustrated in the upper left image in Figure 11, which shows the head contours (at ground surface) from the HGS steady-state flow simulations both before (solid blue lines) and after (dashed blue lines) the local adjustments were made to the hydraulic conductivity of the selected layers.

4.2 Calibration Results

4.2.1 Steady-State Simulation

A Pre-Development steady-state simulation is run and simulated flows are compared to average flows derived from WSC flow stations 02ED009, 02ED010, and 02ED032 (Environment Canada, 2012) (Table 2). Note that there is no flow gauge at the outlet of Minesing Wetland. Simulated steady-state streamflows are somewhat greater than the WSC flow stations averages, ranging from a maximum of 20% greater at Midhurst (02ED010) to 8% greater at Little Lake (02ED009). A simulated streamflow within 20% of observed is considered satisfactory given the potential measurement error at the flow stations (Beckers and Frind, 2001).

Steady-state simulated baseflows are also compared to average baseflows (derived using the BFLOW algorithm) at the WSC flow stations (Table 2). Baseflows derived from the HGS model are lower than those derived from BFLOW, as mentioned earlier. There are several possible explanations for this. Firstly, BFLOW-derived baseflows, like all automated separation methods, are simplified mathematical inferences that inherently result in some departure (including potential overestimation) from true baseflow (Partington et.al., 2012). Secondly, the aforementioned 'surface water cutoff value' may, in some areas close to Willow Creek where the water table is near-surface, result in the 'exiting' of groundwater into the surface water system just prior to reaching the Creek itself. In the post-processing routine, this water is not counted as baseflow; but, in a practical sense, it is. Nonetheless, in the context of overall streamflow, conservation of total flow in the model is maintained.

In the Pre-Development model, the steady-state head solution is compared to 686 static water levels in the WWIS to verify that the groundwater level calibration metrics are satisfactory (Figure 12). The head comparison result and associated statistical measures (Figure 12 insert) indicates a reasonable match to observed water levels and are similar to that provided in the prior FEFLOW model (Golder, 2016[1]).

Finally, the overall fluid balance errors (inflow versus outflow) in the HGS simulation are less than 1%.

4.2.2 Transient Simulation

A Pre-Development transient simulation is run and compared to average monthly flows at the WSC flow stations (Figure 13). A 10-year simulation period is chosen to allow the flow system time to equilibrate with average monthly water surplus and average monthly pumping. The HGS modelled streamflows match the average monthly streamflows trends closely.

5.0 PREDICTIVE SIMULATIONS

Post-Development steady-state and transient predictive simulations are carried out and streamflow and water levels compared relative to Pre-Development conditions. The Neighbourhoods are modelled using full-build out pumping rates (see Table 1 and Figure 7). Flow contributions from the future wastewater treatment plant, which will discharge treated water into Willow Creek at Highway 26, are considered post-simulation.

5.1 Steady-State Simulation

Steady-state annual Pre- to Post-Development flow changes are evaluated for the three WSC flow station locations and Minesing Wetland to provide for an estimate of long-term, average annual flow impacts (Table 2). Flow rates and relative (%) reductions are presented. Prior to a discussion on specific values listed in Table 2, it is important to note the following while reviewing potential impact to Minesing Wetland:

As may be inferred from Table 2, all flow losses incurred in *total streamflow* are derived from a reduction in groundwater baseflow; in other words the volume of water lost from streamflow and baseflow are the same. Willow Creek streamflow reduction increases as we move downstream, with the highest relative reduction of 3.8% at WSC 02ED032 (Table 2). Meanwhile, the Minesing Wetland outlet experiences a streamflow reduction of 3.0% (0.18 m^3/s). However, given the upstream input of the treatment plant (0.143 m^3/s), and the unaccounted for upstream input from the Nottawasaga River outside of the model domain, the actual % flow loss at Minesing Wetland would be less than 1% thus is negligible relative to the total flow reporting to the wetland.

The wetland receives flow from several surface water sources. The largest of these is the Nottawasaga River, which drains a catchment area of over 3,300 km^2; the majority of which lies upstream of the wetland. However, only a fraction of this catchment area (508 km^2) is accounted for in the model. Furthermore, treated water from the Neighbourhoods wastewater treatment plant will be discharged into Willow Creek near Highway 26 (upstream of Minesing Wetland). It is anticipated that the average annual discharge rate of the wastewater treatement plant will be 143 L/s (or 0.143 m^3/s) (Black and Veatch, 2016). These wetland flow contributions, external to the model, would in reality serve to offset any Minesing Wetland potential impacts as described below.

Baseflow changes are also evaluated for the three WSC flow station locations and Minesing Wetland (Table 2). Owing to the underestimation of Pre-Development baseflow (Section 4), the relative (%) loss in Post-Development conditions is overestimated, with reductions reaching up to 17% at Midhurst. However, when the simulated volumetric flow loss is subtracted from the *observed* baseflow, the losses at each station are under 10%. It is important to note that the prior FEFLOW groundwater model provided better correspondence to observed baseflows and indicated Post-Development losses were less than 10% along Willow Creek (Golder, 2016[1]). For context, the Water Budget and Water Quantity Risk Assessment Guide (MNR and MOE, 2011) defines an unacceptable impact to coldwater streams as a circumstance where groundwater discharge is reduced by more than 20% as compared to the average monthly baseflow of the watercourse.

5.2 Transient Simulation

Transient monthly Pre- to Post-Development streamflow changes are evaluated for Willow Creek and Minesing Wetland (Figure 14). The reduction in streamflow is seasonally variable and is affected by both varying pumping rates and, in the case of relative (%) reductions, is sensitive to changing surplus throughout the year. The smallest % streamflow reductions occur at Willow Creek above Little Lake (WSC 02ED009) with losses less than 1.5% for most of the year. The largest % streamflow reduction occurs at Willow Creek at Midhurst (WSC 02ED032) with losses reaching almost 6% during summer months. Similar patterns were predicted for baseflow impacts in the FEFLOW groundwater model (see Figure 11 of Golder, 2016[1]). Losses at Minesing Wetland range between 1% to 5% during the year, with largest % losses incurred during late summer and early fall. However, given the upstream input of the treatment plant (0.143 m^3/s), and the unaccounted for upstream input

from the Nottawasaga River outside of the model domain, the actual % flow loss at Minesing Wetland would be less than 1% and is thus negligible relative to the total flow reporting to the wetland.

Post-Development surface water level changes are tracked for locations in Minesing Wetland and adjacent to Snow Valley Road (Figure 15). Surface water depth in the Minesing Wetland naturally varies from approximately 30 mm over the course of the year and shows less than 1 mm of decline due to the proposed water taking in the Post-Development scenario. Meanwhile, surface water depth at Snow Valley Road is less (~ 2.5 mm), fluctuates by less than 1 mm over the course of the year, and shows negligible water level impact due to the proposed water taking in the Post-Development scenario. The small Post-Development change in water level in these areas is expected for several reasons. Firstly, estimated *groundwater* drawdown is minor in this area owing, in part, to the majority of the pumping occurring closer to Midhurst and the area being underlain by significant aquitard thickness (drawdown maps are provided in Golder, 2016[1]). Secondly, the area receives a considerable influx of surface water which would tend to offset impacts emanating from the underlying groundwater system.

6.0 CONCLUSIONS

Hydrologic modelling using the HydrogGeoSphere code is undertaken to estimate the effects of the operation of deep groundwater wells servicing the proposed Carson and Doran Neighbourhoods on surface water resources within the Willow Creek watershed and Minesing Wetland. The modelling indicates the following surface water changes may occur from Pre- to Post-Development as a result of the proposed well operation:

- Willow Creek may experience an average annual streamflow loss of approximately 4% or less. Seasonally, streamflow losses may reach up to 6% during summer.
- Minesing Wetland has a *simulated* average annual streamflow loss of 3% and a maximum loss of 5% during late-summer to early fall. However, upstream contributions to the wetland from: 1) the Nottwasaga River (upstream of the model domain); and 2) future wastewater treatment plant discharge will offset these losses and result in a negligible change to total wetland flow rates.
- Surface water level changes in Minesing Wetland and the nearby Snow Valley Road area are expected to be less than 1 mm and are thus considered negligible.

7.0 LIMITATIONS

7.1 Use of This Report

This report has been prepared by Golder Associates Ltd. (Golder) for use by The Midhurst Landowners' Group or its agents. The factual information, descriptions, interpretations, comments, results, conclusions and electronic files contained herein are specific to the project described in this report. Information used in this report should be restricted to that specified in the scope of work unless otherwise mutually agreed upon by The Midhurst Landowners' Group and Golder. This report should be read in its entirety as some sections could be improperly interpreted when taken individually or out-of-context. Golder is not responsible for any use of this report and its content by a third party, and/or for its use for purposes other than those intended.

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discovery, past or future, susceptible of modifying the underground conditions described herein, and have had the opportunity of revising its interpretations. In addition, Golder is not responsible for any decrease of a property's value or any failure to complete a transaction as a consequence of this report.

7.2 Modelling General Limitations

Hydrological investigations and modelling are dynamic and inexact sciences. They are dynamic in the sense that the state of any hydrological system is changing with time and the science is continually developing new techniques to evaluate these systems. They are inexact in the sense that field data provides a fraction of information for the site or model domain; as such a truly complete, comprehensive characterization of the groundwater system is not possible. Therefore, every groundwater model is, by necessity, a simplification of a reality.

The professional modelling services described in this report are conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions. The results of previous or simultaneous work provided by sources other than Golder and quoted and/or used herein are considered as having been obtained according to recognized and accepted professional rules and practices, and therefore deemed valid.

The model presented herein provides a predictive scientific tool to evaluate the impacts of specified hydrological stressors on a real system and to compare various scenarios in connection with a decision-making process. The model's accuracy is bound to the normal uncertainty associated to modelling and no warranty, express or implied, is made.

Report Signature Page

GOLDER ASSOCIATES LTD.

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TABLES

TABLE 1
Summary of Pumping Wells

Wellfield	Well ID	Easting	Northing	Aquifer	Existing Conditions Rate Range (m^3/d)	Future Conditions Average Yearly Rate (Steady State Model) (m^3/d)	Future Conditions Rate Range (Monthly Transient Model) (m^3/d)
Midhurst[1]	Greenpine Well 1	601,450	4,921,941	A3	0	0	0
	Greenpine Well 4	601,436	4,921,946	A3	177 - 443	277	177 - 443
	Idlewood Drive Well 2	601,908	4,921,972	A3	367 - 884	585	367 - 884
	Idlewood Drive Well 3	601,894	4,921,949	A3			
	Carson Rd Well 4	601,512	4,920,127	A3	180 - 468	285	180 - 468
Paddy Dunn's Circle[1]	Well 1	601,772	4,920,229	A3	133	133	133
	Well 2	601,784	4,920,233	A3			
	Well 3	601,764	4,920,253	A3			
Doran[2]	Alliance PW1	601,830	4,924,191	A3	-	2,674	1,846 - 3,888
	Alliance PW2	601,759	4,924,262	A3	-	3,269	2,256 - 4,752
	TW21	603,827	4,922,777	A3	-	1,189	821 - 1,728
	TW24	603,687	4,922,700	A3	-	1,189	821 - 1,728
Carson[2]	TW22	598,675	4,920,171	A4	-	2,169	1,497 - 3,154
	TW29	598,604	4,920,119	A4	-	2,169	1,497 - 3,154
	TW34	595,627	4,917,644	A4	-	476	328 - 691
Barrie	3A	603,374	4,914,759	A3	2,087	2,898	2,898
	4	603,331	4,915,148	A3	0	2,150	2,150
	5	602,927	4,914,267	A3	2,619	1,823	1,823
	7	603,533	4,913,835	A3	5,409	2,670	2,670
	11	604,690	4,915,816	A3	0	3,900	3,900
	12	604,499	4,914,593	A3	4,800	2,898	2,898
	14	604,661	4,915,782	A3	3,761	1,823	1,823
	15	604,412	4,915,199	A3	4,131	2,670	2,670
	17	602,045	4,913,788	A3	5,252	7,036	7,036
	18	602,047	4,913,781	A3			
	19	601,394	4,913,017	A3	0	4,178	4,178
	9	607,042	4,917,649	A3	3,766	4,589	4,589
	13	607,016	4,917,670	A3	4,130	3,012	3,012
	16	604,037	4,919,591	A3	4,253	5,095	5,095
Craighurst	Well 1	600,812	4,931,473	A1	0	0	0
	Well 2	600,813	4,931,476	A1	11	11	11
	Well 3	600,812	4,931,480	A2	21	21	21
Angus	Centre Street (McGeorge) Well 1	591,761	4,909,103	A3	306	306	306
	Centre Street (McGeorge) Well 2	591,729	4,909,078	A3	283	283	283
	Brownley Well 4	591,571	4,907,652	A3	0	0	0
	Brownley Well 5						
	Brownley Well 6						

TABLE 1
Summary of Pumping Wells

Wellfield	Well ID	Easting	Northing	Aquifer	Existing Conditions Rate Range (m^3/d)	Future Conditions Average Yearly Rate (Steady State Model) (m^3/d)	Future Conditions Rate Range (Monthly Transient Model) (m^3/d)
Stroud	Well 1	610,368	4,909,451	A3	166	166	166
	Well 2 (Standby)	610,358	4,909,422	A3	166	166	166
	Well 3	610,387	4,909,478	A3	166	166	166
Vespra Downs	Well 1 - 93	594,204	4,911,276	A3	39	39	39
	Well 1- 91	594,176	4,911,266	A3	0	0	0
Minesing	Well 1	592,409	4,921,843	A3	119	119	119
	Well 2	592,409	4,921,843	A2	119	119	119
	Well 3	592,377	4,921,822	A2	137	137	137
Anten Mills	Well 1	593,949	4,926,082	A3	1	1	1
	Well 2	593,935	4,926,073	A3	120	120	120
	Well 3	593,928	4,926,081	A3	151	151	151
Shanty Bay	Well 1	613,031	4,918,903	A3	43	43	43
	Well 2	613,046	4,918,902	A2	49	49	49
	Well 3	613,039	4,918,913	A3	55	55	55
Snow Valley	Well 3	597,054	4,919,329	A3	284	284	284
	Well 4						
	Well 1						
	Well 2						

1. See Figure 6 for monthly rates at Midhurst.
2. See Figure 7 for monthly rates at Carson and Doran Neighbourhoods wells.

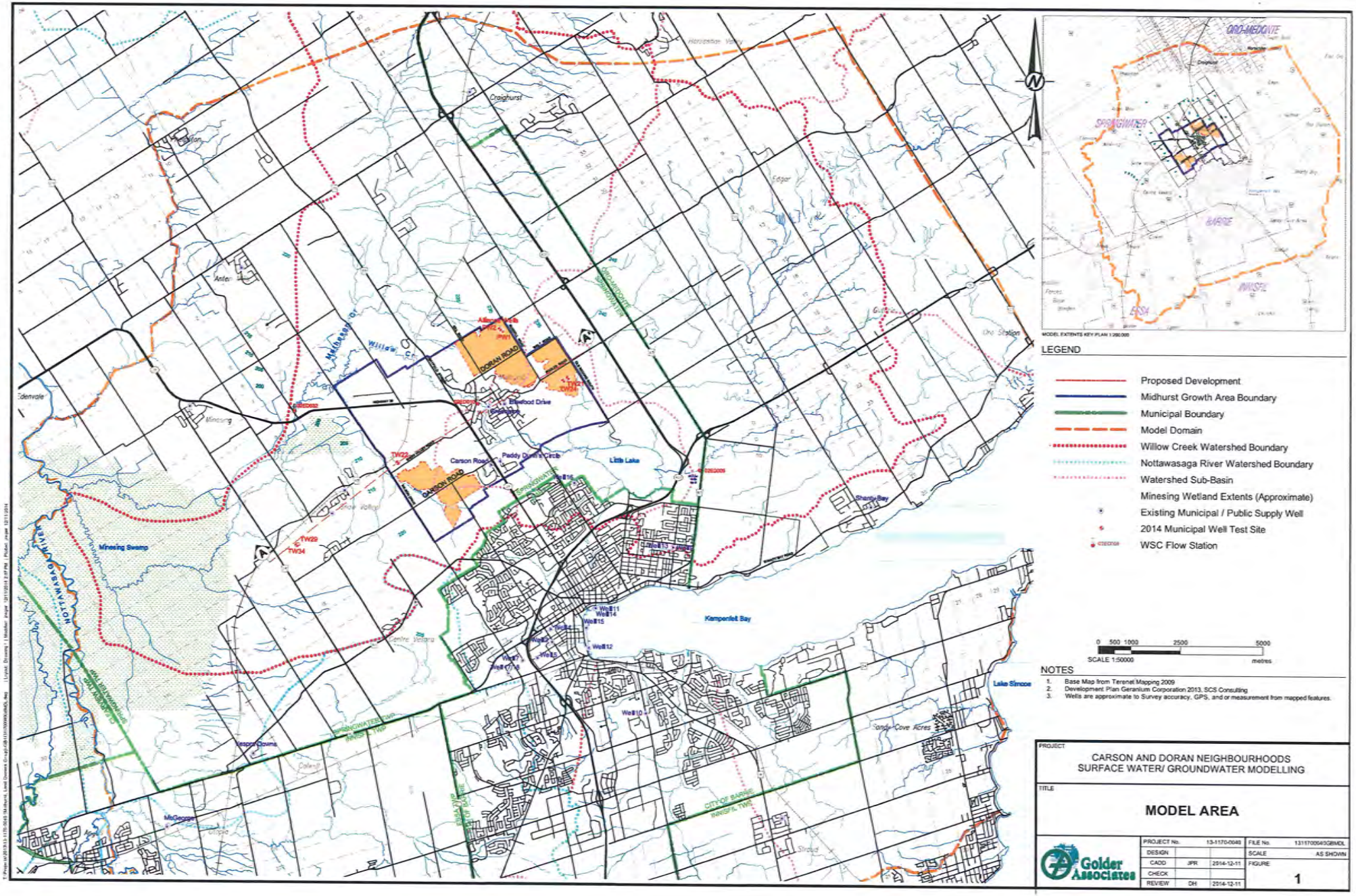
TABLE 2
Average Annual Flows

	Observed		Pre-Development Steady-State Simulation		Post-Development Steady-State Simulation			
Flow Station[1]	Streamflow (m^3/s)	Baseflow (m^3/s)	Streamflow (m^3/s)	Baseflow (m^3/s)	Streamflow (m^3/s)	Baseflow (m^3/s)	% Loss in Streamflow	% Loss in Baseflow[2]
02ED009 (Little Lake)	0.85	0.32	0.92	0.18	0.90	0.16	1.6%	8.5%
02ED010 (Midhurst)	1.15	0.58	1.38	0.28	1.33	0.23	3.5%	17.3%
02ED032 (Minesing)	2.62	1.81	2.98	1.32	2.86	1.21	3.8%	8.6%
Minesing Wetland Outlet	N/A	N/A	6.01	3.15	5.83	2.98	3.0%	5.7%

Notes:

1. See Figure 1 for station locations. Minesing Wetland Outlet includes contributions from upstream Willow Creek, Nottawasga River, and Wetland itself.
2. % baseflow loss is likely overestimated owing to the initial underprediction of baseflow in the Pre-Development scenario.

FIGURES

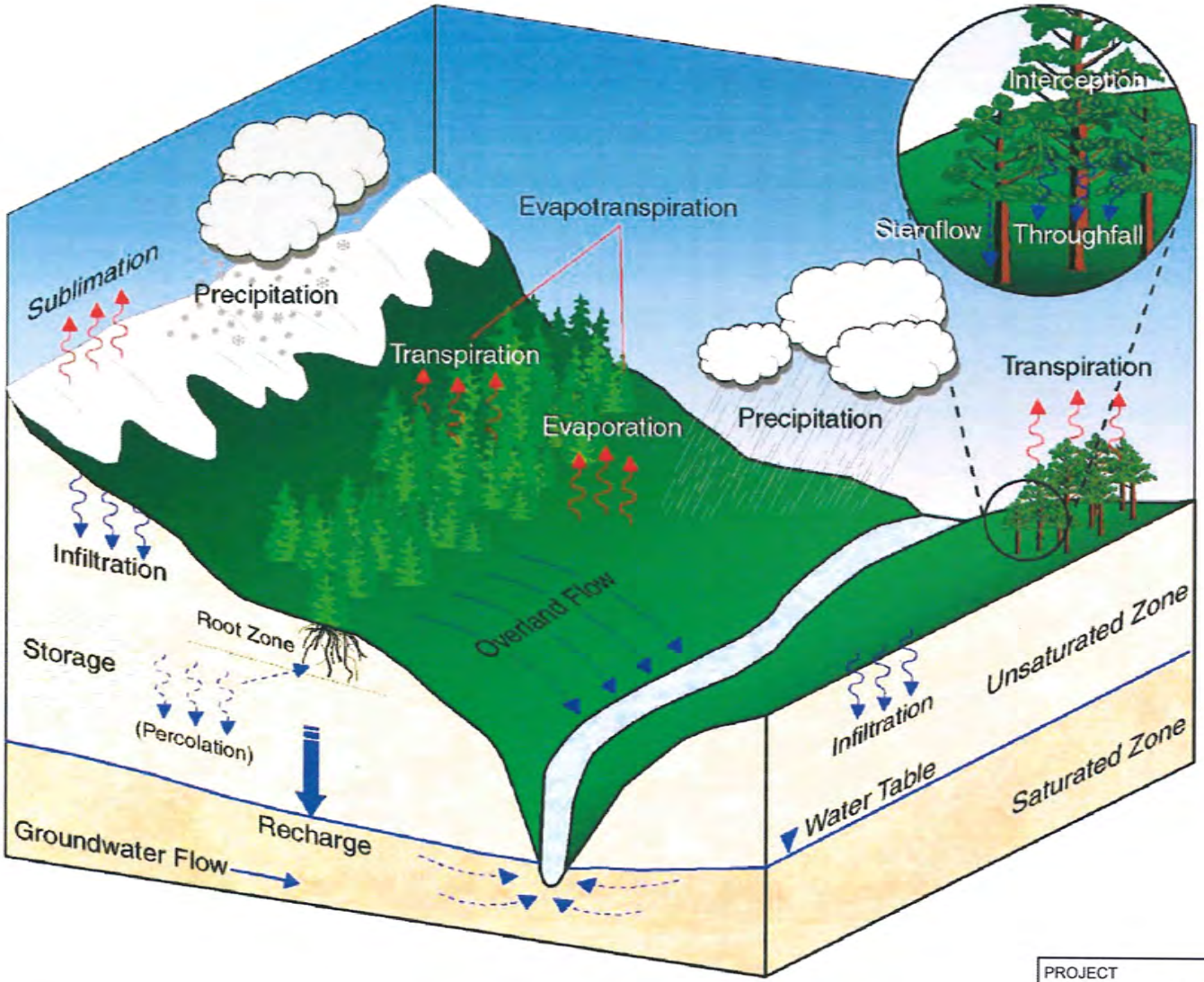


PROJECT
CARSON AND DORAN NEIGHBOURHOODS
SURFACE WATER/ GROUNDWATER MODELLING

TITLE
MODEL AREA

Golder Associates

PROJECT No.		13-1170-0048	FILE No.	13117004803BMDL
DESIGN			SCALE	AS SHOWN
CADD	JPR	2014-12-11	FIGURE	1
CHECK				
REVIEW	DH	2014-12-11		



NOTE

- *Reference: Jyrkama (2003)*

PROJECT

CARSON AND DORAN NEIGHBOURHOODS
SURFACE WATER/GROUNDWATER MODELLING

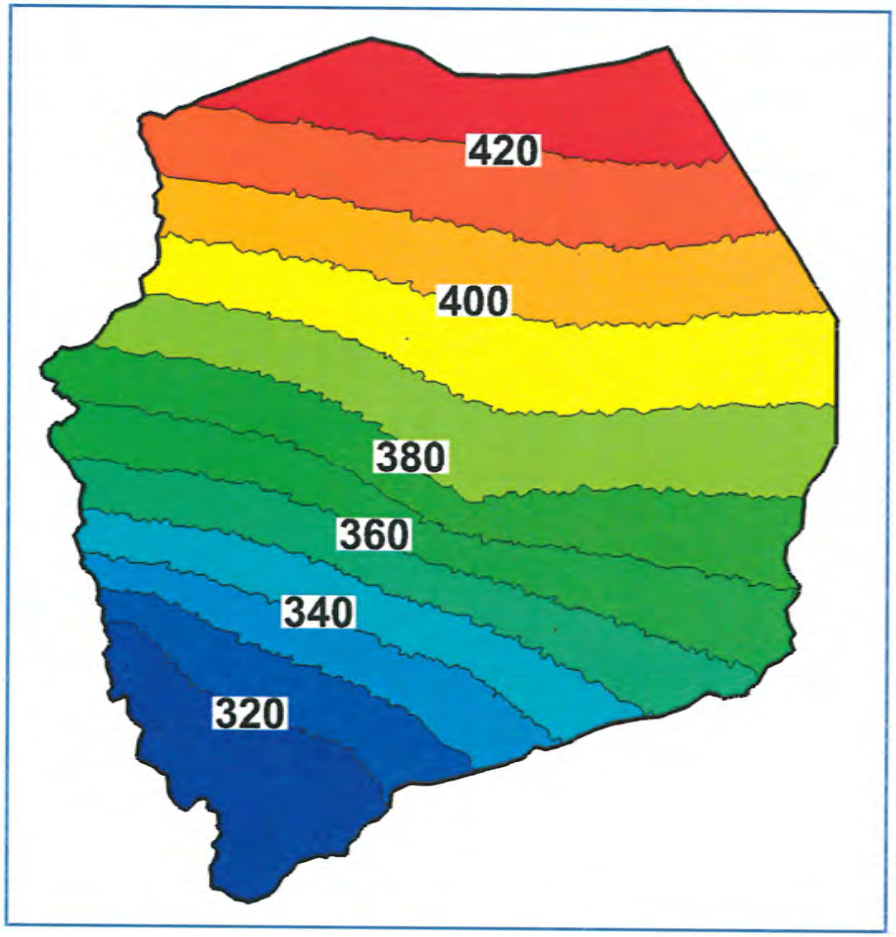
TITLE

HYDROLOGIC CYCLE

Golder Associates

PROJECT No. 13-1170-0040(4000)			SCALE AS SHOWN
DESIGN	RM	MAR 2016	REV. 1
CAD	RM	MAR 2016	FIGURE
CHECK			2
REVIEW			

HGS MODEL SURPLUS WATER DISTRIBUTION (mm/year)



NOTES:

- *HGS model surplus water distribution derived from Beckers and Frind (2001) Figure 7.*

PROJECT

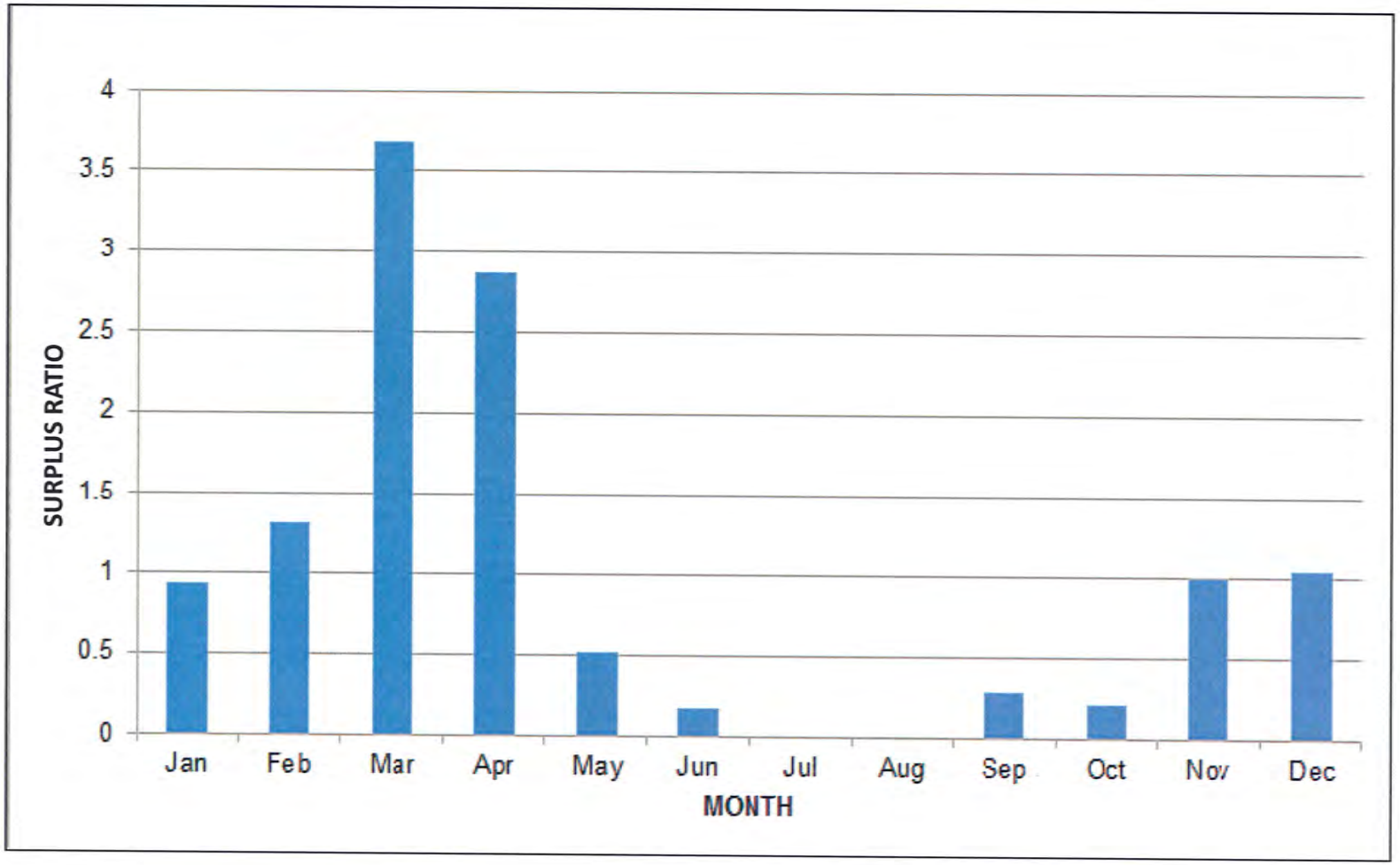
CARSON AND DORAN NEIGHBOURHOODS
SURFACE WATER/GROUNDWATER MODELLING

TITLE

MODEL SURPLUS WATER DISTRIBUTION

Golder Associates

PROJECT No. 13-1170-0040(4000)			SCALE AS SHOWN
DESIGN	RM	JAN 2017	REV. 1
CAD	RM	JAN 2017	FIGURE
CHECK			3
REVIEW			



NOTES:

- *In transient simulations the HGS model surplus water distribution for each month is determined by multiplying the surplus water distribution derived from Beckers and Frind (2001) (Figure 3) by the monthly surplus ratio (see above).*

PROJECT

CARSON AND DORAN NEIGHBOURHOODS
SURFACE WATER/GROUNDWATER MODELLING

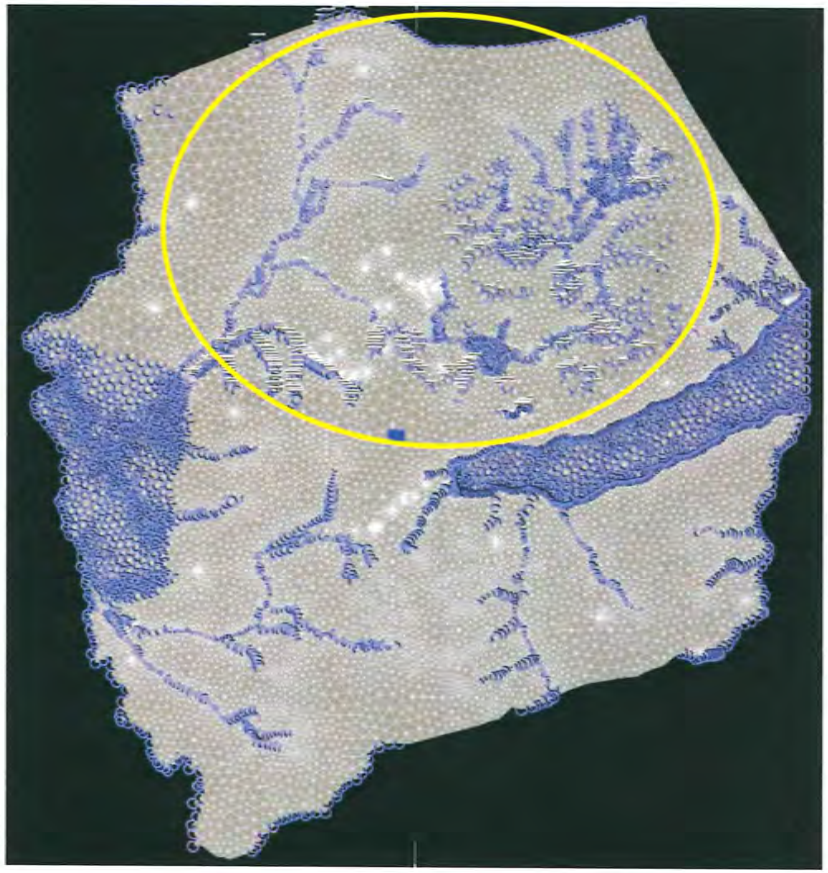
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MONTHLY SURPLUS RATIO

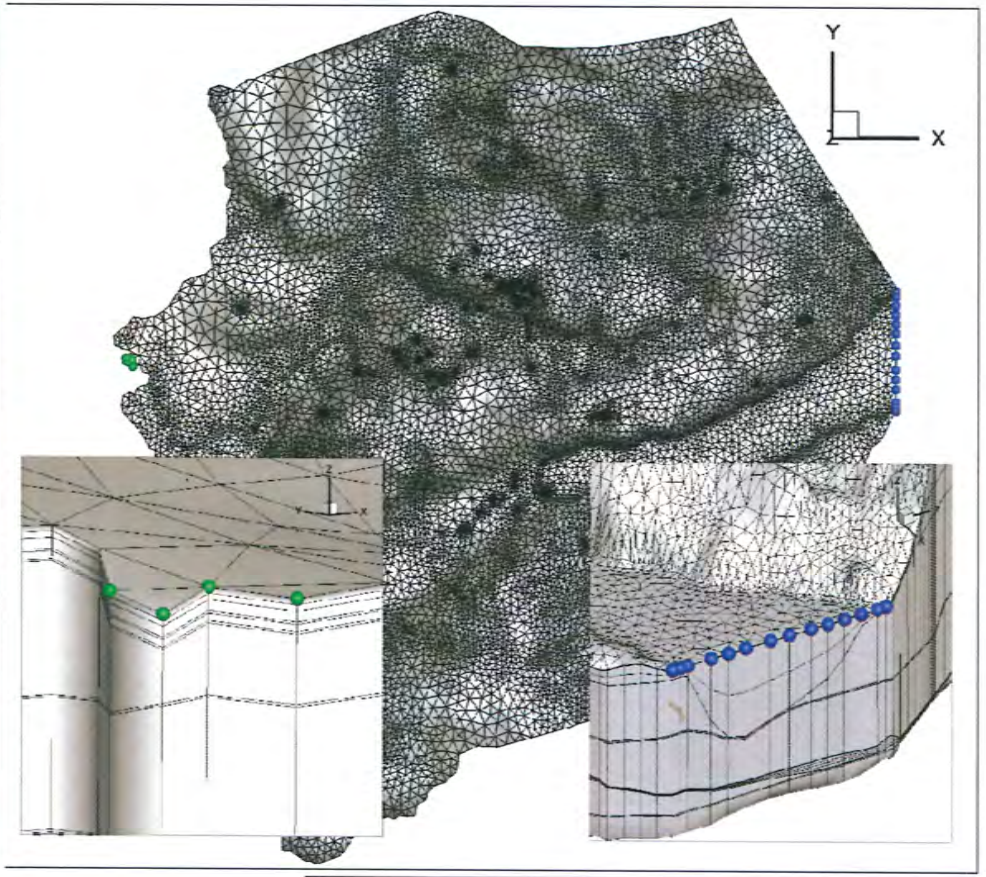
Golder Associates

PROJECT No. 13-1170-0040(4000)			SCALE AS SHOWN
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CHECK			4
REVIEW			

FEFLOW MODEL



HGS MODEL



NOTE

- *FEFLOW model – blue circles indicate constant head nodes, yellow ellipse indicates region of constrained 'discharge only' constant head nodes.*
- *HGS model – green spheres indicate critical depth boundary condition, blue spheres indicate constant head boundary condition. Also shown are oblique views of the critical depth boundary condition at the outlet of the Nottawasaga River (lower left inset, viewed from the west) and the constant head boundary condition at Kempenfelt Bay (lower right inset, viewed from the southeast)*

PROJECT

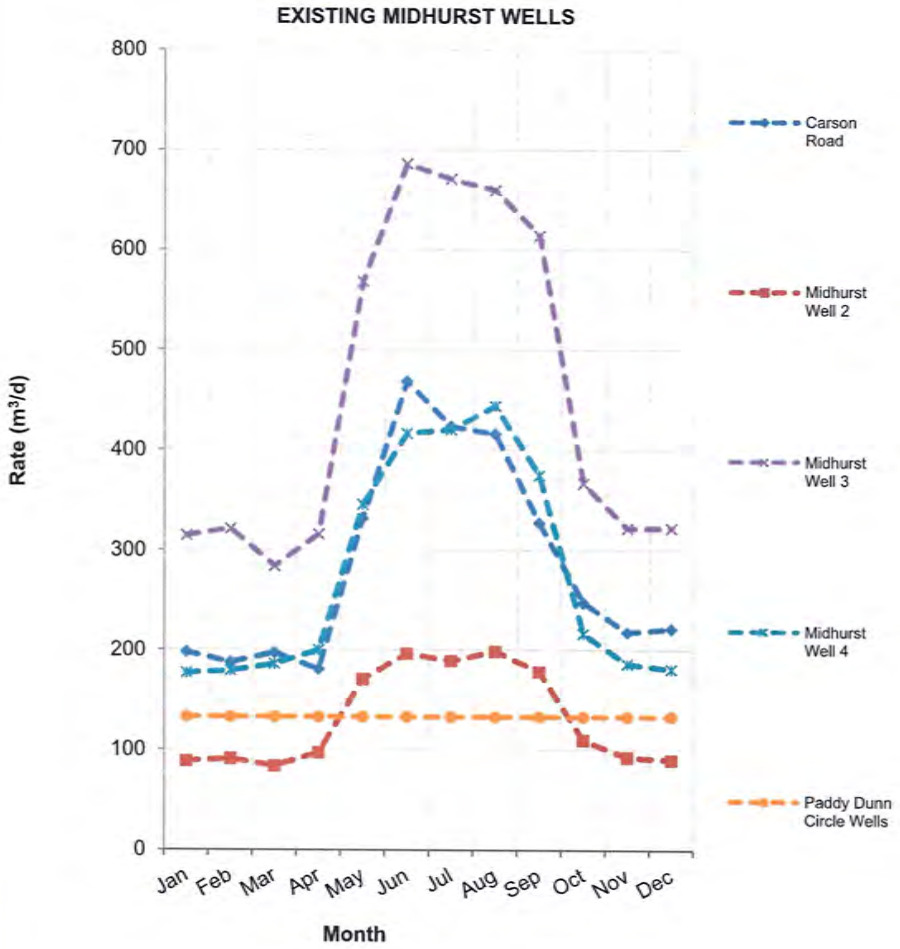
CARSON AND DORAN NEIGHBOURHOODS
SURFACE WATER/GROUNDWATER MODELLING

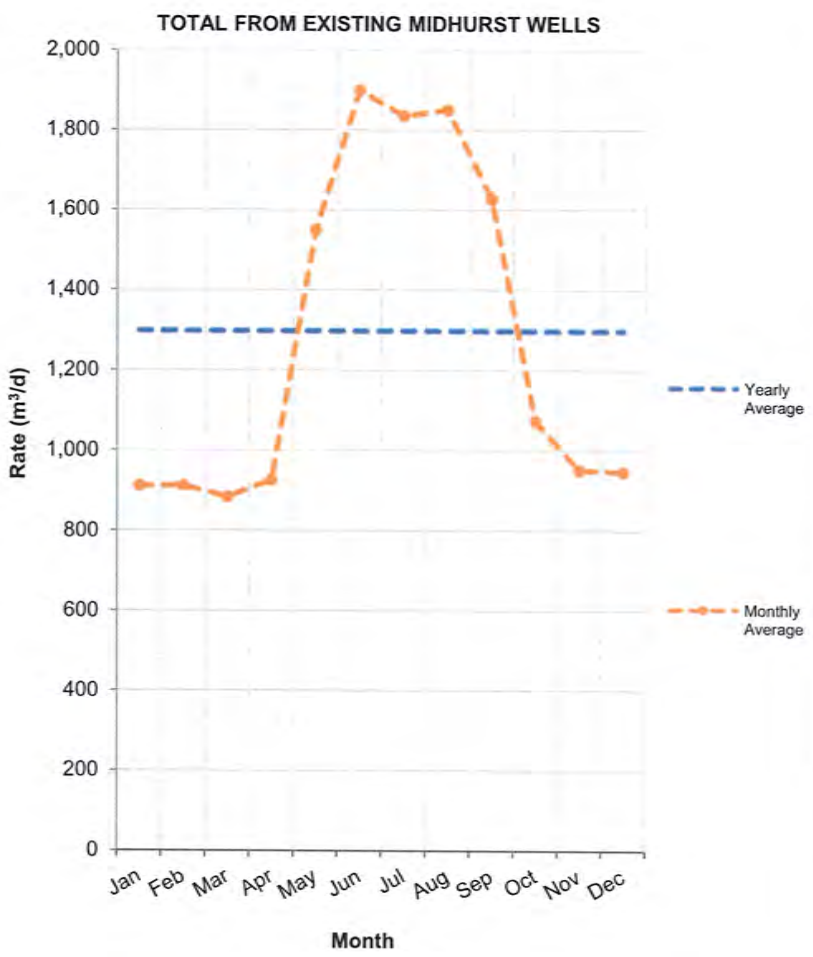
TITLE

BOUNDARY CONDITIONS

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DESIGN	RM	JAN 2017	REV. 1
CAD	RM	JAN 2017	FIGURE
CHECK			5
REVIEW			





NOTE

- *Chart shows 2003 to 2010 monthly averages.*
- *Monthly averages for Paddy Dunn Circle wells not available, average rate for year applied equally every month.*

PROJECT

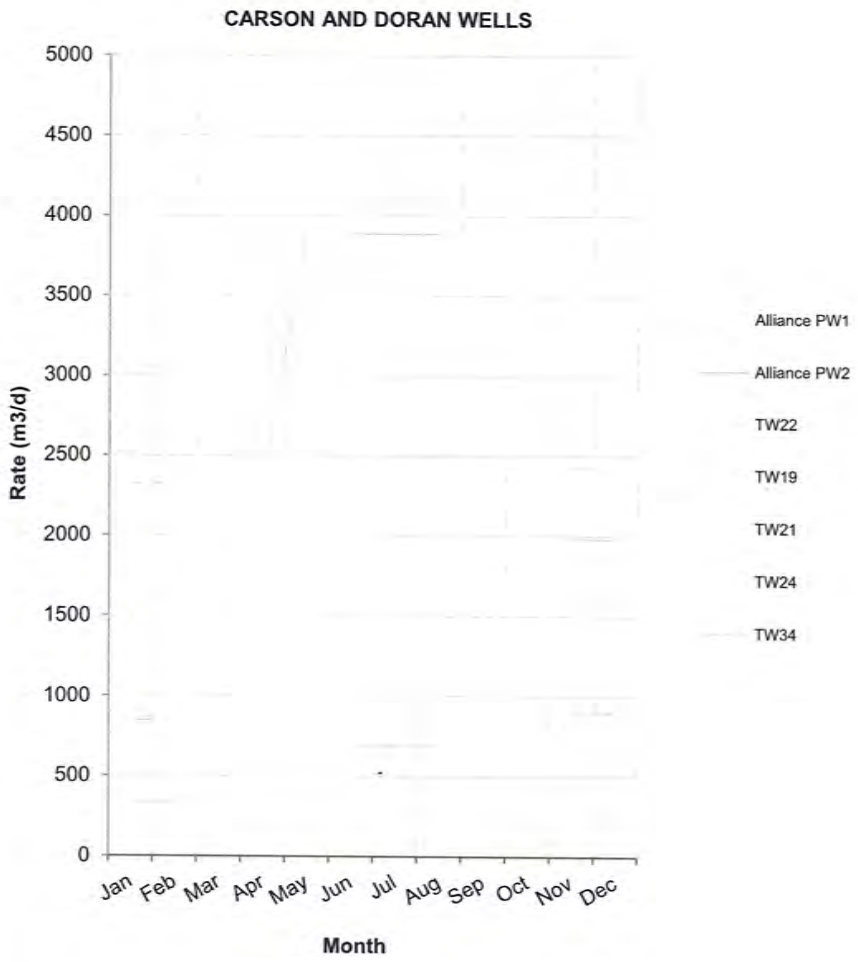
CARSON AND DORAN NEIGHBOURHOODS
SURFACE WATER/GROUNDWATER MODELLING

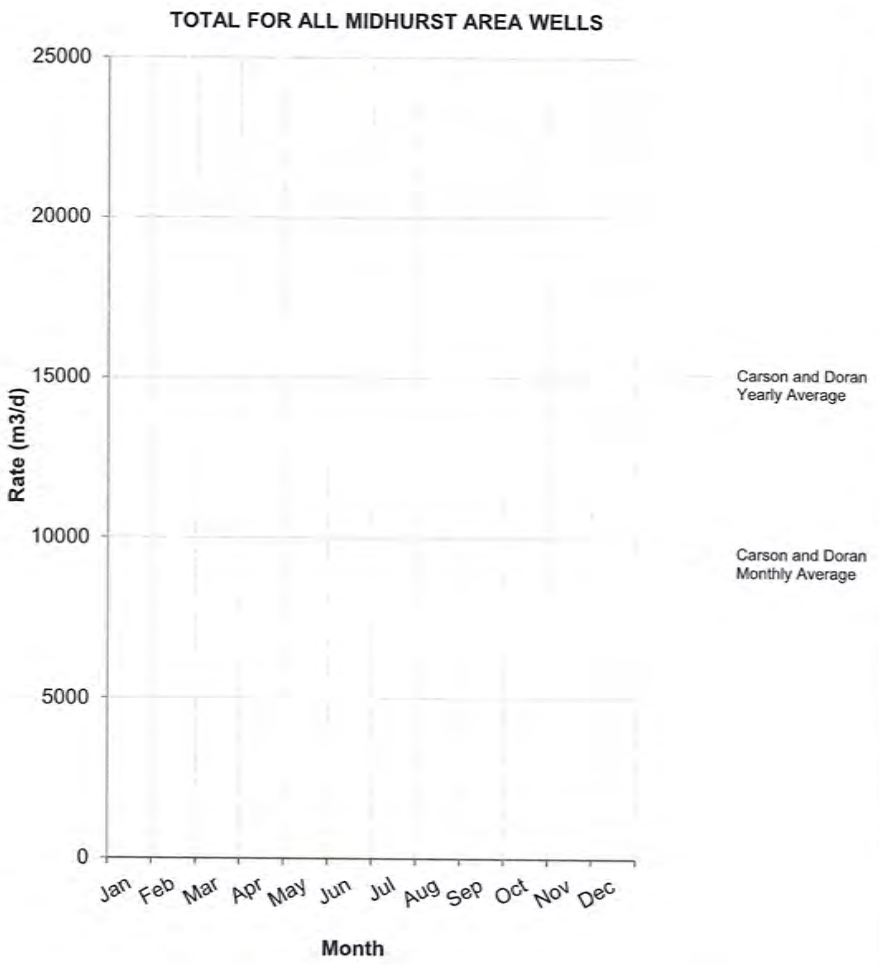
TITLE

PRE-DEVELOPMENT
MIDHURST PUMPING RATES

Golder Associates

PROJECT No. 13-1170-0040(4000)			SCALE AS SHOWN
DESIGN	RM	JAN 2017	REV. 1
CAD	RM	JAN 2017	FIGURE
CHECK			6
REVIEW			





NOTE

- *Projected total monthly demand at Carson and Doran wells calculated by prorating maximum demand (19,095 m³/d) in accordance with Existing Conditions demand (Figure 6).*
- *Midhurst and Paddy Dunn's Circle rates for Future Conditions (not shown) are assumed to continue as per Existing Conditions (Figure 6).*

PROJECT

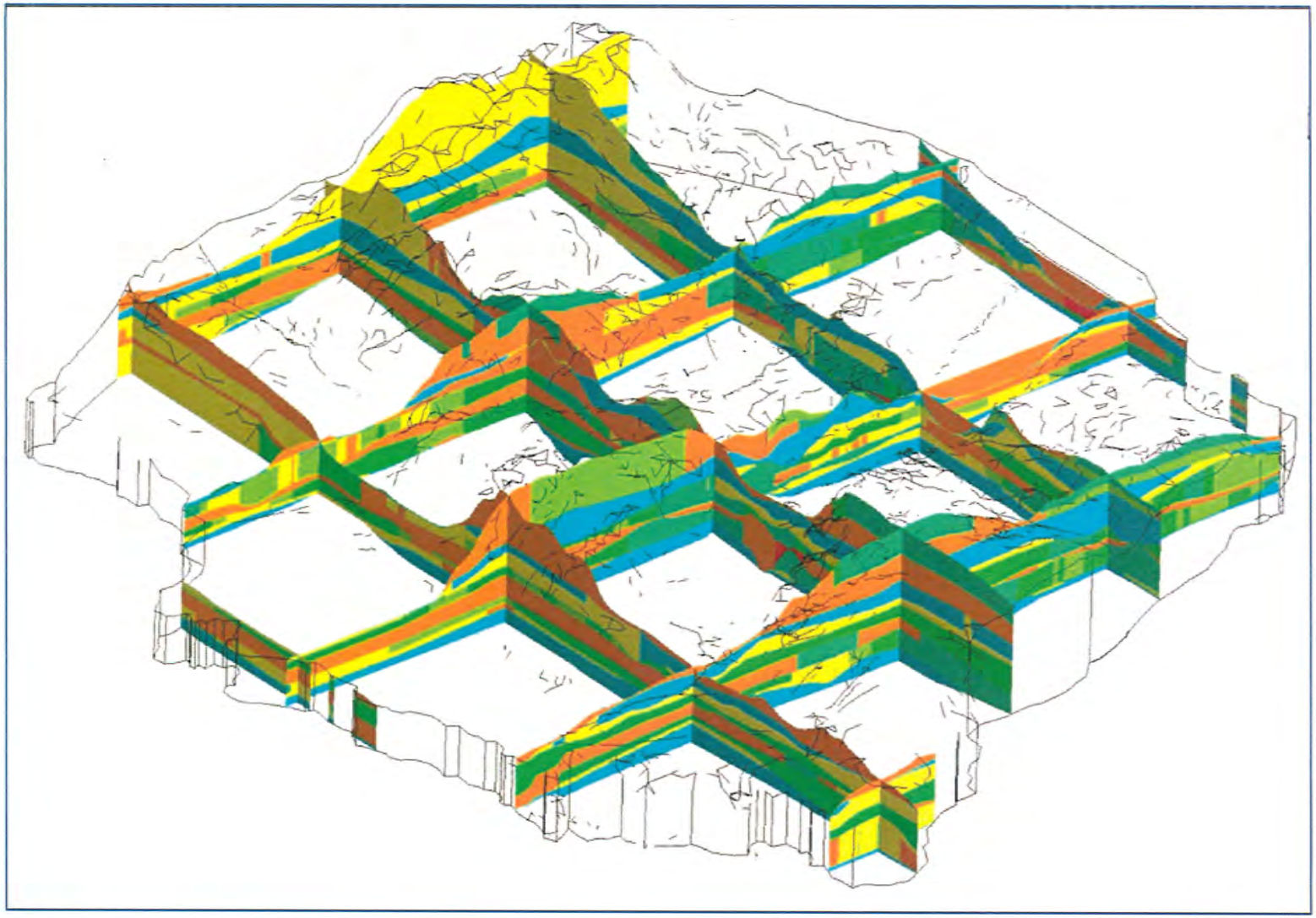
CARSON AND DORAN NEIGHBOURHOODS
SURFACE WATER/GROUNDWATER MODELLING

TITLE

POST-DEVELOPMENT
CARSON AND DORAN PUMPING RATES

Golder Associates

PROJECT No. 13-1170-0040(4000)			SCALE AS SHOWN
DESIGN	RM	JAN 2017	REV. 1
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REVIEW			



LEGEND

HYDRAULIC CONDUCTIVITY IN X-DIRECTION (M/D)

- 100
- 10
- 1
- 0.1
- 0.01
- 0.001
- 0.0001
- 1E-05

PROJECT

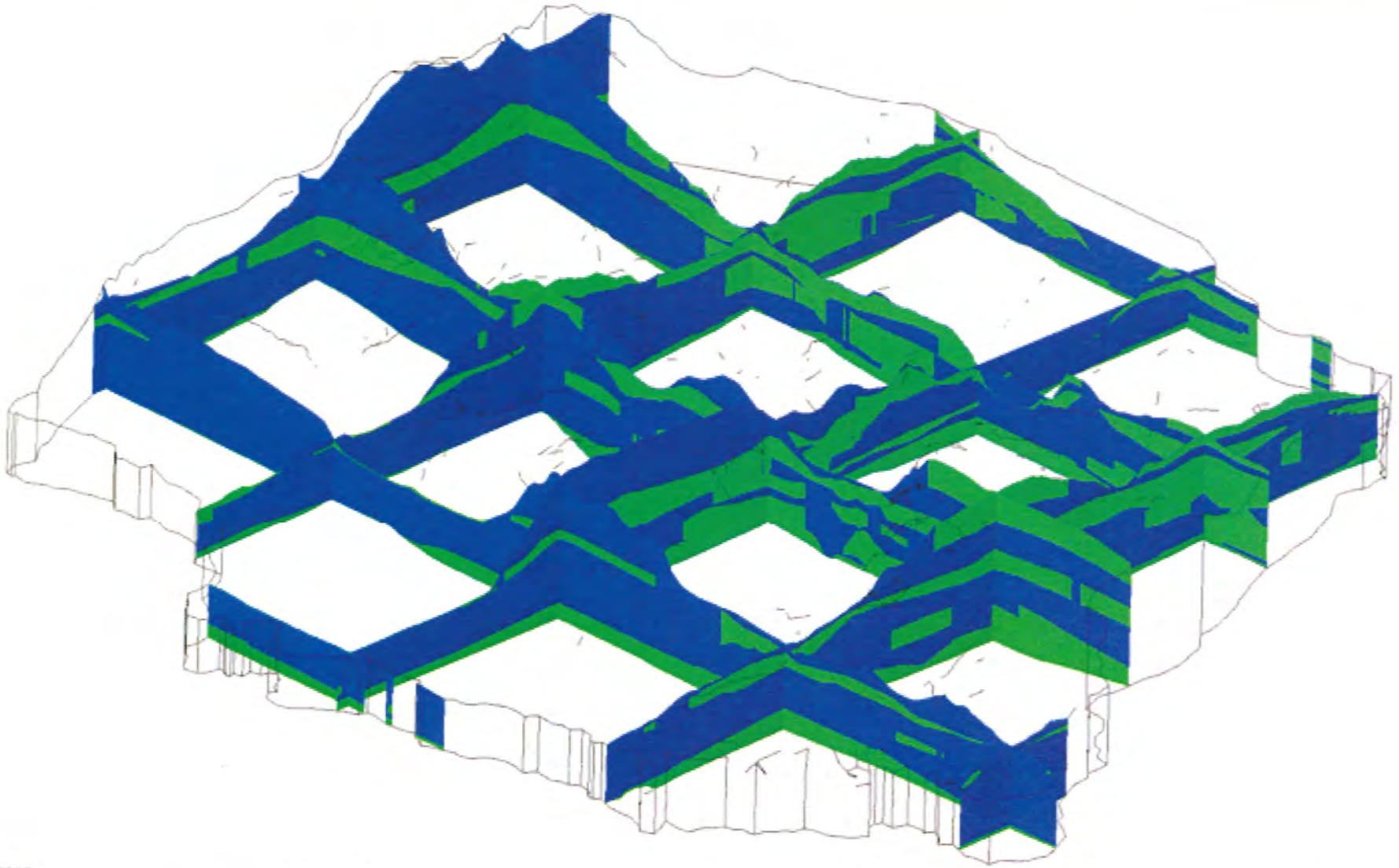
CARSON AND DORAN NEIGHBOURHOODS
SURFACE WATER/GROUNDWATER MODELLING

TITLE

HYDRAULIC CONDUCTIVITY DISTRIBUTION

Golder Associates

PROJECT No. 13-1170-0040(4000)			SCALE AS SHOWN
DESIGN	RM	MAR 2016	REV. 1
CAD	RM	MAR 2016	FIGURE
CHECK			8
REVIEW			



LEGEND

- Aquitard
- Aquifer

NOTES:

- Elements were grouped as aquifer or aquitard depending on the X-direction hydraulic conductivity (Kxx) as follows:
  Aquifer: Kxx >= 0.01 m/day
  Aquitard: Kxx < 0.01 m/day

PROJECT

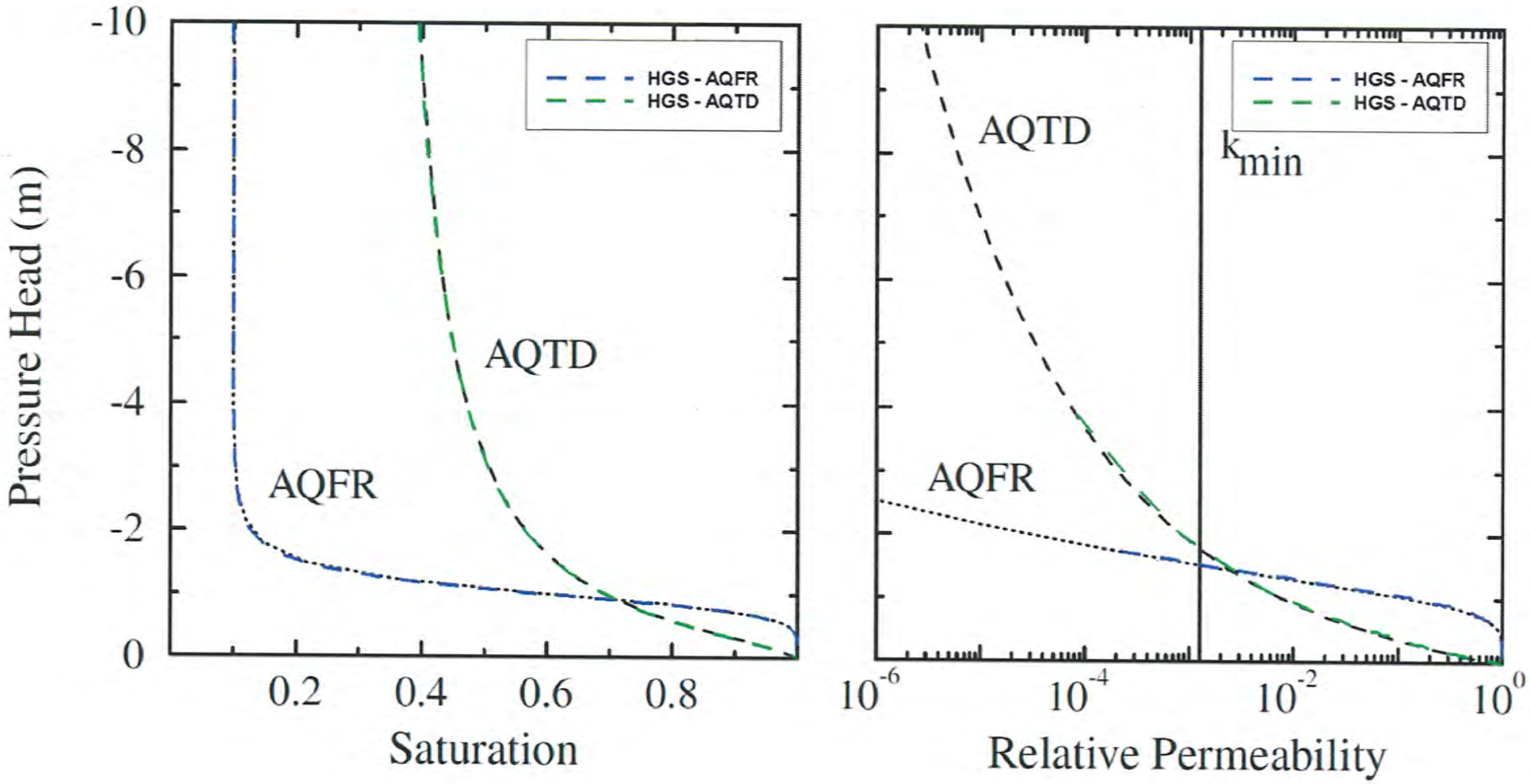
CARSON AND DORAN NEIGHBOURHOODS
SURFACE WATER/GROUNDWATER MODELLING

TITLE

AQUIFER/AQUITARD DISTRIBUTION

Golder Associates

PROJECT No. 13-1170-0040(4000)			SCALE AS SHOWN
DESIGN	RM	MAR 2016	REV. 1
CAD	RM	MAR 2016	FIGURE
CHECK			9
REVIEW			



NOTES:

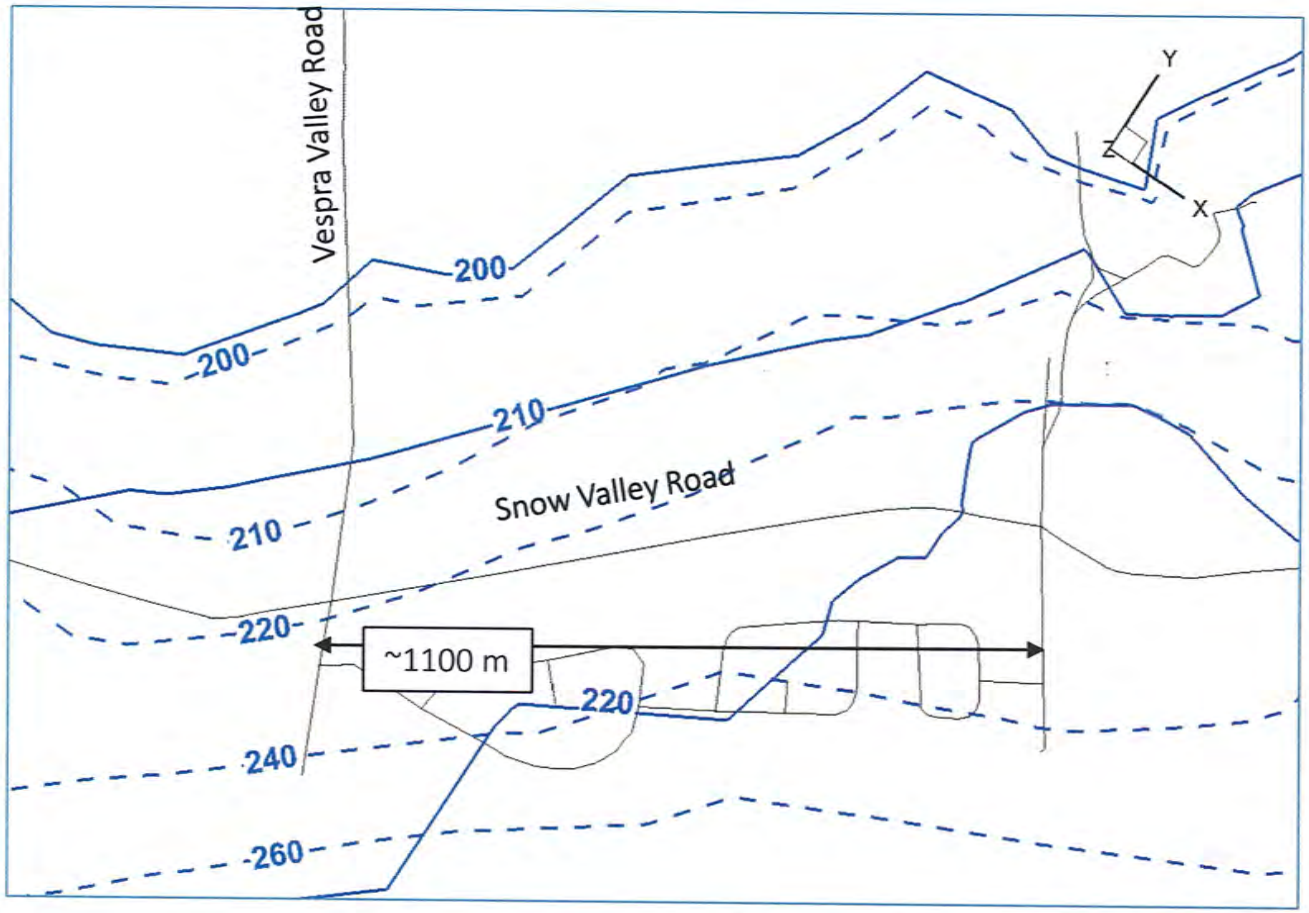
- Reference: Beckers and Frind (2001).
- Blue (AQFR) and green (AQRD) dashed lines are HGS soil retention properties derived from Beckers and Frind (2001) (black dotted and dashed lines).

PROJECT	CARSON AND DORAN NEIGHBOURHOODS SURFACE WATER/GROUNDWATER MODELLING
TITLE	**SOIL RETENTION PROPERTIES**

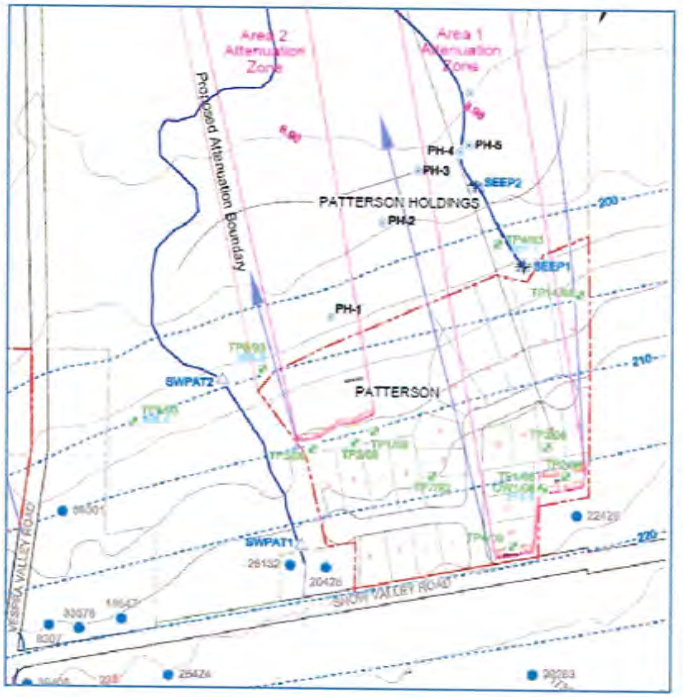
Golder Associates

PROJECT No. 13-1170-0040(4000)			SCALE AS SHOWN
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CAD	RM	MAR 2016	FIGURE
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REVIEW			

HGS MODEL



OBSERVED

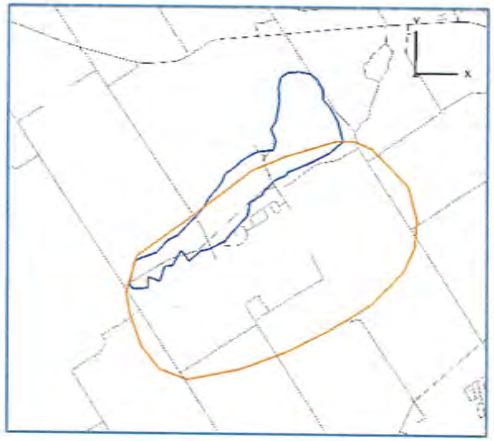


NOTES:

- In image above from Golder (2010b), dashed blue lines are water surface elevation.

NOTES:

- Image above shows hydraulic head contours at ground surface from initial HGS steady-state flow simulation (blue solid lines) and after hydraulic conductivity adjustments (blue dashed lines).
- Image to left shows first (blue line) and second (orange line) areas of hydraulic conductivity adjustments



PROJECT

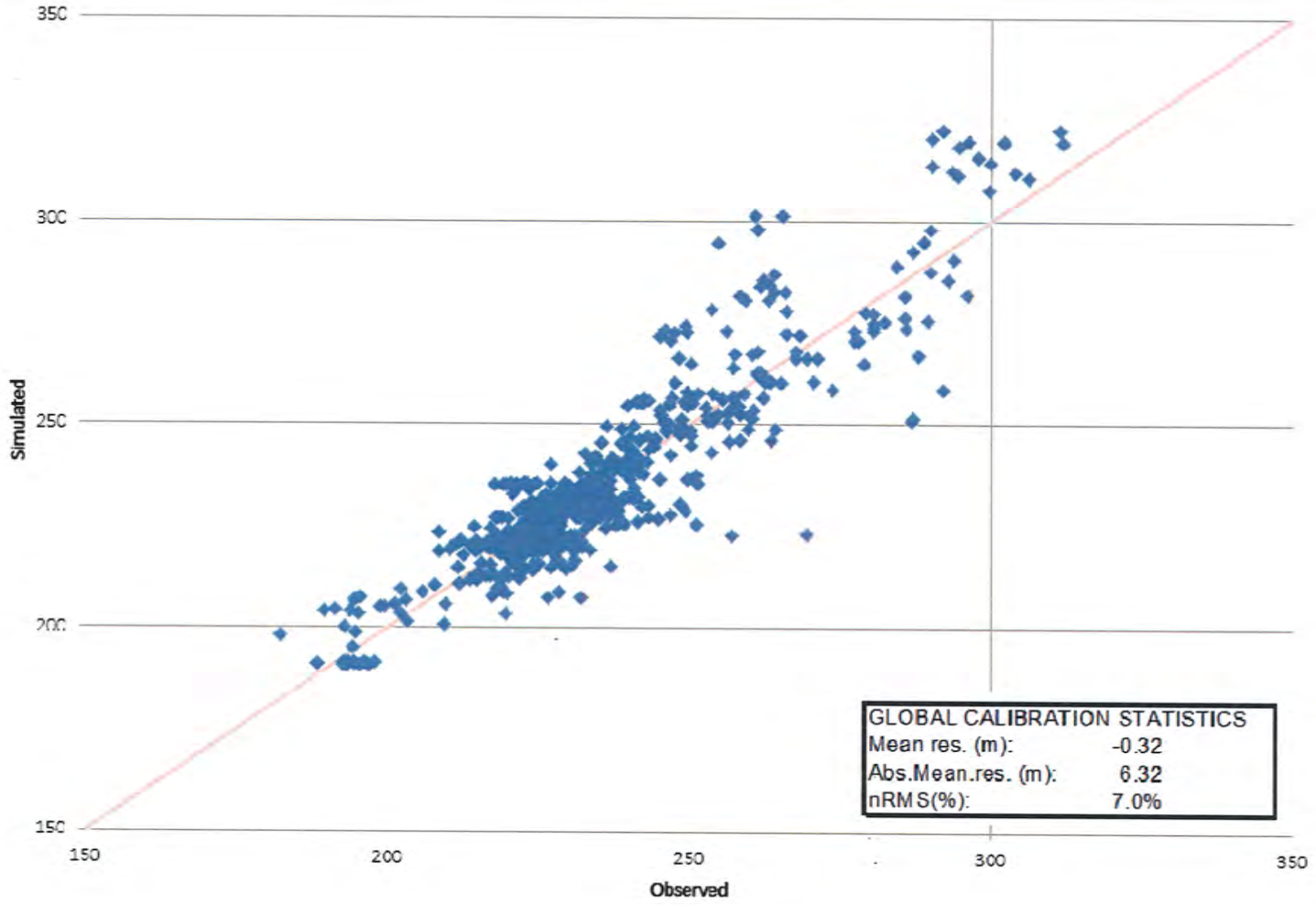
CARSON AND DORAN NEIGHBOURHOODS
SURFACE WATER/GROUNDWATER MODELLING

TITLE

STEADY-STATE HYDRAULIC HEAD IN VICINITY OF SNOW VALLEY

Golder Associates

PROJECT No. 13-1170-0040(4000)			SCALE AS SHOWN
DESIGN	RM	MAR 2016	REV. 1
CAD	RM	MAR 2016	FIGURE
CHECK			11
REVIEW			



PROJECT

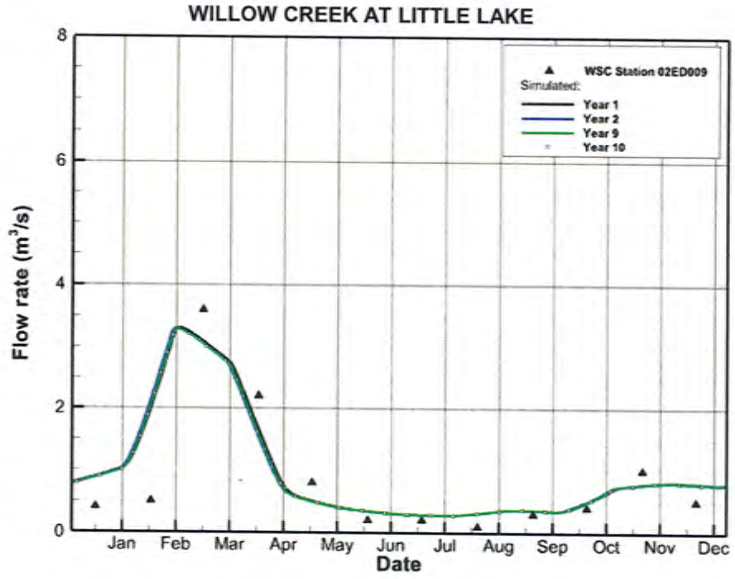
CARSON AND DORAN NEIGHBOURHOODS
SURFACE WATER/GROUNDWATER MODELLING

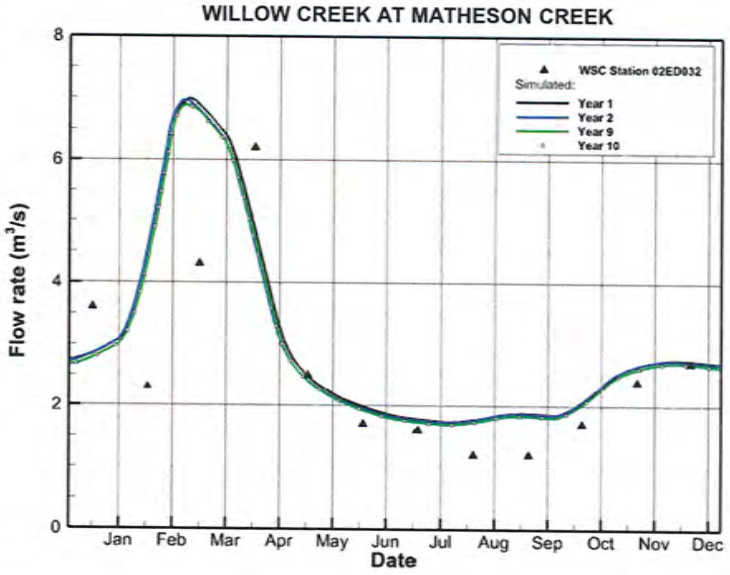
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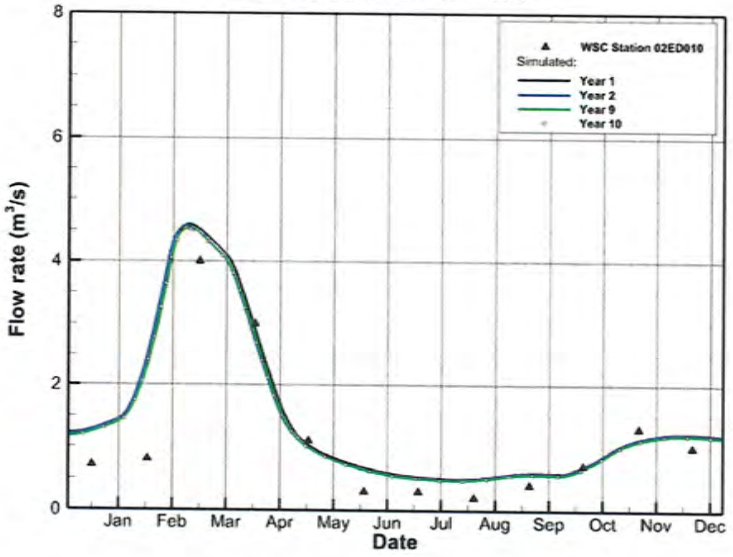
GROUNDWATER LEVEL CALIBRATION (MOECC WWIS WELLS)

Golder Associates

PROJECT No. 13-1170-0040(4000)			SCALE AS SHOWN
DESIGN	RM	JAN 2017	REV. 1
CAD	RM	JAN 2017	FIGURE
CHECK			12
REVIEW			







NOTES:

- *Observed (long-term average) stream flow data (black triangles) from WSC stations (April '06 to Dec'10)*

PROJECT

CARSON AND DORAN NEIGHBOURHOODS
SURFACE WATER/GROUNDWATER MODELLING

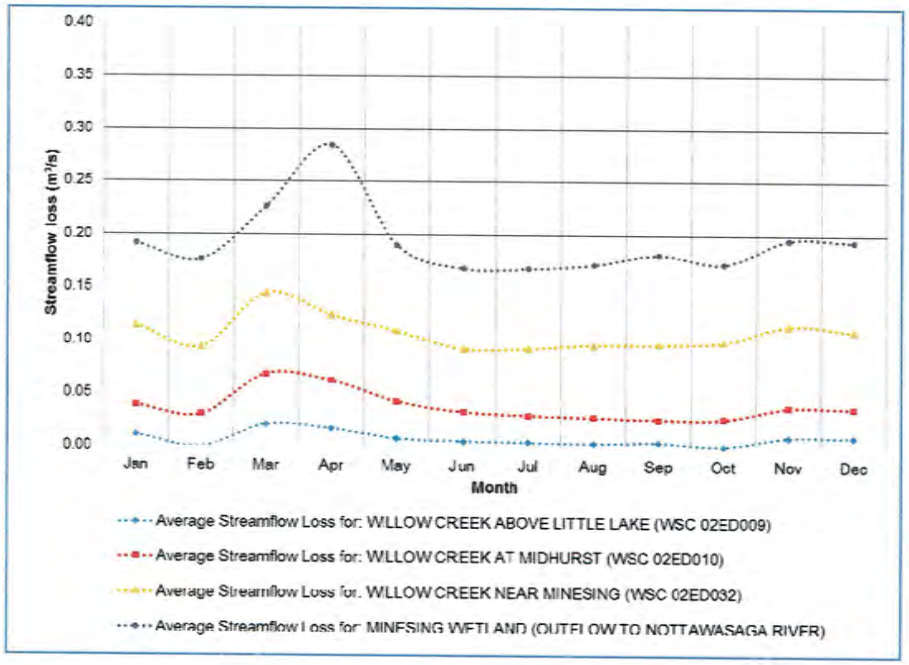
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PRE-DEVELOPMENT
SIMULATED MONTHLY STREAMFLOWS

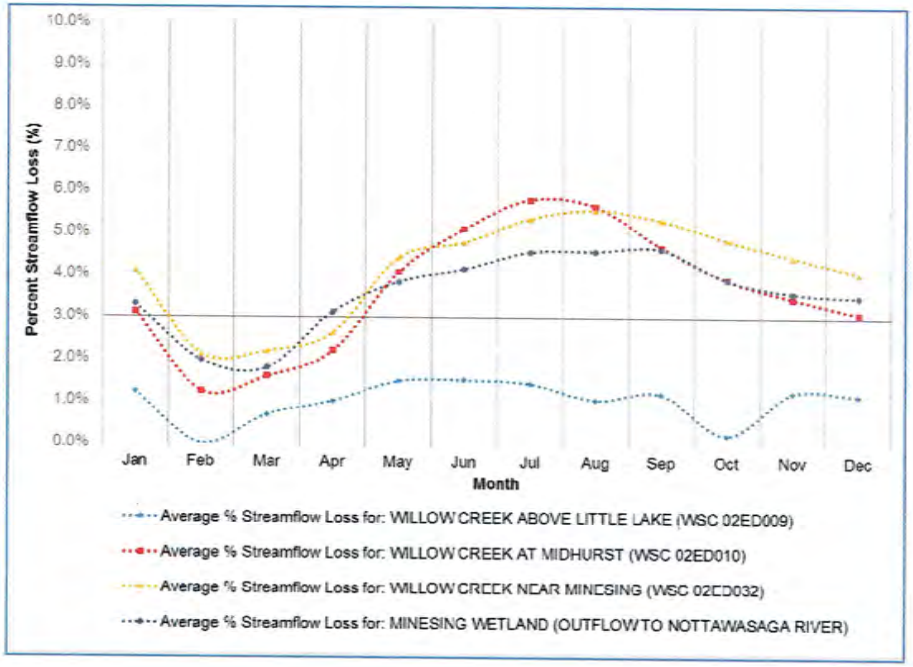
Golder Associates

PROJECT No. 13-1170-0040(4000)			SCALE AS SHOWN
DESIGN	RM	JAN 2017	REV. 1
CAD	RM	JAN 2017	FIGURE
CHECK			13
REVIEW			

STREAMFLOW LOSS EXPRESSED AS FLOW RATE



STREAMFLOW LOSS EXPRESSED AS % OF TOTAL STREAMFLOW FOR SUBCATCHMENT



NOTE

- *Monthly rates and percent changes reflect result for 10th year of simulation.*

PROJECT

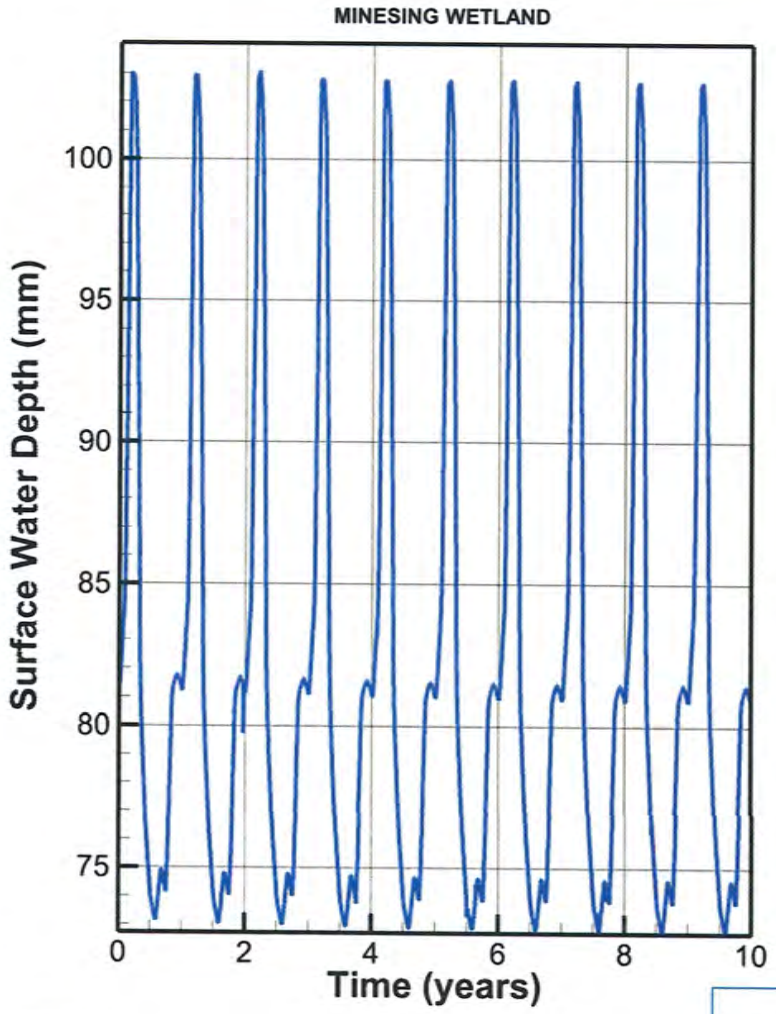
CARSON AND DORAN NEIGHBOURHOODS
SURFACE WATER/GROUNDWATER MODELLING

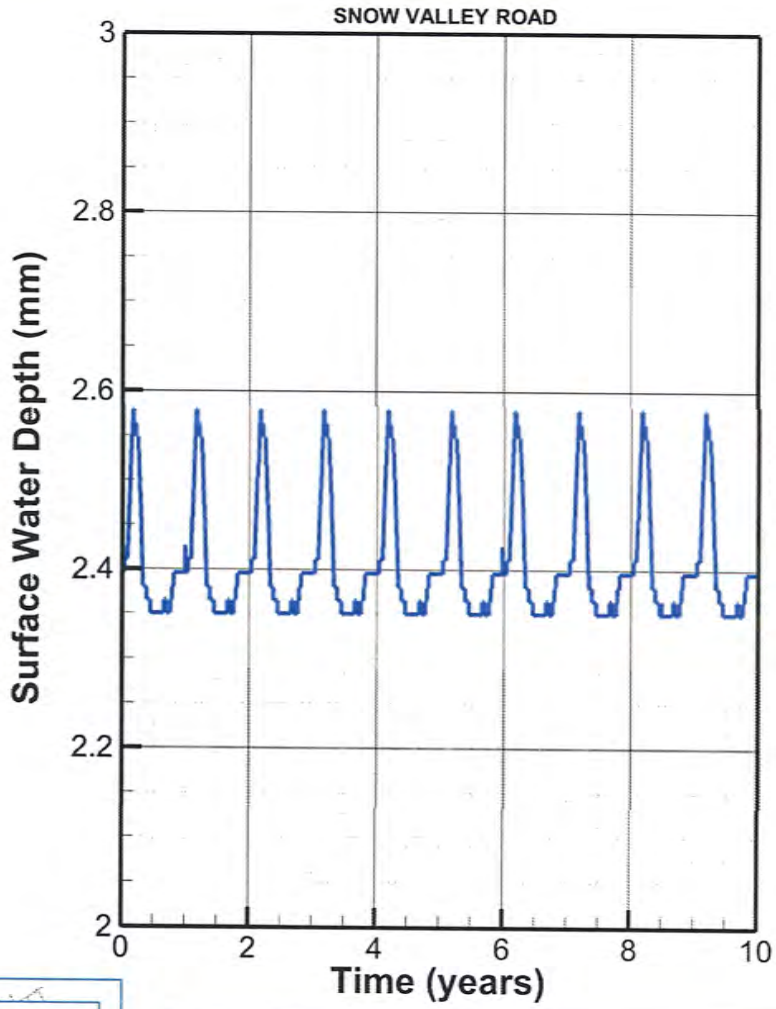
TITLE

POST-DEVELOPMENT
SIMULATED MONTHLY STREAMFLOW CHANGES

Golder Associates

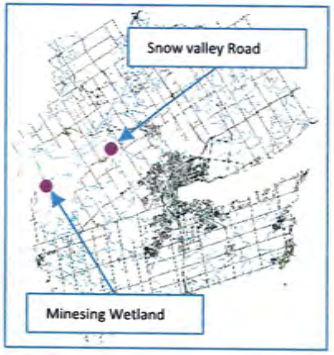
PROJECT No. 13-1170-0040(4000)			SCALE AS SHOWN
DESIGN	RM	APR 2016	REV. 1
CAD	RM	APR 2016	FIGURE
CHECK			14
REVIEW			





NOTES:

- *Simulated surface water depth at Minesing Wetland (left panel) and Snow Valley Road (right panel)*
- *Model output locations shown in panel to right*



PROJECT

CARSON AND DORAN NEIGHBOURHOODS
SURFACE WATER/GROUNDWATER MODELLING

TITLE

POST-DEVELOPMENT SURFACE WATER LEVEL RESPONSE MINESING WETLAND AREA

Golder Associates

PROJECT No. 13-1170-0040(4000)			SCALE AS SHOWN
DESIGN	RM	JAN 2017	REV. 1
CAD	RM	JAN 2017	FIGURE
CHECK			15
REVIEW			

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[DHP 00734293 2]

Appendix F

Water Quantities (Black Creek, Willow Creek)

SCS consulting group ltd

File #: 1168/1194
Date: August 8, 2014

Mr. Glenn Switzer, P. Eng.
Director of Engineering and Technical Services
Nottawasaga Conservation Authority
8195 8th Line
Utopia, Ontario, L0M 1T0

Dear Mr. Switzer:

Re: **Midhurst Master Drainage Plan – Phase 1**
Item #2 – Peak Flow Control
Midhurst, Ontario

Further to our submissions of May 2, 2014 and May 27, 2014, please accept the following supplemental information in support of the Peak Flow Assessment (Item #2) of the Phase 1 work program for the Master Drainage Plan for your review and approval.

As per NVCA's correspondence of May 29, 2014, the target statement for Peak Flow Control is:

> *At each outlet, there would be no increase in peak flow for all storm events from the 2 year through 100 year 4 hour Chicago and 24 hour SCS storms.*

The appended hydrology model includes simulation of the post-development runoff for the 25mm and 2 through 100 year storms assuming the following stormwater management characteristics:

- Extended detention of the 25mm rainfall event for 72 hours (as discussed in detail in Item #4 submission, dated June 5, 2014)
- At source and conveyance infiltration of the 24.6 mm rainfall event, resulting in 23.5 mm of infiltration through LID practices within the Doran community (as discussed in detail in Item #3 submission, dated June 8, 2014)
- At source and conveyance infiltration of the 23.0 mm rainfall event (on average), resulting in 20.5 mm of infiltration through LID practices within the Carson community (on average, as discussed in detail in Item #3 submission, dated June 8, 2014)
- Peak flow control of the 2 through 100 year post-development release rates to pre-development release rates

On this basis, the peak flow runoff control can continue to be achieved, as originally set out in the Functional Servicing Reports, and shown in the attached hydrology modelling and associated calculations.

In addition to the post-development peak flows being equivalent or less than pre-development flows at each SWM pond outlet, the tables below demonstrate that there is no cumulative increase in post-development peak flows as well.

The following five tables are a compilation of the cumulative flow to Black Creek from the Carson Road Development as illustrated on **Figures 1 & 2** (Carson) attached.

Node 1 – Beginning of Watercourse

Return Period Storm	Existing (Chicago) (m^3/s)	Existing (SCS) (m^3/s)	Proposed (Chicago) (m^3/s)	Proposed (SCS) (m^3/s)
2 year	1.823	2.459	1.399	1.995
5 year	3.814	5.262	3.276	5.036
10 year	5.380	7.468	4.793	7.251
25 year	7.604	10.564	7.309	10.373
50 year	9.407	13.041	9.115	12.859
100 year	11.347	15.616	11.065	15.456

Node 2 – Upstream of Carson Road

Return Period Storm	Existing (Chicago) (m^3/s)	Existing (SCS) (m^3/s)	Proposed (Chicago) (m^3/s)	Proposed (SCS) (m^3/s)
2 year	2.586	3.488	1.923	2.708
5 year	5.416	7.466	4.428	6.762
10 year	7.640	10.597	6.515	9.791
25 year	10.803	14.994	9.883	14.086
50 year	13.367	18.506	12.357	17.446
100 year	16.127	22.162	15.028	20.94

Node 3 – Upstream of Wilson Drive

Return Period Storm	Existing (Chicago) (m^3/s)	Existing (SCS) (m^3/s)	Proposed (Chicago) (m^3/s)	Proposed (SCS) (m^3/s)
2 year	3.195	4.311	2.237	3.151
5 year	6.702	9.246	5.122	7.994
10 year	9.464	13.141	7.772	11.739
25 year	13.404	18.621	11.779	17.005
50 year	16.604	23.006	14.794	21.166
100 year	20.053	27.578	18.052	25.49

Node 4 – Between Wilson Drive and Snow Valley Road

Return Period Storm	Existing (Chicago) (m^3/s)	Existing (SCS) (m^3/s)	Proposed (Chicago) (m^3/s)	Proposed (SCS) (m^3/s)
2 year	3.261	4.410	2.313	3.267
5 year	6.848	9.471	5.277	8.206
10 year	9.677	13.469	8.005	12.104
25 year	13.711	19.098	12.115	17.543
50 year	16.990	23.609	15.223	21.849
100 year	20.524	28.309	18.582	26.321

Node 5 – Upstream of Snow Valley Road

Return Period Storm	Existing (Chicago) (m^3/s)	Existing (SCS) (m^3/s)	Proposed (Chicago) (m^3/s)	Proposed (SCS) (m^3/s)
2 year	4.064	5.580	3.125	4.412
5 year	8.654	12.089	7.097	10.816
10 year	12.305	17.303	10.662	15.945
25 year	17.553	24.701	15.992	23.158
50 year	21.847	30.664	20.134	28.926
100 year	26.496	36.917	24.624	34.952

As shown above, the post-development peak release rates for the 2 through 100 year storm events are equivalent or less than pre-development peak release rates for the Carson Road community as required by the NVCA.

The following table demonstrates the cumulative flow to the existing municipal infrastructure downstream of the Russell Road Pond within the Doran Road development, which was deemed an acceptable outlet as noted in the Item #6 submission, dated June 10, 2014. The nodes referenced below are illustrated on the attached **Figure 2** (Doran).

Pooles Road Drainage – Peak Flows – Drainage Route to Existing Municipal Infrastructure

Node	Existing 100 year (SCS) (m^3/s)	Proposed 100 year (SCS) (m^3/s)
1 – Existing Culvert at Pooles Road	2.598	1.863
2 – Existing Midves Court Municipal Ditch system	3.224	2.769
3 – Catchbasins at termination of Midves Court	3.546	3.545

As shown above, the peak flows for the 2 through 100 year storm will be maintained on a cumulative basis, in addition to at the Russell Road Pond outlet, along the outfall routes for the Doran and Carson communities.

Please call the undersigned if you have any questions or require any additional information.

Sincerely,

SCS Consulting Group Ltd.

Steve Schaefer, P. Eng.
Principal
sschaefer@scsconsultinggroup.com

Attachments: Hydrology Model and parameters

c. Mr. Wayne Wilson, NVCA
Mr. Chris Hibbard, NVCA
Mr. Brad Sokach, Township of Springwater
Mr. Brent Spagnol, Township of Springwater
Mr. Joe Mullan, Ainley
Mr. Greg Marek, Simcoe County
Ms. Shauna Dudding, Geranium Corporation
Mr. Matthew Cory, Malone Given Parsons

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ATTACHMENT A

HYDROLOGY MODEL AND PARAMETERS



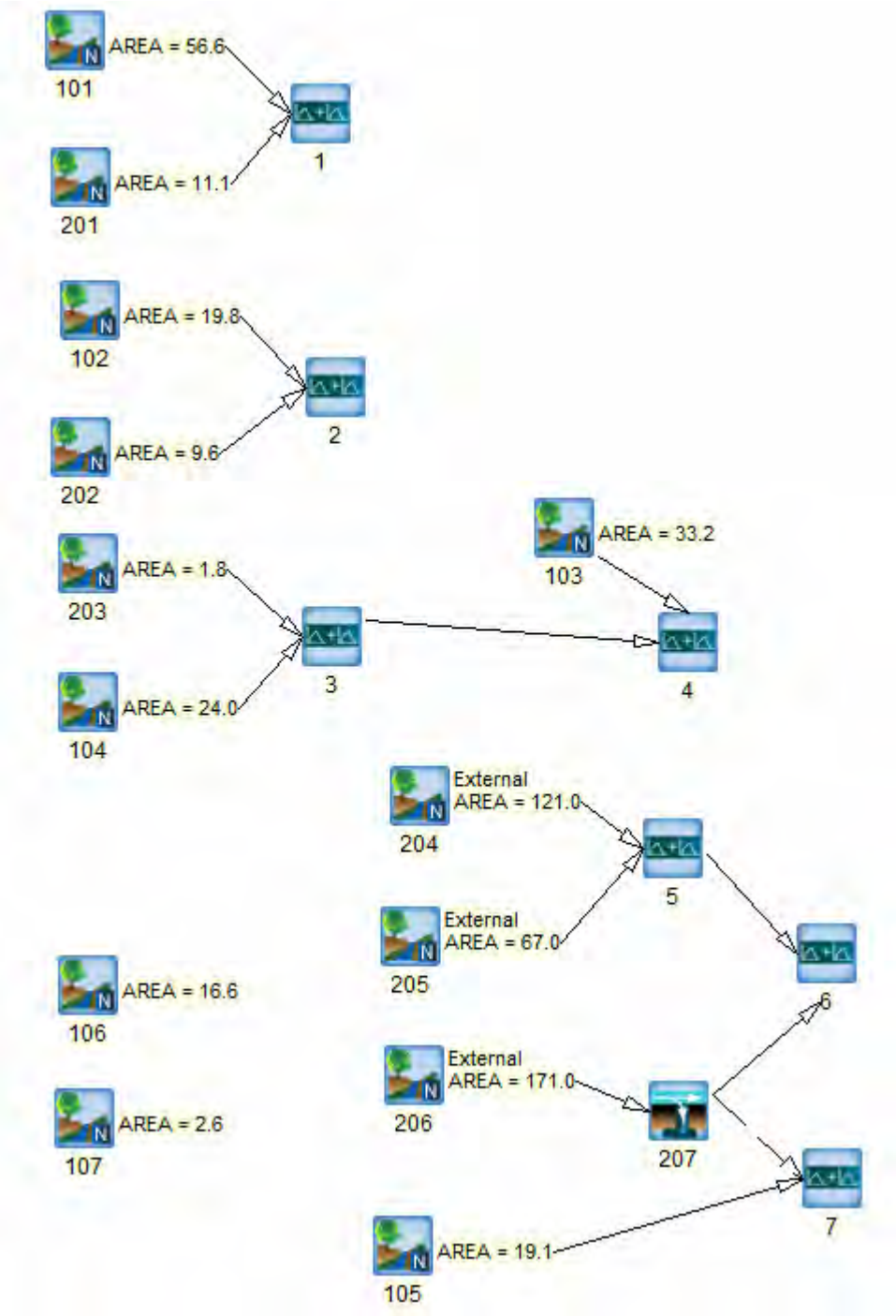
PRE-DEVELOPMENT MODELLING – PEAK FLOWS AT SWM FACILITIES (FROM ITEM #4 SUBMISSION)

SCS consulting group ltd

APPENDIX A1

CARSON ROAD

SCS consulting group ltd


AREA = 56.6
101
AREA = 11.1
201
1
AREA = 19.8
102
AREA = 9.6
202
2
AREA = 33.2
103
AREA = 1.8
203
AREA = 24.0
104
3
4
External
AREA = 121.0
204
External
AREA = 67.0
205
5
6
AREA = 16.6
106
AREA = 2.6
107
External
AREA = 171.0
206
207
7
AREA = 19.1
105

Carson Road Existing Conditions
VO2 Parameter Summary

Midhurst - Carson Road
Project Number : 1194
Date: June 2014
Designer Initials: JMP

NASHYD

Number	101	102	103	104	105	106	107
Description							
DT(min)	5	5	5	5	5	5	5
Area (ha)	56.6	19.8	33.2	24.0	19.1	16.6	2.6
CN	67.0	68.0	68.0	68.0	68.0	55.0	68.0
IA(mm)	7.0	7.0	7.0	7.0	7.0	8.5	7.0
TP (hr)	1.340	1.140	0.800	0.820	0.370	0.590	0.340

Number	201	202	203	204	205	206
Description						
DT(min)	5	5	5	5	5	5
Area (ha)	11.1	9.6	1.8	121.0	67.0	171.0
CN	66.0	68.0	68.0	67.0	68.0	65.0
IA(mm)	7.0	7.0	7.0	7.0	7.0	7.0
TP (hr)	0.650	0.470	0.320	1.210	0.920	1.370

Total Area = 553.4 ha

Initial Abstraction (IA) Values*

Cover	Depth (mm)
Woods	10.00
Pasture/Meadow	8.00
Cultivated	7.0
Lawns	5.0
Wetlands	12/16
Impervious Areas	2

*Values as per Table 10.2 of NVCA Stormwater Technical Guide

SCS CURVE NUMBER DETERMINATION

Site Soils: (as per Soils Mapping)

Soil Type	Hydrologic Soil Group
Tioga Loamy Sand	A
Vassey Sandy Loam	AB

TABLE OF CURVE NUMBERS (CN's)

Land Use	Hydrologic Soil Type						
	A	AB	B	BC	C	CD	D
Wetlands/Lakes/SWMF	50	50	50	50	50	50	50
Woods	32	46	60	67	73	76	79
Meadows	38	51	65	71	76	79	81
Pasture/Lawn	49	59	69	74	79	82	84
Cultivated	62	68	74	78	82	84	86
Impervious Areas	100	100	100	100	100	100	100

1. MTO Drainage Manual (1997), Design Chart 1.09-Soil/Land Use Curve Numbers
2. Chin (2000), Water-Resources Engineering, Table 6.13-Curve Numbers for Various Urban Land Uses

HYDROLOGIC SOIL TYPE (%) - Existing Conditions

Catchment	Hydrologic Soil Type							TOTAL
	A	AB	B	BC	C	CD	D	
101	23.5	76.5						100
102	0	100						100
103	0	100						100
104	0	100						100
105	0	100						100
106	20	80						100
107	0	100						100
201	35	65						100
202	0	100						100
203	0	100						100
204	20	80						100
205	0	100						100
206	50	50						100

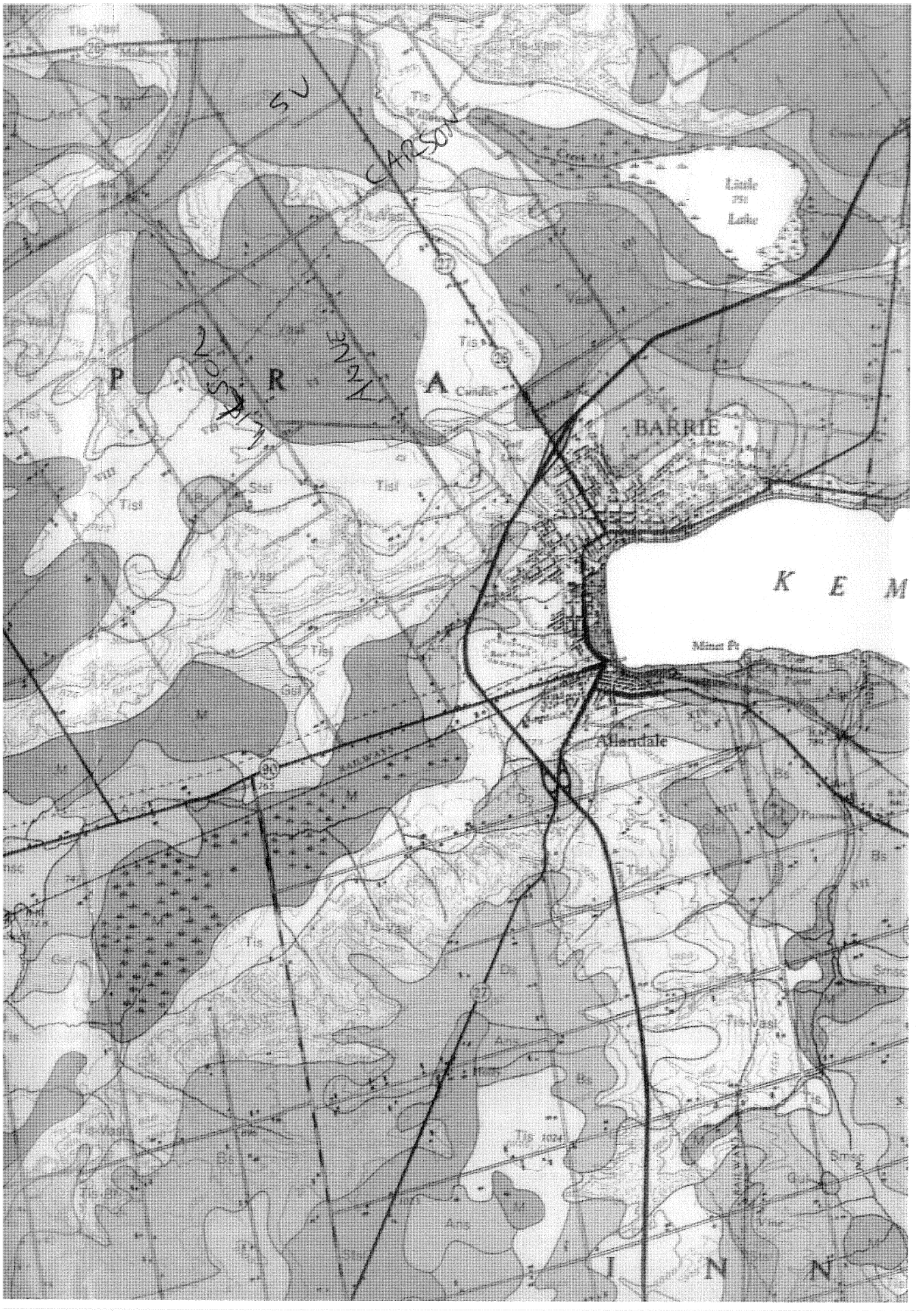
LAND USE (%) - Existing Conditions

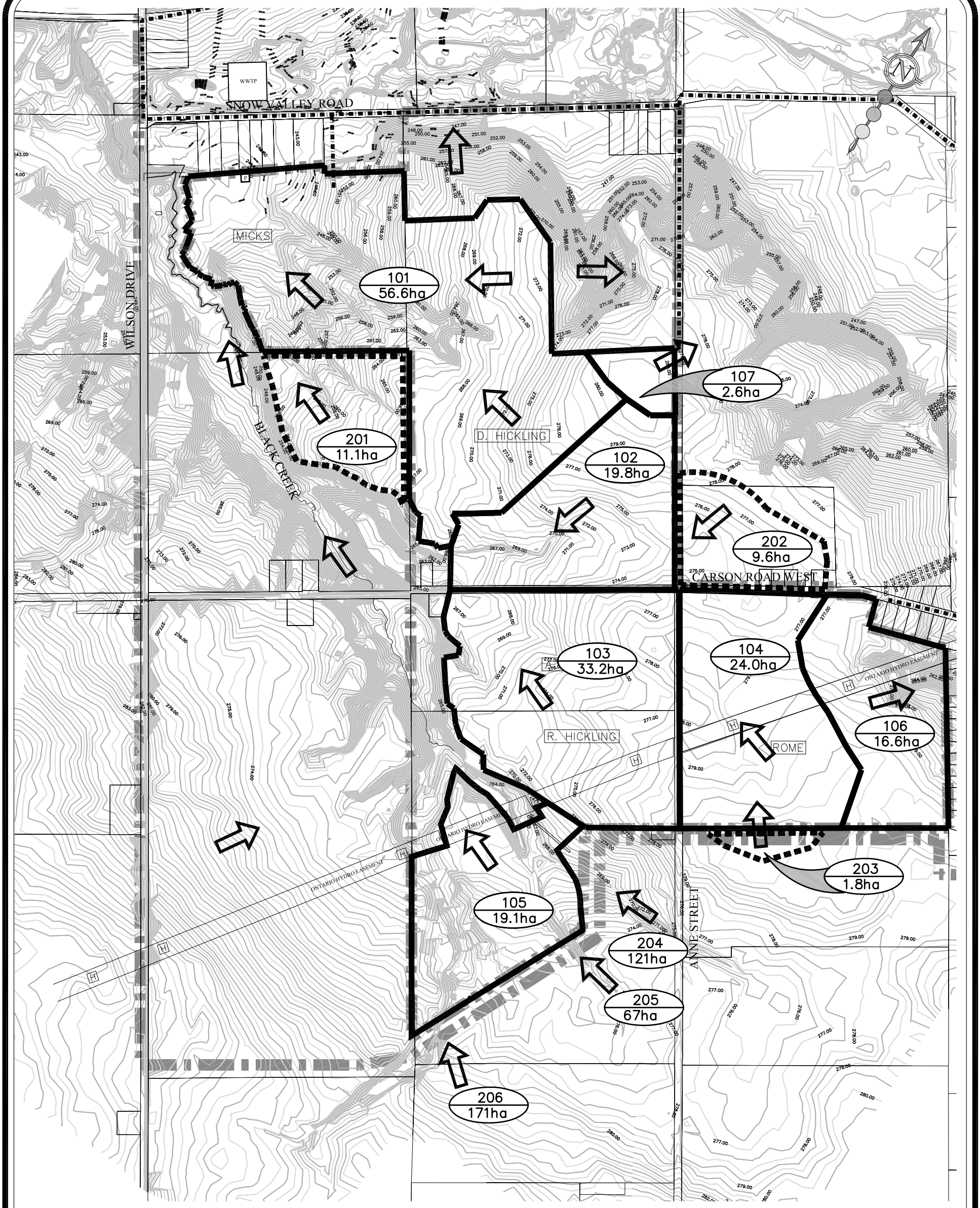
Catchment	Wetlands/Lakes/SWM	Woods	Meadows	Pasture/Lawn	Cultivated	Impervious Areas	Total
101	0.0	0.0	0.0	0.0	100.0	0.0	100.0
102	0.0	0.0	0.0	0.0	100.0	0.0	100.0
103	0.0	0.0	0.0	0.0	100.0	0.0	100.0
104	0.0	0.0	0.0	0.0	100.0	0.0	100.0
105	0.0	0.0	0.0	0.0	100.0	0.0	100.0
106	0.0	50.0	0.0	0.0	50.0	0.0	100.0
107	0.0	0.0	0.0	0.0	100.0	0.0	100.0
201	0.0	0.0	0.0	0.0	100.0	0.0	100.0
202	0.0	0.0	0.0	0.0	100.0	0.0	100.0
203	0.0	0.0	0.0	0.0	100.0	0.0	100.0
204	0.0	0.0	0.0	0.0	100.0	0.0	100.0
205	0.0	0.0	0.0	0.0	100.0	0.0	100.0
206	0.0	0.0	0.0	0.0	100.0	0.0	100.0

CURVE NUMBER (CN) - Existing Conditions

Catchment	Wetlands/Lakes/SWM	Woods	Meadows	Pasture/Lawn	Cultivated	Impervious Areas	Weighted CN
101	0.0	0.0	0.0	0.0	66.6	0.0	67
102	0.0	0.0	0.0	0.0	68.0	0.0	68
103	0.0	0.0	0.0	0.0	68.0	0.0	68
104	0.0	0.0	0.0	0.0	68.0	0.0	68
105	0.0	0.0	0.0	0.0	68.0	0.0	68
106	0.0	21.6	0.0	0.0	33.4	0.0	55
107	0.0	0.0	0.0	0.0	68.0	0.0	68
201	0.0	0.0	0.0	0.0	65.9	0.0	66
202	0.0	0.0	0.0	0.0	68.0	0.0	68
203	0.0	0.0	0.0	0.0	68.0	0.0	68
204	0.0	0.0	0.0	0.0	66.8	0.0	67
205	0.0	0.0	0.0	0.0	68.0	0.0	68
206	0.0	0.0	0.0	0.0	65.0	0.0	65

** post development catchments concerned with pervious CN values only
** AMC II assumed
** Hydrological Soil Group taken from MTO Drainage Manual for each soil type


SV
CARSON
P R A
BARRIE
K E M
Allendale
Minet Pt
I N N



LEGEND:

- LIMIT OF DEVELOPMENT APPLICATION
- LIMIT OF SECONDARY PLAN STUDY
- HYDRO TOWER
- OVERLAND FLOW DIRECTION
- 101 / 20.0ha — CATCHMENT ID / DRAINAGE AREA
- STORM DRAINAGE BOUNDARY
- EXTERNAL DRAINAGE BOUNDARY

CARSON ROAD DEVELOPMENT INC. (CRDI)

PRE-DEVELOPMENT DRAINAGE PLAN

CARSON ROAD DEVELOPMENT INC.
3190 STEELES AVE. EAST, SUITE 3000
MARKHAM, ONTARIO L3R 1G9
TEL: (905) 477-1177
FAX: (905) 477-1279

SCS consulting group ltd
30 CENTURIAN DRIVE, SUITE 100
MARKHAM, ONTARIO L3R 8B8
TEL: (905) 475-1900
FAX: (905) 475-8335

DATE:	APRIL 2013	CHECKED BY:	J.M.P
SCALE:	1:10000	DRAWN BY:	S.F./V.W.
PROJECT No:	1194	FIGURE No:	4.1

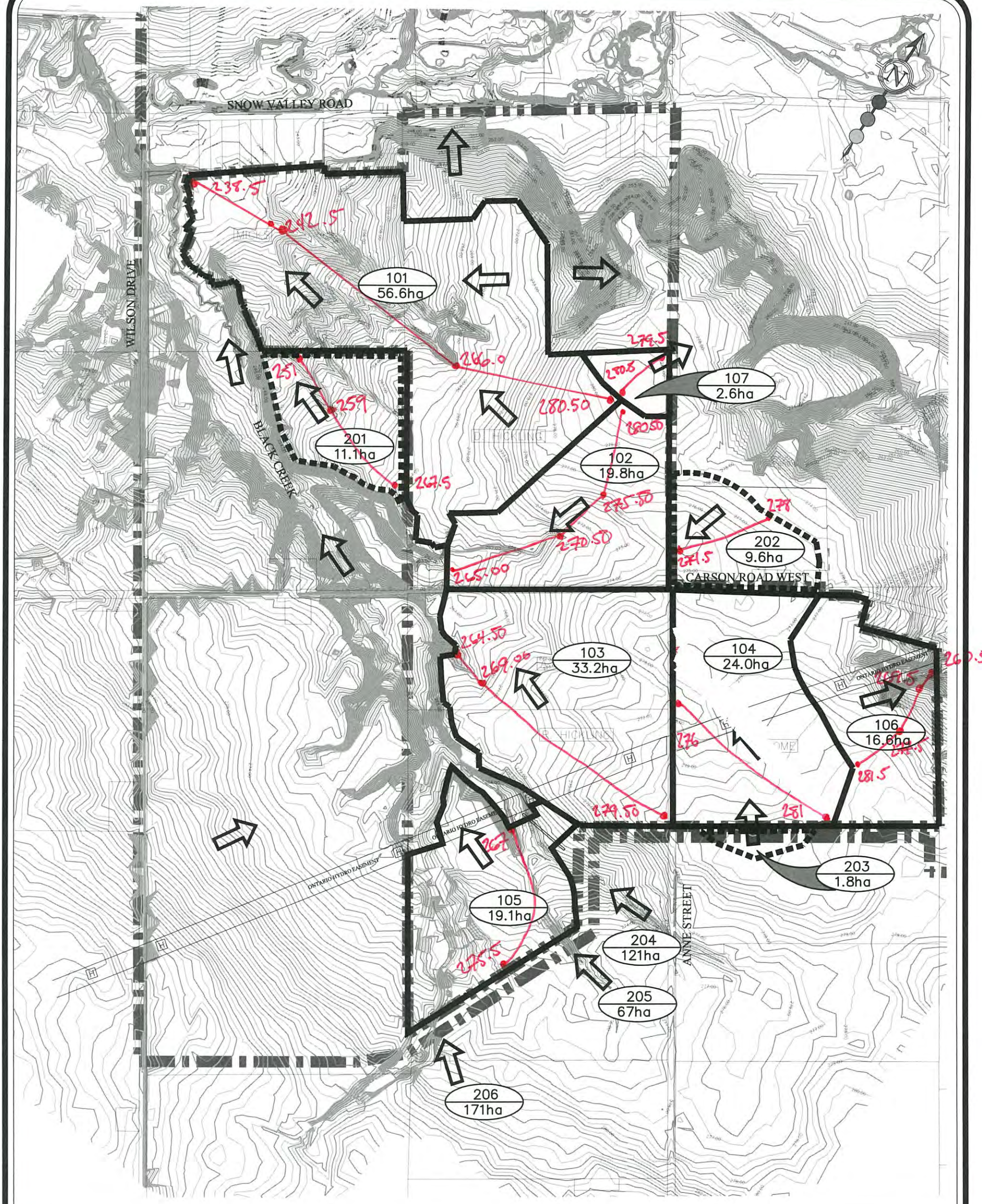
File: P:\1194 Midhurst Carson Road\Drawings\FSP\Figs\Report Figures\1194D-PREL-PRED-4.1.dwg - Revised by <KPESENGCO> : Wed, Jun 04 2014 - 3:43pm

Airport Equation

Catchment ID	High Elevation	Low Elevation	Length (m)	Slope (%)	Runoff Coefficient		Time of Concentration (min)	Time of Concentration (hr)	Time to Peak (hr)
101	280.5	266	482	3.0	0.22		43.8	0.73	0.49
101	266	242.5	530	4.4	0.22		40.4	0.67	0.45
101	242.5	238.5	227	1.8	0.22		35.9	0.60	0.40
101									**1.34**
102	280.5	275.5	231	2.2	0.22		33.8	0.56	0.38
102	275.5	270.5	150	3.3	0.22		23.6	0.39	0.26
102	270.5	265.0	332	1.7	0.22		44.3	0.74	0.49
102									**1.14**
103	279.5	269	552	1.9	0.22		54.5	0.91	0.61
103	269	264.5	100	4.5	0.22		17.5	0.29	0.20
103									**0.80**
104	281	276	586	0.9	0.22		73.2	1.22	0.82
104									**0.82**
105	275.5	267	283	3.0	0.22		33.6	0.56	0.37
105									**0.37**
106	281.5	277.5	173	2.3	0.22		28.6	0.48	0.32
106	277.5	269.5	105	7.6	0.12		16.7	0.28	0.19
106	269.5	260.5	44	20.5	0.18		7.3	0.12	0.08
106									**0.59**
107	280.8	279.5	120	1.1	0.22		30.6	0.51	0.34
107									**0.34**
201	267.5	259	271	3.1	0.22		32.4	0.54	0.36
201	259	251	200	4.0	0.22		25.7	0.43	0.29
201									**0.65**
202	278	274.5	264	1.3	0.22		42.5	0.71	0.47
202									**0.47**
203	282.5	280.8	123	1.4	0.22		28.6	0.48	0.32
203									**0.32**
204	290	268	1695	1.3	0.22		108.4	1.81	1.21
204									**1.21**
205	296	270	1300	2.0	0.22		82.3	1.37	0.92
205									**0.92**
206	311	275	2390	1.5	0.22		122.5	2.04	1.37
206									**1.37**

Uplands Method

Catchment ID	High Elevation	Low Elevation	Length (m)	Slope (%)	Land Cover Type	Velocity (m/s)	Time of Concentration (s)	Time of Concentration (hr)	Time to Peak (hr)
101	280.5	266	482	3.0	Cultivated Straight Row	0.48	997.0	0.28	0.19
101	266	242.5	530	4.4	Cultivated Straight Row	0.59	904.0	0.25	0.17
101	242.5	238.5	227	1.8	Cultivated Straight Row	0.37	612.6	0.17	0.11
101									**0.47**
102	280.5	275.5	231	2.2	Cultivated Straight Row	0.41	562.8	0.16	0.10
102	275.5	270.5	150	3.3	Cultivated Straight Row	0.51	294.8	0.08	0.05
102	270.5	265.0	332	1.7	Cultivated Straight Row	0.36	923.9	0.26	0.17
102									**0.33**
103	279.5	269	552	1.9	Cultivated Straight Row	0.38	1434.0	0.40	0.27
103	269	264.5	100	4.5	Cultivated Straight Row	0.59	169.3	0.05	0.03
103									**0.30**
104	281	276	586	0.9	Cultivated Straight Row	0.26	2267.9	0.63	0.42
104									**0.42**
105	275.5	267	283	3.0	Cultivated Straight Row	0.48	585.8	0.16	0.11
105									**0.11**
106	281.5	277.5	173	2.3	Cultivated Straight Row	0.42	407.9	0.11	0.08
106	277.5	269.5	105	7.6	Woodland	0.42	252.2	0.07	0.05
106	269.5	260.5	44	20.5	Woodland	0.68	64.6	0.02	0.01
106									**0.13**
107	280.8	279.5	120	1.1	Cultivated Straight Row	0.29	412.4	0.11	0.08
107									**0.08**
201	267.5	259	271	3.1	Cultivated Straight Row	0.49	549.0	0.15	0.10
201	259	251	200	4.0	Cultivated Straight Row	0.56	359.0	0.10	0.07
201									**0.17**
202	278	274.5	264	1.3	Cultivated Straight Row	0.32	820.7	0.23	0.15
202									**0.15**
203	282.5	280.8	123	1.4	Cultivated Straight Row	0.33	374.5	0.10	0.07
203									**0.07**
204	290	268	1695	1.3	Cultivated Straight Row	0.32	5325.0	1.48	0.99
204									**0.99**
205	296	270	1300	2.0	Cultivated Straight Row	0.39	3294.1	0.92	0.61
205									**0.61**
206	311	275	2390	1.5	Cultivated Straight Row	0.34	6972.8	1.94	1.30
206									**1.30**



LEGEND:

- LIMIT OF DEVELOPMENT APPLICATION
- LIMIT OF SECONDARY PLAN STUDY
- HYDRO TOWER
- OVERLAND FLOW DIRECTION
- 101 / 20.0ha — CATCHMENT ID / DRAINAGE AREA
- STORM DRAINAGE BOUNDARY
- EXTERNAL DRAINAGE BOUNDARY

CARSON ROAD DEVELOPMENT INC. (CRDI)

PRE-DEVELOPMENT ~~DRAINAGE PLAN~~ TIME TO PEAK FIGURE

CARSON ROAD DEVELOPMENT INC.
3190 STEELES AVE. EAST, SUITE 3000
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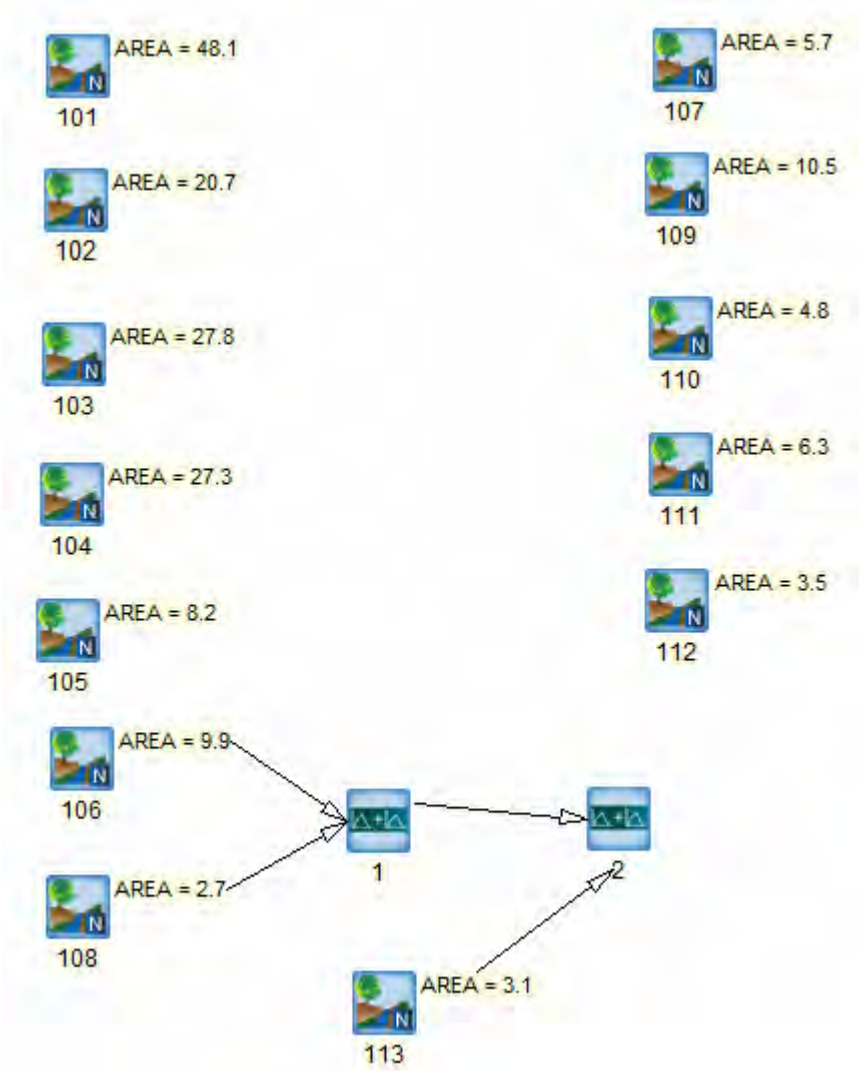
DATE:	APRIL 2013	CHECKED BY:	J.M.P
SCALE:	1:10000	DRAWN BY:	S.F./V.W.
PROJECT No:	1194	FIGURE No:	4.1

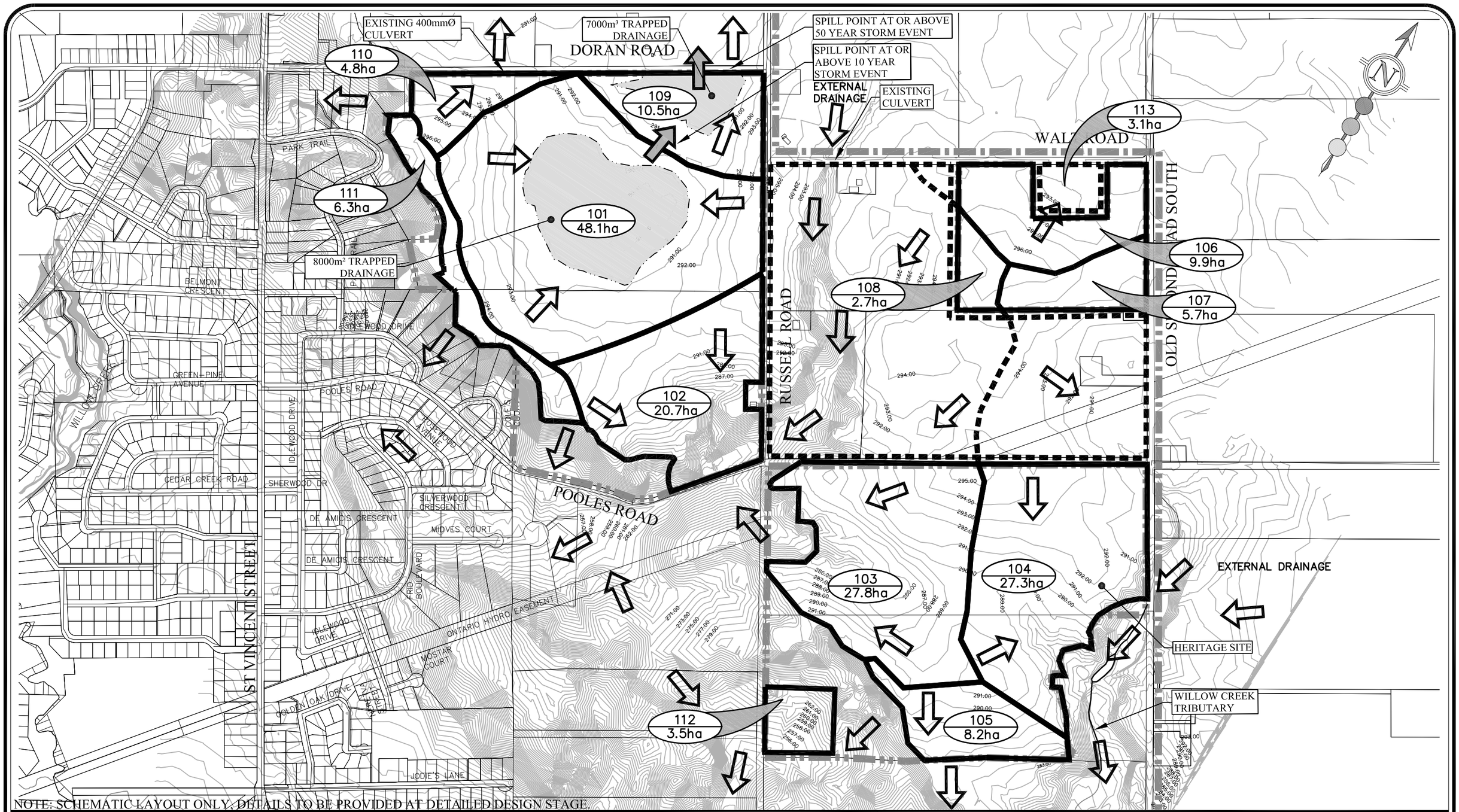
File: P:\1194 Midhurst Carson Road\Drawings\FSP\Figs\Report Figures\1194D-PREL-PRED-4.1.dwg - Revised by <KPESENGCO> : Wed, Jun 04 2014 - 3:43pm

APPENDIX A2

DORAN ROAD

SCS consulting group ltd


AREA = 48.1
101
AREA = 20.7
102
AREA = 27.8
103
AREA = 27.3
104
AREA = 8.2
105
AREA = 9.9
106
AREA = 2.7
108
1
2
AREA = 3.1
113
AREA = 5.7
107
AREA = 10.5
109
AREA = 4.8
110
AREA = 6.3
111
AREA = 3.5
112



NOTE: SCHEMATIC LAYOUT ONLY. DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE.

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TEL: (905) 475-1900
FAX: (905) 475-8335

LEGEND:

- LIMIT OF DEVELOPMENT APPLICATION
- LIMIT OF SECONDARY PLAN STUDY
- EXISTING STORM DRAINAGE BOUNDARY
- EXTERNAL DRAINAGE BOUNDARY
- TRAPPED DRAINAGE AREA
- TRAPPED DRAINAGE FLOW
- OVERLAND FLOW DIRECTION
- 101 / 20.0ha — CATCHMENT ID / DRAINAGE AREA

MIDHURST DEVELOPMENT DORAN ROAD INC. (MDDRI)

PRE-DEVELOPMENT DRAINAGE PLAN

DRAWN BY: S.F.	CHECKED BY: T.A.P.
SCALE: 1:10000	DATE: SEPTEMBER 2009
PROJECT No: 1168	FIGURE No: 4.1

File: P:\1168 Midhurst – Doran Road\Drawings\FSP\Fig\Report Figures\1168D-PREL-DRNG-4.1.dwg – Revised by <VSZEGHALMI> : Wed, Sep 23 2009 – 10:56am

Doran Road Existing Conditions
VO2 Parameter Summary

Midhurst - Doran Road
Project Number : 1168
Date: June 2014
Designer Initials: JMP

NASHYD

Number	101	102	103	104	105	106	107
Description							
DT(min)	5	5	5	5	5	5	5
Area (ha)	48.1	20.7	27.8	27.3	8.2	9.9	5.7
CN	68.0	65.0	66.0	68.0	65.0	68.0	68.0
IA(mm)	7.0	7.0	7.0	7.0	7.0	7.0	7.0
TP (hr)	0.729	0.676	0.882	0.858	0.340	0.429	0.511

Number	108	109	110	111	112	113
Description						
DT(min)	5	5	5	5	5	5
Area (ha)	2.7	10.5	4.8	6.3	3.5	3.1
CN	68.0	68.0	68.0	68.0	54.0	68.0
IA(mm)	7.0	7.0	7.0	7.0	7.0	7.0
TP (hr)	0.468	0.417	0.468	0.194	0.255	0.507

Total Area = 178.6 ha

Initial Abstraction (IA) Values*

Cover	Depth (mm)
Woods	10.00
Pasture/Meadow	8.00
Cultivated	7.0
Lawns	5.0
Wetlands	12/16
Impervious Areas	2

*Values as per Table 10.2 of NVCA Stormwater Technical Guide

SCS CURVE NUMBER DETERMINATION

Site Soils: (as per Soils Mapping)

Soil Type	Hydrologic Soil Group
Tioga Loamy Sand	A
Vassey Sandy Loam	AB
Dundonald Sandy Loam	AB

TABLE OF CURVE NUMBERS (CN's)

Land Use	Hydrologic Soil Type							Manning's 'n'
	A	AB	B	BC	C	CD	D	
Wetlands/Lakes/SWMF	50	50	50	50	50	50	50	0.40
Woods	32	46	60	67	73	76	79	0.40
Meadows	38	51	65	71	76	79	81	0.17
Pasture/Lawn	49	59	69	74	79	82	84	0.20
Cultivated	62	68	74	78	82	84	86	0.05
Impervious Areas	100	100	100	100	100	100	100	0.01

HYDROLOGIC SOIL TYPE (%) - Existing Conditions

Catchment	Hydrologic Soil Type							TOTAL
	A	AB	B	BC	C	CD	D	
101		100						100
102	50	50						100
103	37.5	62.5						100
104		100						100
105	50	50						100
106		100						100
107		100						100
108		100						100
109		100						100
110		100						100
111		100						100
112	50	50						100
113	50	50						100

LAND USE (%) - Existing Conditions

Catchment	Wetlands/Lakes/SWM	Woods	Meadows	Pasture/Lawn	Cultivated	Impervious Areas	Total
101	0.0	0.0	0.0	0.0	100.0	0.0	100.0
102	0.0	0.0	0.0	0.0	100.0	0.0	100.0
103	0.0	0.0	0.0	0.0	100.0	0.0	100.0
104	0.0	0.0	0.0	0.0	100.0	0.0	100.0
105	0.0	0.0	0.0	0.0	100.0	0.0	100.0
106	0.0	0.0	0.0	0.0	100.0	0.0	100.0
107	0.0	0.0	0.0	0.0	100.0	0.0	100.0
108	0.0	0.0	0.0	0.0	100.0	0.0	100.0
109	0.0	0.0	0.0	0.0	100.0	0.0	100.0
110	0.0	0.0	0.0	0.0	100.0	0.0	100.0
111	0.0	0.0	0.0	0.0	100.0	0.0	100.0
112	0.0	0.0	0.0	100.0	0.0	0.0	100.0
113	0.0	0.0	0.0	100.0	0.0	0.0	100.0

CURVE NUMBER (CN) - Existing Conditions

Catchment	Wetlands/Lakes/SWM	Woods	Meadows	Pasture/Lawn	Cultivated	Impervious Areas	Weighted CN	IA	Manning's 'n'
101	0.0	0.0	0.0	0.0	68.0	0.0	68	23.91	0.05
102	0.0	0.0	0.0	0.0	65.0	0.0	65	27.35	0.05
103	0.0	0.0	0.0	0.0	65.8	0.0	66	26.17	0.05
104	0.0	0.0	0.0	0.0	68.0	0.0	68	23.91	0.05
105	0.0	0.0	0.0	0.0	65.0	0.0	65	27.35	0.05
106	0.0	0.0	0.0	0.0	68.0	0.0	68	23.91	0.05
107	0.0	0.0	0.0	0.0	68.0	0.0	68	23.91	0.05
108	0.0	0.0	0.0	0.0	68.0	0.0	68	23.91	0.05
109	0.0	0.0	0.0	0.0	68.0	0.0	68	23.91	0.05
110	0.0	0.0	0.0	0.0	68.0	0.0	68	23.91	0.05
111	0.0	0.0	0.0	0.0	68.0	0.0	68	23.91	0.05
112	0.0	0.0	0.0	54.0	0.0	0.0	54	43.27	0.20
113	0.0	0.0	0.0	54.0	0.0	0.0	54	43.27	0.20

** post development catchments concerned with pervious CN values only
** AMC II assumed
** Hydrological Soil Group taken from MTO Drainage Manual for each soil type


Craighurst
Tis-Vasl
Gsl
Stsl
Tis
Ds
Vasl-b
Gus
Bs
Ans
Gul
Vasl
Bl
Li
M
Dalton
Midhurst
BARRIE
HWY 400
SOUTH
SIDE RD
RUSSELL RD
RAILWAY
WASTED
DORAN RD
KEMPENFELT
Ds - Dundonald Sandy Loam (AB)
Tis - Tioga (A)
Vsl - Vassey Sandy Loam (AB)

Uplands Method

Catchment ID	High Elevation	Low Elevation	Length (m)	Slope (%)	Land Cover Type	Velocity (m/s)	Time of Concentration (hr)	Time to Peak (hr)
101	296.25	288.75	600	1.3	Cultivated Straight Row	0.31	0.53	**0.36**
102	294	285	378	2.4	Cultivated Straight Row	0.43	0.24	0.16
102	285	272	54	24.1	Cultivated Straight Row	1.36	0.01	0.01
102	272	266	86	7.0	Cultivated Straight Row	0.73	0.03	0.02
102								**0.19**
103	291.7	283.75	477	1.7	Cultivated Straight Row	0.36	0.37	0.25
103	283.75	281	133	2.1	Cultivated Straight Row	0.40	0.09	0.06
103								**0.31**
104	295.18	288	400	1.8	Cultivated Straight Row	0.37	0.30	0.20
104	288	284	180	2.2	Cultivated Straight Row	0.42	0.12	0.08
104								**0.28**
105	291.75	286	215	2.7	Cultivated Straight Row	0.46	0.13	**0.09**
106	296.25	293.25	220	1.4	Cultivated Straight Row	0.33	0.19	**0.13**
107	296.3	293	282	1.2	Cultivated Straight Row	0.30	0.26	**0.17**
108	296.3	294.6	195	0.9	Cultivated Straight Row	0.26	0.21	**0.14**
109	294	289.5	250	1.8	Cultivated Straight Row	0.37	0.19	**0.12**
110	296.3	294.6	195	0.9	Cultivated Straight Row	0.26	0.21	**0.14**
111	296.25	293.8	78	3.1	Cultivated Straight Row	0.49	0.04	**0.03**
112	273	254	275	6.9	Pasture	0.58	0.13	**0.09**
113	294	292.5	175	0.9	Pasture	0.20	0.24	**0.16**

Airport Equation

Catchment ID	High Elevation	Low Elevation	Length (m)	Slope (%)	Runoff Coefficient	Time of Concentration (hr)	Time to Peak (hr)
101	296.25	288.75	600	1.3	0.22	1.088	**0.729**
102	294	285	378	2.4	0.22	0.698	0.468
102	285	272	54	24.1	0.4	0.098	0.066
102	272	266	86	7.0	0.3	0.212	0.142
102							**0.676**
103	291.7	283.75	477	1.7	0.22	0.882	0.591
103	283.75	281	133	2.1	0.22	0.434	0.291
103							**0.882**
104	295.18	288	400	1.8	0.22	0.788	0.528
104	288	284	180	2.2	0.22	0.493	0.330
104							**0.858**
105	291.75	286	215	2.7	0.22	0.507	**0.340**
106	296.25	293.25	220	1.4	0.22	0.640	**0.429**
107	296.3	293	282	1.2	0.22	0.762	**0.511**
108	296.3	294.6	195	0.9	0.22	0.699	**0.468**
109	294	289.5	250	1.8	0.22	0.623	**0.417**
110	296.3	294.6	195	0.9	0.22	0.699	**0.468**
111	296.25	293.8	78	3.1	0.22	0.289	**0.194**
112	273	254	275	6.9	0.15	0.452	**0.303**
113	294	292.5	175	0.9	0.10	0.756	**0.507**

EXISTING 400mmØ CULVERT

7000m³ TRAPPED DRAINAGE

SPILL POINT AT OR ABOVE 50 YEAR STORM EVENT

SPILL POINT AT OR ABOVE 10 YEAR STORM EVENT

EXTERNAL DRAINAGE

EXISTING CULVERT

DORAN ROAD

WALL ROAD

OLD SCUGOG ROAD SOUTH

RUSSELL ROAD

POOLES ROAD

ST VINCENT STREET

8000m² TRAPPED DRAINAGE

110 4.8ha

111 6.3ha

109 10.5ha

101 48.1ha

102 20.7ha

113 3.1ha

106 9.9ha

107 5.7ha

108 2.7ha

104 27.3ha

103 27.8ha

105 8.2ha

112 3.5ha

HERITAGE SITE

WILLOW CREEK TRIBUTARY

EXTERNAL DRAINAGE

PARK TRAIL

BELMONT CRESCENT

IDLEWOOD DRIVE

GREEN-PINE AVENUE

CEDAR CREEK ROAD

SHERWOOD DR

SILVERWOOD CRESCENT

DE AMICIS CRESCENT

MIDVES COURT

GOLDEN OAK DRIVE

JODIE'S LANE

NOTE: SCHEMATIC LAYOUT ONLY, DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE

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SCS consulting group ltd

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TEL: (905) 475-1900
FAX: (905) 475-8335

LEGEND:

- LIMIT OF DEVELOPMENT APPLICATION
- LIMIT OF SECONDARY PLAN STUDY
- EXISTING STORM DRAINAGE BOUNDARY
- EXTERNAL DRAINAGE BOUNDARY
- TRAPPED DRAINAGE AREA
- TRAPPED DRAINAGE FLOW
- OVERLAND FLOW DIRECTION
- 101 / 20.0ha — CATCHMENT ID / DRAINAGE AREA

MIDHURST DEVELOPMENT DORAN ROAD INC. (MDDRI)

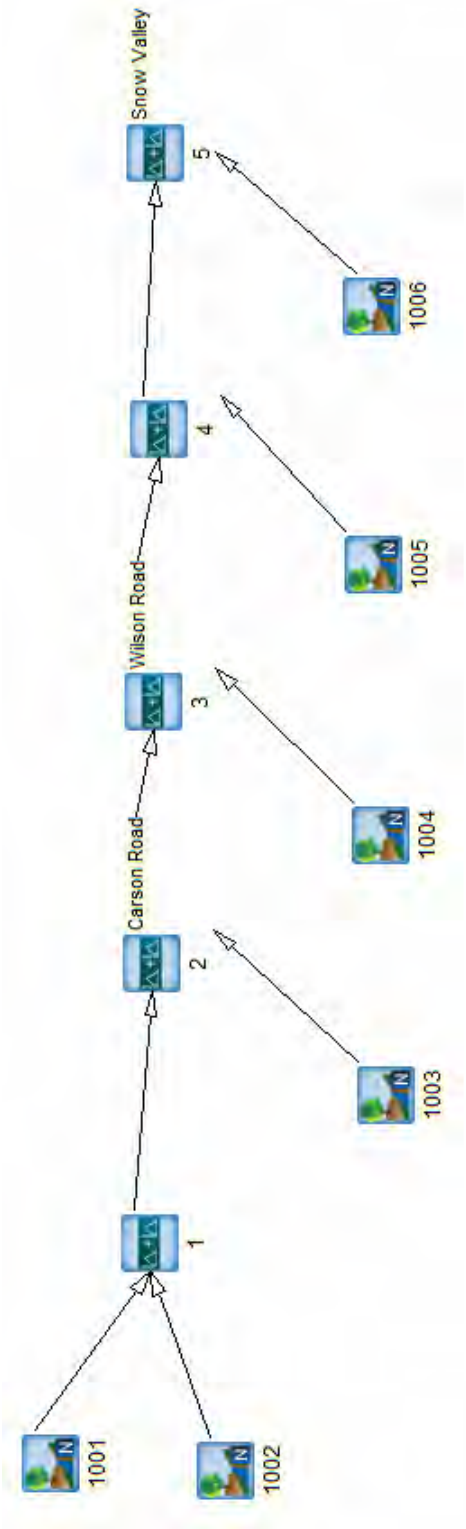
PRE-DEVELOPMENT TIME TO ~~DRAINAGE PLAN~~ Peak Figures

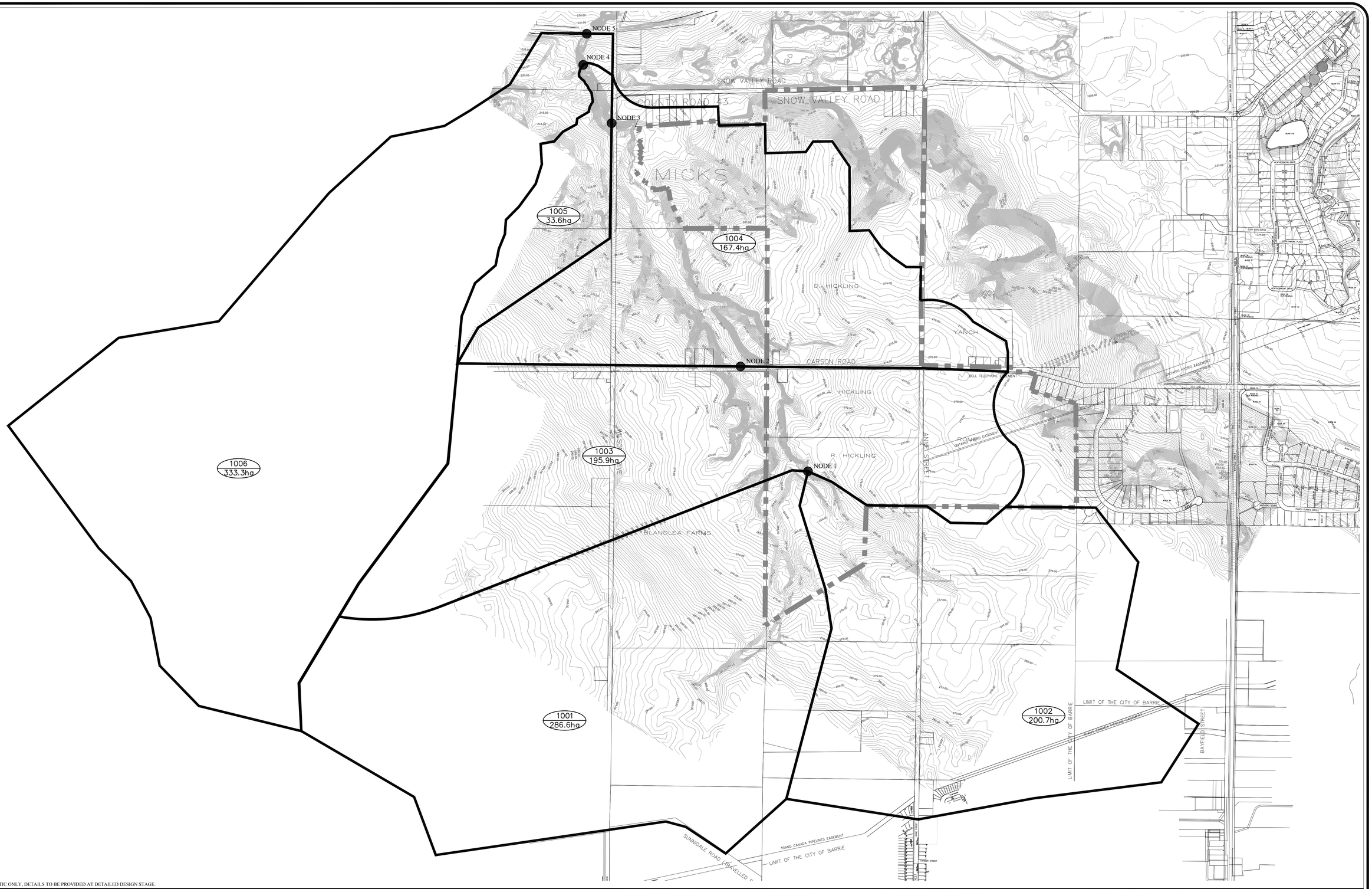
DRAWN BY: S.F.	CHECKED BY: T.A.P.
SCALE: 1:10000	DATE: SEPTEMBER 2009
PROJECT No: 1168	FIGURE No: 4.1

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PRE-DEVELOPMENT MODELLING – CUMULATIVE ANALYSIS




Snow Valley
5
1006
4
1005
Wilson Road
3
1004
Carson Road
2
1003
1
1001
1002



*NOTE: LAYOUT IS SCHEMATIC ONLY, DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE.

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FAX: (905) 475-8335

LEGEND:

- PROPERTY LIMIT
- STORM DRAINAGE BOUNDARY
- 1001 / 279.1ha* — CATCHMENT ID / DRAINAGE AREA (HECTARES)

MIDHURST SECONDARY PLAN - CARSON ROAD

PRE-DEVELOPMENT DRAINAGE PLAN

DESIGNED BY: J.M.P.	CHECKED BY: S.M.S.	PROJECT No: 1194	FIGURE No: 1
SCALE: 1:7500	DATE: MAY 2014		

File: P:\1212 Midhurst Growth Study\Drawings\Secondary Plan\Fig\MDP Figures\1212D-PREL-PRED-CARSON.dwg – Revised by <CDUNNING> : Tue, May 06 2014 – 11:02am

Existing Conditions
VO2 Parameter Summary

NASHYD

Number	1001	1002	1003	1004	1005	1006
Description						
DT(min)	2	2	2	2	2	2
Area (ha)	286.6	200.7	195.9	167.4	33.6	333.3
CN	68.0	68.0	68.0	64.0	57.0	55.0
IA(mm)	6.8	6.7	6.9	6.8	7.5	8.3
TP (hr)	1.66	1.26	1.40	1.21	0.45	1.16

Existing Conditions

Site Soils: (per Simcoe County Soils Mapping)

Soil Type	Hydrologic Soil Group
Tioga Loamy Sand	A
Tioga Sandy Loam	A
Vasey Sandy Loam	AB
Sargent Gravelly Sandy Loam	AB

TABLE OF CURVE NUMBERS (CN's)**

Land Use	Hydrologic Soil Type							Manning's 'n'	Source
	A	AB	B	BC	C	CD	D		
Meadow "Good"	38	51	65	71	76	79	81	0.40	MTO
Woodlot "Fair"	32	46	60	67	73	76	79	0.40	MTO
Gravel	76	80.5	85	87	89	90	91	0.30	USDA
Lawns "Good"	49	59	69	74	79	82	84	0.25	USDA
Pasture/Range	49	59	69	74	79	82	84	0.17	MTO
Crop	62	68	74	78	82	84	86	0.13	MTO
Fallow (Bare)	77	82	86	89	91	93	94	0.05	MTO
Low Density Residences	57	64.5	72	76.5	81	83.5	86	0.25	USDA
Streets, paved	100	100	100	100	100	100	100	0.01	USDA

1. MTO Drainage Manual (1997), Design Chart 1.09-Soil/Land Use Curve Numbers
2. USDA (1986), Urban Hydrology for Small Watersheds, Table 2.2-Runoff Curve Numbers for Urban Areas

HYDROLOGIC SOIL TYPE (%) - Existing Conditions

Catchment	Hydrologic Soil Type							TOTAL
	A	AB	B	BC	C	CD	D	
1001	29.9	70.1						100
1002	14.8	85.2						100
1003	11.8	88.2						100
1004	100							100
1005	100							100
1006	32.1	67.9						100

LAND USE (%) - Existing Conditions

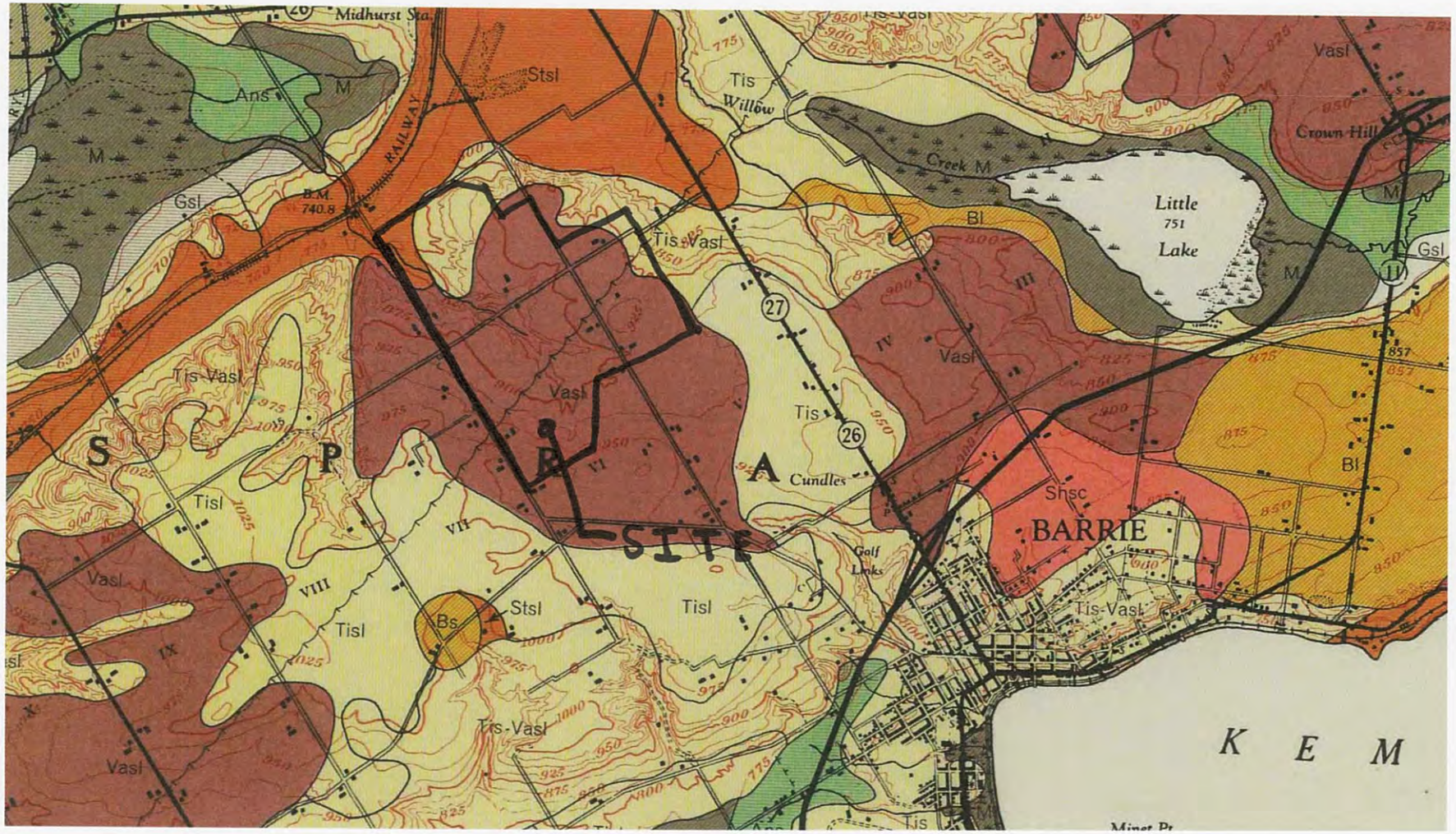
Catchment	Meadow	Woodlot	Gravel	Lawns	Pasture Range	Crop	Fallow (Bare)	Low Density Residences	Impervious	Total
1001						95.6			4.4	100.0
1002						93.0		5.2	1.8	100.0
1003						97.6			2.4	100.0
1004						95.3			4.7	100.0
1005		15.9				84.1				100.0
1006		44.4				55.6				100.0

Note: Where STANDHYD command used (shaded), impervious fraction is not considered in CN determination, since %Imp directly input in STANDHYD command

CURVE NUMBER (CN) - Existing Conditions

Catchment	Meadow	Woodlot	Gravel	Lawns	Pasture Range	Crop	Fallow (Bare)	Low Density Residences	Impervious	Weighted CN
1001	0.0	0.0	0.0	0.0	0.0	63.3	0.0	0.0	4.4	68
1002	0.0	0.0	0.0	0.0	0.0	62.4	0.0	3.3	1.8	68
1003	0.0	0.0	0.0	0.0	0.0	65.6	0.0	0.0	2.4	68
1004	0.0	0.0	0.0	0.0	0.0	59.1	0.0	0.0	4.7	64
1005	0.0	5.1	0.0	0.0	0.0	52.2	0.0	0.0	0.0	57
1006	0.0	18.4	0.0	0.0	0.0	36.7	0.0	0.0	0.0	55

** AMC II assumed


Midhurst Sta.
RAILWAY
Ans
M
Stsl
Tis
Willow
Creek
Vasl
Crown Hill
Gsl
B.M.
740.8
Tis-Vasl
Little
751
Lake
Bl
27
26
11
Vasl
Tis
Cundles
SITE
S
P
A
Tisl
Golf
Links
Shsc
BARRIE
Bs
Stsl
Tisl
Tis-Vasl
K E M
Vasl
Tis-Vasl
Vasl

Existing Conditions

LAND USE (%) - Existing Conditions										
Catchment	Meadow	Woodlot	Gravel	Lawns	Pasture Range	Crop	Fallow (Bare)	Low Density Residences	Impervious	Total
1001						95.6			4.4	100.0
1002						93.0		5.2	1.8	100.0
1003						97.6			2.4	100.0
1004						95.3			4.7	100.0
1005		15.9				84.1				100.0
1006		44.4				55.6				100.0

IA VALUES (mm) - Existing Conditions										
Catchment	Meadow	Woodlot	Gravel	Lawns	Pasture Range	Crop	Fallow (Bare)	Low Density Residences	Impervious	Total
IA (mm)	8	10	2	5	8	7	3	2	2	
1001						6.7			0.1	6.8
1002						6.5		0.1	0.0	6.7
1003						6.8			0.0	6.9
1004						6.7			0.1	6.8
1005		1.6				5.9				7.5
1006		4.4				3.9				8.3

* IA values based on NVCA guidelines

Uplands Method:

Catchment ID	High Elevation	Low Elevation	Length (m)	Slope (%)	Land Cover Type	Velocity (m/s)	Time of Concentration (s)	Time of Concentration (hr)	Time to Peak (hr)
1001a	311.00	275.00	2390	1.51	Cultivated Straight Row	0.34	6972.8	1.94	1.30
1001b	275.00	259.00	775	2.06	Cultivated Straight Row	0.40	1933.0	0.54	0.36
1001									**1.66**
1002a	290.00	268.00	1711	1.29	Cultivated Straight Row	0.32	5399.2	1.50	1.00
1002b	268.00	262.50	435	1.27	Cultivated Straight Row	0.31	1382.8	0.38	0.26
1002									**1.26**
1003a	305.50	301.00	787	0.57	Cultivated Straight Row	0.21	3718.1	1.03	0.69
1003b	301.00	284.25	700	2.39	Cultivated Straight Row	0.43	1621.2	0.45	0.30
1003c	284.25	269.00	484	3.15	Cultivated Straight Row	0.49	977.3	0.27	0.18
1003d	269.00	254.50	367	3.95	Cultivated Straight Row	0.55	661.9	0.18	0.12
1003e	254.50	252.50	244	0.82	Waterway	0.43	568.7	0.16	0.11
1003									**1.40**
1004a	277.25	270.00	722	1.00	Cultivated Straight Row	0.28	2576.6	0.72	0.48
1004b	270.00	265.00	329	1.52	Cultivated Straight Row	0.34	955.9	0.27	0.18
1004c	265.00	251.50	395	3.42	Cultivated Straight Row	0.52	765.9	0.21	0.14
1004d	251.50	243.00	440	1.93	Waterway	0.65	680.0	0.19	0.13
1004e	243.00	234.00	775	1.16	Waterway	0.51	1528.0	0.42	0.28
1004									**1.21**
1005a	295.00	260.00	797	4.39	Cultivated Straight Row	0.58	1365.5	0.38	0.25
1005b	260.00	227.25	910	3.60	Waterway	0.88	1039.2	0.29	0.19
1005									**0.45**
1006a	305.50	300.00	307	1.79	Cultivated Straight Row	0.37	821.7	0.23	0.15
1006b	300.00	265.00	1710	2.05	Waterway	0.67	2566.6	0.71	0.48
1006c	265.00	255.00	729	1.37	Waterway	0.55	1327.5	0.37	0.25
1006d	255.00	240.00	723	2.07	Waterway	0.67	1078.1	0.30	0.20
1006e	240.00	225.00	382	3.93	Waterway	0.91	418.0	0.12	0.08
1006									**1.16**

NODE 5
NODE 4
NODE 3
NODE 2
NODE 1
1005
33.6ha
1004
167.4ha
1003
195.9ha
1006
333.3ha
1001
286.6ha
1002
200.7ha
COUNTY ROAD 4
CARSON ROAD
SUNNIDALE ROAD (TRAVELLED
LOT 14
LOT 15
LOT 16
LOT 17
LOT 18
LOT 19
CON 5
CON 6
LOT 13
CON 5
LIMIT OF THE CITY OF BARRIE
TRANS-CANADA PIPELINES EASEMENT
BELL TELEPHONE
R.O.W.
BARRIE AIRFIELD
D. HICKLING
R. HICKLING
ANNE STREET
DUNLOP STREET
*NOTE: LAYOUT IS SCHEMATIC ONLY, DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE.

Pre-Development Time To Peak Figure

1110 HIGHWAY 26
MIDHURST, ONTARIO L0L 1X0
TEL.: (705) 728-4784
FAX: (705) 728-6957

30 CENTURIAN DRIVE, SUITE 100
MARKHAM, ONTARIO L3R 8B8
TEL.: (905) 475-1900
FAX: (905) 475-8335

LEGEND:

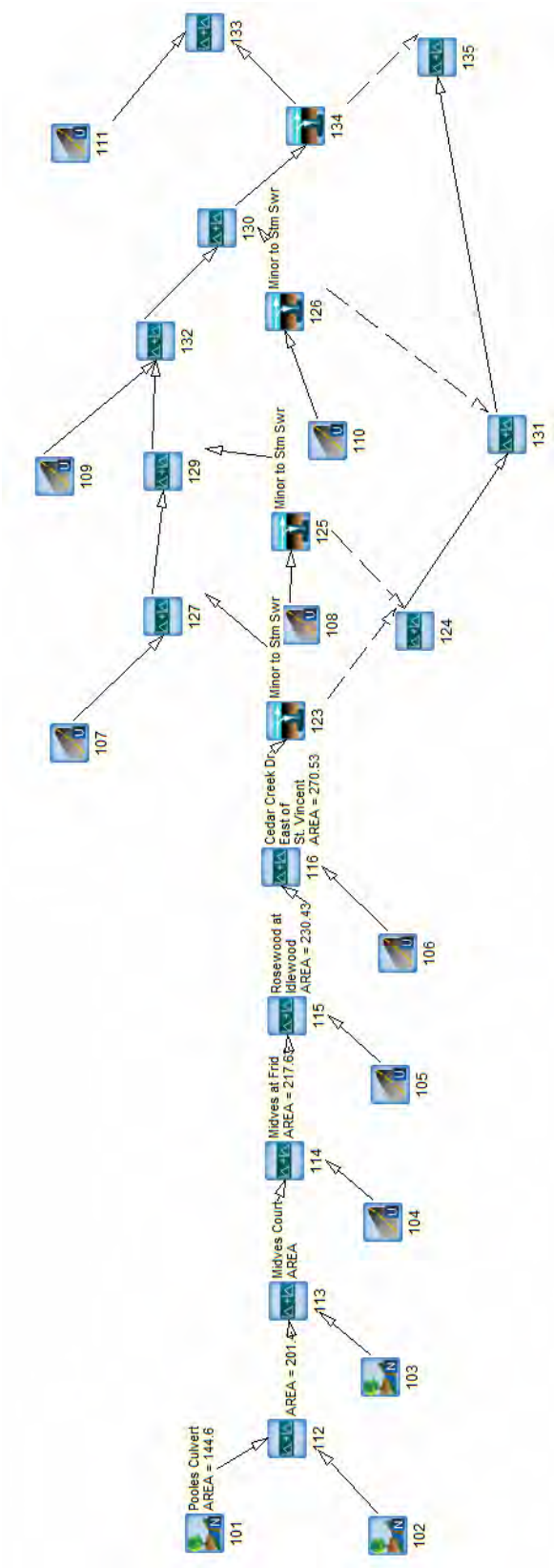
- PROPERTY LIMIT
- STORM DRAINAGE BOUNDARY
- 1001 / 279.1ha — CATCHMENT ID / DRAINAGE AREA (HECTARES)

MIDHURST SECONDARY PLAN - CARSON ROAD

PRE-DEVELOPMENT DRAINAGE PLAN

DESIGNED BY: J.M.P.	CHECKED BY: S.E.K.	PROJECT No: 1212	FIGURE No: 1
SCALE: 1:7500	DATE: APRIL 2014		

File: P:\1212 Midhurst Growth Study\Drawings\Secondary Plan\Fig\MDP Figures\1212D-PREL-PRED-CARSON.dwg – Revised by <MBRITTON> : Mon, May 05 2014 – 7:46pm


133
135
111
134
130
Minor to Stm Swr
126
132
131
110
109
129
Minor to Stm Swr
125
127
108
124
Minor to Stm Swr
123
107
Cedar Creek Dr
East of
St. Vincent
AREA = 270.53
116
106
Rosewood at
Idlewood
AREA = 230.43
115
105
Midves at Frid
AREA = 217.65
114
104
Midves Court
AREA
113
AREA = 201.4
103
Pooles Culvert
AREA = 144.6
112
101
102

*NOTE: LAYOUT IS SCHEMATIC ONLY, DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE.

1110 HIGHWAY 26
MIDHURST, ONTARIO L0L 1X0
TEL: (705) 728-4784
FAX: (705) 728-6957

30 CENTURIAN DRIVE, SUITE 100
MARKHAM, ONTARIO L3R 8B8
TEL: (905) 475-1900
FAX: (905) 475-8335

LEGEND:

- LIMIT OF PHASE/DEVELOPMENT
- STORM DRAINAGE BOUNDARY
- MAJOR SYSTEM - OVERLAND FLOW
- 0.50 / 0.20ha* — CATCHMENT ID / DRAINAGE AREA (HECTARES)

MIDHURST SECONDARY PLAN - DORAN ROAD

PRE-DEVELOPMENT DRAINAGE PLAN

DESIGNED BY: J.M.P.	CHECKED BY: S.M.S.	PROJECT No: 1168	FIGURE No: 2
SCALE: 1:5000	DATE: APRIL 2014		

File: P:\1212 Midhurst Growth Study\Drawings\Secondary Plan\Fig\MDP Figures\1212D-PREL-PRED-DORAN.dwg – Revised by <MORECCHIA> : Tue, May 06 2014 – 10:16am

Existing Conditions
VO2 Parameter Summary

Doran Road Neighbourhood
Project Number : 1168
Date: June 2014
Designer Initials: JMP

NASHYD

Number	101	102	103
Description			
DT(min)	2	2	2
Area (ha)	144.6	56.8	3.83
CN	66.0	46.0	46.0
IA(mm)	7.3	10.0	10.0
TP (hr)	3.03	0.99	0.08

STANDHYD

Number	104	105	106	107	108	109	110	111
Description								
DT(min)	2	2	2	2	2	2	2	2
Area (ha)	12.4	12.8	40.1	16.4	6.97	10.6	6.15	1.85
XIMP*	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
TIMP	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
CN	71.0	71.0	70.0	67.0	64.0	64.0	64.0	64.0
IA(mm)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
SLPP(%)	2	2	2	2	2	2	2	2
LGP(m)	40	40	40	40	40	40	40	40
MNP	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
DPSI (mm)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
SLPI(%)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
LGI(m)	287.52	292.12	517.04	330.66	215.56	265.83	202.48	111.06
MNI	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013

*Note that where there is NO directly connected area (ie: roof runoff to grassed areas), the hydrology program does not accept XIMP=0%, therefore, XIMP = 1% has been used

Existing Conditions

Site Soils: (per Simcoe County Soils Mapping)

Soil Type	Hydrologic Soil Group
Tioga Loamy Sand	A
Vasey Sandy Loam	AB
Dundonald Sandy Loam	AB

TABLE OF CURVE NUMBERS (CN's)**

Land Use		Hydrologic Soil Type							Manning's 'n'	Source
		A	AB	B	BC	C	CD	D		
Meadow	"Good"	38	51	65	71	76	79	81	0.40	MTO
Woodlot	"Fair"	32	46	60	67	73	76	79	0.40	MTO
Gravel		76	80.5	85	87	89	90	91	0.30	USDA
Lawns	"Good"	49	59	69	74	79	82	84	0.25	USDA
Pasture/Range		49	59	69	74	79	82	84	0.17	MTO
Crop		62	68	74	78	82	84	86	0.13	MTO
Fallow (Bare)		77	82	86	89	91	93	94	0.05	MTO
Low Density Residences		57	64.5	72	76.5	81	83.5	86	0.25	USDA
Streets, paved		100	100	100	100	100	100	100	0.01	USDA

1. MTO Drainage Manual (1997), Design Chart 1.09-Soil/Land Use Curve Numbers
2. USDA (1986), Urban Hydrology for Small Watersheds, Table 2.2-Runoff Curve Numbers for Urban Areas

HYDROLOGIC SOIL TYPE (%) - Existing Conditions

Catchment	Hydrologic Soil Type							TOTAL
	A	AB	B	BC	C	CD	D	
101		100						100
102		100						100
103		100						100
104		100						100
105		100						100
106	12	88						100
107	55	45						100
108	100							100
109	100							100
110	100							100
111	100							100

LAND USE (%) - Existing Conditions

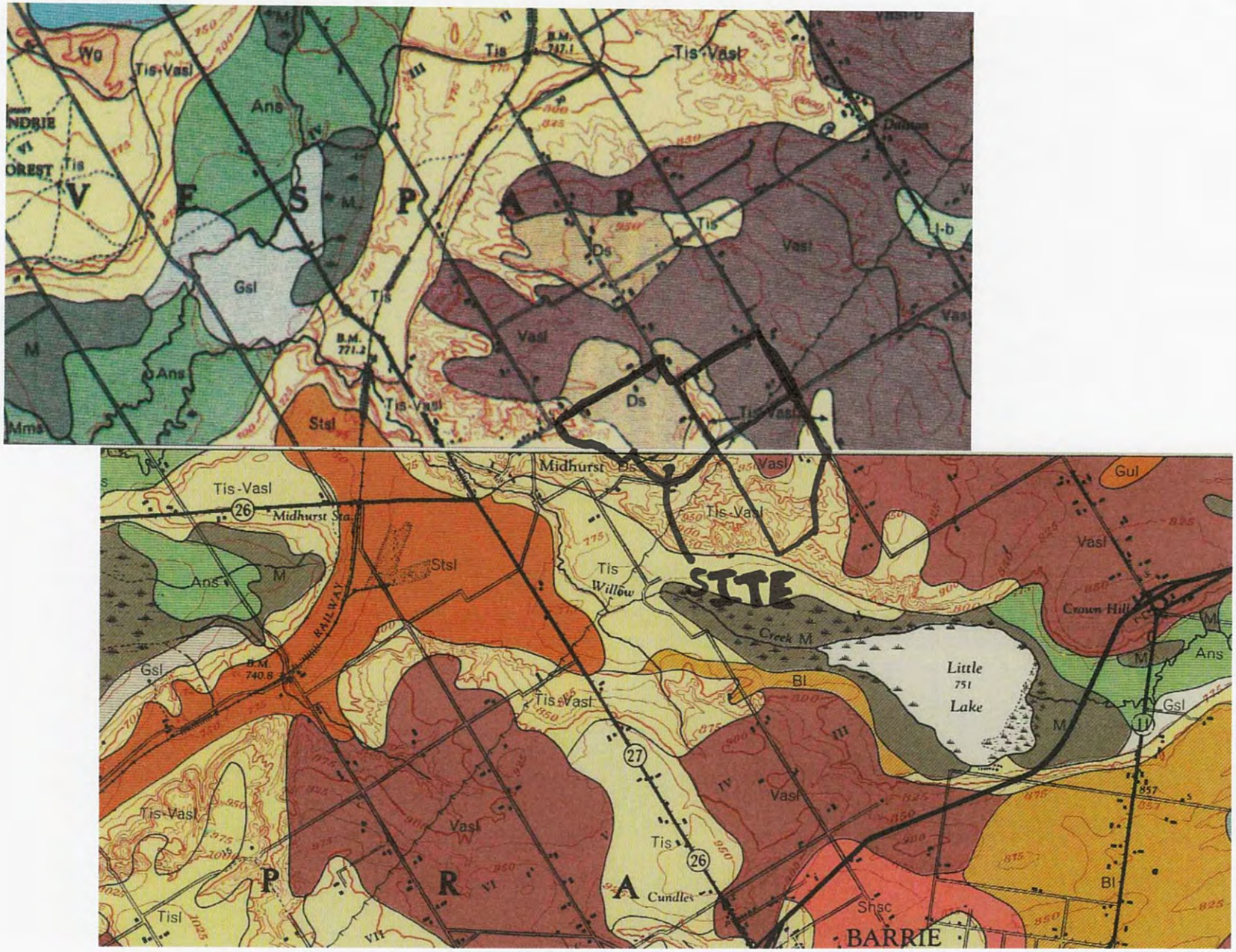
Catchment	Meadow	Woodlot	Gravel	Lawns	Pasture Range	Crop	Fallow (Bare)	Low Density Residences	Impervious	Total
101		10.0				90.0				100.0
102		100.0								100.0
103		100.0								100.0
104				71.0					29.0	100.0
105				71.0					29.0	100.0
106				71.0					29.0	100.0
107				71.0					29.0	100.0
108				71.0					29.0	100.0
109				71.0					29.0	100.0
110				71.0					29.0	100.0
111				71.0					29.0	100.0

Note: Where STANDHYD command used (shaded), impervious fraction is not considered in CN determination, since %Imp directly input in STANDHYD command

Existing Conditions
CN Calculations

CURVE NUMBER (CN) - Existing Conditions										
Catchment	Meadow	Woodlot	Gravel	Lawns	Pasture Range	Crop	Fallow (Bare)	Low Density Residences	Impervious	Weighted CN
101	0.0	4.6	0.0	0.0	0.0	61.2	0.0	0.0	0.0	66
102	0.0	46.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46
103	0.0	46.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46
104	0.0	0.0	0.0	41.9	0.0	0.0	0.0	0.0	29.0	71
105	0.0	0.0	0.0	41.9	0.0	0.0	0.0	0.0	29.0	71
106	0.0	0.0	0.0	41.0	0.0	0.0	0.0	0.0	29.0	70
107	0.0	0.0	0.0	38.0	0.0	0.0	0.0	0.0	29.0	67
108	0.0	0.0	0.0	34.8	0.0	0.0	0.0	0.0	29.0	64
109	0.0	0.0	0.0	34.8	0.0	0.0	0.0	0.0	29.0	64
110	0.0	0.0	0.0	34.8	0.0	0.0	0.0	0.0	29.0	64
111	0.0	0.0	0.0	34.8	0.0	0.0	0.0	0.0	29.0	64

** AMC II assumed


Wo
Tis-Vasl
Ans
Tis
Vasl
Ds
Gsl
Stsl
Mms
B.M. 771.2
B.M. 747.1
Midhurst
Midhurst Sta.
Tis-Vasl
Stsl
Ans
M
RAILWAY
Gsl
B.M. 740.8
Tis
Willow
SITE
Creek M
Little
751
Lake
Bl
Gul
Crown Hill
Vasl
Ans
Gsl
Tis-Vasl
Vasl
Tis
Cundles
Shsc
BARRIE
Tisl
PARA

Existing Conditions

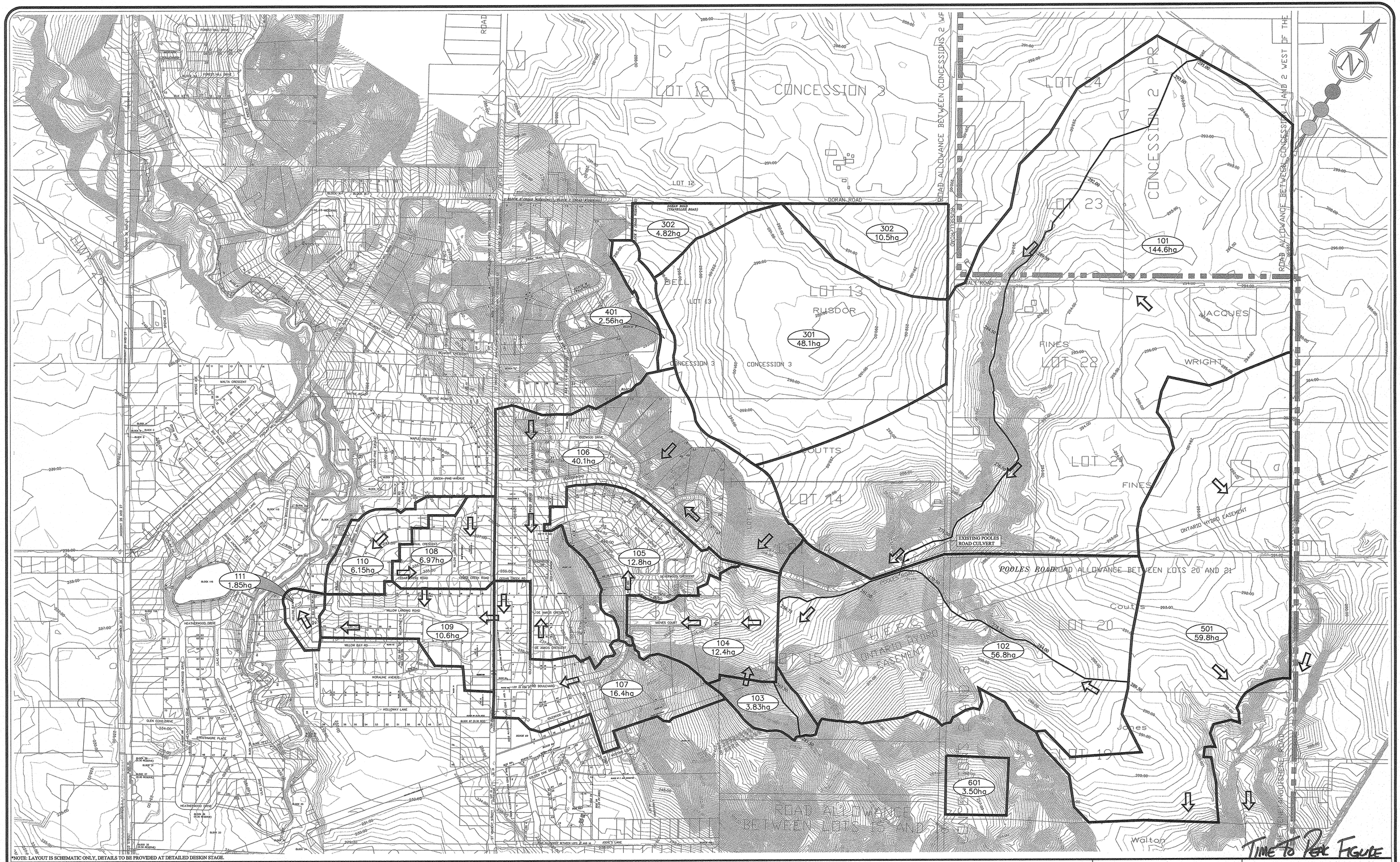
LAND USE (%) - Existing Conditions										
Catchment	Meadow	Woodlot	Gravel	Lawns	Pasture Range	Crop	Fallow (Bare)	Low Density Residences	Impervious	Total
101		10.0				90.0				100.0
102		100.0								100.0
103		100.0								100.0
104				100.0						100.0
105				100.0						100.0
106				100.0						100.0
107				100.0						100.0
108				100.0						100.0
109				100.0						100.0
110				100.0						100.0
111				100.0						100.0

IA VALUES (mm) - Existing Conditions										
Catchment	Meadow	Woodlot	Gravel	Lawns	Pasture Range	Crop	Fallow (Bare)	Low Density Residences	Impervious	Total
IA (mm)	8	10	2	5	8	7	3	2	2	
101		1.0				6.3				7.3
102		10.0								10.0
103		10.0								10.0
104				5.0						5.0
105				5.0						5.0
106				5.0						5.0
107				5.0						5.0
108				5.0						5.0
109				5.0						5.0
110				5.0						5.0
111				5.0						5.0

* IA values based on NVCA guidelines

Uplands Method:

Catchment ID	High Elevation	Low Elevation	Length (m)	Slope (%)	Land Cover Type	Velocity (m/s)	Time of Concentration (s)	Time of Concentration (hr)	Time to Peak (hr)
101a	295.00	293.00	100	2.00	Pasture	0.31	324.9	0.09	0.06
101b	293.00	292.00	445	0.22	Pasture	0.10	4353.1	1.21	0.81
101c	292.00	289.50	113	2.21	Pasture	0.32	349.0	0.10	0.06
101d	289.50	284.50	298	1.68	Forest (Heavy Litter)	0.10	3078.4	0.86	0.57
101e	284.50	276.50	469	1.70	Forest (Heavy Litter)	0.10	4806.8	1.34	0.89
101f	276.50	271.50	279	1.79	Forest (Heavy Litter)	0.10	2782.6	0.77	0.52
101g	271.50	267.00	195	2.31	Pasture	0.33	588.0	0.16	0.11
101									**3.03**
102a	289.5	284	323	1.70	Woodland	0.20	1635.3	0.45	0.30
102b	284	278.5	158	3.48	Woodland	0.28	560.3	0.16	0.10
102c	278.5	270.5	265	3.02	Woodland	0.26	1010.3	0.28	0.19
102d	270.5	261.5	229	3.94	Woodland	0.30	763.2	0.21	0.14
102e	261.5	256.75	267	1.78	Woodland	0.20	1325.5	0.37	0.25
102									**0.99**
103a	281.5	263.5	195	9.21	Woodland	0.46	427.2	0.12	0.08
103									**0.08**



*NOTE: LAYOUT IS SCHEMATIC ONLY, DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE.

Time To Peak Figure

1110 HIGHWAY 26
MIDHURST, ONTARIO L0L 1X0
TEL: (705) 728-4784
FAX: (705) 728-6957

30 CENTURIAN DRIVE, SUITE 100
MARKHAM, ONTARIO L3R 8B8
TEL: (905) 475-1900
FAX: (905) 475-8335

LEGEND:

- LIMIT OF PHASE/DEVELOPMENT
- STORM DRAINAGE BOUNDARY
- MAJOR SYSTEM - OVERLAND FLOW
- 0.50 / 0.20ha — CATCHMENT ID / DRAINAGE AREA (HECTARES)

MIDHURST SECONDARY PLAN - DORAN ROAD

PRE-DEVELOPMENT ~~DRAINAGE PLAN~~

DESIGNED BY: J.M.P.	CHECKED BY: S.M.S.	PROJECT No: 1212	FIGURE No: 2
SCALE: 1:5000	DATE: APRIL 2014		

File: P:\1212 Midhurst Growth Study\Drawings\Secondary Plan\Fig\MDP Figures\1212D-PREL-PRED-DORAN.dwg – Revised by <MBRITTON> : Mon, May 05 2014 – 9:47am

Existing Conditions
Percent Impervious Calculations

Land Use Areas (ha)	StandHyd IDs							
	104	105	106	107	108	109	110	111
Total Impervious Area	3.60	3.71	11.63	4.76	2.02	3.07	1.78	0.54
Total Impervious Area Directly Connected	0	0	0	0	0	0	0	0
Total Area	12.4	12.8	40.1	16.4	6.97	10.6	6.15	1.85
Total Pervious Area	8.80	9.09	28.47	11.64	4.95	7.53	4.37	1.31
Timp	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
Ximp	0	0	0	0	0	0	0	0

POST-DEVELOPMENT MODELLING



Peak Flow Analysis at SWM Facilities

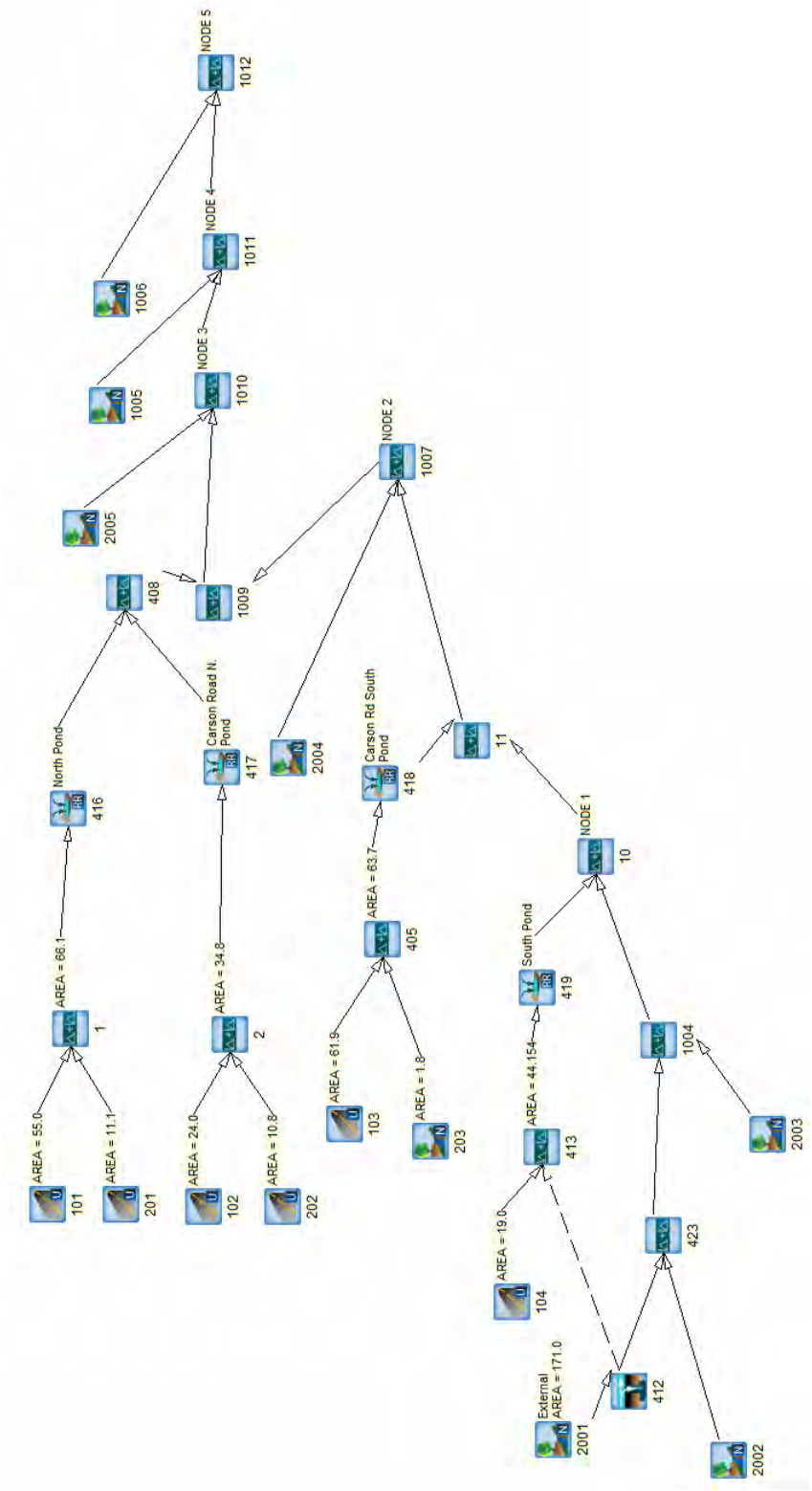
Russell Road Pond				
Return Period	Pre-Development		Post-Development	
	Chicago	SCS	Chicago	SCS
2 Year	0.114	0.134	0.019	0.021
5 Year	0.241	0.288	0.022	0.024
10 Year	0.340	0.410	0.024	0.032
25 Year	0.487	0.582	0.034	0.047
50 Year	0.607	0.719	0.043	0.060
100 Year	0.737	0.863	0.053	0.073

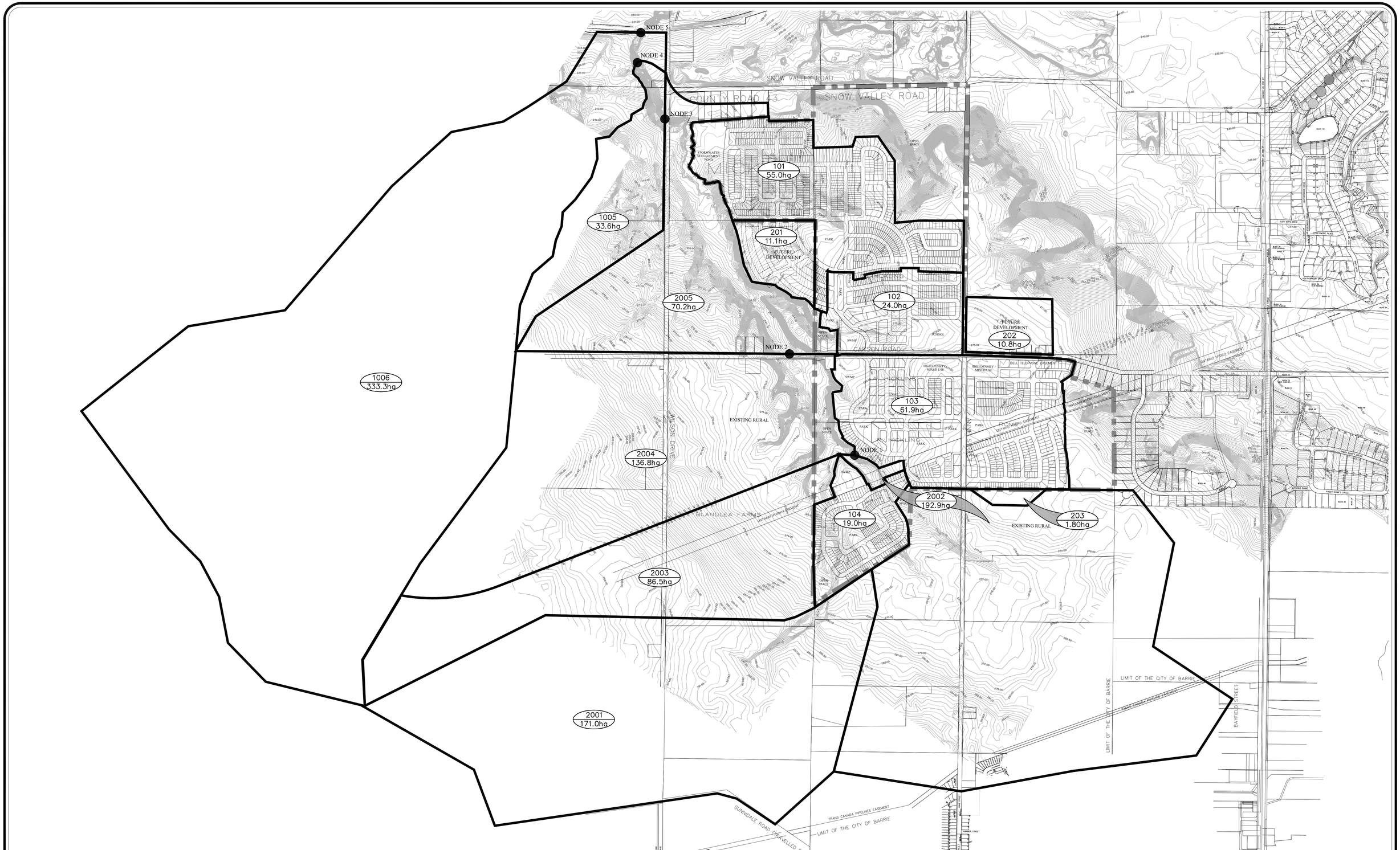
North Pond				
Return Period	Pre-Development		Post-Development	
	Chicago	SCS	Chicago	SCS
2 Year	0.260	0.355	0.018	0.024
5 Year	0.549	0.761	0.145	0.294
10 Year	0.776	1.082	0.318	0.499
25 Year	1.103	1.534	0.507	0.800
50 Year	1.368	1.898	0.664	1.053
100 Year	1.655	2.276	0.835	1.323

Carson Road North Pond				
Return Period	Pre-Development		Post-Development	
	Chicago	SCS	Chicago	SCS
2 Year	0.136	0.178	0.013	0.017
5 Year	0.284	0.380	0.083	0.153
10 Year	0.400	0.539	0.166	0.260
25 Year	0.569	0.761	0.265	0.417
50 Year	0.707	0.939	0.347	0.550
100 Year	0.855	1.124	0.436	0.691

Carson Road South Pond				
Return Period	Pre-Development		Post-Development	
	Chicago	SCS	Chicago	SCS
2 Year	0.140	0.174	0.021	0.028
5 Year	0.293	0.370	0.142	0.254
10 Year	0.413	0.524	0.280	0.444
25 Year	0.587	0.740	0.462	0.732
50 Year	0.728	0.911	0.614	0.893
100 Year	0.881	1.090	0.765	1.051

South Pond				
Return Period	Pre-Development		Post-Development	
	Chicago	SCS	Chicago	SCS
2 Year	0.436	0.441	0.110	0.323
5 Year	0.643	0.614	0.356	0.439
10 Year	0.789	0.748	0.427	0.561
25 Year	1.005	0.937	0.475	0.784
50 Year	1.180	1.087	0.536	0.957
100 Year	1.372	1.242	0.615	1.116


NODE 5
1012
NODE 4
1011
1006
NODE 3
1010
1005
NODE 2
1007
2005
408
1009
Carson Road N. Pond
417
North Pond
416
2004
Carson Rd South Pond
418
11
NODE 1
10
AREA = 66.1
1
AREA = 34.8
2
AREA = 63.7
405
South Pond
419
1004
AREA = 55.0
101
AREA = 11.1
201
AREA = 24.0
102
AREA = 10.8
202
AREA = 61.9
103
AREA = 1.8
203
AREA = 44.154
413
2003
AREA = 19.0
104
423
External AREA = 171.0
2001
412
2002



*NOTE: LAYOUT IS SCHEMATIC ONLY, DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE.

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LEGEND:

- LIMIT OF PHASE/DEVELOPMENT
- STORM DRAINAGE BOUNDARY
- MINOR SYSTEM - STORM SEWER
- MAJOR SYSTEM - OVERLAND FLOW
- 1001 / 279.1ha — CATCHMENT ID / DRAINAGE AREA (HECTARES)

MIDHURST SECONDARY PLAN - CARSON ROAD

POST-DEVELOPMENT DRAINAGE PLAN

DESIGNED BY: J.M.P.	CHECKED BY: S.M.S.	PROJECT No: 1194	FIGURE No: 2
SCALE: 1:7500	DATE: MAY 2014		

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Proposed Conditions
VO2 Parameter Summary

NASHYD

Number	1005	1006	2001	2002	2003	2004	2005	203
Description								
DT(min)	2	2	2	2	2	2	2	2
Area (ha)	33.6	333.3	171	192.9	86.5	136.8	70.2	1.8
CN	57.0	55.0	65.0	67.0	66.0	67.0	68.0	68.0
IA(mm)	7.5	8.3	7.0	7.0	7.0	7.0	7.0	7.0
TP (hr)	0.45	1.16	1.31	1.27	1.37	1.40	0.68	0.15

STANDHYD

Number	101	102	103	104	201	202
Description						
DT(min)	2	2	2	2	2	2
Area (ha)	55	24	61.9	19	11.1	10.8
XIMP*	0.30	0.39	0.33	0.25	0.30	0.35
TIMP	0.48	0.51	0.48	0.42	0.50	0.55
CN	57.0	59.0	59.0	59.0	56.0	59.0
IA(mm)	20.0	18.7	20.3	21.5	20.0	18.7
SLPP(%)	2	2	2	2	2	2
LGP(m)	40	40	40	40	40	40
MNP	0.25	0.25	0.25	0.25	0.25	0.25
DPSI (mm)	1.0	1.0	1.0	1.0	1.0	1.0
SLPI(%)	1.0	1.0	1.0	1.0	1.0	1.0
LGI(m)	605.53	400.00	642.39	355.90	272.03	268.33
MNI	0.013	0.013	0.013	0.013	0.013	0.013

*Note that where there is NO directly connected area (ie: roof runoff to grassed areas), the hydrology program does not accept XIMP=0%, therefore, XIMP = 1% has been used

Proposed Conditions

Site Soils: (per Simcoe County Soils Mapping)

Soil Type	Hydrologic Soil Group
Tioga Loamy Sand	A
Tioga Sandy Loam	A
Vasey Sandy Loam	AB
Sargent Gravelly Sandy Loam	AB

TABLE OF CURVE NUMBERS (CN's)**

Land Use		Hydrologic Soil Type							Manning's 'n'	Source
		A	AB	B	BC	C	CD	D		
Meadow	"Good"	38	51	65	71	76	79	81	0.40	MTO
Woodlot	"Fair"	32	46	60	67	73	76	79	0.40	MTO
Gravel		76	80.5	85	87	89	90	91	0.30	USDA
Lawns	"Good"	49	59	69	74	79	82	84	0.25	USDA
Pasture/Range		49	59	69	74	79	82	84	0.17	MTO
Crop		62	68	74	78	82	84	86	0.13	MTO
Fallow (Bare)		77	82	86	89	91	93	94	0.05	MTO
Low Density Residences		57	64.5	72	76.5	81	83.5	86	0.25	USDA
Streets, paved		100	100	100	100	100	100	100	0.01	USDA

1. MTO Drainage Manual (1997), Design Chart 1.09-Soil/Land Use Curve Numbers
2. USDA (1986), Urban Hydrology for Small Watersheds, Table 2.2-Runoff Curve Numbers for Urban Areas

HYDROLOGIC SOIL TYPE (%) - Proposed Conditions

Catchment	Hydrologic Soil Type							TOTAL
	A	AB	B	BC	C	CD	D	
1005	100.0							100
1006	32.1	67.9						100
2001	50.0	50.0						100
2002	20.0	80.0						100
2003	25.5	74.5						100
2004	16.8	83.2						100
2005		100.0						100
203		100.0						100
101	23.5	76.5						100
102		100.0						100
103		100.0						100
104		100.0						100
201	35.0	65.0						100
202		100.0						100

LAND USE (%) - Proposed Conditions

Catchment	Meadow	Woodlot	Gravel	Lawns	Pasture Range	Crop	Fallow (Bare)	Low Density Residences	Impervious	Total
1005		15.9				84.1				100.0
1006		44.4				55.6				100.0
2001						100.0				100.0
2002						100.0				100.0
2003						100.0				100.0
2004						100.0				100.0
2005						100.0				100.0
203						100.0				100.0
101				100.0						100.0
102				100.0						100.0
103				100.0						100.0
104				100.0						100.0
201				100.0						100.0
202				100.0						100.0

Note: Where STANDHYD command used (shaded), impervious fraction is not considered in CN determination, since %Imp directly input in STANDHYD command

CURVE NUMBER (CN) - Proposed Conditions										
Catchment	Meadow	Woodlot	Gravel	Lawns	Pasture Range	Crop	Fallow (Bare)	Low Density Residences	Impervious	Weighted CN
1005	0.0	5.1	0.0	0.0	0.0	52.2	0.0	0.0	0.0	57
1006	0.0	18.4	0.0	0.0	0.0	36.7	0.0	0.0	0.0	55
2001	0.0	0.0	0.0	0.0	0.0	65.0	0.0	0.0	0.0	65
2002	0.0	0.0	0.0	0.0	0.0	66.8	0.0	0.0	0.0	67
2003	0.0	0.0	0.0	0.0	0.0	66.5	0.0	0.0	0.0	66
2004	0.0	0.0	0.0	0.0	0.0	67.0	0.0	0.0	0.0	67
2005	0.0	0.0	0.0	0.0	0.0	68.0	0.0	0.0	0.0	68
203	0.0	0.0	0.0	0.0	0.0	68.0	0.0	0.0	0.0	68
101	0.0	0.0	0.0	56.7	0.0	0.0	0.0	0.0	0.0	57
102	0.0	0.0	0.0	59.0	0.0	0.0	0.0	0.0	0.0	59
103	0.0	0.0	0.0	59.0	0.0	0.0	0.0	0.0	0.0	59
104	0.0	0.0	0.0	59.0	0.0	0.0	0.0	0.0	0.0	59
201	0.0	0.0	0.0	55.5	0.0	0.0	0.0	0.0	0.0	56
202	0.0	0.0	0.0	59.0	0.0	0.0	0.0	0.0	0.0	59

** AMC II assumed

Proposed Conditions

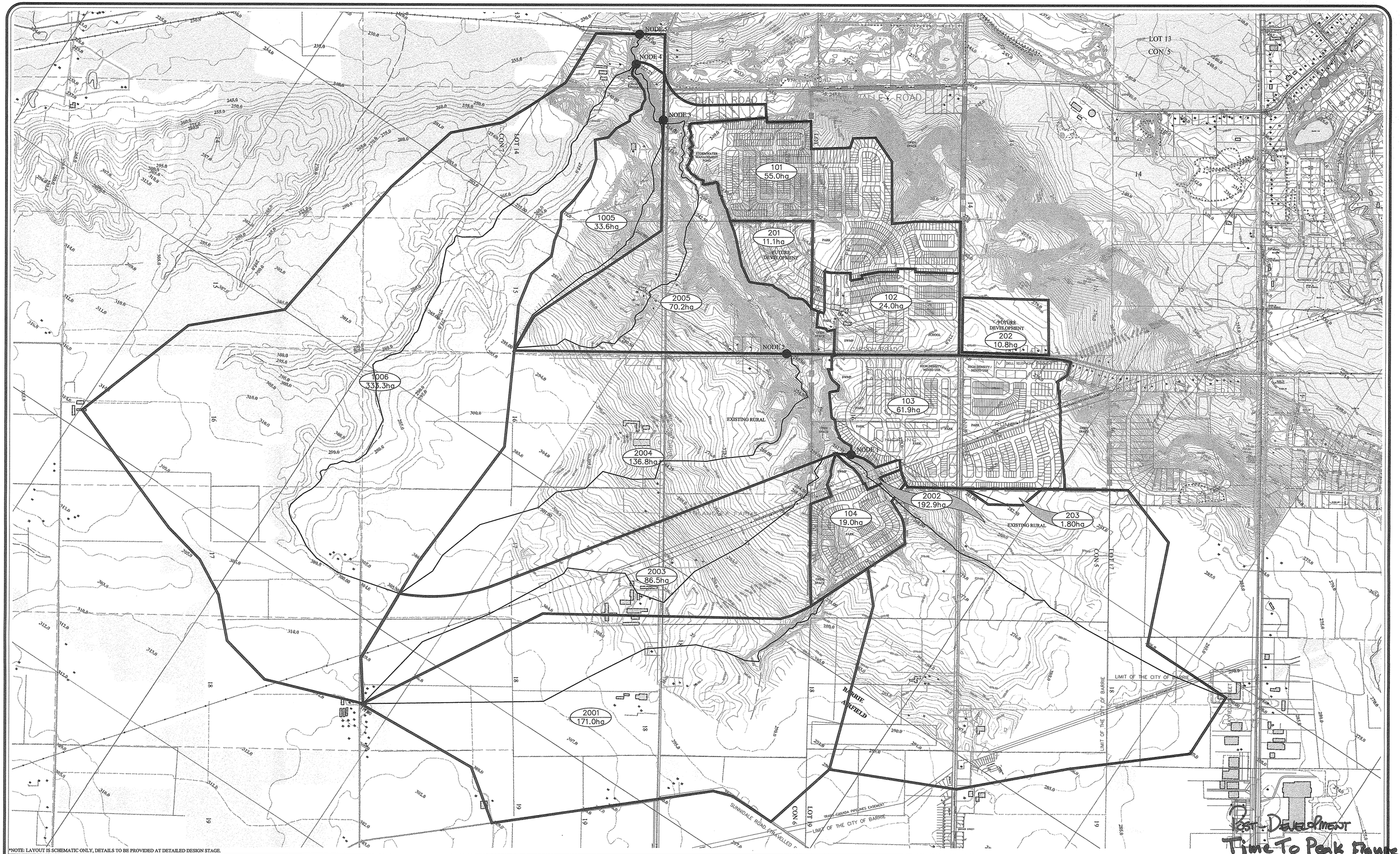
LAND USE (%) - Proposed Conditions										
Catchment	Meadow	Woodlot	Gravel	Lawns	Pasture Range	Crop	Fallow (Bare)	Low Density Residences	Impervious	Total
1005		15.9				84.1				100.0
1006		44.4				55.6				100.0
2001						100.0				100.0
2002						100.0				100.0
2003						100.0				100.0
2004						100.0				100.0
2005						100.0				100.0
203						100.0				100.0

IA VALUES (mm) - Proposed Conditions										
Catchment	Meadow	Woodlot	Gravel	Lawns	Pasture Range	Crop	Fallow (Bare)	Low Density Residences	Impervious	Total
IA (mm)	8	10	2	5	8	7	3	2	2	
1005		1.6				5.9				7.5
1006		4.4				3.9				8.3
2001						7.0				7.0
2002						7.0				7.0
2003						7.0				7.0
2004						7.0				7.0
2005						7.0				7.0
203						7.0				7.0

* IA values based on NVCA guidelines
* Catchment 101, 102 & 106 IA values as per infiltration calculations in Item #5 submission

Uplands Method:

Catchment ID	High Elevation	Low Elevation	Length (m)	Slope (%)	Land Cover Type	Velocity (m/s)	Time of Concentration (s)	Time of Concentration (hr)	Time to Peak (hr)
1005a	295.00	260.00	797	4.39	Cultivated Straight Row	0.58	1365.5	0.38	0.25
1005b	260.00	227.25	910	3.60	Waterway	0.88	1039.2	0.29	0.19
1005									**0.45**
1006a	305.50	300.00	307	1.79	Cultivated Straight Row	0.37	821.7	0.23	0.15
1006b	300.00	265.00	1710	2.05	Waterway	0.67	2566.6	0.71	0.48
1006c	265.00	255.00	730	1.37	Waterway	0.55	1329.6	0.37	0.25
1006d	255.00	240.00	723	2.07	Waterway	0.67	1078.1	0.30	0.20
1006e	240.00	225.00	382	3.93	Waterway	0.91	418.0	0.12	0.08
1006									**1.16**
2001a	311.00	275.00	2406	1.50	Cultivated Straight Row	0.34	7044.8	1.96	1.31
2001									**1.31**
2002a	290.00	268.00	1711	1.29	Cultivated Straight Row	0.32	5399.2	1.50	1.00
2002b	268.00	261.75	462	1.35	Cultivated Straight Row	0.33	1420.3	0.39	0.26
2002									**1.27**
2003a	311.00	268.00	2512	1.71	Cultivated Straight Row	0.37	6875.2	1.91	1.28
2003b	268.00	264.50	24	14.74	Cultivated Straight Row	1.07	22.3	0.01	0.00
2003c	264.50	259.00	212	2.60	Cultivated Straight Row	0.45	471.0	0.13	0.09
2003									**1.37**
2004a	305.50	301.00	787	0.57	Cultivated Straight Row	0.21	3718.1	1.03	0.69
2004b	301.00	284.25	700	2.39	Cultivated Straight Row	0.43	1621.2	0.45	0.30
2004c	284.25	269.00	484	3.15	Cultivated Straight Row	0.49	977.3	0.27	0.18
2004d	269.00	254.50	367	3.95	Cultivated Straight Row	0.55	661.9	0.18	0.12
2004e	254.50	252.50	244	0.82	Waterway	0.43	568.7	0.16	0.11
2004									**1.40**
2005a	295.00	280.50	534	2.72	Cultivated Straight Row	0.46	1161.0	0.32	0.22
2005b	280.50	242.50	750	5.07	Cultivated Straight Row	0.63	1196.7	0.33	0.22
2005c	242.50	239.50	89	3.36	Pasture	0.40	222.3	0.06	0.04
2005d	239.50	234.00	528	1.04	Waterway	0.48	1099.4	0.31	0.20
2005									**0.68**
203a	282.50	281.00	198	0.76	Cultivated Straight Row	0.24	812.2	0.23	0.15
203									**0.15**



*NOTE: LAYOUT IS SCHEMATIC ONLY, DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE.

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SCS consulting group ltd

LEGEND:

- LIMIT OF PHASE/DEVELOPMENT
- STORM DRAINAGE BOUNDARY
- MINOR SYSTEM - STORM SEWER
- MAJOR SYSTEM - OVERLAND FLOW
- 1001 / 279.1ha* — CATCHMENT ID / DRAINAGE AREA (HECTARES)

MIDHURST SECONDARY PLAN - CARSON ROAD

POST-DEVELOPMENT DRAINAGE PLAN

DESIGNED BY: J.M.P. | CHECKED BY: S.M.S.

SCALE: 1:7500 | DATE: MAY 2014

PROJECT No: 1212 | FIGURE No: 2

Post-Development
Time To Peak Figure

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NORTH POND

DRAINAGE AREA CHARACTERISTICS

Development Type	Area (Ha)	% Imperviousness (TIMP)	% Imperviousness (XIMP)	Impervious Area (Ha)
Singles	44.90	60%	25%	26.94
Townhouses	0.00	90%	30%	0.00
Park	5.56	10%	0%	0.56
Pond	4.20	50%	50%	2.10
Pumping Station Block	0.05	50%	50%	0.03
Open Space	0.27	0%	0%	0.00
Subtotal	*54.97*	*54%*	*24%*	*29.62*
Fut. Townhouses	0.00	90%	30%	0.00
Fut. Singles	10.23	60%	25%	6.14
Fut. Park	0.87	10%	0%	0.09
Subtotal	*11.10*	*50%*	*30%*	*6.23*
Total	**66.07**	**54%**	**24%**	**35.84**

PERMANENT POOL

Level of Protection = 1 (Enhanced)

Weighted Impervious = 54 %

Drainage Area = 66.07 ha

SWMP Type = 4. Wet Pond

Required Permanent Pool (including 40m^3/ha for extended detention)= 188 m^3/ha
Required Permanent Pool (minus 40m^3/ha for extended detention)= 148 m^3/ha

Required Permanent Pool = 9787 m^3

TABLE 3.2 - WATER QUALITY STORAGE REQUIREMENTS
(FROM MOE SWM PLANNING AND DESIGN MANUAL - 2004)

Protection Level	SWMP Type	Storage Volume (m^3/s) for Impervious Level			
		35%	55%	70%	85%
Enhanced (Level 1)	1. Infiltration	25	30	35	40
	2. Wetlands	80	105	120	140
	3. Hybrid Wet Pond/Wetland	110	150	175	195
	4. Wet Pond	140	190	225	250
Normal (Level 2)	1. Infiltration	20	20	25	30
	2. Wetlands	60	70	80	90
	3. Hybrid Wet Pond/Wetland	75	90	105	120
	4. Wet Pond	90	110	130	150
Basic (Level 3)	1. Infiltration	20	20	20	20
	2. Wetlands	60	60	60	60
	3. Hybrid Wet Pond/Wetland	60	70	75	80
	4. Wet Pond	60	75	85	95
	5. Dry Pond (Continuous Flow)	90	150	200	240

EXTENDED DETENTION

Using the 25mm - 4 hour Chicago Storm

Erosion Control Volume (V) = Runoff Depth (mm) x Drainage Area (ha) x 10 (m^3) / (mm)(ha)

Erosion Control Volume (V) = 1.49 mm x 66.07 ha x 10 m^3 / mm·ha

Erosion Control Volume (V) = 984 m^3

Using 40m^3/ha

Extended Detention Volume (V) = 40m^3/ha x Drainage Area (ha)

Extended Detention Volume (V) = 40 m^3/ha 66.07 ha

Extended Detention Volume (V) = 2643 m^3

Governing Volume (V) = 2643 m^3

Peak Flowrate (Q_p) = Extended Detention Volume (m^3) / Detention Time (hr) x 1 (hr) / 3600 (s) x 1.5 (peaking factor)

Peak Flowrate (Q_p) = 2643 m^3 / 72 hr x 1 (hr) / 3600 (s) x 1.5 (peaking factor)

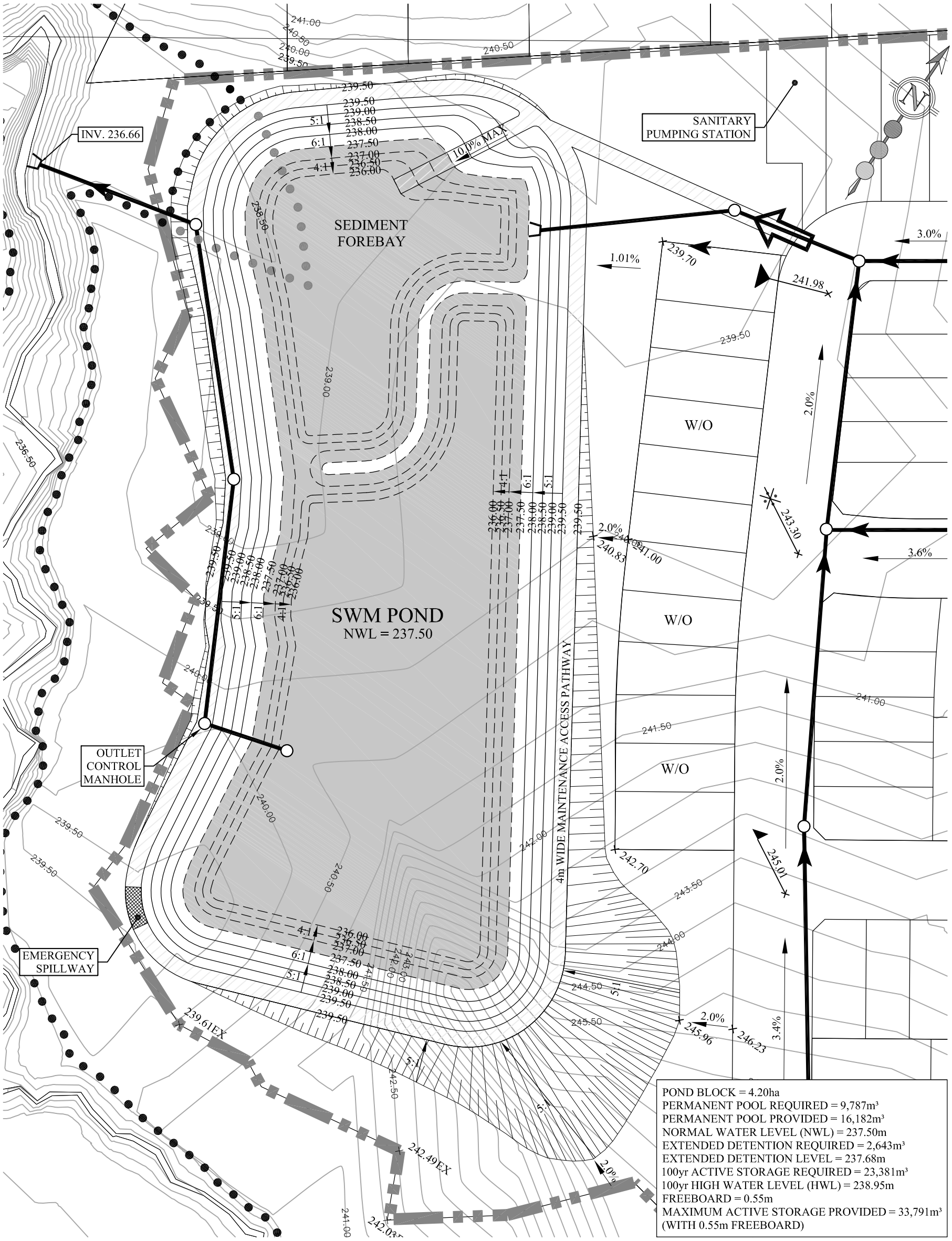
Peak Flowrate (Q_p) = 0.015 m^3/s

NORTH POND

STAGE STORAGE TABLE

Elevation (m)	Area (m^2)	Avg Area (m^2)	ΔH (m)	ΔVolume (m^3)	Total Volume (m3)	Active Storage (m3)	Depth (m)	
236.00	8613				0		0	
		9274	0.5	4637				
236.50	9934				4637		0.5	
		10651	0.5	5325				
237.00	11367				9962	0	1	
		12440	0.5	6220				
237.50	**13513**				**16182**	**0**	**1.5**	**N.W.L.**
		14493	0.5	7247				
238.00	15473				23429	7247	2	
		16211	0.5	8105				
238.50	16948				31534	15352	2.5	
		17703	0.5	8852				
239.00	18459				40386	24204	3	
		19175	0.5	9588				
239.50	19892				49973	33791	3.5	

Permanent Pool Volume Required =	9787	m^3	
Permanent Pool Volume Provided =	16182	m^3	65% Extra
Extended Detention volume required =	2643	m^3	
Extended Detention waterlevel =	237.68	m	
5 year control volume required =	8919	m^3	
5 year control waterlevel =	238.10	m	
100 year control volume required =	23381	m^3	
100 year waterlevel =	238.95	m	
Freeboard =	0.55	m	



LEGEND:

- LIMIT OF DEVELOPMENT APPLICATION
- EXISTING FLOODLINE
- PROPOSED FLOODLINE
- MAX. 3:1 SLOPE
- 243.00 — EXISTING CONTOUR
- × 246.50 — PROPOSED GRADE
- ×237.59EX — EXISTNG GRADE
- OVERLAND FLOW
- 238.50 — POND CONTOUR
- PROPOSED MAINTENACE ACCESS ROAD
- PROPOSED EMERGENCY SPILLWAY
- PROPOSED OVERLAND FLOW ROUTE
- PROPOSED STORM SEWER

CARSON ROAD DEVELOPMENT INC. (CRDI)

PRELIMINARY SWM POND GRADING - NORTH POND

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DATE:	AUGUST 2014	CHECKED BY:	J.M.P
SCALE:	1:1000	DRAWN BY:	Y.K.
PROJECT No:	1194	FIGURE No:	4.4.1

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DRAINAGE AREA CHARACTERISTICS

Development Type	Area (Ha)	% Imperviousness (TIMP)	% Imperviousness (XIMP)	Impervious Area (Ha)
Singles	15.9	60%	25%	9.5
Townhouses	0.0	90%	30%	0.0
Park	2.3	10%	0%	0.2
Pond	1.5	50%	50%	0.8
School	4.3	55%	55%	2.4
subtotal	*24.0*	*54%*	*30%*	*12.9*
Future Development	10.8	60%	25%	6.5
Total	**34.8**	**56%**	**28%**	**19.4**

CARSON ROAD NORTH POND

PERMANENT POOL

Level of Protection = 1 (Enhanced)

Weighted Impervious = 56 %

Drainage Area = 34.80 ha

SWMP Type = 4. Wet Pond

Required Permanent Pool (including 40m^3/ha for extended detention)= 192 m^3/ha
Required Permanent Pool (minus 40m^3/ha for extended detention)= 152 m^3/ha

Required Permanent Pool = 5273 m^3

TABLE 3.2 - WATER QUALITY STORAGE REQUIREMENTS
(FROM MOE SWM PLANNING AND DESIGN MANUAL - 2004)

Protection Level	SWMP Type	Storage Volume (m^3/s) for Impervious Level			
		35%	55%	70%	85%
Enhanced (Level 1)	1. Infiltration	25	30	35	40
	2. Wetlands	80	105	120	140
	3. Hybrid Wet Pond/Wetland	110	150	175	195
	4. Wet Pond	140	190	225	250
Normal (Level 2)	1. Infiltration	20	20	25	30
	2. Wetlands	60	70	80	90
	3. Hybrid Wet Pond/Wetland	75	90	105	120
	4. Wet Pond	90	110	130	150
Basic (Level 3)	1. Infiltration	20	20	20	20
	2. Wetlands	60	60	60	60
	3. Hybrid Wet Pond/Wetland	60	70	75	80
	4. Wet Pond	60	75	85	95
	5. Dry Pond (Continuous Flow)	90	150	200	240

EXTENDED DETENTION

Using the 25mm - 4 hour Chicago Storm

Erosion Control Volume (V) = Runoff Depth (mm) x Drainage Area (ha) x 10 (m^3) / (mm)(ha)

Erosion Control Volume (V) = 2.83 mm x 34.80 ha x 10 m^3 / mm·ha

Erosion Control Volume (V) = 985 m^3

Using 40m^3/ha

Extended Detention Volume (V) = 40m^3/ha x Drainage Area (ha)

Extended Detention Volume (V) = 40 m^3/ha 34.80 ha

Extended Detention Volume (V) = 1392 m^3

Governing Volume (V) = 1392 m^3

Peak Flowrate (Q_p) = Extended Detention Volume (m^3) / Detention Time (hr) x 1 (hr) / 3600 (s) x 1.5 (peaking factor)

Peak Flowrate (Q_p) = 1392 m^3 / 72 hr x 1 (hr) / 3600 (s) x 1.5 (peaking factor)

Peak Flowrate (Q_p) = 0.008 m^3/s

STAGE STORAGE TABLE

Elevation (m)	Area (m^2)	Avg Area (m^2)	ΔH (m)	ΔVolume (m^3)	Total Volume (m3)	Active Storage (m3)	Depth (m)	
262.00	2226				0		0	
		2652	0.5	1326				
262.50	3079				1326		0.5	
		3485	0.5	1743				
263.00	3892				3069		1	
		4345	0.5	2173				
263.50	4799				5242		1.5	
		5423	0.5	2711				
264.00	**6047**				**7953**	**0**	**2**	**N.W.L.**
		6614	0.5	3307				
264.50	7181				11260	3307	2.5	
		8582	1.8	15447				
266.30	9982				26707	18754	4.3	

Permanent Pool Volume Required =	5273	m^3	
Permanent Pool Volume Provided =	7953	m^3	50.83% Extra
Extended Detention volume required =	1392	m^3	
Extended Detention waterlevel =	264.28	m	
5 year control volume required =	5668	m^3	
5 year control waterlevel =	264.78	m	
100 year control volume required =	13972	m^3	
100 year waterlevel =	265.74	m	
Freeboard =	0.56	m	

POND BLOCK = 1.30ha
PERMANENT POOL REQUIRED = 5,273m³
PERMANENT POOL PROVIDED = 7,953m³
NORMAL WATER LEVEL (NWL) = 264.00m
EXTENDED DETENTION REQUIRED = 1,392m³
EXTENDED DETENTION LEVEL = 264.28m
100yr ACTIVE STORAGE REQUIRED = 13,972m³
100yr HIGH WATER LEVEL (HWL) = 265.74m
FREEBOARD = 0.56m
MAXIMUM ACTIVE STORAGE PROVIDED = 18,754m³
(WITH 0.56m FREEBOARD)

PARK

OPEN SPACE

CARSON ROAD WEST

SWM POND
NWL = 264.00

SEDIMENT FOREBAY

1 m BUFFER

LIMIT OF DEVELOPMENT

2 m FLAT BERM

EMERGENCY SPILLWAY

OVERLAND FLOW ROUTE

MAINTENANCE ACCESS ROAD

MAINTENANCE ACCESS ROAD

TO BLACK CREEK VIA EXISTING CARSON ROAD CULVERT

CARSON ROAD SOUTH POND OUTLET

NOTE: SCHEMATIC LAYOUT ONLY, DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE.

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LEGEND:
- MAX. 3:1 SLOPE
- LIMIT OF DEVELOPMENT APPLICATION
- PROPOSED FLOODLINE
- 290.00 EXISTING CONTOUR
- × 166.50 PROPOSED GRADE
- 291.70 POND CONTOUR
- OVERLAND FLOW
- PROPOSED MAINTENACE ACCESS ROAD
- PROPOSED EMERGENCY SPILLWAY
- PROPOSED OVERLAND FLOW ROUTE
- PROPOSED STORM SEWER

CARSON ROAD DEVELOPMENT INC. (CRDI)

PRELIMINARY SWM POND GRADING - CARSON ROAD NORTH POND

DRAWN BY:	S.F.	CHECKED BY:	J.M.P.
SCALE:	1:1000	DATE:	JUNE 2014
PROJECT No:	1194	FIGURE No:	4.4.2

File: P:\1194 Midhurst Carson Road\Drawings\FSP\Figs\Report Figures\1194D-PREL-POND-CARS-NRTH-4.4.2.dwg – Revised by <MBRITTON> : Tue, Aug 05 2014 – 4:59pm

CARSON ROAD SOUTH POND

DRAINAGE AREA CHARACTERISTICS

Development Type	Area (Ha)	% Imperviousness (TIMP)	% Imperviousness (XIMP)	Impervious Area (Ha)
Singles	29.4	60%	25%	17.6
Townhouses	17.1	90%	30%	15.4
High Density/Mixed Use	4.5	85%	85%	3.8
Park	5.0	10%	0%	0.5
Pond	2.0	50%	50%	1.0
Open Space/External Drainage	5.6	0%	0%	0.0
Total	**63.7**	**60%**	**27%**	**38.4**

CARSON ROAD SOUTH POND

PERMANENT POOL

Level of Protection = 1 (Enhanced)

Weighted Impervious = 60 %

Drainage Area = 63.7 ha

SWMP Type = 4. Wet Pond

Required Permanent Pool (including 40m^3/ha for extended detention)= 202 m^3/ha
Required Permanent Pool (minus 40m^3/ha for extended detention)= 162 m^3/ha

Required Permanent Pool = 10340 m^3

TABLE 3.2 - WATER QUALITY STORAGE REQUIREMENTS
(FROM MOE SWM PLANNING AND DESIGN MANUAL - 2004)

Protection Level	SWMP Type	Storage Volume (m^3/s) for Impervious Level			
		35%	55%	70%	85%
Enhanced (Level 1)	1. Infiltration	25	30	35	40
	2. Wetlands	80	105	120	140
	3. Hybrid Wet Pond/Wetland	110	150	175	195
	4. Wet Pond	140	190	225	250
Normal (Level 2)	1. Infiltration	20	20	25	30
	2. Wetlands	60	70	80	90
	3. Hybrid Wet Pond/Wetland	75	90	105	120
	4. Wet Pond	90	110	130	150
Basic (Level 3)	1. Infiltration	20	20	20	20
	2. Wetlands	60	60	60	60
	3. Hybrid Wet Pond/Wetland	60	70	75	80
	4. Wet Pond	60	75	85	95
	5. Dry Pond (Continuous Flow)	90	150	200	240

EXTENDED DETENTION

Using the 25mm - 4 hour Chicago Storm

Erosion Control Volume (V) = Runoff Depth (mm) x Drainage Area (ha) x 10 (m^3) / (mm)(ha)

Erosion Control Volume (V) = 2.09 mm x 63.69 ha x 10 m^3 / mm·ha

Erosion Control Volume (V) = 1331 m^3

Using 40m^3/ha

Extended Detention Volume (V) = 40m^3/ha x Drainage Area (ha)

Extended Detention Volume (V) = 40 m^3/ha 63.69 ha

Extended Detention Volume (V) = 2547 m^3

Governing Volume (V) = 2547 m^3

Peak Flowrate (Q_p) = Extended Detention Volume (m^3) / Detention Time (hr) x 1 (hr) / 3600 (s) x 1.5 (peaking factor)

Peak Flowrate (Q_p) = 2547 m^3 / 72 hr x 1 (hr) / 3600 (s) x 1.5 (peaking factor)

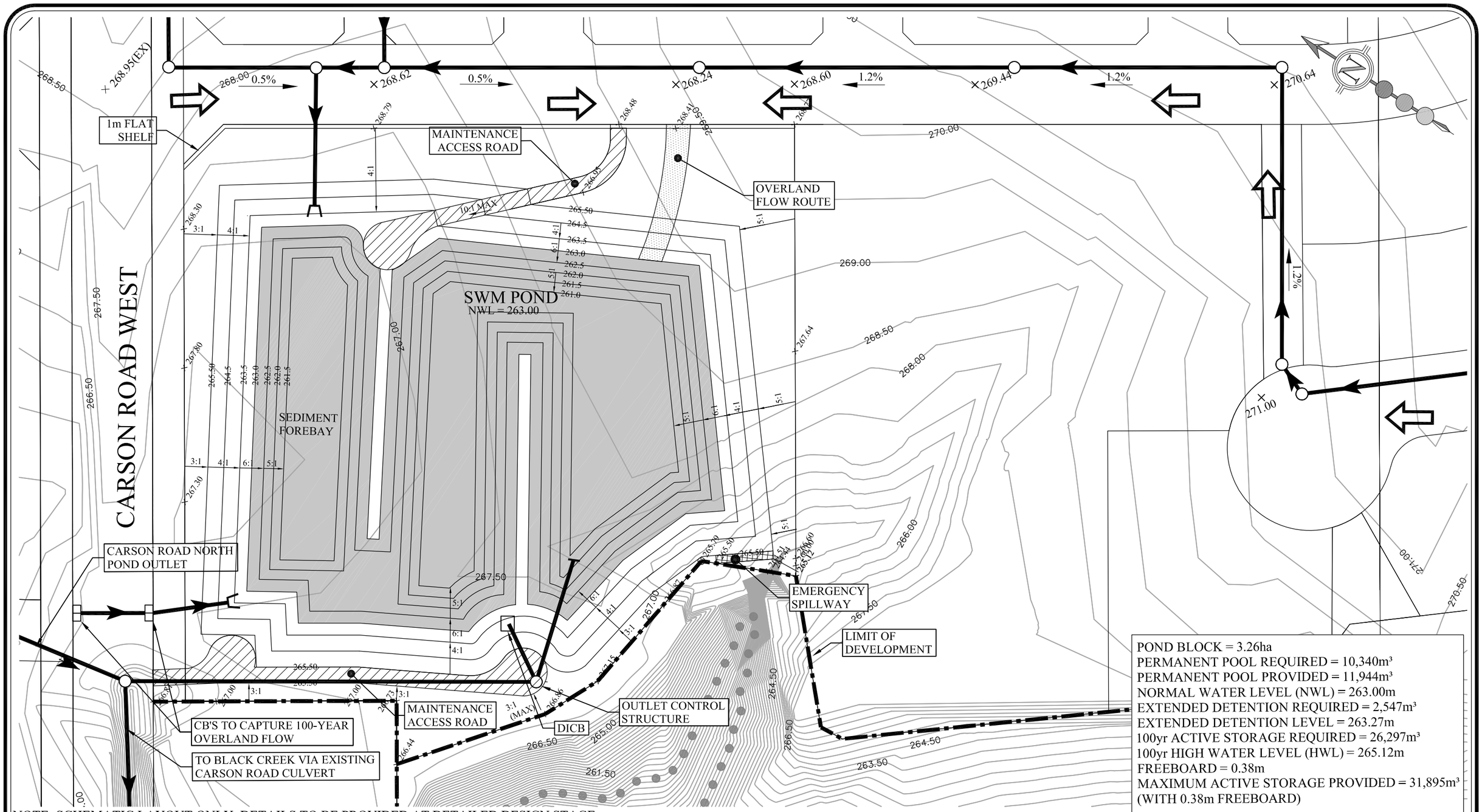
Peak Flowrate (Q_p) = 0.015 m^3/s

CARSON ROAD SOUTH POND

STAGE STORAGE TABLE

Elevation (m)	Area (m^2)	Avg Area (m^2)	ΔH (m)	ΔVolume (m^3)	Total Volume (m3)	Active Storage (m3)	Depth (m)	
261.00	2372				0		0	
		3373	0.5	1686				
261.50	4373				1686		0.5	
		5113	0.5	2557				
262.00	5853				4243		1	
		6752	0.5	3376				
262.50	7650				7619		1.5	
		8649	0.5	4325				
263.00	**9648**				**11944**	**0**	**2**	**N.W.L.**
		10554	0.5	5277				
263.50	11460				17221	5277	2.5	
		11917	0.5	5959				
264.00	12375				23179	11236	3	
		12831	0.5	6416				
264.50	13288				29595	17651	3.5	
		13762	0.5	6881				
265.00	14237				36476	24532	4	
		14725	0.5	7362				
265.50	15212				43838	31895	4.5	

Permanent Pool Volume Required =	10340	m^3	
Permanent Pool Volume Provided =	11944	m^3	15.51% Extra
Extended Detention volume required =	2547	m^3	
Extended Detention waterlevel =	263.27	m	
5 year control volume required =	10071	m^3	
5 year control waterlevel =	263.90	m	
5 year active fluctuation =	0.90	m	
100 year control volume required =	26297	m^3	
100 year waterlevel =	265.12	m	
Freeboard =	0.38	m	



POND BLOCK = 3.26ha
PERMANENT POOL REQUIRED = 10,340m³
PERMANENT POOL PROVIDED = 11,944m³
NORMAL WATER LEVEL (NWL) = 263.00m
EXTENDED DETENTION REQUIRED = 2,547m³
EXTENDED DETENTION LEVEL = 263.27m
100yr ACTIVE STORAGE REQUIRED = 26,297m³
100yr HIGH WATER LEVEL (HWL) = 265.12m
FREEBOARD = 0.38m
MAXIMUM ACTIVE STORAGE PROVIDED = 31,895m³
(WITH 0.38m FREEBOARD)

NOTE: SCHEMATIC LAYOUT ONLY, DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE.

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TEL: (905) 475-1900
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LEGEND:

- MAX. 3:1 SLOPE
- PROPOSED FLOODLINE
- 290.00 EXISTING CONTOUR
- × 166.50 PROPOSED GRADE
- 291.70 POND CONTOUR
- OVERLAND FLOW
- PROPOSED MAINTENACE ACCESS ROAD
- PROPOSED OVERLAND FLOW ROUTE
- PROPOSED STORM SEWER

CARSON ROAD DEVELOPMENT INC. (CRDI)

PRELIMINARY SWM POND GRADING - CARSON ROAD SOUTH POND

DRAWN BY:	S.F.	CHECKED BY:	J.M.P.
SCALE:	1:1000	DATE:	JUNE 2014
PROJECT No:	1194	FIGURE No:	4.4.3

File: P:\1194 Midhurst Carson Road\Drawings\FSP\Figs\Report Figures\1194D-PREL-POND-CARS-SOTH-4.4.3.dwg – Revised by <MBRITTON> : Tue, Aug 05 2014 – 3:32pm

DRAINAGE AREA CHARACTERISTICS

Development Type	Area (Ha)	% Imperviousness (TIMP)	% Imperviousness (XIMP)	Impervious Area (Ha)
Singles	14.1	60%	25%	8.5
Townhouses	0.0	90%	30%	0.0
Park	1.2	10%	0%	0.1
Pond	1.1	50%	50%	0.6
Open Space	2.6	0%	0%	0.0
Total	**19.0**	**48%**	**21%**	**9.1**

PERMANENT POOL

Level of Protection = 1 (Enhanced)

Weighted Impervious = 48 %

Drainage Area = 19.00 ha

SWMP Type = 4. Wet Pond

Required Permanent Pool (including 40m^3/ha for extended detention)= 173 m^3/ha
Required Permanent Pool (minus 40m^3/ha for extended detention)= 133 m^3/ha

Required Permanent Pool = 2520 m^3

TABLE 3.2 - WATER QUALITY STORAGE REQUIREMENTS
(FROM MOE SWM PLANNING AND DESIGN MANUAL - 2004)

Protection Level	SWMP Type	Storage Volume (m^3/s) for Impervious Level			
		35%	55%	70%	85%
Enhanced (Level 1)	1. Infiltration	25	30	35	40
	2. Wetlands	80	105	120	140
	3. Hybrid Wet Pond/Wetland	110	150	175	195
	4. Wet Pond	140	190	225	250
Normal (Level 2)	1. Infiltration	20	20	25	30
	2. Wetlands	60	70	80	90
	3. Hybrid Wet Pond/Wetland	75	90	105	120
	4. Wet Pond	90	110	130	150
Basic (Level 3)	1. Infiltration	20	20	20	20
	2. Wetlands	60	60	60	60
	3. Hybrid Wet Pond/Wetland	60	70	75	80
	4. Wet Pond	60	75	85	95
	5. Dry Pond (Continuous Flow)	90	150	200	240

EXTENDED DETENTION

Using the 25mm - 4 hour Chicago Storm

Erosion Control Volume (V) = Runoff Depth (mm) x Drainage Area (ha) x 10 (m^3) / (mm)(ha)

Erosion Control Volume (V) = 2.01 mm x 190.00 ha x 10 m^3 / mm·ha

Erosion Control Volume (V) = 3819 m^3

Using 40m^3/ha

Extended Detention Volume (V) = 40m^3/ha x Drainage Area (ha)

Extended Detention Volume (V) = 40 m^3/ha 19.00 ha

Extended Detention Volume (V) = 760 m^3

Governing Volume (V) = 3819 m^3

Peak Flowrate (Q_p) = Extended Detention Volume (m^3) / Detention Time (hr) x 1 (hr) / 3600 (s) x 1.5 (peaking factor)

Peak Flowrate (Q_p) = 3819 m^3 / 72 hr x 1 (hr) / 3600 (s) x 1.5 (peaking factor)

Peak Flowrate (Q_p) = 0.022 m^3/s

STAGE STORAGE TABLE

Elevation (m)	Area (m^2)	Avg Area (m^2)	ΔH (m)	ΔVolume (m^3)	Total Volume (m^3)	Active Storage (m^3)	Depth (m)	
262.75	1190				0		0	
		1520	0.5	760				
263.25	1850				760		0.5	
		2226	0.5	1113				
263.75	2602				1873		1	
		3144	0.5	1572				
264.25	**3685**				**3445**	**0**	**1.5**	**N.W.L.**
		4190	0.5	2095				
264.75	4695				5540	2095	2	
		5017	0.5	2509				
265.25	5339				8048	4604	2.5	
		5688	0.5	2844				
265.75	6037				10892	7448	3	
		6253	0.3	1876				
266.05	6468				12768	9323	2.8	

Permanent Pool Volume Required =	2520	m^3	
Permanent Pool Volume Provided =	3445	m^3	36.69% Extra
Extended Detention volume required =	3819	m^3	
Extended Detention waterlevel =	265.11	m	
5 year control volume required =	5153	m^3	
5 year control waterlevel =	265.35	m	
5 year active fluctuation =	1.10	m	
100 year control volume required =	6663	m^3	
100 year waterlevel =	265.61	m	
Freeboard =	0.44	m	

POND BLOCK = 0.95 ha
PERMANENT POOL REQUIRED = 2,520 m³
PERMANENT POOL PROVIDED = 3,445 m³
NORMAL WATER LEVEL (NWL) = 264.25 m
EXTENDED DETENTION REQUIRED = 3,819 m³
EXTENDED DETENTION LEVEL = 265.11 m
100yr ACTIVE STORAGE REQUIRED = 6,663 m³
100yr HIGH WATER LEVEL (HWL) = 265.61 m
FREEBOARD = 0.44m
MAXIMUM ACTIVE STORAGE PROVIDED = 9,323 m³
(WITH 0.44m FREEBOARD)

EMERGENCY SPILLWAY
LIMIT OF DEVELOPMENT
MAINTENANCE ACCESS ROAD
OVERLAND FLOW ROUTE
SEDIMENT FOREBAY
SWM POND
NWL = 264.25
ONTARIO HYDRO EASEMENT
OVERLAND FLOW ROUTE/MAINTENANCE ACCESS ROAD

264.11 EX
265.89 EX
266.50 EX
266.05 EX
266.71 EX
267.55 EX
267.73 EX
267.61 EX
268.83 EX
269.19 EX
268.85 EX
267.87 EX
268.22

NOTE: SCHEMATIC LAYOUT ONLY, DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE.

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FAX: (905) 475-8335

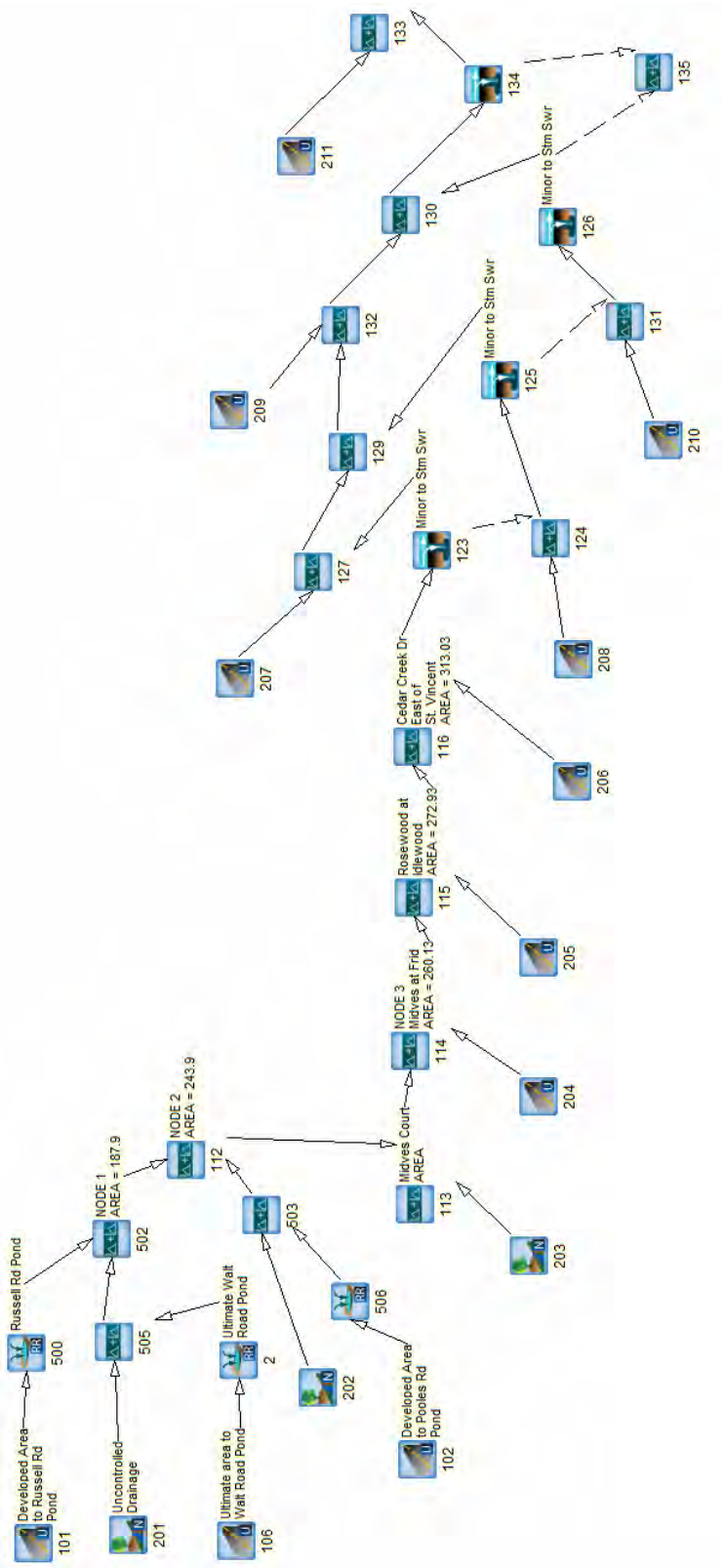
LEGEND:
- LIMIT OF DEVELOPMENT APPLICATION
- PROPOSED FLOODLINE
- 290.00 EXISTING CONTOUR
- × 268.83 EX EXISTING GRADE
- 266.05 POND CONTOUR
- PROPOSED MAINTENACE ACCESS ROAD
- PROPOSED EMERGENCY SPILLWAY
- PROPOSED OVERLAND FLOW ROUTE
- PROPOSED STORM SEWER

CARSON ROAD DEVELOPMENT INC. (CRDI)

PRELIMINARY SWM POND GRADING - SOUTH POND

DRAWN BY:	S.F.	CHECKED BY:	J.M.P.
SCALE:	1:1000	DATE:	JUNE 2014
PROJECT No:	1194	FIGURE No:	4.4.4

File: P:\1194 Midhurst Carson Road\Drawings\FSP\Figs\Report Figures\1194D-PREL-POND-SOTH-4.4.4.dwg - Revised by <MBRITTON> : Tue, Aug 05 2014 - 3:57pm


133
134
135
211
130
Minor to Stm Swr
126
132
131
209
Minor to Stm Swr
125
129
210
Minor to Stm Swr
123
124
127
207
208
Cedar Creek Dr East of St. Vincent AREA = 313.03
116
206
Rosewood at Idlewood AREA = 272.93
115
205
NODE 3 Midves at Frid AREA = 260.13
114
204
NODE 2 AREA = 243.9
112
Midves Court AREA
113
203
NODE 1 AREA = 187.9
502
503
Russell Rd Pond
500
505
Ultimate Wait Road Pond
2
506
202
Developed Area to Pooles Rd Pond
102
Developed Area to Russell Rd Pond
101
Uncontrolled Drainage
201
Ultimate area to Wait Road Pond
106

ROSE ALLIANCE LANDS

DORAN ROAD

POOLES ROAD

ROAD ALLOWANCE BETWEEN LOTS 15 AND 16

ROAD ALLOWANCE BETWEEN CONCESSIONS 2 WF

ROAD ALLOWANCE BETWEEN CONCESSIONS 1 AND 2 WEST OF THE

101	85.0ha
102	26.9ha
103	24.2ha
104	7.90ha
105	49.5ha
106	21.8ha
201	81.1ha
202	29.1ha
203	3.83ha
204	12.4ha
205	12.8ha
206	38.9ha
207	16.4ha
208	6.97ha
209	10.6ha
210	6.15ha
211	1.85ha
401	3.50ha
202	1.40ha
203	2.50ha

ULTIMATE SWM POND LOCATION

WALT ROAD POND BLOCK (TEMPORARY)

NORTHEAST POND BLOCK (TEMPORARY)

RUSSELL ROAD POND

EXISTING POOLES ROAD CULVERT

ULTIMATE SWM POND LOCATION

EXISTING MIDVES COURT EXTENSION

POOLES ROAD POND BLOCK

EXISTING ST. VINCENT STREET CULVERT

HERITAGE SITE

EAST POND BLOCK

WILLOW CREEK TRIBUTARY

SOUTH POND BLOCK

*NOTE: LAYOUT IS SCHEMATIC ONLY, DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE.

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FAX: (905) 475-8335

LEGEND:

- LIMIT OF PHASE/DEVELOPMENT
- STORM DRAINAGE BOUNDARY
- MINOR SYSTEM - STORM SEWER
- MAJOR SYSTEM - OVERLAND FLOW
- 0.50 / 0.20ha — CATCHMENT ID / DRAINAGE AREA (HECTARES)

MIDHURST SECONDARY PLAN - DORAN ROAD

POST-DEVELOPMENT DRAINAGE PLAN

DESIGNED BY: J.M.P.	CHECKED BY: S.M.S.	PROJECT No: 1168	FIGURE No: 3
SCALE: 1:5000	DATE: APRIL 2014		

File: P:\1212 Midhurst Growth Study\Drawings\Secondary Plan\Fig\MDP Figures\1212D-PREL-POST-DORAN.dwg – Revised by <MORECCHIA> : Tue, May 06 2014 – 10:16am

Proposed Conditions
VO2 Parameter Summary

Doran Road Neighbourhood
Project Number: 1168
Date: June 2014
Designer Initials: JMP

NASHYD

Number	201	202	203
Description			
DT(min)	2	2	2
Area (ha)	81.1	29.1	3.83
CN	66.0	46.0	46.0
IA(mm)	7.3	10.0	10.0
TP (hr)	3.03	0.59	0.08

STANDHYD

Number	101	102	106	204	205	206	207	208	209	210	211
Description											
DT(min)	2	2	2	2	2	2	2	2	2	2	2
Area (ha)	85	26.9	21.8	12.4	12.8	38.9	16.4	6.97	10.6	6.15	1.85
XIMP*	0.33	0.36	0.33	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
TIMP	0.50	0.52	0.52	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
CN	52.0	55.0	59.0	71.0	71.0	70.0	67.0	64.0	64.0	64.0	64.0
IA(mm)	23.0	20.0	20.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
SLPP(%)	2	2	2	2	2	2	2	2	2	2	2
LGP(m)	40	40	40	40	40	40	40	40	40	40	40
MNP	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
DPSI (mm)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
SLPI(%)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
LGI(m)	752.8	423.5	381.2	287.5	292.1	509.2	330.7	215.6	265.8	202.5	111.1
MNI	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013

*Note that where there is NO directly connected area (ie: roof runoff to grassed areas), the hydrology program does not accept XIMP=0%, therefore, XIMP = 1% has been used

Proposed Conditions

Site Soils: (per Simcoe County Soils Mapping)

Soil Type	Hydrologic Soil Group
Tioga Loamy Sand	A
Vasey Sandy Loam	AB
Dundonald Sandy Loam	AB

TABLE OF CURVE NUMBERS (CN's)**

Land Use	Hydrologic Soil Type							Manning's 'n'	Source
	A	AB	B	BC	C	CD	D		
Meadow "Good"	38	51	65	71	76	79	81	0.40	MTO
Woodlot "Fair"	32	46	60	67	73	76	79	0.40	MTO
Gravel	76	80.5	85	87	89	90	91	0.30	USDA
Lawns "Good"	49	59	69	74	79	82	84	0.25	USDA
Pasture/Range	49	59	69	74	79	82	84	0.17	MTO
Crop	62	68	74	78	82	84	86	0.13	MTO
Fallow (Bare)	77	82	86	89	91	93	94	0.05	MTO
Low Density Residences	57	64.5	72	76.5	81	83.5	86	0.25	USDA
Streets, paved	100	100	100	100	100	100	100	0.01	USDA

1. MTO Drainage Manual (1997), Design Chart 1.09-Soil/Land Use Curve Numbers
2. USDA (1986), Urban Hydrology for Small Watersheds, Table 2.2-Runoff Curve Numbers for Urban Areas

HYDROLOGIC SOIL TYPE (%) - Proposed Conditions

Catchment	Hydrologic Soil Type							TOTAL
	A	AB	B	BC	C	CD	D	
101	71	29						100
102	37	63						100
106	5	95						100
201		100						100
202		100						100
203		100						100
204		100						100
205		100						100
206	12	88						100
207	55	45						100
208	100							100
209	100							100
210	100							100
211	100							100

LAND USE (%) - Proposed Conditions

Catchment	Meadow	Woodlot	Gravel	Lawns	Pasture Range	Crop	Fallow (Bare)	Low Density Residences	Impervious	Total
101				100.0						100.0
102				100.0						100.0
106				100.0						100.0
201		10.0				90.0				100.0
202		100.0								100.0
203		100.0								100.0
204				71.0					29.0	100.0
205				71.0					29.0	100.0
206				71.0					29.0	100.0
207				71.0					29.0	100.0
208				71.0					29.0	100.0
209				71.0					29.0	100.0
210				71.0					29.0	100.0
211				71.0					29.0	100.0

Note: Where STANDHYD command used (shaded), impervious fraction is not considered in CN determination, since %Imp directly input in STANDHYD command

CURVE NUMBER (CN) - Proposed Conditions										
Catchment	Meadow	Woodlot	Gravel	Lawns	Pasture Range	Crop	Fallow (Bare)	Low Density Residences	Impervious	Weighted CN
101	0.0	0.0	0.0	51.9	0.0	0.0	0.0	0.0	0.0	52
102	0.0	0.0	0.0	55.3	0.0	0.0	0.0	0.0	0.0	55
106	0.0	0.0	0.0	58.5	0.0	0.0	0.0	0.0	0.0	59
201	0.0	4.6	0.0	0.0	0.0	61.2	0.0	0.0	0.0	66
202	0.0	46.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46
203	0.0	46.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46
204	0.0	0.0	0.0	41.9	0.0	0.0	0.0	0.0	29.0	71
205	0.0	0.0	0.0	41.9	0.0	0.0	0.0	0.0	29.0	71
206	0.0	0.0	0.0	41.0	0.0	0.0	0.0	0.0	29.0	70
207	0.0	0.0	0.0	38.0	0.0	0.0	0.0	0.0	29.0	67
208	0.0	0.0	0.0	34.8	0.0	0.0	0.0	0.0	29.0	64
209	0.0	0.0	0.0	34.8	0.0	0.0	0.0	0.0	29.0	64
210	0.0	0.0	0.0	34.8	0.0	0.0	0.0	0.0	29.0	64
211	0.0	0.0	0.0	34.8	0.0	0.0	0.0	0.0	29.0	64

** AMC II assumed

Proposed Conditions

LAND USE (%) - Proposed Conditions										
Catchment	Meadow	Woodlot	Gravel	Lawns	Pasture Range	Crop	Fallow (Bare)	Low Density Residences	Impervious	Total
201		10.0				90.0				100.0
202		100.0								100.0
203		100.0								100.0
204				100.0						100.0
205				100.0						100.0
206				100.0						100.0
207				100.0						100.0
208				100.0						100.0
209				100.0						100.0
210				100.0						100.0
211				100.0						100.0

IA VALUES (mm) - Proposed Conditions										
Catchment	Meadow	Woodlot	Gravel	Lawns	Pasture Range	Crop	Fallow (Bare)	Low Density Residences	Impervious	Total
IA (mm)	8	10	2	5	8	7	3	2	2	
201		1.0				6.3				7.3
202		10.0								10.0
203		10.0								10.0
204				5.0						5.0
205				5.0						5.0
206				5.0						5.0
207				5.0						5.0
208				5.0						5.0
209				5.0						5.0
210				5.0						5.0
211				5.0						5.0

* IA values based on NVCA guidelines, Catchment 101 per Item #5 submission, Catchments 102 & 106 estimated at 20.0mm

Uplands Method:

Catchment ID	High Elevation	Low Elevation	Length (m)	Slope (%)	Land Cover Type	Velocity (m/s)	Time of Concentration (s)	Time of Concentration (hr)	Time to Peak (hr)
201a	295.00	293.00	100	2.00	Pasture	0.31	324.9	0.09	0.06
201b	293.00	292.00	445	0.22	Pasture	0.10	4353.1	1.21	0.81
201c	292.00	289.50	113	2.21	Pasture	0.32	349.0	0.10	0.06
201d	289.50	284.50	298	1.68	Forest (Heavy Litter)	0.10	3078.4	0.86	0.57
201e	284.50	276.50	469	1.70	Forest (Heavy Litter)	0.10	4806.8	1.34	0.89
201f	276.50	271.50	279	1.79	Forest (Heavy Litter)	0.10	2782.6	0.77	0.52
201g	271.50	267.00	195	2.31	Pasture	0.33	588.0	0.16	0.11
201									**3.03**
202a	285	277.5	46	16.42	Woodland	0.61	74.8	0.02	0.01
202b	277.5	270.5	252	2.78	Woodland	0.25	998.3	0.28	0.19
202c	270.5	261.5	229	3.94	Woodland	0.30	763.2	0.21	0.14
202d	261.5	256.75	267	1.78	Woodland	0.20	1325.5	0.37	0.25
202									**0.59**
203a	281.5	263.5	195	9.21	Woodland	0.46	427.2	0.12	0.08
203									**0.08**

ROSE ALLIANCE LANDS

LOT 12

CONCESSION 3

ROAD ALLOWANCE BETWEEN CONCESSIONS 2 WPR

LOT 24

CONCESSION 2 WPR

DORAN ROAD

LOT 23

LOT 13

RUSDOR

LOT 22

FINES

JACQUES

MYRICK

LOT 21

LOT 20

ROAD ALLOWANCE BETWEEN LOTS 21 AND 22

POOLES ROAD

ROAD ALLOWANCE BETWEEN LOTS 20 AND 21

WALT ROAD

ROAD ALLOWANCE BETWEEN LOTS 19 AND 20

ROAD ALLOWANCE BETWEEN LOTS 18 AND 19

ROAD ALLOWANCE BETWEEN LOTS 17 AND 18

ROAD ALLOWANCE BETWEEN LOTS 16 AND 17

ROAD ALLOWANCE BETWEEN LOTS 15 AND 16

ROAD ALLOWANCE BETWEEN LOTS 14 AND 15

ROAD ALLOWANCE BETWEEN LOTS 13 AND 14

ROAD ALLOWANCE BETWEEN LOTS 12 AND 13

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ROAD ALLOWANCE BETWEEN LOTS 8 AND 9

ROAD ALLOWANCE BETWEEN LOTS 7 AND 8

ROAD ALLOWANCE BETWEEN LOTS 6 AND 7

ROAD ALLOWANCE BETWEEN LOTS 5 AND 6

ROAD ALLOWANCE BETWEEN LOTS 4 AND 5

ROAD ALLOWANCE BETWEEN LOTS 3 AND 4

ROAD ALLOWANCE BETWEEN LOTS 2 AND 3

ROAD ALLOWANCE BETWEEN LOTS 1 AND 2

101
85.0ha

201
81.1ha

106
21.8ha

105
49.5ha

206
38.9ha

208
6.97ha

210
6.15ha

211
1.85ha

209
10.6ha

205
12.8ha

202
29.1ha

204
12.4ha

207
16.4ha

203
3.83ha

401
3.50ha

102
26.9ha

103
24.2ha

104
7.90ha

202
1.40ha

203
2.50ha

ULTIMATE SWM POND LOCATION

WALT ROAD POND BLOCK (TEMPORARY)

NORTHEAST POND BLOCK (TEMPORARY)

ULTIMATE SWM POND LOCATION

RUSSELL ROAD POND

EXISTING POOLES ROAD CULVERT

EXISTING MIDVES COURT EXTENSION

POOLES ROAD POND BLOCK

EXISTING ST. VINCENT STREET CULVERT

HERITAGE SITE

EAST POND BLOCK

WILLOW CREEK TRIBUTARY

SOUTH POND BLOCK

ONTARIO HYDRO EASEMENT

TIME TO REAL FIGURE

*NOTE: LAYOUT IS SCHEMATIC ONLY, DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE.

LEGEND:

- LIMIT OF PHASE/DEVELOPMENT
- STORM DRAINAGE BOUNDARY
- MINOR SYSTEM - STORM SEWER
- MAJOR SYSTEM - OVERLAND FLOW
- 0.50 / 0.20ha — CATCHMENT ID / DRAINAGE AREA (HECTARES)

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MIDHURST SECONDARY PLAN - DORAN ROAD

POST-DEVELOPMENT ~~DRAINAGE PLAN~~

DESIGNED BY:	J.M.P.	CHECKED BY:	S.M.S.	PROJECT No:	FIGURE No:
SCALE:	1:5000	DATE:	APRIL 2014	1212	3

File: P:\1212 Midhurst Growth Study\Drawings\Secondary Plan\Fig\MDP Figures\1212D-PREL-POST-DORAN.dwg - Revised by <MORECCHIA> : Fri, May 02 2014 - 10:22am

DRAINAGE AREA CHARACTERISTICS

Development Type	Area (Ha)	% Imperviousness (TIMP)	% Imperviousness (XIMP)	Impervious Area (Ha)
Singles	66.13	60%	25%	39.68
Townhouses	5.71	90%	30%	5.14
Mixed Use	1.10	85%	85%	0.94
Park	7.62	10%	0%	0.76
Pond	4.44	50%	50%	2.22
Total	**85.00**	**57%**	**25%**	**48.73**

PERMANENT POOL

Level of Protection = 1 (Enhanced)

Weighted Impervious = 57 %

Drainage Area = 85.00 ha

SWMP Type = 4. Wet Pond

Required Permanent Pool (including 40m^3/ha for extended detention)= 195 m^3/ha
Required Permanent Pool (minus 40m^3/ha for extended detention)= 155 m^3/ha

Required Permanent Pool = 13213 m^3

TABLE 3.2 - WATER QUALITY STORAGE REQUIREMENTS
(FROM MOE SWM PLANNING AND DESIGN MANUAL - 2004)

Protection Level	SWMP Type	Storage Volume (m^3/s) for Impervious Level			
		35%	55%	70%	85%
Enhanced (Level 1)	1. Infiltration	25	30	35	40
	2. Wetlands	80	105	120	140
	3. Hybrid Wet Pond/Wetland	110	150	175	195
	4. Wet Pond	140	190	225	250
Normal (Level 2)	1. Infiltration	20	20	25	30
	2. Wetlands	60	70	80	90
	3. Hybrid Wet Pond/Wetland	75	90	105	120
	4. Wet Pond	90	110	130	150
Basic (Level 3)	1. Infiltration	20	20	20	20
	2. Wetlands	60	60	60	60
	3. Hybrid Wet Pond/Wetland	60	70	75	80
	4. Wet Pond	60	75	85	95
	5. Dry Pond (ContinuousFlow)	90	150	200	240

EXTENDED DETENTION

Using the 25mm - 4 hour Chicago Storm

Erosion Control Volume (V) = Runoff Depth (mm) x Drainage Area (ha) x 10 (m^3) / (mm)(ha)

Erosion Control Volume (V) = 0.81 mm x 85.00 ha x 10 m^3 / mm·ha

Erosion Control Volume (V) = 689 m^3

Using 40m^3/ha

Extended Detention Volume (V) = 40m^3/ha x Drainage Area (ha)

Extended Detention Volume (V) = 40 m^3/ha 85.00 ha

Extended Detention Volume (V) = 3400 m^3

Governing Volume (V) = 3400 m^3

Peak Flowrate (Q_p) = Extended Detention Volume (m^3) / Detention Time (hr) x 1 (hr) / 3600 (s) x 1.5 (peaking factor)

Peak Flowrate (Q_p) = 3400 m^3 / 72 hr x 1 (hr) / 3600 (s) x 1.5 (peaking factor)

Peak Flowrate (Q_p) = 0.020 m^3/s

RUSSELL ROAD POND

STAGE STORAGE TABLE

Elevation (m)	Area (m^2)	Avg Area (m^2)	ΔH (m)	ΔVolume (m^3)	Total Volume (m3)	Active Storage (m3)	Depth (m)	
278.5	1478				0		0	
		2299	0.5	1150				
279.0	13584				1150		0.5	
		14478	0.5	7239				
279.5	15372				8389		1	
		16462	0.5	8231				
280.0	**17551**				**16619**	**0**	**1.5**	**N.W.L.**
		18580	0.5	9290				
280.5	19608				25909	9290	2	
		22409	1.8	40335				
282.3	25209				66244	49625	3.8	
		26049	0.3	7815				
282.6	26889				74059	57440	4.1	

Permanent Pool Volume Required =	13213	m^3	
Permanent Pool Volume Provided =	16619	m^3	25.78% Extra
Extended Detention volume required =	3400	m^3	
Extended Detention waterlevel =	280.18	m	
5 year control volume required =	12007	m^3	
5 year control waterlevel =	280.62	m	
5 year active fluctuation =	0.62	m	
100 year control volume required =	37532	m^3	
100 year waterlevel =	281.76	m	
Freeboard =	0.84	m	

POND BLOCK = 4.39ha
PERMANENT POOL REQUIRED = 13,213m³
PERMANENT POOL PROVIDED = 16,619m³
NORMAL WATER LEVEL (NWL) = 280.00m
EXTENDED DETENTION REQUIRED = 3,400m³
EXTENDED DETENTION LEVEL = 280.18m
100yr ACTIVE STORAGE REQUIRED = 37,532m³
100yr HIGH WATER LEVEL (HWL) = 281.76m
FREEBOARD = 0.84m
MAXIMUM ACTIVE STORAGE PROVIDED = 57,440m³
(WITH 0.84m FREEBOARD)

RUSSELL ROAD

POOLES ROAD

PARK

SWM POND
NWL = 280.00

SEDIMENT FOREBAY

SEDIMENT FOREBAY

INLET STRUCTURE

4.0m WIDE MAINTENANCE ACCESS ROAD

OVERLAND FLOW ROUTE

OVERLAND FLOW ROUTE

LIMIT OF DEVELOPMENT

4.0m WIDE FLAT BERM

MAX 3:1 TO MATCH EXISTING

EMERGENCY SPILLWAY

DICB

OUTLET CONTROL STRUCTURE

4.0m WIDE MAINTENANCE ACCESS ROAD

TO EXISTING MUNICIPAL OUTLET

NOTE: SCHEMATIC LAYOUT ONLY, DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE.

MIDHURST DEVELOPMENT
DORAN ROAD INC.
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LEGEND:

- LIMIT OF DEVELOPMENT APPLICATION
- MAX. 3:1 SLOPE
- 290.00 EXISTING CONTOUR
- × 166.50 PROPOSED GRADE
- × 287.59 EX EXISTNG GRADE
- 291.70 POND CONTOUR
- OVERLAND FLOW
- PROPOSED MAINTENACE ACCESS ROAD
- PROPOSED EMERGENCY SPILLWAY
- PROPOSED OVERLAND FLOW ROUTE
- PROPOSED STORM SEWER

MIDHURST DEVELOPMENT DORAN ROAD INC. (MDDRI)

PRELIMINARY SWM POND GRADING - RUSSELL ROAD POND

DRAWN BY:	S.F.	CHECKED BY:	J.M.P.
SCALE:	1:1500	DATE:	JUNE 2014
PROJECT No:	1168	FIGURE No:	4.4.1

File: P:\1168 Midhurst – Doran Road\Drawings\FSP\Fig\Report Figures\1168-PREL-POND-RUSL-4.4.1.dwg – Revised by <MBRITTON> : Tue, Aug 05 2014 – 4:45pm

Priamo, John

From: Schaefer, Steve
Sent: Tuesday, June 24, 2014 3:29 AM
To: Tom Reeve
Cc: Glenn Switzer; Brad Sokach; Joe Mullan; (chibberd@nvca.on.ca); Renata T. Sadowska P.Eng. (sadowska@ainleygroup.com); Richard Sloan; Susan Rosenthal; Kim Beckman (kimb@davieshowe.com); Shindruk, Cheryl; Patel, Vimal; Dudding, Shauna; Priamo, John
Subject: FW: June 20 Midhurst Review Meeting Notes and Comments
Attachments: XSTEVE_002.pdf; XSTEVE_006.pdf; XSTEVE_004.pdf

Tom, please see our response to your meeting notes below in red:

We trust this completes the information requirements at this stage of the review process and any required conditions of draft plan approval can be forwarded to the municipality.

This submission will be added to the FTP site on Tuesday morning.

Steve Schaefer, P. Eng.
Principal
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From: Tom Reeve [mailto:treeve@nvca.on.ca]
Sent: June-20-14 1:35 PM
To: Christopher F. Crozier (ccrozier@cfcrozier.ca); Schaefer, Steve
Cc: Glenn Switzer; Chris Hibberd; Brad.Sokach@springwater.ca; Richard Sloan (sloan@ainleygroup.com); Kaitlin Wilmshurst
Subject: June 20 Midhurst Review Meeting Notes and Comments

Hello,

Thanks for being able to meet on short notice.

The below comments are based on our meeting and review to date. Although some items overlap with Township expressed concerns this email is not intended to speak for the Township/Ainley.

1. To confirm the ponds are reasonably constructible, accessible and maintainable sections and more detailed grading plans are requested. PLEASE FIND ATTACHED UPDATED SWM POND FIGURES. THE FIGURES HAVE BEEN UPDATED TO INCLUDE:
    - Highlighted limit of development line (environmental constraint + buffer)
    - Current draft plan base
    - Additional grades around the perimeter of the pond block
    - Updated maintenance access road locations, including widened radii and turning areas where necessary (12m centerline turning radii and10% maximum grade)

- Additional grades and slope designations within the pond blocks
- Flattened slopes along potential pedestrian access locations where possible

THE UPDATED POND FIGURES INCLUDE THE HYDRAULIC CHARACTERISTICS BASED ON A CONSERVATIVE MODELLING APPROACH WHICH DOES NOT RECOGNIZE ANY INFILTRATION FROM THE EXTENSIVE LIDS PROPOSED ON THE SITE. THE MODELLING ALSO USES THE INCREASED IMPERVIOUSNESS FACTORS AS NOTED BELOW AND DISCUSSED ON JUNE 20, 2014

THE UPDATED HYDROLOGY MODEL WILL BE UPLOADED TO THE FTP SITE, ALONG WITH THE REMAINDER OF THIS SUBMISSION ON TUESDAY MORNING.

2. In some cases the pond side slopes are based on minimum criteria, not preferred criteria as recommended by MOE. IN ALL CASES, THE POND SLOPES ARE BASED ON THE MOE PREFERRED CRITERIA OF 4:1 SLOPES, WITH SOME AREAS USING 5:1 SLOPES. 3:1 SLOPES ARE ONLY SHOWN IN AREAS OUTSIDE OF THE POND NORMAL OPERATING ELEVATIONS, WHICH MEETS THE TOWNS MAXIMUM GRADING CRITERIA FOR LANDSCAPE AREAS. FLATTER 6:1 SLOPES ARE USED ON EVERY POND FOR 0.5M ABOVE AND BELOW THE NORMAL WATER LEVEL AS A SAFETY SHELF. THE USE OF THESE RELATIVELY FLAT SLOPES WAS DONE AT THIS STAGE TO PROVIDE FLEXIBILITY AT THE DESIGN STAGE TO ACCOMMODATE ANY MINOR VARIATIONS REQUIRED IN THE POND CONFIGURATION. As well, the geotechnical comments on the pond, recommend further analysis of side slopes and soil in the area. A POND SLOPE ASSESSMENT WILL BE COMPLETED AT THE DETAIL DESIGN STAGE. Additionally, Springwater has concerns about side slopes and fencing. Further discussion will be taking place on this between the proponents and Springwater with regards to pond safety for the public. THE NEED FOR FENCING OR PLANTINGS DESIGNED FOR SCREENING WILL BE CONFIRMED AT THE DETAIL DESIGN STAGE.

3. Please provide more details on how impervious % were calculated. PLEASE FIND ATTACHED A SKETCH DEMONSTRATING THE % IMPERVIOUSNESS OF A 9.75m AND 12.2m SINGLE FAMILY RESIDENTIAL LOT , AS WELL AS A 39m WIDE REAR LANE TOWNHOUSE BLOCK. ALSO ATTACHED IS A CHART SHOWING THE CURRENTLY PROPOSED ZONING. THE SINGLE FAMILY LOTS AVERAGE 60% BASED ON MAXIMIZED HOUSE SIZE AND THE SMALLEST LOT SIZE. THE TOWNHOUSE BLOCK REESULTED IN AN 80% IMPERVIOUSNESS, AGAIN BASED ON A MAXIMIZED HOUSE SIZE AND A 100% IMPERVIOUS LANEWAY. Some values seem a little on the low side compared to recent development proposals in the NVCA. Are roads included in the calculation? YES, THE ROADS ARE INCLUDED, AS SHOWN ON THE ATTACHED FIGURES Do these numbers match with the proposed zoning limits for lot coverage? YES, THE CALCULATIONS WERE COMPLETED USING THE ATTACHED ZONING CHART AND MAXIMIZING THE HOUSE SIZE (some addition material was provided in meeting to revise the impervious % to 60% and it will be reviewed)THE 4 CARSON PONDS WERE PREVIOUSLY UPDATED WITH THE INCREASED IMPERVIOUSNESS VALUES AND SUBMITTED AT OUR MEETING ON JUNE 20, 2014. PLEASE FIND ATTACHED THE UPDATED HYDROLOGY FOR THE DORAN SWM POND USING THE UPDATED IMPERVOUSNESS VALUES. AS SHOWN, THE POND BLOCKS HAVE SUFFICIENT SIZE AND VOLUME TO ACCOMMODATE THE REQUIRED STORAGE.

4. The storage values in storage-discharge curves in the report are inconsistent with the Visual OTTHYMO / SWMHYMO model input. Please ensure the discharge portion of the calculation are included. THE MODELLING HAS BEEN UPDATED TO REFLECT THE HIGHER IMPERVIOUSNESS VALUES.

5. For the 'North Pond' the outlet pipe appears below the elevation of flood level in Black Creek. The permanent pool should be above the 100 year flood level. (The additional material provided in meeting will be reviewed) THE HEC-RAS MODEL WAS UPDATED WITH THE 100 YEAR ELEVATIONS AND SUBMITTED TO NVCA AT OUR MEETING ON JUNE 20, 2014. ON THE BASIS OF THIS MODEL, THE OUTFALL FOR THE NORTH POND HAS BEEN MOVED NORTH TO A POINT WHERE THE 100 YEAR FLOODLINE IS BELOW THE NORMAL WATER LEVEL OF THE POND (SEE THE ATTACHED NORTH POND FIGURE).

6. The "North Pond' drawing does not show the lots that are west of the road as shown on the draft plan. AS NOTED IN ITEM 1, ALL THE POND FIGURES HAVE BEEN UPDATED WITH THE LATEST LOT FABRIC FROM THE CURRENT DRAFT PLANS.
7. Additional consideration of the 'Johns Lands' is requested and discussed in the meeting. TO BE ADDRESSED BY ROSE-ALLIANCE
8. The final submission should include geotechnical comments on the pond design that was previously provided and if any of the ponds change, the comment should be updated. The geotechnical comments on the 'Russell Road Pond' was not in the May 2014 .pdf submission. PLEASE FIND ATTACHED THE PRELIMINARY GEOTECHNICAL MEMO RELATED TO THE DORAN SWM POND (GOLDER, MAY 3, 2014). UPDATED GEOTECHNIAL COMMENTS WILL BE PROVIDED AT THE DETAIL DESIGN STAGE.
9. The geotechnical comments on the ponds did not include discussion of groundwater because data was not available. Is it possible to conclude at this point that pond construction will not affect groundwater levels on neighbouring properties? In the event that is might, an approach to mitigate should be noted. ALTHOUGH THIS WAS NOT RAISED BY THE NVCA AT OUR MEETING, WE CONFIRM THAT THIS IS A DESIGN ISSUE. ALL PONDS WILL ALL BE LINED IN ACCORDNACE WITH THE GEOTECHNICAL RECOMMENDATIONS AND A WELL MONITORING PROGRAM WILL BE IMPLEMENTED.
10. For the lands to the south, that currently drain through the Alliance lands but in the future will be direct south, has allowance been made for an interim drainage condition or will the Alliance subdivision require full buildout of the Bell-Coutts-Rusdor subdivision to be completed prior to development of the Alliance lands.TO BE ADDRESSED BY ROSE-ALLIANCE
11. The analysis for the flood hazard, shown on the "North Pond" drawings should be included in the report and the modeling submitted for review. (Material provided in meeting will be reviewed THE REGIONAL STORM HEC-RAS MODEL WAS INCLUDED IN THE 2009 FSR, AND WAS RECENTLY PROVIDED TO NVCA AT OUR MEETING ON JUNE 20, 2014. AS IDENTIFIED IN OUR 2009 FSR (SECTION 6.1 AND FIGURE 6.1), THE LIMIT OF DEVLEOPMENT ALONG THE WESTERN BOUNDARY OF THE NORTH POND IS BASED ON THE GREATER OF 30M FROM THE WATERCOURSE, TOP OF BANK +6M BUFFER, DRIPLINE +5M BUFFER OR REGIONAL FLOODLINE +6M BUFFER. AN ADDITIONAL SLOPE STABILITY EVALUATION WAS RECENTLY SUBMITTED FOR NVCA'S REVIEW (AND POSTED ON THE FTP SITE), WHICH CONFIRMED IN ALL LOCATIONS THE STABLE SLOPE LINE DOES NOT IMPACT THE LIMIT OF DEVELOMPENT.
12. Please provide some more conceptual detail as to what the residential lot LIDs will consist of. AS SHOWN ON THE ATTACHED FIGURE, THE PROPOSED LIDs ON THE RESIDENTIAL LOTS WILL CONSIST OF AN INFILTRATION STRUCTURE LOCATED IN BOTH THE FRONT AND REAR YARD AREAS, TO INFILTRATE THE 25MM RAINFALL RUNOFF FROM THE ROOF AREA. BASED ON A 12.2 LOT AND A 189.3 m^2 ROOF AREA, TWO 280HD CULTECH RECHARGERS (OR EQUIVALENT) HAVE BEEN SHOWN AS AN OPTION TO PROVIDE THE INFILTRATION STORAGE. THE TOTAL FOOTPRINT AREA OF THE CULTECH CHAMBER AND SURROUDING STONE IS APPROXIMATLEY 1.2m X 2.4m. THE UNITS HAVE BEEN SHOWN BOTH UNDER THE DRIVEWAY AND IN THE REAR LOT CORNER TO MINIMIZE FUTURE DISTURBANCE BY THE HOMEOWNER. THE FINAL LOCATION OF THE UNITS CAN BE CONFIRMED AT THE DETAIL DESIGN STAGE.
13. Please provide some more conceptual detail as to what the park block infiltration features will look like. Will they treat water from areas external to the park? PARK DESIGNS HAVE NOT BEEN COMPLETED AT THIS STAGE OF THE DESIGN. THE PROPOSED DESIGN INCLUDES CULTECH STORAGE CHAMBERS (OR EQUIVALENT) IN 50% OF THE PARK AREA TO ACCOMMODATE DRAINAGE FROM THE ADJACENT STORM SEWER SYSTEM WHICH CONVEYS DRAINAGE FROM UPSTREAM AREAS INCLUDING ROADS AND NON-ROOF LOT AREAS. THE REQUIREMENT FOR THE CULTECH CHAMBERS WILL BE INCOROPRATED INTO THE PARK DESIGN AT THE DETAIL DESIGN STAGE. THE CHAMBERS CAN BE INCLUDED UNDER ANY GRASS, WALKWAY, PLAYING FIELD, OR PLAY AREA THAT DOESN'T INCLUDE DEEP FOOTINGS OR TREES. THE CHAMBERS WILL BE BELOW THE FROST LEVEL AND CAN EASILY BE DESIGNED TO MEANDER AROUND THE PARK AREA TO MAXIMIZE THE INFILTRATION POTENTIAL.
14. Alliance Pond: general conformance with forebay sizing and permanent pool requirements should be demonstrated. TO BE ADDRESSED BY ROSE-ALLIANCE

15. Feasibility of Gill Road Outlet: A plan-profile drawing would provide more certainty that the pipe can be constructed. TO BE ADDRESSED BY ROSE-ALLIANCE
16. It was pointed out that constraint mapping has been provided in a number of past submissions and new material was provided. NVCA will review and provide comment if required. NO ACTION REQUIRED
17. The CN numbers we selected primarily for cultivated land over AB soil. This was based on soil mapping. The soil testing provided as part of the Target 5 report shows much more variability in soil including very sandy soils and soils with high silt/clay content. Do you (and/or your geotechnical engineer) think that values selected conservatively represents the soil conditions for the purposes of supporting the draft plan and the targets for stormwater management plan and LID design? WE BELIEVE THE CN VALUES GENERALLY REPRESENT THE SOIL CONDITIONS FOUND ON SITE. A DETAILED GEOTECHNICAL REPORT WILL BE COMPLETED AS A CONDITION OF DRAFT PLAN APPROVAL. THE INFORMATION FROM THIS REPORT WILL BE INCORPORATED INTO THE HYDROLOGY MODELLING THROUGH THE DETAIL DESIGN PROCESS TO ACURATELY REFLECT THE SITE CONDITIONS. ALL SWM POND MODELLING AND POND DESIGN WILL BE SUBJECT TO NVCA'S REVIEW AND APROVAL PRIOR TO CONSTRUCTION.
18. Table shows Block 819 in south Carson pond. Doesn't this block go north? ALTHOUGH THIS ITEM WASN'T DISCUSSED IN OUR MEETING ON JUNE 20, 2014, WE ARE ASSUMING THIS REFERS TO THE TABLES INCLUDED IN THE JUNE 8, 2014 LETTER RELATED TO TARGET ITEM #5 – 25MM RAINFALL TARGET. THE BLOCK NUMBERS HAVE BEEN MODIFIED SEVERAL TIMES DURING VARIOUS DRAFT PLAN REVISIONS OVER THE PAST FEW WEEKS. THE ONLY LARGE PARK DRAINING TO THE SOUTH POND IS NOW REFERRED TO AS BLOCK 535 AND WAS PREVIOUSLY REFERED TO AS BLOCK 537. PLEASE REVISE YOUR SOUTH POND TABLE ACCORDINGLY TO REVISE BLOCK 819 TO BLOCK 535
19. 0.27 metres of freeboard is shown for the Carson Road South Pond.

Two items I noted, but did not capture the conclusion/action in my notes:

20. A discussion of LIDs in the road ROW was requested by Springwater. A DISCUSSION OF LIDs IN THE ROAD ROW IS INCLUDED IN OUR JUNE 8, 2014 LETTER RELATED TO TARGET ITEM #5 – 25MM RAINFALL TARGET. THE LETTER IS INCLUDED ON THE PROJECT FTP SITE.
21. Digital drawings were requested by Ainley for the overall secondary plan area. DIGITAL DRAWINGS WERE PROVIDED TO AINLEY ON FRIDAY JUNE 20, 2014.

Please feel free to contact me if you have any questions or I captured our discussion incorrectly.

Regards,

Tom Reeve | Water Resources Engineer | Nottawasaga Valley Conservation Authority

8195 8th Line | Utopia, Ontario LOM 1T0 | ☎ (705) 424-1479 x247 | treeve@nvca.on.ca | www.nvca.on.ca

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SCS consulting group ltd

File #: 1168/1194
Date: August 8, 2014

Mr. Glenn Switzer, P. Eng.
Director of Engineering and Technical Services
Nottawasaga Conservation Authority
8195 8th Line
Utopia, Ontario, L0M 1T0

Dear Mr. Switzer:

Re: **Midhurst Master Drainage Plan – Phase 1**
Item #3 – Volume Control
Midhurst, Ontario

Further to our submissions of May 2, 2014 and May 27, 2014, please accept the following supplemental information in support of the Volume Control Assessment (Item #3) of the Phase 1 work program for the Master Drainage Plan for your review and approval.

As per NVCA's correspondence of May 29, 2014, the target statement for Volume Control is:

> *At each outlet there would be no increase in the volume of post development runoff from the pre development runoff both on an annual basis and on a storm basis. Due to the assumed sensitivity of the watercourses to the volume of runoff, the storm based target should be incorporated to provide volume control for all storm events up to the 100 year storm. This may be difficult to attain, but should be implemented to the extent possible and if not, the fluvial geomorphologist should provide comments on the potential impacts to receiving watercourses based on the level attained so that the NVCA can better understand the potential impacts of a lower target*

The appended hydrology model includes simulation of the post-development runoff for the 25mm and 2 through 100 year storms assuming the following stormwater management characteristics:

- Extended detention of the 25mm rainfall event for 72 hours (as discussed in detail in Item #4 submission, dated June 5, 2014)
- At source and conveyance infiltration of the 24.6 mm rainfall event, resulting in 23.5 mm of infiltration through LID practices within the Doran community (as discussed in detail in Item #5 submission, dated June 10, 2014)
- At source and conveyance infiltration of the 23.0 mm rainfall event (on average), resulting in 20.5 mm of infiltration through LID practices within the Carson community (on average, as discussed in detail in Item #5 submission, dated June 10, 2014)

- Peak flow control of the 2 through 100 year post-development release rates to pre-development release rates

On this basis, the following runoff control can be achieved.

Carson Road Cumulative Volume Summary

Event	Existing Runoff Volume (m^3)	Post-Development Runoff Volume (m^3)	Extended Detention (25mm runoff - 72hr release) (m^3)	Total Remaining Post Development Runoff Volume (m^3)
Annual*	159 mm	65.4 mm	-	65.4 mm
2yr	20078	13759	3546	10213
5yr	41499	31514	3546	27968
10yr	58120	44868	3546	41322
25yr	81233	63169	3546	59623
50yr	99590	77562	3546	74017
100yr	118594	92398	3546	88852

*Note: Based on annual precipitation within Golder Water Balance Report provided May 2, 2014

Doran Road (To Pooles Road) Cumulative Volume Summary

Event	Existing Runoff Volume (m^3)	Post-Development Runoff Volume (m^3)	Extended Detention (25mm runoff - 72hr release) (m^3)	Total Remaining Post Development Runoff Volume (m^3)
Annual*	80 mm	46.7 mm	-	46.7 mm
2yr	7995	11053	2806	8248
5yr	21787	26147	2806	23341
10yr	25954	37866	2806	35060
25yr	37476	54252	2806	51447
50yr	46833	67354	2806	64549
100yr	56685	81011	2806	78205

* Note: Based on annual precipitation within Golder Water Balance Report provided May 2, 2014

As shown above, these measures will reduce the Carson Road community post development runoff to below the pre-development volumes in all events. Since the post development volumes have been demonstrated to be less than the existing condition, no further geomorphological comment is required.

The Doran Road average exceedance of pre-development event based runoff volume is approximately 26%, although less in the more frequent events. Despite the increase in post-development runoff volumes for the Doran Road development, the additional volume of water released is mitigated through the prolonged release of the extended detention flow volumes (over 72 hours), as well as a lower post-development peak event runoff compared to the pre-development condition (Total Remaining Runoff Volume). Therefore, the increase in overall runoff volume released to the receiving waters, during the 2-100 year storms, is mitigated. In addition, it is noted that the post-development annual runoff volume has been dramatically reduced in the Carson Road scenario (59% less), and in the Doran Road scenario by (42% less) per hectare. Through further

analysis of the areas downstream of Pooles Road, it is expected that further reduction of annual runoff volumes can be provided.

The Rapid Assessment Analysis by AquaLogic, demonstrates that the receiving watercourse for the Doran Road development (Willow Creek, main branch) has a combined score of 73.4 and scored high in stability.

Therefore the demonstrated ability to control up to 72 hours within the current SWM facilities will provide a significant further factor of safety to this already acceptable condition. Based on the significant over-control potential for both extended detention (72hr) and infiltration (19-24 mm of runoff) that has been demonstrated in the SWM facilities, along with the geomorphic assessments provided to date, the SWM facilities are expected to be more than adequate to protect the downstream watercourses with respect to stormwater management discharge volumes.

Please call the undersigned if you have any questions or require any additional information.

Sincerely,

SCS Consulting Group Ltd.

Steve Schaefer, P. Eng.
Principal
sschaefer@scsconsultinggroup.com

Attachments: Hydrology Model and parameters
Aqualogic correspondence and evaluations
Golder Water Balance

c. Mr. Wayne Wilson, NVCA
Mr. Chris Hibbard, NVCA
Mr. Brad Sokach, Township of Springwater
Mr. Brent Spagnol, Township of Springwater
Mr. Joe Mullan, Ainley
Mr. Greg Marek, Simcoe County
Ms. Shauna Dudding, Geranium Corporation
Mr. Matthew Cory, Malone Given Parsons
Mr. Bill De Geus, Aqualogic

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ATTACHMENT A

RUNOFF VOLUME CALCULATIONS
(FOR MODELLING PARAMETERS PLEASE REFER TO ITEM #2)

Carson Road
Runoff Volume Calculations

Carson Road Neighbourhood
Project Number: 1212
Date: August 2014
Designer: C.M.D.

Pre-Development Runoff Volume

Storm	Node (from VO2 Schematic)									
	Node 1		Node 2		Node 4		Node 105		Total	
	Area (ha)	67.7	Area (ha)	29.4	Area (ha)	59.0	Area (ha)	19.1	Area (ha)	175.2
	Runoff Depth (mm)	Runoff Volume (m^3)	Runoff Depth (mm)	Runoff Volume (m^3)	Runoff Depth (mm)	Runoff Volume (m^3)	Runoff Depth (mm)	Runoff Volume (m^3)	Runoff Depth (mm)	Runoff Volume (m^3)
2 Year	11.19	7576	11.63	3419	11.63	6862	11.63	2221	-	20078
5 Year	23.19	15700	24.00	7056	24.00	14160	24.00	4583	-	41499
10 Year	32.53	22023	33.58	9873	33.58	19812	33.57	6412	-	58120
25 Year	45.55	30837	46.88	13783	46.88	27659	46.88	8954	-	81233
50 Year	55.90	37844	57.44	16887	57.44	33890	57.43	10969	-	99590
100 Year	66.63	45109	68.36	20098	68.36	40332	68.35	13055	-	118594

Post-Development Runoff Volume

Storm	Node (from VO2 Schematic) (SCS 24hr)									
	Node 1		Node 2		Node 405		Node 2005		Total	
	Area (ha)	66.1	Area (ha)	34.8	Area (ha)	63.7	Area (ha)	19.1	Area (ha)	183.7
	Runoff Depth (mm)	Runoff Volume (m^3)	Runoff Depth (mm)	Runoff Volume (m^3)	Runoff Depth (mm)	Runoff Volume (m^3)	Runoff Depth (mm)	Runoff Volume (m^3)	Runoff Depth (mm)	Runoff Volume (m^3)
25 mm	1.49	985	2.83	985	2.09	1331	1.28	244	-	3546
2 Year	6.73	4449	8.73	3038	8.02	5109	6.09	1163	-	13759
5 Year	15.96	10550	18.77	6532	18.21	11600	14.83	2833	-	31514
10 Year	22.96	15177	26.23	9128	25.82	16447	21.55	4116	-	44868
25 Year	32.60	21549	36.40	12667	36.19	23053	30.89	5900	-	63169
50 Year	40.22	26585	44.37	15441	44.30	28219	38.31	7317	-	77562
100 Year	48.09	31787	52.56	18291	52.64	33532	46.01	8788	-	92398

Doran Road
Runoff Volume Calculations

Pre-Development Runoff Volume

Storm	Node (from VO2 Schematic)	
	Node 101	
	Area (ha)	144.6
	Runoff Depth (mm)	Runoff Volume (m^3)
2 Year	5.5	7995
5 Year	15.1	21787
10 Year	17.9	25954
25 Year	25.9	37476
50 Year	32.4	46833
100 Year	39.2	56685

Post-Development Runoff Volume

Storm	Node (from VO2 Schematic)							
	Node 101		Node 106		Node 201		Total	
	Area (ha)	85.0	Area (ha)	21.8	Area (ha)	81.1	Area (ha)	187.9
	Runoff Depth (mm)	Runoff Volume (m^3)	Runoff Depth (mm)	Runoff Volume (m^3)	Runoff Depth (mm)	Runoff Volume (m^3)	Runoff Depth (mm)	Runoff Volume (m^3)
25 mm	0.81	689	1.87	408	2.11	1710	-	2806
2 Year	5.80	4930	7.52	1639	5.53	4484	-	11053
5 Year	14.54	12359	17.16	3741	12.39	10047	-	26147
10 Year	21.18	18003	24.34	5306	17.95	14557	-	37866
25 Year	30.34	25789	34.15	7445	25.92	21019	-	54252
50 Year	37.60	31960	41.87	9128	32.39	26267	-	67354
100 Year	45.13	38361	49.81	10859	39.20	31792	-	81011

ATTACHMENT B

AQUALOGIC EVALUATIONS

SCS consulting group ltd

Erosion Threshold Analysis
Willow Creek Tributaries
Carson Road Development Inc.
Midhurst Development Doran Road Inc.
Township of Springwater






Submitted to:

SCS Consulting Group Ltd.
30 Centurian Drive, Suite 100
Markham, ON L3R 8B8

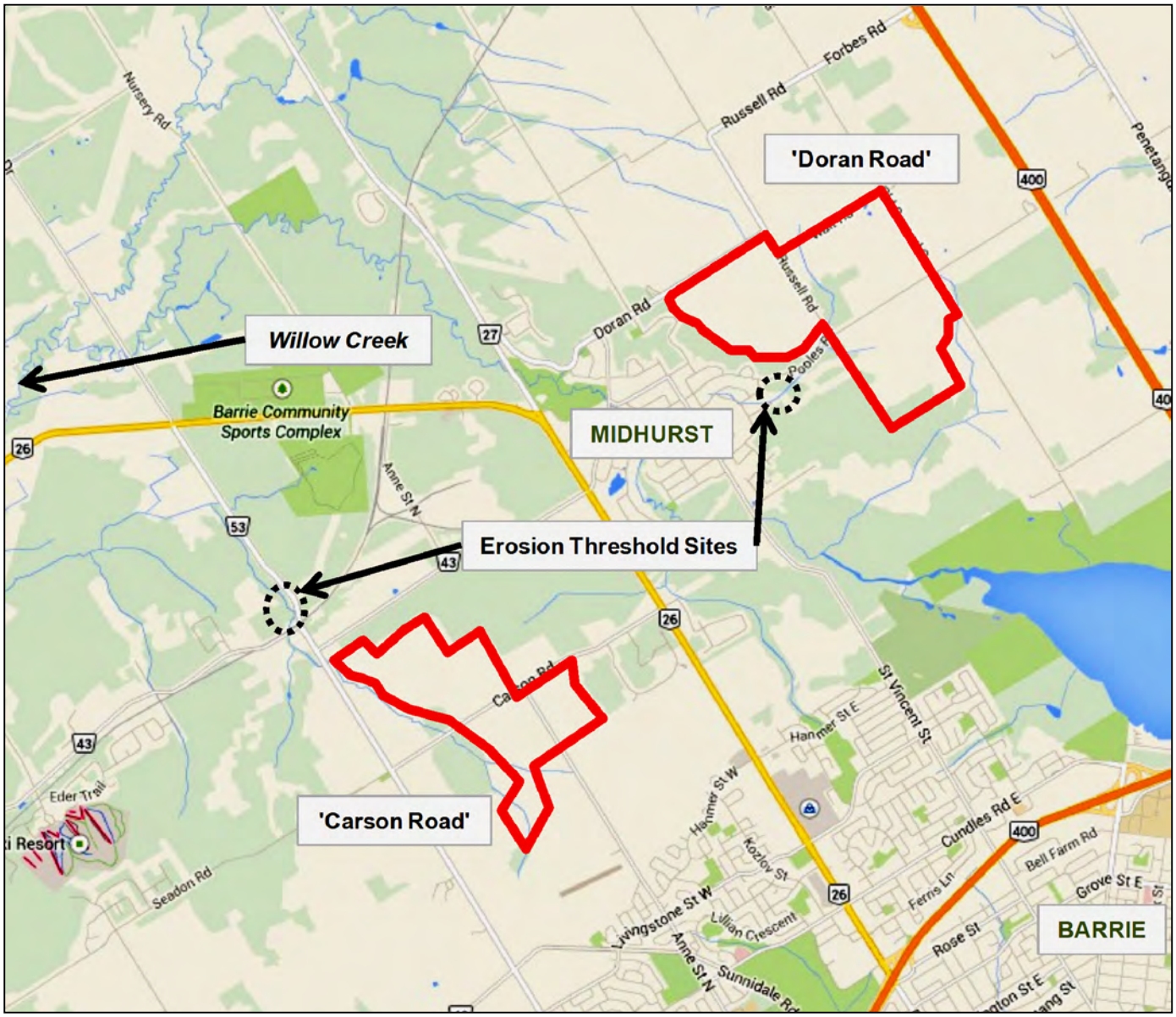
May 2, 2014

AquaLogic Consulting • 9 Ellen St. #1, Mississauga, ON L5M 1R8 • 905.819.9076 • bill.degeus@sympatico.ca

Erosion Threshold Analysis
Willow Creek Tributaries
Carson Road Development Inc.
Midhurst Development Doran Road Inc.
Township of Springwater

Erosion threshold analysis has been undertaken for two reaches of Willow Creek Tributaries that will receive stormwater discharge from proposed residential developments in the Township of Springwater. The study area locations are shown in Figure 1.

Figure 1: Location Map (not to scale, N▲)



Analysis has been done based on field review of channel sensitivity below proposed stormwater pond outlets and detailed cross-section surveys of the downstream locations that will receive combined flows from the development blocks. Field measurements were used for erosion threshold modeling and the results were then used to determine the appropriate methodology for impact analysis. Exceedance-duration analysis was identified to be appropriate for the 'Carson Road' development and vegetation-hydroperiod analysis was identified to be appropriate for the Doran Road development.

Willow Creek Tributary Characterization

Carson Road

The 'Carson Road' Willow Creek Tributary is transitional from a 1st order to 2nd order watercourse with upstream drainage area increments of 1.40km^2 to Anne St. N. for the easterly 1st order feature, 1.80km^2 for the westerly 1st order feature, 5.47km^2 to Carson Rd. W. for the 2nd order branch, and 6.83km^2 to Wilson Dr. at the downstream study limit of the 2nd order branch. Two additional short local drainage features are confluent in the lower study area. The small westerly feature represents drainage from a small wet meadow area (possibly a former beaver pond/meadow) and the easterly feature is characterized by local farm field drainage contribution. The 1st and 2nd order features are officially identified on 1:10,000 Provincial OBM mapping and 1:50,000 Federal NTS mapping. The local drainage features as described above are not seen on mapping and would therefore be deemed not to represent primary drainage functions. The main branch 2nd order tributary is confluent downstream of the study area with the main branch of Willow Creek, which is confluent with the Nottawasaga River in the Minesing Wetlands.

The study area is mainly within the Simcoe Uplands physiographic region, with the downstream area near Wilson Dr. falling to the Simcoe Lowlands physiographic region. Topography is characterized as a deeply rolling till plain with the tributary falling from a shallow U-shaped valley at Anne St. N. to a relatively deep glacial moraine valley at Carson Rd. and a moderately steep valley transition near Wilson Dr. to downstream of Snow Valley Drive beyond the development block. At its deepest point near Carson Rd. the valley is 15-20m deep. The valley slopes are variable from well defined to convex, with gentle to steep gradients and valley width varying from 50m to over 300m.

The valley floor flood plain varies from agricultural row crop and pasture at Anne St. N. to well vegetated lowland forest and transitional upland forest conditions. Forest cover

upstream of Carson Rd. includes a mix of swamp wetland, scrub forest, and coniferous-deciduous forest. Vegetative cover above Wilson Dr. has scrub forest definition with openings in the canopy resulting in thicker herbaceous groundcover and wet meadow.

The tributary branches are ephemeral to intermittent in the south study area while the main branch appears to gain permanent base flow in the forest upstream of Carson Rd. Channel width varies from about 3-5m in the two 1st order features to as high as 8m in wet meadow sections of the northerly 2nd order study reach. Low flow definition varies from ill-defined ephemeral/intermittent at the upstream limits of the 1st order southerly features, up to about 3m wide, at the downstream development limits of the northerly study reach. The tributary flows over deposits of the parent geology with variable low flow bed forms from ill-defined swale, in the south, to occasional pools and riffles and eventually steps of coarser gravel to cobble material, in the northerly reach. There are areas of wetland diffusion, and influence from apparent beaver activity in intervening forest areas. Channel sinuosity is relatively low while the reach average slope is approximately 1%. Channel stability varies from moderate to relatively high due to changes in biotechnical reinforcement and channel bed materials. Some erosion scars are evident on outside banks, in the mid to lower reach. As expected, the channel tributaries are very stable near the upstream end were flows are ephemeral to intermittent and groundcover vegetation density is high. Stability is moderate to high in the shaded forest areas upstream and downstream of Carson Road. Near the downstream study limits the tributary emerges from forest cover into denser groundcover and shrub thicket cover and stability is very high just upstream of Wilson Drive. Downstream of Wilson Dr. and the next crossing at Snow Valley Road the tributary increases in gradient and is partially to fully confined against valley walls. Below Snow Valley Road partial entrenchment also occurs and the steeper channel requires a generally narrower cross-section with higher conveyance velocities, than some upstream areas. In the reach below Snow Valley Road exposed sand and gravel material is seen in channel banks, localized instability is observed and outside bends show colluvial slope failure above distinct bank erosion scars.

Doran Road

Two tributary reaches of Willow Creek border proposed development areas with only the westerly tributary, in the Pooles Road area, identified for analysis during pre-consulting. This feature is 1st order ephemeral and is seen on 1:50,000 scale Federal topographic mapping, but it is not seen on 1:10,000 scale Provincial topographic mapping. The western feature also has two small tributary drainage features within the study area. These features are ephemeral, contour based, overland flow routes that would arguably not be classified as independent 1st order features. Upstream drainage

area is 2.53km^2 for the westerly tributary at Pooles Road. Both tributaries are confluent downstream with the main branch of Willow Creek, which is confluent with the Nottawasaga River in the Minesing Wetlands. Part of the westerly feature is contained in roadside ditching leading to an enclosed storm sewer in the residential area of Midhurst, before it meets Willow Creek. The study area falls mainly within the Simcoe Uplands physiographic region, with the downstream tributary connections to Willow Creek being within the Simcoe Lowlands physiographic region. Topography is characterized as deeply rolling till plain with the tributaries falling from shallow U-shaped valleys at upstream limits to relatively deep glacial moraine valleys at downstream confluence points. At its deepest point, the western valley is approximately 13m deep. Valley side slopes vary from well defined to convex, with gentle to steep gradients and width varying up to approximately 200m. The west tributary valley floor varies from herbaceous old field pasture at Walt Rd. to a continuous swamp forest at the downstream study area limits.

The westerly tributary appears to be fully ephemeral with no flow identified at the time of field work. The feature was found to not have well defined channel bed and bank conditions and would not necessarily meet technical and legal definition as a true watercourse at any point from downstream of Pooles Road to the upstream limits. After passing through mixed forest conditions below Pooles Road the feature opens up into a recently cleared and graded block designed for new residential development. In this area a very modest swale like channel easement appears to have been recently constructed which passes between lots and meets roadside ditching around a cul-de-sac bulb of Midves Court. A small gravel filled trench is seen within the realignment easement and is reported to be an infiltration feature (Gemmell Engineering 2012). Feature sinuosity is very low in the feature, being just over a ratio value of 1.0. Reach average study area slope is approximately 0.01 m m^{-1} for the western feature. Stability is noted to be very high due to the lack of well defined geometry and the extensive vegetation coverage. The lack of channel definition suggests that flow is opportunistic and will anastomise through vegetative cover without sufficient energy to carve a distinct bankfull channel. Soil conditions and vegetative attenuation also appear to encourage a reasonably high amount of recharge that would help account for the lack of flow forming channel definition on the surface.

Rapid Assessment Analysis

Three rapid assessment protocols were undertaken for three reaches of the Carson Road site and two reaches of the Doran Road site, to help characterize existing conditions and determine appropriate locations for detailed erosion threshold analysis. Field observations were used to score relative geomorphic and environmental

attributes. Rapid Geomorphic Assessment (RGA) was used to rate channel stability and infrastructure impact. Rapid Habitat Assessment (RHA) was used to define in-stream and riparian habitat. Rapid Stream Assessment Technique (RSAT) was used to test broad indicators of channel stability, aquatic habitat, and water quality. A weighted score out of 100 was transposed from the results of each protocol and a combined average score was determined from the three tests. Four qualifying ranges of poor, fair, good, and optimal are maintained in the RHA and RSAT protocols, between the original scoring and the weighted scoring out of 100, while the three original ranges in RGA scoring are reflected as poor, fair, and good. The combined average score is qualified by poor to optimal ranges designed as a best fit of the individual protocol ranges. The detailed results are appended and included with each are photographs of typical reach conditions.

Carson Road

Three reaches representing upstream to downstream of Carson Road, upstream to downstream of Wilson Road, and downstream of Snow Valley Road, were scored with rapid assessments.

The detailed results show that both the Carson Road and Wilson Road areas have high levels of both channel stability and habitat quality. Integrated scores in the optimal range and channel stability scores showing ‘in regime’ stability indices are similar for both of these reaches. Biotechnical vegetation control is providing channel reinforcement and habitat canopy and riparian complexity through these reaches.

Downstream of Wilson Road the channel transitions to steeper gradient and deeper valley confinement and entrenchment. A large drop on the downstream face of Snow Valley Road defines the start of what is deemed the most sensitive reach in proximity to the proposed development area. Existing bank erosion and valley wall contact points show a high fraction of cohesionless material that is exposed and available for entrainment under high flows. Channel stability is scored as ‘transitional’ based on scour pool incision at the culvert drop and channel widening in downstream areas causing slope toe and slope face erosion, and moderate to high numbers of undermined trees. Despite the observed erosion, the continuous natural valley conditions contribute to good aquatic habitat, and integrated scoring is relatively high.

Doran Road

Two reaches representing upstream to downstream of Pooles Road and upstream of the east end of Midves Court, were scored with rapid assessments.

The detailed results show that both locations have very high levels of stability but fair habitat quality. Biotechnical vegetation control is providing reinforcement and habitat canopy and complexity through these reaches. The lack of permanent or even intermittent flow results in low habitat scores because there is no observable habitat use by aquatic organisms. Downstream enclosures may also limit seasonal fish access even when spring freshet flows may occur.

The Midves Court area is deemed the most sensitive to upstream development simply due to the nature of the recently constructed swale feature in proximity to near future development of adjacent lots.

Erosion Threshold Characterization

Erosion threshold characterization was undertaken to establish benchmark targets for discharge control provided by stormwater management treatment of the proposed development blocks. Channel forming cross-section surveys for detailed modeling analysis were located in the sensitive reaches identified through rapid assessment. Five cross-sections are generally considered adequate to represent the natural variability of channel conditions in a localized study reach over the equivalent of two meander wavelengths. Backwater influences caused by large woody debris were avoided. Distinct erosion scars and channel forming flow lines were used in the Snow Valley Road reach below the Carson Road development, while fallen and matted groundcover vegetation lines were used as best as possible in the Midves Court reach below the Doran Road development. Channel geometry was measured laterally at each cross-section and the longitudinal profile was shot using bankfull indicators. Channel bed substrates were measured through random-step Wolman pebble counts and recorded using the Wentworth sediment distribution scale.

Open channel flow models were created for each cross-section location. Each model required input of channel bed substrate data, cross-section dimensions, gradient, and bank geometry. Modeling tests were done for each cross-section and erosion indicators and thresholds were reviewed.

Subsequent checks were done to determine the critical stability threshold discharge. This discharge represents a reach based average point at which channel instability begins to occur with rising flow stage and rising discharge, or conversely when instability stops with falling flow stage and falling discharge. This discharge then becomes the comparative flow regime target for detailed analysis of stormwater management hydrology. Iterative flow stage adjustments can be made in each cross-section model until the appropriate stability criteria are achieved over the primary shear

stress and velocity threshold tests, with secondary checks made of stream power and Froude number. **Table 1** presents the threshold criteria used for this analysis based on 'small' watercourse channel typology which display a high degree of vegetation control.

Table 1: Critical stability threshold criteria

	low flow morphology		
	riffle	run	pool / glide
semi-alluvial firm to dense till channels	D_{84} pavement	D_{84} pavement or vegetation control*	D_{100} pavement or vegetation control*
alluvial cohesionless channels	D_{50} pavement	D_{50} pavement or vegetation control*	D_{84} pavement or vegetation control*

*vegetation control criteria varies depending on vegetation type and density
note: step-pool and cascade-step-pool channels require case by case study

The second row criteria are applied for this study case, based on soil conditions and channel typology. The surveyed reach is dominated by run typology, with a combination of particle size and vegetation control deemed to be appropriate for testing overall stability. Conservative vegetation control criteria are identified as 40N m^{-2} for shear stress and 1.2m s^{-1} for channel velocity (Fischenich 2001) based on average to above average rooting depth and density. Higher thresholds are common and viable under very high levels of vegetative encroachment and realistically this could be argued as applicable in the Midves Court reach, especially as it continues to grow in.

Carson Road

The reach average bankfull flow from cross-section modeling, as appended, was determined to be 1.69m^3 s^{-1} in the Snow Valley Road reach. Geomorphic characteristics are summarized in **Table 2** and erosion threshold indicators are shown in **Table 3**.

Table 2: Willow Creek Tributary below Snow Valley Road, bankfull summary

	low flow morphology type	active width (m)	width / max depth ratio	gradient (m m^{-1})	substrate D_{50} (mm)
X-sec. 1	riffle	4.65	8.5	0.016	20
X-sec. 2	riffle	5.10	8.4	0.022	25
X-sec. 3	run	4.75	8.3	0.019	45
X-sec. 4	pool	5.10	7.8	0.011	15
X-sec. 5	pool	5.10	7.4	0.009	20

Table 3: Willow Creek Tributary below Snow Valley Road, erosion threshold indicators

	shear stress (N m^{-2})	mean velocity (m s^{-1})	stream power (watts m^{-1})	Froude #
X-sec. 1	47.7	1.14	264	0.65
X-sec. 2	56.6	1.21	364	0.74
X-sec. 3	52.2	1.18	315	0.68
X-sec. 4	34.4	0.98	183	0.53
X-sec. 5	30.2	0.92	149	0.49
mean	44.2	1.09	255	0.62

Existing condition shear and velocity results fully meet criteria for vegetation control at two sections while all sections meet stream power criteria. Particle size criteria are generally not met for the D_{50} size but are met for the D_{84} size on average. Based on the integrated consideration of both vegetation control and particle size stability, two cross-sections are considered potentially unstable, two are considered cautionary for dynamic stability and one section has dynamic stability.

The secondary checks of stream power and Froude number, under existing conditions, suggest that although there is evidence of erosion, the reach is not aggressively adjusting. Stream power is below a stability threshold of 400 watts m^{-1} (Sear et. al. 2003) and all Froude numbers are less than one thus confirming subcritical flow.

Based on these results, minor iterations were made to adjust flow stage at four of five sections to produce a net result of dynamic stability with a balance of stable criteria exceeding potentially unstable conditions. The detailed cross-section modeling results are appended, showing stage lowering adjustments ranging from 4 to 10cm. The comparison between existing bankfull and dynamic stability adjusted conditions are further shown in a summary model after the cross-section results. The reach averaged stability flow threshold was determined to be 1.29m^3 s^{-1} representing a flow stage 6cm on average below existing bankfull.

The results for Carson Road indicate that an exceedance-duration analysis methodology should be used for proposed hydrology conditions. Given that the depth average difference between bankfull and dynamic stability is only 6cm, a single flow stage step representing this difference is deemed appropriate to establish the existing and proposed stability indices.

Doran Road

The reach average bankfull flow from cross-section modeling was determined to be 0.59m^3 s^{-1} in the Midves Court reach. Due to the relative simplicity of the feature in this reach only four cross-sections were surveyed. Geomorphic characteristics are summarized in **Table 4** and erosion threshold indicators are shown in **Table 5**. The detailed cross-section modeling results are appended.

Table 4: Willow Creek Tributary at Midves Court, bankfull summary

	low flow morphology type	active width (m)	width / max depth ratio	gradient (m m^{-1})	substrate D_{50} (mm)
X-sec. 1	run	3.00	7.7	0.019	0.1
X-sec. 2	run	2.90	7.4	0.019	0.1
X-sec. 3	run	3.00	7.9	0.020	0.25
X-sec. 4	run	3.20	9.1	0.021	0.25

Table 5: Willow Creek Tributary at Midves Court, erosion threshold indicators

	shear stress (N m^{-2})	mean velocity (m s^{-1})	stream power (watts m^{-1})	Froude #
X-sec. 1	39.4	0.89	110	0.60
X-sec. 2	40.1	0.90	110	0.60
X-sec. 3	40.9	0.90	115	0.62
X-sec. 4	40.7	0.89	121	0.63
mean	40.3	0.9	114	0.61

Existing condition shear and velocity results fully meet criteria for vegetation control at all sections. The secondary checks of stream power and Froude number corroborate that the reach is stable as each stream power calculation is well below a stability threshold of 400 watts m^{-1} (Sear et. al. 2003) and all Froude numbers are less than one thus confirming continuous subcritical flow.

Based on these measurements there is no need to adjust flow stage for stability testing because the reach is deemed fully stable at bankfull or active flow due to biotechnical reinforcement. The results suggest that vegetation-hydroperiod analysis is appropriate as a conservative check of future stability. This analysis will check potential impacts to

vegetation viability under longer flow event inundation of the bankfull stage, under post development flows.

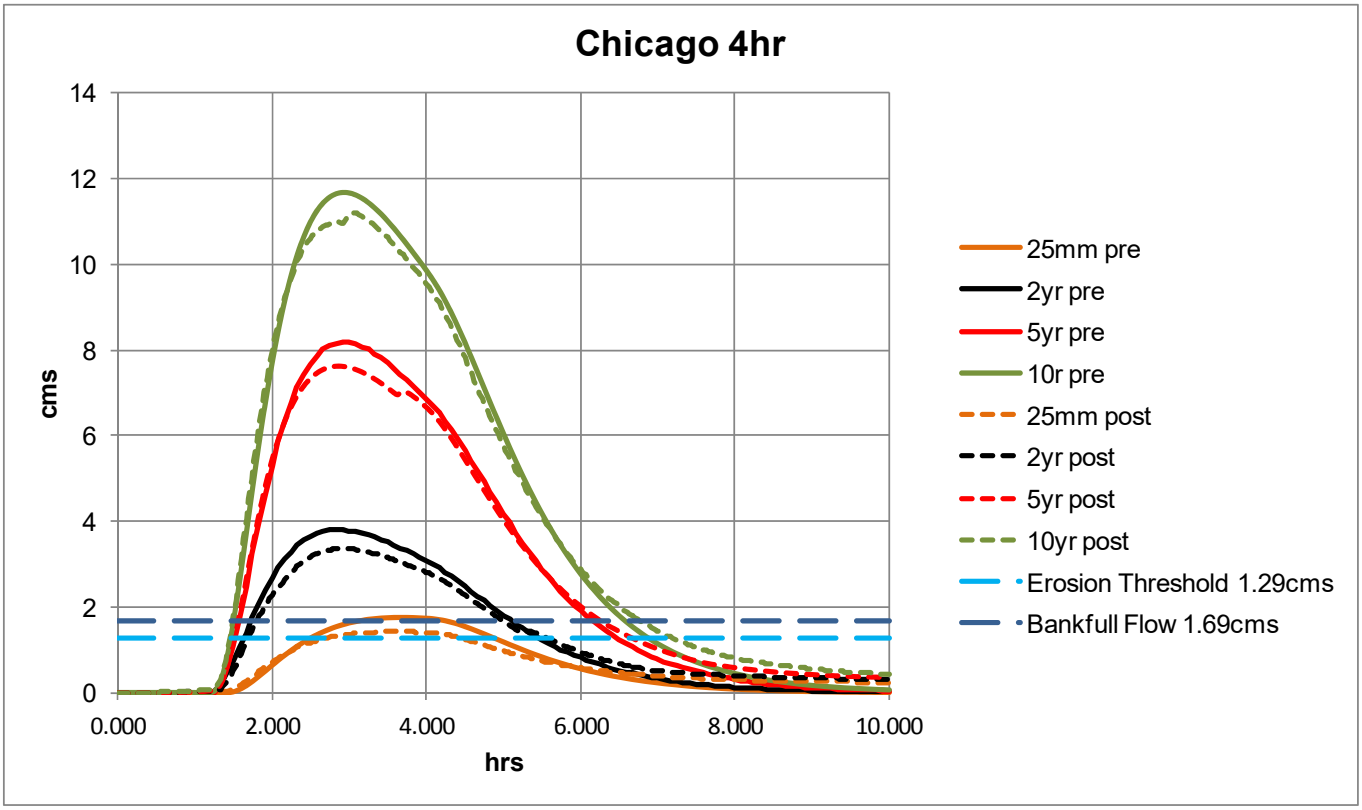
Erosion Threshold Analysis

Carson Road - Flow Exceedance and Time Duration Analysis

Based on the results of threshold determination, exceedance-duration analysis is appropriate using the flow stage interval from 1.29m^3 s^{-1} to 1.69m^3 s^{-1}. Given that this flow difference only represents an average 6cm reduction in flow stage, there is no need to iteratively break down the analysis in more than one stage step (which is appropriate at greater flow depth differences and when channel geometry influences the related flow rates at each step, i.e. certain steps can have greater influence). Multiple flow steps are thus not needed as multipliers to determine an overall stability discharge index. Using the single increment recommendation, the exceedance test is therefore simply presented as a time exceedance matching exercise between existing and proposed conditions. Further, although the channel and flood plain connection has been characterized as partially confined and partially entrenched, peak flow stages are qualified as relatively low. It is deemed that there is no need to include the time interval of flows exceeding and falling back over the bankfull rate. These flood plain peak flows generally have a lower ratio of cross-sectional area to wetted perimeter, thus resulting in a lower net hydraulic radius than bankfull flows, which in turn lowers the determinations of velocity and shear stress. The flow duration of specific applicability for the flows of interest is therefore measured by the rising hydrograph time component, from 1.29m^3 s^{-1} to 1.69m^3 s^{-1}, and the falling component, from 1.69m^3 s^{-1} to 1.29m^3 s^{-1} plus the full time component of all flow events above 1.29m^3 s^{-1} but less than 1.69m^3 s^{-1}. Recognizing that these flows occur below the bankfull peak, the time duration of this component is conservative (the magnitude of potential erosion increases with stage) and thus qualitatively may help balance against the condition when flow peaks over bankfull will reverse shear and velocity values at the point of breaking bank, until they drop sufficiently below the original threshold criteria.

The detailed analysis and results of event hydrology modeling are presented under separate cover by SCS Consulting. The hydrology modeling is noted to incorporate a 15% flow increase over standard or existing criteria, based on a theoretical future climate change scenario. Using the detailed hydrograph results, plots were made of the Chicago 4hr storm distribution, including the 25mm event, to show existing and proposed conditions at Snow Valley Road, representing the flow node location of channel cross-section surveys. Plots up the 10yr event were made to illustrate frequent event hydrographs. **Figure 2** shows the plotting results.

Figure 2: Chicago 4hr hydrographs



The hydrograph time steps were reviewed and the rising and falling time durations from threshold flow to bankfull flow were charted for the events up to and including the 10yr. From Figure 2 it can be seen that the 5 and 10yr events are well above the bankfull flow. As explained earlier, overbank flows generally result in dropping erosion indicators due to the function of hydraulic geometry. Nonetheless, given the also noted partial confinement and partial entrenchment seen discontinuously through the study reach it was felt appropriate to include at least these events, even though the effects on erosion potential would be variable. Inclusion is therefore conservative as the analysis of time duration assumes the full time step is available for erosion to occur, when realistically it will actually be dynamic in response to geometry and flow rate.

Exceedance hours were totalled for each event and multiplied by a coefficient representing frequency over 10 years, with the 25mm event assumed to happen 3 times per year on average. The full time duration of the 25mm was used over the threshold flow because the proposed condition peak is less than bankfull and the existing condition peak is marginally above. **Table 6** presents the results of duration exceedance analysis with regard to existing and proposed conditions.

Table 6: Duration exceedance results for frequent flows (4hr Chicago)

	rising hrs	falling hrs	rising + falling hrs	prop - ex hrs	coeff	(prop - ex) X coeff	
25mm ex	n.a.	n.a.	2.417				
25mm prop	n.a.	n.a.	1.700	-0.717	30	-21.51	
2yr ex	0.166	0.416	0.582				
2yr prop	0.166	0.533	0.500	-0.082	5	-0.41	
5yr ex	0.083	0.417	0.501				
5yr prop	0.067	0.434	0.501	0	2	0	
10yr ex	0.083	0.417	0.500				
10yr prop	0.067	0.467	0.534	0.034	1	0.034	
						-21.886	hrs

The detailed results show that over a representative 10 year scenario there will be approximately 22 hours less duration of flow resulting in potential erosion under proposed conditions compared to existing conditions. The largest difference in event duration occurs through extended detention of the 25mm storm. Based on these results, the proposed stormwater management program is deemed to not result in an increase in future erosion potential.

Doran Road - Vegetation-Hydroperiod Analysis

Vegetation-hydroperiod testing was done to check the integrity of the soil and vegetation matrix lining the channel due to flow duration changes at levels below the threshold or stable bankfull flow. Modeling was used to gauge the affect of saturation over time on the mechanical rooting density and surface layer velocity protection thresholds of biotechnical reinforcement. Cross-section 3 was used for this analysis because it has the highest or most conservative bankfull velocity, combined with the highest tractive force, compared to the other surveyed sections.

Using flow stage adjustments in the cross-section model to achieve flow stage increments for the 25mm, 2yr, and 5yr events, the velocity at each stage was conservatively tested against allowable duration curves for average and high density groundcover vegetation conditions. The 25mm event falls below the determined bankfull flow while the 2yr is marginally under with the 5yr being the highest frequency modelled event that fully incorporates bankfull flow. Using the results of event hydrology modeling prepared by SCS Consulting, the existing and proposed flow duration at each flow increment was tabulated within the model. Allowable event durations were generated and comparative results were produced. The analysis is qualified as being conservative because the velocities at the peak of flow stages under bankfull are used to represent

the entire flow stage increment. The 5yr event is further qualified by using the velocity representing bankfull, and not the peak of the event because of the velocity reversal that occurs after flows enter the flood plain. Flow rate cut-offs of 25 litres/sec were used in the duration counting due to experience with lesser flows rarely defining identifiable low flow characterization (i.e. no geometry with highly anastomising or stagnant flow in vegetation) and due to the excessive drawn out recession effect of the synthetic storm hydrograph (i.e. nominal declining flow volume, which technically is at much lower velocity than used for conservative modeling). Detailed modeling results and the representative velocity duration curves used for this analysis are appended.

The results for both average and high density vegetative conditions corroborate the qualitative observations of existing conditions and suggest that biotechnical vegetation control is presently the defining stability condition for the study site. The results for proposed conditions show that under average density vegetative conditions there are duration exceedances in all events. However, the results also show that high density vegetative conditions are sufficient under proposed conditions to meet targets. Existing and proposed durations under high density conditions show that despite the increase in event times from approximately 3hrs to 34-59hrs across the flow range, allowable durations are significantly higher in the range of 10 to 21 days (essentially semi permanent flow). The results thus show that there is some risk under proposed conditions if only average density groundcover vegetation exists, but that the risk can be mitigated if high density vegetative protection is maintained.

The results also suggest that existing vegetation type may be affected with regard to the duration relationship for wet or dry conditions affinity species. In this regard the extended event flows represent durations that existing vegetative types are not exposed to. Given that existing vegetative growth and density is a function of recent channel easement work, it would be expected that if left unmaintained the density of vegetation will increase naturally until such time that it might be affected by future flow duration change. Without significant forest canopy shading, when future flow durations increase there will be a shift to wet affinity species under longer term shallow saturation. Typically in channels that lack depth and steep banks there can be development of emergent cattail stands and related riparian wet meadow vegetation. This naturalization response would still be deemed to represent high density vegetation, and may in fact evolve to represent the highest density potential for the site due to the positive influence of enhanced availability of base flow.

Based on the vegetation-hydroperiod analysis results, biotechncial control maintaining channel stability is concluded to be provided under proposed conditions on the

assumption that high density vegetation conditions will continue to evolve and will be preserved in the future.

Conclusions

Erosion threshold analysis has been undertaken for two reaches of Willow Creek Tributaries that will receive stormwater discharge from proposed residential developments in the Township of Springwater.

Analysis has been done based on field review of channel sensitivity below proposed stormwater pond outlets and detailed cross-section surveys of the downstream locations that will receive combined flows from the development blocks. Erosion threshold modeling results were used in exceedance duration analysis for the Carson Road development and vegetation-hydroperiod analysis was used for the Doran Road development. Results of analysis conclude that levels of dynamic stability will be maintained in the receiving reaches based on the proposed stormwater management program. Flow duration between the threshold flow and bankfull flow will be slightly lower in proposed conditions below the Carson Road development, from an exceedance-duration basis. Allowable criteria for extended saturation levels below bankfull flow will not be detrimental to stability for the system below the Doran Road development, from a vegetation-hydroperiod basis, based on the recommendation to perpetually maintain high density vegetation.

The methods of analysis presented in this report do not preclude a catastrophic event potentially causing some erosion due to unforeseen circumstances (e.g. SWM pond failure, culvert failures, major debris jam scour, beaver dam construction/breaching, or combinations thereof, etc.). The results presented here are also contingent on long term preservation and maintenance of the existing natural vegetation and local geology conditions within the respective corridors.

Prepared by,



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B. de Geus 03.12

Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Carson Road Reach
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	
	n/7 =	0.14
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	1
	Exposed tree roots	1
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.30
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.00
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	0.11
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	88.9

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	16	20--16	15-11	10-6	5-0
Embeddedness	11	20--16	15-11	10-6	5-0
Velocity / Depth Regime	11	20--16	15-11	10-6	5-0
Sediment Deposition	14	20--16	15-11	10-6	5-0
Channel Flow Status	12	20--16	15-11	10-6	5-0
Channel Alteration	18	20--16	15-11	10-6	5-0
Frequency of Riffles	9	20--16	15-11	10-6	5-0
Bank Stability u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
/200	147				
/100	73.5	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Pool Substrate Characterization		20--16	15-11	10-6	5-0
Pool Variability		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Channel Sinuosity		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	9	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	7	8-7	6-5	4-3	2-0
Physical Instream Habitat	7	8-7	6-5	4-3	2-0
Water Quality	7	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	7	7-6	5-4	3-2	1-0
Biological Indicators	6	8-7	6-5	4-3	2-0
/50	43				
/100	86.0	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	82.8	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0



▲ Overview looking upstream from Carson Road showing dense groundcover encroachment and thicket

▼ Overview looking downstream from Carson Road showing transition from wetland pool to thicket



References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

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Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Wilson Road Reach
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	
	n/7 =	0.14
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	
	Exposed tree roots	
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.10
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	1
	n/7 =	0.14
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.10**
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	**90.4**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	16	20--16	15-11	10-6	5-0
Embeddedness	11	20--16	15-11	10-6	5-0
Velocity / Depth Regime	12	20--16	15-11	10-6	5-0
Sediment Deposition	14	20--16	15-11	10-6	5-0
Channel Flow Status	13	20--16	15-11	10-6	5-0
Channel Alteration	17	20--16	15-11	10-6	5-0
Frequency of Riffles	11	20--16	15-11	10-6	5-0
Bank Stability u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
/200	150				
/100	**75.0**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Pool Substrate Characterization		20--16	15-11	10-6	5-0
Pool Variability		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Channel Sinuosity		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	9	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	6	8-7	6-5	4-3	2-0
Physical Instream Habitat	7	8-7	6-5	4-3	2-0
Water Quality	7	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	6	7-6	5-4	3-2	1-0
Biological Indicators	6	8-7	6-5	4-3	2-0
/50	41				
/100	**82.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	**82.5**	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0



▲ Overview looking upstream from Wilson Road showing dense groundcover encroachment



▼ Overview looking downstream from Wilson Road showing transition from groundcover encroachment to forest

References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

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Project: **Erosion Threshold Analysis - CRDI**
Willow Creek Tributary, Snow Valley Road Reach
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	1
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	1
	n/7 =	0.43
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	1
	Scour pools d/s of culverts/stormsewer outlets	1
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.20

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	1
	Exposed tree roots	1
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.30
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	1
	n/7 =	0.14
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.27**
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	**73.2**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	18	20--16	15-11	10-6	5-0
Embeddedness	11	20--16	15-11	10-6	5-0
Velocity / Depth Regime	15	20--16	15-11	10-6	5-0
Sediment Deposition	14	20--16	15-11	10-6	5-0
Channel Flow Status	16	20--16	15-11	10-6	5-0
Channel Alteration	17	20--16	15-11	10-6	5-0
Frequency of Riffles	14	20--16	15-11	10-6	5-0
Bank Stability u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	7	10-8	7-6	5-3	2-0
u/s R	7	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
/200	153				
/100	**76.5**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Pool Substrate Characterization		20--16	15-11	10-6	5-0
Pool Variability		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Channel Sinuosity		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	8	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	6	8-7	6-5	4-3	2-0
Physical Instream Habitat	7	8-7	6-5	4-3	2-0
Water Quality	7	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	6	7-6	5-4	3-2	1-0
Biological Indicators	6	8-7	6-5	4-3	2-0
/50	40				
/100	**80.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	**76.6**	100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		100-80	80-56	55-30	29-0



▲ Overview looking upstream from top of slope, towards Snow Valley Road, showing confinement and toe contact

▼ Overview looking downstream at creek level showing entrenched valley form



References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

B. de Geus 03.12

Project: Erosion Threshold Analysis - MDDRI
Willow Creek Tributary, Pooles Road Reach
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	
	Medial bars	
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	
	n/7 =	0.00
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	
	Occurrence of Large Organic Debris	
	Exposed tree roots	
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.00
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	1
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.14
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	0.04
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	96.4

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Embeddedness		20--16	15-11	10-6	5-0
Velocity / Depth Regime		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Frequency of Riffles		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	1	20--16	15-11	10-6	5-0
Pool Substrate Characterization	0	20--16	15-11	10-6	5-0
Pool Variability	0	20--16	15-11	10-6	5-0
Sediment Deposition	20	20--16	15-11	10-6	5-0
Channel Flow Status	0	20--16	15-11	10-6	5-0
Channel Alteration	15	20--16	15-11	10-6	5-0
Channel Sinuosity	5	20--16	15-11	10-6	5-0
Bank Stability u/s L	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
Vegetative Protection	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
/200	101				
/100	50.5	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	10	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	4	8-7	6-5	4-3	2-0
Physical Instream Habitat	1	8-7	6-5	4-3	2-0
Water Quality	7	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	4	7-6	5-4	3-2	1-0
Biological Indicators	0	8-7	6-5	4-3	2-0
/50	26				
/100	52.0	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	66	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0



▲ Overview looking downstream from Russel Road to Pooles Road; no defined channel, dense groundcover, ephemeral wide shallow level spreading surface flow or influent

▼ Looking downstream from Pooles Road; no defined channel until modest ephemeral swale gradually develops in forest



References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

B. de Geus 03.12

Project: Erosion Threshold Analysis - MDDRI
Willow Creek Tributary, Midves Court Reach
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	
	Medial bars	
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	1
	n/7 =	0.14
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	
	Occurrence of Large Organic Debris	
	Exposed tree roots	
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.00
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	1
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	1
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.29
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.11**
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	**89.3**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Embeddedness		20--16	15-11	10-6	5-0
Velocity / Depth Regime		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Frequency of Riffles		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	6	20--16	15-11	10-6	5-0
Pool Substrate Characterization	7	20--16	15-11	10-6	5-0
Pool Variability	4	20--16	15-11	10-6	5-0
Sediment Deposition	8	20--16	15-11	10-6	5-0
Channel Flow Status	2	20--16	15-11	10-6	5-0
Channel Alteration	10	20--16	15-11	10-6	5-0
Channel Sinuosity	6	20--16	15-11	10-6	5-0
Bank Stability u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Vegetative Protection	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
/200	95				
/100	**47.5**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	9	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	4	8-7	6-5	4-3	2-0
Physical Instream Habitat	4	8-7	6-5	4-3	2-0
Water Quality	6	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	4	7-6	5-4	3-2	1-0
Biological Indicators	0	8-7	6-5	4-3	2-0
/50	27				
/100	**54.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	**64**	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0



▲ Overview looking upstream over recently constructed 'swale' definition, confluent with cul-de-sac ditching in foreground

▼ Overview looking downstream at confluence with cul-de-sac ditching



References

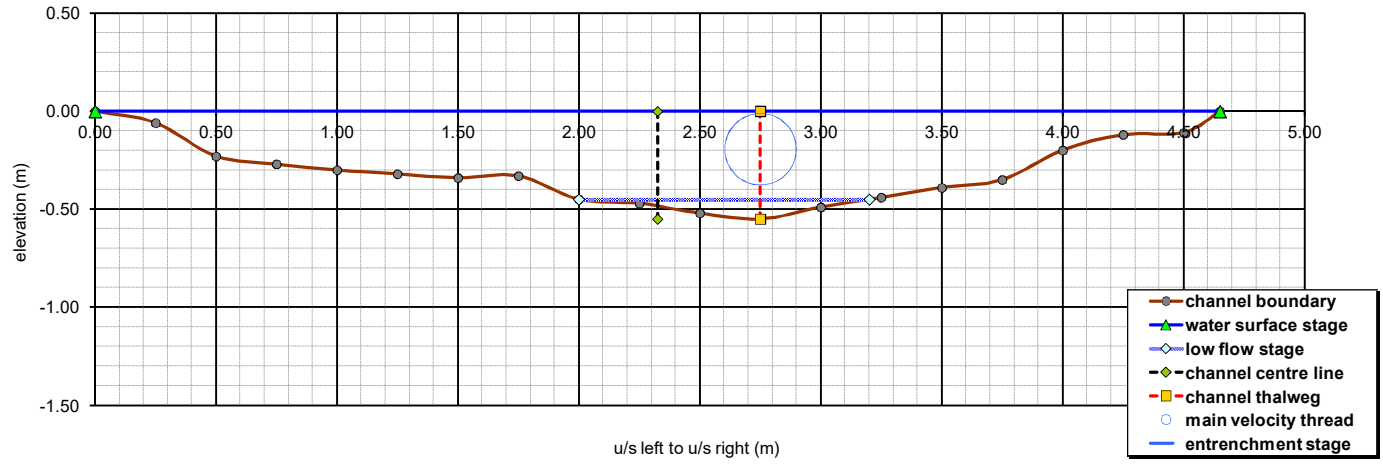
1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Snow Valley Road Reach
Section 1

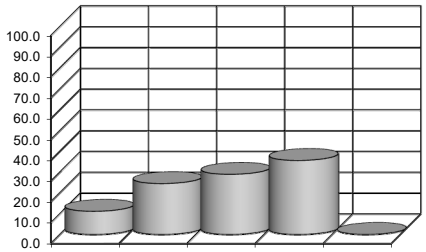
B. de Geus 05.11

Cross Section Plot





Substrate Type



Morphology Type	
cascade	
step	
riffle	●
run	
glide	
pool	
thalweg out of phase	

Hydraulic Roughness	
rr R/D_{84}	2.54
ff V mean/V*	5.39
ff D_{84}	5.24
ff mean	5.32
ROUGH BED	

Hydraulic Geometry	
A (m^2)	1.48
R (m)	0.30
TW (m)	4.65
WP (m)	4.86
max d (m)	0.55
mean d (m)	0.32
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Ratios	
ER max d	4.30
r_c / TW	
TW / Lf_w	3.88
TW/max d	8.5
TW/mean d	14.6

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.126	3.12	NO	NO	NO	YES
V_* (m s^{-1})	0.099	D_{50}	0.655	16.19	NO	NO	NO	NO
		D_{84}	1.608	39.73	NO	NO	NO	NO

Section Data

ER_e (m)	0.55	ER stations L / R	-5.00	15.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	4.65	4.65
Lf_e (m)	-0.450	Lf stations L / R	2.00	3.20	
W_{fp} (m)	20.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.55	2.75	
E_g (m m^{-1})	0.0160				

Bedload Transport Data

Rosgen type	Strickler Q_{sb} (kg sec^{-1})	Limerinos Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
B3	0.0022	0.0023	T_*	49.2	2.5	0.4
C3	0.0008	0.0009	saltation	YES	YES	NO
C4	0.0083	0.0086	rolling	YES	YES	NO
			Ø	NO	NO	YES

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.30	1.00	20.00	120.00	190.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.29	0.97	19.40	116.40	184.30
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds

		V_c / V_b	
τ_{calc} (kg m^{-2})	4.87		
τ_{calc} (N m^{-2})	47.72	Strickler	Limerinos
$\tau\ D_{crit}$ (gr-co) (mm)	49.20	0.87	
D_{50} V_c (vcs +) (m s^{-1})	0.69	0.87	
D_{84} V_c (vcs +) (m s^{-1})	1.70	2.13	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
11.1	24.4	28.9	35.6	0.0

Bank Data u/s L u/s R

H_b (m)	
Bf_d (m)	
RDp (m)	
H_b/Bf_d	
RDp/H_b	
RDn (%)	
BA (°)	
BFP (%)	

Flow Regime

Strickler method	
Q (cms)	1.687
V (m s^{-1})	1.14
n	0.050
Fr	0.65
D_c rectangular (m)	0.24
D_c trapezoidal (m)	0.40
D_c triangular (m)	0.58
D_c parabolic (m)	0.37
D_c mean (m)	0.40
flow type	SUBCRITICAL
Ω (watts m^{-1})	264.48
ω_a (watts m^{-2})	54.40
ω_a/TW (watts m^{-1})	11.70
Re^*	39.2
Re	304351
turbulence	HIGH

Flow Regime

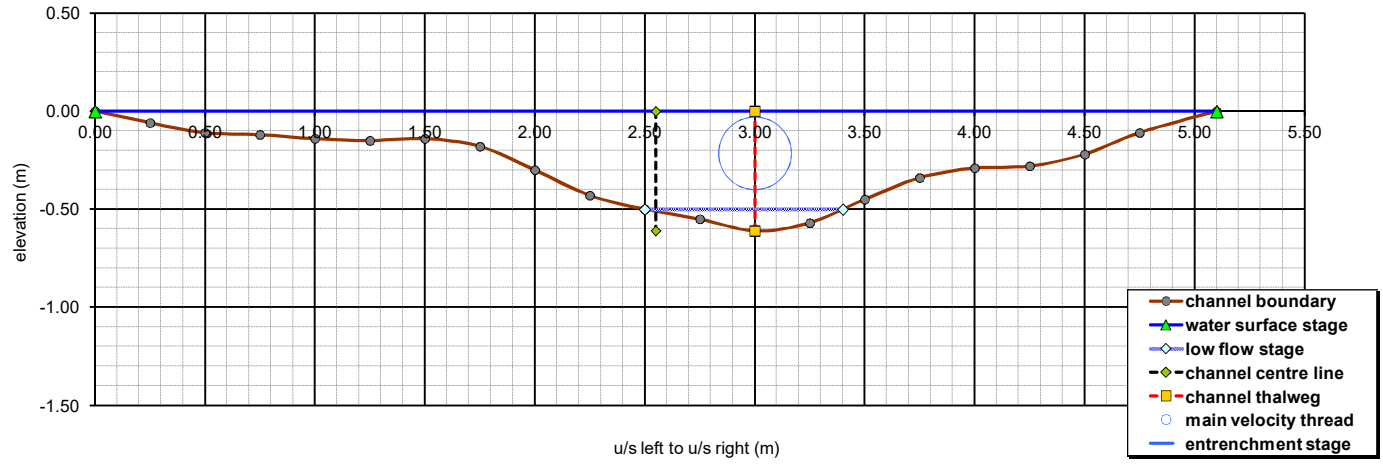
Limerinos method	
Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
Re^*	
Re	
turbulence	

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

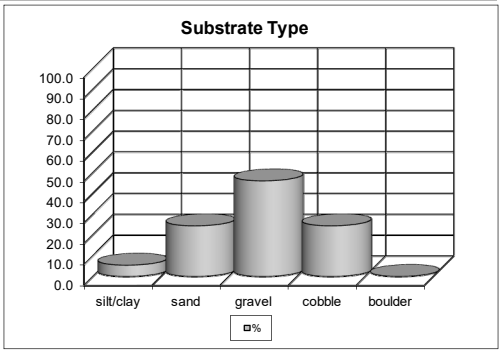
Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Snow Valley Road Reach
Section 2

B. de Geus 05.11

Cross Section Plot







Morphology Type	
cascade	
step	
riffle	●
run	
glide	
pool	
thalweg out of phase	

Hydraulic Roughness	
rr R/D_{84}	3.28
ff V mean/V*	5.63
ff D_{84}	5.87
ff mean	5.75
ROUGH BED	

Hydraulic Geometry	
A (m^2)	1.39
R (m)	0.26
TW (m)	5.10
WP (m)	5.30
max d (m)	0.61
mean d (m)	0.27
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Ratios	
ER max d	3.14
r_c / TW	
TW / Lf_w	5.67
TW/max d	8.4
TW/mean d	18.7

Sediment Transport Mode			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.247	5.59	NO	NO	NO	YES
V_* (m s^{-1})	0.108	D_{50}	0.733	16.63	NO	NO	NO	NO
		D_{84}	1.313	29.77	NO	NO	NO	NO

Section Data					
ER_e (m)	0.61	ER stations L / R	-10.00	6.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	5.10	5.10
Lf_e (m)	-0.500	Lf stations L / R	2.50	3.40	
W_{fp} (m)	16.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m)	$T_{o/s}$ (m)	-0.61	3.00
E_g (m m^{-1})	0.0220				

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.20	3.00	25.00	80.00	150.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.19	2.91	24.25	77.60	145.50
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds		V_c / V_b	
τ_{calc} (kg m^{-2})	5.78		
τ_{calc} (N m^{-2})	56.63		
$\tau\ D_{crit}$ (gr-co) (mm)	58.38	Strickler	Limerinos
D_{50} V_c (vcs +) (m s^{-1})	0.78	0.91	
D_{84} V_c (vcs +) (m s^{-1})	1.39	1.64	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
5.4	24.3	45.9	24.3	0.0

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Bedload Transport Data						
	Strickler Q	Limerinos Q		D_{30}	D_{50}	D_{84}
Rosgen type	Q_{sb} (kg sec^{-1})	Q_{sb} (kg sec^{-1})	T_*	19.5	2.3	0.7
B3	0.0022	0.0023	saltation	YES	YES	NO
C3	0.0008	0.0012	rolling	YES	YES	NO
C4	0.0083	0.0091	Ø	NO	NO	YES

Flow Regime Strickler method	
Q (cms)	1.687
V (m s^{-1})	1.21
n	0.050
Fr	0.74
D_c rectangular (m)	0.23
D_c trapezoidal (m)	0.40
D_c triangular (m)	0.58
D_c parabolic (m)	0.38
D_c mean (m)	0.40
flow type	SUBCRITICAL
Ω (watts m^{-1})	363.78
ω_a (watts m^{-2})	68.60
ω_a/TW (watts m^{-1})	13.45
Re^*	50.1
Re	279093
turbulence	HIGH

Flow Regime Limerinos method	
Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
Re^*	
Re	
turbulence	

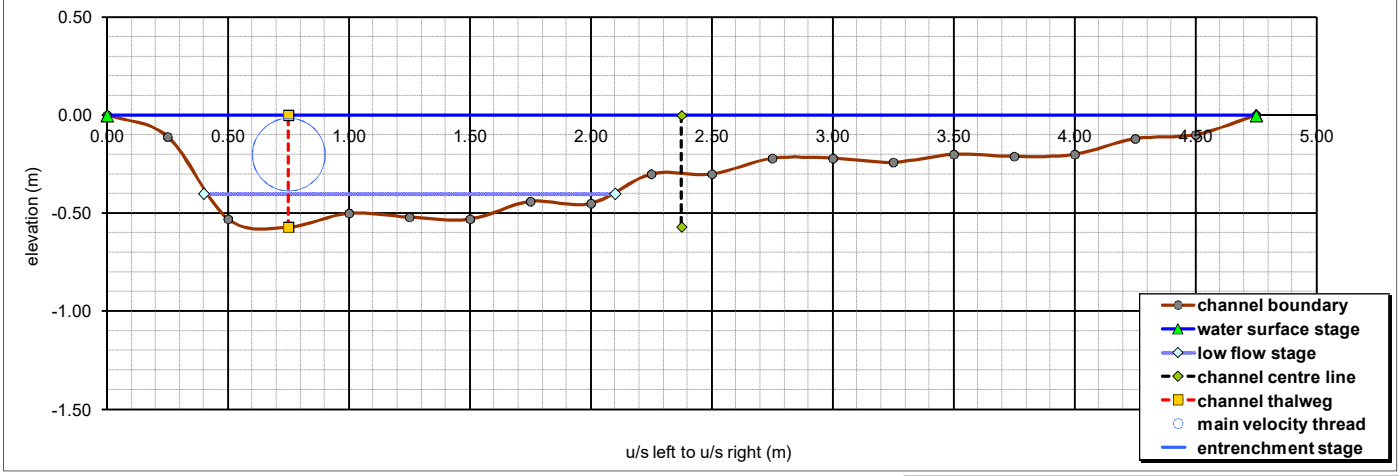
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Snow Valley Road Reach
Section 3

AquaLogic

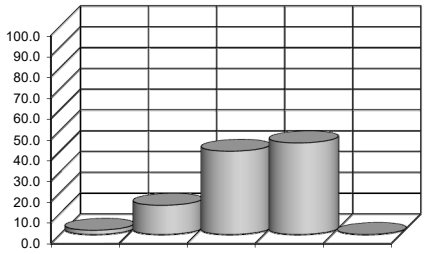
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Cross Section Plot





Substrate Type



Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	1.44
R (m)	0.28
TW (m)	4.75
WP (m)	5.13
max d (m)	0.57
mean d (m)	0.30
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R/D_{84}	2.55
ff V mean/V*	5.38
ff D_{84}	5.34
ff mean	5.36
ROUGH BED	

Hydraulic Ratios	
ER max d	5.26
r_c / TW	
TW / Lf_w	2.79
TW/max d	8.3
TW/mean d	15.7

Sediment Transport Mode			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.412	9.74	NO	NO	NO	NO
V_* (m s^{-1})	0.103	D_{50}	0.984	23.24	NO	NO	NO	NO
		D_{84}	1.540	36.35	NO	NO	NO	NO

Section Data					
ER_e (m)	0.57	ER stations L / R	-10.00	15.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	4.75	4.75
Lf_e (m)	-0.400	Lf stations L / R	0.40	2.10	
W_{fp} (m)	25.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.57	0.75	
E_g (m m^{-1})	0.0190				

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	1.00	8.00	45.00	110.00	210.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.97	7.76	43.65	106.70	203.70
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds		V_c / V_b	
τ_{calc} (kg m^{-2})	5.33		
τ_{calc} (N m^{-2})	52.24	Strickler	Limerinos
$\tau\ D_{crit}$ (gr-co) (mm)	53.86		
D_{50} V_c (vcs +) (m s^{-1})	1.04	1.26	
D_{84} V_c (vcs +) (m s^{-1})	1.63	1.97	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
2.0	14.0	40.0	44.0	0.0

Bank Data u/s L	u/s R
H_b (m)	
Bf_d (m)	
RDp (m)	
H_b/Bf_d	
RDp/H_b	
RDn (%)	
BA (°)	
BFP (%)	

Bedload Transport Data						
	Strickler Q	Limerinos Q		D_{30}	D_{50}	D_{84}
Rosgen type	Q_{sb} (kg sec^{-1})	Q_{sb} (kg sec^{-1})	T_*	6.7	1.2	0.5
B3	0.0022	0.0023	saltation	YES	NO	NO
C3	0.0008	0.0010	rolling	YES	YES	NO
C4	0.0083	0.0087	Ø	NO	NO	YES

Flow Regime Strickler method	
Q (cms)	1.694
V (m s^{-1})	1.18
n	0.050
Fr	0.68
D_c rectangular (m)	0.24
D_c trapezoidal (m)	0.40
D_c triangular (m)	0.58
D_c parabolic (m)	0.37
D_c mean (m)	0.40
flow type	SUBCRITICAL
Ω (watts m^{-1})	315.45
ω_a (watts m^{-2})	61.46
ω_a/TW (watts m^{-1})	12.94
*Re**	90.8
Re	289540
turbulence	HIGH

Flow Regime Limerinos method	
Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
*Re**	
Re	
turbulence	

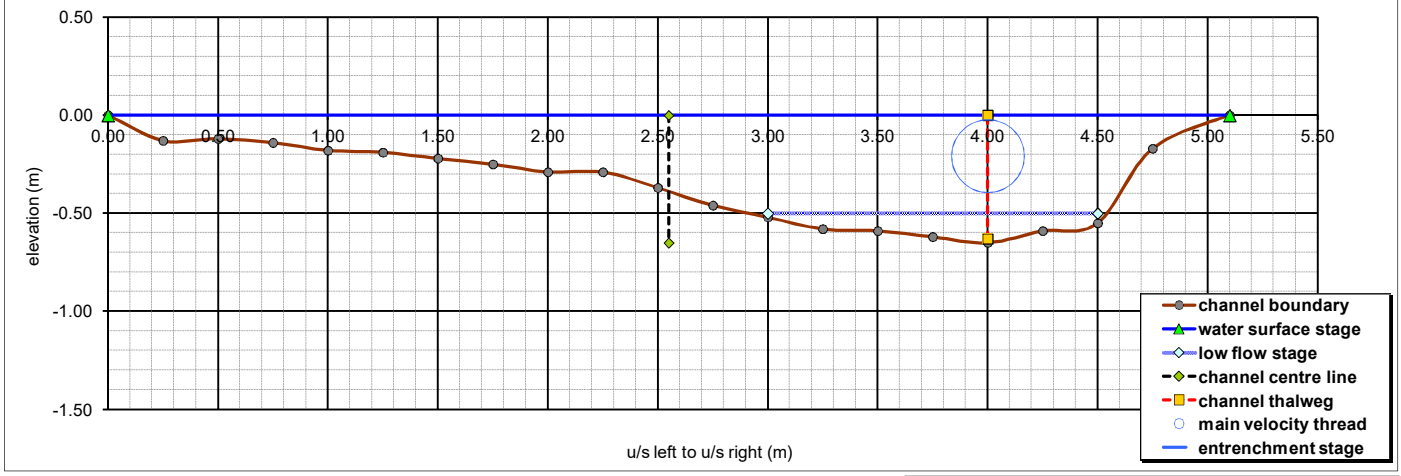
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

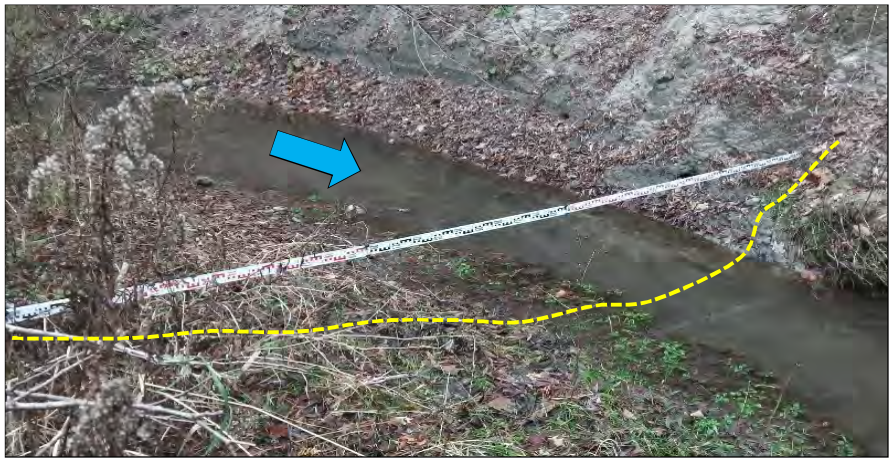
Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Snow Valley Road Reach
Section 4

AquaLogic

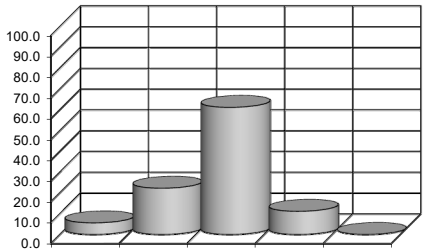
B. de Geus 05.11

Cross Section Plot





Substrate Type



Morphology Type	
cascade	
step	
riffle	
run	
glide	
pool	●
thalweg out of phase	

Hydraulic Roughness	
rr R/D_{84}	5.80
ff V mean/V*	6.42
ff D_{84}	7.34
ff mean	6.88
ROUGH BED	

Hydraulic Geometry	
A (m^2)	1.74
R (m)	0.32
TW (m)	5.10
WP (m)	5.44
max d (m)	0.65
mean d (m)	0.34
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Ratios	
ER max d	3.14
r_c / TW	
TW / Lf_w	3.40
TW/max d	7.8
TW/mean d	15.0

Sediment Transport Mode			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.040	1.17	NO	YES	YES	YES
V_* (m s^{-1})	0.084	D_{50}	0.567	16.50	NO	NO	NO	NO
		D_{84}	1.089	31.68	NO	NO	NO	NO

Section Data					
ER_e (m)	0.65	ER stations L / R	-10.00	6.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	5.10	5.10
Lf_e (m)	-0.500	Lf stations L / R	3.00	4.50	
W_{fp} (m)	16.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.63	4.00	
E_g (m m^{-1})	0.0110				

Bedload Transport Data						
	Strickler Q	Limerinos Q		D_{30}	D_{50}	D_{84}
Rosgen type	Q_{sb} (kg sec^{-1})	Q_{sb} (kg sec^{-1})	T_*	118.1	2.4	0.6
B3	0.0022	0.0025	saltation	YES	YES	NO
C3	0.0008	0.0017	rolling	YES	YES	NO
C4	0.0083	0.0099	Ø	NO	NO	YES

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.30	0.30	15.00	55.00	130.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.29	0.29	14.55	53.35	126.10
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds		V_c / V_b	
τ_{calc} (kg m^{-2})	3.51		
τ_{calc} (N m^{-2})	34.38	Strickler	Limerinos
$\tau\ D_{crit}$ (gr-co) (mm)	35.44		
D_{50} V_c (vcs +) (m s^{-1})	0.60	0.88	
D_{84} V_c (vcs +) (m s^{-1})	1.15	1.68	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
5.6	22.2	61.1	11.1	0.0

Bank Data u/s L	u/s R
H_b (m)	
Bf_d (m)	
RDp (m)	
H_b/Bf_d	
RDp/H_b	
RDn (%)	
BA (°)	
BFP (%)	

Flow Regime Strickler method	
Q (cms)	1.693
V (m s^{-1})	0.98
n	0.050
Fr	0.53
D_c rectangular (m)	0.23
D_c trapezoidal (m)	0.39
D_c triangular (m)	0.58
D_c parabolic (m)	0.36
D_c mean (m)	0.39
flow type	SUBCRITICAL
Ω (watts m^{-1})	182.54
ω_a (watts m^{-2})	33.53
ω_a/TW (watts m^{-1})	6.58
Re^*	29.4
Re	272881
turbulence	HIGH

Flow Regime Limerinos method	
Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
Re^*	
Re	
turbulence	

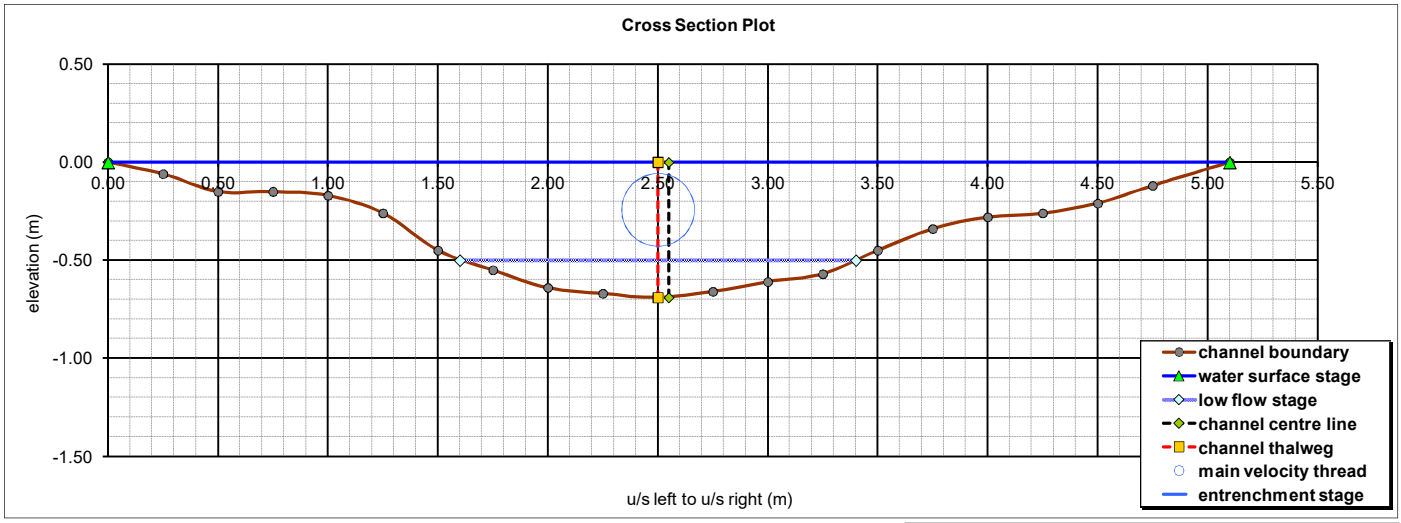
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

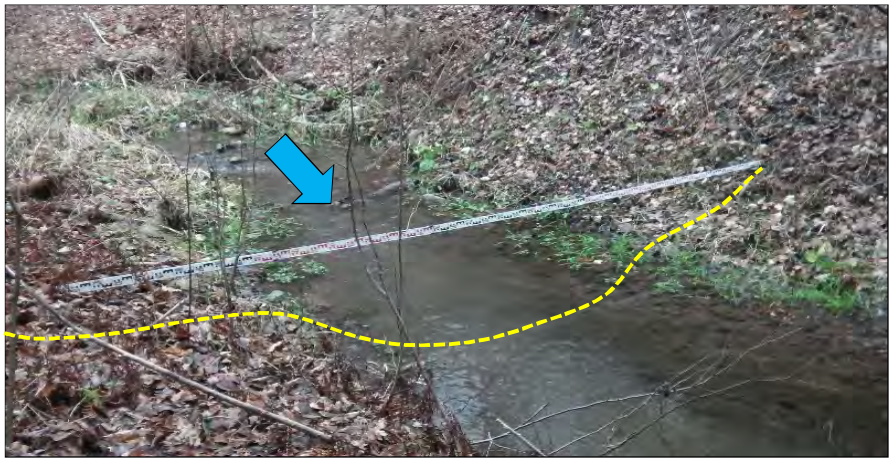
Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Snow Valley Road Reach
Section 5

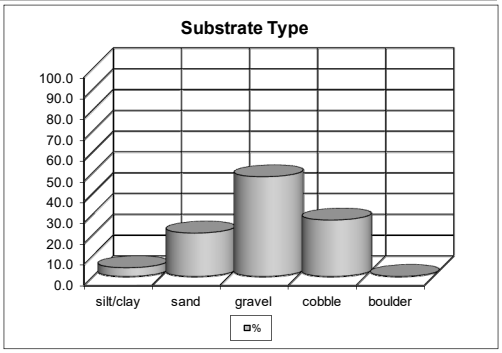
AquaLogic

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Cross Section Plot







Morphology Type	
cascade	
step	
riffle	
run	
glide	
pool	●
thalweg out of phase	

Hydraulic Roughness	
rr R/D_{84}	3.42
ff V mean/V*	5.81
ff D_{84}	5.99
ff mean	5.90
ROUGH BED	

Hydraulic Geometry	
A (m^2)	1.83
R (m)	0.34
TW (m)	5.10
WP (m)	5.35
max d (m)	0.69
mean d (m)	0.36
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Ratios	
ER max d	3.14
r_c / TW	
TW / Lf_w	2.83
TW/max d	7.4
TW/mean d	14.2

Sediment Transport Mode			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.324	10.06	NO	NO	NO	NO
V_* (m s^{-1})	0.078	D_{50}	0.655	20.37	NO	NO	NO	NO
		D_{84}	1.468	45.63	NO	NO	NO	NO

Section Data					
ER_e (m)	0.69	ER stations L / R	-10.00	6.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	5.10	5.10
Lf_e (m)	-0.500	Lf stations L / R	1.60	3.40	
W_{fp} (m)	16.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.69	2.50	
E_g (m m^{-1})	0.0090				

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.10	5.00	20.00	100.00	170.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.10	4.85	19.40	97.00	164.90
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds		V_c / V_b	
τ_{calc} (kg m^{-2})	3.08		
τ_{calc} (N m^{-2})	30.15		
$\tau\ D_{crit}$ (gr-co) (mm)	31.08	Strickler	Limerinos
D_{50} V_c (vcs +) (m s^{-1})	0.69	1.07	
D_{84} V_c (vcs +) (m s^{-1})	1.55	2.40	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
4.2	20.8	47.9	27.1	0.0

Bank Data u/s L	u/s R
H_b (m)	
Bf_d (m)	
RDp (m)	
H_b/Bf_d	
RDp/H_b	
RDn (%)	
BA (°)	
BFP (%)	

Bedload Transport Data						
	Strickler Q	Limerinos Q		D_{30}	D_{50}	D_{84}
Rosgen type	Q_{sb} (kg sec^{-1})	Q_{sb} (kg sec^{-1})	T_*	6.2	1.6	0.3
B3	0.0022	0.0023	saltation	YES	NO	NO
C3	0.0008	0.0012	rolling	YES	YES	NO
C4	0.0083	0.0090	Ø	NO	NO	YES

Flow Regime Strickler method	
Q (cms)	1.690
V (m s^{-1})	0.92
n	0.050
Fr	0.49
D_c rectangular (m)	0.23
D_c trapezoidal (m)	0.39
D_c triangular (m)	0.58
D_c parabolic (m)	0.36
D_c mean (m)	0.39
flow type	SUBCRITICAL
Ω (watts m^{-1})	149.05
ω_a (watts m^{-2})	27.86
ω_a/TW (watts m^{-1})	5.46
Re^*	38.5
Re	277091
turbulence	HIGH

Flow Regime Limerinos method	
Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
Re^*	
Re	
turbulence	

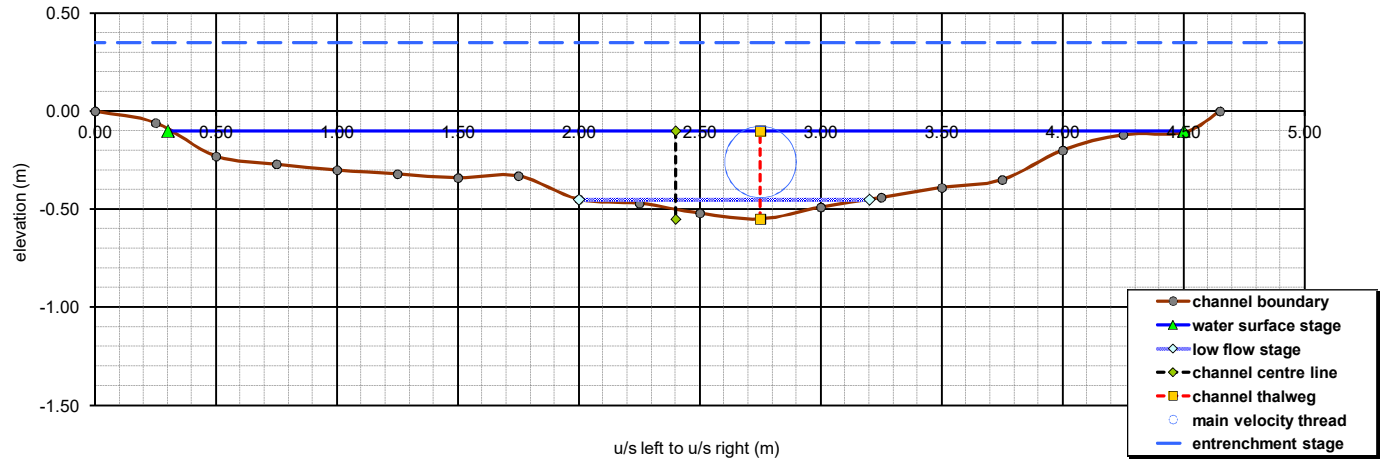
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Snow Valley Road Reach
Section 1 - Dynamic Stability Flow

AquaLogic

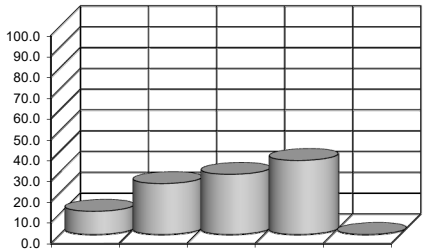
B. de Geus 05.11

Cross Section Plot





Substrate Type



Morphology Type

cascade	
step	
riffle	●
run	
glide	
pool	
thalweg out of phase	

Hydraulic Roughness

rr R/D_{84}	1.99
ff V mean/V*	4.98
ff D_{84}	4.62
ff mean	4.80
ROUGH BED	

Hydraulic Geometry

A (m^2)	1.04
R (m)	0.24
TW (m)	4.20
WP (m)	4.36
max d (m)	0.45
mean d (m)	0.25
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Ratios

ER max d	4.76
r_c / TW	
TW / Lf_w	3.50
TW/max d	9.3
TW/mean d	17.0

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.126	3.52	NO	NO	NO	YES
V_* (m s^{-1})	0.087	D_{50}	0.655	18.30	NO	NO	NO	NO
		D_{84}	1.608	44.90	NO	NO	NO	NO

Section Data

ER_e (m)	0.35	ER stations L / R	-5.00	15.00	TW ck
WS_e (m)	-0.100	WS stations L / R	0.30	4.50	4.20
Lf_e (m)	-0.450	Lf stations L / R	2.00	3.20	
W_{fp} (m)	20.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.55	2.75	
E_g (m m^{-1})	0.0160				

Bedload Transport Data

Rosgen type	Strickler Q_{sb} (kg sec^{-1})	Limerinos Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
B3	0.0019	0.0019	T_*	38.5	1.9	0.3
C3	0.0003	0.0003	saltation	YES	NO	NO
C4	0.0065	0.0065	rolling	YES	YES	NO
			Ø	NO	NO	YES

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.30	1.00	20.00	120.00	190.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.29	0.97	19.40	116.40	184.30
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime — Strickler method

Q (cms)	1.006
V (m s^{-1})	0.97
n	0.050
Fr	0.62
D_c rectangular (m)	0.18
D_c trapezoidal (m)	0.32
D_c triangular (m)	0.47
D_c parabolic (m)	0.30
D_c mean (m)	0.32
flow type	SUBCRITICAL
Ω (watts m^{-1})	157.81
ω_a (watts m^{-2})	36.16
ω_a/TW (watts m^{-1})	8.60
*Re**	40.7
Re	202300
turbulence	HIGH

Flow Regime — Limerinos method

Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
*Re**	
Re	
turbulence	

Erosion Thresholds

		V_c / V_b	
τ_{calc} (kg m^{-2})	3.81		
τ_{calc} (N m^{-2})	37.37	Strickler	Limerinos
τ D_{crit} (gr-co) (mm)	38.52		
D_{50} V_c (vcs +) (m s^{-1})	0.69	1.02	
D_{84} V_c (vcs +) (m s^{-1})	1.70	2.51	

Bank Data u/s L u/s R

H_b (m)	
Bf_d (m)	
RDp (m)	
H_b/Bf_d	
RDp/H_b	
RDn (%)	
BA (°)	
BFP (%)	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
11.1	24.4	28.9	35.6	0.0

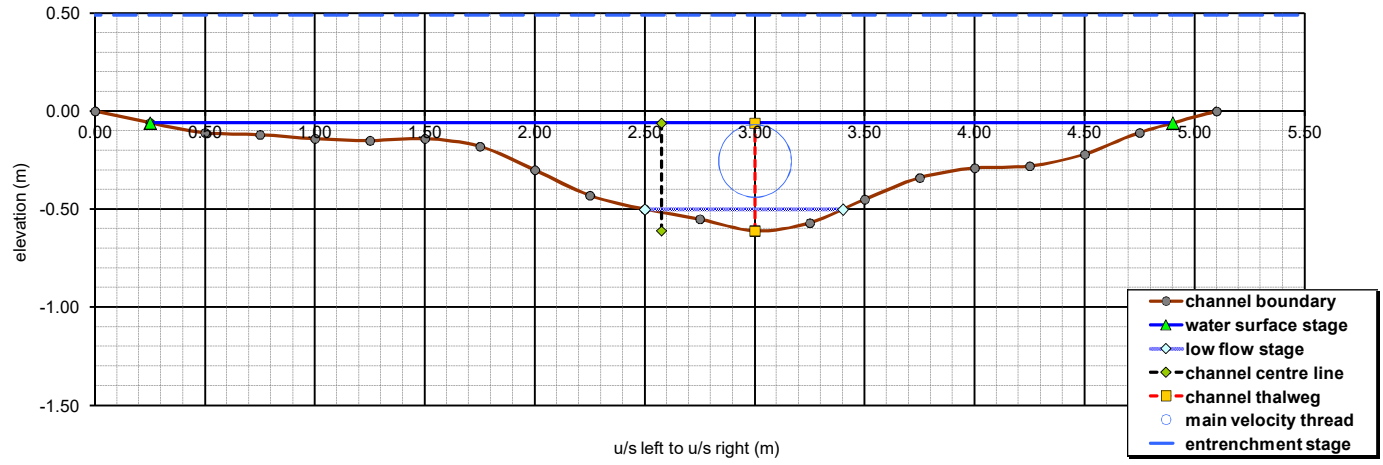
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Snow Valley Road Reach
Section 2 - Dynamic Stability Flow

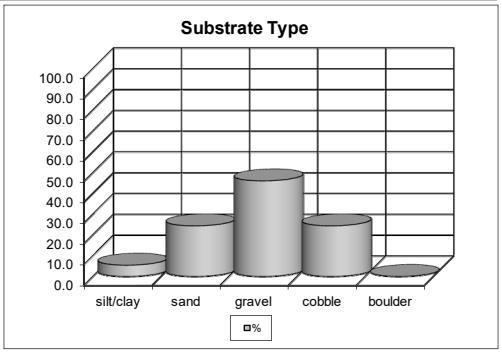
AquaLogic

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Cross Section Plot







Morphology Type	
cascade	
step	
riffle	●
run	
glide	
pool	
thalweg out of phase	

Hydraulic Roughness	
rr R/D_{84}	2.84
ff V mean/V*	5.39
ff D_{84}	5.51
ff mean	5.45
ROUGH BED	

Hydraulic Geometry	
A (m^2)	1.10
R (m)	0.23
TW (m)	4.66
WP (m)	4.85
max d (m)	0.55
mean d (m)	0.24
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Ratios	
ER max d	3.43
r_c / TW	
TW / Lf_w	5.18
TW/max d	8.5
TW/mean d	19.7

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.247	6.01	NO	NO	NO	YES
V_* (m s^{-1})	0.100	D_{50}	0.733	17.88	NO	NO	NO	NO
		D_{84}	1.313	32.03	NO	NO	NO	NO

Section Data

ER_e (m)	0.49	ER stations L / R	-10.00	6.00	TW ck
WS_e (m)	-0.060	WS stations L / R	0.25	4.90	4.65
Lf_e (m)	-0.500	Lf stations L / R	2.50	3.40	
W_{fp} (m)	16.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.61	3.00	
E_g (m m^{-1})	0.0220				

Bedload Transport Data

Rosgen type	Strickler Q_{sb} (kg sec^{-1})	Limerinos Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
B3	0.0020	0.0021	T_*	16.8	2.0	0.6
C3	0.0004	0.0006	saltation	YES	YES	NO
C4	0.0071	0.0077	rolling	YES	YES	NO
			Ø	NO	NO	YES

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.20	3.00	25.00	80.00	150.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.19	2.91	24.25	77.60	145.50
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds

		V_c / V_b	
τ_{calc} (kg m^{-2})	4.99		
τ_{calc} (N m^{-2})	48.95	Strickler	Limerinos
$\tau\ D_{crit}$ (gr-co) (mm)	50.46		
D_{50} V_c (vcs +) (m s^{-1})	0.78	1.01	
D_{84} V_c (vcs +) (m s^{-1})	1.39	1.80	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
5.4	24.3	45.9	24.3	0.0

Bank Data u/s L u/s R

H_b (m)	
Bf_d (m)	
RDp (m)	
H_b/Bf_d	
RDp/H_b	
RDn (%)	
BA (°)	
BFP (%)	

Flow Regime

Strickler method	
Q (cms)	1.209
V (m s^{-1})	1.10
n	0.050
Fr	0.72
D_c rectangular (m)	0.19
D_c trapezoidal (m)	0.35
D_c triangular (m)	0.51
D_c parabolic (m)	0.34
D_c mean (m)	0.35
flow type	SUBCRITICAL
Ω (watts m^{-1})	260.59
ω_a (watts m^{-2})	53.77
ω_a/TW (watts m^{-1})	11.54
Re^*	51.3
Re	218784
turbulence	HIGH

Flow Regime

Limerinos method	
Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
Re^*	
Re	
turbulence	

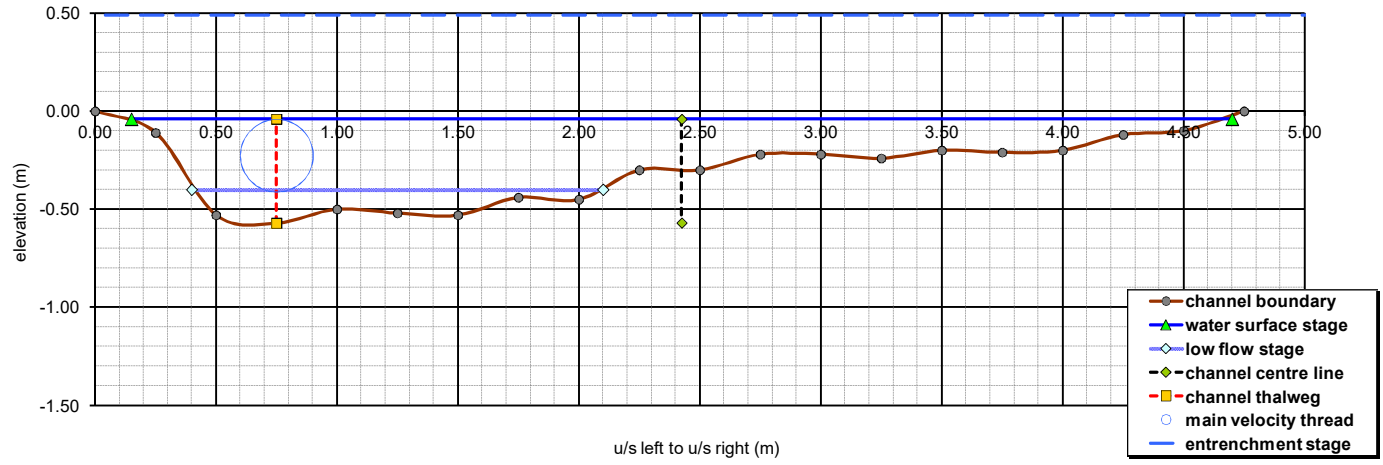
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Snow Valley Road Reach
Section 3 - Dynamic Stability Flow

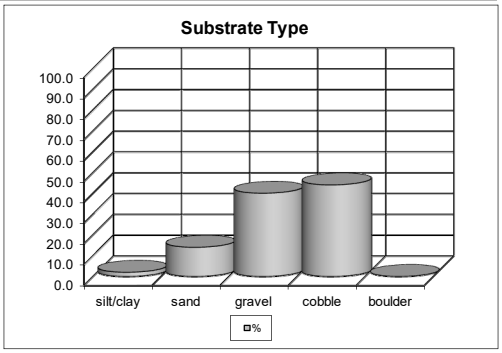
AquaLogic

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Cross Section Plot







Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	1.25
R (m)	0.25
TW (m)	4.56
WP (m)	4.93
max d (m)	0.53
mean d (m)	0.28
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R/D_{84}	2.31
ff V mean/V*	5.22
ff D_{84}	5.10
ff mean	5.16
ROUGH BED	

Hydraulic Ratios	
ER max d	5.48
r_c / TW	
TW / Lf_w	2.68
TW/max d	8.6
TW/mean d	16.6

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.412	10.22	NO	NO	NO	NO
V_* (m s^{-1})	0.098	D_{50}	0.984	24.40	NO	NO	NO	NO
		D_{84}	1.540	38.17	NO	NO	NO	NO

Section Data

ER_e (m)	0.49	ER stations L / R	-10.00	15.00	TW ck
WS_e (m)	-0.040	WS stations L / R	0.15	4.70	4.55
Lf_e (m)	-0.400	Lf stations L / R	0.40	2.10	
W_{fp} (m)	25.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.57	0.75	
E_g (m m^{-1})	0.0190				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
B3	0.0021	0.0021	T_*	6.1	1.1	0.4
C3	0.0006	0.0006	saltation	YES	NO	NO
C4	0.0076	0.0078	rolling	YES	YES	NO
			Ø	NO	NO	YES

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	1.00	8.00	45.00	110.00	210.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.97	7.76	43.65	106.70	203.70
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime

Strickler method		Limerinos method
Q (cms)	1.382	Q (cms)
V (m s^{-1})	1.10	V (m s^{-1})
n	0.050	n
Fr	0.67	*Fr*
D_c rectangular (m)	0.21	D_c rectangular (m)
D_c trapezoidal (m)	0.36	D_c trapezoidal (m)
D_c triangular (m)	0.53	D_c triangular (m)
D_c parabolic (m)	0.35	D_c parabolic (m)
D_c mean (m)	0.36	D_c mean (m)
flow type	SUBCRITICAL	flow type
Ω (watts m^{-1})	257.33	Ω (watts m^{-1})
ω_a (watts m^{-2})	52.24	ω_a (watts m^{-2})
ω_a/TW (watts m^{-1})	11.46	ω_a/TW (watts m^{-1})
*Re**	92.3	*Re**
Re	246125	*Re*
turbulence	HIGH	turbulence

Erosion Thresholds

		V_c / V_b	
τ_{calc} (kg m^{-2})	4.84		
τ_{calc} (N m^{-2})	47.40	Strickler	Limerinos
$\tau\ D_{crit}$ (gr-co) (mm)	48.86		
D_{50} V_c (vcs +) (m s^{-1})	1.04	1.35	
D_{84} V_c (vcs +) (m s^{-1})	1.63	2.11	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
2.0	14.0	40.0	44.0	0.0

Bank Data u/s L u/s R

H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

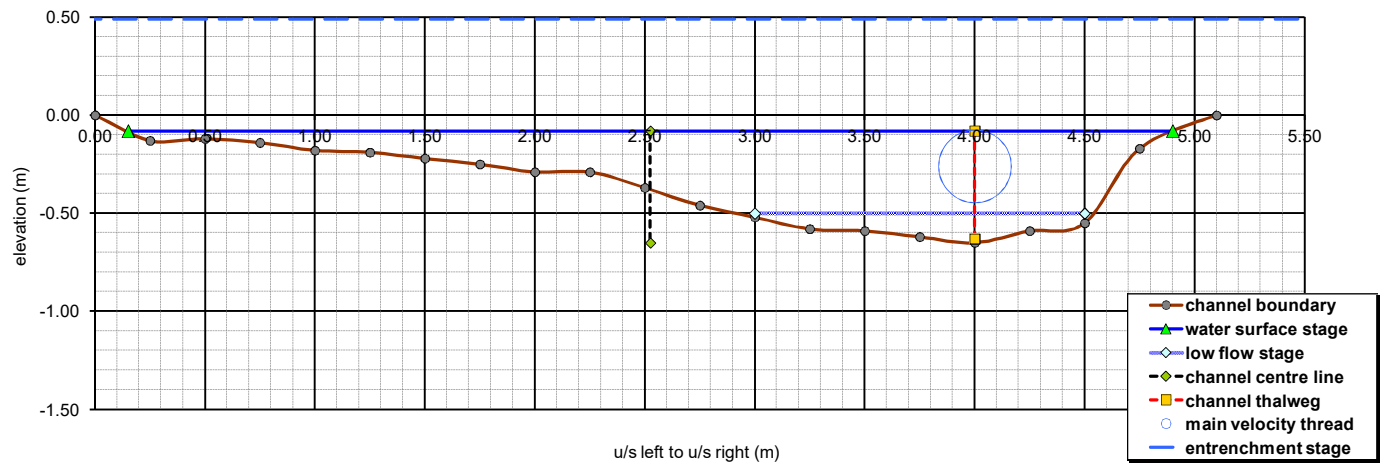
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

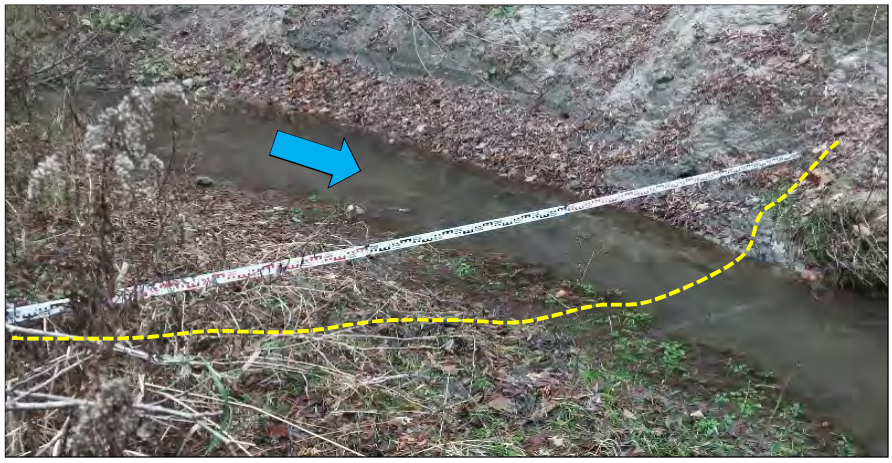
Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Snow Valley Road Reach
Section 4 - Dynamic Stability Flow

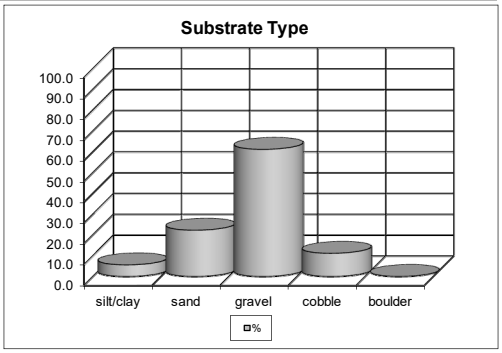
AquaLogic

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Cross Section Plot







Morphology Type	
cascade	
step	
riffle	
run	
glide	
pool	●
thalweg out of phase	

Hydraulic Roughness	
rr R/D_{84}	4.79
ff V mean/V*	6.10
ff D_{84}	6.86
ff mean	6.48
ROUGH BED	

Hydraulic Geometry	
A (m^2)	1.34
R (m)	0.26
TW (m)	4.78
WP (m)	5.09
max d (m)	0.57
mean d (m)	0.28
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Ratios	
ER max d	3.35
r_c / TW	
TW / Lf_w	3.19
TW/max d	8.4
TW/mean d	17.1

Sediment Transport Mode			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.040	1.29	NO	NO	YES	YES
V_* (m s^{-1})	0.076	D_{50}	0.567	18.15	NO	NO	NO	NO
		D_{84}	1.089	34.85	NO	NO	NO	NO

Section Data					
ER_e (m)	0.49	ER stations L / R	-10.00	6.00	TW ck
WS_e (m)	-0.080	WS stations L / R	0.15	4.90	4.75
Lf_e (m)	-0.500	Lf stations L / R	3.00	4.50	
W_{fp} (m)	16.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.63	4.00	
E_g (m m^{-1})	0.0110				

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.30	0.30	15.00	55.00	130.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.29	0.29	14.55	53.35	126.10
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds		V_c / V_b	
τ_{calc} (kg m^{-2})	2.90		
τ_{calc} (N m^{-2})	28.41	Strickler	Limerinos
$\tau\ D_{crit}$ (gr-co) (mm)	29.29		
D_{50} V_c (vcs +) (m s^{-1})	0.60	1.00	
D_{84} V_c (vcs +) (m s^{-1})	1.15	1.91	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
5.6	22.2	61.1	11.1	0.0

Bank Data u/s L	u/s R
H_b (m)	
Bf_d (m)	
RDp (m)	
H_b/Bf_d	
RDp/H_b	
RDn (%)	
BA (°)	
BFP (%)	

Bedload Transport Data						
	Strickler Q	Limerinos Q				
Rosgen type	Q_{sb} (kg sec^{-1})	Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
B3	0.0020	0.0022	T_*	97.6	2.0	0.5
C3	0.0004	0.0008	saltation	YES	NO	NO
C4	0.0069	0.0081	rolling	YES	YES	NO
			Ø	NO	NO	YES

Flow Regime Strickler method	
Q (cms)	1.151
V (m s^{-1})	0.86
n	0.050
Fr	0.52
D_c rectangular (m)	0.18
D_c trapezoidal (m)	0.33
D_c triangular (m)	0.50
D_c parabolic (m)	0.31
D_c mean (m)	0.33
flow type	SUBCRITICAL
Ω (watts m^{-1})	124.08
ω_a (watts m^{-2})	24.39
ω_a/TW (watts m^{-1})	5.10
Re^*	30.4
Re	198481
turbulence	HIGH

Flow Regime Limerinos method	
Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
Re^*	
Re	
turbulence	

GEO - ESUM v.1.3 Erosion Threshold Summary Model

Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Snow Valley Road Reach

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Existing Bankfull	Q $m^3 s^{-1}$	V $m s^{-1}$	veg control	D_{50} particle	D_{84}-D_{100} particle	τ_{calc} $N m^{-2}$	veg control	D_{50} particle*	D_{84}-D_{100} particle	Ω watts m^{-1}	Ω threshold
Xsec. 1	1.687	1.14	Y	N	Y	47.7	D	N	Y	264	Y
Xsec. 2	1.687	1.21	Y	N	Y	56.6	N	N	Y	363	Y
Xsec. 3	1.694	1.18	Y	Y	Y	52.2	N	N	N	315	Y
Xsec. 4	1.693	0.98	Y	N	Y	34.4	Y	N	Y	183	Y
Xsec. 5	1.690	0.92	Y	Y	Y	30.2	Y	N	Y	149	Y

Dynamic Stability	Q $m^3 s^{-1}$	V $m s^{-1}$	veg control	D_{50} particle	D_{84}-D_{100} particle	τ_{calc} $N m^{-2}$	veg control	D_{50} particle*	D_{84}-D_{100} particle	Ω watts m^{-1}	Ω threshold
Xsec. 1	1.01	0.97	Y	Y	Y	37.4	Y	N	Y	158	Y
Xsec. 2	1.21	1.10	Y	Y	Y	49.0	D	N	Y	261	Y
Xsec. 3	1.38	1.11	Y	Y	Y	47.4	D	Y	Y	257	Y
Xsec. 4	1.15	0.86	Y	Y	Y	28.4	Y	N	Y	125	Y
Xsec. 5	1.69	0.92	Y	Y	Y	30.2	Y	N	Y	149	Y

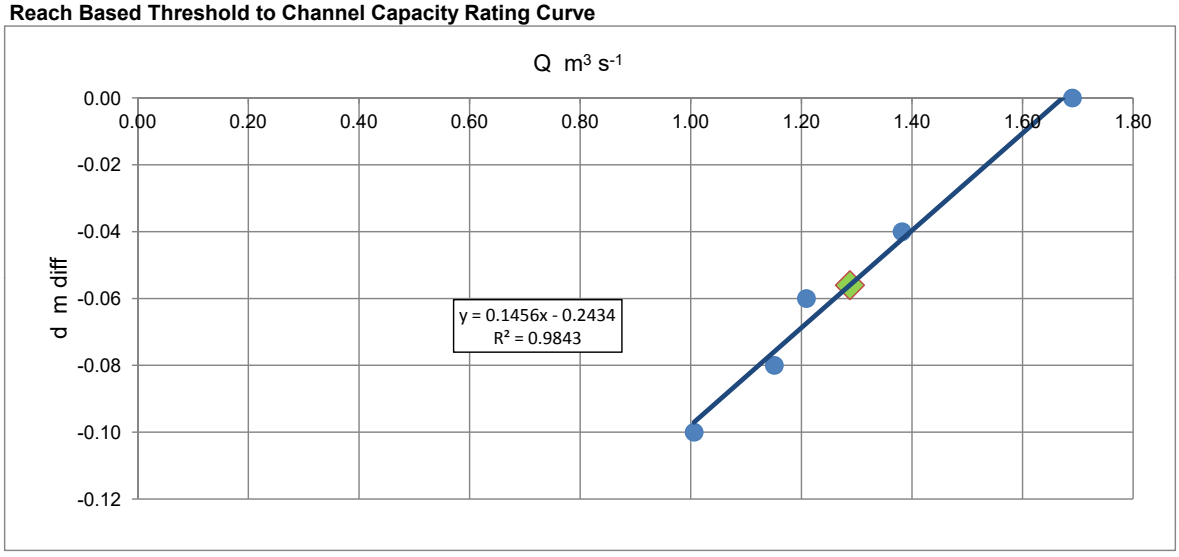
Stability Criteria Met: Y - Yes, N - No, D - Dynamic

* - within 5 mm

Dynamic Stability
Dynamic Stability = Cautionary
Potentially Unstable

	Q $m^3 s^{-1}$ existing	Q $m^3 s^{-1}$ stable	Q $m^3 s^{-1}$ diff	d m diff
Xsec. 1	1.69	1.01	0.68	-0.10
Xsec. 2	1.69	1.21	0.48	-0.06
Xsec. 3	1.69	1.38	0.31	-0.04
Xsec. 4	1.69	1.15	0.54	-0.08
Xsec. 5	1.69	1.69	0.00	0.00
mean	**1.69**	**1.29**	0.40	-0.06

Reach Based Threshold to Channel Capacity Rating Curve

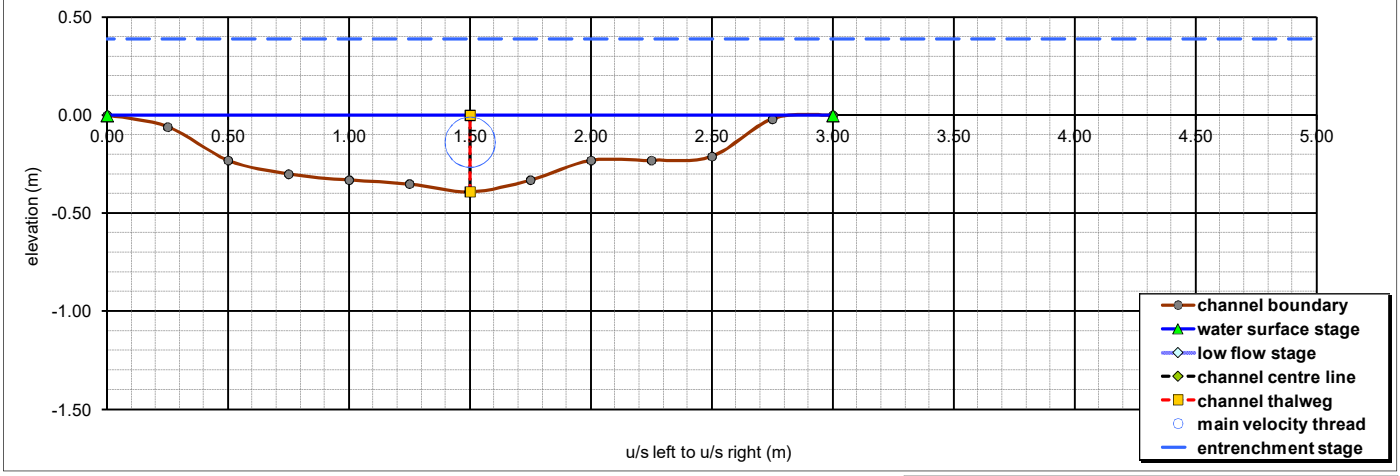


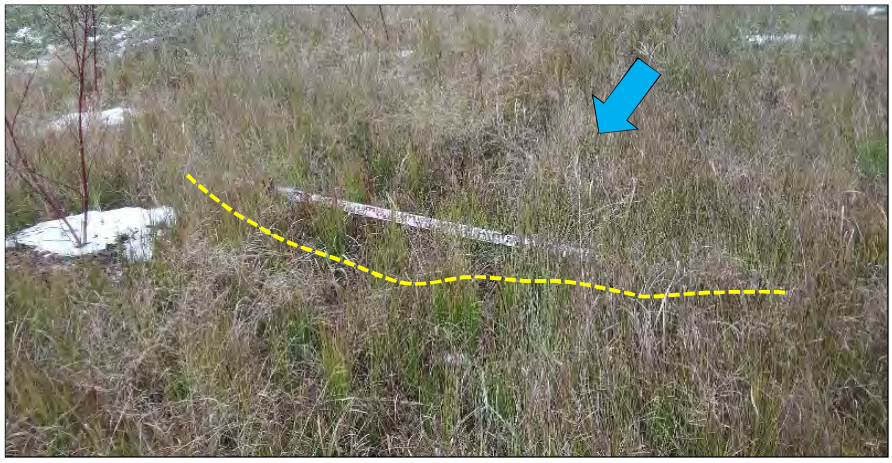
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: Erosion Threshold Analysis - MDDRI
Willow Creek Tributary, Midves Court Reach
Section 1

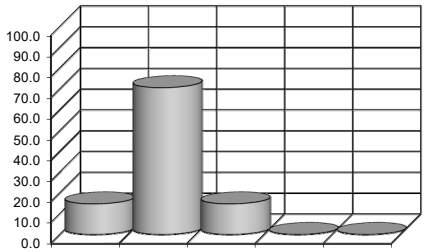
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Cross Section Plot





Substrate Type



Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Roughness	
rr R/D_{84}	105.79
ff V mean/V*	9.48
ff D_{84}	14.50
ff mean	11.99
	SMOOTH BED

Hydraulic Geometry	
A (m^2)	0.67
R (m)	0.21
TW (m)	3.00
WP (m)	3.17
max d (m)	0.39
mean d (m)	0.22
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Ratios	
ER max d	15.00
r_c / TW	
TW / Lf_w	
TW/max d	7.7
TW/mean d	13.4

Sediment Transport Mode			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.005	0.14	YES	YES	YES	YES
V_* (m s^{-1})	0.090	D_{50}	0.008	0.20	YES	YES	YES	YES
		D_{84}	0.196	5.34	NO	NO	NO	YES

Section Data					
ER_e (m)	0.39	ER stations L / R	-20.00	25.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	3.00	3.00
Lf_e (m)	-0.390	Lf stations L / R	1.50	1.50	
W_{fp} (m)	45.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.39	1.50	
E_g (m m^{-1})	0.0190				

Bedload Transport Data	Strickler Q	Limerinos Q				
Rosgen type	Q_{sb} (kg sec^{-1})	Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
B3	0.0016	0.0023	T_*	507.7	406.1	20.3
C3	0.0001	0.0011	saltation	YES	YES	YES
C4	0.0051	0.0089	rolling	YES	YES	YES
			Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.08	0.10	2.00	6.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.06	0.08	0.10	1.94	5.82
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds		V_c / V_b	
τ_{calc} (kg m^{-2})	4.02		
τ_{calc} (N m^{-2})	39.39		
τ D_{crit} (gr-co) (mm)	40.61	Strickler	Limerinos
D_{50} V_c (vcs +) (m s^{-1})	0.05	0.08	
D_{84} V_c (vcs +) (m s^{-1})	0.22	0.35	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
14.7	70.6	14.7	0.0	0.0

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Flow Regime Strickler method	
Q (cms)	0.593
V (m s^{-1})	0.89
n	0.055
Fr	0.60
D_c rectangular (m)	0.16
D_c trapezoidal (m)	0.26
D_c triangular (m)	0.38
D_c parabolic (m)	0.24
D_c mean (m)	0.26
flow type	SUBCRITICAL
Ω (watts m^{-1})	110.44
ω_a (watts m^{-2})	34.87
ω_a/TW (watts m^{-1})	11.62
*Re**	0.2
Re	164295
turbulence	LOW

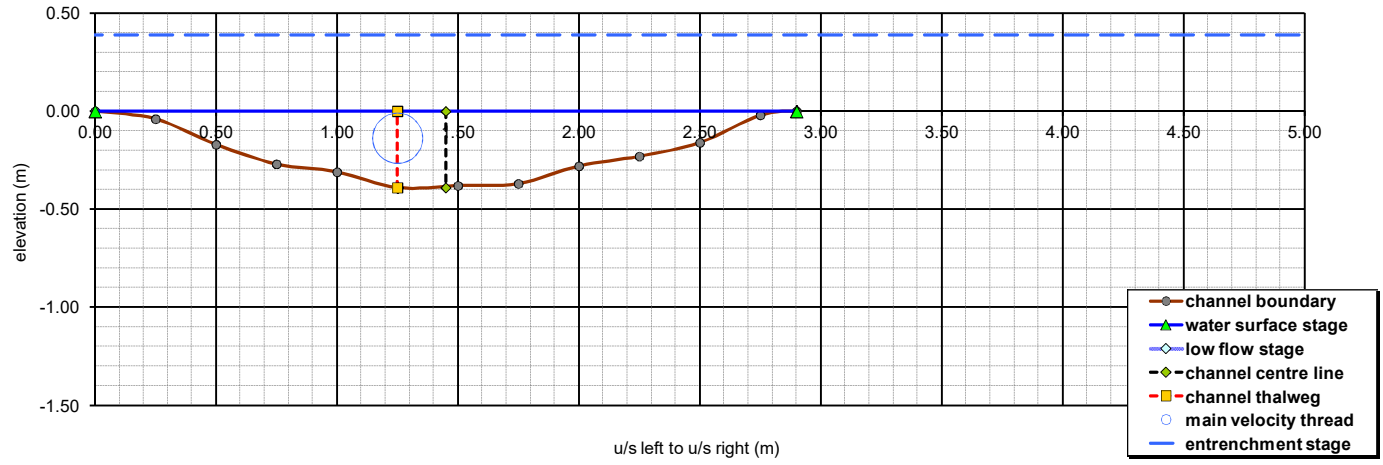
Flow Regime Limerinos method	
Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
*Re**	
Re	
turbulence	

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

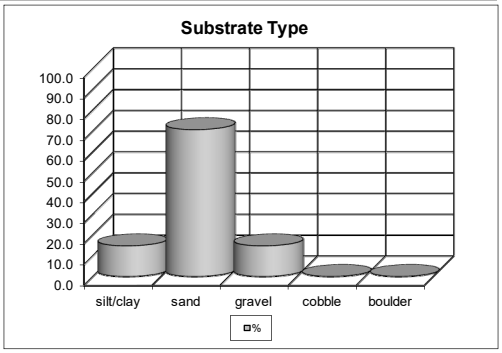
Project: Erosion Threshold Analysis - MDDRI
Willow Creek Tributary, Midves Court Reach
Section 2

B. de Geus 05.11

Cross Section Plot







Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Roughness	
rr R/D_{84}	107.62
ff V mean/V*	9.50
ff D_{84}	14.53
ff mean	12.02
	SMOOTH BED

Hydraulic Geometry	
A (m^2)	0.65
R (m)	0.22
TW (m)	2.90
WP (m)	3.04
max d (m)	0.39
mean d (m)	0.23
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Ratios	
ER max d	15.52
r_c / TW	
TW / Lf_w	
TW/max d	7.4
TW/mean d	12.9

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.005	0.14	YES	YES	YES	YES
V_* (m s^{-1})	0.090	D_{50}	0.008	0.20	YES	YES	YES	YES
		D_{84}	0.196	5.29	NO	NO	NO	YES

Section Data

ER_e (m)	0.39	ER stations L / R	-20.00	25.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	2.90	2.90
Lf_e (m)	-0.390	Lf stations L / R	1.25	1.25	
W_{fp} (m)	45.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.39	1.25	
E_g (m m^{-1})	0.0190				

Bedload Transport Data

Rosgen type	Strickler Q_{sb} (kg sec^{-1})	Limerinos Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
B3	0.0016	0.0023	T_*	516.5	413.2	20.7
C3	0.0001	0.0011	saltation	YES	YES	YES
C4	0.0050	0.0088	rolling	YES	YES	YES
			Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.08	0.10	2.00	6.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.06	0.08	0.10	1.94	5.82
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime
Strickler method

Q (cms)	0.586
V (m s^{-1})	0.90
n	0.055
Fr	0.60
D_c rectangular (m)	0.16
D_c trapezoidal (m)	0.26
D_c triangular (m)	0.38
D_c parabolic (m)	0.24
D_c mean (m)	0.26
flow type	SUBCRITICAL
Ω (watts m^{-1})	109.05
ω_a (watts m^{-2})	35.89
ω_a/TW (watts m^{-1})	12.38
Re^*	0.2
Re	169084
turbulence	LOW

Flow Regime
Limerinos method

Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
Re^*	
Re	
turbulence	

Erosion Thresholds

		V_c / V_b	
τ_{calc} (kg m^{-2})	4.09		
τ_{calc} (N m^{-2})	40.08		
τ D_{crit} (gr-co) (mm)	41.32	Strickler	Limerinos
D_{50} V_c (vcs +) (m s^{-1})	0.05	0.08	
D_{84} V_c (vcs +) (m s^{-1})	0.22	0.35	

Bank Data u/s L u/s R

H_b (m)	
Bf_d (m)	
RDp (m)	
H_b/Bf_d	
RDp/H_b	
RDn (%)	
BA (°)	
BFP (%)	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
14.7	70.6	14.7	0.0	0.0

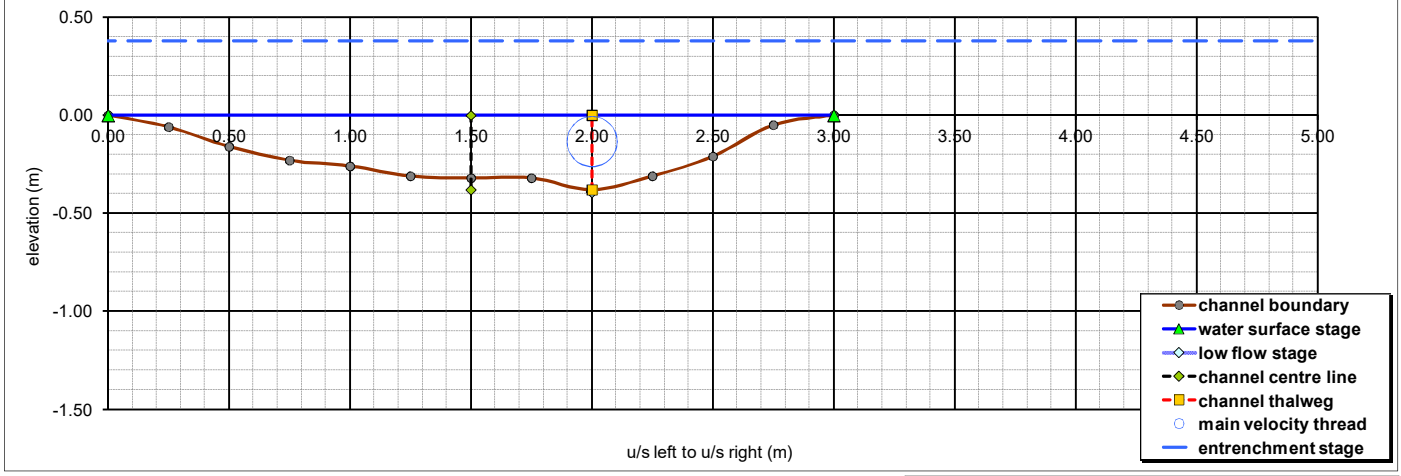
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

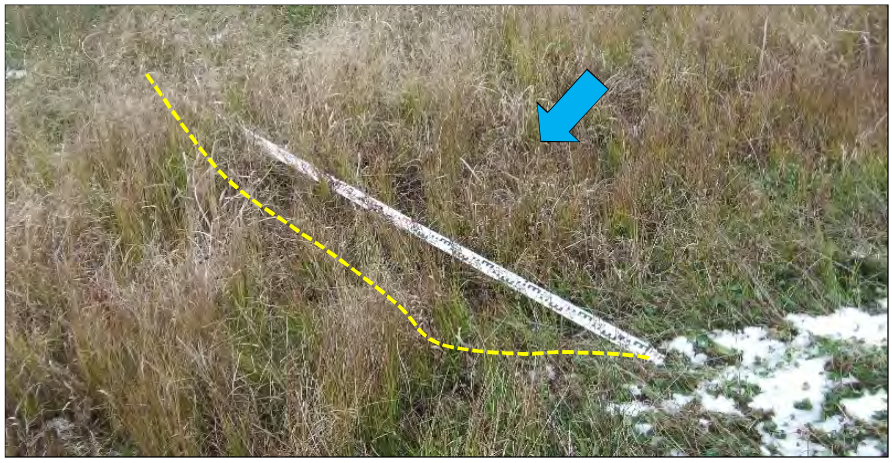
Project: Erosion Threshold Analysis - MDDRI
Willow Creek Tributary, Midves Court Reach
Section 3

AquaLogic

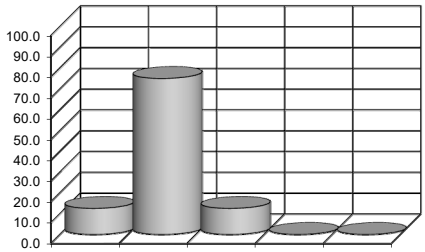
B. de Geus 05.11

Cross Section Plot





Substrate Type



Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.65
R (m)	0.21
TW (m)	3.00
WP (m)	3.13
max d (m)	0.38
mean d (m)	0.22
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R/D_{84}	208.42
ff V mean/V*	10.28
ff D_{84}	16.15
ff mean	13.22
	SMOOTH BED

Hydraulic Ratios	
ER max d	15.00
r_c / TW	
TW / Lf_w	
TW/max d	7.9
TW/mean d	13.8

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.20	YES	YES	YES	YES
V_* (m s^{-1})	0.091	D_{50}	0.032	0.85	NO	YES	YES	YES
		D_{84}	0.126	3.37	NO	NO	NO	YES

Section Data

ER_e (m)	0.38	ER stations L / R	-20.00	25.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	3.00	3.00
Lf_e (m)	-0.390	Lf stations L / R	2.00	2.00	
W_{fp} (m)	45.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.38	2.00	
E_g (m m^{-1})	0.0200				

Bedload Transport Data

Rosgen type	Strickler Q_{sb} (kg sec^{-1})	Limerinos Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
B3	0.0016	0.0024	T_*	421.1	168.5	42.1
C3	0.0001	0.0013	saltation	YES	YES	YES
C4	0.0051	0.0093	rolling	YES	YES	YES
			Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.25	1.00	4.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.06	0.10	0.24	0.97	3.88
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime
Strickler method

Q (cms)	0.587
V (m s^{-1})	0.90
n	0.055
Fr	0.62
D_c rectangular (m)	0.16
D_c trapezoidal (m)	0.26
D_c triangular (m)	0.38
D_c parabolic (m)	0.24
D_c mean (m)	0.26
flow type	SUBCRITICAL
Ω (watts m^{-1})	115.00
ω_a (watts m^{-2})	36.73
ω_a/TW (watts m^{-1})	12.24
Re^*	0.6
Re	164394
turbulence	LOW

Flow Regime
Limerinos method

Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
Re^*	
Re	
turbulence	

Erosion Thresholds

		V_c / V_b	
τ_{calc} (kg m^{-2})	4.17		
τ_{calc} (N m^{-2})	40.85		
τ D_{crit} (gr-co) (mm)	42.11	Strickler	Limerinos
D_{50} V_c (vcs +) (m s^{-1})	0.08	0.12	
D_{84} V_c (vcs +) (m s^{-1})	0.16	0.25	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
12.5	75.0	12.5	0.0	0.0

Bank Data u/s L u/s R

H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

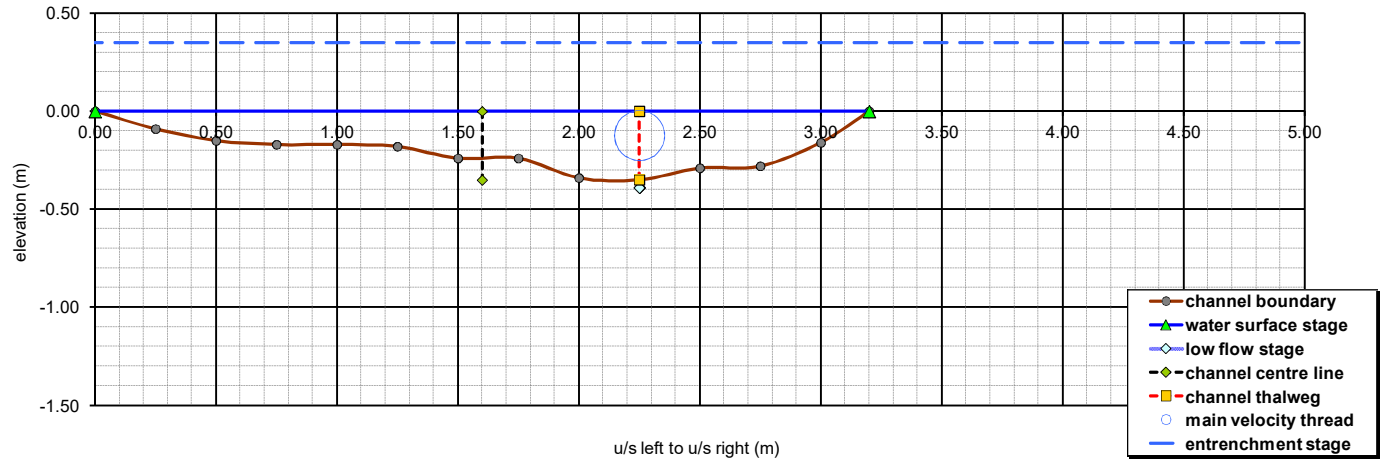
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

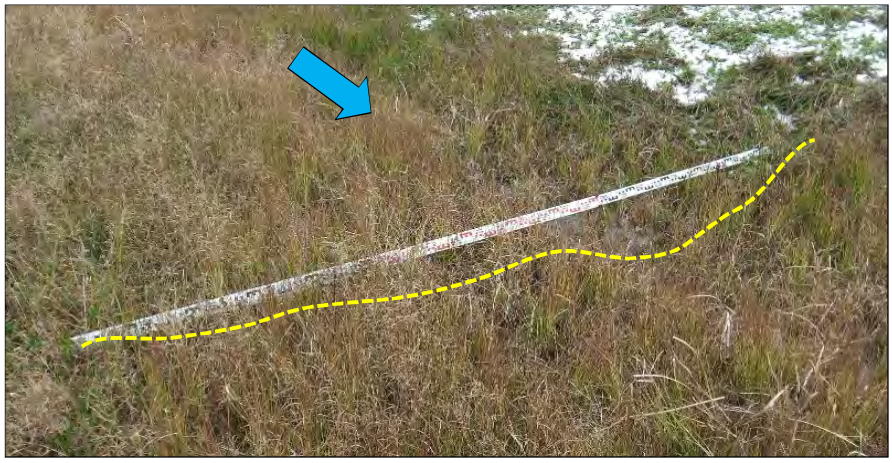
Project: Erosion Threshold Analysis - MDDRI
Willow Creek Tributary, Midves Court Reach
Section 4

AquaLogic

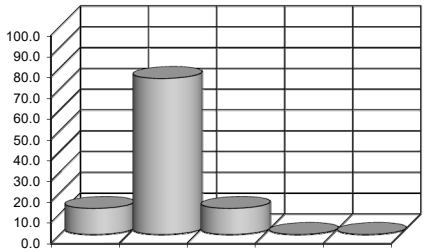
B. de Geus 05.11

Cross Section Plot





Substrate Type



Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.66
R (m)	0.20
TW (m)	3.20
WP (m)	3.34
max d (m)	0.35
mean d (m)	0.21
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R/D_{84}	197.84
ff V mean/V*	10.20
ff D_{84}	16.03
ff mean	13.11
	SMOOTH BED

Hydraulic Ratios	
ER max d	14.06
r_c / TW	
TW / Lf_w	
TW/max d	9.1
TW/mean d	15.5

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.20	YES	YES	YES	YES
V_* (m s^{-1})	0.091	D_{50}	0.032	0.85	NO	YES	YES	YES
		D_{84}	0.126	3.38	NO	NO	NO	YES

Section Data

ER_e (m)	0.35	ER stations L / R	-20.00	25.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	3.20	3.20
Lf_e (m)	-0.390	Lf stations L / R	2.25	2.25	
W_{fp} (m)	45.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.35	2.25	
E_g (m m^{-1})	0.0210				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
B3	0.0016	0.0024	T_*	419.7	167.9	42.0
C3	0.0001	0.0013	saltation	YES	YES	YES
C4	0.0051	0.0093	rolling	YES	YES	YES
			Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.25	1.00	4.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.06	0.10	0.24	0.97	3.88
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds

		V_c / V_b	
τ_{calc} (kg m^{-2})	4.15		
τ_{calc} (N m^{-2})	40.72		
τ D_{crit} (gr-co) (mm)	41.97	Strickler	Limerinos
D_{50} V_c (vcs +) (m s^{-1})	0.08	0.12	
D_{84} V_c (vcs +) (m s^{-1})	0.16	0.25	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
12.5	75.0	12.5	0.0	0.0

Bank Data u/s L u/s R

H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Flow Regime
Strickler method

Q (cms)	0.588
V (m s^{-1})	0.89
n	0.055
Fr	0.63
D_c rectangular (m)	0.15
D_c trapezoidal (m)	0.26
D_c triangular (m)	0.38
D_c parabolic (m)	0.24
D_c mean (m)	0.26
flow type	SUBCRITICAL
Ω (watts m^{-1})	121.04
ω_a (watts m^{-2})	36.23
ω_a/TW (watts m^{-1})	11.32
*Re**	0.6
Re	154413
turbulence	LOW

Flow Regime
Limerinos method

Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
*Re**	
Re	
turbulence	

GEO-VEG v.1.3 Vegetation-Hydroperiod Erosion Risk Model

Project: **Erosion Threshold Analysis - MDDRI**
Willow Creek Tributary, Midves Court Reach
Event Model Test at Average Groundcover Density + 15% Qs

AquaLogic

B. de Geus 04.14

RETURN EVENT MODELING

i) $T_a = 4.7568V^{-3.4664}$

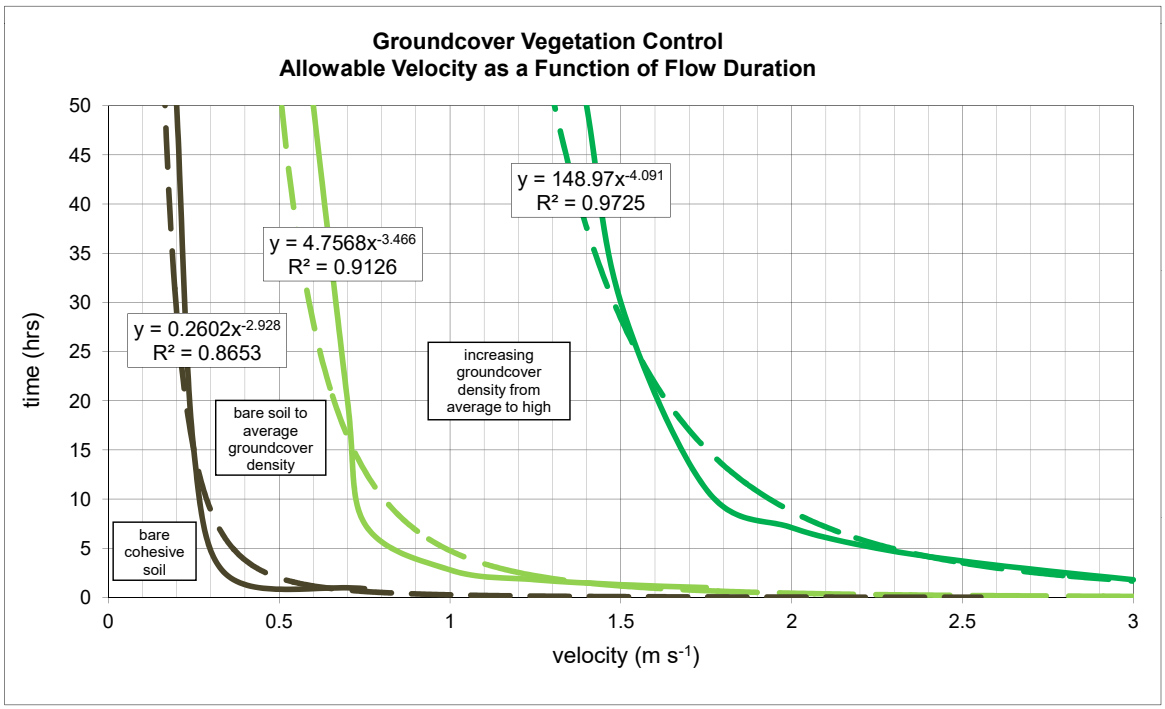
	25mm	2yr	5yr	10yr	25yr	50yr	100yr	
existing stage flow Q ($m^3 s^{-1}$)	0.15	0.31	0.70					
proposed stage flow Q ($m^3 s^{-1}$)	0.26	0.46	0.83					
existing stage velocity V ($m s^{-1}$)	0.63	0.78	0.90					
proposed stage velocity V ($m s^{-1}$)	0.74	0.86	0.90					
existing event duration T_e (hrs)	2.83	3.25	2.83					
proposed event duration T_p (hrs)	33.90	46.70	58.87					
i) allowable existing event duration T_a (hrs)	23.598	11.255	6.854					
i) allowable proposed event duration T_a (hrs)	13.509	8.024	6.854					
number of events N_e	300	50	25	10	4	2	1	
total time existing T_{te} (hrs)	849.00	162.50	70.75					
total time proposed T_{tp} (hrs)	10170.00	2335.00	1471.75					
$T_e < T_a$ (yes/no)	yes	yes	yes					
$T_p < T_a$ (yes/no)	no	no	no					total
total time existing over threshold OT_{te}	0.00	0.00	0.00					
total time proposed over threshold OT_{tp}	6117.42	1933.82	1300.41					
time % existing over 100yrs	0.0000	0.0000	0.0000					
time % proposed over 100yrs	0.0070	0.0022	0.0015					

CONTINUOS MODELING

i) $T_a = 4.7568V^{-3.4664}$

	step 1	step 2	step 3	step 4	step 5	step 6	step 7
flow range Q ($m^3 s^{-1}$)							
*max velocity V ($m s^{-1}$)							
total time existing T_{te} (hrs)							
total time proposed T_{tp} (hrs)							
i) allowable event duration T_a (hrs)							
existing number events N_e							
proposed number events N_p							
existing mean event time T_{te}/N_e (hrs)							
proposed mean event time T_{tp}/N_p (hrs)							
$T_{te}/N_e < T_a$ (yes/no)							
$T_{tp}/N_p < T_a$ (yes/no)							

*note: max velocity represents the velocity at the next highest flow step to balance the rising and falling velocity range



GEO-VEG v.1.3 Vegetation-Hydroperiod Erosion Risk Model

Project: **Erosion Threshold Analysis - MDDRI**
Willow Creek Tributary, Midves Court Reach
Event Model Test at High Groundcover Density + 15% Qs

AquaLogic

B. de Geus 04.14

RETURN EVENT MODELING

i) $T_a = 148.97V^{-4.091}$

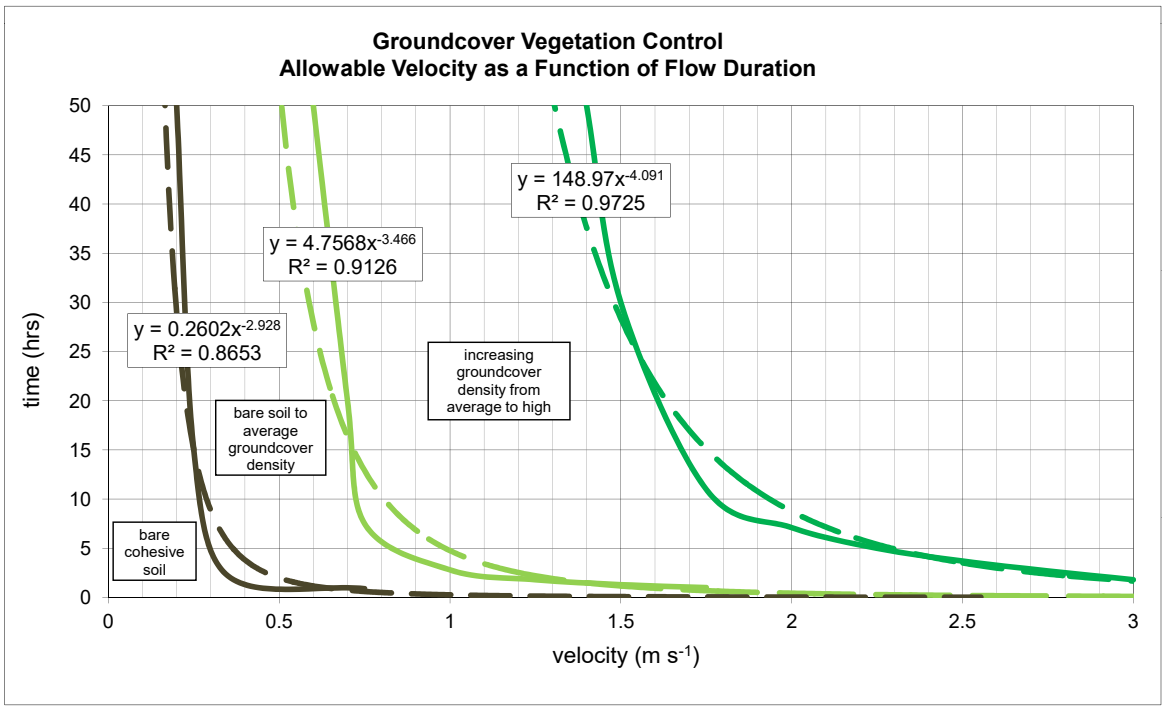
	25mm	2yr	5yr	10yr	25yr	50yr	100yr	
existing stage flow Q ($m^3 s^{-1}$)	0.15	0.31	0.70					
proposed stage flow Q ($m^3 s^{-1}$)	0.26	0.46	0.83					
existing stage velocity V ($m s^{-1}$)	0.63	0.78	0.90					
proposed stage velocity V ($m s^{-1}$)	0.74	0.86	0.90					
existing event duration T_e (hrs)	2.83	3.25	2.83					
proposed event duration T_p (hrs)	33.90	46.70	58.87					
i) allowable existing event duration T_a (hrs)	986.272	411.661	229.241					
i) allowable proposed event duration T_a (hrs)	510.589	276.100	229.241					
number of events N_e	300	50	25	10	4	2	1	
total time existing T_{te} (hrs)	849.00	162.50	70.75					
total time proposed T_{tp} (hrs)	10170.00	2335.00	1471.75					
$T_e < T_a$ (yes/no)	yes	yes	yes					
$T_p < T_a$ (yes/no)	yes	yes	yes					total
total time existing over threshold OT_{te}	0.00	0.00	0.00					
total time proposed over threshold OT_{tp}	0.00	0.00	0.00					
time % existing over 100yrs	0.0000	0.0000	0.0000					
time % proposed over 100yrs	0.0000	0.0000	0.0000					

CONTINUOS MODELING

i) $T_a = 4.7568V^{-3.4664}$

	step 1	step 2	step 3	step 4	step 5	step 6	step 7
flow range Q ($m^3 s^{-1}$)							
*max velocity V ($m s^{-1}$)							
total time existing T_{te} (hrs)							
total time proposed T_{tp} (hrs)							
i) allowable event duration T_a (hrs)							
existing number events N_e							
proposed number events N_p							
existing mean event time T_{te}/N_e (hrs)							
proposed mean event time T_{tp}/N_p (hrs)							
$T_{te}/N_e < T_a$ (yes/no)							
$T_{tp}/N_p < T_a$ (yes/no)							

*note: max velocity represents the velocity at the next highest flow step to balance the rising and falling velocity range



Rapid Assessment Analysis Update
Black Creek, Willow Creek, Willow Creek Tributary
Carson Road Development Inc.
Midhurst Development Doran Road Inc.
Township of Springwater







Submitted to:

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May 27, 2014

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Rapid Assessment Analysis Update
Black Creek, Willow Creek, Willow Creek Tributary
Carson Road Development Inc.
Midhurst Development Doran Road Inc.
Township of Springwater

Updated 'Rapid Assessment' analysis has been undertaken for Black Creek, Willow Creek, and a Willow Creek Tributary, further to previous reporting of May 2, 2014. Updated analysis has been requested based on proposed stormwater outlet location revisions noted in discussion at and follow-up from a site walk with NVCA, proponent representatives, consultants, and Township staff, on May 8, 2014. Previous analysis only included key reaches and what were deemed as the most sensitive locations below combined flows from each respective development site. Analysis immediately below every pond outlet location is now required to cover all sub-reaches in close proximity to Draft Plan areas. This report includes rapid assessment results from the previous submission that are still applicable, combined with the extra analysis requirements.

Also noted at the site walk meeting was the need to address at the detailed design stage any emergency overflow locations as standalone erosion control sites that may differ from the proposed outlet and receiving watercourse locations.

It is also understood that a watershed wide MDP process will occur subsequent to Draft Plan Approval (Phase 2). At present, preliminary engineering details are being provided that demonstrate extra contingencies for extended detention durations are possible in both the Carson Road and Doran Road development areas. The extended detention rates will therefore be fine tuned through MDP recommendations.

Black Creek Characterization
(Note that previous analysis referred to this watercourse as 'Willow Creek Tributary', for the Carson Road development)

Carson Road

The 'Carson Road' Black Creek system is transitional from a 1st order to 2nd order watercourse with upstream drainage area increments of 1.40km^2 to Anne St. N. for the easterly 1st order feature, 1.80km^2 for the westerly 1st order feature, 5.47km^2 to Carson Rd. W. for the 2nd order branch, and 6.83km^2 to Wilson Dr. at the downstream study limit of the 2nd order branch. Two additional short local drainage features are confluent in the lower study area. The small westerly feature represents drainage from a small wet meadow area (possibly a former beaver pond/meadow) and the easterly feature is

characterized by local farm field drainage contribution. The 1st and 2nd order features are officially identified on 1:10,000 Provincial OBM mapping and 1:50,000 Federal NTS mapping. The local drainage features as described above are not seen on mapping and would therefore be deemed not to represent primary drainage functions. The main branch 2nd order tributary is confluent further downstream of the study area with the main branch of Willow Creek, which is confluent with the Nottawasaga River in the Minesing Wetlands.

The study area is mainly within the Simcoe Uplands physiographic region, with the downstream area near Wilson Dr. falling to the Simcoe Lowlands physiographic region. Topography is characterized as a deeply rolling till plain with the tributary falling from a shallow U-shaped valley at Anne St. N. to a relatively deep glacial moraine valley at Carson Rd. and a moderately steep valley transition near Wilson Dr. to downstream of Snow Valley Drive beyond the development block. At its deepest point near Carson Rd. the valley is 15-20m deep. The valley slopes are variable from well defined to convex, with gentle to steep gradients and valley width varying from 50m to over 300m.

The valley floor flood plain varies from agricultural row crop and pasture at Anne St. N. to well vegetated lowland forest and transitional upland forest conditions. Forest cover upstream of Carson Rd. includes a mix of swamp wetland, scrub forest, and coniferous-deciduous forest. Vegetative cover above Wilson Dr. has scrub forest definition with openings in the canopy resulting in thicker herbaceous groundcover and wet meadow, with a transition to mature forest at Carson Road.

The tributary branches are ephemeral to intermittent in the south study area while the main branch appears to gain permanent base flow in the forest upstream of Carson Rd. Channel width varies from about 3-5m in the two 1st order features to as high as 8m in wet meadow sections of the northerly 2nd order study reach. Low flow definition varies from ill-defined ephemeral/intermittent at the upstream limits of the 1st order southerly features, up to about 3m wide, at the downstream development limits of the northerly study reach. The tributary flows over deposits of the parent geology with variable low flow bed forms from ill-defined swale, in the south, to occasional pools and riffles and eventually steps of coarser gravel to cobble material, in the northerly reach. There are areas of wetland diffusion, and influence from apparent beaver activity in intervening forest areas. Channel sinuosity is relatively low upstream of Carson Road but increases downstream, while the reach average slope is approximately 1%. Channel stability varies from moderate to relatively high due to changes in biotechnical reinforcement and channel bed materials. Some erosion scars are evident on outside banks, in the mid to lower reach and in the forest upstream of Carson Road. As expected, the channel tributaries are very stable near the upstream end were flows are ephemeral to

intermittent and groundcover vegetation density is high. Stability is moderate to high in the shaded forest areas upstream and downstream of Carson Road. Near the downstream study limits the tributary emerges from forest cover into denser groundcover and shrub thicket cover. Stability is high just upstream of Wilson Drive except where confined and partially entrenched meanders contact low slopes resulting in toe cutting and cantilevered failure of the low slope faces. Downstream of Wilson Dr. and the next crossing at Snow Valley Road the tributary increases in gradient and is partially to fully confined against valley walls. Below Snow Valley Road partial entrenchment also occurs and the steeper channel requires a generally narrower cross-section with higher conveyance velocities, than some upstream areas. In the reach below Snow Valley Road exposed sand and gravel material is seen in channel banks, localized instability is observed and outside bends show colluvial failure of high slopes above distinct bank erosion scars.

Willow Creek and Willow Creek Tributary Characterization

Doran Road

Two tributary reaches of Willow Creek border proposed development areas with the westerly tributary, in the Pooles Road area, identified for analysis during pre-consulting and the easterly feature identified for analysis during the May 8 site walk. The westerly feature was removed from the need for detailed analysis based on site walk discussions but characterization is included here for completeness of coverage of all features in the study area. The main branch of Willow Creek will receive piped flows, in lieu of the westerly feature receiving surface flows, therefore Willow Creek has been added to the analysis requirements.

This westerly feature is 1st order ephemeral and is seen on 1:50,000 scale Federal topographic mapping, but it is not seen on 1:10,000 scale Provincial topographic mapping. The western feature also has two small tributary drainage features within the study area. These features are ephemeral, contour based, overland flow routes that would arguably not be classified as independent 1st order features. Upstream drainage area is 2.53km^2 for the westerly tributary at Pooles Road. Part of the westerly feature is contained in roadside ditching leading to an enclosed storm sewer in the residential area of Midhurst, before it meets Willow Creek. The study area falls mainly within the Simcoe Uplands physiographic region. Topography is characterized as deeply rolling till plain with the tributaries falling from shallow U-shaped valleys at upstream limits to relatively deep glacial moraine valleys at downstream confluence points. At its deepest point, the western valley is approximately 13m deep. Valley side slopes vary from well defined to convex, with gentle to steep gradients and width varying up to approximately

200m. The west tributary valley floor varies from herbaceous old field pasture at Walt Rd. to a continuous swamp forest at the downstream study area limits.

The westerly tributary appears to be fully ephemeral with no flow identified at the time of field work. The feature was found to not have well defined channel bed and bank conditions and would not necessarily meet technical and legal definition as a true watercourse at any point from downstream of Pooles Road to the upstream limits. After passing through mixed forest conditions below Pooles Road the feature opens up into a recently cleared and graded block designed for new residential development. In this area a very modest swale like channel easement appears to have been recently constructed which passes between lots and meets roadside ditching around a cul-de-sac bulb of Midves Court. A small gravel filled trench is seen within the realignment easement and is reported to be an infiltration feature (Gemmell Engineering 2012). Feature sinuosity is very low in the feature, being just over a ratio value of 1.0. Reach average study area slope is approximately 0.01 m m^{-1} for the western feature. Stability is noted to be very high due to the lack of well defined geometry and the extensive vegetation coverage. The lack of channel definition suggests that flow is opportunistic and will anastomise through vegetative cover without sufficient energy to carve a distinct bankfull channel. Soil conditions and vegetative attenuation also appear to encourage a reasonably high amount of recharge that would help account for the lack of flow forming channel definition on the surface.

Based on the above characterization and discussions at the site walk, the feature would not be defined as permanently flowing with associated suitability as a permanent outlet for future drainage. As a result, the focus of analysis would shift to the receiving natural channel reach below where flows will be piped from proposed development and added to existing minor and major storm systems in the village of Midhurst. These systems outlet to the main branch of Willow Creek. Willow Creek therefore requires preliminary rapid assessment for the sake of this reporting and detailed erosion threshold analysis for subsequent proposed MDP work.

Willow Creek in Midhurst is a 4th order watercourse with an upstream drainage area of 127km^2. Flows to the village area are highly attenuated by the 225ha surface area of Little Lake, southeast of the village. The reach within the village is largely entrenched and confined on outside meanders within relatively steep valley walls that vary from 5-12m deep. Sandy soils are dominant and erosion and aggradation patterns are clearly seen along channel limits. Sinuosity is moderate to high in natural areas and observations suggest that past straightening may have occurred over approximately 400m of length, including the area where storm systems outlet to the creek. Mixed riparian vegetation conditions of groundcover to coniferous swamp forest line the valley

and channel banks and large woody debris deposits are frequent. Low flow widths are up to approximately 10m and entrenched channel forming widths are estimated up to 15m. Bedform definition of deeper pools up to 2m deep and shallow runs ranging from 0.5-1m are dominant at low velocity, with occasional short riffles of gravel-cobble at moderate velocity.

The second or easterly Willow Creek tributary feature at Old Second South road was identified during site walk discussions to require preliminary rapid assessment and detailed erosion threshold analysis for proposed MDP work. This 1st order feature has a topographic drainage area of approximately 1.2km^2 to Old Second South which is in proximity to the proposed SWM outlet. Flows are reported by land tenant observations to be permanent, albeit having very low baseflow in summer. A small swamp forest block occurs below Old Second South with the channel confluent to an online manmade pond below the forest. Storm flows will be confluent either above or into the manmade pond. The pond discharges to several hundreds of metres of wet meadow channel with groundcover and shrub thicket vegetation resulting in anastomising flow patterns. The channel transitions into a large cedar swamp forest further downstream and is eventually confluent with the main branch of Willow Creek near the outlet of Little Lake above the Midhurst village area.

Rapid Assessment Analysis

Three rapid assessment protocols were undertaken for six locations relative to the Carson Road site and two locations relative to the Doran Road site, to help characterize existing conditions and determine appropriate locations for detailed erosion threshold analysis. Previous analysis included three sites for Carson Road and two different sites for Doran Road. Field observations were used to score relative geomorphic and environmental attributes. Rapid Geomorphic Assessment (RGA) was used to rate channel stability and infrastructure impact. Rapid Habitat Assessment (RHA) was used to define in-stream and riparian habitat. Rapid Stream Assessment Technique (RSAT) was used to test broad indicators of channel stability, aquatic habitat, and water quality. A weighted score out of 100 was transposed from the results of each protocol and a combined average score was determined from the three tests. Four qualifying ranges of poor, fair, good, and optimal are maintained in the RHA and RSAT protocols, between the original scoring and the weighted scoring out of 100, while the three original ranges in RGA scoring are reflected as poor, fair, and good. The combined average score is qualified by poor to optimal ranges designed as a best fit of the individual protocol ranges. The detailed results are appended and included with each are photographs of typical conditions.

Carson Road

Six locations representing the 'South Pond' outlet, the Carson Road upstream sub-reach representing the initial 'Carson Road South Pond' outlet, the revised and combined 'Carson Road South Pond' and 'Carson Road North Pond' outlet, the 'North Pond' outlet, upstream to downstream of Wilson Road, and downstream of Snow Valley Road, were scored with rapid assessments to cover all previous and updated considerations for sub-reaches of Black Creek that will receive and convey confluent storm flows.

The detailed results show that the South Pond outlet location has the highest level of stability while the intervening forest area upstream of Carson Road has lower stability due to forest shading and lower rooting density. The Carson Road South Pond and Carson Road North Pond combined outlet has good stability due to denser groundcover and swamp thicket biotechnical reinforcement. The North Pond location scores as transitional due to the evidence of erosion impacting a former agricultural building (albeit a structure likely to be removed) and due to entrenched and confined conditions leading to instability at the sharp bend in proximity to private property limits downstream of the outlet. This location is targeted for site specific erosion control works through detailed design. The immediate area around Wilson Road has a good relative level of stability despite deterioration in the crossing itself from age weathering and spalling and associated slope impact failure from surface runoff (capital works are already proposed at the crossing).

Downstream of Wilson Road the channel transitions to steeper gradient and deeper valley confinement and entrenchment. A large drop on the downstream face of Snow Valley Road defines the start of what is deemed the most sensitive reach in proximity to the proposed development area. Existing bank erosion and valley wall contact points show a high fraction of cohesionless material that is exposed and available for entrainment under high flows. Stability is scored lowest in this location relative to the whole study area. Scour pool incision impacting the culvert drop and channel widening in downstream areas is causing slope toe and slope face erosion, and moderate to high numbers of undermined trees. Despite the observed erosion, the continuous natural valley conditions contribute to good aquatic habitat, and integrated scoring is relatively high. The area below Snow Valley Road is therefore deemed to be the most sensitive to erosion and is thus the most suitable location for detailed erosion threshold analysis which has already been presented in the previous submission.

Doran Road

The location for much of the Doran Road storm flow discharge is the main branch of Willow Creek. The previously proposed outlet through private lands between Pooles Road and the existing Midves Court location is not deemed to be a permanent flowing outlet based on site walk discussions. The private lands downstream of Pooles Road will not receive additional storm event flows and are thus not included in updated analysis. The easterly Willow Creek Tributary is now included at both the preliminary rapid assessment and at the subsequent detailed MDP analysis stages.

The Willow Creek main branch scores as transitional due principally to observations of aggradation and some widening. The entrenched conditions at low gradient result in slowly moving but likely near constant shifting of sand material at storm event flows of high frequency. Infrequent larger storms likely scour the toe of slope areas through increased tractive force. Widening results in locally mobilized material that deposits on steep point bars and some accessible valley floor flood plain.

The eastern Willow Creek tributary scores relatively high stability due to dense groundcover and shrub thicket biotechnical reinforcement in a wide well vegetated flood plain. Stability would score even higher if not for the localized influence of the manmade pond resulting in a driveway crossing elevated culvert that is cantilevered over a scour pool.

Rapid Assessment Results Summary

The results of rapid assessment scoring are summarized in **Table 1.**

Table 1: Rapid Assessment Results Summary

	RGA Score	RHA Score	RSAT Score	Combined Score
Black Creek, Snow Valley Road Reach	73.2	76.5	80.0	76.6
Black Creek, Wilson Road Reach	90.4	75.0	82.0	82.5
Black Creek, North Pond Outlet	75.7	66.0	74.0	71.9
Black Creek, Carson Road North & South Pond Outlet	88.9	73.5	86.0	82.8
Black Creek, Carson Road Upstream Reach	78.2	70.5	68.0	72.2
Black Creek, South Pond Outlet	95.0	70.0	70.0	78.3
Willow Creek main branch, Midhurst Village Reach	75.7	68.5	76.0	73.4
Willow Creek Tributary, Old Second South Reach	81.8	59.5	68.0	70.0

All scores are standaridized to be out of 100.

The results confirm that a mix of good, or 'in regime', channel stability and transitional stability occurs over the study properties while related habitat quality scoring mainly falls in the good range with a couple locations considered optimal. The results show that the Snow Valley Road reach is the lowest scoring with regard to channel stability in proximity to the Carson Road development.

Conclusions

Updated 'Rapid Assessment' analysis' has been undertaken for Black Creek, Willow Creek, and a Willow Creek Tributary, further to previous reporting of May 2, 2014. Updated analysis was requested based on a need to inventory all receiving reaches below individual pond outlet locations as a response to discussion at and follow-up from a site walk with NVCA, proponent representatives, consultants, and Township staff, on May 8, 2014. Previous analysis only included key reaches and the most sensitive locations below combined flows from each respective site. This report includes rapid assessment results from the previous submission combined with the extra analysis requirements noted above.

The previously analyzed Snow Valley Road location for Black Creek relative to the Carson Road proposed development has been confirmed as the most sensitive erosion potential location. The previous erosion threshold analysis done for this location is appropriate from a standalone perspective.

The Willow Creek main branch is the default location for erosion threshold analysis relative to much of the Doran Road proposed development. This development will be connected to existing storm sewers in Midhurst that discharge directly to Willow Creek.

The Willow Creek easterly tributary will receive some Doran Road proposed development storm flows.

Based on the previous reporting conclusions that 24hr extended detention is suitable for erosion potential control of the Doran and Carson Road developments, the current Draft Plan contingency to provide up to 72hr extended detention, in combination with extensive LID infiltration, is deemed to be adequate across all properties with regard to future conditions erosion potential control. The MDP watershed wide modelling to be prepared as part of Stage 2 will allow fine tuning of control rates on a location by location basis as combined over all future development discharge points with due consideration of cumulative downstream impacts.

Prepared by,



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References

AquaLogic Consulting. 2014. Erosion Threshold Analysis, Willow Creek Tributaries, Carson Road Development Inc., Midhurst Development Doran Road Inc., Township of Springwater. Report to SCS Consulting Group Ltd., May 2, 2014.

Chapman, L.J., and D.F. Putnam. 1984. The Physiography of Southern Ontario: Ontario Geological Survey, Special Volume 2.

Gemmell Engineering Limited. 2012. Midves Court Extension SWM Design Brief. Report dated July 4, 2012.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

B. de Geus 03.12

Project: Erosion Threshold Analysis - CRDI
Black Creek, Snow Valley Road Reach
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	1
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	1
	n/7 =	0.43
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	1
	Scour pools d/s of culverts/stormsewer outlets	1
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.20

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	1
	Exposed tree roots	1
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.30
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	1
	n/7 =	0.14
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.27**
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	**73.2**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	18	20--16	15-11	10-6	5-0
Embeddedness	11	20--16	15-11	10-6	5-0
Velocity / Depth Regime	15	20--16	15-11	10-6	5-0
Sediment Deposition	14	20--16	15-11	10-6	5-0
Channel Flow Status	16	20--16	15-11	10-6	5-0
Channel Alteration	17	20--16	15-11	10-6	5-0
Frequency of Riffles	14	20--16	15-11	10-6	5-0
Bank Stability u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	7	10-8	7-6	5-3	2-0
u/s R	7	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
/200	153				
/100	**76.5**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Pool Substrate Characterization		20--16	15-11	10-6	5-0
Pool Variability		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Channel Sinuosity		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	8	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	6	8-7	6-5	4-3	2-0
Physical Instream Habitat	7	8-7	6-5	4-3	2-0
Water Quality	7	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	6	7-6	5-4	3-2	1-0
Biological Indicators	6	8-7	6-5	4-3	2-0
/50	40				
/100	**80.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	**76.6**	100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		100-80	80-56	55-30	29-0



▲ Overview looking upstream from top of slope, towards Snow Valley Road, showing confinement and toe contact

▼ Overview looking downstream at creek level showing entrenched valley form



References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

B. de Geus 03.12

Project: Erosion Threshold Analysis - CRDI
Black Creek, Wilson Road Reach
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	
	n/7 =	0.14
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	
	Exposed tree roots	
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.10
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	1
	n/7 =	0.14
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.10**
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	**90.4**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	16	20--16	15-11	10-6	5-0
Embeddedness	11	20--16	15-11	10-6	5-0
Velocity / Depth Regime	12	20--16	15-11	10-6	5-0
Sediment Deposition	14	20--16	15-11	10-6	5-0
Channel Flow Status	13	20--16	15-11	10-6	5-0
Channel Alteration	17	20--16	15-11	10-6	5-0
Frequency of Riffles	11	20--16	15-11	10-6	5-0
Bank Stability u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
/200	150				
/100	**75.0**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Pool Substrate Characterization		20--16	15-11	10-6	5-0
Pool Variability		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Channel Sinuosity		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	9	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	6	8-7	6-5	4-3	2-0
Physical Instream Habitat	7	8-7	6-5	4-3	2-0
Water Quality	7	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	6	7-6	5-4	3-2	1-0
Biological Indicators	6	8-7	6-5	4-3	2-0
/50	41				
/100	**82.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	**82.5**	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0



▲ Overview looking upstream from Wilson Road showing dense groundcover encroachment

▼ Overview looking downstream from Wilson Road showing transition from groundcover encroachment to forest



References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

B. de Geus 03.12

Project: Erosion Threshold Analysis - CRDI
Black Creek, North Pond Outlet
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	1
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	1
	Poor longitudinal sorting of bed materials	1
	Deposition in the overbank zone	
	n/7 =	0.57
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	1
	Exposed tree roots	1
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	1
	n/10 =	0.40
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.00
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.24**
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	**75.7**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	16	20--16	15-11	10-6	5-0
Embeddedness	11	20--16	15-11	10-6	5-0
Velocity / Depth Regime	15	20--16	15-11	10-6	5-0
Sediment Deposition	14	20--16	15-11	10-6	5-0
Channel Flow Status	13	20--16	15-11	10-6	5-0
Channel Alteration	7	20--16	15-11	10-6	5-0
Frequency of Riffles	9	20--16	15-11	10-6	5-0
Bank Stability u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	8	10-8	7-6	5-3	2-0
u/s R	7	10-8	7-6	5-3	2-0
/200	132				
/100	**66.0**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Pool Substrate Characterization		20--16	15-11	10-6	5-0
Pool Variability		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Channel Sinuosity		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	8	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	5	8-7	6-5	4-3	2-0
Physical Instream Habitat	6	8-7	6-5	4-3	2-0
Water Quality	7	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	5	7-6	5-4	3-2	1-0
Biological Indicators	6	8-7	6-5	4-3	2-0
/50	37				
/100	**74.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	**71.9**	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0



▲ Looking upstream at northerly meander and subsequent opposite bank, showing entrenchment and confinement related erosion, ~200m below pond outlet

▼ Looking upstream at receiving channel below proposed SWM outlet, showing entrenchment and confinement related conditions



References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

B. de Geus 03.12

Project: Erosion Threshold Analysis - CRDI
Black Creek, Carson Road North & South Pond Outlet
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	
	n/7 =	0.14
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	1
	Exposed tree roots	1
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.30
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.00
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	0.11
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	88.9

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	16	20--16	15-11	10-6	5-0
Embeddedness	11	20--16	15-11	10-6	5-0
Velocity / Depth Regime	11	20--16	15-11	10-6	5-0
Sediment Deposition	14	20--16	15-11	10-6	5-0
Channel Flow Status	12	20--16	15-11	10-6	5-0
Channel Alteration	18	20--16	15-11	10-6	5-0
Frequency of Riffles	9	20--16	15-11	10-6	5-0
Bank Stability u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
/200	147				
/100	73.5	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Pool Substrate Characterization		20--16	15-11	10-6	5-0
Pool Variability		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Channel Sinuosity		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	9	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	7	8-7	6-5	4-3	2-0
Physical Instream Habitat	7	8-7	6-5	4-3	2-0
Water Quality	7	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	7	7-6	5-4	3-2	1-0
Biological Indicators	6	8-7	6-5	4-3	2-0
/50	43				
/100	86.0	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	82.8	100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		100-80	80-56	55-30	29-0



Overview looking downstream from Carson Road showing transition from wetland pool to thicket

References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

B. de Geus 03.12

Project: Erosion Threshold Analysis - CRDI
Black Creek, Carson Road Upstream Reach
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	1
	Coarse material in riffles embedded	
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	1
	Poor longitudinal sorting of bed materials	1
	Deposition in the overbank zone	
	n/7 =	0.57
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	1
	Exposed tree roots	1
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.30
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.00
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	0.22
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	78.2

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	16	20--16	15-11	10-6	5-0
Embeddedness	11	20--16	15-11	10-6	5-0
Velocity / Depth Regime	10	20--16	15-11	10-6	5-0
Sediment Deposition	14	20--16	15-11	10-6	5-0
Channel Flow Status	13	20--16	15-11	10-6	5-0
Channel Alteration	16	20--16	15-11	10-6	5-0
Frequency of Riffles	13	20--16	15-11	10-6	5-0
Bank Stability u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	6	10-8	7-6	5-3	2-0
u/s R	6	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
/200	141				
/100	70.5	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Pool Substrate Characterization		20--16	15-11	10-6	5-0
Pool Variability		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Channel Sinuosity		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	8	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	4	8-7	6-5	4-3	2-0
Physical Instream Habitat	5	8-7	6-5	4-3	2-0
Water Quality	6	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	5	7-6	5-4	3-2	1-0
Biological Indicators	6	8-7	6-5	4-3	2-0
/50	34				
/100	68.0	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	72.2	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0



▲ Downstream overview in proximity to proposed outfall

▼ Upstream overview in



References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

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Project: **Erosion Threshold Analysis - CRDI**
Black Creek, South Pond Outlet
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	
	Medial bars	
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	
	n/7 =	0.00
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	1
	Exposed tree roots	
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.20
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.00
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.05**
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	**95.0**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	11	20--16	15-11	10-6	5-0
Embeddedness	11	20--16	15-11	10-6	5-0
Velocity / Depth Regime	10	20--16	15-11	10-6	5-0
Sediment Deposition	16	20--16	15-11	10-6	5-0
Channel Flow Status	13	20--16	15-11	10-6	5-0
Channel Alteration	16	20--16	15-11	10-6	5-0
Frequency of Riffles	9	20--16	15-11	10-6	5-0
Bank Stability u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
/200	140				
/100	**70.0**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Pool Substrate Characterization		20--16	15-11	10-6	5-0
Pool Variability		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Channel Sinuosity		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	10	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	6	8-7	6-5	4-3	2-0
Physical Instream Habitat	4	8-7	6-5	4-3	2-0
Water Quality	6	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	3	7-6	5-4	3-2	1-0
Biological Indicators	6	8-7	6-5	4-3	2-0
/50	35				
/100	**70.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	**78.3**	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0



▲ Confluence of 1st order features / proposed receiver on right

▼ Upstream overview in proximity to proposed outfall



References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

B. de Geus 03.12

Project: **Erosion Threshold Analysis - MDDRI**
Willow Creek main branch, Midhurst Village Reach
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	1
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	1
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	1
	n/7 =	0.57
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	1
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.10

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	1
	Exposed tree roots	1
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.30
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.00
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.24**
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	**75.7**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	15	20--16	15-11	10-6	5-0
Embeddedness	10	20--16	15-11	10-6	5-0
Velocity / Depth Regime	19	20--16	15-11	10-6	5-0
Sediment Deposition	8	20--16	15-11	10-6	5-0
Channel Flow Status	20	20--16	15-11	10-6	5-0
Channel Alteration	11	20--16	15-11	10-6	5-0
Frequency of Riffles	10	20--16	15-11	10-6	5-0
Bank Stability u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	6	10-8	7-6	5-3	2-0
u/s R	6	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
/200	137				
/100	**68.5**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Pool Substrate Characterization		20--16	15-11	10-6	5-0
Pool Variability		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Channel Sinuosity		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection u/s R		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	8	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	5	8-7	6-5	4-3	2-0
Physical Instream Habitat	6	8-7	6-5	4-3	2-0
Water Quality	6	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	6	7-6	5-4	3-2	1-0
Biological Indicators	7	8-7	6-5	4-3	2-0
/50	38				
/100	**76.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	**73.4**	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0



▲ Overview looking downstream from outlet

▼ Overview looking downstream from outlet location off Willow Landing Road



References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

AquaLogic

B. de Geus 03.12

Project: **Erosion Threshold Analysis - MDDRI**
Willow Creek Tributary, Old Second South Reach
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	1
	Deposition in the overbank zone	
	n/7 =	0.29
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	1
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	1
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.20

Widening	Fallen/leaning trees/fence posts etc.	
	Occurrence of Large Organic Debris	1
	Exposed tree roots	
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.10
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	1
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.14
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.18**
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	**81.8**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Embeddedness		20--16	15-11	10-6	5-0
Velocity / Depth Regime		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Frequency of Riffles		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	11	20--16	15-11	10-6	5-0
Pool Substrate Characterization	11	20--16	15-11	10-6	5-0
Pool Variability	6	20--16	15-11	10-6	5-0
Sediment Deposition	8	20--16	15-11	10-6	5-0
Channel Flow Status	5	20--16	15-11	10-6	5-0
Channel Alteration	11	20--16	15-11	10-6	5-0
Channel Sinuosity	11	20--16	15-11	10-6	5-0
Bank Stability u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Vegetative Protection u/s R	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
/200	119				
/100	**59.5**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	8	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	5	8-7	6-5	4-3	2-0
Physical Instream Habitat	5	8-7	6-5	4-3	2-0
Water Quality	6	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	4	7-6	5-4	3-2	1-0
Biological Indicators	6	8-7	6-5	4-3	2-0
/50	34				
/100	**68.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

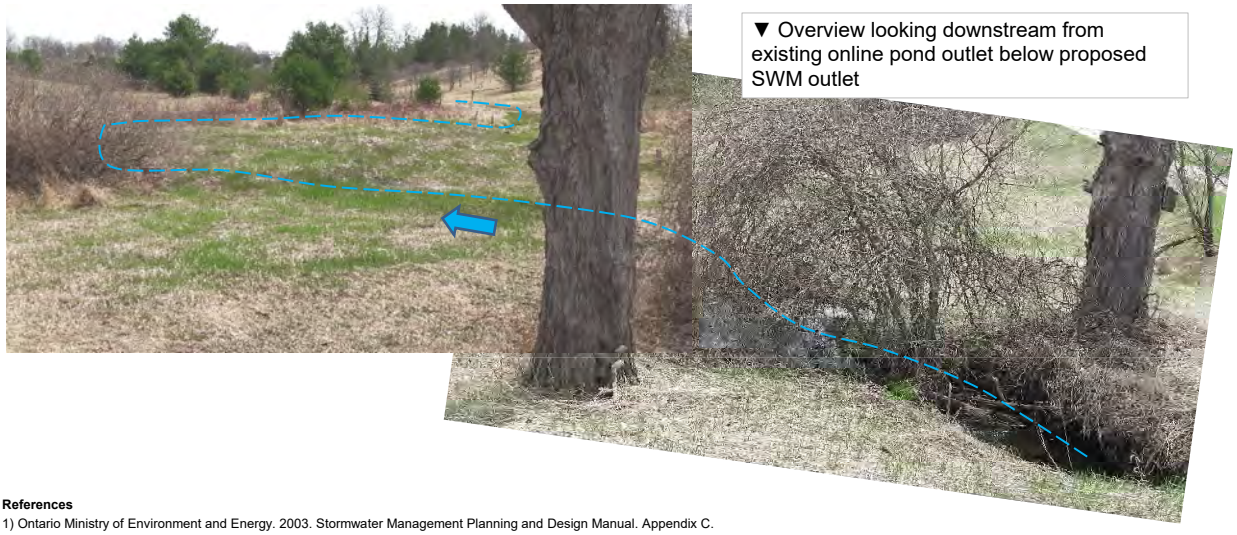
Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	**70**	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0



▼ Overview looking downstream from existing online pond outlet below proposed SWM outlet

References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

ATTACHMENT C

GOLDER WATER BALANCE

SCS consulting group ltd

TECHNICAL MEMORANDUM

DATE May 2, 2014 **PROJECT No.** 13-1170-0040

TO Steve Schaefer
SCS Consulting Group Ltd. 30 Centurian Drive, Suite 100 Markham, ON, L3R 8B8

CC John Easton and Melanie Kennedy, Golder Associates Ltd.

FROM Adriana Parada & Kevin MacKenzie **EMAIL** aparada@golder.com

MIDHURST DEVELOPMENTS WATER BALANCE FOR DRAFT PLAN SUBDIVISION APPLICATION NUMBERS: SP-T-1001, SP-T-1004, SP-T-1005, SP-T-1006, SP-T-1007, SP-T-0703, SP-T-0705 AND SP-T-0904

1.0 INTRODUCTION

Midhurst Development Doran Road Inc. and Carson Road Development Inc. have retained Golder Associates Ltd. (Golder) to conduct hydrogeological and hydrological studies in connection with proposed residential development in the Community of Midhurst. This Technical Memorandum has been prepared in response to a letter received from the Nottasawaga Valley Conservation Authority (NVCA) on October 31, 2013 providing comments to the proposed draft plans of subdivision in the Midhurst Secondary Plan Area.

A water balance assessment was completed for the proposed Midhurst neighbourhoods which are located within the Willow Creek watershed, which flows through the Minesing Swamp via the Nottawasaga River en route to Georgian Bay. The proposed Midhurst developments are located within the NVCA jurisdiction.

The proposed residential developments comprise two neighbourhoods called Carson Road neighbourhood and Doran Road neighbourhood. The first neighbourhood is located west of Willow Creek and the other neighbourhood is located east of Willow Creek.

A pre-development water balance was completed for the study areas to estimate the existing infiltration and runoff. Presently the study areas, within the Willow Creek Watershed are considered undeveloped and as such the primary land use is agriculture. The quaternary soils shown in Figure 1 and Figure 2 were used to characterize the soil types within the Carson and Doran neighbourhoods, respectively.

A post development water balance based on site land use estimates developed by Golder was completed to estimate the amount of infiltration which would be available if Midhurst Development Doran Road Inc. and Carson Road Development Inc. were to pursue a similar layout. The post-development water balance analysis is based on the development areas of the Carson and Doran neighbourhoods. When final development plans and property grading plans are developed for all future development applications this water balance should be re-evaluated.

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2.0 METHODOLOGY

The water balance assessment was based on meteorological data from the Meteorological Service of Canada Thornthwaite water budgets (Barrie WPCC MOE, Ontario between 1978 to 2012), watershed boundaries, land use data and the existing soil types.

Water balance calculations are based on the following equation:

$$P = S + ET + R + I$$

Where: P = precipitation;

S = change in groundwater storage;

ET = evapotranspiration;

R = surface runoff; and

I = infiltration (groundwater recharge).

Precipitation data collected at the Environment Canada (EC) Barrie WPCC MOE monitoring station (1978 to 2012) indicated a mean annual precipitation (P) of 934 mm/yr.

Short-term or seasonal changes in groundwater storage (S) occur as demonstrated by the dry conditions in the summer months and the wet or flooded conditions in the winter and spring. Long-term changes (e.g., year-to-year) in groundwater storage are considered to be negligible.

Evapotranspiration (ET) refers to water lost to the atmosphere from vegetated surfaces. The term combines evaporation (i.e., water lost from soil or water surfaces) and transpiration (i.e., water lost from plants and trees) because of the difficulties in measuring these two processes separately. Potential ET refers to the loss of water from a vegetated surface to the atmosphere under conditions of an unlimited water supply. The actual rate of ET is typically less than the potential rate under dry conditions (e.g., during the summer months when there is a moisture deficit). The mean annual potential ET for the study Site is approximately 604 mm/yr based on data provided by EC.

Annual water surplus is the difference between P and the actual ET. The water surplus represents the total amount of water available for either surface runoff (R) or groundwater infiltration (I) on an annual basis. On a monthly basis, surplus water remains after actual evapotranspiration has been removed from the sum of rainfall and snow-melt, and maximum soil or snow pack storage is exceeded. Maximum soil storage is quantified using a water holding capacity (WHC) specific to the soil type and land use.

Infiltration rates were estimated using the MOE Stormwater Management Planning and Design (SWM) Manual (2003). There are three main factors that determine the percent infiltration of the total surplus: topography, soil type and ground cover. The sum of the fractions representing the three characteristics establishes the approximate annual percentage of surplus which can be infiltrated in an area with a sufficient downward groundwater gradient. Wetlands and water bodies are assumed to have an upward or negligible downward gradient, resulting in all surpluses being contained in these areas, which provide increased evaporation and limited infiltration.

Based on the watershed analysis of the pre-development conditions, 24% of the Carson Road neighbourhood study area drains to the north-east and the remaining 76% drains to the east and south; 54% of the Doran Road

neighbourhood-Pooles Road study area drains to the north-west and the remaining 46% to the south and east; and 43% of the Doran Road neighbourhood-Doran Road study area drains to the north, 39% to the west and the remaining 18% to the south and east.

Land use within each of the subwatersheds within each study area was determined using 2012 aerial imagery. The data were compiled to determine the total area of each land use within each neighbourhood. Data acquired from these databases were used with Table 3.1: Hydrologic Cycle Component Values, from the Ministry of Environment Storm Water Management Manual (March 2003), to identify appropriate water holding capacities (WHC) and the infiltration factor for each land use.

The land use for post development conditions was based on preliminary estimations developed by Golder. The proposed post development conditions contain buildings, paved parking and roadways, road shoulders and lawn/grass areas. It is assumed that 40% of the road allowance is paved and 60% is for the boulevards. The houses and paved parking coverage for post-development conditions is assumed to be 50% of the total allowed area of the lot as indicated by Adrian Cammaert of Malone Given Pasons Ltd.

For the Carson Road neighbourhood, the roadways will cover approximately 7% of the study area; buildings and paved parking will cover approximately 39% of the study area resulting in an impermeable area of approximately 91 ha (46% of the study area). For the Doran Road neighbourhood-Pooles Road area, the roadways will cover approximately 6% of the study area; buildings and paved parking will cover approximately 51% of the study area resulting in an impermeable area of approximately 71 ha (57% of the study area). For the Doran Road neighbourhood-Doran Road area, the roadways will cover approximately 11% of the study area; buildings and paved parking will cover approximately 32% of the study area resulting in an impermeable area of approximately 38 ha (43% of the study area).

3.0 RESULTS

3.1 Pre-Development Conditions

Table 3.1: Hydrologic Cycle Component Values from the Ministry of Environment Storm Water Management Manual (MOE, 2003) summarizes the WHC and infiltration factors for the various soil types and land uses used in the pre-development water balance. For the Carson Road neighbourhood, the agricultural areas located on sandy silt and sand soils, an infiltration factor of 0.6 was used, representing hilly land with an average slope of 28 to 47 m/km, open sandy loam and cultivated land use. Where the soil was silty sand in the agricultural areas during pre-development conditions, an infiltration factor of 0.4 was used, representing hilly land with an average slope of 28 to 47 m/km, medium combinations of clay and loam and cultivated land use. For the pasture/shrub and forest areas which are located on sand or sandy silt an infiltration factor of 0.7 was used, representing hilly land with an average slope of 28 to 47 m/km, open sandy loam and woodland. For the pasture/shrub and forest areas which are located on silty sand an infiltration factor of 0.5 was used, representing hilly land with an average slope of 28 to 47 m/km, medium combinations of clay and loam and woodland.

For the Doran Road neighbourhood, the agricultural areas located on sandy silt and sand soils, an infiltration factor of 0.7 was used, representing rolling land, open sandy loam and cultivated land use. Where the soil was silty sand in the agricultural areas during pre-development conditions, an infiltration factor of 0.5 was used, representing rolling land, medium combinations of clay and loam and cultivated land use. For the pasture/shrub and forest areas which are located on sand or sandy silt an infiltration factor of 0.8 was used, representing rolling land, open sandy loam and woodland.

Since the Carson Road neighbourhood and the Doran Road neighbourhood-Pooles Road area lie within two subwatersheds; and the Doran Road neighbourhood- Doran Road area lies within three subwatersheds (see Figure 13 and 14), the pre-development water balance was completed for each watershed within each study area to provide an estimate of the amount of water from the property contributing to each watershed. Tables 1, 2 and 3 present the results of the water balances for each subwatershed within each study area under pre-development conditions.

Table 1: Pre-development Scenario Water Balance Results - Carson Road neighbourhood

Catchment	Area	Surplus		Infiltration		Runoff	
	(ha)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)
Area 101 - Draining Southwest							
101	150.12	357	536,149	206	309,443	151	226,706
Area 102 - Draining Northeast							
102	46.15	369	170,273	203	93,633	166	76,640
Total	196.28	363	706,422	205	403,076	159	303,346

Table 2: Pre-development Scenario Water Balance Results - Doran Road neighbourhood-Pooles Road area

Catchment	Area	Surplus		Infiltration		Runoff	
	(ha)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)
Area 111 - Draining South/East							
111	57.57	355	204,248	274	157,535	81	46,712
Area 112 - Draining Southwest							
112	67.48	352	237,320	272	183,682	79	53,638
Total	125.04	353	441,568	273	341,217	80	100,351

Table 3: Pre-development Scenario Water Balance Results - Doran Road neighbourhood-Doran Road area

Catchment	Area	Surplus		Infiltration		Runoff	
	(ha)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)
Area 121 - Draining South							
121	16.02	350	56,106	279	44,661	71	11,445
Area 122 - Draining West							
122	34.00	350	118,987	280	95,190	70	23,797
Area 123 - Draining North							
123	38.31	347	133,123	249	95,476	98	37,647
Total	88.33	349	308,216	269	235,326	80	72,890

The total estimated average annual pre-development runoff from the Carson Road neighbourhood is approximately 303,300 m^3 and the estimated infiltration is approximately 403,000 m^3. The total estimated average annual pre-development runoff from the Doran Road neighbourhood-Pooles Road area is approximately 100,400 m^3 and the estimated infiltration is approximately 341,200 m^3. The total estimated average annual pre-development runoff from the Doran Road neighbourhood-Doran Road area is approximately 72,900 m^3 and the estimated infiltration is approximately 235,300 m^3.

3.2 Post-Development Conditions

Table 3.1: Hydrologic Cycle Component Values from the Ministry of Environment Storm Water Management Manual (March 2003) also summarizes the WHC and infiltration factors for the various soil types and land uses used in the post-development water balance (urban lawns category). For paved areas (parking lots and roadways) it was assumed that all precipitation resulted in runoff after evaporation was removed. For the buildings, it was assumed that all precipitation resulted in runoff after evaporation was removed. For the road shoulders (boulevards), lawns and parks, infiltration factors between 0.4 and 0.7 were used depending on the characteristics soil described below.

For the Carson Road neighbourhood, for the sandy silt and sand soils within the lawn, parks and boulevards, an infiltration factor of 0.7 was used, representing hilly land, open sandy loam and cultivated land use. Where the soil was silty sand within the lawn, parks and boulevards areas, an infiltration factor of 0.4 was used, representing hilly land, medium combinations of clay and loam and cultivated land use.

For the Doran Road neighbourhood, for the sandy silt and sand soils within the lawn, parks and boulevards, an infiltration factor of 0.6 was used, representing rolling land, open sandy loam and cultivated land use. Where the soil was silty sand within the lawn, parks and boulevards areas, an infiltration factor of 0.5 was used, representing rolling land, medium combinations of clay and loam and cultivated land use.

For the Carson Road neighbourhood under the post development scenario, it is assumed the total of the study area surplus will flow towards the southwest valley as shown in Figure 3. Under the post development scenario, the infiltration will contribute to two aquifers, northwest and southwest of the groundwater divide.

For the Doran Road neighbourhood-Pooles Road area under the post development scenario, it is assumed the total of the study area surplus will flow towards the northwest valley as shown in Figure 4. Under the post development scenario, the infiltration will contribute to two aquifers, northwest and southeast of the groundwater divide.

For the Doran Road neighbourhood-Doran Road area under the post development scenario, it is assumed the total of the study area surplus will flow towards the southeast valley as shown in Figure 4. Under the post-development scenario, the infiltration will contribute to one aquifer.

Tables 4, 5 and 6 present the results of the water balances for each subwatershed within each study area under post-development conditions.

Table 4: Post-development Scenario Water Balance Results without mitigation- Carson Road neighbourhood

Catchment	Area	Surplus		Infiltration		Runoff[1]	
	(ha)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)
Area 201 - Draining Southwest							
201	196.28	425	833,917	95	185,632	330	648,286
Infiltration draining northeast							
				25	48,504		
Total	196.28	425	833,917	120	234,136	330	648,286

[1] without mitigation

Table 5: Post-development Scenario Water Balance Results without mitigation- Doran Road neighbourhood-Pooles Road area

Catchment	Area	Surplus		Infiltration		Runoff[1]	
	(ha)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)
Area 211 - Draining Northwest							
211	125.04	428	535,060	86	107,726	342	427,334
Infiltration draining southeast							
				66	83,101		
Total	125.04	428	535,060	152	190,827	342	427,334

[1] without mitigation

Table 6: Post-development Scenario Water Balance Results without mitigation- Doran Road neighbourhood-Doran Road area

Catchment	Area	Surplus		Infiltration		Runoff[1]	
	(ha)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)
Area 221 - Draining Southeast							
221	88.33	424	374,218	152	134,070	272	240,149

[1] without mitigation

The total estimated average annual post-development runoff from the Carson Road neighbourhood to the northwest is approximately 648,300 m^3 (an increase of 114% with respect to pre development conditions) without mitigation. The total estimated average annual post-development runoff from the Doran Road neighbourhood-Pooles Road area to the northwest is approximately 427,300 m^3 (an increase of 326% with respect to pre development conditions) without mitigation. The total estimated average annual post-development runoff from the Doran Road neighbourhood-Doran Road area to the southeast is approximately 240,100 m^3 (an increase of 229% with respect to pre development conditions) without mitigation.

The infiltration over the Carson Road neighbourhood will contribute to two aquifers (northwest and southwest of the groundwater divide). The estimated infiltration draining to the southwest and northeast aquifers are approximately 185,600 m^3 and 48,500 m^3 respectively. The total infiltration for the study area for the post

development scenario is 234,100 m^3 without mitigation as compared to approximately 403,000 m^3 pre development conditions (a decrease of 42% with respect to pre development conditions).

The infiltration over the Doran Road neighbourhood-Pooles Road area will contribute to two aquifers (northwest and southwest of the groundwater divide). The estimated infiltration draining to the southwest and northeast aquifers are approximately 83,100 m^3 and 107,700 m^3 respectively. The total infiltration for the study for the post development scenario is 190,800 m^3 without mitigation as compared to approximately 341,200 m^3 pre development conditions (a decrease of 44% with respect to pre development conditions).

The infiltration over the Doran Road neighbourhood-Doran Road area entire site will contribute to one aquifer. Therefore, the estimated infiltration over the site is approximately 134,000 m^3 without mitigation as compared to approximately 235,300 m^3 pre development conditions (a decrease of 43% with respect to pre development conditions).

These results indicate an overall increase without mitigation in runoff of approximately 344,900 m^3/year for the Carson Road neighbourhood and 494,200 m^3/year for the Doran Road neighbourhood. These results indicate an overall decrease without mitigation in infiltration of approximately 168,900 m^3/year for the Carson Road neighbourhood and 251,600 m^3/year for the Doran Road neighbourhood.

4.0 LOW IMPACT DEVELOPMENT

Details on the use of low impact development (LID) features to achieve both quantity and enhanced water quality control such as roof drain pits, rear lot exfiltration trenches or right-of-way infiltration measures will be considered during the design stage of the developments.

The NVCA promotes the use of infiltration systems to support the natural hydrologic cycle for stormwater runoff from the site. This helps to maintain groundwater recharge, provides additional water quality treatment and reduces the volume of runoff from the site that may cause erosion downstream (NVCA, 2013). In order to deal with the additional volume of runoff produced as a result of urbanization, a minimum of the first 5 mm of rainfall should be retained on site using LID measures as recommended in the NVCA Stowmwater Technical Guide (NVCA, 2013). Stormwater from rooftops was selected as the preferred infiltration source option due to its relatively good water quality.

Assuming storage of runoff from the first 5 mm of rainfall over the roof top areas (40% of the lot area is occupied by roof tops), the target infiltration volumes per event for the study areas are approximately 3,000 m^3 for the Carson Road neighbourhood and 3,700 m^3 for the Doran Road neighbourhood. The annual infiltration volumes were estimated based on 65 % of the average total annual rainfall in days with 5 mm or less, (approximately 216 mm/yr) using daily rainfall records from the Barrie WCCP station between 1978 and 2007. The 65% of the average annual rainfall in days with 5 mm or less was used to consider that the first approximately 2 mm to 3 mm of rainfall on roof surfaces will enter interception storage and will be lost as evaporation. The estimated annual infiltration volumes using LID features compared to pre-development and post-development results without mitigation are shown in Table 7.

Table 7: Post-development Scenario results using LID features

Neighbourhood	Area occupied by rooftops		Pre-development Infiltration	Post-development Infiltration without mitigation	Difference between pre-development and post-development	LID features	Post-development Infiltration including LID features
	(ha)	(%)	(m^3/yr)	(m^3/yr)	(m^3/yr)	(m^3/yr)	(m^3/yr)
Carson Road	60.97	31%	403,100	234,100	-169,000	131,900	366,000
Doran Road - Pooles Road Area	38.98	31%	341,200	190,800	-150,400	109,700	300,500
Doran Road - Doran Road Area	22.64	26%	235,300	134,100	-101,200	49,000	183,100
Total	122.59	30%	979,600	559,000	-420,600	290,600	849,600

These results indicate that LID features will compensate the infiltration volume reductions estimated for the post-development scenario without mitigation. Other infiltration systems such as a rear lot catchbasin exfiltration systems or infiltration trenches in open space areas could also be considered where feasible during the design stage to increase annual infiltration rates. The specific LID measures to be implemented will be confirmed at the detail design stage.

An average of 322.4 mm per year (total rainfall of 438.9 mm including 35% losses to interception and evaporation) will be required to be stored to compensate completely the infiltration losses from the pre-development scenario.

Adriana Parada, P.Eng.
Water Resources Engineer

Kevin MacKenzie, P.Eng.
Water Resources Engineer, Associate

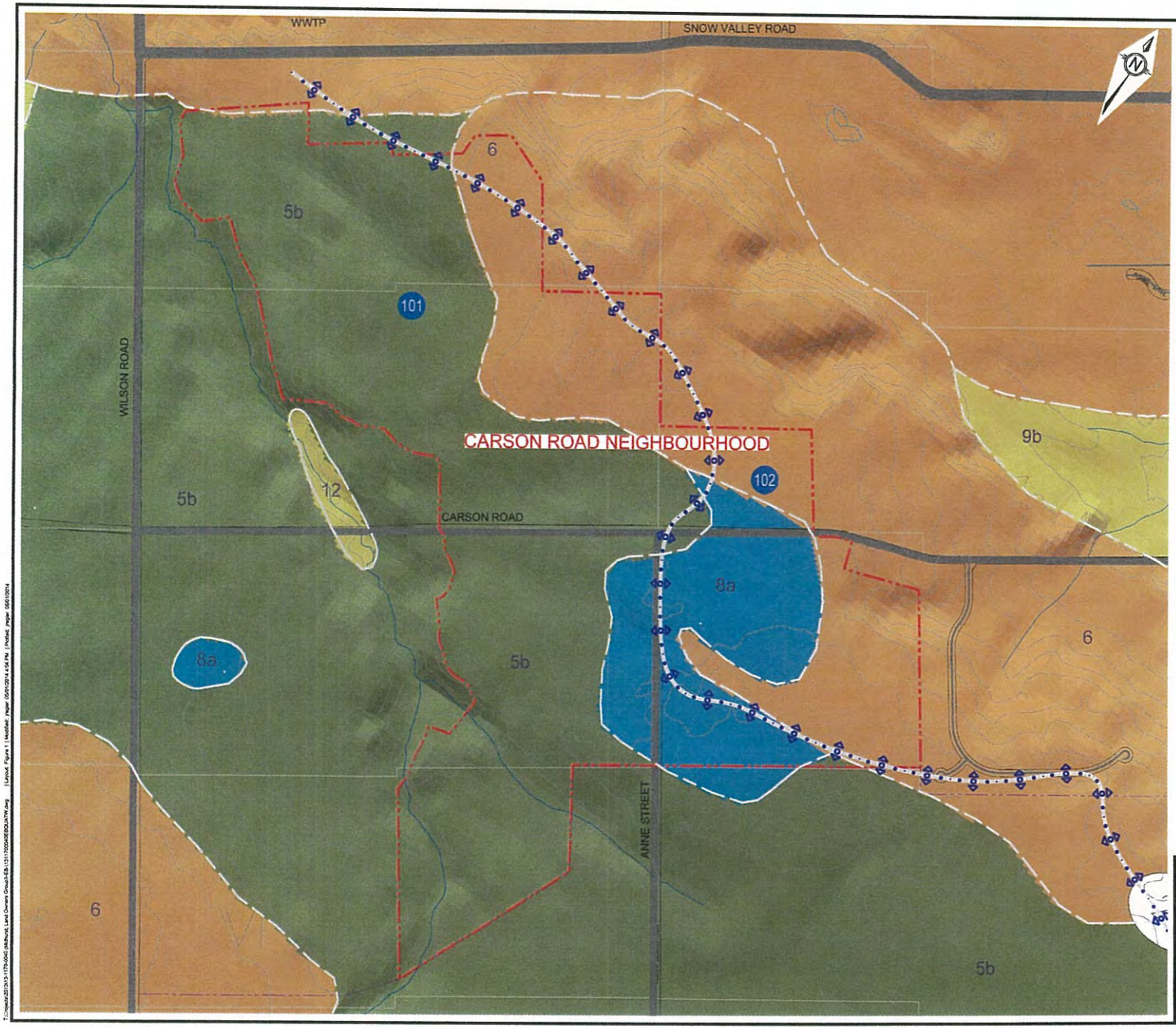
AP/KMM/JE/sp

Attachments:
Figure 1: Carson Road neighbourhood Pre-Development Catchments and Quaternary Soils
Figure 2: Doran Road neighbourhood Pre-Development Catchments and Quaternary Soils
Figure 3: Carson Road neighbourhood Post Development Plan
Figure 4: Doran Road neighbourhood Post Development Plan

REFERENCES

Ministry of the Environment (2003). *Stormwater Management, Planning and Design Manual*, March 2003.

Nottawasaga Valley Conservation Authority (NVCA) (2013). *NVCA Stormwater Technical Guide*, December 2013.



LEGEND:

- Development Property Limits
- 20 Organic Deposits — Peat, Muck, Marl
- 12 Fluvial or Deltaic Sediments — Sand, Minor Gravel, Silt & Clay
- 9b Glaciolacustrine Coarse Grained Deposits — Gravel, Sand gravel, and Gravelly Sand
- 9c Glaciolacustrine Coarse Grained Deposits — f Sands, Silt
- 8a Glaciolacustrine Fine Grained Deposits — Silt and Clay
- 6 Glaciofluvial Ice-contact Stratified Deposits — Gravel, Sand gravel, and Gravelly Sand
- 5b Till (Newmarket) — Stoney Silty Sand / Sand Till
- Existing Grade Contours (5 masl interval)
- Surface Water / Inferred Shallow Water Table Divide
- 100 Surface Water Basin ID

REFERENCES:

1. Map Base courtesy SCS Consulting, digital CAD files
2. Map to be read in conjunction with the accompanying Report
3. Ontario Base Map contours, ESRI Geography Network

0 100 250 500 750 metres

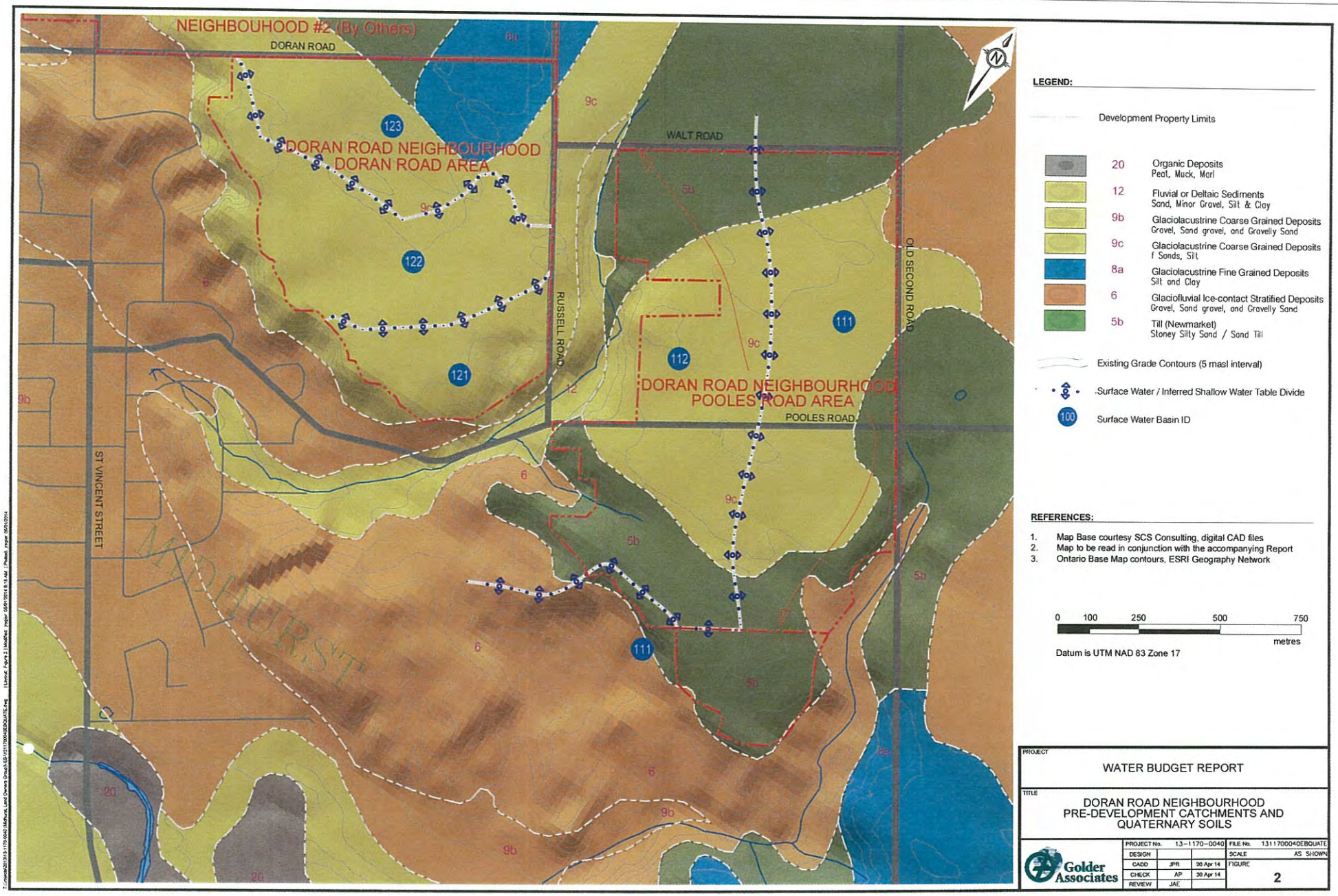
Datum is UTM NAD 83 Zone 17

PROJECT: WATER BUDGET REPORT

TITLE: CARSON ROAD NEIGHBOURHOOD PRE-DEVELOPMENT CATCHMENTS AND QUATERNARY SOILS

Golder Associates

PROJECT No.	13-1170-0040		FILE No.	1311700040EBQUATW	
DESIGN			SCALE	AS SHOWN	
CADD	JPR	23 Apr 14	FIGURE	1	
CHECK	AP	30 Apr 14			
REVIEW	JAE	30 Apr 14			

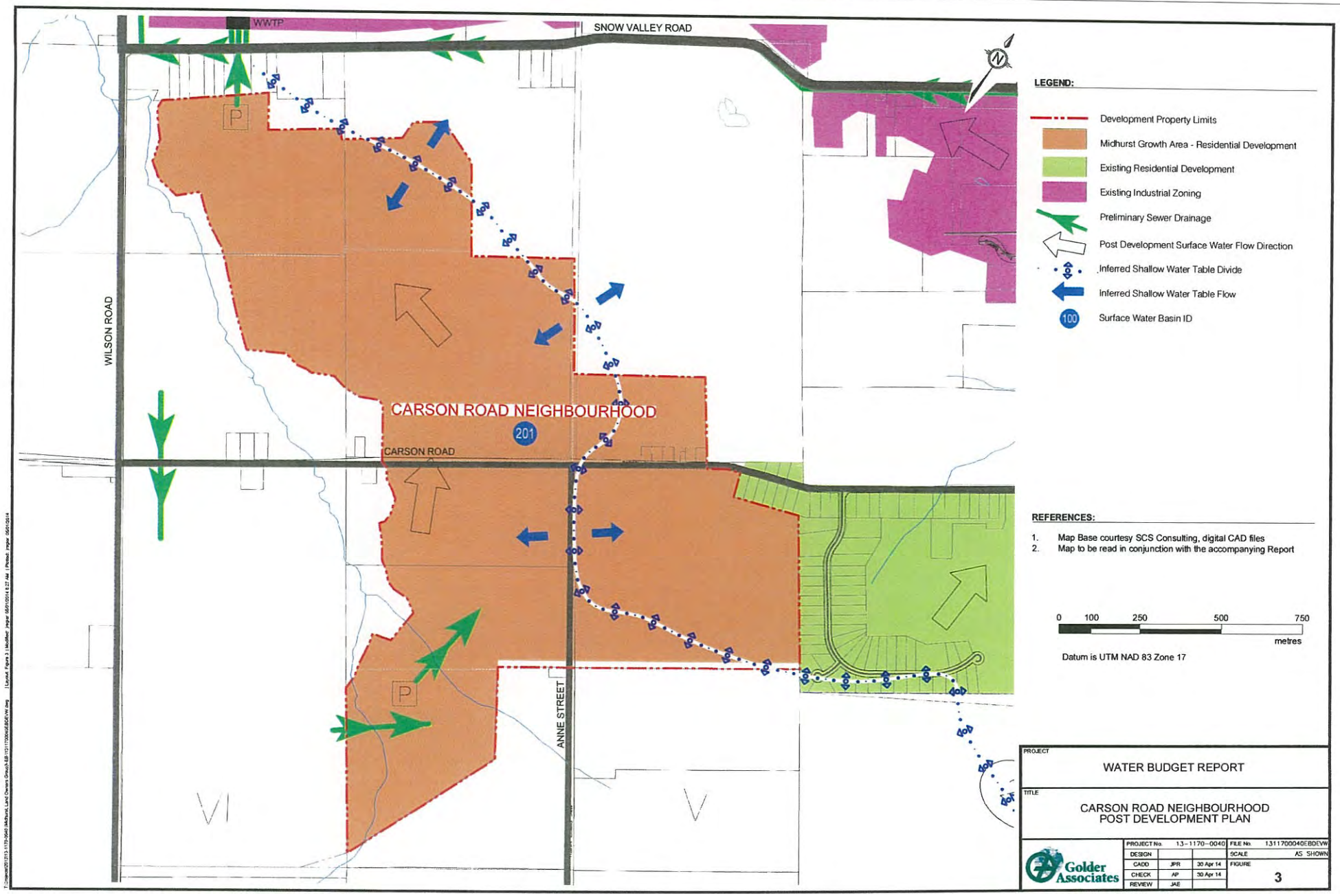


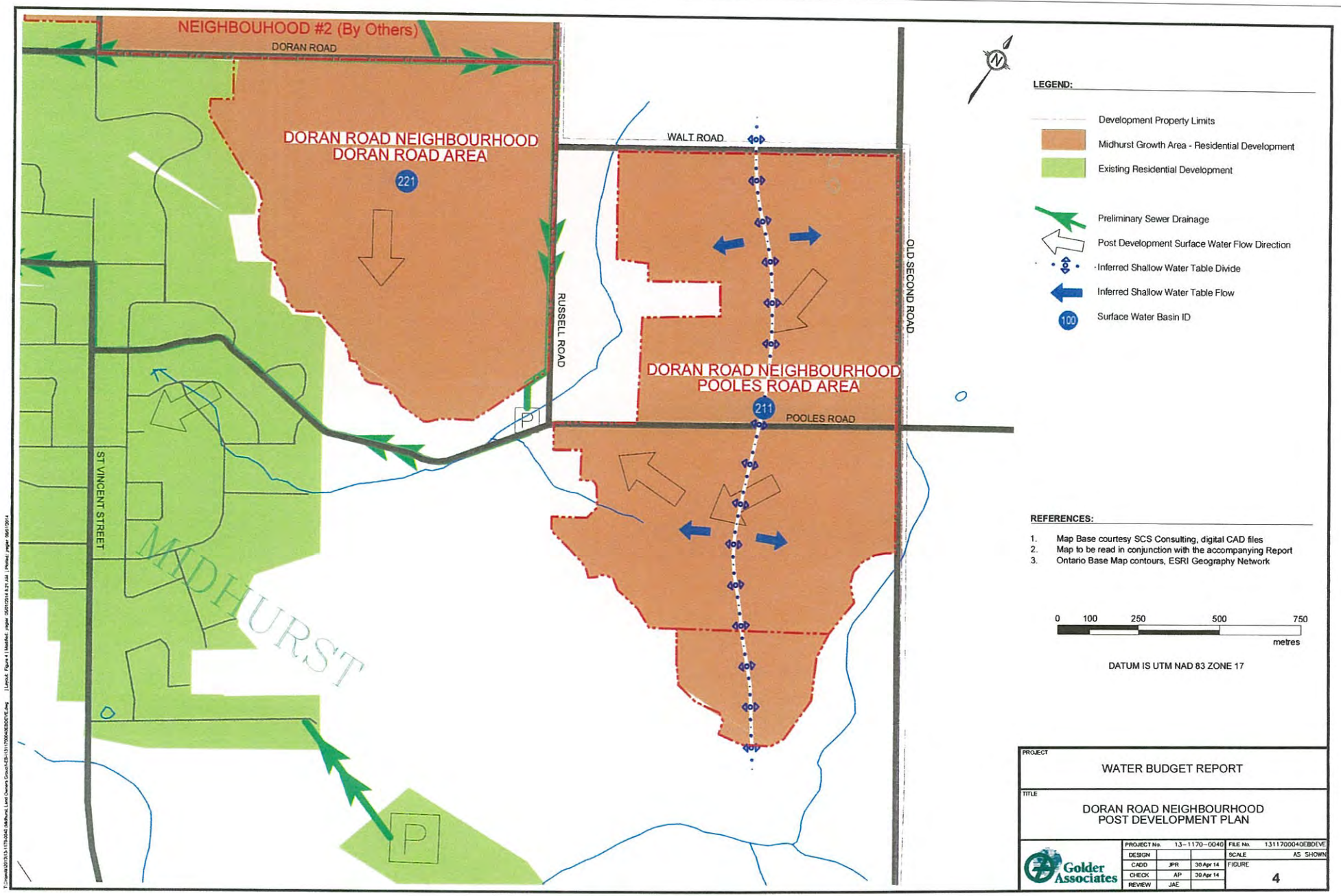
PROJECT
WATER BUDGET REPORT

TITLE
DORAN ROAD NEIGHBOURHOOD
PRE-DEVELOPMENT CATCHMENTS AND
QUATERNARY SOILS

Golder Associates

PROJECT No.	13-1170-0040		FILE No.	1311700040EBQUATE	
DESIGN			SCALE	AS SHOWN	
CADD	JPR	30 Apr 14	FIGURE	2	
CHECK	AP	30 Apr 14			
REVIEW	JAE				


WWTP
SNOW VALLEY ROAD
WILSON ROAD
CARSON ROAD NEIGHBOURHOOD
201
CARSON ROAD
ANNE STREET
VI
V
LEGEND:
Development Property Limits
Midhurst Growth Area - Residential Development
Existing Residential Development
Existing Industrial Zoning
Preliminary Sewer Drainage
Post Development Surface Water Flow Direction
Inferred Shallow Water Table Divide
Inferred Shallow Water Table Flow
100
Surface Water Basin ID
REFERENCES:
1. Map Base courtesy SCS Consulting, digital CAD files
2. Map to be read in conjunction with the accompanying Report
0 100 250 500 750
metres
Datum is UTM NAD 83 Zone 17
PROJECT
WATER BUDGET REPORT
TITLE
CARSON ROAD NEIGHBOURHOOD
POST DEVELOPMENT PLAN
Golder Associates
PROJECT No. 13-1170-0040
FILE No. 1311700040EBDEVW
DESIGN
CADD JPR 30 Apr 14
CHECK AP 30 Apr 14
REVIEW JAE
SCALE AS SHOWN
FIGURE
3


NEIGHBOUHOOD #2 (By Others)
DORAN ROAD
DORAN ROAD NEIGHBOURHOOD
DORAN ROAD AREA
221
WALT ROAD
RUSSELL ROAD
OLD SECOND ROAD
DORAN ROAD NEIGHBOURHOOD
POOLES ROAD AREA
211
POOLES ROAD
ST VINCENT STREET
MIDHURST
P
P
LEGEND:
Development Property Limits
Midhurst Growth Area - Residential Development
Existing Residential Development
Preliminary Sewer Drainage
Post Development Surface Water Flow Direction
Inferred Shallow Water Table Divide
Inferred Shallow Water Table Flow
100
Surface Water Basin ID
REFERENCES:
1. Map Base courtesy SCS Consulting, digital CAD files
2. Map to be read in conjunction with the accompanying Report
3. Ontario Base Map contours, ESRI Geography Network
0 100 250 500 750
metres
DATUM IS UTM NAD 83 ZONE 17
PROJECT
WATER BUDGET REPORT
TITLE
DORAN ROAD NEIGHBOURHOOD
POST DEVELOPMENT PLAN
Golder Associates
PROJECT No. 13-1170-0040
FILE No. 1311700040EBDEVE
DESIGN
SCALE AS SHOWN
CADD JPR 30 Apr 14
FIGURE
CHECK AP 30 Apr 14
4
REVIEW JAE

Appendix F-1

Stormwater outlet assessment for Black Creek and Willow Creek

File: 213115
June 2020

SCS consulting group ltd

File #: 1168/1194
Date: August 8, 2014

Mr. Glenn Switzer, P. Eng.
Director of Engineering and Technical Services
Nottawasaga Conservation Authority
8195 8th Line
Utopia, Ontario, L0M 1T0

Dear Mr. Switzer:

Re: **Midhurst Master Drainage Plan – Phase 1**
Item #6 – Suitable Pond Outlets
Midhurst, Ontario

Further to our submissions of May 2, 2014 and May 27, 2014, please accept the following supplemental information in support of confirming a Suitable Outlet is available for each SWM Pond (Item #6) of the Phase 1 work program for the Master Drainage Plan for your review and approval.

As per NVCA's correspondence of May 29, 2014, the target statement for provision of a Suitable Outlet is:

> *Provide conceptual information on how each SWMP outlet is conveyed to a suitable outlet and assess the impacts of proposed diversions including ecological impacts. The fluvial geomorphologist should address potential impacts of diversions using estimates of discharge rates.*

Updated SWM pond figures have been appended for each facility to identify the outlet location to a suitable outfall, as agreed to during our site walks on May 8 and June 9, 2014

As shown, the following outlets were provided:

Carson (Micks, North Pond) – At the proposed outlet location, Black Creek was deemed a permanent watercourse. The outlet location and emergency spillway configuration were deemed acceptable in principal at the June 9th site walk with respect to ecology per Beacon's attached memo.

Carson (D Hickling, Carson Road North Pond) –As shown on Figures 4.4.2 and 4.4.5, the pond outfall has been modified to direct the 100 year flows via pipe from the pond, along Carson Road, to the Black Creek. Emergency overflows will continue to be directed to the existing swale on the west side of the pond, which drains to the Black Creek. No design flows are directed to this swale. The Black Creek at the existing Carson Road culvert crossing is a permanent flowing watercourse. In addition the outlet configuration for the storm sewer was deemed acceptable in principal at the June 9th site walk with respect to ecology per Beacon's attached memo. The proposed emergency spillway as shown on Figure 4.4.2 has been revised based on the NVCA preferred location as discussed on site June 9.

Carson (A&R Hickling, Carson Road South Pond) –As shown on Figures 4.4.3 and 4.4.5, the pond outfall has been modified to direct the 100 year flows via pipe from the pond, along Carson Road, to the Black Creek. Emergency overflows will continue to be directed to the existing swale on the west side of the pond, which drains to the Black Creek. No design flows are directed to this swale. The Black Creek at the existing Carson Road culvert crossing is a permanent flowing watercourse. In addition the outlet configuration for the storm sewer was deemed acceptable in principal at the June 9th site walk with respect to ecology per Beacon's attached memo. The proposed emergency spillway as shown on Figure 4.4.2 has been revised based on the NVCA preferred location as discussed on site June 9.

Carson (A&R Hickling, South Pond) – North of Hydro Corridor – Outfall to the Black Creek on-site was deemed acceptable on May 8th. In the subsequent June 9th site walk, it was determined that the outfall and emergency spillway orientation should be revised for ecological reasons. This preferred orientation has been reflected on the attached Figure 4.4.4. Per Beacon's attached memo, the proposed outlet and emergency spillway location are preferred with respect to ecological function and potential valley enhancement.

Doran – Russell Road Pond - As shown on Figures 4.4.1 and 4.4.1.1, the pond outfall has been modified to include a 100 year storm sewer from the north side of Pooles Road, along Pooles Road, through an easement on a lot extending between Pooles Road and Midves Court to the Midves Court right-of-way. As directed by the Town, a storm sewer will be provided along the Midves Court right of way (likely under the existing ditch system) to the existing Frid Boulevard storm sewer. Emergency overflows and potentially, a suitable existing condition volume and peak flow for infrequent storm events will be directed to the existing Pooles Road drainage feature, which ultimately is directed to the Midves Court ditch and downstream municipal storm drainage system. A more detailed analysis of the capability of the drainage feature to accept some flows will be undertaken through the Phase 2 work program. If required, all flows can be piped to Midves Court. The proposed piped outlet alignment and emergency spillway configuration were both deemed acceptable to the NVCA in principal on the June 9th site walk. The ultimate outlet to Willow Creek was also observed on the June 9th site walk and deemed an acceptable outlet as discussed further in the attached Beacon memo.

Doran (Future Phases) – Although not part of the initial phase of the Midhurst Secondary Plan, the outfall configuration for all future SWM ponds draining to the Pooles Road drainage feature will be directed via pipe along the same storm sewer system described above. The proposed SWM pond facilities draining to Willow Creek, west of Old Second South were deemed by NVCA to have suitable on-site outlets during our site walk of May 8, 2014. An additional review of the SWM pond locations and general suitability of locations to outlet to Willow Creek were further review on site on June 9th with the NVCA for ecology considerations. For the proposed northerly SWM pond there is an existing on-line man-made pond along Willow Creek and a second off-line pond with old field meadow surrounding this location. For the proposed southerly SWM pond there is old field meadow and a cultural woodland to the south. Suitable outlet locations for both SWM ponds were determined to be feasible in principle.

The only diversion of flows proposed in the Doran and Carson areas is the conveyance of 58.6 ha of trapped drainage and 4.8 ha of natural drainage from the south side of Doran Road to the Pooles Road Drainage Feature (Figure 4.1). The trapped drainage area currently ponds in the existing agricultural field and spills north of Doran Road in events greater than the 50 year storm. The drainage north of Doran Road is tributary to the Matheson Creek, which ultimately joins the Willow Creek west of Wilson Road. Since the trapped drainage area does not produce any runoff during the majority of rainfall events, any direct conveyance of

flows to either north or south of Doran Road would be in excess of the existing conditions. As result, the stormwater management system within the Doran community has been designed to maximize infiltration of frequent rainfall events and to maintain the existing 2 through 100 year peak flow from the existing drainage area to the Pooles Road drainage feature, which drains to Willow Creek via a municipal pipe and ditch system starting at Midves Court. The following Geomorphological evaluation and Ecological review of the drainage to the Pooles Road system has been provided to demonstrate the suitability of the outlet location.

As shown in the appended memo from Aqualogic, the applicable rapid assessments at the proposed SWM facility outlet locations have a combined score of 73.4 or above. The memo also states that the provision of 72 hour extended detention from the proposed SWM facilities (see Item #4 submission), extensive implementation of low impact development measures (see Item #5 submission), in combination with information provided through previous studies (appended to this letter) the proposed SWM facility outlet locations are adequate with regard to future conditions erosion potential control.

As discussed in the appended memo from Beacon, the location of the pipe outlet and emergency spillway for the Russell SWM pond was acceptable as the alignment does not impact any sensitive features and the vegetation is relatively young. The combination of upstream LIDs, pond plantings, cooling trench and extensive length of pipe is adequate for thermal mitigation of Willow Creek. The outlet at Willow Creek is acceptable as it is an existing outfall at a location along Willow Creek which is relatively stable and will be adequately cooled.

Please call the undersigned if you have any questions or require any additional information.

Sincerely,

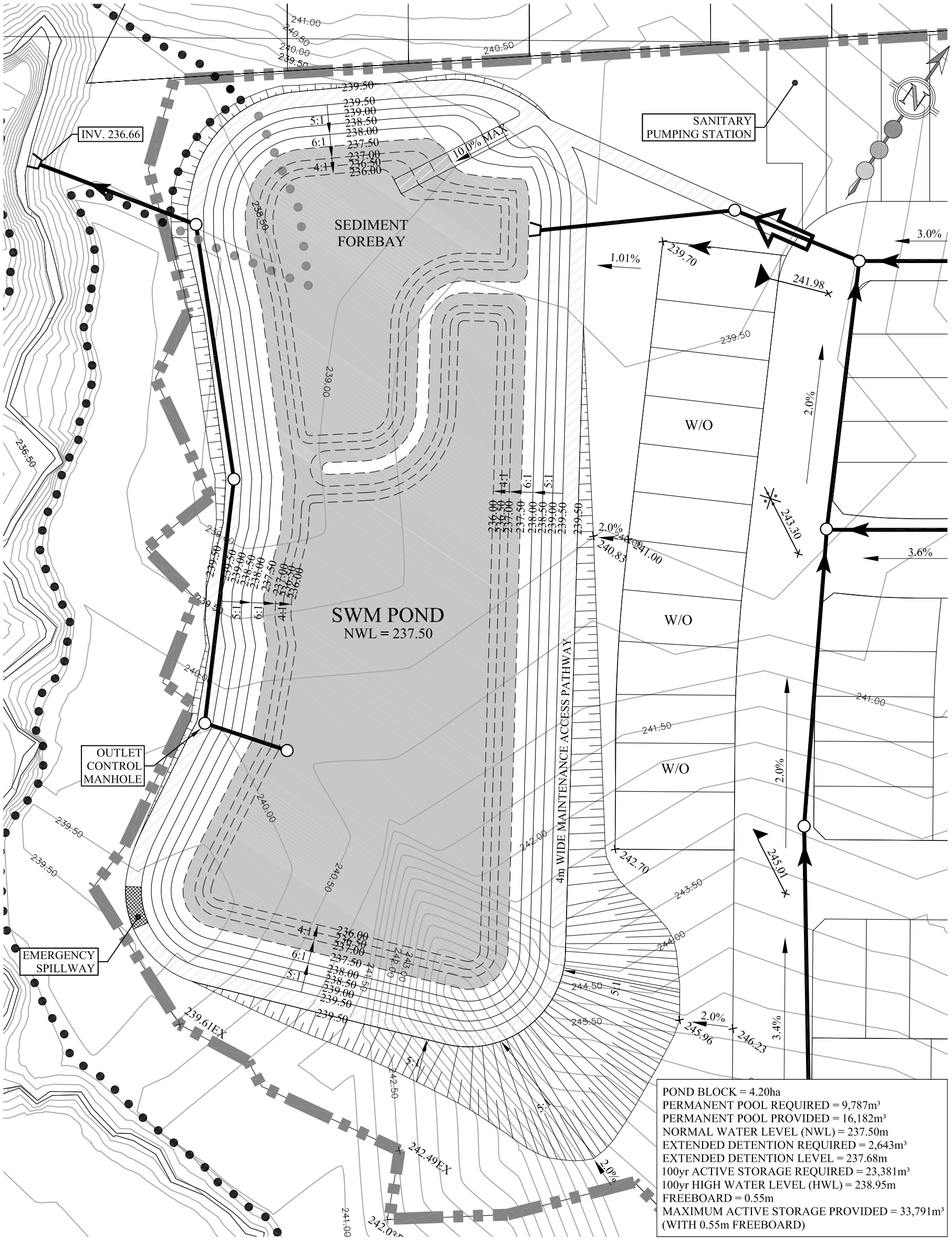
SCS Consulting Group Ltd.

Steve Schaefer, P. Eng.
Principal
sschaefer@scsconsultinggroup.com

Attachments: SWM Pond Figures
Memo from Beacon Re: Pooles Road Outlet Impact Assessment
Memos from Aqualogic

c. Mr. Wayne Wilson, NVCA
Mr. Chris Hibbard, NVCA
Mr. Brad Sokach, Township of Springwater
Mr. Brent Spagnol, Township of Springwater
Mr. Joe Mullan, Ainley
Mr. Greg Marek, Simcoe County
Ms. Shauna Dudding, Geranium Corporation
Mr. Dirk Janas, Beacon Environmental
Mr. Bill De Geus, AquaLogic
Mr. Matthew Cory, Malone Given Parsons

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LEGEND:

- LIMIT OF DEVELOPMENT APPLICATION
- EXISTING FLOODLINE
- PROPOSED FLOODLINE
- MAX. 3:1 SLOPE
- 243.00 — EXISTING CONTOUR
- × 246.50 — PROPOSED GRADE
- ×237.59EX — EXISTNG GRADE
- OVERLAND FLOW
- 238.50 — POND CONTOUR
- PROPOSED MAINTENACE ACCESS ROAD
- PROPOSED EMERGENCY SPILLWAY
- PROPOSED OVERLAND FLOW ROUTE
- PROPOSED STORM SEWER

CARSON ROAD DEVELOPMENT INC. (CRDI)

PRELIMINARY SWM POND GRADING - NORTH POND

CARSON ROAD DEVELOPMENT INC.
3190 STEELES AVE. EAST, SUITE 3000
MARKHAM, ONTARIO L3R 1G9
TEL: (905) 477-1177
FAX: (905) 477-1279

SCS consulting group ltd
30 CENTURIAN DRIVE, SUITE 100
MARKHAM, ONTARIO L3R 8B8
TEL: (905) 475-1900
FAX: (905) 475-8335

DATE:	AUGUST 2014	CHECKED BY:	J.M.P
SCALE:	1:1000	DRAWN BY:	Y.K.
PROJECT No:	1194	FIGURE No:	4.4.1

File: P:\1194 Midhurst Carson Road\Drawings\FSP\Figs\Report Figures\1194D-PREL-POND-NRTH-4.4.1.dwg – Revised by <MBRITTON> : Fri, Aug 08 2014 – 9:32am

POND BLOCK = 1.30ha
PERMANENT POOL REQUIRED = 5,273m³
PERMANENT POOL PROVIDED = 7,953m³
NORMAL WATER LEVEL (NWL) = 264.00m
EXTENDED DETENTION REQUIRED = 1,392m³
EXTENDED DETENTION LEVEL = 264.28m
100yr ACTIVE STORAGE REQUIRED = 13,972m³
100yr HIGH WATER LEVEL (HWL) = 265.74m
FREEBOARD = 0.56m
MAXIMUM ACTIVE STORAGE PROVIDED = 18,754m³
(WITH 0.56m FREEBOARD)

PARK

OPEN SPACE

CARSON ROAD WEST

SWM POND
NWL = 264.00

SEDIMENT FOREBAY

LIMIT OF DEVELOPMENT

1 m BUFFER

2 m FLAT BERM

EMERGENCY SPILLWAY

OVERLAND FLOW ROUTE

MAINTENANCE ACCESS ROAD

MAINTENANCE ACCESS ROAD

TO BLACK CREEK VIA EXISTING CARSON ROAD CULVERT

CARSON ROAD SOUTH POND OUTLET

NOTE: SCHEMATIC LAYOUT ONLY, DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE.

CARSON ROAD DEVELOPMENT INC.
3190 STEELES AVENUE EAST, SUITE 300
MARKHAM, ONTARIO L3R 1G9
TEL: (905) 477-1177
FAX: (905) 477-1279

SCS consulting group ltd
30 CENTURIAN DRIVE, SUITE 100
MARKHAM, ONTARIO L3R 8B8
TEL: (905) 475-1900
FAX: (905) 475-8335

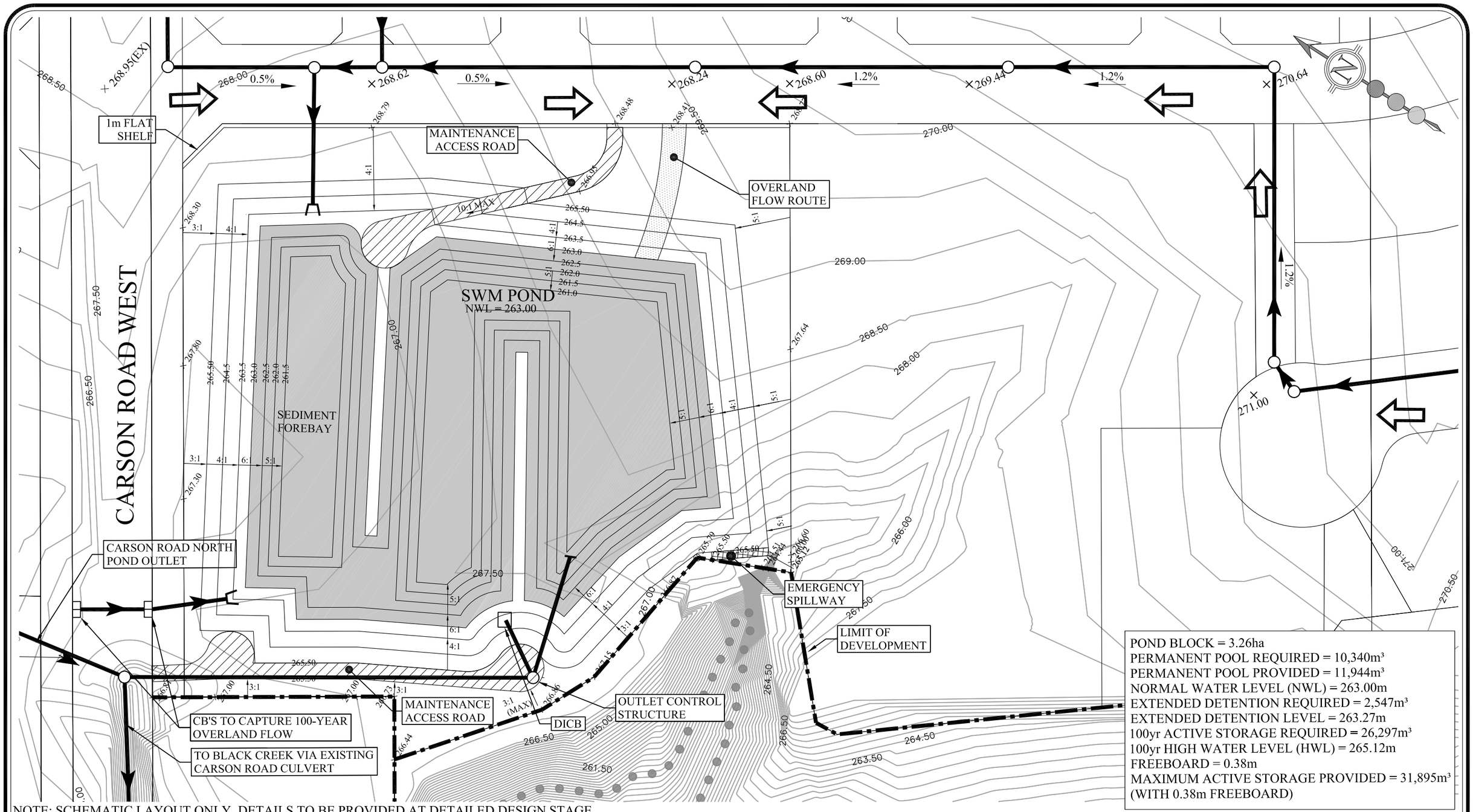
LEGEND:
- MAX. 3:1 SLOPE
- LIMIT OF DEVELOPMENT APPLICATION
- PROPOSED FLOODLINE
- 290.00 EXISTING CONTOUR
- × 166.50 PROPOSED GRADE
- 291.70 POND CONTOUR
- OVERLAND FLOW
- PROPOSED MAINTENACE ACCESS ROAD
- PROPOSED EMERGENCY SPILLWAY
- PROPOSED OVERLAND FLOW ROUTE
- PROPOSED STORM SEWER

CARSON ROAD DEVELOPMENT INC. (CRDI)

PRELIMINARY SWM POND GRADING - CARSON ROAD NORTH POND

DRAWN BY: S.F.	CHECKED BY: J.M.P.
SCALE: 1:1000	DATE: JUNE 2014
PROJECT No: 1194	FIGURE No: 4.4.2

File: P:\1194 Midhurst Carson Road\Drawings\FSP\Figs\Report Figures\1194D-PREL-POND-CARS-NRTH-4.4.2.dwg – Revised by <MBRITTON> : Tue, Aug 05 2014 – 4:59pm



NOTE: SCHEMATIC LAYOUT ONLY, DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE.

POND BLOCK = 3.26ha
PERMANENT POOL REQUIRED = 10,340m³
PERMANENT POOL PROVIDED = 11,944m³
NORMAL WATER LEVEL (NWL) = 263.00m
EXTENDED DETENTION REQUIRED = 2,547m³
EXTENDED DETENTION LEVEL = 263.27m
100yr ACTIVE STORAGE REQUIRED = 26,297m³
100yr HIGH WATER LEVEL (HWL) = 265.12m
FREEBOARD = 0.38m
MAXIMUM ACTIVE STORAGE PROVIDED = 31,895m³
(WITH 0.38m FREEBOARD)

CARSON ROAD DEVELOPMENT INC.
3190 STEELES AVENUE EAST, SUITE 300
MARKHAM, ONTARIO L3R 1G9
TEL: (905) 477-1177
FAX: (905) 477-1279

SCS consulting group ltd
30 CENTURIAN DRIVE, SUITE 100
MARKHAM, ONTARIO L3R 8B8
TEL: (905) 475-1900
FAX: (905) 475-8335

LEGEND:

- MAX. 3:1 SLOPE
- PROPOSED FLOODLINE
- 290.00 EXISTING CONTOUR
- × 166.50 PROPOSED GRADE
- 291.70 POND CONTOUR
- OVERLAND FLOW
- PROPOSED MAINTENACE ACCESS ROAD
- PROPOSED OVERLAND FLOW ROUTE
- PROPOSED STORM SEWER

CARSON ROAD DEVELOPMENT INC. (CRDI)

PRELIMINARY SWM POND GRADING - CARSON ROAD SOUTH POND

DRAWN BY:	S.F.	CHECKED BY:	J.M.P.
SCALE:	1:1000	DATE:	JUNE 2014
PROJECT No:	1194	FIGURE No:	4.4.3

File: P:\1194 Midhurst Carson Road\Drawings\FSP\Figs\Report Figures\1194D-PREL-POND-CARS-SOTH-4.4.3.dwg – Revised by <MBRITTON> : Tue, Aug 05 2014 – 3:32pm

POND BLOCK = 0.95 ha
PERMANENT POOL REQUIRED = 2,520 m³
PERMANENT POOL PROVIDED = 3,445 m³
NORMAL WATER LEVEL (NWL) = 264.25 m
EXTENDED DETENTION REQUIRED = 3,819 m³
EXTENDED DETENTION LEVEL = 265.11 m
100yr ACTIVE STORAGE REQUIRED = 6,663 m³
100yr HIGH WATER LEVEL (HWL) = 265.61 m
FREEBOARD = 0.44m
MAXIMUM ACTIVE STORAGE PROVIDED = 9,323 m³
(WITH 0.44m FREEBOARD)

EMERGENCY SPILLWAY
LIMIT OF DEVELOPMENT
MAINTENANCE ACCESS ROAD
OVERLAND FLOW ROUTE
SWM POND
NWL = 264.25
SEDIMENT FOREBAY
ONTARIO HYDRO EASEMENT
OVERLAND FLOW ROUTE/MAINTENANCE ACCESS ROAD

264.11 EX
265.89EX
266.50 EX
266.05EX
266.71EX
267.55 EX
267.73 EX
267.61EX
268.83 EX
269.19 EX
268.85 EX
267.87 EX
268.22

NOTE: SCHEMATIC LAYOUT ONLY, DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE.

CARSON ROAD DEVELOPMENT INC.
3190 STEELES AVENUE EAST, SUITE 300
MARKHAM, ONTARIO L3R 1G9
TEL: (905) 477-1177
FAX: (905) 477-1279

SCS consulting group ltd
30 CENTURIAN DRIVE, SUITE 100
MARKHAM, ONTARIO L3R 8B8
TEL: (905) 475-1900
FAX: (905) 475-8335

LEGEND:

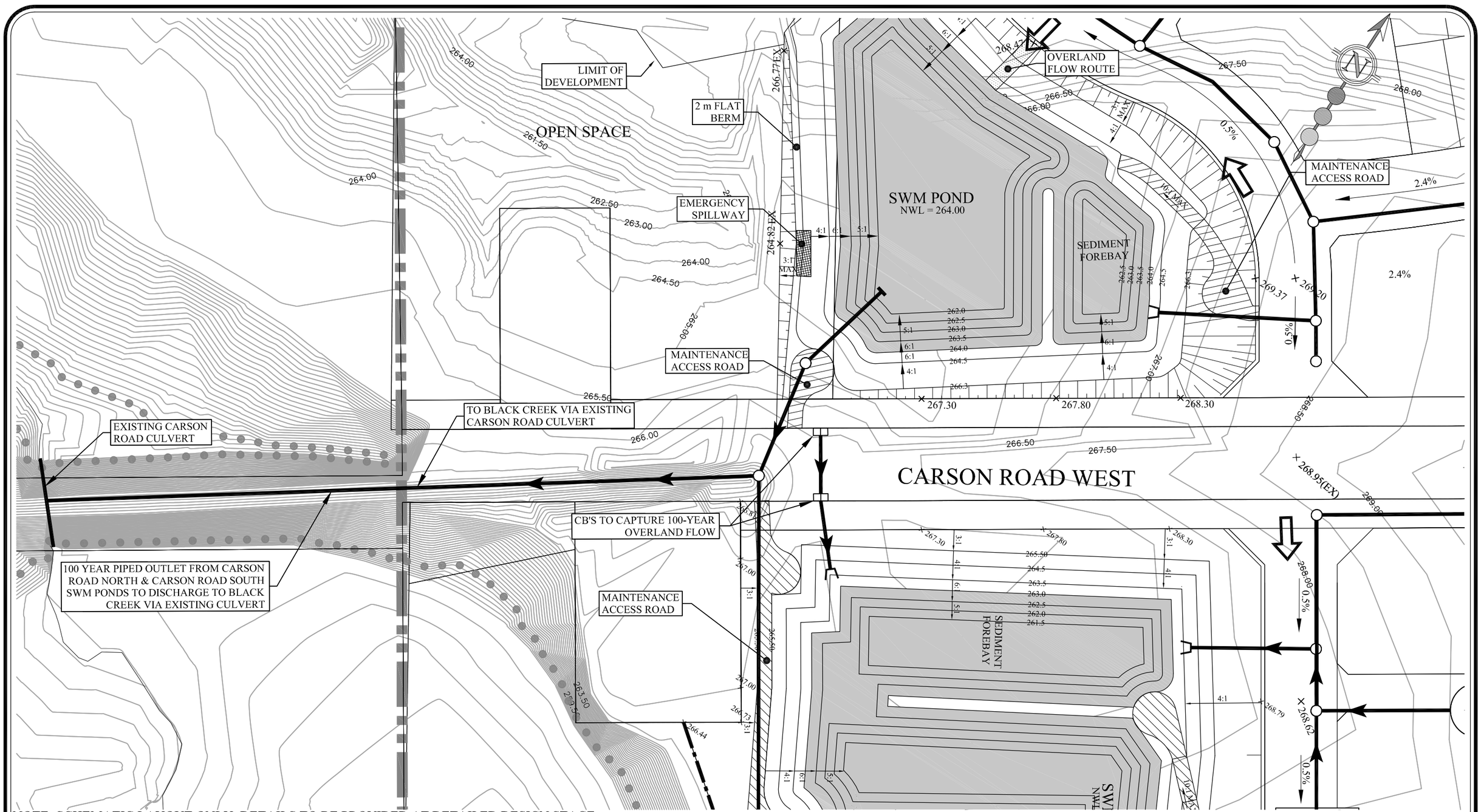
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- PROPOSED FLOODLINE
- 290.00 EXISTING CONTOUR
- × 268.83 EX EXISTING GRADE
- 266.05 POND CONTOUR
- PROPOSED MAINTENACE ACCESS ROAD
- PROPOSED EMERGENCY SPILLWAY
- PROPOSED OVERLAND FLOW ROUTE
- PROPOSED STORM SEWER

CARSON ROAD DEVELOPMENT INC. (CRDI)

PRELIMINARY SWM POND GRADING - SOUTH POND

DRAWN BY:	S.F.	CHECKED BY:	J.M.P.
SCALE:	1:1000	DATE:	JUNE 2014
PROJECT No:	1194	FIGURE No:	4.4.4

File: P:\1194 Midhurst Carson Road\Drawings\FSP\Figs\Report Figures\1194D-PREL-POND-SOTH-4.4.4.dwg - Revised by <MBRITTON> : Tue, Aug 05 2014 - 3:57pm



NOTE: SCHEMATIC LAYOUT ONLY, DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE.

CARSON ROAD DEVELOPMENT INC.
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TEL: (905) 477-1177
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SCS consulting group ltd
30 CENTURIAN DRIVE, SUITE 100
MARKHAM, ONTARIO L3R 8B8
TEL: (905) 475-1900
FAX: (905) 475-8335

LEGEND:

- MAX. 3:1 SLOPE
- LIMIT OF DEVELOPMENT APPLICATION
- PROPOSED FLOODLINE
- 290.00 EXISTING CONTOUR
- × 166.50 PROPOSED GRADE
- 291.70 POND CONTOUR
- OVERLAND FLOW
- PROPOSED MAINTENACE ACCESS ROAD
- PROPOSED EMERGENCY SPILLWAY
- PROPOSED OVERLAND FLOW ROUTE
- PROPOSED STORM SEWER

CARSON ROAD DEVELOPMENT INC. (CRDI)

PRELIMINARY SWM PONDS GRADING - CARSON ROAD NORTH AND SOUTH POND

DRAWN BY:	S.F.	CHECKED BY:	J.M.P.
SCALE:	1:1000	DATE:	JUNE 2014
PROJECT No:	1194	FIGURE No:	4.4.5

File: P:\1194 Midhurst Carson Road\Drawings\FSP\Figs\Report Figures\1194D-PREL-POND-CARS-BOTH-4.4.5.dwg – Revised by <MBRITTON> : Fri, Aug 08 2014 – 2:52pm

POND BLOCK = 4.39ha
PERMANENT POOL REQUIRED = 13,213m³
PERMANENT POOL PROVIDED = 16,619m³
NORMAL WATER LEVEL (NWL) = 280.00m
EXTENDED DETENTION REQUIRED = 3,400m³
EXTENDED DETENTION LEVEL = 280.18m
100yr ACTIVE STORAGE REQUIRED = 37,532m³
100yr HIGH WATER LEVEL (HWL) = 281.76m
FREEBOARD = 0.84m
MAXIMUM ACTIVE STORAGE PROVIDED = 57,440m³
(WITH 0.84m FREEBOARD)

RUSSELL ROAD

POOLES ROAD

PARK

SWM POND
NWL = 280.00

SEDIMENT FOREBAY

SEDIMENT FOREBAY

INLET STRUCTURE

4.0m WIDE MAINTENANCE ACCESS ROAD

OVERLAND FLOW ROUTE

OVERLAND FLOW ROUTE

LIMIT OF DEVELOPMENT

4.0m WIDE FLAT BERM

MAX 3:1 TO MATCH EXISTING

EMERGENCY SPILLWAY

DICB

OUTLET CONTROL STRUCTURE

4.0m WIDE MAINTENANCE ACCESS ROAD

TO EXISTING MUNICIPAL OUTLET

NOTE: SCHEMATIC LAYOUT ONLY, DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE.

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LEGEND:

- LIMIT OF DEVELOPMENT APPLICATION
- MAX. 3:1 SLOPE
- 290.00 EXISTING CONTOUR
- × 166.50 PROPOSED GRADE
- × 287.59 EX EXISTNG GRADE
- 291.70 POND CONTOUR
- OVERLAND FLOW
- PROPOSED MAINTENACE ACCESS ROAD
- PROPOSED EMERGENCY SPILLWAY
- PROPOSED OVERLAND FLOW ROUTE
- PROPOSED STORM SEWER

MIDHURST DEVELOPMENT DORAN ROAD INC. (MDDRI)

PRELIMINARY SWM POND GRADING - RUSSELL ROAD POND

DRAWN BY: S.F.	CHECKED BY: J.M.P.
SCALE: 1:1500	DATE: JUNE 2014
PROJECT No: 1168	FIGURE No: 4.4.1

File: P:\1168 Midhurst – Doran Road\Drawings\FSP\Fig\Report Figures\1168–PREL–POND–RUSL–4.4.1.dwg – Revised by <MBRITTON> : Tue, Aug 05 2014 – 4:45pm



NOTE: SCHEMATIC LAYOUT ONLY, DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE.

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FAX: (905) 475-8335

LEGEND:

- LIMIT OF DEVELOPMENT APPLICATION
- MAX. 3:1 SLOPE
- 290.00 EXISTING CONTOUR
- × 166.50 PROPOSED GRADE
- × 287.59 EX EXISTNG GRADE
- 291.70 POND CONTOUR
- OVERLAND FLOW
- PROPOSED MAINTENACE ACCESS ROAD
- PROPOSED EMERGENCY SPILLWAY
- PROPOSED OVERLAND FLOW ROUTE
- PROPOSED STORM SEWER

MIDHURST DEVELOPMENT DORAN ROAD INC. (MDDRI)

PRELIMINARY SWM POND GRADING - RUSSELL ROAD POND

DRAWN BY: M.T.C.	CHECKED BY: J.M.P.
SCALE: 1:2000	DATE: MAY 2014
PROJECT No: 1168	FIGURE No: 4.4.1.1

File: P:\1168 Midhurst – Doran Road\Drawings\FSP\Fig\Report Figures\1168-PREL-POND-RUSL-4.4.1.1.dwg – Revised by <KPESENGCO> : Fri, Aug 08 2014 – 3:11pm

Memorandum

To: Dave Featherstone and Glenn Switzer, NVCA

From: Dirk Janas, Geri Poisson and Don Fraser

Date: June 11, 2014

Ref: 213405

Re: **Environmental Review of SWM pond outfall locations, Carson Road and Doran Road Neighbourhoods, Township of Springwater.**

Introduction

The following memo provides a site-specific review of the proposed stormwater management (SWM) pond and outfall locations within the Carson Road neighbourhood and the Doran Road neighbourhood that are part of the Phase 1 of development of the Midhurst Secondary Plan area. Site surveys were completed by Beacon ecologists (G. Poisson and/or D. Janas) on May 8 and June 9, 2014, with David Featherstone (Manager of Watershed Monitoring) of the Nottawasaga Valley Conservation Authority (NVCA) participating in the June 9th site walk along with John Priamo of SCS Consulting and representatives from the Township of Springwater's consultant, Ainley Group.

The two 2014 surveys build on the existing environmental conditions provided in the Beacon Environmental Impact Study (EIS) reports (2009) for the Carson Road and Doran Road properties. These studies were used as the primary background information, with further refinement and understanding of existing conditions at the proposed SWM pond and outfall locations.

The specific SWM ponds that are included as part of the environmental review include (see attached **Figure 1** and **2**):

Carson Neighbourhood

- North Pond
- Carson Road North Pond
- Carson Road South Pond
- South Pond

Doran Neighbourhood

- Russell Road Pond

Site Location

The Carson Road Neighbourhood is located on the north and south sides of Carson Road from Wilson Road to the west to just beyond Anne St. to the east. The Doran Neighbourhoods are located to the east of the existing built Midhurst development and are generally bounded by Doran and Walt Roads on the north, Old 2nd Road South on the east and the existing forested natural heritage lands to the west and south.

Purpose

The purpose of the site-specific review and site walks of the proposed SWM ponds, including the location and alignment of the outfall storm sewers and the emergency spillways was to assess the existing natural heritage features and functions in these areas. This included an on-site opportunity to review and discuss site conditions with the NVCA and to provide input and recommendations for both the Master Drainage Plan and future detailed design of these facilities. The objective included appropriate siting of the SWM facilities to avoid sensitive areas and minimize impacts to natural features.

Following the June 9th site walk and discussions with the NVCA some modifications were made. These included identifying alternate locations for some of the SWM outlets to meet the objective described above. In addition, there was discussion and agreement on the types of approaches and additional considerations to be incorporated at the detailed design stage. These included approaches such as minimizing tree and vegetation removal, emphasizing the importance of good Erosion and Sediment Control (ESC) measures particularly adjacent to sensitive features, and providing restoration plantings as part of the impact mitigation and enhancement of natural features.

Carson Road Neighbourhood

North Pond

This stormwater management pond is proposed to be located on the east side of Black Creek, east of Wilson Drive and south of Snow Valley Road (see **Figure 1**). Due to the steep side slopes, the riparian area along Black Creek was classified as a Sumac Cultural Thicket (CUT1-1) but also includes patches of treed areas and open grassy areas. The tree cover along the east side of the creek varies and consists of scattered Manitoba Maple (*Acer negundo*), Green Ash (*Fraxinus pennsylvanica*) and a few Butternut (*Juglans cinerea*), with the latter tree species being located in the buffer and outside of the area of proposed development. The vegetation in the area of the pipe outlet and the emergency spillway is an open meadow area with mainly grasses dominated by Smooth Brome (*Bromus inermis*) and some Reed Canary Grass (*Phalaris arundinacea*) (**Photograph 1**). The topography in the proposed outlet area is gently sloping.

The following points were agreed upon during the June 9th site walk:

- The location of the pipe outlet as shown on the SCS Figure 4.4.1 is acceptable and preferred by NVCA;
- The location of the emergency spillway is also acceptable and in the preferred location;
- The area adjacent to the spillway and pipe outlet to the creek is a good candidate for restoration to provide more shade for the tributary;
- The buffer area between the creek and the pond could be used for additional plantings to provide shade that will assist in keeping the existing tributary cool; and
- The combination of upstream LIDs, pond plantings, cooling trench, and additional plantings at the creek is adequate for thermal mitigation for Phase 1, recognizing that it will be part of the overall monitoring and Adaptive Management Plan.
- There will be no impacts to the features and functions of the adjacent vegetation communities.

It should be noted that there were five Butternut trees found along the edge of farm field, between the creek and the proposed North Pond, including one large mature tree identified in the EIS and four new saplings. No formal Butternut Health Assessment was conducted on these trees, but the mature tree is likely non-retainable. The site grading and site disturbance is proposed to be at least 25 m from any of the Butternut trees.



Photograph 1. View of proposed outlet pipe and emergency spillway for the North Pond. Pond to be located in background (right) and creek is on left side of photo.

Carson Road North Pond

The Carson Road North Pond is proposed to be located just north of Carson Road on the east side of the Black Creek valleyland (see **Figure 1**). The pond will be located within the existing agricultural lands adjacent to a small grassy meadow and a Sugar Maple Deciduous Forest (FOD5-2), with the outlet for the emergency spillway being directed into the grassy meadow. This area is dominated by Smooth Brome from the existing drive west towards the forest (**Photograph 2**), where the plant community transitions into a small area with wetland plants including Spotted Touch-me-not (*Impatiens capensis*), Ostrich Fern (*Matteuccia struthiopteris*), and Sensitive Fern (*Onoclea sensibilis*) as well as Wild Red Raspberry (*Rubus idaeus*). Beyond this there is a small, dry defined channel from historic flows. The topography in the proposed spillway area is gently sloping. The storm pond outlet will follow the existing driveway south towards Carson Road and outlet to the existing Black Creek culvert crossing on Carson Road.

The following points were agreed upon during the June 9th site walk:

- The location of the pipe outlet as shown on SCS Figures 4.4.2 and 4.4.5 is acceptable to NVCA;
- The location of the emergency spillway was shifted south to line up with the existing draw (into the grassy meadow, as shown on SCS Figure 4.4.2), which was acceptable and preferred by NVCA; and
- The outlet into Black Creek at the culvert on Carson Road is a sensitive location with respect to temperatures and Brook Trout fish habitat. The proposed upstream LIDs, pond plantings, cooling trench and extensive length of underground pipe are adequate for thermal mitigation for Phase 1, recognizing that it will be part of the overall monitoring and Adaptive Management Plan.

Based on the assessment there will be no impacts to the features and functions of the adjacent vegetation communities.



Photograph 2. View of proposed emergency spillway route for Carson Road North Pond. Pond to be located in the agricultural field and outlet to follow existing driveway toward Carson Road.

Carson Road South Pond

The Carson Road South Pond is proposed to be located just south of Carson Road on the east side of the Black Creek valleyland (see **Figure 1**). The pond will be located within the existing agricultural lands adjacent to a Sugar Maple Deciduous Forest (FOD5-2) with a well-defined forest edge. The outlet for the emergency spillway will be in the agricultural field with flows being directed into the buffer lands and then into a forest draw down in the valleyland. The immediate edge of the forest supports White Ash (*Fraxinus americana*), American Basswood (*Tilia americana*) and Sugar Maple (*Acer saccharum*), with a row of planted Norway Spruce (*Picea abies*) to the north of the spillway. The topography in the proposed spillway area is gently to moderately sloping in the agricultural lands and buffer, then is steeper into the valleyland within the forest with a small defined channel down towards the floodplain. The storm pond outlet will approximately follow the existing driveway north towards Carson Road and outlet to the existing Black Creek culvert crossing on Carson Road.

The following points were agreed upon during the June 9th site walk:

- The location of the pipe outlet as shown on SCS Figures 4.4.3 and 4.4.5 is acceptable to NVCA;
- The location of the emergency spillway was shifted south and east further from the woodland/valleyland edge, and made wider to allow for additional dissipation prior to

entering the forest and draw (SCS Figure 4.4.3). With this change the NVCA found the location acceptable and preferable; and,

- The outlet into Black Creek at the culvert on Carson Road is a sensitive location with respect to temperatures and Brook Trout fish habitat. The proposed upstream LIDs, pond plantings, cooling trench and extensive length of pipe is adequate for thermal mitigation for Phase 1, recognizing that it will be part of the overall monitoring and Adaptive Management Plan.

Based on the assessment there will be no impacts to the features and functions of the adjacent vegetation communities.



Photograph 3. View of proposed emergency spillway route for Carson Road South Pond. Pond to be located in the agricultural field and outlet to follow buffer lands before entering the valleyland.

South Pond

The South Pond is proposed to be located in the agricultural lands between Drainage Feature A and B, north of the hydro corridor (see **Figure 1**). The adjacent vegetation communities include a Cultural Thicket (CUT1-1) area to the north of the proposed pond and an organic Shallow Marsh (MAS3-1) to the west of the pond. The CUT1-1 community supports mixed tree species cover including White Pine (*Pinus strobus*), White Elm (*Ulmus americana*), and White Ash, with a ground cover of typical old field meadow species such as Smooth Brome and goldenrods (*Solidago* sp.) (**Photograph 4**). The MAS3-1 wetland is considered a senstive feature as it is mostly supported by groundwater with evidence of seepage, organic soils and groundwater indicator plants. The community is dominated by Broad-

leaved Cattail (*Typha latifolia*), Sensitive Fern, Marsh Marigold (*Caltha palustris*), Rough Sedge (*Carex scabrata*), Fowl Meadow Grass (*Poa palustris*) and Reed-canary Grass (**Photograph 5**). The topography in the proposed outlet and spillway area is moderately sloping from the pond down into Drainage Feature A.

The following points were agreed upon during the June 9th site walk:

- The location of the pipe outlet as previously shown on SCS Figure 4.4.4 has been relocated to the northeast side of the pond, which is NVCA's preference so as to avoid flows into the MAS3-1;
- The location of the emergency spillway has also been relocated to the northeast side of the pond which is acceptable and preferable to the NVCA.
- In addition, remedial works of Drainage Feature A from the pond outlet to the existing "pool" at the beginning of the Black Creek channel will likely be required (at detailed design);
- This is an appropriate location for buffer plantings to enhance existing feature; and
- The combination of upstream LIDs, pond plantings, cooling trench, and additional plantings at the creek is adequate for thermal mitigation for Phase 1, recognizing that it will be part of the overall Adaptive Management Plan.

Based on the assessment there will be no impacts to the features and functions of the adjacent vegetation communities.



Photograph 4. View of proposed pond outlet and emergency spillway route for South Pond. Pond to be located in agricultural field and the outlet will pass through Cultural Thicket into Drainage Feature A before entering the valleyland and Black Creek



Photograph 5. View of Shallow Marsh wetland (MAS3-1) to the west of the South Pond that is dependent on groundwater. The SWM pond outlet will be directed away from this feature due to the sensitivity of the area.

Doran Road Neighbourhood

Russell Road Pond

This stormwater management pond is proposed to be located on the west side of Russell Road and north of Pooles Road (**Figure 2**). Vegetation communities that are found within the footprint of the pond, the outlet pipe and emergency spill way include active agricultural fields and the following ELC communities: (**Photograph 6**)

Old-field Meadow (CUM1-1)
This community is dominated by Smooth Brome, Orchard Grass (*Dactylis glomerata*), Canada Goldenrod (*Solidago canadensis*) and Kentucky Bluegrass (*Poa pratensis*) with some scattered Staghorn Sumac (*Rhus typhina*), hawthorns (*Crataegus* spp.) and regenerating Scots Pine (*Pinus sylvestris*) and Green Ash.

Sumac Cultural Thicket (CUT1-1)
This community is very similar to the Old Field Meadow community with the exception that Staghorn Sumac is the dominant species.

Red Pine Coniferous Plantation (CUP3-1)
This immature and sometimes sparsely treed area on the slopes below the SWM pond location is characterized by planted pine trees up to 8 m tall. Tree species include Red Pine (*Pinus resinosa*), Scots Pine, Green Ash and White Pine with a few Northern Red Oak (*Quercus rubra*), Black Walnut (*Juglans nigra*) and White Birch (*Betula papyrifera*). The shrub species include Chokecherry (*Prunus virginiana*), rose species (*Rosa* sp.) and hawthorns. The more common herbaceous species include Bracken Fern (*Pteridium aquilinum*), Canada Goldenrod, Wild Strawberry (*Fragaria virginiana*), Orchard Grass and Wild Bergamot (*Monarda fistulosa*).

Mineral Cultural Woodland (CUW1)
This forested community is similar to the Red Pine Coniferous Plantation but with a greater proportion of naturally regenerating tree species such as Green Ash and Sugar Maple.

The following points were agreed upon during the June 9th site walk:

- The location of the pipe outlet as shown on Figure 4.4.1 is acceptable to NVCA;
- The location of the emergency spillway, lining up with the existing draw is acceptable to NVCA;
- The combination of upstream LIDs, pond plantings, cooling trench and extensive length of pipe is adequate for thermal mitigation for Phase 1, knowing that it will be part of the overall Adaptive Management Plan; and
- The outlet at Willow Creek is acceptable to NVCA as it is an existing outfall, at a location along Willow Creek which is relatively stable and will be adequately cooled.

Based on the assessment there will be no impacts to the features and functions of the adjacent vegetation communities.



Photograph 5. View facing southwest of vegetation communities in the location of the proposed outlet pipe and emergency spillway. Pond is to be located upslope (out of photo) to the right.

Conclusions

The Environmental Review of the SWM pond outlets for the pond outlets for the Phase 1 lands consisting of four ponds in the Carson Neighbourhood and one pond in the Doran Neighbourhood has concluded that the proposed locations are acceptable and avoid sensitive areas and minimize impacts to the identified natural heritage features and functions. The proposed pond and outlet locations as illustrated on the SCS Preliminary SWM Pond Grading Plans (Figures 1186 - 4.4.1 for Doran and 4.4.1; and Figures 1194 - 4.4.1, 4.4.3, 4.4.4 and 4.4.5 for Carson) have been finalized for the first phase of the Master Drainage Plan through on-site consultation and input from NVCA during the May 9 and June 9, 2014 site walks.

Discussion and agreement with the NVCA includes the understanding that final refinement of the SWM facilities during detailed design will include further approaches to minimize impact and provide enhancement of natural features. For example, this will include minimizing vegetation removal (e.g., directional bore instead of open cut where feasible), providing restoration plantings in disturbed areas in a manner that still provides maintenance access, and riparian plantings throughout to improve thermal shading, among other considerations. Furthermore, the monitoring of Willow Creek and Black Creek will be important to understand the benefits of the combination of upstream LIDs, pond plantings, cooling trench and extensive length of SWM pipe that have been incorporated into the design for thermal mitigation of these features. This information will be utilized to identify the performance of the design measures that can then be incorporated into the Adaptive Management Plan for input to future phases of the development.

Carson Neighbourhood SWMP locations

Figure 1

Geranium



Legend

- ELC Communities
- Watercourse
- Proposed Stormwater Management Ponds (SCS Consulting 2014)
- Outlet Piping

Code	Description
CUM 1-1	Dry-Moist Old Field Mineral Cultural Meadow
CUP 3-1	Coniferous Plantation Red Pine
CUT 1-1	Sumac Cultural Thicket
FOD 5-2	Dry-Fresh Sugar Maple Beech Deciduous Forest
FOD 5-3	Dry-Fresh Sugar Maple Oak Deciduous Forest
MAS 3-1	Cattail Organic Shallow Marsh

Note: Existing Conditions base on EIS (Beacon 2009)

First Base Solutions
Web Mapping Service 2012

UTM Zone 17 N, NAD 83

N W E S

0 75 150 300 Metres

1:6,500

BEACON ENVIRONMENTAL

Project 213405
June 2014



Russell SWM Pond

Figure 2

Geranium

Legend

- ELC Communities
- Watercourses
- Proposed Stormwater Management Ponds (SCS Consulting 2014)
- Outlet Piping

Terrestrial System

Forest (FO)
FOD5: Sugar Maple Deciduous Forest Ecosite
FOD5-8: Sugar Maple - White Ash Deciduous Forest
FOM2-2: Dry-Fresh White Pine - Sugar Maple Mixed Forest

Cultural (CU)
CUP3: Red Pine Coniferous Plantation
CUW1: Cultural Woodland Ecosite
CUT1-1: Sumac Deciduous Shrub Thicket
CUM1-1: Dry-Fresh Old Field Meadow
H: Hedgerow

Note: Existing Conditions base on EIS (Beacon 2009)

First Base Solutions
Web Mapping Service 2012

UTM Zone 17 N, NAD 83

N W E S

0 25 50 100 Metres

1:2,500

BEACON ENVIRONMENTAL

Project 213405
June 2014

Erosion Threshold Analysis
Willow Creek Tributaries
Carson Road Development Inc.
Midhurst Development Doran Road Inc.
Township of Springwater






Submitted to:

SCS Consulting Group Ltd.
30 Centurian Drive, Suite 100
Markham, ON L3R 8B8

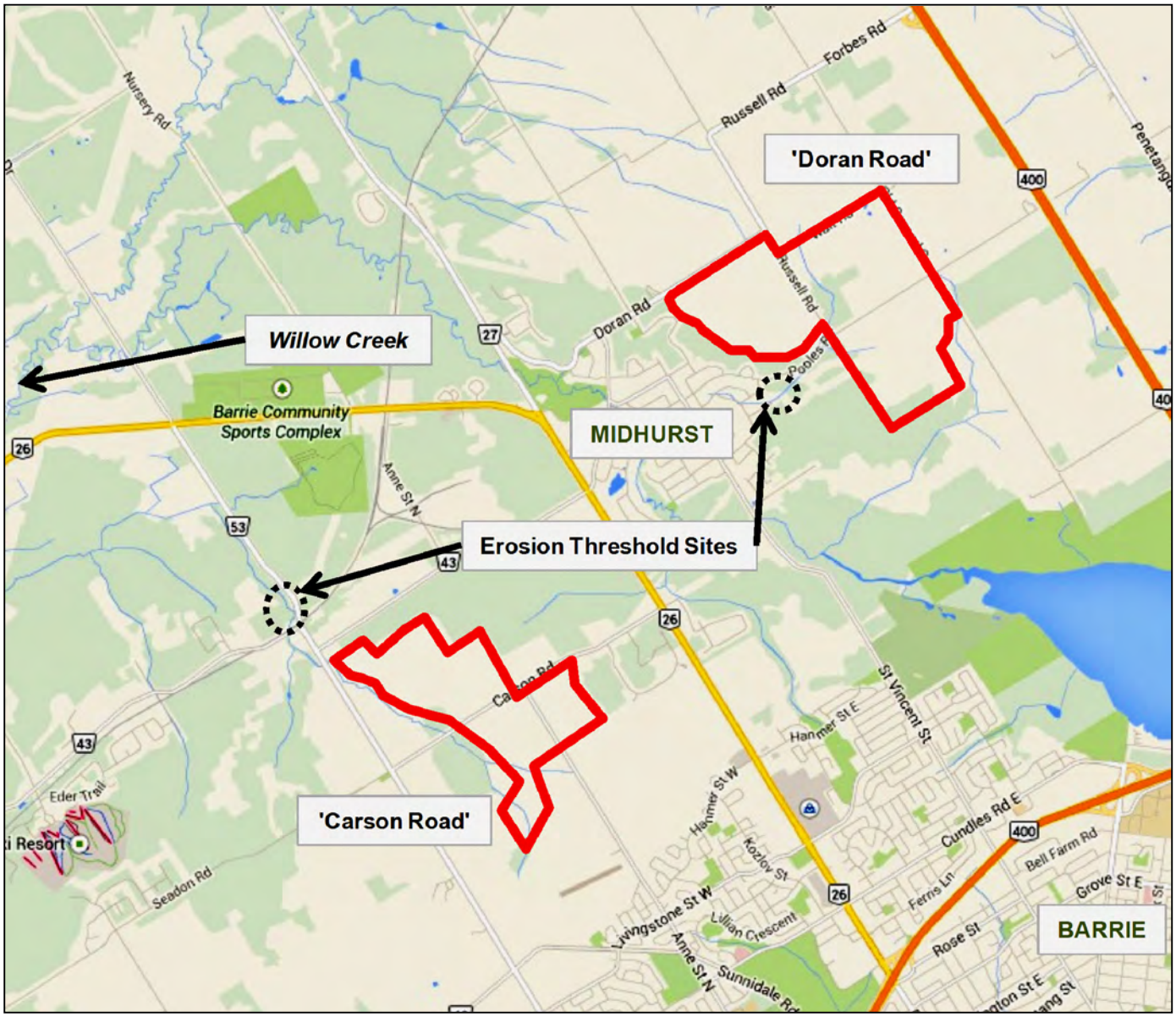
May 2, 2014

AquaLogic Consulting • 9 Ellen St. #1, Mississauga, ON L5M 1R8 • 905.819.9076 • bill.degeus@sympatico.ca

Erosion Threshold Analysis
Willow Creek Tributaries
Carson Road Development Inc.
Midhurst Development Doran Road Inc.
Township of Springwater

Erosion threshold analysis has been undertaken for two reaches of Willow Creek Tributaries that will receive stormwater discharge from proposed residential developments in the Township of Springwater. The study area locations are shown in Figure 1.

Figure 1: Location Map (not to scale, N▲)



Analysis has been done based on field review of channel sensitivity below proposed stormwater pond outlets and detailed cross-section surveys of the downstream locations that will receive combined flows from the development blocks. Field measurements were used for erosion threshold modeling and the results were then used to determine the appropriate methodology for impact analysis. Exceedance-duration analysis was identified to be appropriate for the 'Carson Road' development and vegetation-hydroperiod analysis was identified to be appropriate for the Doran Road development.

Willow Creek Tributary Characterization

Carson Road

The 'Carson Road' Willow Creek Tributary is transitional from a 1st order to 2nd order watercourse with upstream drainage area increments of 1.40km^2 to Anne St. N. for the easterly 1st order feature, 1.80km^2 for the westerly 1st order feature, 5.47km^2 to Carson Rd. W. for the 2nd order branch, and 6.83km^2 to Wilson Dr. at the downstream study limit of the 2nd order branch. Two additional short local drainage features are confluent in the lower study area. The small westerly feature represents drainage from a small wet meadow area (possibly a former beaver pond/meadow) and the easterly feature is characterized by local farm field drainage contribution. The 1st and 2nd order features are officially identified on 1:10,000 Provincial OBM mapping and 1:50,000 Federal NTS mapping. The local drainage features as described above are not seen on mapping and would therefore be deemed not to represent primary drainage functions. The main branch 2nd order tributary is confluent downstream of the study area with the main branch of Willow Creek, which is confluent with the Nottawasaga River in the Minesing Wetlands.

The study area is mainly within the Simcoe Uplands physiographic region, with the downstream area near Wilson Dr. falling to the Simcoe Lowlands physiographic region. Topography is characterized as a deeply rolling till plain with the tributary falling from a shallow U-shaped valley at Anne St. N. to a relatively deep glacial moraine valley at Carson Rd. and a moderately steep valley transition near Wilson Dr. to downstream of Snow Valley Drive beyond the development block. At its deepest point near Carson Rd. the valley is 15-20m deep. The valley slopes are variable from well defined to convex, with gentle to steep gradients and valley width varying from 50m to over 300m.

The valley floor flood plain varies from agricultural row crop and pasture at Anne St. N. to well vegetated lowland forest and transitional upland forest conditions. Forest cover

upstream of Carson Rd. includes a mix of swamp wetland, scrub forest, and coniferous-deciduous forest. Vegetative cover above Wilson Dr. has scrub forest definition with openings in the canopy resulting in thicker herbaceous groundcover and wet meadow.

The tributary branches are ephemeral to intermittent in the south study area while the main branch appears to gain permanent base flow in the forest upstream of Carson Rd. Channel width varies from about 3-5m in the two 1st order features to as high as 8m in wet meadow sections of the northerly 2nd order study reach. Low flow definition varies from ill-defined ephemeral/intermittent at the upstream limits of the 1st order southerly features, up to about 3m wide, at the downstream development limits of the northerly study reach. The tributary flows over deposits of the parent geology with variable low flow bed forms from ill-defined swale, in the south, to occasional pools and riffles and eventually steps of coarser gravel to cobble material, in the northerly reach. There are areas of wetland diffusion, and influence from apparent beaver activity in intervening forest areas. Channel sinuosity is relatively low while the reach average slope is approximately 1%. Channel stability varies from moderate to relatively high due to changes in biotechnical reinforcement and channel bed materials. Some erosion scars are evident on outside banks, in the mid to lower reach. As expected, the channel tributaries are very stable near the upstream end were flows are ephemeral to intermittent and groundcover vegetation density is high. Stability is moderate to high in the shaded forest areas upstream and downstream of Carson Road. Near the downstream study limits the tributary emerges from forest cover into denser groundcover and shrub thicket cover and stability is very high just upstream of Wilson Drive. Downstream of Wilson Dr. and the next crossing at Snow Valley Road the tributary increases in gradient and is partially to fully confined against valley walls. Below Snow Valley Road partial entrenchment also occurs and the steeper channel requires a generally narrower cross-section with higher conveyance velocities, than some upstream areas. In the reach below Snow Valley Road exposed sand and gravel material is seen in channel banks, localized instability is observed and outside bends show colluvial slope failure above distinct bank erosion scars.

Doran Road

Two tributary reaches of Willow Creek border proposed development areas with only the westerly tributary, in the Pooles Road area, identified for analysis during pre-consulting. This feature is 1st order ephemeral and is seen on 1:50,000 scale Federal topographic mapping, but it is not seen on 1:10,000 scale Provincial topographic mapping. The western feature also has two small tributary drainage features within the study area. These features are ephemeral, contour based, overland flow routes that would arguably not be classified as independent 1st order features. Upstream drainage

area is 2.53km^2 for the westerly tributary at Pooles Road. Both tributaries are confluent downstream with the main branch of Willow Creek, which is confluent with the Nottawasaga River in the Minesing Wetlands. Part of the westerly feature is contained in roadside ditching leading to an enclosed storm sewer in the residential area of Midhurst, before it meets Willow Creek. The study area falls mainly within the Simcoe Uplands physiographic region, with the downstream tributary connections to Willow Creek being within the Simcoe Lowlands physiographic region. Topography is characterized as deeply rolling till plain with the tributaries falling from shallow U-shaped valleys at upstream limits to relatively deep glacial moraine valleys at downstream confluence points. At its deepest point, the western valley is approximately 13m deep. Valley side slopes vary from well defined to convex, with gentle to steep gradients and width varying up to approximately 200m. The west tributary valley floor varies from herbaceous old field pasture at Walt Rd. to a continuous swamp forest at the downstream study area limits.

The westerly tributary appears to be fully ephemeral with no flow identified at the time of field work. The feature was found to not have well defined channel bed and bank conditions and would not necessarily meet technical and legal definition as a true watercourse at any point from downstream of Pooles Road to the upstream limits. After passing through mixed forest conditions below Pooles Road the feature opens up into a recently cleared and graded block designed for new residential development. In this area a very modest swale like channel easement appears to have been recently constructed which passes between lots and meets roadside ditching around a cul-de-sac bulb of Midves Court. A small gravel filled trench is seen within the realignment easement and is reported to be an infiltration feature (Gemmell Engineering 2012). Feature sinuosity is very low in the feature, being just over a ratio value of 1.0. Reach average study area slope is approximately 0.01 m m^{-1} for the western feature. Stability is noted to be very high due to the lack of well defined geometry and the extensive vegetation coverage. The lack of channel definition suggests that flow is opportunistic and will anastomise through vegetative cover without sufficient energy to carve a distinct bankfull channel. Soil conditions and vegetative attenuation also appear to encourage a reasonably high amount of recharge that would help account for the lack of flow forming channel definition on the surface.

Rapid Assessment Analysis

Three rapid assessment protocols were undertaken for three reaches of the Carson Road site and two reaches of the Doran Road site, to help characterize existing conditions and determine appropriate locations for detailed erosion threshold analysis. Field observations were used to score relative geomorphic and environmental

attributes. Rapid Geomorphic Assessment (RGA) was used to rate channel stability and infrastructure impact. Rapid Habitat Assessment (RHA) was used to define in-stream and riparian habitat. Rapid Stream Assessment Technique (RSAT) was used to test broad indicators of channel stability, aquatic habitat, and water quality. A weighted score out of 100 was transposed from the results of each protocol and a combined average score was determined from the three tests. Four qualifying ranges of poor, fair, good, and optimal are maintained in the RHA and RSAT protocols, between the original scoring and the weighted scoring out of 100, while the three original ranges in RGA scoring are reflected as poor, fair, and good. The combined average score is qualified by poor to optimal ranges designed as a best fit of the individual protocol ranges. The detailed results are appended and included with each are photographs of typical reach conditions.

Carson Road

Three reaches representing upstream to downstream of Carson Road, upstream to downstream of Wilson Road, and downstream of Snow Valley Road, were scored with rapid assessments.

The detailed results show that both the Carson Road and Wilson Road areas have high levels of both channel stability and habitat quality. Integrated scores in the optimal range and channel stability scores showing ‘in regime’ stability indices are similar for both of these reaches. Biotechnical vegetation control is providing channel reinforcement and habitat canopy and riparian complexity through these reaches.

Downstream of Wilson Road the channel transitions to steeper gradient and deeper valley confinement and entrenchment. A large drop on the downstream face of Snow Valley Road defines the start of what is deemed the most sensitive reach in proximity to the proposed development area. Existing bank erosion and valley wall contact points show a high fraction of cohesionless material that is exposed and available for entrainment under high flows. Channel stability is scored as ‘transitional’ based on scour pool incision at the culvert drop and channel widening in downstream areas causing slope toe and slope face erosion, and moderate to high numbers of undermined trees. Despite the observed erosion, the continuous natural valley conditions contribute to good aquatic habitat, and integrated scoring is relatively high.

Doran Road

Two reaches representing upstream to downstream of Pooles Road and upstream of the east end of Midves Court, were scored with rapid assessments.

The detailed results show that both locations have very high levels of stability but fair habitat quality. Biotechnical vegetation control is providing reinforcement and habitat canopy and complexity through these reaches. The lack of permanent or even intermittent flow results in low habitat scores because there is no observable habitat use by aquatic organisms. Downstream enclosures may also limit seasonal fish access even when spring freshet flows may occur.

The Midves Court area is deemed the most sensitive to upstream development simply due to the nature of the recently constructed swale feature in proximity to near future development of adjacent lots.

Erosion Threshold Characterization

Erosion threshold characterization was undertaken to establish benchmark targets for discharge control provided by stormwater management treatment of the proposed development blocks. Channel forming cross-section surveys for detailed modeling analysis were located in the sensitive reaches identified through rapid assessment. Five cross-sections are generally considered adequate to represent the natural variability of channel conditions in a localized study reach over the equivalent of two meander wavelengths. Backwater influences caused by large woody debris were avoided. Distinct erosion scars and channel forming flow lines were used in the Snow Valley Road reach below the Carson Road development, while fallen and matted groundcover vegetation lines were used as best as possible in the Midves Court reach below the Doran Road development. Channel geometry was measured laterally at each cross-section and the longitudinal profile was shot using bankfull indicators. Channel bed substrates were measured through random-step Wolman pebble counts and recorded using the Wentworth sediment distribution scale.

Open channel flow models were created for each cross-section location. Each model required input of channel bed substrate data, cross-section dimensions, gradient, and bank geometry. Modeling tests were done for each cross-section and erosion indicators and thresholds were reviewed.

Subsequent checks were done to determine the critical stability threshold discharge. This discharge represents a reach based average point at which channel instability begins to occur with rising flow stage and rising discharge, or conversely when instability stops with falling flow stage and falling discharge. This discharge then becomes the comparative flow regime target for detailed analysis of stormwater management hydrology. Iterative flow stage adjustments can be made in each cross-section model until the appropriate stability criteria are achieved over the primary shear

stress and velocity threshold tests, with secondary checks made of stream power and Froude number. **Table 1** presents the threshold criteria used for this analysis based on 'small' watercourse channel typology which display a high degree of vegetation control.

Table 1: Critical stability threshold criteria

	low flow morphology		
	riffle	run	pool / glide
semi-alluvial firm to dense till channels	D_{84} pavement	D_{84} pavement or vegetation control*	D_{100} pavement or vegetation control*
alluvial cohesionless channels	D_{50} pavement	D_{50} pavement or vegetation control*	D_{84} pavement or vegetation control*

*vegetation control criteria varies depending on vegetation type and density
note: step-pool and cascade-step-pool channels require case by case study

The second row criteria are applied for this study case, based on soil conditions and channel typology. The surveyed reach is dominated by run typology, with a combination of particle size and vegetation control deemed to be appropriate for testing overall stability. Conservative vegetation control criteria are identified as 40N m^{-2} for shear stress and 1.2m s^{-1} for channel velocity (Fischenich 2001) based on average to above average rooting depth and density. Higher thresholds are common and viable under very high levels of vegetative encroachment and realistically this could be argued as applicable in the Midves Court reach, especially as it continues to grow in.

Carson Road

The reach average bankfull flow from cross-section modeling, as appended, was determined to be 1.69m^3 s^{-1} in the Snow Valley Road reach. Geomorphic characteristics are summarized in **Table 2** and erosion threshold indicators are shown in **Table 3**.

Table 2: Willow Creek Tributary below Snow Valley Road, bankfull summary

	low flow morphology type	active width (m)	width / max depth ratio	gradient (m m^{-1})	substrate D_{50} (mm)
X-sec. 1	riffle	4.65	8.5	0.016	20
X-sec. 2	riffle	5.10	8.4	0.022	25
X-sec. 3	run	4.75	8.3	0.019	45
X-sec. 4	pool	5.10	7.8	0.011	15
X-sec. 5	pool	5.10	7.4	0.009	20

Table 3: Willow Creek Tributary below Snow Valley Road, erosion threshold indicators

	shear stress (N m^{-2})	mean velocity (m s^{-1})	stream power (watts m^{-1})	Froude #
X-sec. 1	47.7	1.14	264	0.65
X-sec. 2	56.6	1.21	364	0.74
X-sec. 3	52.2	1.18	315	0.68
X-sec. 4	34.4	0.98	183	0.53
X-sec. 5	30.2	0.92	149	0.49
mean	44.2	1.09	255	0.62

Existing condition shear and velocity results fully meet criteria for vegetation control at two sections while all sections meet stream power criteria. Particle size criteria are generally not met for the D_{50} size but are met for the D_{84} size on average. Based on the integrated consideration of both vegetation control and particle size stability, two cross-sections are considered potentially unstable, two are considered cautionary for dynamic stability and one section has dynamic stability.

The secondary checks of stream power and Froude number, under existing conditions, suggest that although there is evidence of erosion, the reach is not aggressively adjusting. Stream power is below a stability threshold of 400 watts m^{-1} (Sear et. al. 2003) and all Froude numbers are less than one thus confirming subcritical flow.

Based on these results, minor iterations were made to adjust flow stage at four of five sections to produce a net result of dynamic stability with a balance of stable criteria exceeding potentially unstable conditions. The detailed cross-section modeling results are appended, showing stage lowering adjustments ranging from 4 to 10cm. The comparison between existing bankfull and dynamic stability adjusted conditions are further shown in a summary model after the cross-section results. The reach averaged stability flow threshold was determined to be 1.29m^3 s^{-1} representing a flow stage 6cm on average below existing bankfull.

The results for Carson Road indicate that an exceedance-duration analysis methodology should be used for proposed hydrology conditions. Given that the depth average difference between bankfull and dynamic stability is only 6cm, a single flow stage step representing this difference is deemed appropriate to establish the existing and proposed stability indices.

Doran Road

The reach average bankfull flow from cross-section modeling was determined to be 0.59m^3 s^{-1} in the Midves Court reach. Due to the relative simplicity of the feature in this reach only four cross-sections were surveyed. Geomorphic characteristics are summarized in **Table 4** and erosion threshold indicators are shown in **Table 5**. The detailed cross-section modeling results are appended.

Table 4: Willow Creek Tributary at Midves Court, bankfull summary

	low flow morphology type	active width (m)	width / max depth ratio	gradient (m m^{-1})	substrate D_{50} (mm)
X-sec. 1	run	3.00	7.7	0.019	0.1
X-sec. 2	run	2.90	7.4	0.019	0.1
X-sec. 3	run	3.00	7.9	0.020	0.25
X-sec. 4	run	3.20	9.1	0.021	0.25

Table 5: Willow Creek Tributary at Midves Court, erosion threshold indicators

	shear stress (N m^{-2})	mean velocity (m s^{-1})	stream power (watts m^{-1})	Froude #
X-sec. 1	39.4	0.89	110	0.60
X-sec. 2	40.1	0.90	110	0.60
X-sec. 3	40.9	0.90	115	0.62
X-sec. 4	40.7	0.89	121	0.63
mean	40.3	0.9	114	0.61

Existing condition shear and velocity results fully meet criteria for vegetation control at all sections. The secondary checks of stream power and Froude number corroborate that the reach is stable as each stream power calculation is well below a stability threshold of 400 watts m^{-1} (Sear et. al. 2003) and all Froude numbers are less than one thus confirming continuous subcritical flow.

Based on these measurements there is no need to adjust flow stage for stability testing because the reach is deemed fully stable at bankfull or active flow due to biotechnical reinforcement. The results suggest that vegetation-hydroperiod analysis is appropriate as a conservative check of future stability. This analysis will check potential impacts to

vegetation viability under longer flow event inundation of the bankfull stage, under post development flows.

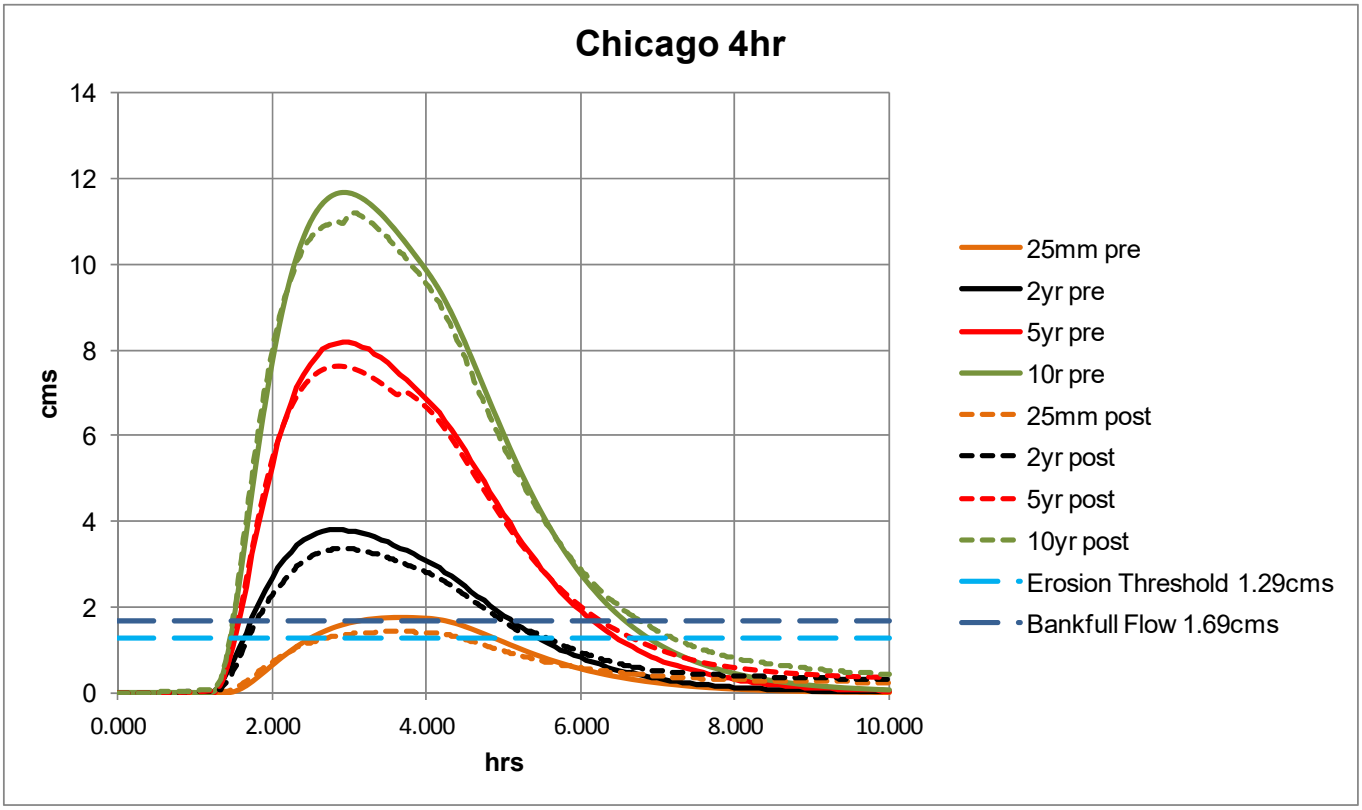
Erosion Threshold Analysis

Carson Road - Flow Exceedance and Time Duration Analysis

Based on the results of threshold determination, exceedance-duration analysis is appropriate using the flow stage interval from 1.29m^3 s^{-1} to 1.69m^3 s^{-1}. Given that this flow difference only represents an average 6cm reduction in flow stage, there is no need to iteratively break down the analysis in more than one stage step (which is appropriate at greater flow depth differences and when channel geometry influences the related flow rates at each step, i.e. certain steps can have greater influence). Multiple flow steps are thus not needed as multipliers to determine an overall stability discharge index. Using the single increment recommendation, the exceedance test is therefore simply presented as a time exceedance matching exercise between existing and proposed conditions. Further, although the channel and flood plain connection has been characterized as partially confined and partially entrenched, peak flow stages are qualified as relatively low. It is deemed that there is no need to include the time interval of flows exceeding and falling back over the bankfull rate. These flood plain peak flows generally have a lower ratio of cross-sectional area to wetted perimeter, thus resulting in a lower net hydraulic radius than bankfull flows, which in turn lowers the determinations of velocity and shear stress. The flow duration of specific applicability for the flows of interest is therefore measured by the rising hydrograph time component, from 1.29m^3 s^{-1} to 1.69m^3 s^{-1}, and the falling component, from 1.69m^3 s^{-1} to 1.29m^3 s^{-1} plus the full time component of all flow events above 1.29m^3 s^{-1} but less than 1.69m^3 s^{-1}. Recognizing that these flows occur below the bankfull peak, the time duration of this component is conservative (the magnitude of potential erosion increases with stage) and thus qualitatively may help balance against the condition when flow peaks over bankfull will reverse shear and velocity values at the point of breaking bank, until they drop sufficiently below the original threshold criteria.

The detailed analysis and results of event hydrology modeling are presented under separate cover by SCS Consulting. The hydrology modeling is noted to incorporate a 15% flow increase over standard or existing criteria, based on a theoretical future climate change scenario. Using the detailed hydrograph results, plots were made of the Chicago 4hr storm distribution, including the 25mm event, to show existing and proposed conditions at Snow Valley Road, representing the flow node location of channel cross-section surveys. Plots up the 10yr event were made to illustrate frequent event hydrographs. **Figure 2** shows the plotting results.

Figure 2: Chicago 4hr hydrographs



The hydrograph time steps were reviewed and the rising and falling time durations from threshold flow to bankfull flow were charted for the events up to and including the 10yr. From Figure 2 it can be seen that the 5 and 10yr events are well above the bankfull flow. As explained earlier, overbank flows generally result in dropping erosion indicators due to the function of hydraulic geometry. Nonetheless, given the also noted partial confinement and partial entrenchment seen discontinuously through the study reach it was felt appropriate to include at least these events, even though the effects on erosion potential would be variable. Inclusion is therefore conservative as the analysis of time duration assumes the full time step is available for erosion to occur, when realistically it will actually be dynamic in response to geometry and flow rate.

Exceedance hours were totalled for each event and multiplied by a coefficient representing frequency over 10 years, with the 25mm event assumed to happen 3 times per year on average. The full time duration of the 25mm was used over the threshold flow because the proposed condition peak is less than bankfull and the existing condition peak is marginally above. **Table 6** presents the results of duration exceedance analysis with regard to existing and proposed conditions.

Table 6: Duration exceedance results for frequent flows (4hr Chicago)

	rising hrs	falling hrs	rising + falling hrs	prop - ex hrs	coeff	(prop - ex) X coeff	
25mm ex	n.a.	n.a.	2.417				
25mm prop	n.a.	n.a.	1.700	-0.717	30	-21.51	
2yr ex	0.166	0.416	0.582				
2yr prop	0.166	0.533	0.500	-0.082	5	-0.41	
5yr ex	0.083	0.417	0.501				
5yr prop	0.067	0.434	0.501	0	2	0	
10yr ex	0.083	0.417	0.500				
10yr prop	0.067	0.467	0.534	0.034	1	0.034	
						-21.886	hrs

The detailed results show that over a representative 10 year scenario there will be approximately 22 hours less duration of flow resulting in potential erosion under proposed conditions compared to existing conditions. The largest difference in event duration occurs through extended detention of the 25mm storm. Based on these results, the proposed stormwater management program is deemed to not result in an increase in future erosion potential.

Doran Road - Vegetation-Hydroperiod Analysis

Vegetation-hydroperiod testing was done to check the integrity of the soil and vegetation matrix lining the channel due to flow duration changes at levels below the threshold or stable bankfull flow. Modeling was used to gauge the affect of saturation over time on the mechanical rooting density and surface layer velocity protection thresholds of biotechnical reinforcement. Cross-section 3 was used for this analysis because it has the highest or most conservative bankfull velocity, combined with the highest tractive force, compared to the other surveyed sections.

Using flow stage adjustments in the cross-section model to achieve flow stage increments for the 25mm, 2yr, and 5yr events, the velocity at each stage was conservatively tested against allowable duration curves for average and high density groundcover vegetation conditions. The 25mm event falls below the determined bankfull flow while the 2yr is marginally under with the 5yr being the highest frequency modelled event that fully incorporates bankfull flow. Using the results of event hydrology modeling prepared by SCS Consulting, the existing and proposed flow duration at each flow increment was tabulated within the model. Allowable event durations were generated and comparative results were produced. The analysis is qualified as being conservative because the velocities at the peak of flow stages under bankfull are used to represent

the entire flow stage increment. The 5yr event is further qualified by using the velocity representing bankfull, and not the peak of the event because of the velocity reversal that occurs after flows enter the flood plain. Flow rate cut-offs of 25 litres/sec were used in the duration counting due to experience with lesser flows rarely defining identifiable low flow characterization (i.e. no geometry with highly anastomising or stagnant flow in vegetation) and due to the excessive drawn out recession effect of the synthetic storm hydrograph (i.e. nominal declining flow volume, which technically is at much lower velocity than used for conservative modeling). Detailed modeling results and the representative velocity duration curves used for this analysis are appended.

The results for both average and high density vegetative conditions corroborate the qualitative observations of existing conditions and suggest that biotechnical vegetation control is presently the defining stability condition for the study site. The results for proposed conditions show that under average density vegetative conditions there are duration exceedances in all events. However, the results also show that high density vegetative conditions are sufficient under proposed conditions to meet targets. Existing and proposed durations under high density conditions show that despite the increase in event times from approximately 3hrs to 34-59hrs across the flow range, allowable durations are significantly higher in the range of 10 to 21 days (essentially semi permanent flow). The results thus show that there is some risk under proposed conditions if only average density groundcover vegetation exists, but that the risk can be mitigated if high density vegetative protection is maintained.

The results also suggest that existing vegetation type may be affected with regard to the duration relationship for wet or dry conditions affinity species. In this regard the extended event flows represent durations that existing vegetative types are not exposed to. Given that existing vegetative growth and density is a function of recent channel easement work, it would be expected that if left unmaintained the density of vegetation will increase naturally until such time that it might be affected by future flow duration change. Without significant forest canopy shading, when future flow durations increase there will be a shift to wet affinity species under longer term shallow saturation. Typically in channels that lack depth and steep banks there can be development of emergent cattail stands and related riparian wet meadow vegetation. This naturalization response would still be deemed to represent high density vegetation, and may in fact evolve to represent the highest density potential for the site due to the positive influence of enhanced availability of base flow.

Based on the vegetation-hydroperiod analysis results, biotechncial control maintaining channel stability is concluded to be provided under proposed conditions on the

assumption that high density vegetation conditions will continue to evolve and will be preserved in the future.

Conclusions

Erosion threshold analysis has been undertaken for two reaches of Willow Creek Tributaries that will receive stormwater discharge from proposed residential developments in the Township of Springwater.

Analysis has been done based on field review of channel sensitivity below proposed stormwater pond outlets and detailed cross-section surveys of the downstream locations that will receive combined flows from the development blocks. Erosion threshold modeling results were used in exceedance duration analysis for the Carson Road development and vegetation-hydroperiod analysis was used for the Doran Road development. Results of analysis conclude that levels of dynamic stability will be maintained in the receiving reaches based on the proposed stormwater management program. Flow duration between the threshold flow and bankfull flow will be slightly lower in proposed conditions below the Carson Road development, from an exceedance-duration basis. Allowable criteria for extended saturation levels below bankfull flow will not be detrimental to stability for the system below the Doran Road development, from a vegetation-hydroperiod basis, based on the recommendation to perpetually maintain high density vegetation.

The methods of analysis presented in this report do not preclude a catastrophic event potentially causing some erosion due to unforeseen circumstances (e.g. SWM pond failure, culvert failures, major debris jam scour, beaver dam construction/breaching, or combinations thereof, etc.). The results presented here are also contingent on long term preservation and maintenance of the existing natural vegetation and local geology conditions within the respective corridors.

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GEO-RAP v.1.2 Rapid Assessment Protocol Model

B. de Geus 03.12

Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Carson Road Reach
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	
	n/7 =	0.14
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	1
	Exposed tree roots	1
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.30
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.00
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	0.11
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	88.9

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	16	20--16	15-11	10-6	5-0
Embeddedness	11	20--16	15-11	10-6	5-0
Velocity / Depth Regime	11	20--16	15-11	10-6	5-0
Sediment Deposition	14	20--16	15-11	10-6	5-0
Channel Flow Status	12	20--16	15-11	10-6	5-0
Channel Alteration	18	20--16	15-11	10-6	5-0
Frequency of Riffles	9	20--16	15-11	10-6	5-0
Bank Stability u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
/200	147				
/100	73.5	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Pool Substrate Characterization		20--16	15-11	10-6	5-0
Pool Variability		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Channel Sinuosity		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	9	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	7	8-7	6-5	4-3	2-0
Physical Instream Habitat	7	8-7	6-5	4-3	2-0
Water Quality	7	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	7	7-6	5-4	3-2	1-0
Biological Indicators	6	8-7	6-5	4-3	2-0
/50	43				
/100	86.0	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	82.8	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0



▲ Overview looking upstream from Carson Road showing dense groundcover encroachment and thicket

▼ Overview looking downstream from Carson Road showing transition from wetland pool to thicket



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GEO-RAP v.1.2 Rapid Assessment Protocol Model

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Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Wilson Road Reach
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	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	
	n/7 =	0.14
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	
	Exposed tree roots	
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.10
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	1
	n/7 =	0.14
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.10**
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	**90.4**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	16	20--16	15-11	10-6	5-0
Embeddedness	11	20--16	15-11	10-6	5-0
Velocity / Depth Regime	12	20--16	15-11	10-6	5-0
Sediment Deposition	14	20--16	15-11	10-6	5-0
Channel Flow Status	13	20--16	15-11	10-6	5-0
Channel Alteration	17	20--16	15-11	10-6	5-0
Frequency of Riffles	11	20--16	15-11	10-6	5-0
Bank Stability u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
/200	150				
/100	**75.0**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Pool Substrate Characterization		20--16	15-11	10-6	5-0
Pool Variability		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Channel Sinuosity		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	9	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	6	8-7	6-5	4-3	2-0
Physical Instream Habitat	7	8-7	6-5	4-3	2-0
Water Quality	7	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	6	7-6	5-4	3-2	1-0
Biological Indicators	6	8-7	6-5	4-3	2-0
/50	41				
/100	**82.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	**82.5**	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0



▲ Overview looking upstream from Wilson Road showing dense groundcover encroachment



▼ Overview looking downstream from Wilson Road showing transition from groundcover encroachment to forest

References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

B. de Geus 03.12

Project: **Erosion Threshold Analysis - CRDI**
Willow Creek Tributary, Snow Valley Road Reach
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	1
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	1
	n/7 =	0.43
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	1
	Scour pools d/s of culverts/stormsewer outlets	1
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.20

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	1
	Exposed tree roots	1
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.30
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	1
	n/7 =	0.14
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.27**
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	**73.2**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	18	20--16	15-11	10-6	5-0
Embeddedness	11	20--16	15-11	10-6	5-0
Velocity / Depth Regime	15	20--16	15-11	10-6	5-0
Sediment Deposition	14	20--16	15-11	10-6	5-0
Channel Flow Status	16	20--16	15-11	10-6	5-0
Channel Alteration	17	20--16	15-11	10-6	5-0
Frequency of Riffles	14	20--16	15-11	10-6	5-0
Bank Stability u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	7	10-8	7-6	5-3	2-0
u/s R	7	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
/200	153				
/100	**76.5**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Pool Substrate Characterization		20--16	15-11	10-6	5-0
Pool Variability		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Channel Sinuosity		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	8	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	6	8-7	6-5	4-3	2-0
Physical Instream Habitat	7	8-7	6-5	4-3	2-0
Water Quality	7	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	6	7-6	5-4	3-2	1-0
Biological Indicators	6	8-7	6-5	4-3	2-0
/50	40				
/100	**80.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	**76.6**	100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		100-80	80-56	55-30	29-0



▲ Overview looking upstream from top of slope, towards Snow Valley Road, showing confinement and toe contact

▼ Overview looking downstream at creek level showing entrenched valley form



References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

B. de Geus 03.12

Project: Erosion Threshold Analysis - MDDRI
Willow Creek Tributary, Pooles Road Reach
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	
	Medial bars	
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	
	n/7 =	0.00
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	
	Occurrence of Large Organic Debris	
	Exposed tree roots	
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.00
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	1
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.14
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	0.04
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	96.4

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Embeddedness		20--16	15-11	10-6	5-0
Velocity / Depth Regime		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Frequency of Riffles		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	1	20--16	15-11	10-6	5-0
Pool Substrate Characterization	0	20--16	15-11	10-6	5-0
Pool Variability	0	20--16	15-11	10-6	5-0
Sediment Deposition	20	20--16	15-11	10-6	5-0
Channel Flow Status	0	20--16	15-11	10-6	5-0
Channel Alteration	15	20--16	15-11	10-6	5-0
Channel Sinuosity	5	20--16	15-11	10-6	5-0
Bank Stability u/s L	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
Vegetative Protection	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
/200	101				
/100	50.5	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	10	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	4	8-7	6-5	4-3	2-0
Physical Instream Habitat	1	8-7	6-5	4-3	2-0
Water Quality	7	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	4	7-6	5-4	3-2	1-0
Biological Indicators	0	8-7	6-5	4-3	2-0
/50	26				
/100	52.0	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	66	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0



▲ Overview looking downstream from Russel Road to Pooles Road; no defined channel, dense groundcover, ephemeral wide shallow level spreading surface flow or influent

▼ Looking downstream from Pooles Road; no defined channel until modest ephemeral swale gradually develops in forest



References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

B. de Geus 03.12

Project: Erosion Threshold Analysis - MDDRI
Willow Creek Tributary, Midves Court Reach
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	
	Medial bars	
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	1
	n/7 =	0.14
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	
	Occurrence of Large Organic Debris	
	Exposed tree roots	
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.00
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	1
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	1
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.29
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.11**
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	**89.3**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Embeddedness		20--16	15-11	10-6	5-0
Velocity / Depth Regime		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Frequency of Riffles		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	6	20--16	15-11	10-6	5-0
Pool Substrate Characterization	7	20--16	15-11	10-6	5-0
Pool Variability	4	20--16	15-11	10-6	5-0
Sediment Deposition	8	20--16	15-11	10-6	5-0
Channel Flow Status	2	20--16	15-11	10-6	5-0
Channel Alteration	10	20--16	15-11	10-6	5-0
Channel Sinuosity	6	20--16	15-11	10-6	5-0
Bank Stability u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Vegetative Protection	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
/200	95				
/100	**47.5**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	9	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	4	8-7	6-5	4-3	2-0
Physical Instream Habitat	4	8-7	6-5	4-3	2-0
Water Quality	6	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	4	7-6	5-4	3-2	1-0
Biological Indicators	0	8-7	6-5	4-3	2-0
/50	27				
/100	**54.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	**64**	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0



▲ Overview looking upstream over recently constructed 'swale' definition, confluent with cul-de-sac ditching in foreground

▼ Overview looking downstream at confluence with cul-de-sac ditching



References

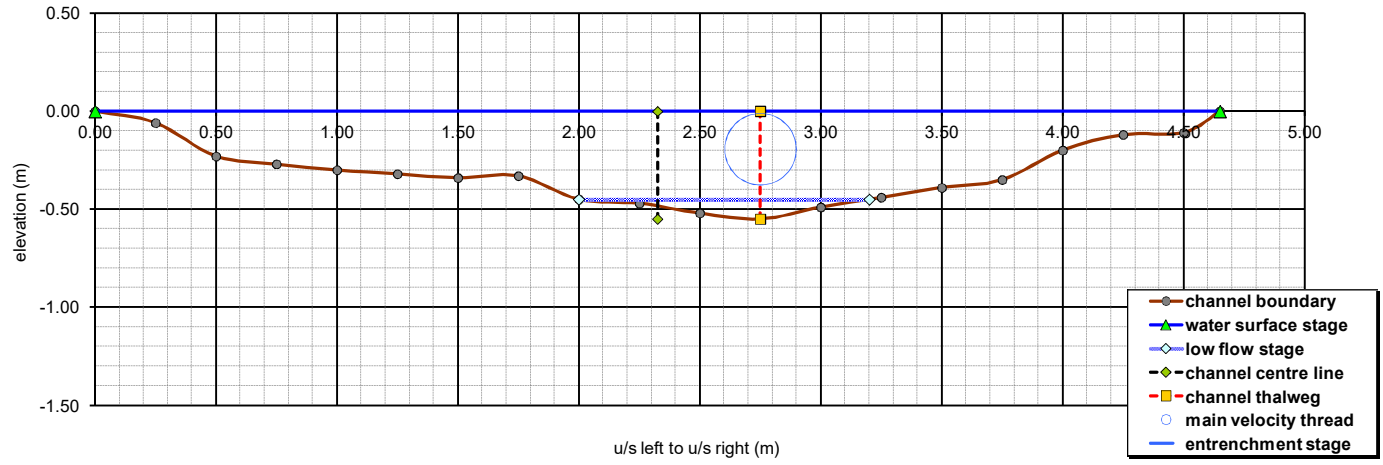
1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Snow Valley Road Reach
Section 1

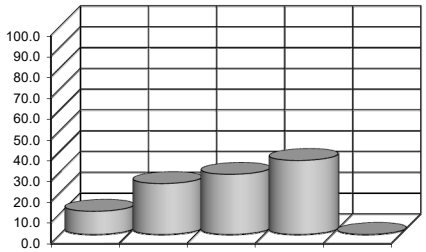
B. de Geus 05.11

Cross Section Plot





Substrate Type



Morphology Type	
cascade	
step	
riffle	●
run	
glide	
pool	
thalweg out of phase	

Hydraulic Roughness	
rr R/D_{84}	2.54
ff V mean/V*	5.39
ff D_{84}	5.24
ff mean	5.32
ROUGH BED	

Hydraulic Geometry	
A (m^2)	1.48
R (m)	0.30
TW (m)	4.65
WP (m)	4.86
max d (m)	0.55
mean d (m)	0.32
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Ratios	
ER max d	4.30
r_c / TW	
TW / Lf_w	3.88
TW/max d	8.5
TW/mean d	14.6

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.126	3.12	NO	NO	NO	YES
V_* (m s^{-1})	0.099	D_{50}	0.655	16.19	NO	NO	NO	NO
		D_{84}	1.608	39.73	NO	NO	NO	NO

Section Data

ER_e (m)	0.55	ER stations L / R	-5.00	15.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	4.65	4.65
Lf_e (m)	-0.450	Lf stations L / R	2.00	3.20	
W_{fp} (m)	20.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.55	2.75	
E_g (m m^{-1})	0.0160				

Bedload Transport Data

Rosgen type	Strickler Q_{sb} (kg sec^{-1})	Limerinos Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
B3	0.0022	0.0023	T_*	49.2	2.5	0.4
C3	0.0008	0.0009	saltation	YES	YES	NO
C4	0.0083	0.0086	rolling	YES	YES	NO
			Ø	NO	NO	YES

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.30	1.00	20.00	120.00	190.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.29	0.97	19.40	116.40	184.30
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds

		V_c / V_b	
τ_{calc} (kg m^{-2})	4.87		
τ_{calc} (N m^{-2})	47.72	Strickler	Limerinos
$\tau\ D_{crit}$ (gr-co) (mm)	49.20	0.87	
D_{50} V_c (vcs +) (m s^{-1})	0.69	0.87	
D_{84} V_c (vcs +) (m s^{-1})	1.70	2.13	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
11.1	24.4	28.9	35.6	0.0

Bank Data u/s L u/s R

H_b (m)	
Bf_d (m)	
RDp (m)	
H_b/Bf_d	
RDp/H_b	
RDn (%)	
BA (°)	
BFP (%)	

Flow Regime

Strickler method	
Q (cms)	1.687
V (m s^{-1})	1.14
n	0.050
Fr	0.65
D_c rectangular (m)	0.24
D_c trapezoidal (m)	0.40
D_c triangular (m)	0.58
D_c parabolic (m)	0.37
D_c mean (m)	0.40
flow type	SUBCRITICAL
Ω (watts m^{-1})	264.48
ω_a (watts m^{-2})	54.40
ω_a/TW (watts m^{-1})	11.70
Re^*	39.2
Re	304351
turbulence	HIGH

Flow Regime

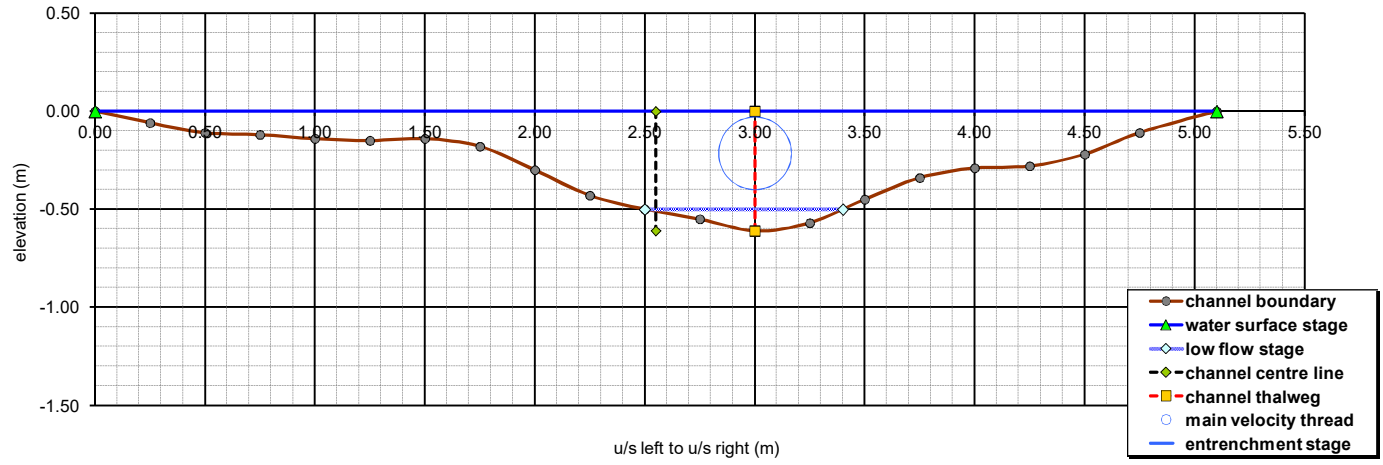
Limerinos method	
Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
Re^*	
Re	
turbulence	

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

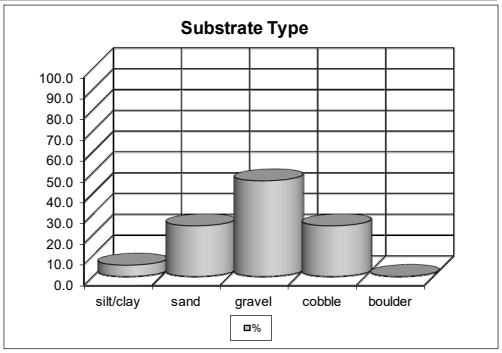
Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Snow Valley Road Reach
Section 2

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Cross Section Plot







Morphology Type	
cascade	
step	
riffle	●
run	
glide	
pool	
thalweg out of phase	

Hydraulic Roughness	
rr R/D_{84}	3.28
ff V mean/V*	5.63
ff D_{84}	5.87
ff mean	5.75
ROUGH BED	

Hydraulic Geometry	
A (m^2)	1.39
R (m)	0.26
TW (m)	5.10
WP (m)	5.30
max d (m)	0.61
mean d (m)	0.27
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Ratios	
ER max d	3.14
r_c / TW	
TW / Lf_w	5.67
TW/max d	8.4
TW/mean d	18.7

Sediment Transport Mode			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.247	5.59	NO	NO	NO	YES
V_* (m s^{-1})	0.108	D_{50}	0.733	16.63	NO	NO	NO	NO
		D_{84}	1.313	29.77	NO	NO	NO	NO

Section Data					
ER_e (m)	0.61	ER stations L / R	-10.00	6.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	5.10	5.10
Lf_e (m)	-0.500	Lf stations L / R	2.50	3.40	
W_{fp} (m)	16.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m)	$T_{o/s}$ (m)	-0.61	3.00
E_g (m m^{-1})	0.0220				

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.20	3.00	25.00	80.00	150.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.19	2.91	24.25	77.60	145.50
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds		V_c / V_b	
τ_{calc} (kg m^{-2})	5.78		
τ_{calc} (N m^{-2})	56.63		
$\tau\ D_{crit}$ (gr-co) (mm)	58.38	Strickler	Limerinos
D_{50} V_c (vcs +) (m s^{-1})	0.78	0.91	
D_{84} V_c (vcs +) (m s^{-1})	1.39	1.64	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
5.4	24.3	45.9	24.3	0.0

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Bedload Transport Data						
	Strickler Q	Limerinos Q		D_{30}	D_{50}	D_{84}
Rosgen type	Q_{sb} (kg sec^{-1})	Q_{sb} (kg sec^{-1})	T_*	19.5	2.3	0.7
B3	0.0022	0.0023	saltation	YES	YES	NO
C3	0.0008	0.0012	rolling	YES	YES	NO
C4	0.0083	0.0091	Ø	NO	NO	YES

Flow Regime Strickler method	
Q (cms)	1.687
V (m s^{-1})	1.21
n	0.050
Fr	0.74
D_c rectangular (m)	0.23
D_c trapezoidal (m)	0.40
D_c triangular (m)	0.58
D_c parabolic (m)	0.38
D_c mean (m)	0.40
flow type	SUBCRITICAL
Ω (watts m^{-1})	363.78
ω_a (watts m^{-2})	68.60
ω_a/TW (watts m^{-1})	13.45
Re^*	50.1
Re	279093
turbulence	HIGH

Flow Regime Limerinos method	
Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
Re^*	
Re	
turbulence	

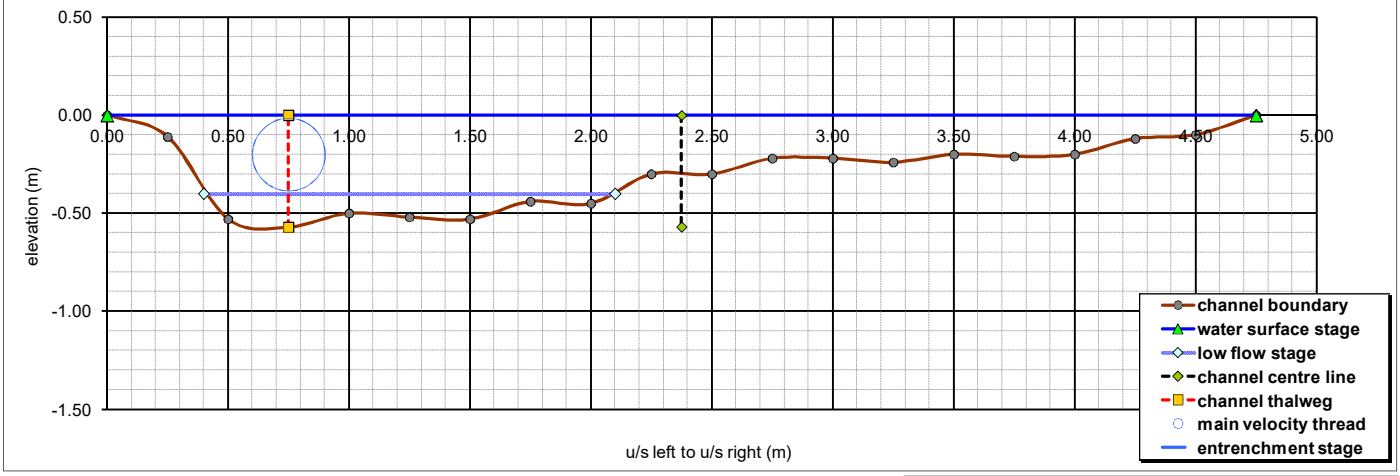
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Snow Valley Road Reach
Section 3

AquaLogic

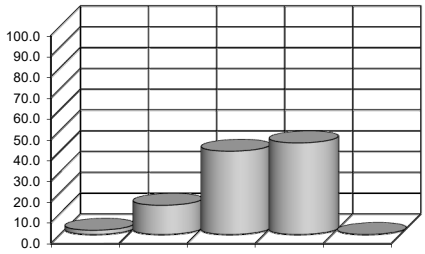
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Cross Section Plot





Substrate Type



Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	1.44
R (m)	0.28
TW (m)	4.75
WP (m)	5.13
max d (m)	0.57
mean d (m)	0.30
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R/D_{84}	2.55
ff V mean/V*	5.38
ff D_{84}	5.34
ff mean	5.36
ROUGH BED	

Hydraulic Ratios	
ER max d	5.26
r_c / TW	
TW / Lf_w	2.79
TW/max d	8.3
TW/mean d	15.7

Sediment Transport Mode			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.412	9.74	NO	NO	NO	NO
V_* (m s^{-1})	0.103	D_{50}	0.984	23.24	NO	NO	NO	NO
		D_{84}	1.540	36.35	NO	NO	NO	NO

Section Data					
ER_e (m)	0.57	ER stations L / R	-10.00	15.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	4.75	4.75
Lf_e (m)	-0.400	Lf stations L / R	0.40	2.10	
W_{fp} (m)	25.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.57	0.75	
E_g (m m^{-1})	0.0190				

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	1.00	8.00	45.00	110.00	210.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.97	7.76	43.65	106.70	203.70
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds		V_c / V_b	
τ_{calc} (kg m^{-2})	5.33		
τ_{calc} (N m^{-2})	52.24	Strickler	Limerinos
$\tau\ D_{crit}$ (gr-co) (mm)	53.86		
D_{50} V_c (vcs +) (m s^{-1})	1.04	1.26	
D_{84} V_c (vcs +) (m s^{-1})	1.63	1.97	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
2.0	14.0	40.0	44.0	0.0

Bank Data u/s L	u/s R
H_b (m)	
Bf_d (m)	
RDp (m)	
H_b/Bf_d	
RDp/H_b	
RDn (%)	
BA (°)	
BFP (%)	

Bedload Transport Data						
	Strickler Q	Limerinos Q		D_{30}	D_{50}	D_{84}
Rosgen type	Q_{sb} (kg sec^{-1})	Q_{sb} (kg sec^{-1})	T_*	6.7	1.2	0.5
B3	0.0022	0.0023	saltation	YES	NO	NO
C3	0.0008	0.0010	rolling	YES	YES	NO
C4	0.0083	0.0087	Ø	NO	NO	YES

Flow Regime Strickler method	
Q (cms)	1.694
V (m s^{-1})	1.18
n	0.050
Fr	0.68
D_c rectangular (m)	0.24
D_c trapezoidal (m)	0.40
D_c triangular (m)	0.58
D_c parabolic (m)	0.37
D_c mean (m)	0.40
flow type	SUBCRITICAL
Ω (watts m^{-1})	315.45
ω_a (watts m^{-2})	61.46
ω_a/TW (watts m^{-1})	12.94
*Re**	90.8
Re	289540
turbulence	HIGH

Flow Regime Limerinos method	
Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
*Re**	
Re	
turbulence	

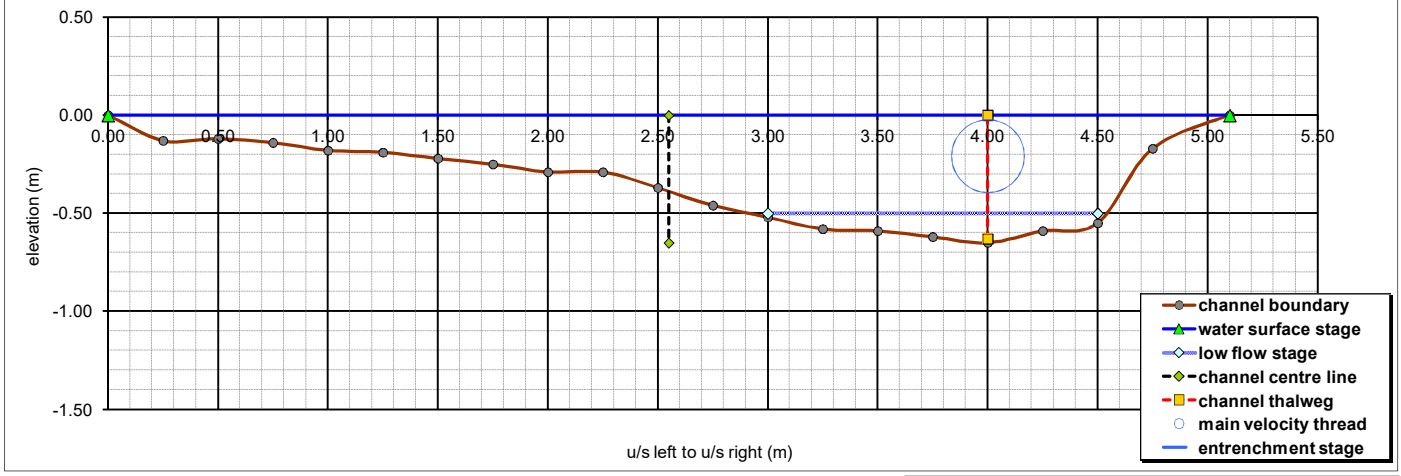
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

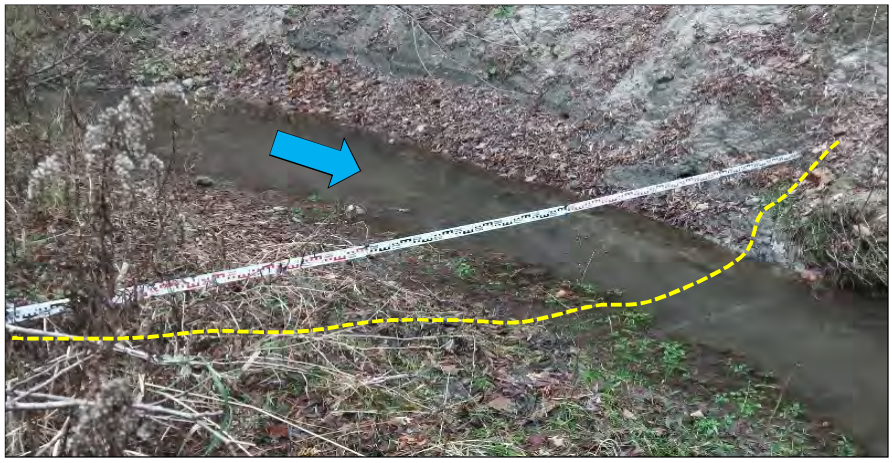
Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Snow Valley Road Reach
Section 4

AquaLogic

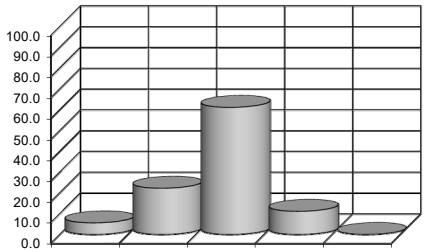
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Cross Section Plot





Substrate Type



Morphology Type	
cascade	
step	
riffle	
run	
glide	
pool	●
thalweg out of phase	

Hydraulic Roughness	
rr R/D_{84}	5.80
ff V mean/V*	6.42
ff D_{84}	7.34
ff mean	6.88
ROUGH BED	

Hydraulic Geometry	
A (m^2)	1.74
R (m)	0.32
TW (m)	5.10
WP (m)	5.44
max d (m)	0.65
mean d (m)	0.34
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Ratios	
ER max d	3.14
r_c / TW	
TW / Lf_w	3.40
TW/max d	7.8
TW/mean d	15.0

Sediment Transport Mode			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.040	1.17	NO	YES	YES	YES
V_* (m s^{-1})	0.084	D_{50}	0.567	16.50	NO	NO	NO	NO
		D_{84}	1.089	31.68	NO	NO	NO	NO

Section Data					
ER_e (m)	0.65	ER stations L / R	-10.00	6.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	5.10	5.10
Lf_e (m)	-0.500	Lf stations L / R	3.00	4.50	
W_{fp} (m)	16.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.63	4.00	
E_g (m m^{-1})	0.0110				

Bedload Transport Data						
	Strickler Q	Limerinos Q		D_{30}	D_{50}	D_{84}
Rosgen type	Q_{sb} (kg sec^{-1})	Q_{sb} (kg sec^{-1})	T_*	118.1	2.4	0.6
B3	0.0022	0.0025	saltation	YES	YES	NO
C3	0.0008	0.0017	rolling	YES	YES	NO
C4	0.0083	0.0099	Ø	NO	NO	YES

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.30	0.30	15.00	55.00	130.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.29	0.29	14.55	53.35	126.10
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds		V_c / V_b	
τ_{calc} (kg m^{-2})	3.51		
τ_{calc} (N m^{-2})	34.38	Strickler	Limerinos
$\tau\ D_{crit}$ (gr-co) (mm)	35.44		
D_{50} V_c (vcs +) (m s^{-1})	0.60	0.88	
D_{84} V_c (vcs +) (m s^{-1})	1.15	1.68	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
5.6	22.2	61.1	11.1	0.0

Bank Data u/s L	u/s R
H_b (m)	
Bf_d (m)	
RDp (m)	
H_b/Bf_d	
RDp/H_b	
RDn (%)	
BA (°)	
BFP (%)	

Flow Regime Strickler method	
Q (cms)	1.693
V (m s^{-1})	0.98
n	0.050
Fr	0.53
D_c rectangular (m)	0.23
D_c trapezoidal (m)	0.39
D_c triangular (m)	0.58
D_c parabolic (m)	0.36
D_c mean (m)	0.39
flow type	SUBCRITICAL
Ω (watts m^{-1})	182.54
ω_a (watts m^{-2})	33.53
ω_a/TW (watts m^{-1})	6.58
Re^*	29.4
Re	272881
turbulence	HIGH

Flow Regime Limerinos method	
Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
Re^*	
Re	
turbulence	

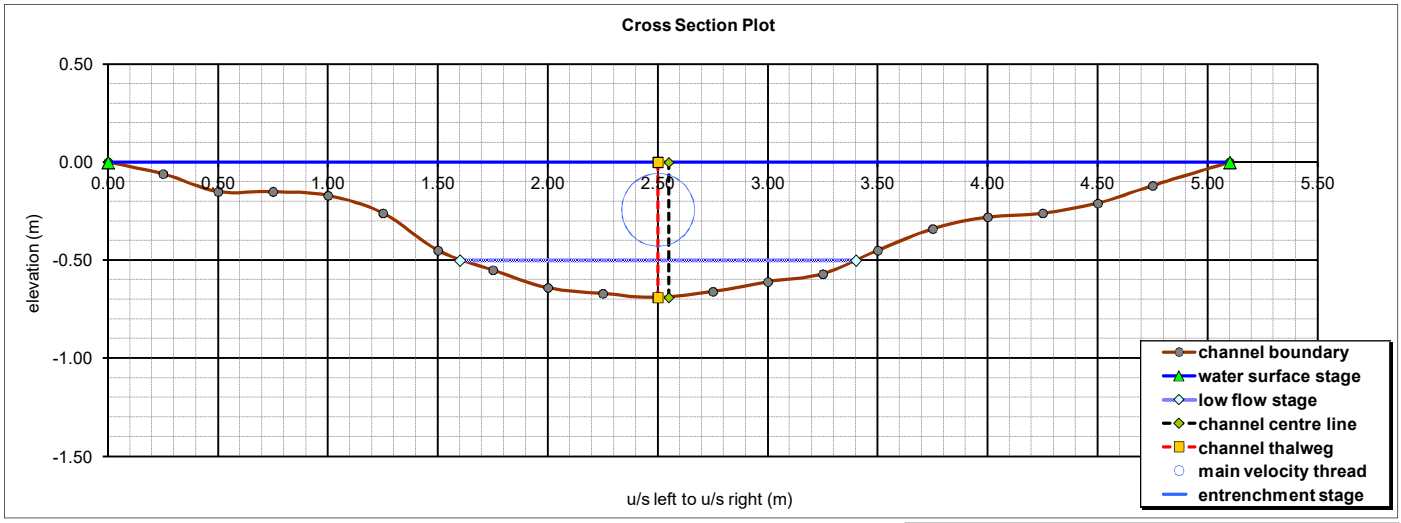
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

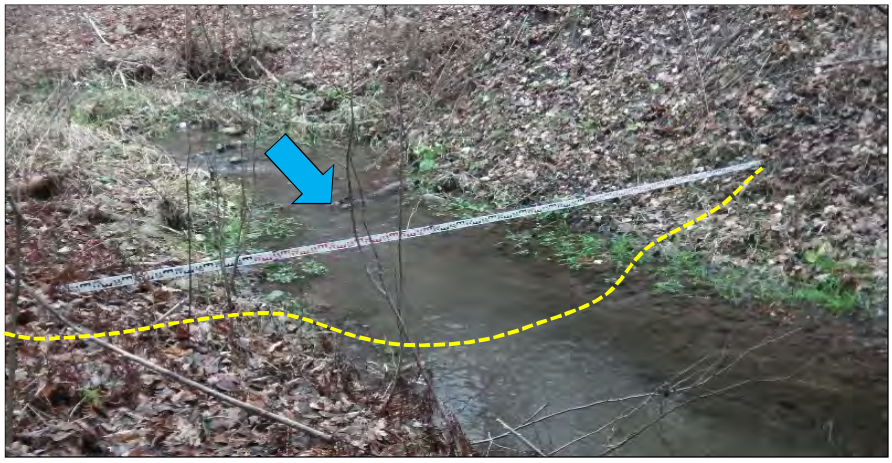
Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Snow Valley Road Reach
Section 5

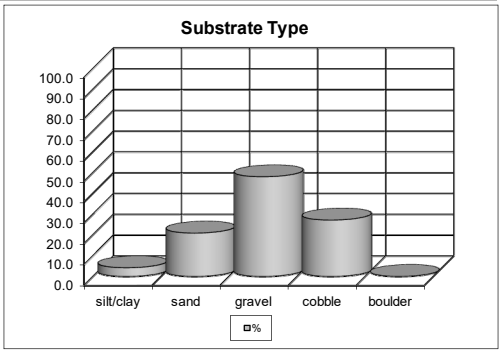
AquaLogic

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Cross Section Plot







Morphology Type	
cascade	
step	
riffle	
run	
glide	
pool	●
thalweg out of phase	

Hydraulic Roughness	
rr R/D_{84}	3.42
ff V mean/V*	5.81
ff D_{84}	5.99
ff mean	5.90
ROUGH BED	

Hydraulic Geometry	
A (m^2)	1.83
R (m)	0.34
TW (m)	5.10
WP (m)	5.35
max d (m)	0.69
mean d (m)	0.36
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Ratios	
ER max d	3.14
r_c / TW	
TW / Lf_w	2.83
TW/max d	7.4
TW/mean d	14.2

Sediment Transport Mode			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.324	10.06	NO	NO	NO	NO
V_* (m s^{-1})	0.078	D_{50}	0.655	20.37	NO	NO	NO	NO
		D_{84}	1.468	45.63	NO	NO	NO	NO

Section Data					
ER_e (m)	0.69	ER stations L / R	-10.00	6.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	5.10	5.10
Lf_e (m)	-0.500	Lf stations L / R	1.60	3.40	
W_{fp} (m)	16.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.69	2.50	
E_g (m m^{-1})	0.0090				

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.10	5.00	20.00	100.00	170.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.10	4.85	19.40	97.00	164.90
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds		V_c / V_b	
τ_{calc} (kg m^{-2})	3.08		
τ_{calc} (N m^{-2})	30.15		
$\tau\ D_{crit}$ (gr-co) (mm)	31.08	Strickler	Limerinos
D_{50} V_c (vcs +) (m s^{-1})	0.69	1.07	
D_{84} V_c (vcs +) (m s^{-1})	1.55	2.40	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
4.2	20.8	47.9	27.1	0.0

Bank Data u/s L	u/s R
H_b (m)	
Bf_d (m)	
RDp (m)	
H_b/Bf_d	
RDp/H_b	
RDn (%)	
BA (°)	
BFP (%)	

Bedload Transport Data						
	Strickler Q	Limerinos Q		D_{30}	D_{50}	D_{84}
Rosgen type	Q_{sb} (kg sec^{-1})	Q_{sb} (kg sec^{-1})	T_*	6.2	1.6	0.3
B3	0.0022	0.0023	saltation	YES	NO	NO
C3	0.0008	0.0012	rolling	YES	YES	NO
C4	0.0083	0.0090	Ø	NO	NO	YES

Flow Regime Strickler method	
Q (cms)	1.690
V (m s^{-1})	0.92
n	0.050
Fr	0.49
D_c rectangular (m)	0.23
D_c trapezoidal (m)	0.39
D_c triangular (m)	0.58
D_c parabolic (m)	0.36
D_c mean (m)	0.39
flow type	SUBCRITICAL
Ω (watts m^{-1})	149.05
ω_a (watts m^{-2})	27.86
ω_a/TW (watts m^{-1})	5.46
Re^*	38.5
Re	277091
turbulence	HIGH

Flow Regime Limerinos method	
Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
Re^*	
Re	
turbulence	

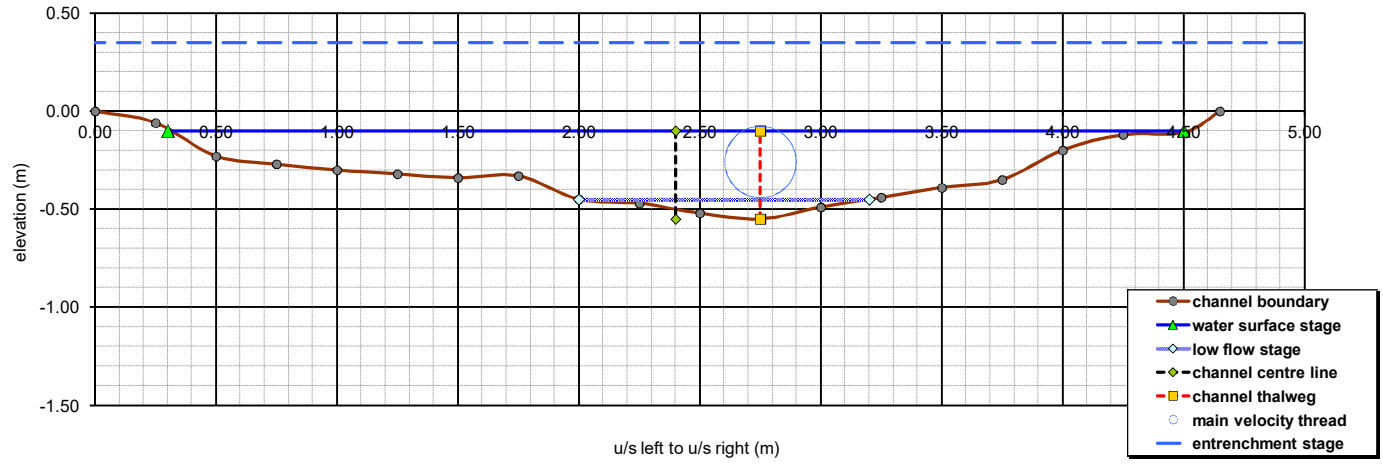
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Snow Valley Road Reach
Section 1 - Dynamic Stability Flow

AquaLogic

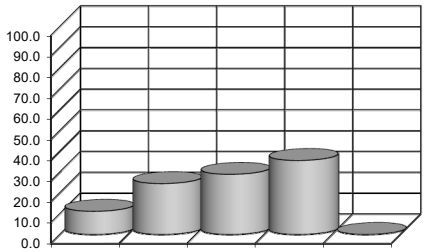
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Cross Section Plot





Substrate Type



Morphology Type

cascade	
step	
riffle	●
run	
glide	
pool	
thalweg out of phase	

Hydraulic Roughness

rr R/D_{84}	1.99
ff V mean/V*	4.98
ff D_{84}	4.62
ff mean	4.80
ROUGH BED	

Hydraulic Geometry

A (m^2)	1.04
R (m)	0.24
TW (m)	4.20
WP (m)	4.36
max d (m)	0.45
mean d (m)	0.25
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Ratios

ER max d	4.76
r_c / TW	
TW / Lf_w	3.50
TW/max d	9.3
TW/mean d	17.0

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.126	3.52	NO	NO	NO	YES
V_* (m s^{-1})	0.087	D_{50}	0.655	18.30	NO	NO	NO	NO
		D_{84}	1.608	44.90	NO	NO	NO	NO

Section Data

ER_e (m)	0.35	ER stations L / R	-5.00	15.00	TW ck
WS_e (m)	-0.100	WS stations L / R	0.30	4.50	4.20
Lf_e (m)	-0.450	Lf stations L / R	2.00	3.20	
W_{fp} (m)	20.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.55	2.75	
E_g (m m^{-1})	0.0160				

Bedload Transport Data

Rosgen type	Strickler Q_{sb} (kg sec^{-1})	Limerinos Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
B3	0.0019	0.0019	T_*	38.5	1.9	0.3
C3	0.0003	0.0003	saltation	YES	NO	NO
C4	0.0065	0.0065	rolling	YES	YES	NO
			Ø	NO	NO	YES

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.30	1.00	20.00	120.00	190.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.29	0.97	19.40	116.40	184.30
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime — Strickler method

Q (cms)	1.006
V (m s^{-1})	0.97
n	0.050
Fr	0.62
D_c rectangular (m)	0.18
D_c trapezoidal (m)	0.32
D_c triangular (m)	0.47
D_c parabolic (m)	0.30
D_c mean (m)	0.32
flow type	SUBCRITICAL
Ω (watts m^{-1})	157.81
ω_a (watts m^{-2})	36.16
ω_a/TW (watts m^{-1})	8.60
*Re**	40.7
Re	202300
turbulence	HIGH

Flow Regime — Limerinos method

Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
*Re**	
Re	
turbulence	

Erosion Thresholds

		V_c / V_b	
τ_{calc} (kg m^{-2})	3.81		
τ_{calc} (N m^{-2})	37.37	Strickler	Limerinos
τ D_{crit} (gr-co) (mm)	38.52		
D_{50} V_c (vcs +) (m s^{-1})	0.69	1.02	
D_{84} V_c (vcs +) (m s^{-1})	1.70	2.51	

Bank Data u/s L u/s R

H_b (m)	
Bf_d (m)	
RDp (m)	
H_b/Bf_d	
RDp/H_b	
RDn (%)	
BA (°)	
BFP (%)	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
11.1	24.4	28.9	35.6	0.0

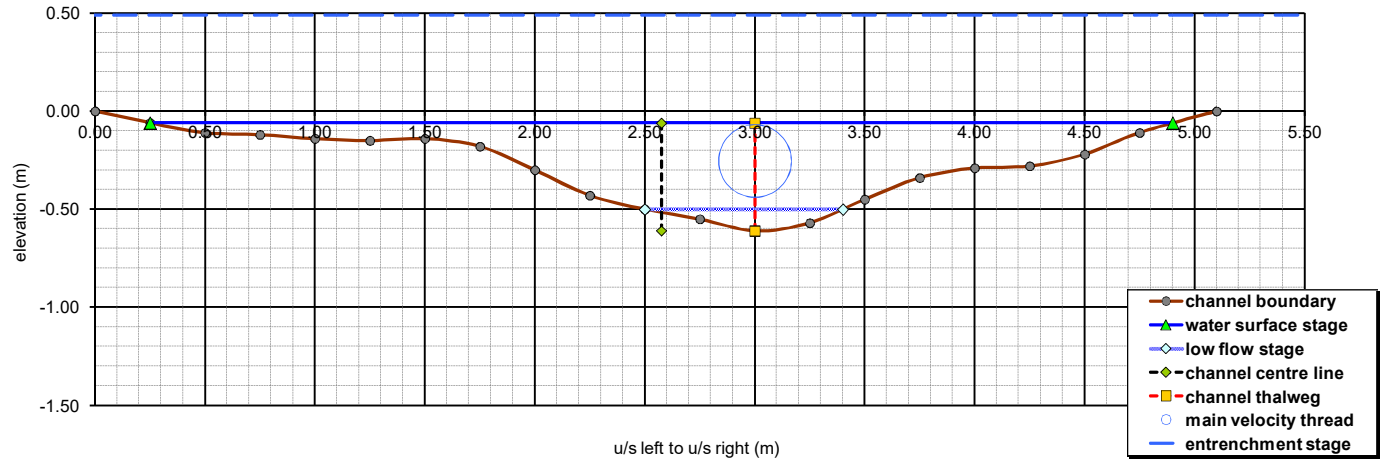
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Snow Valley Road Reach
Section 2 - Dynamic Stability Flow

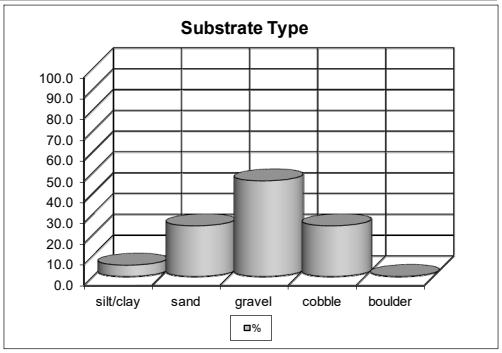
AquaLogic

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Cross Section Plot







Morphology Type	
cascade	
step	
riffle	●
run	
glide	
pool	
thalweg out of phase	

Hydraulic Roughness	
rr R/D_{84}	2.84
ff V mean/V*	5.39
ff D_{84}	5.51
ff mean	5.45
ROUGH BED	

Hydraulic Geometry	
A (m^2)	1.10
R (m)	0.23
TW (m)	4.66
WP (m)	4.85
max d (m)	0.55
mean d (m)	0.24
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Ratios	
ER max d	3.43
r_c / TW	
TW / Lf_w	5.18
TW/max d	8.5
TW/mean d	19.7

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.247	6.01	NO	NO	NO	YES
V_* (m s^{-1})	0.100	D_{50}	0.733	17.88	NO	NO	NO	NO
		D_{84}	1.313	32.03	NO	NO	NO	NO

Section Data

ER_e (m)	0.49	ER stations L / R	-10.00	6.00	TW ck
WS_e (m)	-0.060	WS stations L / R	0.25	4.90	4.65
Lf_e (m)	-0.500	Lf stations L / R	2.50	3.40	
W_{fp} (m)	16.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.61	3.00	
E_g (m m^{-1})	0.0220				

Bedload Transport Data

Rosgen type	Strickler Q_{sb} (kg sec^{-1})	Limerinos Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
B3	0.0020	0.0021	T_*	16.8	2.0	0.6
C3	0.0004	0.0006	saltation	YES	YES	NO
C4	0.0071	0.0077	rolling	YES	YES	NO
			Ø	NO	NO	YES

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.20	3.00	25.00	80.00	150.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.19	2.91	24.25	77.60	145.50
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds

		V_c / V_b	
τ_{calc} (kg m^{-2})	4.99		
τ_{calc} (N m^{-2})	48.95	Strickler	Limerinos
$\tau\ D_{crit}$ (gr-co) (mm)	50.46		
D_{50} V_c (vcs +) (m s^{-1})	0.78	1.01	
D_{84} V_c (vcs +) (m s^{-1})	1.39	1.80	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
5.4	24.3	45.9	24.3	0.0

Bank Data u/s L u/s R

H_b (m)	
Bf_d (m)	
RDp (m)	
H_b/Bf_d	
RDp/H_b	
RDn (%)	
BA (°)	
BFP (%)	

Flow Regime

Strickler method	
Q (cms)	1.209
V (m s^{-1})	1.10
n	0.050
Fr	0.72
D_c rectangular (m)	0.19
D_c trapezoidal (m)	0.35
D_c triangular (m)	0.51
D_c parabolic (m)	0.34
D_c mean (m)	0.35
flow type	SUBCRITICAL
Ω (watts m^{-1})	260.59
ω_a (watts m^{-2})	53.77
ω_a/TW (watts m^{-1})	11.54
Re^*	51.3
Re	218784
turbulence	HIGH

Flow Regime

Limerinos method	
Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
Re^*	
Re	
turbulence	

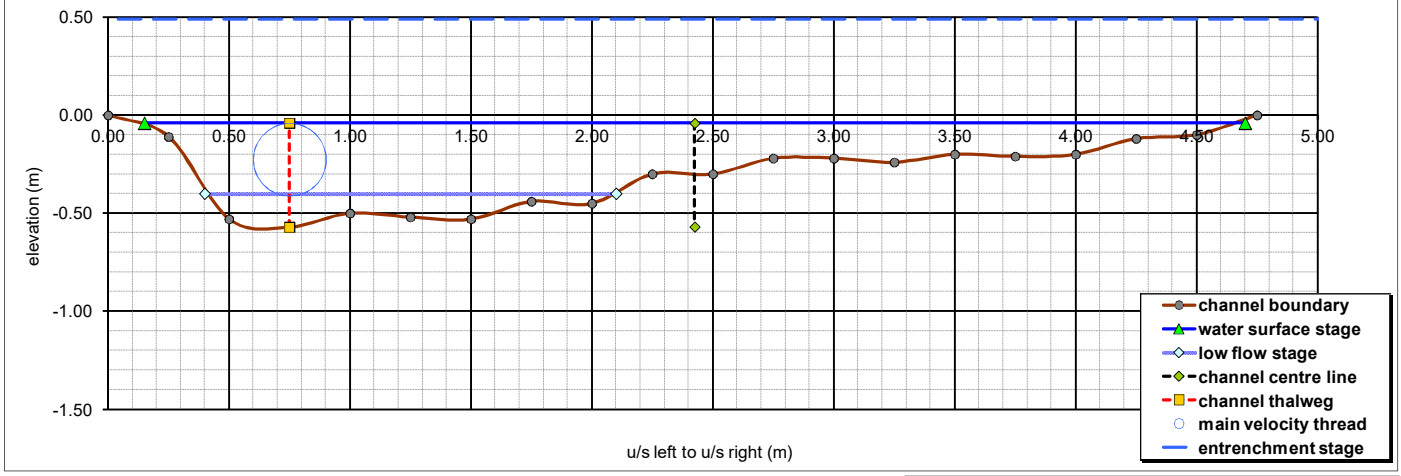
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Snow Valley Road Reach
Section 3 - Dynamic Stability Flow

AquaLogic

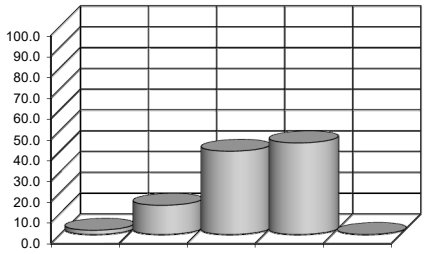
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Cross Section Plot





Substrate Type



Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	1.25
R (m)	0.25
TW (m)	4.56
WP (m)	4.93
max d (m)	0.53
mean d (m)	0.28
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R/D_{84}	2.31
ff V mean/V*	5.22
ff D_{84}	5.10
ff mean	5.16
ROUGH BED	

Hydraulic Ratios	
ER max d	5.48
r_c / TW	
TW / Lf_w	2.68
TW/max d	8.6
TW/mean d	16.6

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.412	10.22	NO	NO	NO	NO
V_* (m s^{-1})	0.098	D_{50}	0.984	24.40	NO	NO	NO	NO
		D_{84}	1.540	38.17	NO	NO	NO	NO

Section Data

ER_e (m)	0.49	ER stations L / R	-10.00	15.00	TW ck
WS_e (m)	-0.040	WS stations L / R	0.15	4.70	4.55
Lf_e (m)	-0.400	Lf stations L / R	0.40	2.10	
W_{fp} (m)	25.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.57	0.75	
E_g (m m^{-1})	0.0190				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
B3	0.0021	0.0021	T_*	6.1	1.1	0.4
C3	0.0006	0.0006	saltation	YES	NO	NO
C4	0.0076	0.0078	rolling	YES	YES	NO
			Ø	NO	NO	YES

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	1.00	8.00	45.00	110.00	210.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.97	7.76	43.65	106.70	203.70
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime

Strickler method		Limerinos method
Q (cms)	1.382	Q (cms)
V (m s^{-1})	1.10	V (m s^{-1})
n	0.050	n
Fr	0.67	*Fr*
D_c rectangular (m)	0.21	D_c rectangular (m)
D_c trapezoidal (m)	0.36	D_c trapezoidal (m)
D_c triangular (m)	0.53	D_c triangular (m)
D_c parabolic (m)	0.35	D_c parabolic (m)
D_c mean (m)	0.36	D_c mean (m)
flow type	SUBCRITICAL	flow type
Ω (watts m^{-1})	257.33	Ω (watts m^{-1})
ω_a (watts m^{-2})	52.24	ω_a (watts m^{-2})
ω_a/TW (watts m^{-1})	11.46	ω_a/TW (watts m^{-1})
*Re**	92.3	*Re**
Re	246125	*Re*
turbulence	HIGH	turbulence

Erosion Thresholds

		V_c / V_b	
τ_{calc} (kg m^{-2})	4.84		
τ_{calc} (N m^{-2})	47.40	Strickler	Limerinos
$\tau\ D_{crit}$ (gr-co) (mm)	48.86		
D_{50} V_c (vcs +) (m s^{-1})	1.04	1.35	
D_{84} V_c (vcs +) (m s^{-1})	1.63	2.11	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
2.0	14.0	40.0	44.0	0.0

Bank Data u/s L u/s R

H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

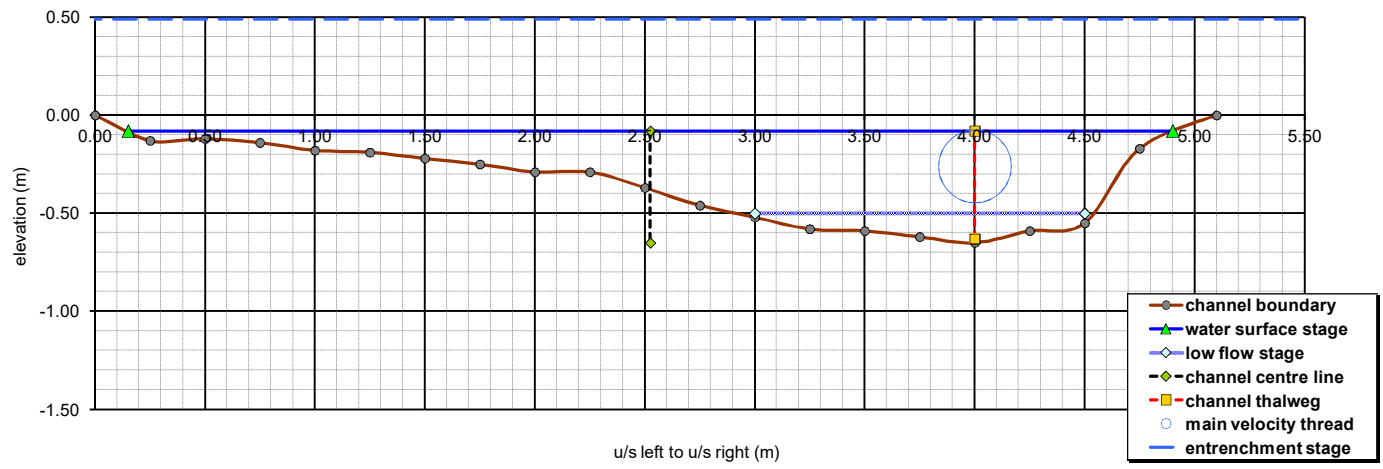
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

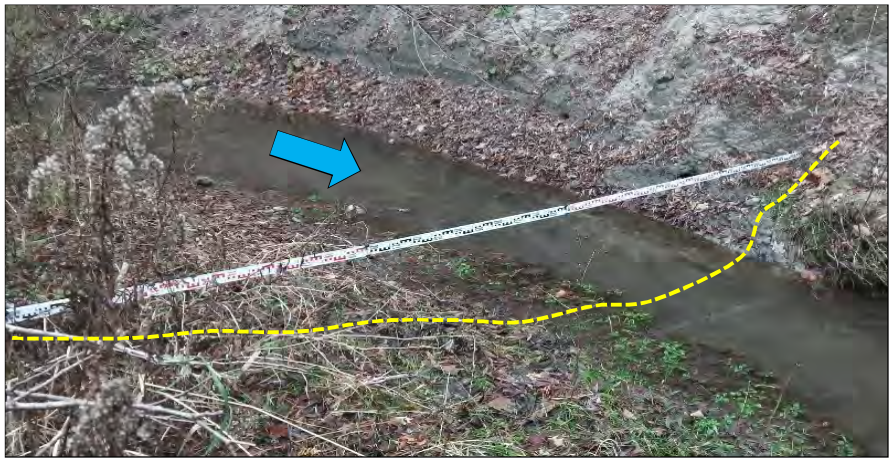
Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Snow Valley Road Reach
Section 4 - Dynamic Stability Flow

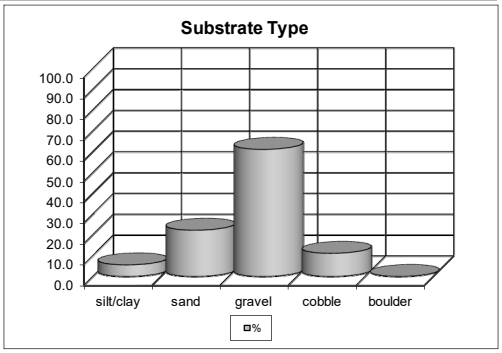
AquaLogic

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Cross Section Plot







Morphology Type	
cascade	
step	
riffle	
run	
glide	
pool	●
thalweg out of phase	

Hydraulic Roughness	
rr R/D_{84}	4.79
ff V mean/V*	6.10
ff D_{84}	6.86
ff mean	6.48
ROUGH BED	

Hydraulic Geometry	
A (m^2)	1.34
R (m)	0.26
TW (m)	4.78
WP (m)	5.09
max d (m)	0.57
mean d (m)	0.28
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Ratios	
ER max d	3.35
r_c / TW	
TW / Lf_w	3.19
TW/max d	8.4
TW/mean d	17.1

Sediment Transport Mode			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.040	1.29	NO	NO	YES	YES
V_* (m s^{-1})	0.076	D_{50}	0.567	18.15	NO	NO	NO	NO
		D_{84}	1.089	34.85	NO	NO	NO	NO

Section Data					
ER_e (m)	0.49	ER stations L / R	-10.00	6.00	TW ck
WS_e (m)	-0.080	WS stations L / R	0.15	4.90	4.75
Lf_e (m)	-0.500	Lf stations L / R	3.00	4.50	
W_{fp} (m)	16.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.63	4.00	
E_g (m m^{-1})	0.0110				

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.30	0.30	15.00	55.00	130.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.29	0.29	14.55	53.35	126.10
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds		V_c / V_b	
τ_{calc} (kg m^{-2})	2.90		
τ_{calc} (N m^{-2})	28.41	Strickler	Limerinos
$\tau\ D_{crit}$ (gr-co) (mm)	29.29		
D_{50} V_c (vcs +) (m s^{-1})	0.60	1.00	
D_{84} V_c (vcs +) (m s^{-1})	1.15	1.91	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
5.6	22.2	61.1	11.1	0.0

Bank Data u/s L	u/s R
H_b (m)	
Bf_d (m)	
RDp (m)	
H_b/Bf_d	
RDp/H_b	
RDn (%)	
BA (°)	
BFP (%)	

Bedload Transport Data						
	Strickler Q	Limerinos Q				
Rosgen type	Q_{sb} (kg sec^{-1})	Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
B3	0.0020	0.0022	T_*	97.6	2.0	0.5
C3	0.0004	0.0008	saltation	YES	NO	NO
C4	0.0069	0.0081	rolling	YES	YES	NO
			Ø	NO	NO	YES

Flow Regime Strickler method	
Q (cms)	1.151
V (m s^{-1})	0.86
n	0.050
Fr	0.52
D_c rectangular (m)	0.18
D_c trapezoidal (m)	0.33
D_c triangular (m)	0.50
D_c parabolic (m)	0.31
D_c mean (m)	0.33
flow type	SUBCRITICAL
Ω (watts m^{-1})	124.08
ω_a (watts m^{-2})	24.39
ω_a/TW (watts m^{-1})	5.10
Re^*	30.4
Re	198481
turbulence	HIGH

Flow Regime Limerinos method	
Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
Re^*	
Re	
turbulence	

GEO - ESUM v.1.3 Erosion Threshold Summary Model

Project: Erosion Threshold Analysis - CRDI
Willow Creek Tributary, Snow Valley Road Reach

B. de Geus 8.11

Existing Bankfull	Q $m^3 s^{-1}$	V $m s^{-1}$	veg control	D_{50} particle	D_{84}-D_{100} particle	τ_{calc} $N m^{-2}$	veg control	D_{50} particle*	D_{84}-D_{100} particle	Ω watts m^{-1}	Ω threshold
Xsec. 1	1.687	1.14	Y	N	Y	47.7	D	N	Y	264	Y
Xsec. 2	1.687	1.21	Y	N	Y	56.6	N	N	Y	363	Y
Xsec. 3	1.694	1.18	Y	Y	Y	52.2	N	N	N	315	Y
Xsec. 4	1.693	0.98	Y	N	Y	34.4	Y	N	Y	183	Y
Xsec. 5	1.690	0.92	Y	Y	Y	30.2	Y	N	Y	149	Y

Dynamic Stability	Q $m^3 s^{-1}$	V $m s^{-1}$	veg control	D_{50} particle	D_{84}-D_{100} particle	τ_{calc} $N m^{-2}$	veg control	D_{50} particle*	D_{84}-D_{100} particle	Ω watts m^{-1}	Ω threshold
Xsec. 1	1.01	0.97	Y	Y	Y	37.4	Y	N	Y	158	Y
Xsec. 2	1.21	1.10	Y	Y	Y	49.0	D	N	Y	261	Y
Xsec. 3	1.38	1.11	Y	Y	Y	47.4	D	Y	Y	257	Y
Xsec. 4	1.15	0.86	Y	Y	Y	28.4	Y	N	Y	125	Y
Xsec. 5	1.69	0.92	Y	Y	Y	30.2	Y	N	Y	149	Y

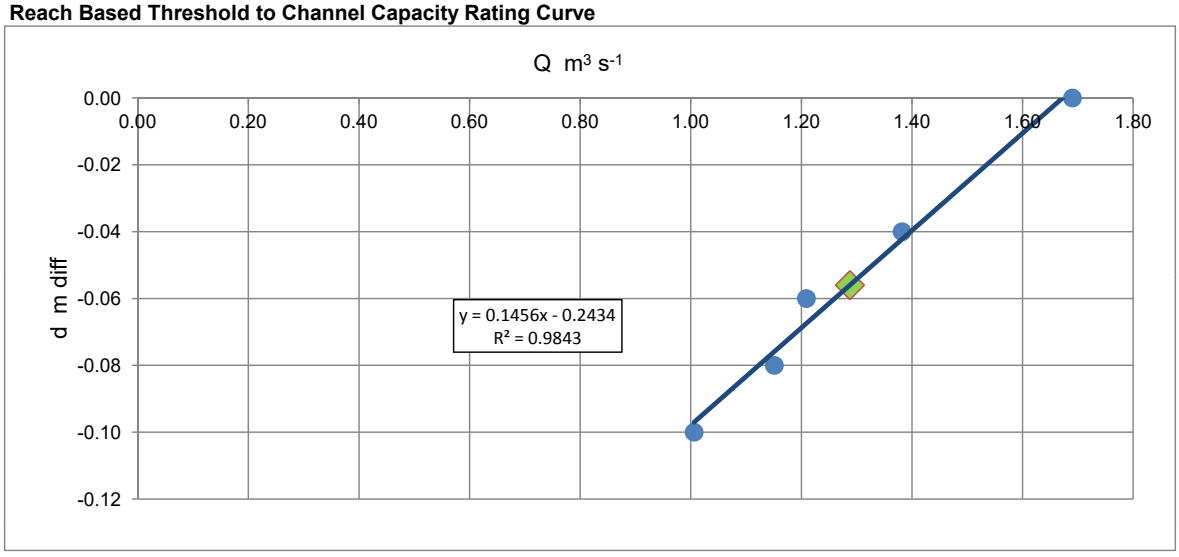
Stability Criteria Met: Y - Yes, N - No, D - Dynamic

* - within 5 mm

Dynamic Stability
Dynamic Stability = Cautionary
Potentially Unstable

	Q $m^3 s^{-1}$ existing	Q $m^3 s^{-1}$ stable	Q $m^3 s^{-1}$ diff	d m diff
Xsec. 1	1.69	1.01	0.68	-0.10
Xsec. 2	1.69	1.21	0.48	-0.06
Xsec. 3	1.69	1.38	0.31	-0.04
Xsec. 4	1.69	1.15	0.54	-0.08
Xsec. 5	1.69	1.69	0.00	0.00
mean	**1.69**	**1.29**	0.40	-0.06

Reach Based Threshold to Channel Capacity Rating Curve

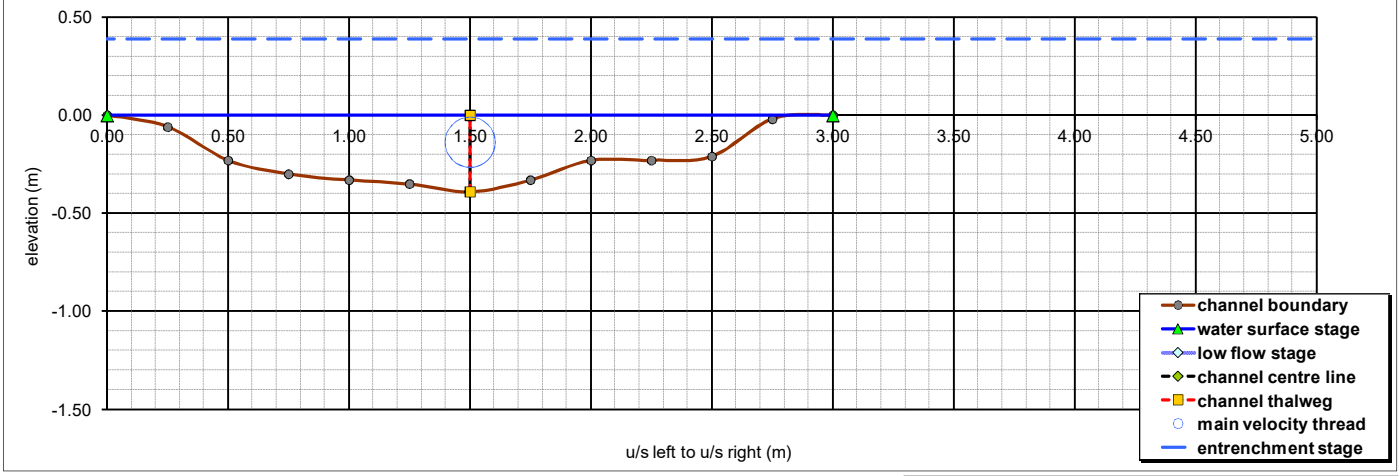


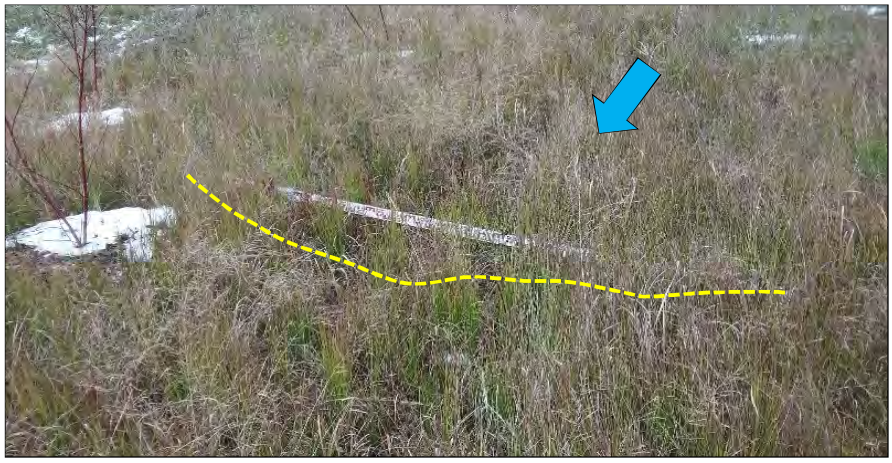
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: Erosion Threshold Analysis - MDDRI
Willow Creek Tributary, Midves Court Reach
Section 1

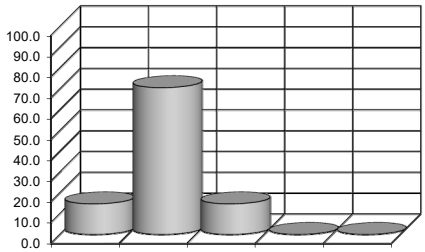
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Cross Section Plot





Substrate Type



Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Roughness	
rr R/D_{84}	105.79
ff V mean/V*	9.48
ff D_{84}	14.50
ff mean	11.99
	SMOOTH BED

Hydraulic Geometry	
A (m^2)	0.67
R (m)	0.21
TW (m)	3.00
WP (m)	3.17
max d (m)	0.39
mean d (m)	0.22
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Ratios	
ER max d	15.00
r_c / TW	
TW / Lf_w	
TW/max d	7.7
TW/mean d	13.4

Sediment Transport Mode			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.005	0.14	YES	YES	YES	YES
V_* (m s^{-1})	0.090	D_{50}	0.008	0.20	YES	YES	YES	YES
		D_{84}	0.196	5.34	NO	NO	NO	YES

Section Data					
ER_e (m)	0.39	ER stations L / R	-20.00	25.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	3.00	3.00
Lf_e (m)	-0.390	Lf stations L / R	1.50	1.50	
W_{fp} (m)	45.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.39	1.50	
E_g (m m^{-1})	0.0190				

Bedload Transport Data	Strickler Q	Limerinos Q				
Rosgen type	Q_{sb} (kg sec^{-1})	Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
B3	0.0016	0.0023	T_*	507.7	406.1	20.3
C3	0.0001	0.0011	saltation	YES	YES	YES
C4	0.0051	0.0089	rolling	YES	YES	YES
			Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.08	0.10	2.00	6.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.06	0.08	0.10	1.94	5.82
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds		V_c / V_b	
τ_{calc} (kg m^{-2})	4.02		
τ_{calc} (N m^{-2})	39.39		
τ D_{crit} (gr-co) (mm)	40.61	Strickler	Limerinos
D_{50} V_c (vcs +) (m s^{-1})	0.05	0.08	
D_{84} V_c (vcs +) (m s^{-1})	0.22	0.35	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
14.7	70.6	14.7	0.0	0.0

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Flow Regime Strickler method	
Q (cms)	0.593
V (m s^{-1})	0.89
n	0.055
Fr	0.60
D_c rectangular (m)	0.16
D_c trapezoidal (m)	0.26
D_c triangular (m)	0.38
D_c parabolic (m)	0.24
D_c mean (m)	0.26
flow type	SUBCRITICAL
Ω (watts m^{-1})	110.44
ω_a (watts m^{-2})	34.87
ω_a/TW (watts m^{-1})	11.62
*Re**	0.2
Re	164295
turbulence	LOW

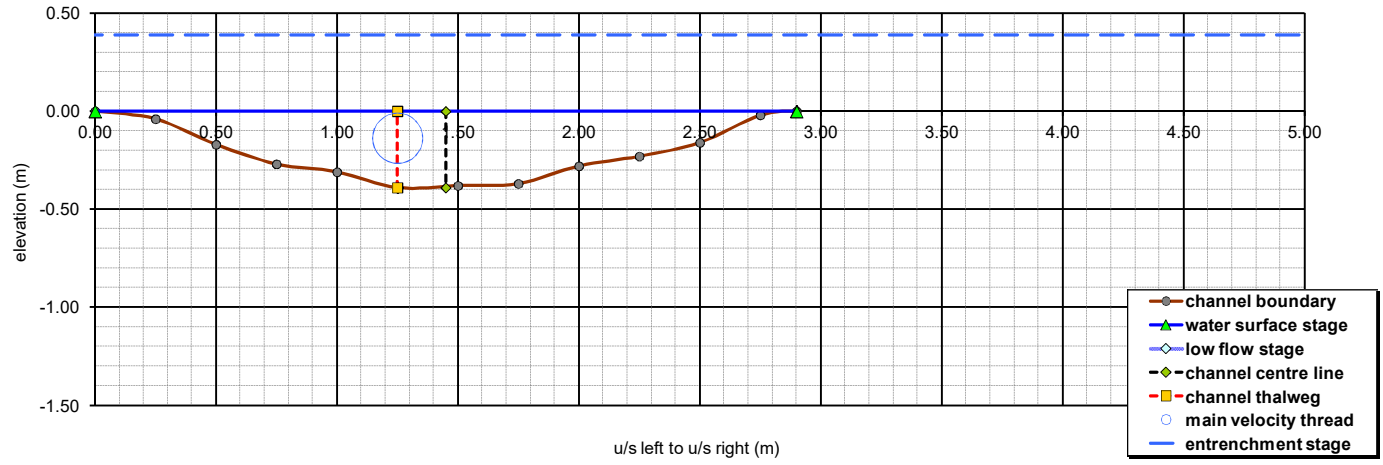
Flow Regime Limerinos method	
Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
*Re**	
Re	
turbulence	

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

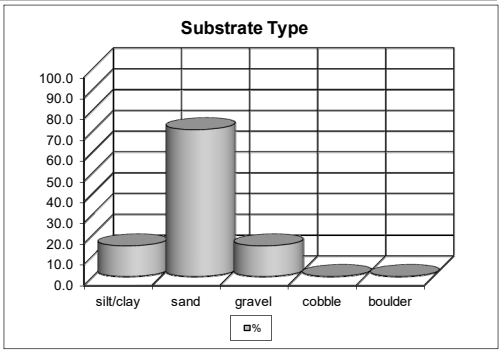
Project: Erosion Threshold Analysis - MDDRI
Willow Creek Tributary, Midves Court Reach
Section 2

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Cross Section Plot







Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Roughness	
rr R/D_{84}	107.62
ff V mean/V*	9.50
ff D_{84}	14.53
ff mean	12.02
	SMOOTH BED

Hydraulic Geometry	
A (m^2)	0.65
R (m)	0.22
TW (m)	2.90
WP (m)	3.04
max d (m)	0.39
mean d (m)	0.23
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Ratios	
ER max d	15.52
r_c / TW	
TW / Lf_w	
TW/max d	7.4
TW/mean d	12.9

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.005	0.14	YES	YES	YES	YES
V_* (m s^{-1})	0.090	D_{50}	0.008	0.20	YES	YES	YES	YES
		D_{84}	0.196	5.29	NO	NO	NO	YES

Section Data

ER_e (m)	0.39	ER stations L / R	-20.00	25.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	2.90	2.90
Lf_e (m)	-0.390	Lf stations L / R	1.25	1.25	
W_{fp} (m)	45.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.39	1.25	
E_g (m m^{-1})	0.0190				

Bedload Transport Data

Rosgen type	Strickler Q_{sb} (kg sec^{-1})	Limerinos Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
B3	0.0016	0.0023	T_*	516.5	413.2	20.7
C3	0.0001	0.0011	saltation	YES	YES	YES
C4	0.0050	0.0088	rolling	YES	YES	YES
			Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.08	0.10	2.00	6.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.06	0.08	0.10	1.94	5.82
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime
Strickler method

Q (cms)	0.586
V (m s^{-1})	0.90
n	0.055
Fr	0.60
D_c rectangular (m)	0.16
D_c trapezoidal (m)	0.26
D_c triangular (m)	0.38
D_c parabolic (m)	0.24
D_c mean (m)	0.26
flow type	SUBCRITICAL
Ω (watts m^{-1})	109.05
ω_a (watts m^{-2})	35.89
ω_a/TW (watts m^{-1})	12.38
Re^*	0.2
Re	169084
turbulence	LOW

Flow Regime
Limerinos method

Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
Re^*	
Re	
turbulence	

Erosion Thresholds

		V_c / V_b	
τ_{calc} (kg m^{-2})	4.09		
τ_{calc} (N m^{-2})	40.08		
τ D_{crit} (gr-co) (mm)	41.32	Strickler	Limerinos
D_{50} V_c (vcs +) (m s^{-1})	0.05	0.08	
D_{84} V_c (vcs +) (m s^{-1})	0.22	0.35	

Bank Data u/s L u/s R

H_b (m)	
Bf_d (m)	
RDp (m)	
H_b/Bf_d	
RDp/H_b	
RDn (%)	
BA (°)	
BFP (%)	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
14.7	70.6	14.7	0.0	0.0

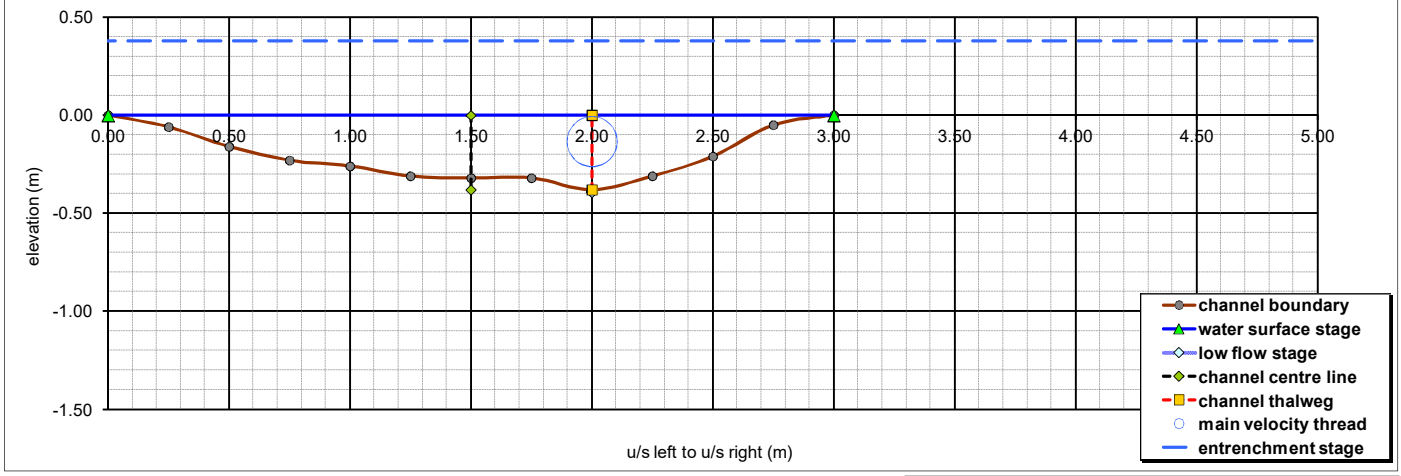
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

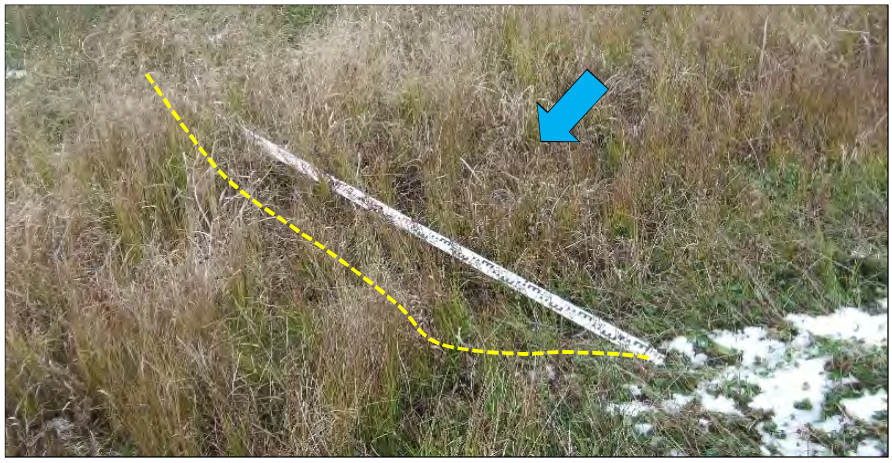
Project: Erosion Threshold Analysis - MDDRI
Willow Creek Tributary, Midves Court Reach
Section 3

AquaLogic

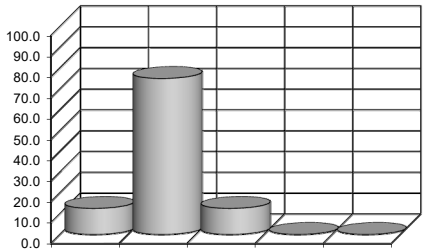
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Cross Section Plot





Substrate Type



Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.65
R (m)	0.21
TW (m)	3.00
WP (m)	3.13
max d (m)	0.38
mean d (m)	0.22
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R/D_{84}	208.42
ff V mean/V*	10.28
ff D_{84}	16.15
ff mean	13.22
	SMOOTH BED

Hydraulic Ratios	
ER max d	15.00
r_c / TW	
TW / Lf_w	
TW/max d	7.9
TW/mean d	13.8

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.20	YES	YES	YES	YES
V_* (m s^{-1})	0.091	D_{50}	0.032	0.85	NO	YES	YES	YES
		D_{84}	0.126	3.37	NO	NO	NO	YES

Section Data

ER_e (m)	0.38	ER stations L / R	-20.00	25.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	3.00	3.00
Lf_e (m)	-0.390	Lf stations L / R	2.00	2.00	
W_{fp} (m)	45.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.38	2.00	
E_g (m m^{-1})	0.0200				

Bedload Transport Data

Rosgen type	Strickler Q_{sb} (kg sec^{-1})	Limerinos Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
B3	0.0016	0.0024	T_*	421.1	168.5	42.1
C3	0.0001	0.0013	saltation	YES	YES	YES
C4	0.0051	0.0093	rolling	YES	YES	YES
			Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.25	1.00	4.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.06	0.10	0.24	0.97	3.88
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime
Strickler method

Q (cms)	0.587
V (m s^{-1})	0.90
n	0.055
Fr	0.62
D_c rectangular (m)	0.16
D_c trapezoidal (m)	0.26
D_c triangular (m)	0.38
D_c parabolic (m)	0.24
D_c mean (m)	0.26
flow type	SUBCRITICAL
Ω (watts m^{-1})	115.00
ω_a (watts m^{-2})	36.73
ω_a/TW (watts m^{-1})	12.24
Re^*	0.6
Re	164394
turbulence	LOW

Flow Regime
Limerinos method

Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
Re^*	
Re	
turbulence	

Erosion Thresholds

		V_c / V_b	
τ_{calc} (kg m^{-2})	4.17		
τ_{calc} (N m^{-2})	40.85		
τ D_{crit} (gr-co) (mm)	42.11	Strickler	Limerinos
D_{50} V_c (vcs +) (m s^{-1})	0.08	0.12	
D_{84} V_c (vcs +) (m s^{-1})	0.16	0.25	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
12.5	75.0	12.5	0.0	0.0

Bank Data u/s L u/s R

H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

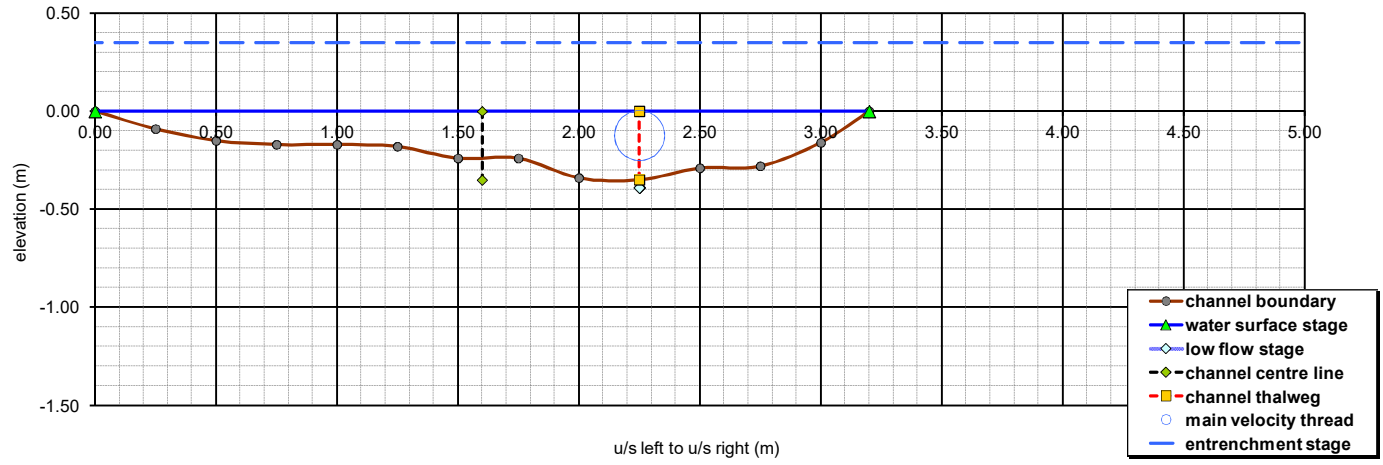
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

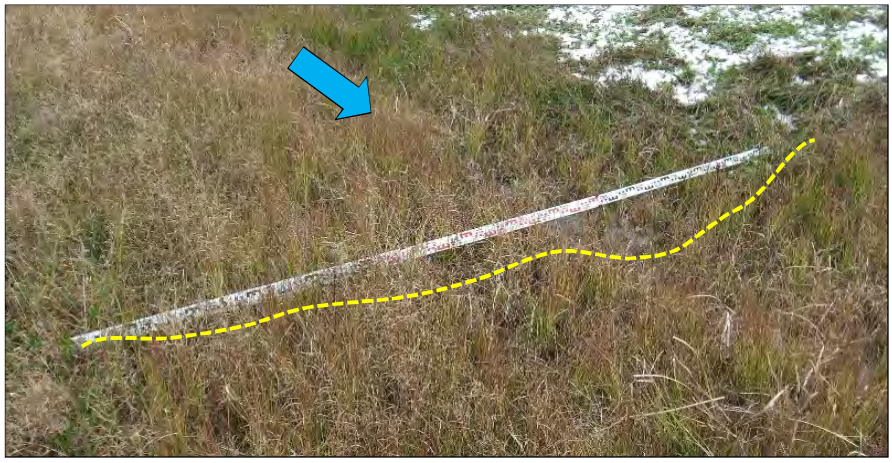
Project: Erosion Threshold Analysis - MDDRI
Willow Creek Tributary, Midves Court Reach
Section 4

AquaLogic

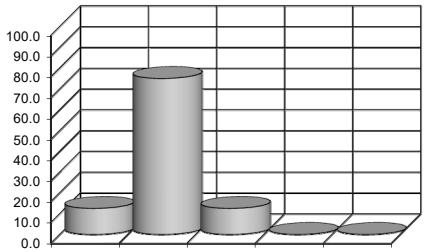
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Cross Section Plot





Substrate Type



Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.66
R (m)	0.20
TW (m)	3.20
WP (m)	3.34
max d (m)	0.35
mean d (m)	0.21
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R/D_{84}	197.84
ff V mean/V*	10.20
ff D_{84}	16.03
ff mean	13.11
	SMOOTH BED

Hydraulic Ratios	
ER max d	14.06
r_c / TW	
TW / Lf_w	
TW/max d	9.1
TW/mean d	15.5

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.20	YES	YES	YES	YES
V_* (m s^{-1})	0.091	D_{50}	0.032	0.85	NO	YES	YES	YES
		D_{84}	0.126	3.38	NO	NO	NO	YES

Section Data

ER_e (m)	0.35	ER stations L / R	-20.00	25.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	3.20	3.20
Lf_e (m)	-0.390	Lf stations L / R	2.25	2.25	
W_{fp} (m)	45.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.35	2.25	
E_g (m m^{-1})	0.0210				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
B3	0.0016	0.0024	T_*	419.7	167.9	42.0
C3	0.0001	0.0013	saltation	YES	YES	YES
C4	0.0051	0.0093	rolling	YES	YES	YES
			Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.25	1.00	4.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})	0.06	0.10	0.24	0.97	3.88
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds

		V_c / V_b	
τ_{calc} (kg m^{-2})	4.15		
τ_{calc} (N m^{-2})	40.72		
$\tau\ D_{crit}$ (gr-co) (mm)	41.97	Strickler	Limerinos
D_{50} V_c (vcs +) (m s^{-1})	0.08	0.12	
D_{84} V_c (vcs +) (m s^{-1})	0.16	0.25	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
12.5	75.0	12.5	0.0	0.0

Bank Data u/s L u/s R

H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Flow Regime
Strickler method

Q (cms)	0.588
V (m s^{-1})	0.89
n	0.055
Fr	0.63
D_c rectangular (m)	0.15
D_c trapezoidal (m)	0.26
D_c triangular (m)	0.38
D_c parabolic (m)	0.24
D_c mean (m)	0.26
flow type	SUBCRITICAL
Ω (watts m^{-1})	121.04
ω_a (watts m^{-2})	36.23
ω_a/TW (watts m^{-1})	11.32
*Re**	0.6
Re	154413
turbulence	LOW

Flow Regime
Limerinos method

Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
*Re**	
Re	
turbulence	

GEO-VEG v.1.3 Vegetation-Hydroperiod Erosion Risk Model

Project: **Erosion Threshold Analysis - MDDRI**
Willow Creek Tributary, Midves Court Reach
Event Model Test at Average Groundcover Density + 15% Qs

AquaLogic

B. de Geus 04.14

RETURN EVENT MODELING

i) $T_a = 4.7568V^{-3.4664}$

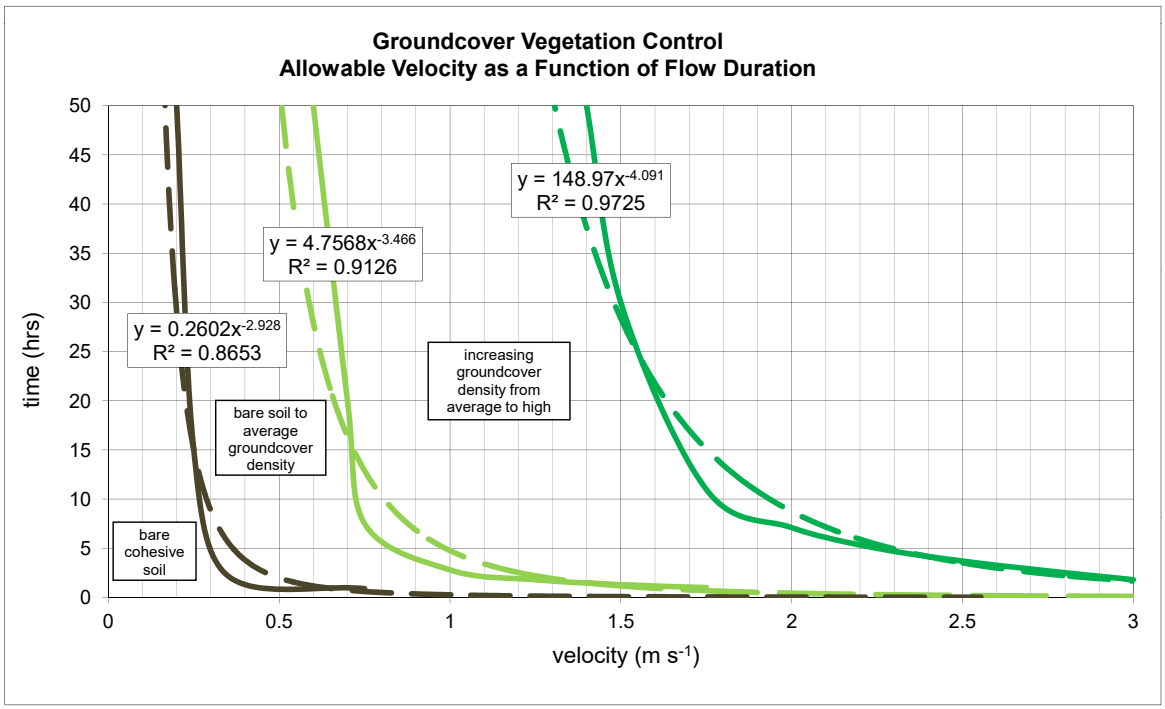
	25mm	2yr	5yr	10yr	25yr	50yr	100yr	
existing stage flow Q ($m^3 s^{-1}$)	0.15	0.31	0.70					
proposed stage flow Q ($m^3 s^{-1}$)	0.26	0.46	0.83					
existing stage velocity V ($m s^{-1}$)	0.63	0.78	0.90					
proposed stage velocity V ($m s^{-1}$)	0.74	0.86	0.90					
existing event duration T_e (hrs)	2.83	3.25	2.83					
proposed event duration T_p (hrs)	33.90	46.70	58.87					
i) allowable existing event duration T_a (hrs)	23.598	11.255	6.854					
i) allowable proposed event duration T_a (hrs)	13.509	8.024	6.854					
number of events N_e	300	50	25	10	4	2	1	
total time existing T_{te} (hrs)	849.00	162.50	70.75					
total time proposed T_{tp} (hrs)	10170.00	2335.00	1471.75					
$T_e < T_a$ (yes/no)	yes	yes	yes					
$T_p < T_a$ (yes/no)	no	no	no					total
total time existing over threshold OT_{te}	0.00	0.00	0.00					
total time proposed over threshold OT_{tp}	6117.42	1933.82	1300.41					
time % existing over 100yrs	0.0000	0.0000	0.0000					
time % proposed over 100yrs	0.0070	0.0022	0.0015					

CONTINUOS MODELING

i) $T_a = 4.7568V^{-3.4664}$

	step 1	step 2	step 3	step 4	step 5	step 6	step 7
flow range Q ($m^3 s^{-1}$)							
*max velocity V ($m s^{-1}$)							
total time existing T_{te} (hrs)							
total time proposed T_{tp} (hrs)							
i) allowable event duration T_a (hrs)							
existing number events N_e							
proposed number events N_p							
existing mean event time T_{te}/N_e (hrs)							
proposed mean event time T_{tp}/N_p (hrs)							
$T_{te}/N_e < T_a$ (yes/no)							
$T_{tp}/N_p < T_a$ (yes/no)							

*note: max velocity represents the velocity at the next highest flow step to balance the rising and falling velocity range



GEO-VEG v.1.3 Vegetation-Hydroperiod Erosion Risk Model

Project: **Erosion Threshold Analysis - MDDRI**
Willow Creek Tributary, Midves Court Reach
Event Model Test at High Groundcover Density + 15% Qs

AquaLogic

B. de Geus 04.14

RETURN EVENT MODELING

i) $T_a = 148.97V^{-4.091}$

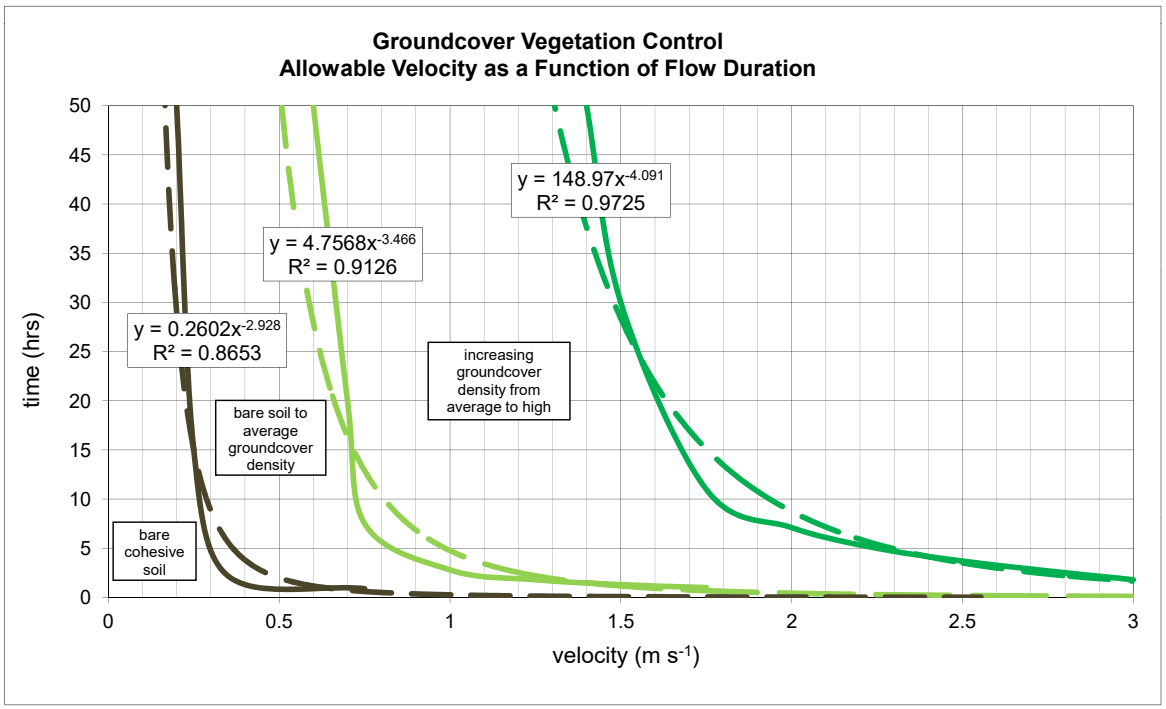
	25mm	2yr	5yr	10yr	25yr	50yr	100yr	
existing stage flow Q ($m^3 s^{-1}$)	0.15	0.31	0.70					
proposed stage flow Q ($m^3 s^{-1}$)	0.26	0.46	0.83					
existing stage velocity V ($m s^{-1}$)	0.63	0.78	0.90					
proposed stage velocity V ($m s^{-1}$)	0.74	0.86	0.90					
existing event duration T_e (hrs)	2.83	3.25	2.83					
proposed event duration T_p (hrs)	33.90	46.70	58.87					
i) allowable existing event duration T_a (hrs)	986.272	411.661	229.241					
i) allowable proposed event duration T_a (hrs)	510.589	276.100	229.241					
number of events N_e	300	50	25	10	4	2	1	
total time existing T_{te} (hrs)	849.00	162.50	70.75					
total time proposed T_{tp} (hrs)	10170.00	2335.00	1471.75					
$T_e < T_a$ (yes/no)	yes	yes	yes					
$T_p < T_a$ (yes/no)	yes	yes	yes					total
total time existing over threshold OT_{te}	0.00	0.00	0.00					
total time proposed over threshold OT_{tp}	0.00	0.00	0.00					
time % existing over 100yrs	0.0000	0.0000	0.0000					
time % proposed over 100yrs	0.0000	0.0000	0.0000					

CONTINUOS MODELING

i) $T_a = 4.7568V^{-3.4664}$

	step 1	step 2	step 3	step 4	step 5	step 6	step 7
flow range Q ($m^3 s^{-1}$)							
*max velocity V ($m s^{-1}$)							
total time existing T_{te} (hrs)							
total time proposed T_{tp} (hrs)							
i) allowable event duration T_a (hrs)							
existing number events N_e							
proposed number events N_p							
existing mean event time T_{te}/N_e (hrs)							
proposed mean event time T_{tp}/N_p (hrs)							
$T_{te}/N_e < T_a$ (yes/no)							
$T_{tp}/N_p < T_a$ (yes/no)							

*note: max velocity represents the velocity at the next highest flow step to balance the rising and falling velocity range



Rapid Assessment Analysis Update
Black Creek, Willow Creek, Willow Creek Tributary
Carson Road Development Inc.
Midhurst Development Doran Road Inc.
Township of Springwater







Submitted to:

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May 27, 2014

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Rapid Assessment Analysis Update
Black Creek, Willow Creek, Willow Creek Tributary
Carson Road Development Inc.
Midhurst Development Doran Road Inc.
Township of Springwater

Updated 'Rapid Assessment' analysis has been undertaken for Black Creek, Willow Creek, and a Willow Creek Tributary, further to previous reporting of May 2, 2014. Updated analysis has been requested based on proposed stormwater outlet location revisions noted in discussion at and follow-up from a site walk with NVCA, proponent representatives, consultants, and Township staff, on May 8, 2014. Previous analysis only included key reaches and what were deemed as the most sensitive locations below combined flows from each respective development site. Analysis immediately below every pond outlet location is now required to cover all sub-reaches in close proximity to Draft Plan areas. This report includes rapid assessment results from the previous submission that are still applicable, combined with the extra analysis requirements.

Also noted at the site walk meeting was the need to address at the detailed design stage any emergency overflow locations as standalone erosion control sites that may differ from the proposed outlet and receiving watercourse locations.

It is also understood that a watershed wide MDP process will occur subsequent to Draft Plan Approval (Phase 2). At present, preliminary engineering details are being provided that demonstrate extra contingencies for extended detention durations are possible in both the Carson Road and Doran Road development areas. The extended detention rates will therefore be fine tuned through MDP recommendations.

Black Creek Characterization
(Note that previous analysis referred to this watercourse as 'Willow Creek Tributary', for the Carson Road development)

Carson Road

The 'Carson Road' Black Creek system is transitional from a 1st order to 2nd order watercourse with upstream drainage area increments of 1.40km^2 to Anne St. N. for the easterly 1st order feature, 1.80km^2 for the westerly 1st order feature, 5.47km^2 to Carson Rd. W. for the 2nd order branch, and 6.83km^2 to Wilson Dr. at the downstream study limit of the 2nd order branch. Two additional short local drainage features are confluent in the lower study area. The small westerly feature represents drainage from a small wet meadow area (possibly a former beaver pond/meadow) and the easterly feature is

characterized by local farm field drainage contribution. The 1st and 2nd order features are officially identified on 1:10,000 Provincial OBM mapping and 1:50,000 Federal NTS mapping. The local drainage features as described above are not seen on mapping and would therefore be deemed not to represent primary drainage functions. The main branch 2nd order tributary is confluent further downstream of the study area with the main branch of Willow Creek, which is confluent with the Nottawasaga River in the Minesing Wetlands.

The study area is mainly within the Simcoe Uplands physiographic region, with the downstream area near Wilson Dr. falling to the Simcoe Lowlands physiographic region. Topography is characterized as a deeply rolling till plain with the tributary falling from a shallow U-shaped valley at Anne St. N. to a relatively deep glacial moraine valley at Carson Rd. and a moderately steep valley transition near Wilson Dr. to downstream of Snow Valley Drive beyond the development block. At its deepest point near Carson Rd. the valley is 15-20m deep. The valley slopes are variable from well defined to convex, with gentle to steep gradients and valley width varying from 50m to over 300m.

The valley floor flood plain varies from agricultural row crop and pasture at Anne St. N. to well vegetated lowland forest and transitional upland forest conditions. Forest cover upstream of Carson Rd. includes a mix of swamp wetland, scrub forest, and coniferous-deciduous forest. Vegetative cover above Wilson Dr. has scrub forest definition with openings in the canopy resulting in thicker herbaceous groundcover and wet meadow, with a transition to mature forest at Carson Road.

The tributary branches are ephemeral to intermittent in the south study area while the main branch appears to gain permanent base flow in the forest upstream of Carson Rd. Channel width varies from about 3-5m in the two 1st order features to as high as 8m in wet meadow sections of the northerly 2nd order study reach. Low flow definition varies from ill-defined ephemeral/intermittent at the upstream limits of the 1st order southerly features, up to about 3m wide, at the downstream development limits of the northerly study reach. The tributary flows over deposits of the parent geology with variable low flow bed forms from ill-defined swale, in the south, to occasional pools and riffles and eventually steps of coarser gravel to cobble material, in the northerly reach. There are areas of wetland diffusion, and influence from apparent beaver activity in intervening forest areas. Channel sinuosity is relatively low upstream of Carson Road but increases downstream, while the reach average slope is approximately 1%. Channel stability varies from moderate to relatively high due to changes in biotechnical reinforcement and channel bed materials. Some erosion scars are evident on outside banks, in the mid to lower reach and in the forest upstream of Carson Road. As expected, the channel tributaries are very stable near the upstream end were flows are ephemeral to

intermittent and groundcover vegetation density is high. Stability is moderate to high in the shaded forest areas upstream and downstream of Carson Road. Near the downstream study limits the tributary emerges from forest cover into denser groundcover and shrub thicket cover. Stability is high just upstream of Wilson Drive except where confined and partially entrenched meanders contact low slopes resulting in toe cutting and cantilevered failure of the low slope faces. Downstream of Wilson Dr. and the next crossing at Snow Valley Road the tributary increases in gradient and is partially to fully confined against valley walls. Below Snow Valley Road partial entrenchment also occurs and the steeper channel requires a generally narrower cross-section with higher conveyance velocities, than some upstream areas. In the reach below Snow Valley Road exposed sand and gravel material is seen in channel banks, localized instability is observed and outside bends show colluvial failure of high slopes above distinct bank erosion scars.

Willow Creek and Willow Creek Tributary Characterization

Doran Road

Two tributary reaches of Willow Creek border proposed development areas with the westerly tributary, in the Pooles Road area, identified for analysis during pre-consulting and the easterly feature identified for analysis during the May 8 site walk. The westerly feature was removed from the need for detailed analysis based on site walk discussions but characterization is included here for completeness of coverage of all features in the study area. The main branch of Willow Creek will receive piped flows, in lieu of the westerly feature receiving surface flows, therefore Willow Creek has been added to the analysis requirements.

This westerly feature is 1st order ephemeral and is seen on 1:50,000 scale Federal topographic mapping, but it is not seen on 1:10,000 scale Provincial topographic mapping. The western feature also has two small tributary drainage features within the study area. These features are ephemeral, contour based, overland flow routes that would arguably not be classified as independent 1st order features. Upstream drainage area is 2.53km^2 for the westerly tributary at Pooles Road. Part of the westerly feature is contained in roadside ditching leading to an enclosed storm sewer in the residential area of Midhurst, before it meets Willow Creek. The study area falls mainly within the Simcoe Uplands physiographic region. Topography is characterized as deeply rolling till plain with the tributaries falling from shallow U-shaped valleys at upstream limits to relatively deep glacial moraine valleys at downstream confluence points. At its deepest point, the western valley is approximately 13m deep. Valley side slopes vary from well defined to convex, with gentle to steep gradients and width varying up to approximately

200m. The west tributary valley floor varies from herbaceous old field pasture at Walt Rd. to a continuous swamp forest at the downstream study area limits.

The westerly tributary appears to be fully ephemeral with no flow identified at the time of field work. The feature was found to not have well defined channel bed and bank conditions and would not necessarily meet technical and legal definition as a true watercourse at any point from downstream of Pooles Road to the upstream limits. After passing through mixed forest conditions below Pooles Road the feature opens up into a recently cleared and graded block designed for new residential development. In this area a very modest swale like channel easement appears to have been recently constructed which passes between lots and meets roadside ditching around a cul-de-sac bulb of Midves Court. A small gravel filled trench is seen within the realignment easement and is reported to be an infiltration feature (Gemmell Engineering 2012). Feature sinuosity is very low in the feature, being just over a ratio value of 1.0. Reach average study area slope is approximately 0.01 m m^{-1} for the western feature. Stability is noted to be very high due to the lack of well defined geometry and the extensive vegetation coverage. The lack of channel definition suggests that flow is opportunistic and will anastomise through vegetative cover without sufficient energy to carve a distinct bankfull channel. Soil conditions and vegetative attenuation also appear to encourage a reasonably high amount of recharge that would help account for the lack of flow forming channel definition on the surface.

Based on the above characterization and discussions at the site walk, the feature would not be defined as permanently flowing with associated suitability as a permanent outlet for future drainage. As a result, the focus of analysis would shift to the receiving natural channel reach below where flows will be piped from proposed development and added to existing minor and major storm systems in the village of Midhurst. These systems outlet to the main branch of Willow Creek. Willow Creek therefore requires preliminary rapid assessment for the sake of this reporting and detailed erosion threshold analysis for subsequent proposed MDP work.

Willow Creek in Midhurst is a 4th order watercourse with an upstream drainage area of 127km^2. Flows to the village area are highly attenuated by the 225ha surface area of Little Lake, southeast of the village. The reach within the village is largely entrenched and confined on outside meanders within relatively steep valley walls that vary from 5-12m deep. Sandy soils are dominant and erosion and aggradation patterns are clearly seen along channel limits. Sinuosity is moderate to high in natural areas and observations suggest that past straightening may have occurred over approximately 400m of length, including the area where storm systems outlet to the creek. Mixed riparian vegetation conditions of groundcover to coniferous swamp forest line the valley

and channel banks and large woody debris deposits are frequent. Low flow widths are up to approximately 10m and entrenched channel forming widths are estimated up to 15m. Bedform definition of deeper pools up to 2m deep and shallow runs ranging from 0.5-1m are dominant at low velocity, with occasional short riffles of gravel-cobble at moderate velocity.

The second or easterly Willow Creek tributary feature at Old Second South road was identified during site walk discussions to require preliminary rapid assessment and detailed erosion threshold analysis for proposed MDP work. This 1st order feature has a topographic drainage area of approximately 1.2km^2 to Old Second South which is in proximity to the proposed SWM outlet. Flows are reported by land tenant observations to be permanent, albeit having very low baseflow in summer. A small swamp forest block occurs below Old Second South with the channel confluent to an online manmade pond below the forest. Storm flows will be confluent either above or into the manmade pond. The pond discharges to several hundreds of metres of wet meadow channel with groundcover and shrub thicket vegetation resulting in anastomising flow patterns. The channel transitions into a large cedar swamp forest further downstream and is eventually confluent with the main branch of Willow Creek near the outlet of Little Lake above the Midhurst village area.

Rapid Assessment Analysis

Three rapid assessment protocols were undertaken for six locations relative to the Carson Road site and two locations relative to the Doran Road site, to help characterize existing conditions and determine appropriate locations for detailed erosion threshold analysis. Previous analysis included three sites for Carson Road and two different sites for Doran Road. Field observations were used to score relative geomorphic and environmental attributes. Rapid Geomorphic Assessment (RGA) was used to rate channel stability and infrastructure impact. Rapid Habitat Assessment (RHA) was used to define in-stream and riparian habitat. Rapid Stream Assessment Technique (RSAT) was used to test broad indicators of channel stability, aquatic habitat, and water quality. A weighted score out of 100 was transposed from the results of each protocol and a combined average score was determined from the three tests. Four qualifying ranges of poor, fair, good, and optimal are maintained in the RHA and RSAT protocols, between the original scoring and the weighted scoring out of 100, while the three original ranges in RGA scoring are reflected as poor, fair, and good. The combined average score is qualified by poor to optimal ranges designed as a best fit of the individual protocol ranges. The detailed results are appended and included with each are photographs of typical conditions.

Carson Road

Six locations representing the 'South Pond' outlet, the Carson Road upstream sub-reach representing the initial 'Carson Road South Pond' outlet, the revised and combined 'Carson Road South Pond' and 'Carson Road North Pond' outlet, the 'North Pond' outlet, upstream to downstream of Wilson Road, and downstream of Snow Valley Road, were scored with rapid assessments to cover all previous and updated considerations for sub-reaches of Black Creek that will receive and convey confluent storm flows.

The detailed results show that the South Pond outlet location has the highest level of stability while the intervening forest area upstream of Carson Road has lower stability due to forest shading and lower rooting density. The Carson Road South Pond and Carson Road North Pond combined outlet has good stability due to denser groundcover and swamp thicket biotechnical reinforcement. The North Pond location scores as transitional due to the evidence of erosion impacting a former agricultural building (albeit a structure likely to be removed) and due to entrenched and confined conditions leading to instability at the sharp bend in proximity to private property limits downstream of the outlet. This location is targeted for site specific erosion control works through detailed design. The immediate area around Wilson Road has a good relative level of stability despite deterioration in the crossing itself from age weathering and spalling and associated slope impact failure from surface runoff (capital works are already proposed at the crossing).

Downstream of Wilson Road the channel transitions to steeper gradient and deeper valley confinement and entrenchment. A large drop on the downstream face of Snow Valley Road defines the start of what is deemed the most sensitive reach in proximity to the proposed development area. Existing bank erosion and valley wall contact points show a high fraction of cohesionless material that is exposed and available for entrainment under high flows. Stability is scored lowest in this location relative to the whole study area. Scour pool incision impacting the culvert drop and channel widening in downstream areas is causing slope toe and slope face erosion, and moderate to high numbers of undermined trees. Despite the observed erosion, the continuous natural valley conditions contribute to good aquatic habitat, and integrated scoring is relatively high. The area below Snow Valley Road is therefore deemed to be the most sensitive to erosion and is thus the most suitable location for detailed erosion threshold analysis which has already been presented in the previous submission.

Doran Road

The location for much of the Doran Road storm flow discharge is the main branch of Willow Creek. The previously proposed outlet through private lands between Pooles Road and the existing Midves Court location is not deemed to be a permanent flowing outlet based on site walk discussions. The private lands downstream of Pooles Road will not receive additional storm event flows and are thus not included in updated analysis. The easterly Willow Creek Tributary is now included at both the preliminary rapid assessment and at the subsequent detailed MDP analysis stages.

The Willow Creek main branch scores as transitional due principally to observations of aggradation and some widening. The entrenched conditions at low gradient result in slowly moving but likely near constant shifting of sand material at storm event flows of high frequency. Infrequent larger storms likely scour the toe of slope areas through increased tractive force. Widening results in locally mobilized material that deposits on steep point bars and some accessible valley floor flood plain.

The eastern Willow Creek tributary scores relatively high stability due to dense groundcover and shrub thicket biotechnical reinforcement in a wide well vegetated flood plain. Stability would score even higher if not for the localized influence of the manmade pond resulting in a driveway crossing elevated culvert that is cantilevered over a scour pool.

Rapid Assessment Results Summary

The results of rapid assessment scoring are summarized in **Table 1.**

Table 1: Rapid Assessment Results Summary

	RGA Score	RHA Score	RSAT Score	Combined Score
Black Creek, Snow Valley Road Reach	73.2	76.5	80.0	76.6
Black Creek, Wilson Road Reach	90.4	75.0	82.0	82.5
Black Creek, North Pond Outlet	75.7	66.0	74.0	71.9
Black Creek, Carson Road North & South Pond Outlet	88.9	73.5	86.0	82.8
Black Creek, Carson Road Upstream Reach	78.2	70.5	68.0	72.2
Black Creek, South Pond Outlet	95.0	70.0	70.0	78.3
Willow Creek main branch, Midhurst Village Reach	75.7	68.5	76.0	73.4
Willow Creek Tributary, Old Second South Reach	81.8	59.5	68.0	70.0

All scores are standaridized to be out of 100.

The results confirm that a mix of good, or 'in regime', channel stability and transitional stability occurs over the study properties while related habitat quality scoring mainly falls in the good range with a couple locations considered optimal. The results show that the Snow Valley Road reach is the lowest scoring with regard to channel stability in proximity to the Carson Road development.

Conclusions

Updated 'Rapid Assessment' analysis' has been undertaken for Black Creek, Willow Creek, and a Willow Creek Tributary, further to previous reporting of May 2, 2014. Updated analysis was requested based on a need to inventory all receiving reaches below individual pond outlet locations as a response to discussion at and follow-up from a site walk with NVCA, proponent representatives, consultants, and Township staff, on May 8, 2014. Previous analysis only included key reaches and the most sensitive locations below combined flows from each respective site. This report includes rapid assessment results from the previous submission combined with the extra analysis requirements noted above.

The previously analyzed Snow Valley Road location for Black Creek relative to the Carson Road proposed development has been confirmed as the most sensitive erosion potential location. The previous erosion threshold analysis done for this location is appropriate from a standalone perspective.

The Willow Creek main branch is the default location for erosion threshold analysis relative to much of the Doran Road proposed development. This development will be connected to existing storm sewers in Midhurst that discharge directly to Willow Creek.

The Willow Creek easterly tributary will receive some Doran Road proposed development storm flows.

Based on the previous reporting conclusions that 24hr extended detention is suitable for erosion potential control of the Doran and Carson Road developments, the current Draft Plan contingency to provide up to 72hr extended detention, in combination with extensive LID infiltration, is deemed to be adequate across all properties with regard to future conditions erosion potential control. The MDP watershed wide modelling to be prepared as part of Stage 2 will allow fine tuning of control rates on a location by location basis as combined over all future development discharge points with due consideration of cumulative downstream impacts.

Prepared by,



Bill de Geus, B.Sc., CET, CPESC, EP
AquaLogic Consulting

References

AquaLogic Consulting. 2014. Erosion Threshold Analysis, Willow Creek Tributaries, Carson Road Development Inc., Midhurst Development Doran Road Inc., Township of Springwater. Report to SCS Consulting Group Ltd., May 2, 2014.

Chapman, L.J., and D.F. Putnam. 1984. The Physiography of Southern Ontario: Ontario Geological Survey, Special Volume 2.

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GEO-RAP v.1.2 Rapid Assessment Protocol Model

B. de Geus 03.12

Project: Erosion Threshold Analysis - CRDI
Black Creek, Snow Valley Road Reach
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	1
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	1
	n/7 =	0.43
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	1
	Scour pools d/s of culverts/stormsewer outlets	1
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.20

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	1
	Exposed tree roots	1
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.30
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	1
	n/7 =	0.14
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.27**
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	**73.2**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	18	20--16	15-11	10-6	5-0
Embeddedness	11	20--16	15-11	10-6	5-0
Velocity / Depth Regime	15	20--16	15-11	10-6	5-0
Sediment Deposition	14	20--16	15-11	10-6	5-0
Channel Flow Status	16	20--16	15-11	10-6	5-0
Channel Alteration	17	20--16	15-11	10-6	5-0
Frequency of Riffles	14	20--16	15-11	10-6	5-0
Bank Stability u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	7	10-8	7-6	5-3	2-0
u/s R	7	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
/200	153				
/100	**76.5**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Pool Substrate Characterization		20--16	15-11	10-6	5-0
Pool Variability		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Channel Sinuosity		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	8	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	6	8-7	6-5	4-3	2-0
Physical Instream Habitat	7	8-7	6-5	4-3	2-0
Water Quality	7	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	6	7-6	5-4	3-2	1-0
Biological Indicators	6	8-7	6-5	4-3	2-0
/50	40				
/100	**80.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	**76.6**	100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		100-80	80-56	55-30	29-0



▲ Overview looking upstream from top of slope, towards Snow Valley Road, showing confinement and toe contact

▼ Overview looking downstream at creek level showing entrenched valley form



References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

B. de Geus 03.12

Project: Erosion Threshold Analysis - CRDI
Black Creek, Wilson Road Reach
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	
	n/7 =	0.14
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	
	Exposed tree roots	
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.10
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	1
	n/7 =	0.14
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.10**
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	**90.4**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	16	20--16	15-11	10-6	5-0
Embeddedness	11	20--16	15-11	10-6	5-0
Velocity / Depth Regime	12	20--16	15-11	10-6	5-0
Sediment Deposition	14	20--16	15-11	10-6	5-0
Channel Flow Status	13	20--16	15-11	10-6	5-0
Channel Alteration	17	20--16	15-11	10-6	5-0
Frequency of Riffles	11	20--16	15-11	10-6	5-0
Bank Stability u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
/200	150				
/100	**75.0**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Pool Substrate Characterization		20--16	15-11	10-6	5-0
Pool Variability		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Channel Sinuosity		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	9	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	6	8-7	6-5	4-3	2-0
Physical Instream Habitat	7	8-7	6-5	4-3	2-0
Water Quality	7	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	6	7-6	5-4	3-2	1-0
Biological Indicators	6	8-7	6-5	4-3	2-0
/50	41				
/100	**82.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	**82.5**	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0



▲ Overview looking upstream from Wilson Road showing dense groundcover encroachment

▼ Overview looking downstream from Wilson Road showing transition from groundcover encroachment to forest



References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

B. de Geus 03.12

Project: Erosion Threshold Analysis - CRDI
Black Creek, North Pond Outlet
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	1
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	1
	Poor longitudinal sorting of bed materials	1
	Deposition in the overbank zone	
	n/7 =	0.57
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	1
	Exposed tree roots	1
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	1
	n/10 =	0.40
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.00
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.24**
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	**75.7**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	16	20--16	15-11	10-6	5-0
Embeddedness	11	20--16	15-11	10-6	5-0
Velocity / Depth Regime	15	20--16	15-11	10-6	5-0
Sediment Deposition	14	20--16	15-11	10-6	5-0
Channel Flow Status	13	20--16	15-11	10-6	5-0
Channel Alteration	7	20--16	15-11	10-6	5-0
Frequency of Riffles	9	20--16	15-11	10-6	5-0
Bank Stability u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	8	10-8	7-6	5-3	2-0
u/s R	7	10-8	7-6	5-3	2-0
/200	132				
/100	**66.0**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Pool Substrate Characterization		20--16	15-11	10-6	5-0
Pool Variability		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Channel Sinuosity		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	8	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	5	8-7	6-5	4-3	2-0
Physical Instream Habitat	6	8-7	6-5	4-3	2-0
Water Quality	7	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	5	7-6	5-4	3-2	1-0
Biological Indicators	6	8-7	6-5	4-3	2-0
/50	37				
/100	**74.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	**71.9**	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0



▲ Looking upstream at northerly meander and subsequent opposite bank, showing entrenchment and confinement related erosion, ~200m below pond outlet

▼ Looking upstream at receiving channel below proposed SWM outlet, showing entrenchment and confinement related conditions



References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

B. de Geus 03.12

Project: Erosion Threshold Analysis - CRDI
Black Creek, Carson Road North & South Pond Outlet
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	
	n/7 =	0.14
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	1
	Exposed tree roots	1
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.30
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.00
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	0.11
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	88.9

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	16	20--16	15-11	10-6	5-0
Embeddedness	11	20--16	15-11	10-6	5-0
Velocity / Depth Regime	11	20--16	15-11	10-6	5-0
Sediment Deposition	14	20--16	15-11	10-6	5-0
Channel Flow Status	12	20--16	15-11	10-6	5-0
Channel Alteration	18	20--16	15-11	10-6	5-0
Frequency of Riffles	9	20--16	15-11	10-6	5-0
Bank Stability u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
/200	147				
/100	73.5	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Pool Substrate Characterization		20--16	15-11	10-6	5-0
Pool Variability		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Channel Sinuosity		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	9	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	7	8-7	6-5	4-3	2-0
Physical Instream Habitat	7	8-7	6-5	4-3	2-0
Water Quality	7	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	7	7-6	5-4	3-2	1-0
Biological Indicators	6	8-7	6-5	4-3	2-0
/50	43				
/100	86.0	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	82.8	100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		100-80	80-56	55-30	29-0



Overview looking downstream from Carson Road showing transition from wetland pool to thicket

References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

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Project: Erosion Threshold Analysis - CRDI
Black Creek, Carson Road Upstream Reach
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	1
	Coarse material in riffles embedded	
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	1
	Poor longitudinal sorting of bed materials	1
	Deposition in the overbank zone	
	n/7 =	0.57
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	1
	Exposed tree roots	1
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.30
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.00
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	0.22
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	78.2

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	16	20--16	15-11	10-6	5-0
Embeddedness	11	20--16	15-11	10-6	5-0
Velocity / Depth Regime	10	20--16	15-11	10-6	5-0
Sediment Deposition	14	20--16	15-11	10-6	5-0
Channel Flow Status	13	20--16	15-11	10-6	5-0
Channel Alteration	16	20--16	15-11	10-6	5-0
Frequency of Riffles	13	20--16	15-11	10-6	5-0
Bank Stability u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	6	10-8	7-6	5-3	2-0
u/s R	6	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
/200	141				
/100	70.5	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Pool Substrate Characterization		20--16	15-11	10-6	5-0
Pool Variability		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Channel Sinuosity		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	8	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	4	8-7	6-5	4-3	2-0
Physical Instream Habitat	5	8-7	6-5	4-3	2-0
Water Quality	6	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	5	7-6	5-4	3-2	1-0
Biological Indicators	6	8-7	6-5	4-3	2-0
/50	34				
/100	68.0	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	72.2	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0



▲ Downstream overview in proximity to proposed outfall

▼ Upstream overview in



References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

B. de Geus 03.12

Project: **Erosion Threshold Analysis - CRDI**
Black Creek, South Pond Outlet
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	
	Medial bars	
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	
	n/7 =	0.00
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	1
	Exposed tree roots	
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.20
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.00
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.05**
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	**95.0**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	11	20--16	15-11	10-6	5-0
Embeddedness	11	20--16	15-11	10-6	5-0
Velocity / Depth Regime	10	20--16	15-11	10-6	5-0
Sediment Deposition	16	20--16	15-11	10-6	5-0
Channel Flow Status	13	20--16	15-11	10-6	5-0
Channel Alteration	16	20--16	15-11	10-6	5-0
Frequency of Riffles	9	20--16	15-11	10-6	5-0
Bank Stability u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
/200	140				
/100	**70.0**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Pool Substrate Characterization		20--16	15-11	10-6	5-0
Pool Variability		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Channel Sinuosity		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	10	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	6	8-7	6-5	4-3	2-0
Physical Instream Habitat	4	8-7	6-5	4-3	2-0
Water Quality	6	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	3	7-6	5-4	3-2	1-0
Biological Indicators	6	8-7	6-5	4-3	2-0
/50	35				
/100	**70.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	**78.3**	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0



▲ Confluence of 1st order features / proposed receiver on right

▼ Upstream overview in proximity to proposed outfall



References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

B. de Geus 03.12

Project: **Erosion Threshold Analysis - MDDRI**
Willow Creek main branch, Midhurst Village Reach
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	1
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	1
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	1
	n/7 =	0.57
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	1
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.10

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	1
	Exposed tree roots	1
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.30
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.00
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.24**
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	**75.7**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	15	20--16	15-11	10-6	5-0
Embeddedness	10	20--16	15-11	10-6	5-0
Velocity / Depth Regime	19	20--16	15-11	10-6	5-0
Sediment Deposition	8	20--16	15-11	10-6	5-0
Channel Flow Status	20	20--16	15-11	10-6	5-0
Channel Alteration	11	20--16	15-11	10-6	5-0
Frequency of Riffles	10	20--16	15-11	10-6	5-0
Bank Stability u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	6	10-8	7-6	5-3	2-0
u/s R	6	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
/200	137				
/100	**68.5**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Pool Substrate Characterization		20--16	15-11	10-6	5-0
Pool Variability		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Channel Sinuosity		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection u/s R		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	8	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	5	8-7	6-5	4-3	2-0
Physical Instream Habitat	6	8-7	6-5	4-3	2-0
Water Quality	6	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	6	7-6	5-4	3-2	1-0
Biological Indicators	7	8-7	6-5	4-3	2-0
/50	38				
/100	**76.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	**73.4**	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0



▲ Overview looking downstream from outlet

▼ Overview looking downstream from outlet location off Willow Landing Road



References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

AquaLogic

B. de Geus 03.12

Project: **Erosion Threshold Analysis - MDDRI**
Willow Creek Tributary, Old Second South Reach
Existing Conditions

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	1
	Deposition in the overbank zone	
	n/7 =	0.29
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	1
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	1
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.20

Widening	Fallen/leaning trees/fence posts etc.	
	Occurrence of Large Organic Debris	1
	Exposed tree roots	
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.10
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	1
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.14
	STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.18**
	SI < 0.2	In Regime
	0.2 < SI < 0.4	Transitional
	SI > 0.4	In Adjustment
	100 - (100*SI) =	**81.8**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Embeddedness		20--16	15-11	10-6	5-0
Velocity / Depth Regime		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Frequency of Riffles		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	11	20--16	15-11	10-6	5-0
Pool Substrate Characterization	11	20--16	15-11	10-6	5-0
Pool Variability	6	20--16	15-11	10-6	5-0
Sediment Deposition	8	20--16	15-11	10-6	5-0
Channel Flow Status	5	20--16	15-11	10-6	5-0
Channel Alteration	11	20--16	15-11	10-6	5-0
Channel Sinuosity	11	20--16	15-11	10-6	5-0
Bank Stability u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Vegetative Protection u/s R	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
/200	119				
/100	**59.5**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	8	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	5	8-7	6-5	4-3	2-0
Physical Instream Habitat	5	8-7	6-5	4-3	2-0
Water Quality	6	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	4	7-6	5-4	3-2	1-0
Biological Indicators	6	8-7	6-5	4-3	2-0
/50	34				
/100	**68.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

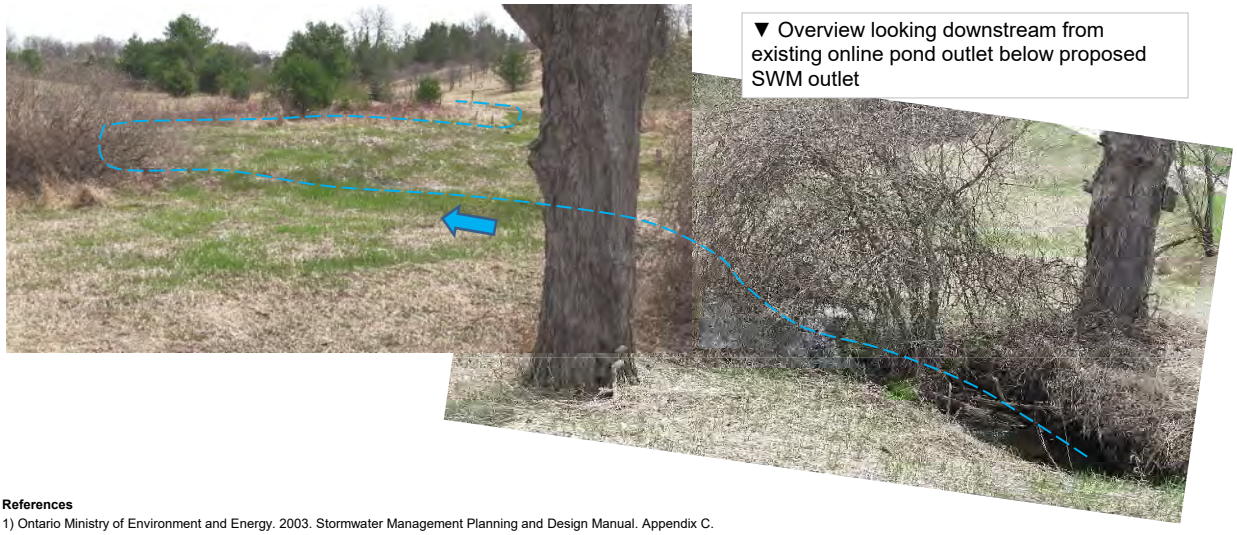
Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	**70**	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0



▼ Overview looking downstream from existing online pond outlet below proposed SWM outlet

References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

BEACON ENVIRONMENTAL

GUIDING SOLUTIONS IN THE NATURAL ENVIRONMENT

Memorandum

To: Dave Featherstone and Glenn Switzer, NVCA

From: Dirk Janas, Geri Poisson and Don Fraser

Date: June 20, 2014

Ref: 213405

Re: **Supplemental Information - Environmental Review of SWM pond outfall locations, Carson Road and Doran Road Neighbourhoods, Township of Springwater.**

Introduction

The following memo provides some additional comments to a memo dated June 11, 2014 regarding a site-specific review of the proposed stormwater management (SWM) pond and outfall locations within the Carson Road neighbourhood and the Doran Road neighbourhood that are part of the first phase of development of the Midhurst Secondary Plan area. These additional comments are based on discussion on site and review comments from Mr. Dave Featherstone from the Nottawasaga Valley Conservation Authority received via email (June 20, 2014) and are as follows:

Carson Road Neighbourhood

North Pond

- Additional works will address "hairpin" bend and downstream eroding banks along Black Creek (upstream of Wilson Drive) to be completed at the detailed design stage.
- There are significant riparian restoration opportunities along the entire reach including on other lands owned by applicant on the west side of Black Creek. Existing conditions include row crop farming to the edge of Black Creek where we observed a "push" of sand over the bank, apparently to facilitate farming along the outside bend of the creek. A reasonable buffer (15 m) could be set aside on other lands as part of mitigation while still allowing agricultural activities (if desired) outside of the buffer area. To be reviewed at detailed design stage.

Carson Road North Pond

- Emergency outfall dissipation will be reviewed in more detail at detailed design to ensure no scouring of downstream feature

Carson Road South Pond

- Emergency outfall dissipation will be reviewed in more detail at detailed design to ensure no scouring of downstream feature

- The stormwater facility is to be set back at least 5 m from drip line (as per Secondary Plan schedule/policy). Note that the SWM pond block has been established based on a 5m setback from the dripline and a 6m setback from the top of bank, addressing this comment.

South Pond

- Significant restoration opportunities along base of north drainage feature (possible meadow marsh/thicket swamp/lowland forest) will be addressed at detailed design.

- Significant restoration opportunities in open space areas outside of stormwater block will be addressed at detailed design (e.g., could connect the north and south drainage feature into one larger future natural block).

Doran Road Neighbourhood

Russell Road Pond

- If open cut trench through regenerating forest is required to bring storm sewer down to Pooles Road, restoration will occur to the extent possible. Directional drilling will avoid these impacts. Reforestation in the valley north of Pooles Road and south of the proposed pond will be reviewed at the detailed design stage as a possible tree compensation area.

Priamo, John

From: Dave Featherstone <dfeatherstone@nvca.on.ca>
Sent: Tuesday, July 01, 2014 9:13 AM
To: 'Dirk Janas' (djanas@beaconenviro.com)
Cc: Chris Hibberd; Glenn Switzer; Priamo, John; Schaefer, Steve
Subject: RE Midhurst MDP - Item #7 - Thermal Mitigation

Hi Dirk. I have compared my comments to the thermal mitigation brief. Comments based on this comparison:

- Riparian plantings are not identified as a potential component of thermal mitigation in the brief; however, your "outfall" memo (Attachment A) does identify these opportunities. Assuming that these opportunities will be carried forward for consideration/design/implementation at detailed design, I would consider this "de facto" acknowledgement that riparian plantings will be part of thermal mitigation and I am satisfied with that.
- Were mitigation measures used, in part, to protect redside dace habitat in northwest Brampton considered as part of thermal mitigation review/development?
- Adaptive management plan – I understand that there is a commitment to thermal monitoring as part of the plan and that associated details can be refined through detailed design. This is satisfactory.

Best regards,

David Featherstone, B.Sc.
Manager, Watershed Monitoring Program
Nottawasaga Valley Conservation Authority
8195 Concession Line 8
Utopia, Ontario
L0M 1T0
(705) 424-1479 Ext. 242
dfeatherstone@nvca.on.ca

From: Dave Featherstone
Sent: Friday, June 27, 2014 1:54 PM
To: 'Dirk Janas' (djanas@beaconenviro.com)
Cc: Chris Hibberd; Glenn Switzer (gswitzer@nvca.on.ca); Priamo, John (jpriamo@scsconsultinggroup.com)
Subject: FW: Midhurst MDP - Item #7 - Thermal Mitigation
Importance: High

Hi Dirk. Has there been any response to these comments to date? I may have missed them in the shuffle. I don't foresee any significant issues but possibly some clarifications. I was in touch with the Alliance Group today (Midhurst Heights) and believe we have that outlet issue figured out. I am heading out shortly but will be checking email periodically over the weekend if we need to touch base. Thanks for your time.

Best regards,

David Featherstone, B.Sc.
Manager, Watershed Monitoring Program
Nottawasaga Valley Conservation Authority
8195 Concession Line 8
Utopia, Ontario

L0M 1T0
(705) 424-1479 Ext. 242
dfeatherstone@nvca.on.ca

From: Dave Featherstone
Sent: Thursday, June 19, 2014 10:18 AM
To: Chris Hibberd; Glenn Switzer (gswitzer@nvca.on.ca); 'Dirk Janas' (djanas@beaconenviro.com); 'KEllis@azimuthenvironmental.com'; Melissa Fuller (MFuller@AzimuthenvironmentaI.Com)
Subject: RE: Midhurst MDP - Item #7 - Thermal Mitigation

Good morning, gentlemen. I have reviewed the thermal mitigation brief. It is generally comprehensive. The Azimuth submission –recognizing we are all under significant time pressures – would have benefitted from a map showing sampling locations. I offer the following thoughts.

Thermal Mitigation

- Sensitive receptors are Black Creek (CRDI) and Matheson tributary (Alliance) – coldwater habitat and brook trout present (or assumed present) in both systems
- Willow Creek: MDDRI sites have > 2 km piped path to Willow so thermal impacts may not be a concern
- Key component of thermal mitigation is LID i.e. runoff from most events infiltrating into ground instead of heading to pond and discharging to receptors
- As well as measures proposed, riparian plantings can also an important component of thermal mitigation (particularly along portions of Black Creek); have mitigation measures required in NW Brampton (I believe in support of redside dace habitat requirements) been considered or would they fall under the components discussed in the brief?
- Only significant storm/melt events will be discharging to receptors; during these significant events, receptors will be also be running high i.e. dilution of any impacts; summer events are most critical
- Monitoring will be required to assess success of measures and to retrofit (where possible) underperforming systems and to inform future phase stormwater design (adaptive management – see below)

Adaptive Management Plan

- Thermal mitigation – we could tie this targets i.e. Black Creek 18 C and Aunt Maggie's Creek 20 C (Dirk – this is from NVCA monitoring and I recognize results are a bit different than identified in the brief) OR tie it directly back to monitoring i.e. demonstrate that stormwater effluent is not impacting thermal regimes of receiving systems (see below)

o Install loggers on receiving systems upstream and downstream of effluent discharge point; install logger at downstream end of stormwater outlet; i.e. three loggers at each sensitive receptor point
o Sensitive receptor points: Black Creek at Carson (CRDI), Black Creek at Wilson (CRDI), Aunt Maggie's/Trib (Alliance)
o Review summer data annually to determine whether impacts have been mitigated/which methods are most effective at mitigating thermal impacts
o Identify a mechanism to ensure that recommendations are used to retrofit existing facilities (where needed/where feasible) and to inform design of future phase facilities

Alliance/Matheson (outlet notes from June 9, 2014 site visit as well as thermal mitigation considerations)

- Reviewed the Craig ROW draw – it is sandy/dry and conveys flows only during significant events; no channel form – sugar maple forest with no wetland indicators; this feature does not need water i.e. no need to "draw off" stormwater into it
- Reviewed the Briarwood draw – similarly sand/dry; possibly conveys flow during significant events; no channel form – disturbed/regenerating and does not need water (few wetland indicators)

- Proposed mix of open and piped outlet channel sections north to Matheson trib (see attached .jpg; larger trib that flows into Aunt Maggie's Creek) – less piping than I understood there to be; piping generally associated with draws (i.e. north of Briarwood); use of open ditch proposed on east side of Gill
- Significant spring enters east side of Gill ditch (see attached) – cold and likely provides habitat for YOY brook trout; need to avoid this feature
- Spring enters larger tributary downstream (see attachment for approximate configuration/nomenclature of watercourses)
- Opportunity to avoid spring by transferring outlet flows to west side (possible engineering considerations i.e. fall to west); length of west side should be maximized to extent possible to maximize afternoon shading (i.e. more shading on west than east during hottest part of day)
- I understand outlet to be the "large tributary" rather than Aunt Maggie's Creek
- Thermal mitigation required to extent possible (maximize piping with potential open area at downstream portion for filtering before entering larger tributary; possible reduced piping but may need to add depending on AMP results)
- Maximum stream temperatures 20 C at Gill Road (we have a station at Aunt Maggie's Creek but not on larger tributary) – need to monitor outlet and US/DS large tributary here as part of AMP and retrofit where possible, use information for future phases

I trust this is helpful. I apologize for the rough notes but best I can do for now. I am out of the office until tomorrow morning but can be reached by cell 705 321-09275 if needed.

Best regards,

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From: Priamo, John [mailto:jpriamo@scsconsultinggroup.com]
Sent: Tuesday, June 17, 2014 4:26 PM
To: Glenn Switzer
Cc: Wayne R.. Wilson; Chris Hibberd; Tom Reeve; Brad Sokach (Brad.Sokach@springwater.ca); Brent Spagnol (brent.spagnol@springwater.ca); Joe A Mullan (mullan@ainleygroup.com); greg.marek@simcoe.ca; Shauna Dudding (shaunad@geraniumcorporation.com); vimalp@geraniumcorporation.com; Alex Troop (ATroop@AllianceHomes.ca); michelle@mntconsulting.ca; Chris Crozier; Dirk Janas (djanas@beaconenviro.com); Paul Neals (paul@azimuthenvironmental.com); Neil Hutchinson (neil.hutchinson@environmentalsciences.ca); 'Matthew Cory'; Dave Featherstone
Subject: Midhurst MDP - Item #7 - Thermal Mitigation

Glenn,

On behalf of the MLG, please note that the submission for Item #7 – Thermal Mitigation has been uploaded to the FTP site and is attached to this email.

Please do not hesitate to call should you have any questions.

Regards,

John Priamo, P. Eng.
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