Hanlon Creek Business Park
2009 Consolidated Monitoring Report

Prepared for:

City of Guelph
Economic Development & Tourism Services
City Hall, 1 Carden Street
Guelph, Ontario

Project No. 726 Date: February 2013

NATURAL RESOURCE SOLUTIONS INC.
Aquatic, Terrestrial and Wetland Biologists

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Report submitted on February 26, 2013

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1.0 Introduction

The monitoring program associated with the Hanlon Creek Business Park (HCBP) is an integration of a series of monitoring requirements arising from recommendations made in the Consolidated EIS (NRSI 2004), the Draft Plan Conditions (OMB 2006), and review comments from agencies during the various stages of the planning process. A consolidation of the monitoring on the HCBP Lands is required as a condition of approval of the *HCBP Environmental Implementation Report 2009* (EIR) prepared by Natural Resource Solutions Inc. (NRSI 2009a). The City of Guelph Environmental Advisory Committee (EAC) recommended approval of the EIR, with a list of conditions that should be met prior to registration of the plans for Phases 1 and 2. Condition 8 states:

> *That a comprehensive and consolidated monitoring program, which specifies frequency, location, protocols, timing, thresholds, and specific contingency measures be submitted and approved by the City of Guelph and the GRCA.*

To meet the above condition, a report titled *Hanlon Creek Business Park Consolidated Monitoring Program* (NRSI 2010) was created as a reference document containing the standards that are to be followed in carrying out the Consolidated Monitoring Program. Refer to that document for detailed information on the framework of the monitoring program and the Standard Operating Procedures for each monitoring component. The Standard Operating Procedures provide detailed methodologies such that each component of the performance monitoring can be carried out consistently over the years of monitoring.

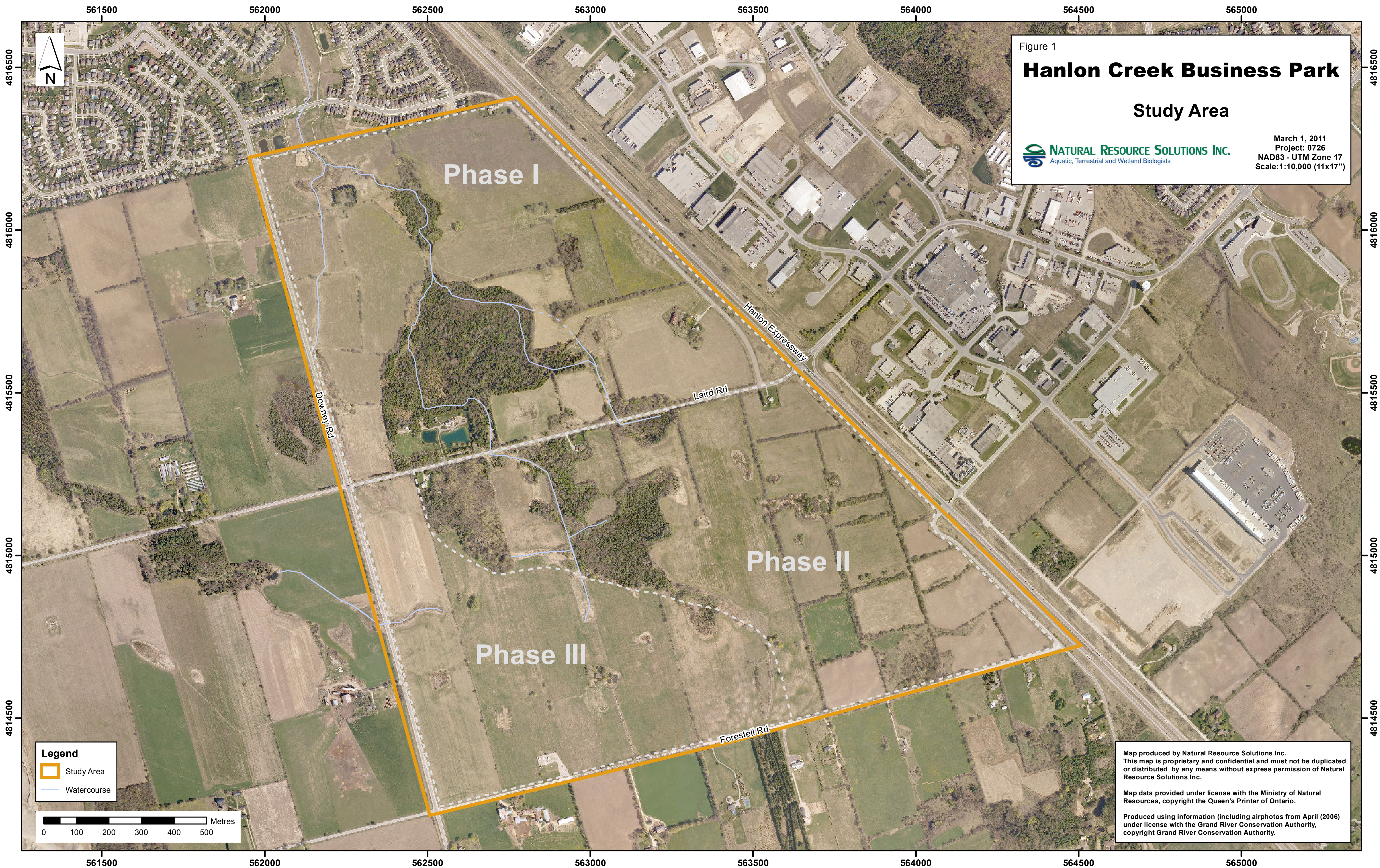
This report integrates the information from all monitoring components for the 2009 calendar year. While some limited construction commenced in 2009, the data collected in this year should generally be interpreted as pre-construction monitoring data. Individual reports from each discipline are appended, and the results are summarized in Section 5.0. 2009 is the first year a consolidated report has been prepared. Individual reports from past years are listed with the references. Natural Resource Solutions Inc. prepared this consolidated report in conjunction with Banks Groundwater Engineering Limited (hydrogeology), and AECOM (surface water).

2.0 Study Area

In 1993, The City of Guelph annexed 1,489 ha of land along its southern boundary with the Township of Puslinch. A portion of this land was then designated by the City as Corporate Business Park and Industrial lands (called the 'Hanlon Creek Business Park'). The study area for this project is comprised of the lands between Downey Road and the Hanlon Expressway, and between Forestell Road and the south end of the Kortright subdivision along Teal Drive (Figure 1). The lands fall within Part Lots 16, 17, 18, 19, and 20 Concession 4 and Part Lots 16, 17, 18 and 19 Concession 5 in the former Geographic Township of Puslinch (now the City of Guelph). Prior to development, lands within Phases 1 and 2 were a mix of agricultural fields, meadow, woodland, forest and Provincially Significant Wetlands consisting of swamp, marsh and thicket, while Phase 3 was primarily agricultural field and cultural meadow, with small wetlands. The core area of natural features was designated as natural heritage lands to be retained in their pre-development state. The agricultural fields and associated hedgerows, and small isolated habitats were designated for roads and development blocks.

The creek, wetlands and forested uplands in the HCBP are part of the much larger Hanlon Creek watershed. The central wetlands in the HCBP are part of the Hanlon Swamp Wetland Complex and therefore are considered provincially significant. In addition, a small wetland in the southwestern portion of the HCBP, next to Downey Road, is part of the provincially significant Speed River Wetland Complex.

This area encompasses a headwater tributary of Hanlon Creek. The tributary within the HCBP was designated as Tributary A in the Hanlon Creek Watershed Study (Marshall Macklin Monaghan Limited 1993). All of Hanlon Creek is designated as a cold-water stream to be managed for brook trout (GRCA and MNR 1998).



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2.1 Construction Activity in 2009

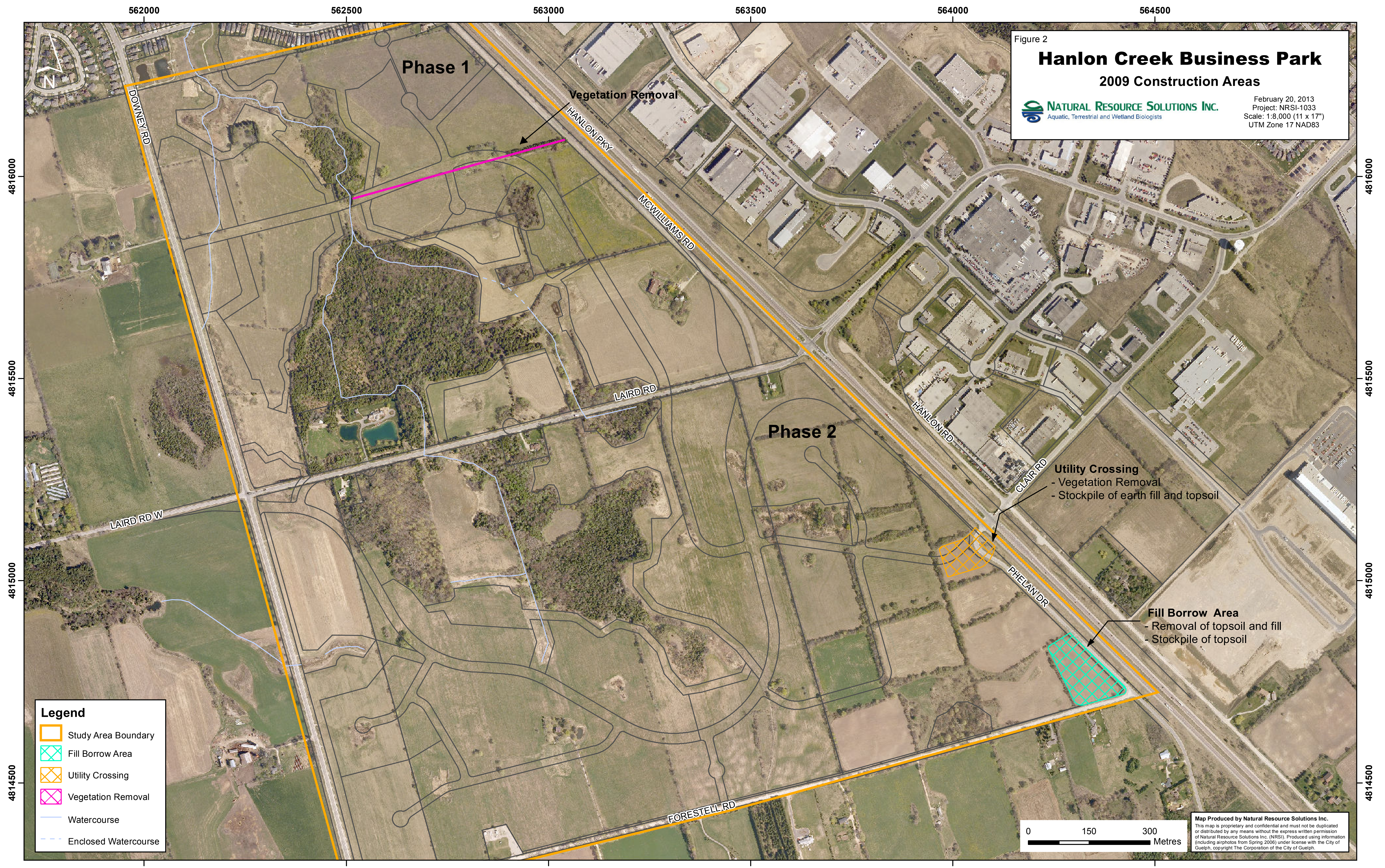
Construction commenced in late 2009 but was limited to three small areas within Phases 1 and 2. Construction activity in 2009 is outlined below and highlighted on Figure 2.

Phase 1 and Phase 2

- Vegetation removal for vehicle access associated with the Hanlon Creek Tributary A/Road A crossing,
- Removal and stockpile of topsoil and earth fill for the utility corridor and watermain crossing,
- Removal and stockpile of topsoil for the fill borrow area,

In preparation for the Hanlon Creek Tributary A/Road A crossing a 3.0m wide access road was cleared of trees and shrubs to Tributary A and heavy duty sediment fence was installed and monitored along the east and west sides of the tributary. Terrafix fencing was also installed around the perimeter of the proposed work site.

Works associated with utility corridor and watermain crossing included the removal of trees and shrubs as well as excavation and stockpiling of topsoil and earth fill adjacent to the Hanlon Parkway. Heavy duty sediment fencing was also installed around the perimeter of the site. Similarly, excavation and stockpiling of topsoil occurred adjacent to Forestell Road in association with the fill borrow area in a small portion of Block 5. Heavy duty sediment fencing was installed around the perimeters of both the fill borrow area and its associated topsoil stockpile, located north of the fill borrow.



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3.0 Monitoring Requirements and Components

As noted above, the monitoring program associated with the HCBP is an integration of a series of monitoring requirements arising from recommendations made in the Consolidated EIS (NRSI 2004), the Draft Plan Conditions (OMB 2006), and review comments from agencies during the various stages of the planning process. There is also a need to monitor the effectiveness of measures arising from the detailed studies and EIR as part of the design, mitigation and restoration of features in the Business Park.

A total of 7 discrete monitoring requirements have been identified. They are:

1. **Performance of Stormwater Management Systems:** Monitoring of hydrogeology, creek flows and temperatures, aquatic biota and wetlands, arising from the Draft Plan Condition #12 to provide baseline information on interactions and as input to the design of stormwater management facilities that discharge to Tributary A, as well as post construction monitoring of performance of the ponds (especially thermal impacts).
2. **Groundwater and Wetlands for the HCBP:** Monitoring arising from the Draft Plan Condition #12 of hydrogeology and wetlands at strategic locations to provide baseline information on spatial distribution and interactions of groundwater/wetlands such that block-level infiltration targets can be assessed.
3. **Groundwater and Wetlands for the Mast-Snyder Gravel Pit:** Monitoring of hydrogeology and wetlands in the western portion of lands south of Laird Road (Speed River PSW) to monitor changes in groundwater and wetlands stemming from concerns over potential impacts of the proposed neighbouring Mast-Snyder Gravel Pit.
4. **Permit Conditions and EIR Recommendations:** Monitoring arising as conditions from permit applications/review as well as impact predictions specifically arising from recommendations out of the EIR process.
5. **Success and Naturalization of Restoration Areas:** Monitoring of success and naturalization processes of restoration areas within buffers, swales and stormwater management areas, arising from agency comments and restoration planting warranty.

6. **Wildlife Movement:** Monitoring of wildlife movement throughout the Business Park, with a focus on movement and mortality associated with Laird Road and Hanlon Creek Boulevard (Road 'A').
7. **Construction Monitoring:** Monitoring arising from the Draft Plan Condition #10, which states that an environmental inspector is to carry out the construction monitoring during grading, servicing, and building construction.

There are 8 performance monitoring components and 2 construction monitoring components that will occur on the HCBP property, and they are being conducted to serve one or more of the requirements listed above. Pre-construction performance monitoring has occurred over a number of years to establish baseline conditions. Most of the monitoring activities have been in effect annually beginning in 2006. Groundwater monitoring began in 1999. Some construction inspection occurred in 2009 associated with the Road 'A' culvert directional service installation under the Hanlon Expressway, and borrow pit operations in the southeast corner of the Business Park. However, construction was of limited extent and the 2009 monitoring is considered 'pre-construction'.

The City of Guelph, as the developer representative, is responsible for this monitoring. The duration of the responsibility to monitor has been defined for each of Phases 1 and 2 as the time when 75% of the area of the individual phase is built, plus an additional 2 years. It is anticipated that this timeframe will also apply to Phase 3.

3.1 Performance Monitoring

The performance monitoring components are indicated as follows, with the past years of monitoring indicated in parentheses.

- Groundwater (most years from 1999 to 2009)
- Stream Temperature and Flow (annually from 2006 to 2009)
- Fish (annually from 2006 to 2009)
- Benthic Invertebrates (annually from 2006 to 2009)
- Vegetation and Soils(annually from 2006 to 2009)
- Breeding Birds(annually from 2006 to 2009)

- Amphibians (annually from 2006 to 2009)
- Salamanders (2009)

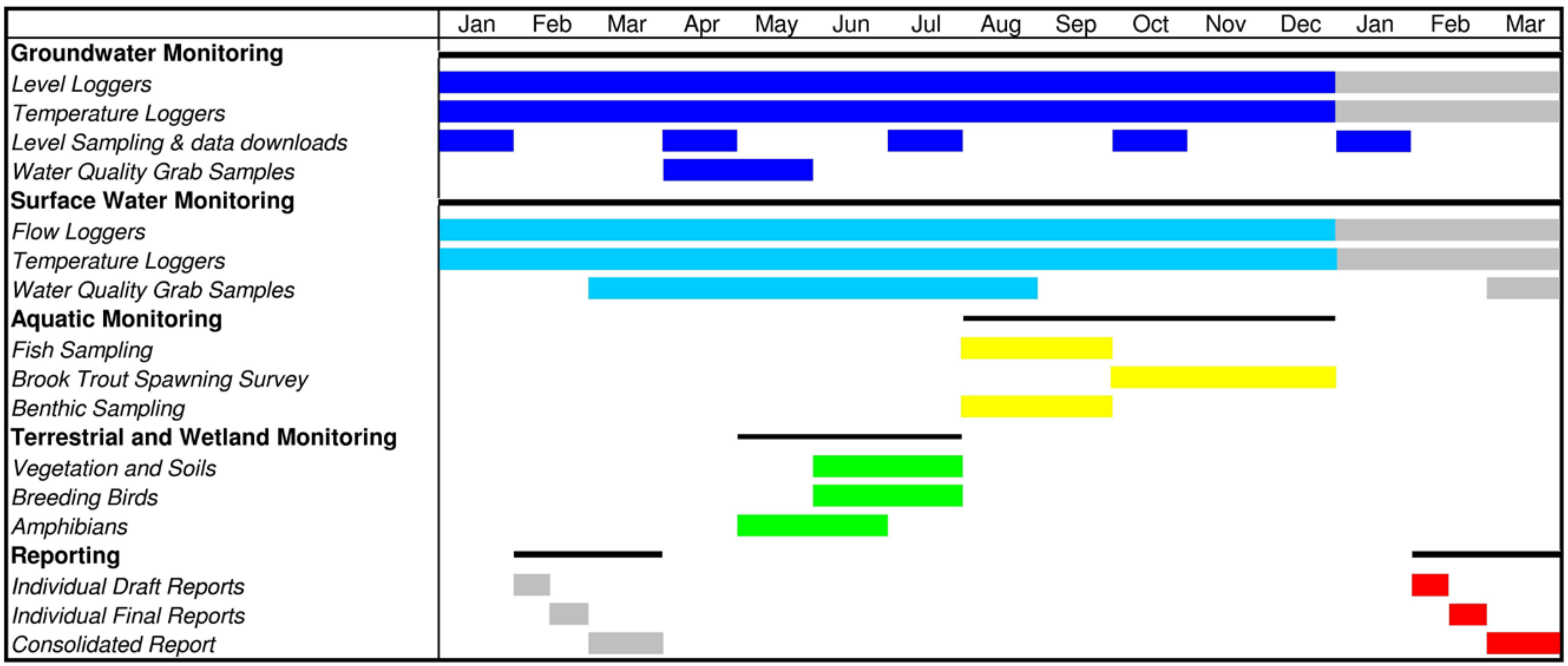
3.2 Construction Monitoring

Construction monitoring is tied to the specific undertaking. Generally, construction monitoring must occur to ensure compliance with the conditions of various permits, including permit(s) from the Grand River Conservation Authority (GRCA) under Ontario Regulation 150/06 and the Letter of Advice from GRCA that constitutes approval under Section 35 of the *Fisheries Act*. Construction monitoring also serves as a means to avoid contravention of other regulations, such as Section 36 of the federal *Fisheries Act* pertaining to deleterious substances. In the specific case of the HCBP, the need for construction monitoring also stems from Condition 10 from the Ontario Municipal Board hearing for the HCBP Draft Plan (June 2006). The condition states that an environmental inspector is to carry out the construction monitoring during grading, servicing, and building construction.

4.0 Annual Schedule of Activities

Table 1 provides the general annual timeline of performance monitoring activities, which approximates the schedule of the 2009 monitoring. The specific dates of monitoring activities for 2009 are provided in Section 5.0 and/or the appended individual reports. Each colour represents an individual monitoring component (Groundwater Monitoring – dark blue, Surface Water Monitoring – light blue, Aquatic Monitoring – yellow, Terrestrial and Wetland Monitoring – green). The timeline for Reporting is represented by red.

Table 1. General Annual Schedule of Performance Monitoring Activities



5.0 Summary of Findings

5.1 Groundwater

Groundwater level monitoring was conducted at this site for more than five years in support of the evaluation of local hydrogeological conditions. The various stages of monitoring that have been completed are summarized in the EIR Hydrogeology Report (Banks Groundwater Engineering Limited 2008). Since January 2007, groundwater levels have been monitored regularly at the HCBP site on a quarterly basis. The locations of the groundwater monitoring stations are shown in Figure 3.

Banks Groundwater Engineering is continuing to monitor groundwater in 35 on-site monitoring wells and 12 wetland mini-piezometers on a quarterly basis. To correspond to previous monitoring, the preferred monitoring periods are January, April, July and October. Data loggers have been installed to measure and record groundwater levels and temperatures on a more frequent basis in 22 selected monitoring wells and mini-piezometers. The data is downloaded from the data loggers during quarterly monitoring. The installation of additional data loggers is planned. Groundwater samples are being collected from selected monitoring wells on an annual basis and analyzed for a representative list of groundwater quality parameters.

The results of the 2009 groundwater monitoring are summarized as follows, along with some background on the long-term and medium-term patterns observed prior to 2009.

5.1.1 Groundwater Levels

<u>Long-Term Observations</u>

Previous analyses presented in the 2008 Technical Memorandum and the EIR Hydrogeology Report showed that it is likely groundwater levels declined from the spring of 1997 to the fall of 2007, based on the recorded precipitation for the period 1997 to 2007 inclusive. However, annual precipitation in 2003, 2006, and 2008 was above average. This appears to have influenced groundwater levels in the spring of 2004 and 2007, and the spring and fall of 2008, when groundwater elevations were among the highest observed between April 2003 and December 2009.

Evidence of the result of the longer trend of below average precipitation is provided by the groundwater levels in July and November 2007, when the lowest observed groundwater elevations occurred. Precipitation in 2007 was well below average and was the lowest observed from 1971 to 2009. As a result groundwater levels continued to decline through to late November 2007. However, this trend was reversed during 2008 with groundwater elevations rising in response to above average annual precipitation.

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Medium-Term Observations

Elevated groundwater levels in April 2008 could be partially attributed to the above-average total monthly precipitation in October, November, and December 2007, followed by closer-to-normal precipitation amounts in January, February, and March 2008. Groundwater elevations increased through the fall of 2008 in response to above-average monthly precipitation, resulting in a peak observed at many locations at the end of December. Groundwater elevations declined through January 2009 as there was no thaw. However, a thaw in early February accompanied by about 38 mm of rainfall over two days caused another sharp rise in groundwater levels, which in many cases was above the subsequent spring levels. Groundwater levels then followed the typical overall decline starting in May, but extended through to mid-November, with two notable increases occurring in response to precipitation events in August and October. Precipitation events then caused a modest rise in levels through to the end of December.

Short-Term Observations

To evaluate the response of the shallow groundwater system to thaws and precipitation events, data loggers were installed to record groundwater levels on a more frequent basis at selected groundwater monitors. The EIR Hydrogeology Report presented a detailed evaluation of daily influences from March 2007 to April 2008. The 2008 Technical Memorandum presented a detailed evaluation of climate influences on groundwater levels for January through December 2008.

Based on the climate and groundwater level data obtained for 2009, the main factors influencing groundwater levels on-site during the 2009 interval are as follows.

- Snowfall through January was equivalent to about 30 mm of precipitation and remained until early February.
- A thaw occurred from February 7 to 19, with about 38 mm of rainfall occurring from February 11 to 12, which was followed by a thaw from February 25 to 27, with about 21 mm of rainfall occurring during this period.

- Total monthly precipitation for January and March was below normal amounts. Conversely, total monthly precipitation in February and from April through August was above normal amounts.
- The gradual rise in maximum daily temperatures from early to mid-March is interpreted to have resulted in a relatively slow melting of the limited snow pack and ground frost, increasing the potential for groundwater recharge.
- Maximum daily air temperatures remained above 0°C from March 4 to December 9, 2009, with the exception of March 12 and April 7.
- Monthly precipitation from April to August and in October 2009 was above average.
- The total precipitation through 2009 was 853 mm, as compared to a 39-year average of about 890 mm.

Specific observations relative to groundwater levels at the Downey Road PSW, the core wetland complex, and at perimeter locations are presented in Appendix I. It is noted that, as expected, the greatest range in groundwater elevations occurred around the perimeter locations of the site where groundwater recharge to the medium- to coarse-grained deposits is most significant. The smallest fluctuations occur in and adjacent to the core wetland and Hanlon Creek Tributary ‘A’. Shallow depths to groundwater and the occurrence of groundwater discharge to these surface water features naturally limit the range of fluctuation in groundwater elevations in these areas.

5.1.2 Groundwater Flow

The EIR Hydrogeology Report illustrated the horizontal direction of shallow groundwater flow from southeast of the site, arcing towards the northern boundary of the site. The horizontal direction of groundwater flow coincides with the wetlands and creek, indicating that a portion of groundwater is discharging to this surface water system.

Results from 2003 to 2009 confirm the downward hydraulic gradients (i.e. groundwater recharge conditions) in the upland portions of the site, and upward hydraulic gradients in the vicinity of, and within, the core wetland complex (i.e. groundwater discharge conditions). Seasonal variations in vertical directions of groundwater flow were also observed in some monitoring well pairs. Groundwater discharge conditions have also been confirmed at the small wetland adjacent to Downey Road (portion of the Speed River Complex PSW).

5.1.3 Groundwater Temperatures

Data loggers installed in the monitoring wells and mini-piezometers recorded groundwater temperature. Groundwater level and temperature monitoring has been conducted using data loggers since 2007 at four PSW monitoring locations (i.e. MW003, PZ-9D, PZ-2D, and PZ-7D). At all of these locations, the shallow groundwater temperature recorded is potentially influenced by cold air temperatures during winter months and by sunlight and standing water in the wetland during summer months.

- MW003, located at the edge of an open agricultural field adjacent to the Downey Road PSW, had temperatures that ranged from about 6°C in March to about 12°C in late October/early November.
- PZ-9D, located in the Downey Road PSW close to MW003, had temperatures that ranged from about 3°C in March to just below 15°C in late August/early September.
- PZ-2D, located in the core wetland complex about 50m east of Tributary A, had temperatures that ranged from just below 3°C in late March/early April to just below 14°C in late August/Early September.
- PZ-7D, located in the core wetland complex in Tributary A1, had temperatures that ranged from just below 5°C in late March/early April to about 12°C from late July through early October.

The temperature range of groundwater at greater depths in this general area tends to fluctuate in a narrower range, typically between 5 and 10°C. It is therefore apparent that the temperatures in the shallower groundwater regime in the vicinity of these four monitors are influenced by seasonal variations in air temperature and solar radiation. These data are interpreted to be representative of the temperature of groundwater discharging to the wetlands and creeks in these locations.

The temperatures recorded in the remaining monitoring stations, starting in 2008 and 2009, also reflect shallow groundwater temperatures near the central wetland complex and around the perimeter of the site. Although the 2009 monitoring is limited for some stations, temperature ranges and the timing of higher and lower temperatures are similar in most monitors. The highest observed groundwater temperatures are evident in monitors where the groundwater elevation is close to surface during summer months, particularly the monitors located in open fields. These monitors also exhibit the lowest groundwater temperatures during the late winter and early spring, when melting snow and frost infiltrate to the shallow groundwater system.

5.1.4 Groundwater Quality

Groundwater samples were first collected in 2003 from 23 selected monitoring wells, and then from 33 selected monitoring wells in 2008 and 2009. The groundwater can be characterized as basic (i.e. pH>7) and, based on the reported calcium and magnesium concentrations, as hard.

In general, the concentrations of the parameters analyzed were below the applicable Ontario Drinking Water Quality Standards (ODWQS) criteria, with the following exceptions.

- Nitrate (as N) concentrations exceeded the ODWQS of 10.0 mg/L on at least one occasion in five monitoring wells.
- Aluminum concentrations exceeded the ODWQS of 0.1 mg/L on at least one occasion in 23 monitoring wells.
- Cadmium concentrations exceeded the ODWQS of 0.005 mg/L on at least one occasion in 11 monitoring wells.
- Iron concentrations exceeded the ODWQS of 0.3 mg/L on at least one occasion in 29 monitoring wells.
- Lead concentrations exceeded the ODWQS of 0.010 mg/L on at least one occasion in 21 monitoring wells.

- Manganese concentrations exceeded the ODWQS of 0.05 mg/L on at least one occasion in 31 monitoring wells.
- Sodium concentrations exceeded the ODWQS of 20 mg/L on at least one occasion in 18 monitoring wells.
- Hardness concentrations exceeded the ODWQS of 100 mg/L in all monitoring wells.
- Colour, turbidity, total dissolved solids, and dissolved organic carbon (DOC) exceeded the respective ODWQS concentrations in most of the monitoring wells.

These results are either typical of groundwater in this area of Ontario, attributable to agricultural use of the site, attributable to the use of road salt on nearby roads, or are explained by the fact that monitoring wells are not typically developed to a sediment-free condition. Improved filtering of samples at the time of collection in 2009 resulted in reduced levels for a variety of parameters. Cadmium is the only parameter not explained by the above factors.

5.2 Surface Water

The 2009 surface water monitoring plan included temperature monitoring at 7 stations distributed along Tributary A from 150m upstream of Laird Road to the existing stormwater management pond near Teal Drive that is to become pond 2 in the HCBP development. Temperature loggers were deployed during winter months to record at 30-minute intervals, and re-deployed during spring and summer months to record at 15-minute intervals. A continuous level/temp logger (at station 5) was installed in 2008 and remained within the stream throughout 2009. In addition, depth and velocity monitoring equipment was installed on May 6, 2009 at the Laird Road culvert. The surface water monitoring stations are shown in Figure 4.

During May-October 2009, sites were visited monthly to download data, perform maintenance, and collect baseflow measurements and water quality parameters (DO, pH, specific conductivity) at all stations. The flow/velocity instrument stopped logging data November 22nd due to battery failure and was removed from the culvert December 14, 2009. The remainder of the data loggers continued to collect continuous data at 30-

minute intervals and were last downloaded December 14, 2009. During the 2009 sampling year, winter stream conditions, equipment malfunctions, and the unauthorized removal of monitoring equipment caused data gaps from some of the station's files.

5.2.1 Surface Water Temperature

A plot of the continuous temperature monitoring throughout the year 2009 is provided in Figure 5. During sub-zero air temperatures in the winter months, Stations 1 and 7 showed no daily variation in temperature and therefore may have been frozen; Station 2 also intermittently exhibited this trend. Stations 2, 5 and 6 showed the greatest fluctuation in daily temperatures during winter months (when Station 2 did not show a freezing trend). Stations 3 and 4 showed very similar trends and maintained the highest temperatures, generally above 1.5°C, with lower diurnal fluctuations.

During summer months the stations which were more exposed (Station 7) and have a wider flow channel with lesser depths (Stations 2 and 6) showed the highest daily variation in temperature as there is greater opportunity for solar radiation impact. Station 3, during the summer, showed the lowest temperatures and daily temperature variation indicating groundwater inputs. Station 4 showed a similar trend but reached higher daily temperatures and showed a much greater variation in the diurnal trends.

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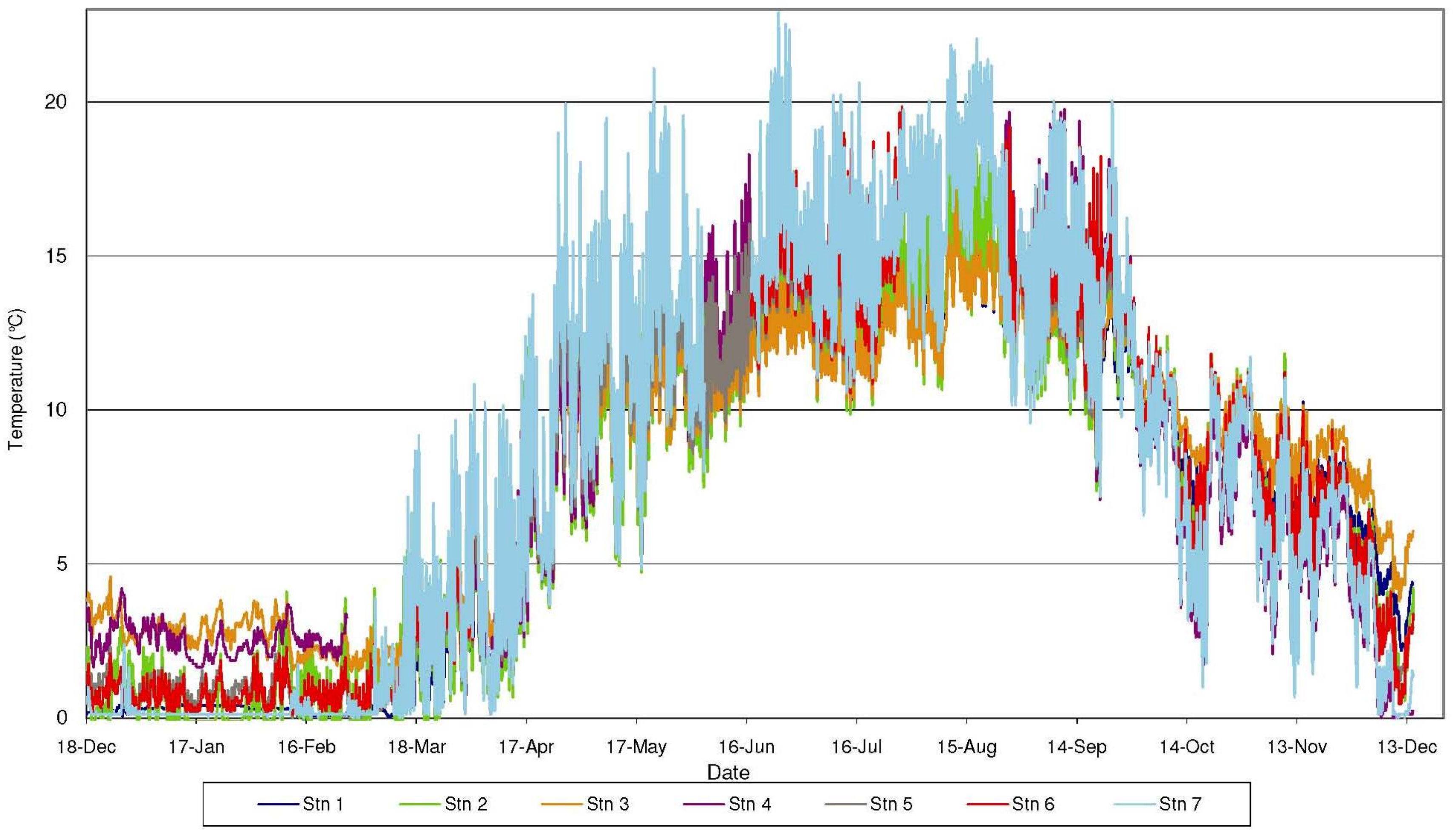


Figure 5. Tributary A Temperature Monitoring – Continuous Temperature for 7 Reaches, December 2008 to December 2009

Further investigation of groundwater monitoring levels and temperatures (provided by Banks Groundwater) provides a better understanding of seasonal surface water temperature variations. The higher temperatures noted at Stations 3 and 4 during the winter may indicate these stations are more influenced by groundwater, as groundwater temperatures are typically above 3°C. This trend changed during the summer when the influence of groundwater was more apparent at Station 3. Groundwater monitoring data showed the water table in proximity to Station 4 to fluctuate more than the water table upstream of Station 3, with water table levels highest in January and lowest in September. Decreases in the groundwater table at Station 4 may explain why groundwater influences at Station 4 were less apparent during summer months.

Extensive descriptive statistics have been calculated for the 2009 continuous monitoring data. These statistics are consistent with those calculated for the *Hanlon Creek Business Park Stream Temperature Impact Report Continuous Modelling with HSP-F* (AECOM 2009). They were calculated for summer and autumn timeframes, and include various averages, maximums, and minimums, and the frequency and duration of any target temperatures exceedances. The statistics are based on stream temperature requirements for Brook Trout (*Salvelinus fontinalis*), which is the target species for management of all parts of Hanlon Creek. The data is provided in Tables 2 and 3, where sufficient data is available.

No stream temperature exceedances of 24°C were recorded in 2009. A single occurrence of 22°C was recorded at Station 7, which is located downstream of the planned Road A crossing, and the existing online pond and cedar swamp (Figure 4). This station has had historically high temperatures compared to the other stations. This reach is wider with riparian vegetation composed of grasses not trees. Further, groundwater monitoring and modeling showed that this is a reach with a recharge area with limited to no groundwater inputs. The single occurrence of 0.5hr duration in a single reach requires no additional action.

Table 2. Summer Temperature Summary using the 2009 Continuous Temperature Data for Tributary A

Stn	Summer (July-August) average maximum	Summer July-August) average	Summer (July-August) average minimum	Maximum 3-day mean	Maximum 7-day mean	Maximum 7-day mean of daily maximums	Hours over 19°C	Percent of Time over 19°C	Frequency of Exceedance over 19°C (Days/yr)	Average Duration of Event Over 19°C (h)	Hours over 22°C	Percent of Time over 22°C	Frequency of Exceedance over 22°C (Days/yr)	Average Duration of Event Over 22°C (h)	Hours over 24°C	Percent of Time over 24°C	Frequency of 24°C Exceedance (Days/yr)	Average Duration of Event Over 24°C (h)
1	15.5	13.8	12.6	13.2	12.8	14.8	0	0.00	0	0	0	0.00	0	0	0	0	0	0
2	16.1	13.9	12.5	13.3	12.8	15.1	0	0.00	0	0	0	0.00	0	0	0	0	0	0
3	13.9	13.0	12.2	0.0	0.0	12.3	0	0.00	0	0	0	0.00	0	0	0	0	0	0
4	17.2*	15.0*	13.1*	n/a	n/a	n/a	11.75*	2.15*	3*	3.9*	0*	0.00*	0*	0*	0*	0*	0*	0*
5	15.2*	13.7*	12.7*	n/a	n/a	n/a	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*
6	17.4*	14.5*	12.3*	n/a	n/a	n/a	11.75*	2.15*	6*	2.0*	0*	0*	0*	0*	0*	0*	0*	0*
7	18.6	16.1	13.8	15.4	14.8	17.8	187	12.57	29	6.2	0.5	0.03%	1	0.5	0	0	0	0

*Data is based on temperature data available July 1-15 and August 24-31, n=21 days

Table 3. Autumn Temperature Summary using the 2009 Continuous Temperature Data for Tributary A

Mid October to End of November					**November Only**			
Stn	Max Temp. (°C)	Frequency of 11°C Exceedance (days/year)	Hours Over 11°C	Average Hrs. Over 11°C per Event	Max Temp. (°C)	Frequency of 11°C Exceedance (days/year)	Hours Over 11°C	Average Hrs. Over 11°C per Event
1	11.2	3	8.5	2.8	11.1	1	2.5	2.5
2	11.8	7	24.0	4.3	11.8	1	5.8	5.8
3	11.6	6	35.0	5.8	11.1	1	3.5	3.5
4	11.4	1	3.5	3.5	10.4	1	0.0	0.0
5	11.4	2	6.8	3.4	10.7	0	0.0	0.0
6	11.8	5	23.5	4.7	11.2	1	3.3	3.3
7	11.7	5	22	4.4	11.0	1	2.0	2.0

A method described in Stoneman and Jones (1996) to determine the temperature classification of each station is based on a comparison of water and air temperature at 16:00 each day during summer months when air temperatures exceed 25°C. This analysis was applied to historical temperature monitoring data. A nomogram is then used to classify results based upon water thermal characteristics (Figure 6).

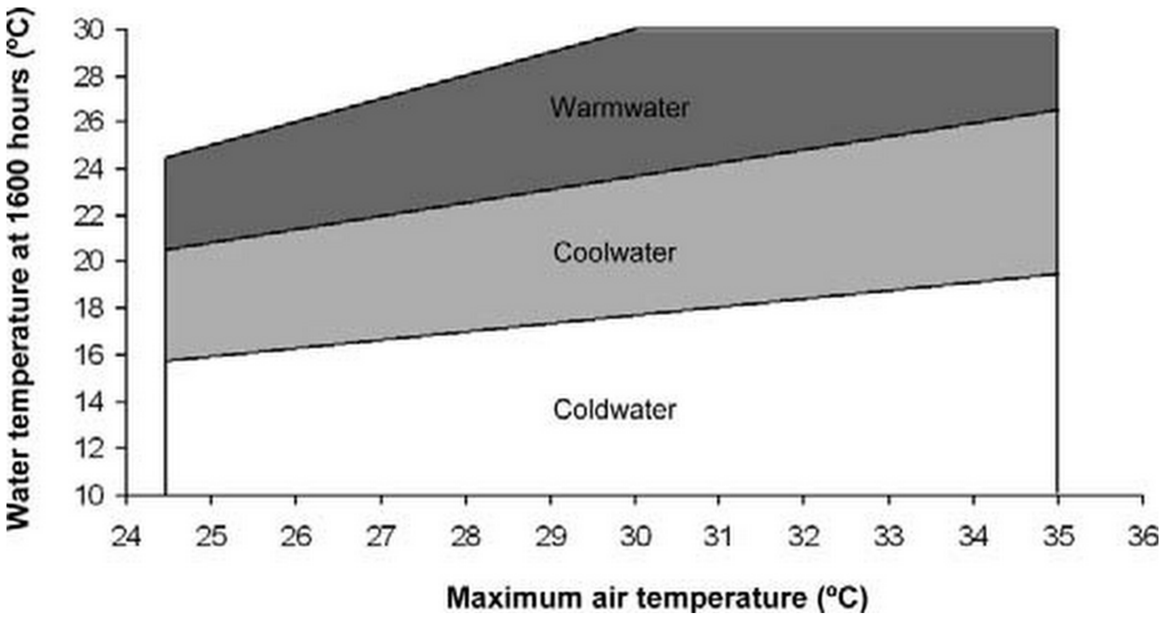


Figure 6. Nomogram of the maximum air temperature and water temperature at 1600 hours, which can be used to estimate the thermal characteristics of streams using measurements of the same parameters (from Stoneman and Jones 1996)

Table 4 shows the results of this analysis for each station within Tributary A of Hanlon Creek. Associated classification plots of each station are included in the 2009 Surface Water Report (Appendix II). Station 6, located at the downstream end of the existing online pond at the planned Road A crossing, is the only station classified as warmwater. The lack of canopy cover at the farm vehicle crossing and the increase in water surface area at the online pond between Stations 5 and 6 likely allowed enough solar radiation penetration to the water surface to allow the creek to warm above the targets.

Table 4. Temperature Classification for Temperature Monitoring Stations on Tributary A for the Years 2006 to 2009

Station	2009	2008	2007	2006	Overall
1	Cool	Cool	Cold	Cold	Cool/Cold
2	Cool	Cool	Cool	Cool	Cool
3	Cold	Cold	Cold	Cold	Cold
4	n/a	Cool	Cold	Cool	Cool
5	n/a	Cold	Cool	Cool	Cool
6	Warm	Cool	Warm	Warm	Warm
7	Cool	Cool	n/a	n/a	Cool

Based on the temperature monitoring results from 2009, we can conclude that the 2009 summer and fall water temperatures were suitable for brook trout habitat.

5.2.2 Surface Water Flow

In 2009, two flow measurement stations were installed along Tributary A of Hanlon Creek. The first, a depth-velocity meter (ISCO 2100) was installed on the downstream end of the 1200mm culvert under Laird Road from May 6th to November 22nd 2009. A stage (level)-discharge relationship is discussed and shown as a rating curve in the 2009 Surface Water report (Appendix II).

The second logger was a HOBO Water Level depth logger, installed at Station 5 on May 6, 2009. This logger was removed from the site by someone without authorization, resulting in the loss of data from July 15 to August 24. A stage (level)-discharge relationship is discussed and shown as a rating curve in the 2009 Surface Water report (Appendix II).

A plot showing the creek flow at Station 5 and Laird Road as well as precipitation data collected at the Elora Research Station, for the 2009 monitoring period is shown in Figure 7. The flow at Laird Road, for the period where the records overlap, is on average about 65% of the flow at Station 5. This is consistent with 2007and 2008 flow data. The additional flow at Station 5 can be attributed to local groundwater and tributary flow contributions.

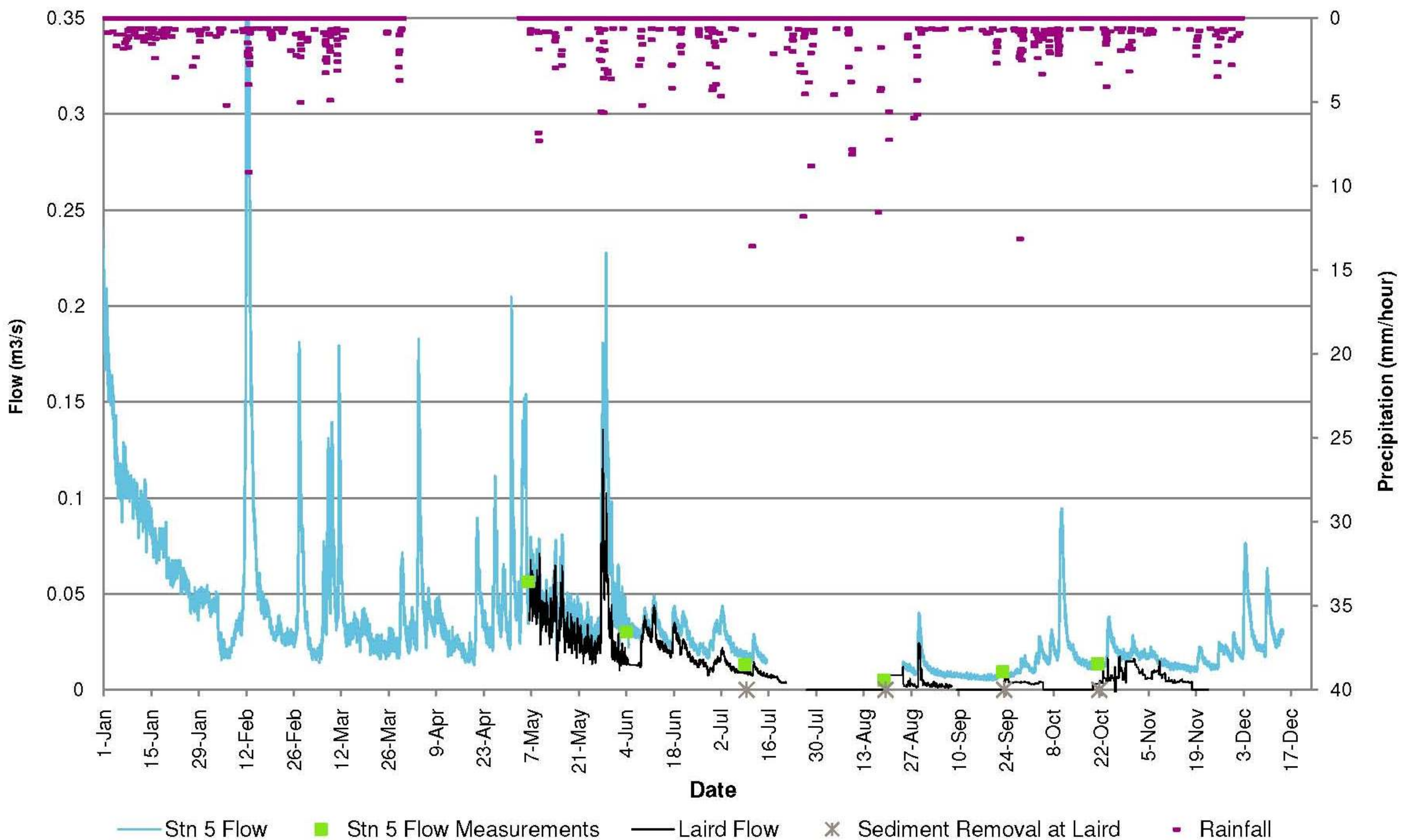


Figure 7. Laird Rd. Station and Station 5 Flow and Precipitation – January to December 2009

In addition to the continuous flow monitoring, 6 baseflow measurements were taken between May 6 and November 21, 2009 at Stations 1, 2, 3, 4, and 7. A Flow Tracker 6300 – Acoustic Doppler Velocity Meter was used for the velocity measurements. The results are discussed and shown in tabular and graphical form in the 2009 Surface Water report (Appendix II). The data obtained provides sufficient data for trends analysis. A comparison of 2008 and 2009 baseflow are shown in Table 5.

Table 5. Hanlon Creek Baseflow Monitoring – 2008-2009 Summary (m^3/s)

Station	2008 Min	2009 Min	2008 Max	2009 Max	2008 Average	2009 Average
1	0.0035	0.0039	0.0113	0.0149	0.006	0.0078
2	0.0027	0.0012	0.0107	0.0256	0.0093	0.0107
3	0.0038	0.0042	0.0094	0.0187	0.0085	0.0106
4	0.0021	0.003	0.01	0.0221	0.009	0.0093
5	0.0077	0.005	0.0168	0.0563	0.0205	0.0213
6	n/a	n/a	n/a	n/a	n/a	n/a
7	0.0009	0.0018	0.0121	0.0538	0.0158	0.0197

5.2.3 Surface Water Quality

During each field visit a YSI multi-parameter probe (600R) was used to collect dissolved oxygen, pH, and specific conductivity conditions at each site. The results are shown graphically in Figures 8, 9, and 10.

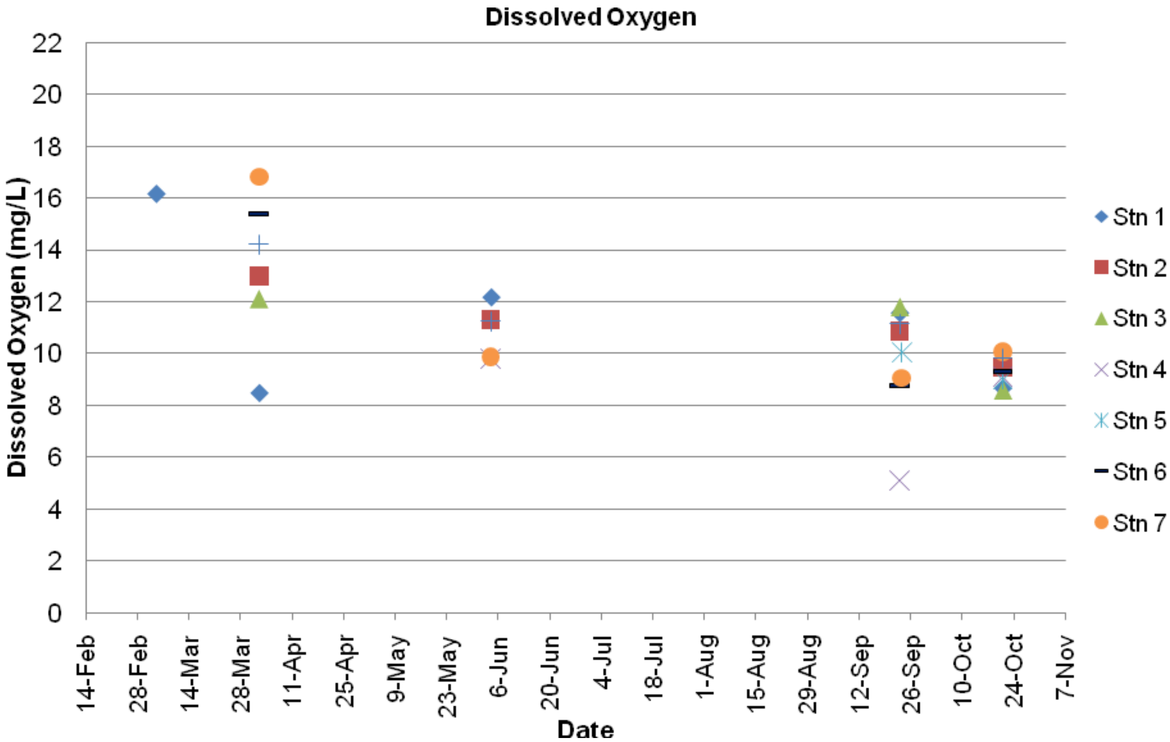


Figure 8. YSI Dissolved Oxygen Readings at 7 stations on Tributary A

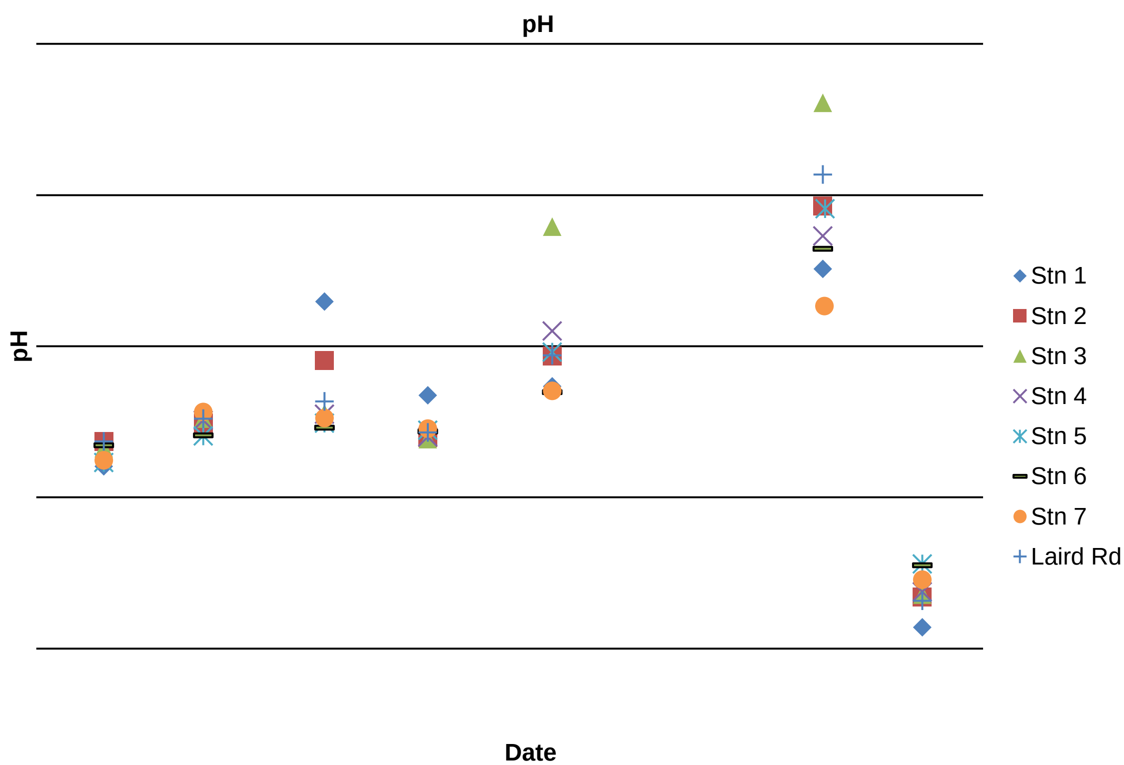


Figure 9. YSI pH Readings at 7 Stations on Tributary A

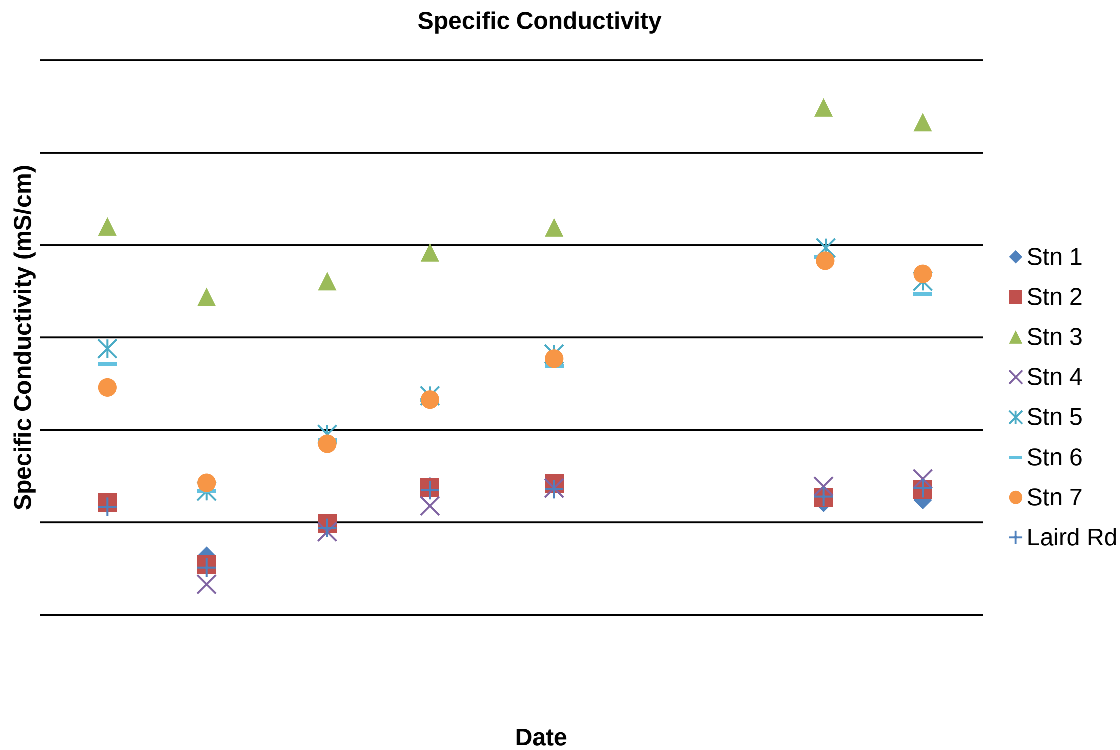


Figure 10. YSI Specific Conductivity Readings at 7 Stations on Tributary A

5.3 Fish

A total of 3 aquatic monitoring sites in the northern portion of the subject property were selected during the 2006 field season. The same sites were sampled again in 2007, 2008 and 2009. Two aquatic monitoring sites were added in 2009 to expand the monitoring program. At each site, there is a benthic invertebrate sampling station (BTH) and a quantitative fish sampling station (EMS). The monitoring stations are shown on Figure 11. The original selection of sites was based in part on historic knowledge of brook trout inhabitance. The sites were also positioned to help locate sources of future impacts, should any occur. Refer to the 2009 Aquatic Monitoring Report in Appendix III for additional details on site selection.

Fish sampling was conducted in August 2009 using a removal method whereby the station was isolated using block nets, and the fish were removed with electrofishing equipment using multiple discrete samples. The data was kept separate for each sample, and a statistical model was used to predict the continued decline in numbers captured, resulting in an estimate of the population in that station.

In addition to the quantitative fish sampling described above, a brook trout spawning survey was conducted in October 2009. The areas of focus were the section of Tributary A from the swamp downstream of the existing online pond and future Road A crossing, the confluence with Tributary A1, and Tributary A1 upstream from the confluence with Tributary A to the outlet of a subsurface (tile) drain. In addition, Tributary A was investigated for several hundred metres upstream (south) of Laird Road, and in the vicinity of Teal Drive, but these areas have less potential as spawning habitat and may not be included in future spawning surveys.

5.3.1 Quantitative Fish Sampling

The following is a summary of fish species captured during the 2009 monitoring.

Station EMS-001:

Electrofishing in 2009 resulted in the capture of three fish species. They were blacknose dace *(Rhinichthys obtusus)*, brook stickleback *(Culaea inconstans)*, and central mudminnow *(Umbra limi)*. A combined total of 48 individual fish were captured through the four passes. These species have been captured at this station in the previous years of monitoring, but in 2008 creek chub (*Semotilus atromaculatus*) were also captured.

Station EMS-002:

Electrofishing in 2009 resulted in the capture of three fish species. They were blacknose dace, brook stickleback, and central mudminnow. A combined total of 33 individual fish were captured in the four passes. Creek chub has been captured at this station before but not since 2008.

Station EMS-003:

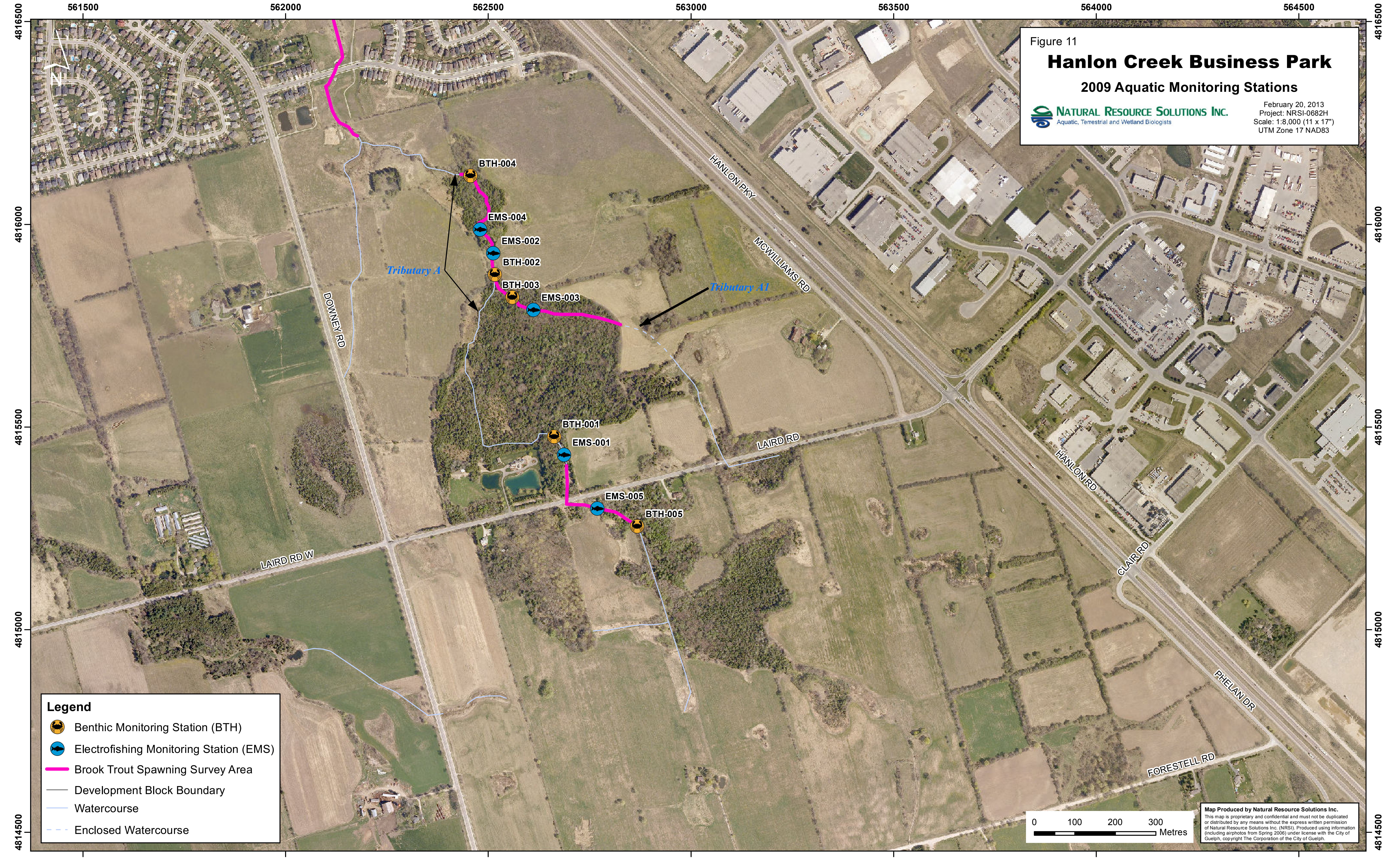
Electrofishing in 2009 resulted in the capture of one fish species, brook stickleback. A combined total of 28 individual fish were captured in the four passes. Blacknose dace was captured at this station in 2008, but was not captured in 2009. Creek chub was captured at this station in 2006, but was not captured at this station in 2007, 2008 or 2009.

Station EMS-004:

Electrofishing took place on this site for the first time in 2009 and resulted in two species being caught. They were blacknose dace and brook stickleback. A combined total of 27 individual fish were captured in three passes.

Station EMS-005:

Electrofishing took place on this site for the first time in 2009 and resulted in three species being captured. They were blacknose dace, brook stickleback, and central mudminnow. A combined total of 61 individual fish were caught in five passes.



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Habitat Preferences of Fish Captured

Brook stickleback prefer “vegetated lake margins, ponds, and clear, quiet to flowing pools and backwaters of creeks and small rivers...” (Eakins 2007).

Blacknose dace prefer “riffles and runs of cool, small- to medium-sized streams with moderate to steep gradient and gravel substrate... “(Eakins 2007).

The central mudminnow prefers “heavily vegetated ponds, wetlands or pools of small creeks and quiet, shallow (0.5 m) areas of lakes with mud and organic substrates” (Eakins 2007).

All of the species captured prefer a cool-water thermal regime (Eakins 2007). The presence of fish with such a thermal preference is consistent with the cool to cold water temperatures known from these watercourses. No trout species were captured in the quantitative sampling stations, which is consistent with the previous years of pre-construction monitoring.

Population Estimates

Comparability from year to year is limited due to data variability. The reliable results show substantial variation from year to year, which is attributable to natural variation. The results of the population estimates from all years of pre-construction monitoring are summarized in Table 6 and described below.

Table 6. Fish Population Estimates (Number of fish) by Station

Station	2006	2007	2008	2009
EMS-001	9.07	> 87*	80	48.5
EMS-002	55.56	173.07	>53*	40.2
EMS-003	> 31*	13.89	31	32.7
EMS-004				29.4**
EMS-005				82.3

* These results are approximate because the population estimate was not statistically valid.
** Estimate obtained using the least squares regression method.

In 2009, the estimated number of fish at station EMS-001 decreased compared to 2008. Considerable variability in the population has been observed over the years at EMS-001.

In 2009, the population estimate at EMS-002 is lower than all other years of monitoring. The estimate for 2007 stands out as a high year, and the other 3 years may be considered more typical.

At EMS-003 the population estimate for 2009 is very similar to 2008. Although the estimate for 2007 is lower, there is no obvious trend in the population at this station.

At EMS-004 the predicted population is 29.4 using the least squares regression method ($r^2 = 0.969$). Comparison with previous years of monitoring data is not possible as this site was established in 2009.

At EMS-005 the population estimate was 82.3. Comparison with previous years of monitoring data is not possible as this site was established in 2009.

5.3.2 Brook Trout Spawning Survey

No brook trout redds or fish were observed during the spawning survey. The survey included selected sections of Tributary A on the HCBP lands and downstream of Teal Drive, and the entire length of Tributary A1 (Figure 11).

The water temperatures taken during the October 14, 2009 spawning survey are summarized in Table 7.

Table 7. Water Temperatures in Tributary A on October 14, 2009

Location	Water Temperature (°C)	Air Temperature (°C)	Time of Day
Approx. 50 to 100m downstream of Teal Drive	3.4 to 3.6	5	1045 hrs
Approx. 50 to 100m upstream of Teal Drive	4.1 to 4.2	7	1130 hrs
Swamp downstream of Road A crossing	6.6	4	1200 hrs
Between Road A and confluence with Tributary A1	6.3	8	1215 hrs
Tributary A immediately upstream of the confluence with Tributary A1	4.5	7	1225 hrs
Tributary A1	9.0	8	1240 hrs

From these temperatures, it is evident that groundwater was providing the most stable water temperatures in Tributary A1. This is consistent with the 2009 continuous temperature monitoring (AECOM 2009), which showed that Station 3 on Tributary A1 was one of the most temperature-stable of the 7 monitoring locations.

Tributary A in the vicinity of Teal Drive was observed on October 14, 2009. The substrates in this section of Tributary A are predominantly fine material, which is generally not suitable for brook trout spawning. The water temperatures measured during the October 14 investigation in this area ranged from 3.4 to 4.2°C with air temperatures of 5 to 7°C.

Tributary A from the swamp downstream of the Road A crossing to the confluence with Tributary A1 was observed during both site visits. Some of the substrate materials near the confluence are more suitable for spawning than most other areas on the HCBP lands. The water temperature in this section of Tributary A was 10°C during the second investigation (October 21, 2009). Air temperature was 13°C, and time of day was 10:35am.

Tributary A1 is the most likely location for spawning to occur, based on the influence of groundwater. For this reason, its entire length was investigated during both site visits. On October 21, 2009, the water temperature at the tile drain outlet, which provides most of the flow to this tributary, was 11°C. The air temperature was 12°C, and the time of day was 9:30am.

The investigation in the vicinity of Laird Road was conducted on October 21, 2009. While there is some variation in substrate immediately upstream of Laird Road, fine materials predominate. The water temperature on this date was 10°C while the air temperature was 12°C at 11:45am.

5.4 Benthic Invertebrates

A total of 3 aquatic monitoring sites in the northern portion of the subject property were selected during the 2006 field season. The same sites were sampled again in 2007, 2008 and 2009. Two aquatic monitoring sites were added in 2009 to expand the monitoring program. At each site, there is a benthic invertebrate sampling station (BTH) and a quantitative fish sampling stations (EMS). The monitoring stations are shown on Figure 11. The original selection of sites was based in part on historic knowledge of brook trout inhabitance. The sites were also positioned to help locate sources of future impacts, should any occur. Refer to the 2009 Aquatic Monitoring Report in Appendix III for additional details on site selection.

The Percent Model Affinity (PMA) index calculation generates Percent Similar Community (PSC) values, which are summarized in Table 8. Values that are higher than the critical PSC value indicate no impact, while values that are lower than the critical PSC value indicate impact. The term “impact” indicates that the benthic community in a subject stream deviates from the expected model community for a stream in southern Ontario with similar bottom substrates based on a statistical comparison. The presence of “impact” determinations at Station BTH-002 in Tributary A prior to construction of the HCBP suggests that the station differs in physical characteristics from those of the model community streams. This may be attributed to factors such as impacts from land uses that occurred prior to development, or a simple difference in habitat characteristics. The purpose of making the impact determination is to monitor for trends over time.

The impact determinations for 2006, 2007 and 2008 are given along with the 2009 results for comparison.

Table 8. Percent Similar Community Values and Impact Determination

Station	2006 Result	2007 Result	2008 Result	2009 Critical PSC	2009 Sample PSC	2009 Result
BTH – 001	No Impact	No Impact	No Impact	42.12	55.04	No Impact
BTH – 002	Impact	No Impact	Impact	50.70	42.58	Impact
BTH – 003	No Impact	No Impact	No Impact	42.12	57.51	No Impact
BTH – 004	-	-	-	42.12	54.14	No Impact
BTH - 005	-	-	-	42.12	48.08	No Impact

The additional indices that were calculated include taxonomic richness, Ephemeroptera, Plecoptera, and Trichoptera (EPT) richness, and % dominant taxon. These results are summarized in Figures 12, 13 and 14 and are discussed by station in the text that follows.

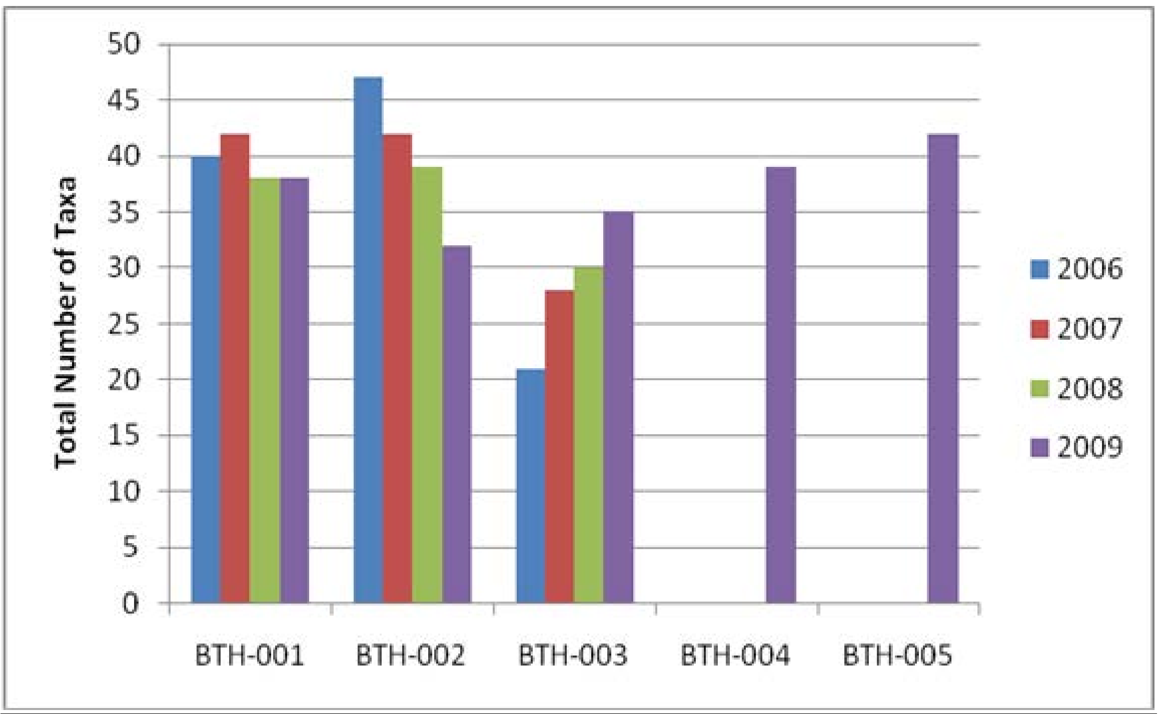


Figure 12. Benthic Invertebrate Taxonomic Richness for the Years 2006 to 2009

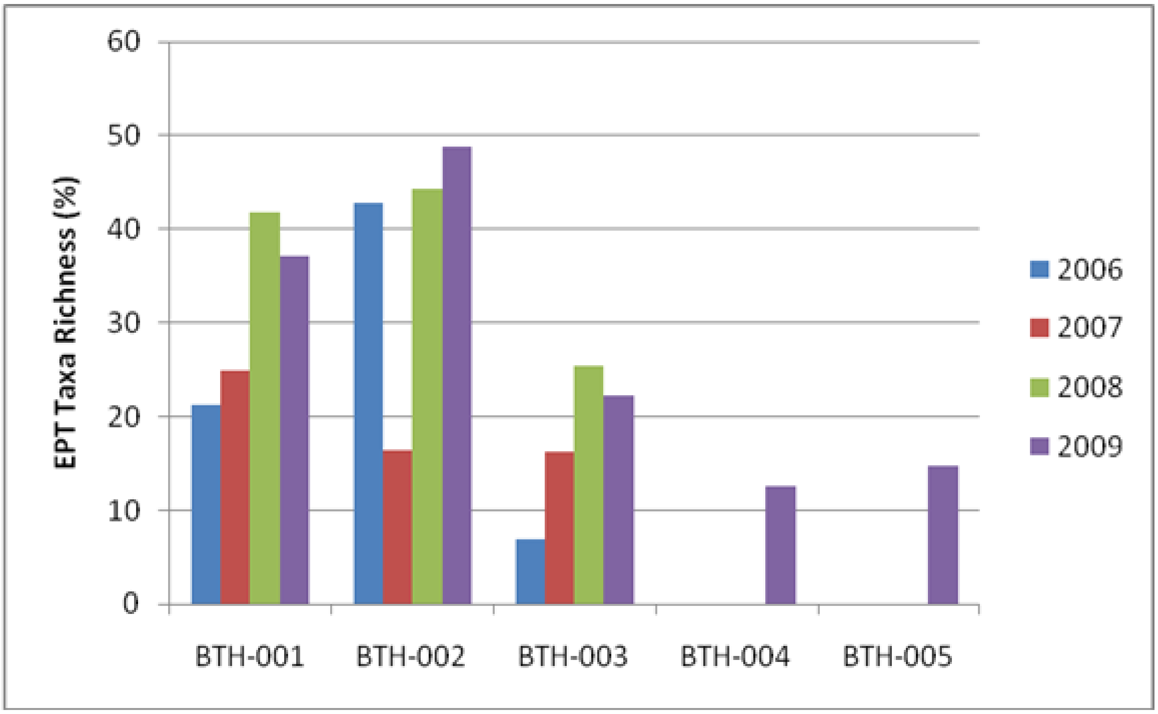


Figure 13. Benthic Invertebrate EPT Taxa Richness for the Years 2006 to 2009

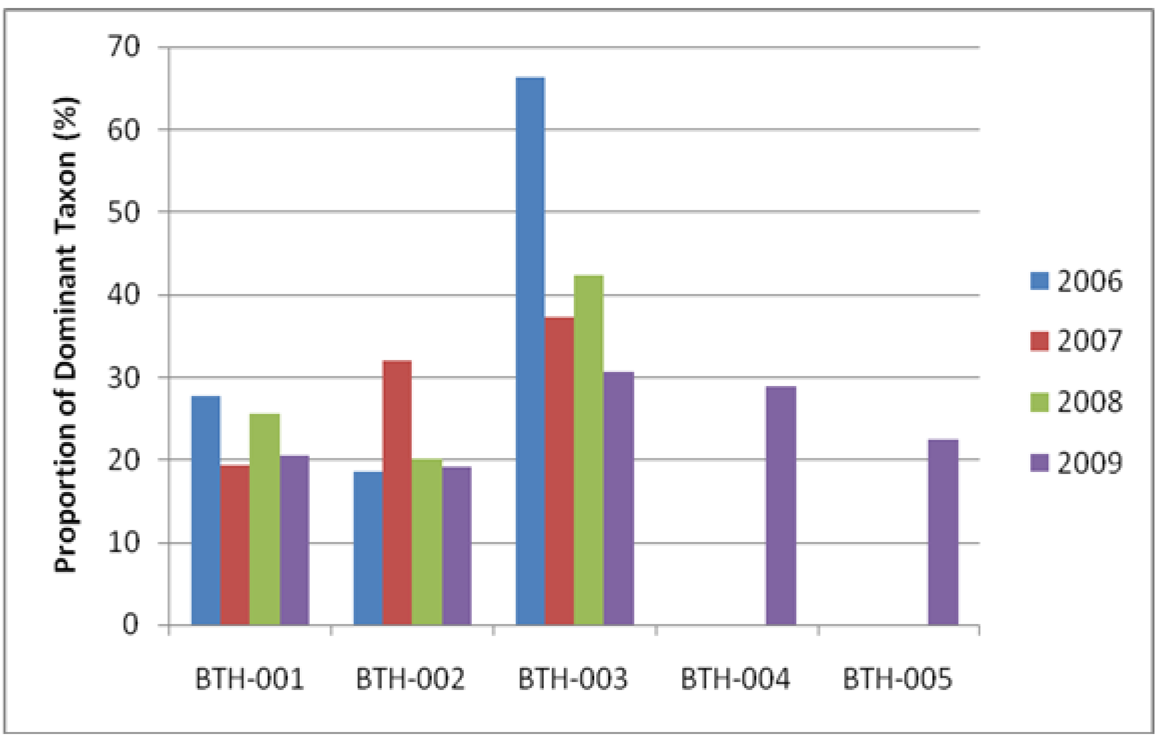


Figure 14. Benthic Invertebrate Proportion of Dominant Taxon, Years 2006 to 2009

BTH-001

Aside from some expected natural variation, the benthic invertebrate data indicates that habitat and water quality conditions at station BTH-001 have generally remained consistent during pre-construction monitoring for the years 2006 to 2009. Taxonomic richness has remained very similar. The EPT richness for 2008 and 2009 stand out as being higher than the results for 2006 and 2007. This suggests improved water quality and/or habitat conditions as Ephemeroptera, Plecoptera and Tricoptera (EPT) are generally considered pollution intolerant. The dominant taxon in 2009 was *Diplectrona modesta*, a caddisfly (Trichopteran) of the family Hydropsychidae. This species represented 20.5% of the individuals in the sample. This is a similar percentage to previous years, and the dominant taxon is the same taxon that was dominant in the 2008 data. Lastly, the PMA index continued to show “no impact” in 2009.

BTH-002

The benthic invertebrate data at station BTH-002 has exhibited considerable variation during pre-construction monitoring. Taxonomic richness was 32 in 2009, which is a continuation of a general decline in this metric. Reduction in numbers of taxa suggests degrading habitat and/or water quality conditions. The EPT richness was 48.8% in 2009. This is similar to most years of pre-construction monitoring, with the exception of 2007 when this value was much lower (16.4%). The dominant taxon at station BTH-002 in 2009 was *Cheumatopsyche* spp., a genus of caddisflies (Trichopterans) of the family Hydropsychidae. This genus represented 19.1% of the individuals in the sample. This quantitative result for % dominant taxon is typical for this station over the years of monitoring. However, the dominant taxonomic group has changed twice during pre-construction monitoring. The 2009 PMA index returned a result of “impact”. This is the same result as in 2006 and 2008. In 2007, the PMA index indicated “no impact”. The “impact” determinations indicate that the water quality and/or habitat conditions differ from the model community for streams in southern Ontario with rock substrates.

BTH-003

Overall, the benthic invertebrate data suggests that habitat and/or water quality conditions at station BTH-003 have generally improved throughout the 4 years of pre-construction monitoring. Taxonomic richness at station BTH-003 was 35 in 2009. There has been a general increase in this metric, which was at its lowest (21) in 2006. The

EPT richness was 22.2% in 2009. The results have been variable over the years. The lowest result was 6.9% in 2006, and the highest was 25.4% in 2008. The dominant taxon in 2009 was *Micropsectra* spp., a genus of the order Diptera, family Chironomidae, and subfamily Chironominae. It has been dominant throughout all 4 years of pre-construction monitoring. They represented 30.7% of the sample in 2009, the lowest value of all the years of pre-construction monitoring. The highest value occurred in 2006 when the genus *Micropsectra* represented 66.3% of individuals in the sample. The PMA analysis continued to show "no impact" in 2009.

BTH-004

This station was sampled for the first time in 2009. Taxonomic richness at Station BTH-004 was 39 in 2009, which is typical for the benthic monitoring stations at the HCBP. The EPT richness was 12.5% - lower than most results at other stations during pre-construction monitoring. The dominant taxon was *Caecidotea* spp., a genus of the order Isopoda and family Asellidae. They represented 29% of the sample in 2009. Isopods are Crustaceans. Some species of *Caecidotea* are cave-dwelling or are associated with groundwater (Smithsonian National Museum of Natural History 2009). The PMA index returned a result of "no impact".

BTH-005

This station was sampled for the first time in 2009. Taxonomic richness at Station BTH-005 was 42 in 2009, which is typical for the benthic monitoring stations at the HCBP. The EPT richness was 14.8% - lower than most results at other stations during pre-construction monitoring. The dominant taxon was *Caecidotea* spp., the same group found at station BTH-005. They represented 22.5% of the sample in 2009. The PMA index returned a result of "no impact".

5.5 Vegetation and Soils

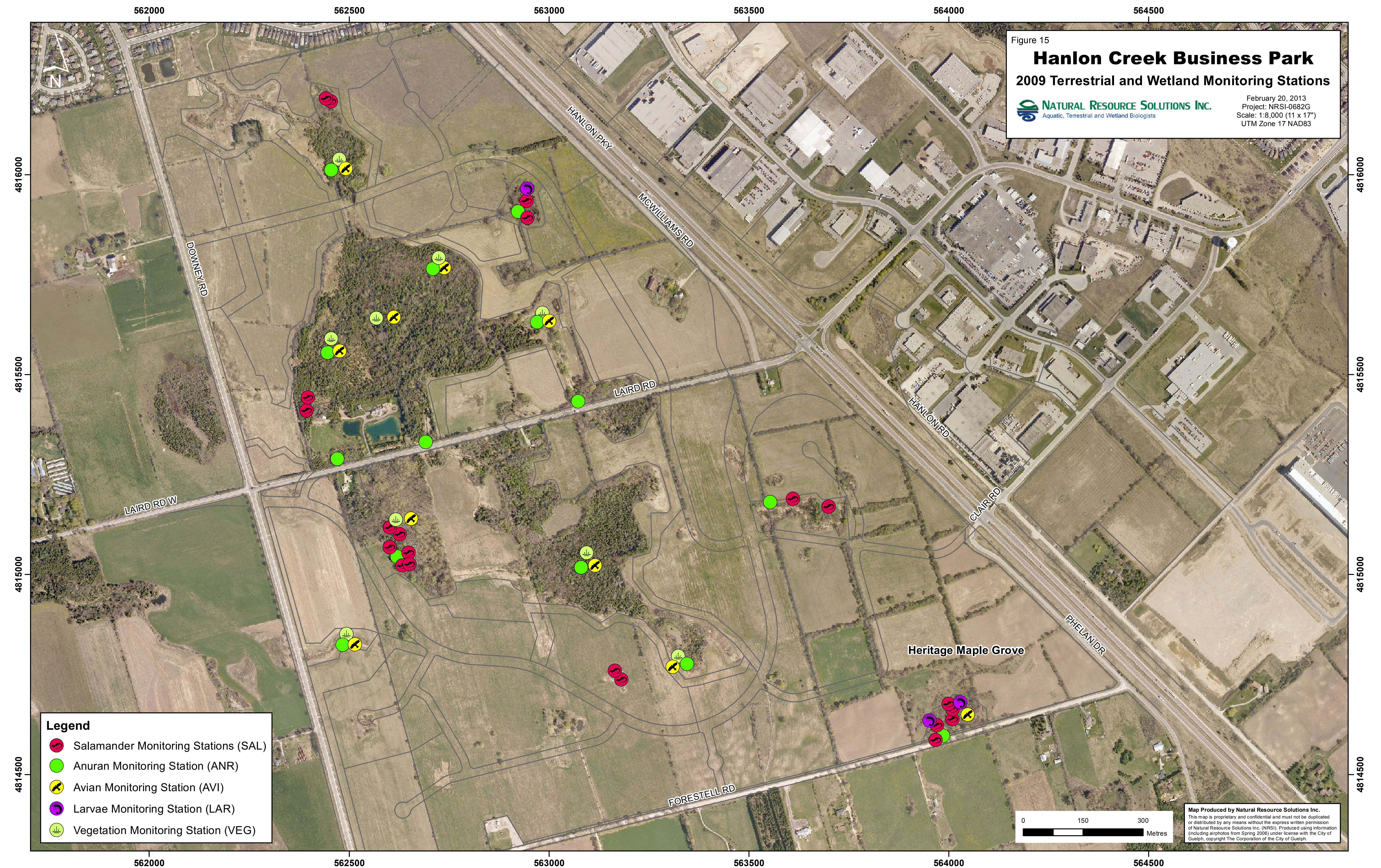
Eight vegetation plots were monitored in 2006, with an additional plot added in 2007. Since 2007, 9 permanent vegetation plots have been sampled each year, including 2009. The vegetation monitoring stations are shown on Figure 15. These stations were originally selected to represent a range of vegetation plot types and locations, focusing primarily on wetlands within the study area. They also represent larger upland woodlots north and south of Laird Road. Each randomly selected permanent plot is 10x10m in size. Trees and shrubs were surveyed in each plot. Within each plot, 5 subplots were used again in 2009 for sampling herbaceous plant species. In addition, soils were sampled in a central location within each plot. The data collected to date provides a good baseline data set for comparison to future years.

The ELC community names were revised by Lee (2008). The new community descriptions have been used and are listed in Table 9. A map showing the vegetation communities is included in the 2009 Terrestrial Monitoring Report (Appendix IV).

Table 9. Monitoring Plot ELC Communities

Plot	Previous ELC Code	New ELC Code	New Community Description Name
1	MAM2-2	MAMM1-3	Reed-canary Grass Graminoid Mineral Meadow Marsh
2	SWC3-2	SWCO1-2	White Cedar - Conifer Organic Coniferous Swamp
3	FOD6	FODM6	Fresh - Moist Sugar Maple Deciduous Forest
4	SWM1-1	SWMM1-1	White Cedar - Hardwood Mineral Mixed Swamp
5	FOM6	FOMM6	Fresh - Moist Hemlock-Hardwood Mixed Forest
6	MAM2-2	MAMM1-3	Reed-canary Grass Graminoid Mineral Meadow Marsh
7	SWM1-1	SWMM1-1	White Cedar - Hardwood Mineral Mixed Swamp
8	SWM1-1	SWMM1-1	White Cedar - Hardwood Mineral Mixed Swamp
9	MAS2-1	MASM1-1	Cattail Mineral Shallow Marsh

Refer to the 2009 Terrestrial and Wetland Monitoring Report (Appendix IV) for a comprehensive list of the vegetation species observed from 2006 to 2009. The data from past years was thoroughly reviewed for inclusion in the 2009 report, and only those species that were recorded from within the monitoring plots was included in the list. A total of 95 vegetation species were recorded in 2006, 108 in 2007, 107 in 2008, and 116 in 2009. Overall, 171 species have been observed in the vegetation monitoring plots. None of these species are rare or regionally significant.



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5.5.1 Floristic Indices

A common method for evaluating and assessing natural areas is using floristic composition. This method is based on the character of a region's flora. Plant species display varying degrees of fidelity to specific habitats, which is expressed by species conservatism. Species conservatism is the degree of faithfulness a plant displays to a set of environmental conditions. The quality of a natural area is reflected in the number of conservative species found within a certain habitat (Wilhem and Ladd 1988 *In* Oldham et al. 1995). There are several floristic indices which can be used to describe the character of the vegetation in the plot. These include the Coefficient of Wetness, the Coefficient of Conservatism, and the Natural Area Index. All species (herbs, shrubs, and trees) from each plot are considered in these equations.

<u>Coefficient of Wetness</u>

The Coefficient of Wetness (CW) is based on wetland values given to each individual plant species. Values range from -5 to +5, where -5 indicates an obligate wetland species, and +5 indicates an obligate upland species. "0" is assigned to facultative species, those that are just as likely to be found in wetland or upland habitats. The Coefficient of Wetness values used are based on Oldham et al. (1995). Figure 16 shows the average wetness per plot, based on the wetness coefficients of all species found within a plot. Most plots are wetlands. Plots 3 and 5 are upland, designated as a sugar maple forest and hemlock-hardwood forest respectively. Plot 1 is the wettest, with an average coefficient of wetness score of -3.9 in 2009. This plot is located in a reed-canary grass marsh.

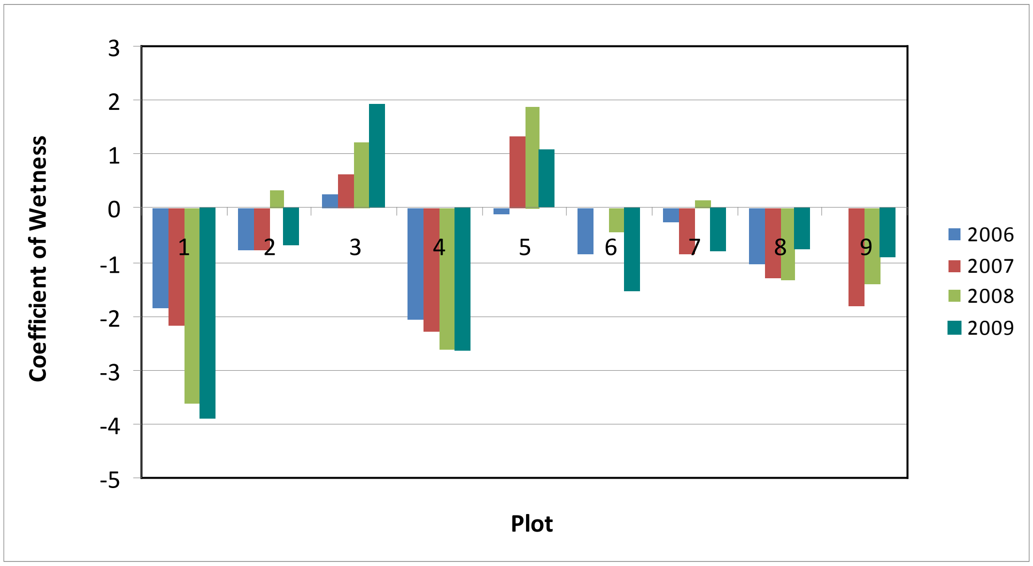

Figure 16. Coefficient of Wetness by Plot 2006-2009

<u>Coefficient of Conservatism</u>

The Coefficient of Conservatism (CC) is also based on Oldham et al. (1995). Each species is given a rank between 0 and 10, based on its degree of fidelity to a range of synecological parameters (Oldham et al. 1995). Synecology is the study of the structure, development, and distribution of ecological communities. Species ranked between 0 and 3 are found in a variety of plant communities, including disturbed sites. Species ranked between 4 and 6 are those associated with a specific plant community, but which can tolerate moderate disturbance. Species ranked from 7 to 8 are found in plant communities in an advanced stage of succession with minor disturbance. Plants with a ranking of 9 or 10 have high degrees of fidelity to a narrow range of synecological factors. The average Coefficient of Conservatism per plot is shown in Figure 17. The highest scores are found at Plots 1, 5, and 7. Plot 1 is the reed-canary grass marsh, Plot 5 is located in a hemlock-hardwood forest, and Plot 7 is found in a white-cedar – hardwood swamp. The lowest average Coefficient of Conservatism is found at Plot 9, a cattail marsh.

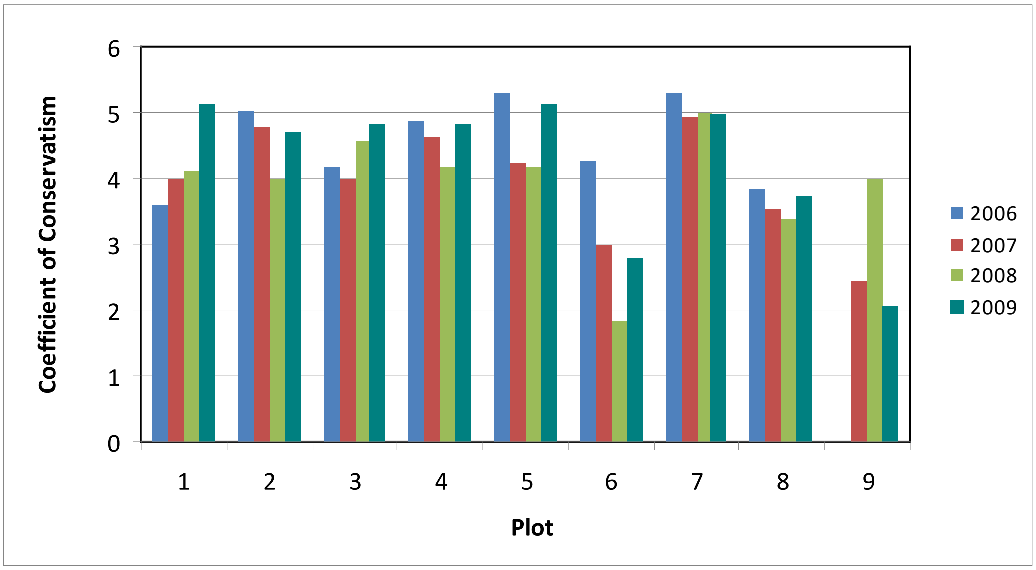

Figure 17. Coefficient of Conservatism by Plot 2006-2009

<u>Natural Area Index</u>

The Natural Area Index (NAI), or floristic quality index, allows the objective comparison of two or more natural areas or vegetation types (Oldham et al. 1995). The NAI is calculated by multiplying the average coefficient of conservatism by the square root of the total number of *native* species. Whereas the abundance and frequency of species can fluctuate greatly by season and year, the NAI is more stable and offers a more accurate picture. The NAI for each plot is shown in Figure18.

The Ministry of Natural Resources reports that natural areas with NAI values of over 35 are considered significant at the provincial level (Wilhelm and Ladd 1988 *in* MNR 1994). For comparison, an old successional field may score as low as <5 (Andreas et al. 2002). None of the plots score a value of 35 or higher. The highest value is found at Plot 7, in the white-cedar – hardwood swamp. Its NAI is 32.3. The plot with the lowest NAI score is Plot 9, the cattail marsh, with a value of 8.0.

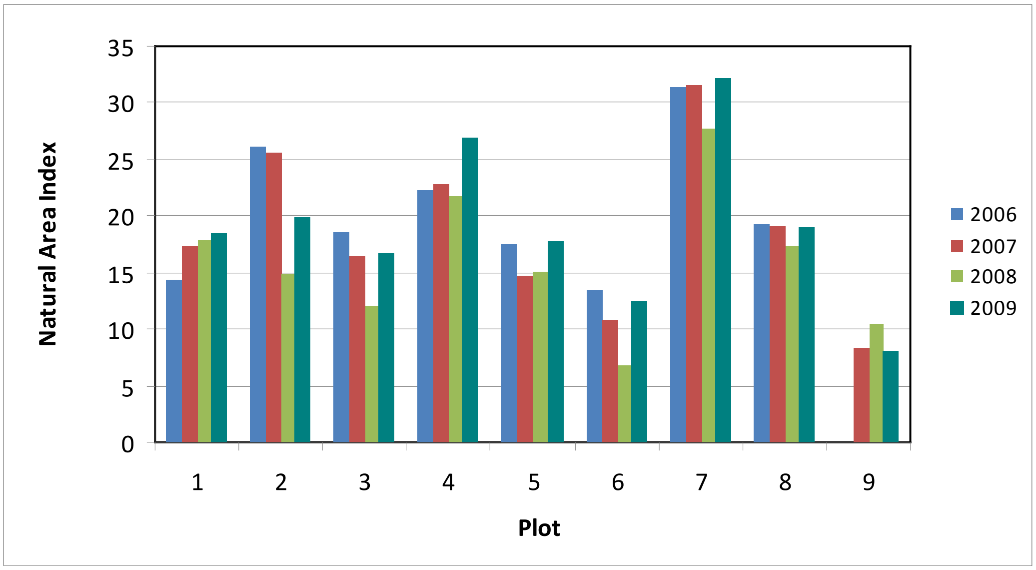

Figure 18. Natural Area Index by Plot 2006-2009

5.5.2 Non-Native Species

The number of non-native species found in each plot is compared in Figure 19. All plots have had non-native species recorded. The greatest number of non-native species (13) recorded was at Plot 8, located in the white-cedar – hardwood swamp.

Certain species are considered particularly invasive, and are given a score of '-3' on a weediness scale ranging from '-1' to '-3'. The invasive species found in the HCBP include three different types of shrubs: common buckthorn (*Rhamnus cathartica*), glossy buckthorn (*Rhamnus frangula*), and tartarian honeysuckle (*Lonicera tatarica*). Common buckthorn is the most widely dispersed, being found in five plots. Plot 8 is the most impacted, containing all three of these highly invasive species.

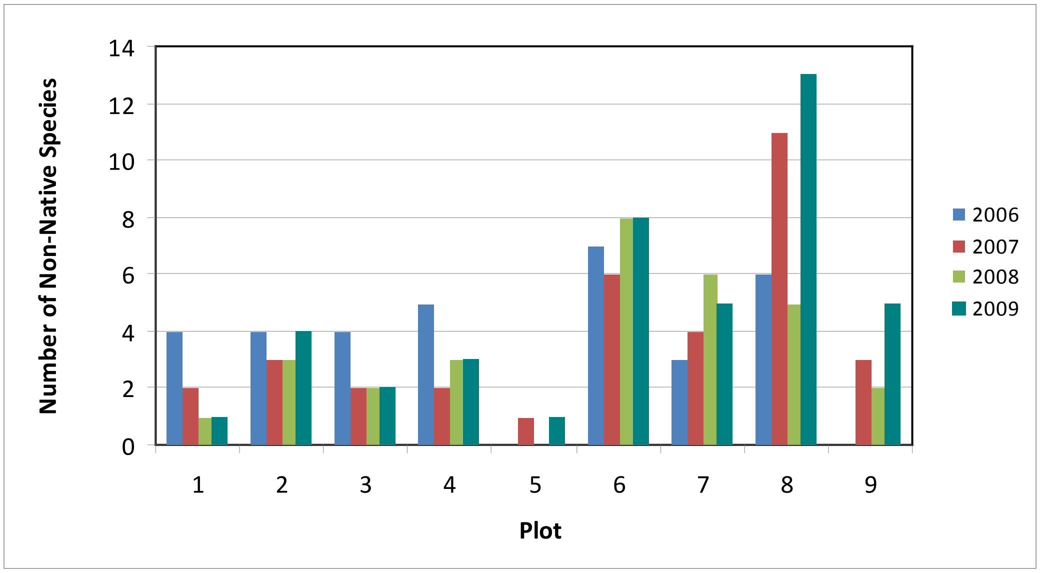

Figure 19. Non-Native Species by Plot 2006-2009

In previous years, two other invasive species were recorded: quack grass (*Elymus repens*) and moneywort (*Lysimachia nummularia*). Quack grass was recorded from Plot 6 in 2008, and moneywort was recorded from Plots 7 and 8 in 2007.

Of note is that garlic mustard (*Alliaria officinalis*) was never recorded in any of the vegetation monitoring plots. Garlic mustard is a very common, invasive species, and it is rare to find areas that do not contain this species.

5.5.3 Herbaceous Inventory

The 2009 Terrestrial and Wetland Monitoring Report (Appendix IV) provides species observed in 2009 within each vegetation plot. A total of 57 species of herbaceous plants were observed during the plot-based vegetation monitoring that was conducted in 2009.

The 2009 Terrestrial and Wetland Monitoring Report (Appendix IV) also compares the herbaceous species recorded in each subplot between 2006 and 2009. Even though the same subplot is monitored each year, the results vary. It is very difficult to monitor the exact same location from year to year, despite using the same bearing and location as listed in Table 1.

5.5.4 Shrub Inventory

The number of shrub species found within each monitoring plot and their approximate percent cover was recorded. Fifteen shrub species were observed in 2009, in comparison to 16 in 2006, and 15 in 2007 and 2008. Refer to the 2009 Terrestrial and Wetland Monitoring Report (Appendix IV) for shrub species recorded within each monitoring plot in 2009, and a comparison between all years. Composition of species recorded has varied from year to year, although all shrubs seen within the entire plot are recorded.

5.5.5 Tree Inventory

Results from 2009 are provided in the 2009 Terrestrial and Wetland Monitoring Report (Appendix IV). Trees are absent from Plots 1, 6 and 9. The dominant tree species found within each plot did not change from the data obtained in previous years.

The tree data collected from 2006 to 2009 is compared in the 2009 Terrestrial and Wetland Monitoring Report (Appendix IV). The trees were re-numbered and re-tagged in 2008 to aid in field identification.

5.5.6 Soil Surveys

Refer to the 2009 Terrestrial and Wetland Monitoring Report (Appendix IV) for results obtained during the 2009 soil surveys, as well as previous data.

5.6 Breeding Birds

Breeding bird point counts were performed according to the standard Ontario Breeding Bird Atlas protocol (OBBA 2001). According to protocol, each of the stations was visited between dawn and 10:00 a.m. on two occasions during the breeding bird season. Ten minute point counts were conducted at each of the stations. Bird species, breeding evidence, and the number of birds encountered were recorded. The first point count was taken on June 11, 2009, with a follow-up visit on June 29, 2009 at the 9 previously existing plots. These plots coincided with the vegetation plots. A tenth plot was added in 2009, which was surveyed on June 18 and 29, 2009. The additional breeding bird station was added to monitor the Heritage Maple Grove along Forestell Road. This area became a focal point for amphibian monitoring in 2009, and it was felt prudent by NRSI to add a bird station as well.

A total of 45 species of birds were observed during the breeding bird monitoring that was conducted in 2009. Birds observed in the study area while conducting other field surveys and transects between breeding bird stations were also recorded as incidentals. Table 10 summarizes the number of birds observed under each breeding evidence code.

Table 10. Breeding Bird Evidence

Breeding Evidence	Number of Species			
	2006	2007	2008	2009
PO	30	12	20	21
PR	11	15	14	20
CO	0	11	2	4
X	0	8	4	0

LEGEND	
PO	Possible
PR	Probable
CO	Confirmed
X	Observed

The most abundant species observed during 2009 surveys was red-winged blackbird (*Agelaius phoeniceus*), making up 15.9% of the observations during breeding bird point counts. This was followed by European starling (*Sturnus vulgaris*) with 11.3%, and song sparrow (*Melospiza melodia*) with 8.0%. All other species made up less than 5%. Figure 20 represents the seven most abundant species observed in 2009. NRSI did not observe any rare or provincially significant bird species during the breeding bird surveys.

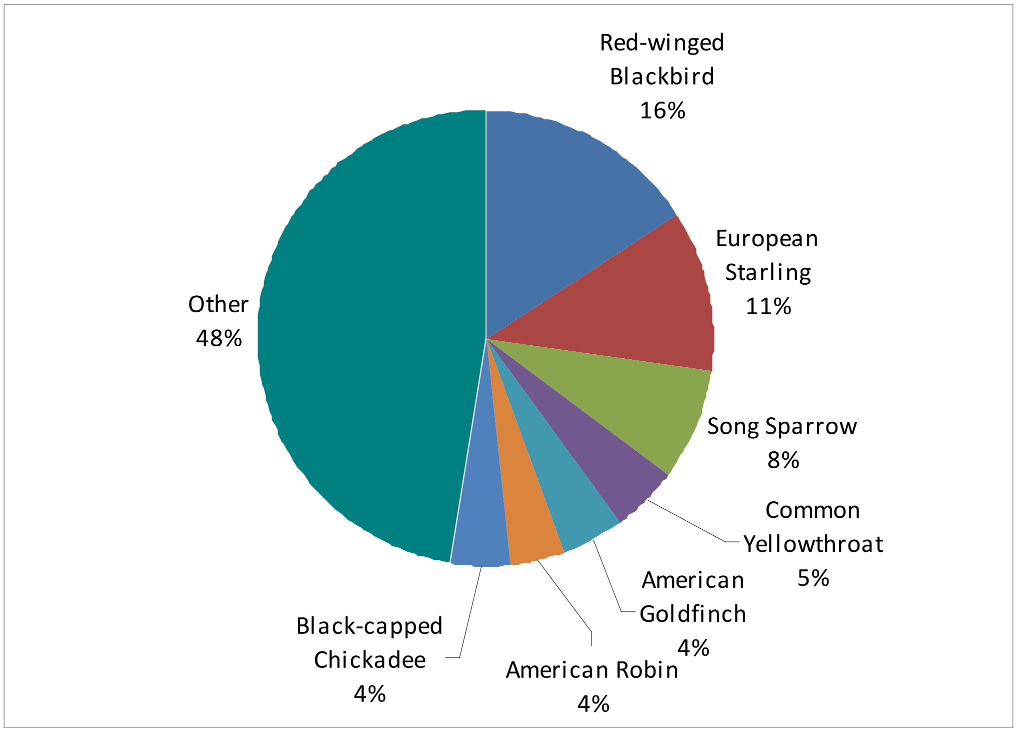

Figure 20. Most Abundant Bird Species Observed in 2009

Figures 21 and 22 represent a comparison of breeding bird species abundance and richness for each monitoring year within each habitat type found within the study area. Species abundance is the number of individuals of all species found at each plot. Species richness is the number of different species found at each plot.

During each pre-construction monitoring year, average species abundance was greatest in the meadow marsh communities and lowest in the fresh-moist forests (i.e. Fresh-Moist Sugar Maple Deciduous Forest and Fresh-Moist Hemlock Mixed Forest). This trend continued in 2009, with even more individuals recorded in the marsh and swamp communities. In the fresh-moist forest, one individual less was recorded over 2008. The newly added dry-fresh forest community had the second highest number of individuals, with an average of 33 per plot.

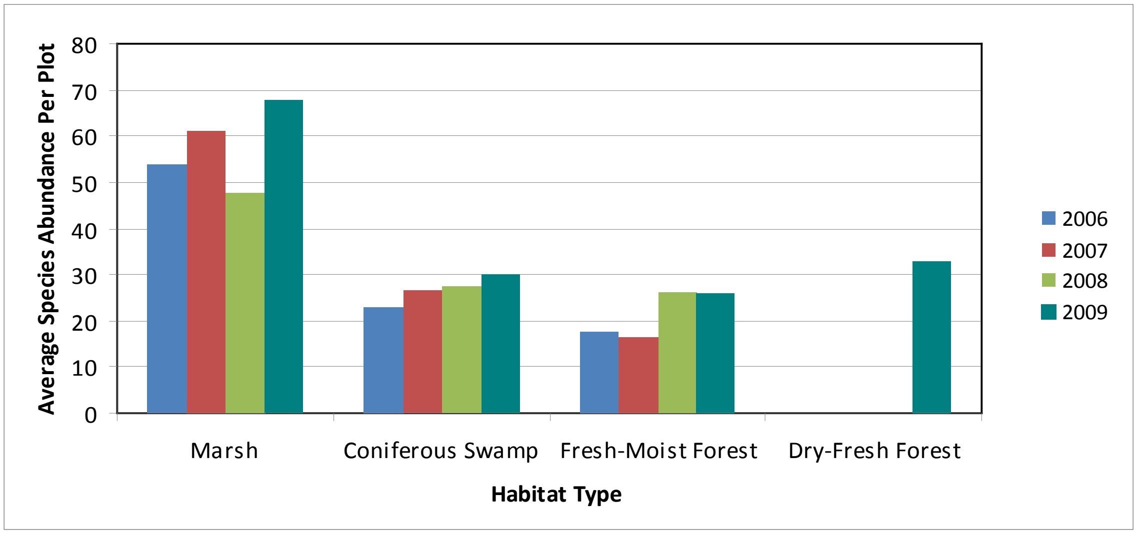

Figure 21. Breeding Bird Species Abundance by Habitat Type

Figure 22 shows that average species richness per plot is highest within the coniferous swamp communities, followed by the dry-fresh forest. The number of species seen in each habitat type has been increasing over the years. In 2009, a greater number of species was seen in all habitat areas, than in previous years. This may be a result of less agricultural disturbance. Each year more fields are being left fallow, providing more grassland habitat for birds to nest and forage in. The decrease in pesticides also has a positive benefit in providing more food (i.e. insects) for the birds.

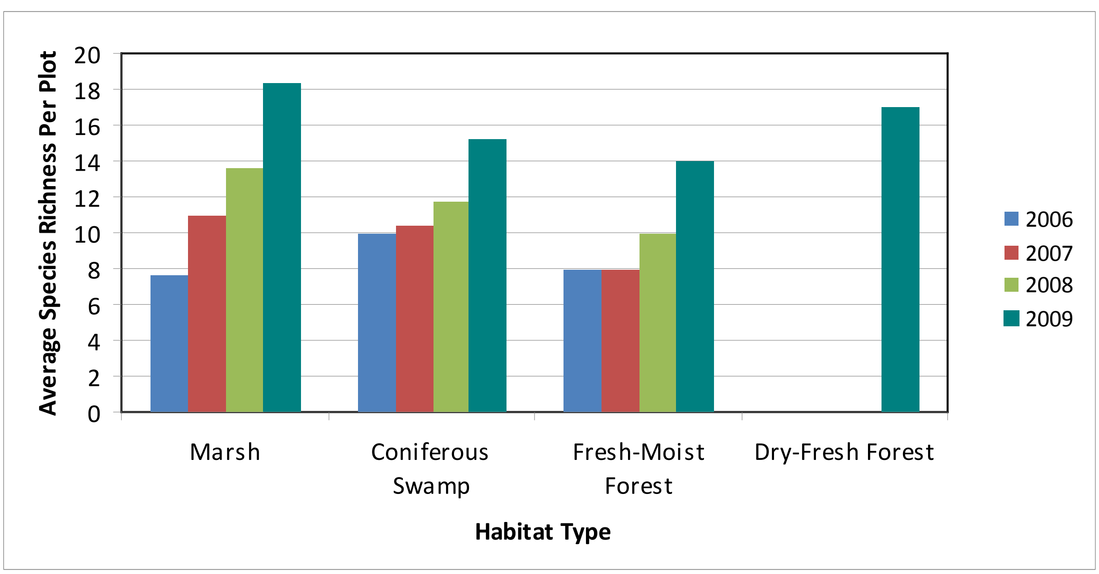

Figure 22. Breeding Bird Species Richness by Habitat Type

5.7 Amphibians

Call counts, salamander surveys, larval surveys, and road mortality surveys were all undertaken to assess the amphibian population in the area.

Call counts were conducted on the evenings of April 23, May 11, and June 2, 2009. During 3-minute call counts, call intensity and an estimated number of amphibian individuals were recorded following the Marsh Monitoring Program protocol (Bird Studies Canada 2008). A total of 15 stations were monitored for anurans in 2009. Plots 1, 2, 4, 6-9 coincided with the wetland vegetation plots. Additional call count stations were added in 2009 based on a recommendation in the 2008 Terrestrial and Wetland Monitoring Report (NRSI 2009b), that additional herpetofauna monitoring stations be established within the Business Park, with focus on the vernal pools within the Heritage Maple Grove along Forestell Road and wetlands adjacent to Laird Road. There were also concerns raised by EAC (2009) over the Great Lakes/St. Lawrence – Canadian Shield population of the western chorus frog (*Pseudacris triseriata* pop. 2). This frog species is considered threatened in Canada and vulnerable in Ontario (NHIC 2010), and was recorded from Plot 6 in 2007 by NRSI. The call count stations are shown as Anuran Monitoring Stations on Figure 15.

Salamander trap surveys were conducted between March 27 and April 9, 2009 using a total of 21 un-baited minnow traps set within vernal pools, ponds and wetlands dispersed in the study area. These stations are shown as Salamander Monitoring Stations on Figure 15.

Wetlands were assessed for potential salamander breeding habitat, and salamander larval surveys were conducted under the direction of MNR Species at Risk Biologist, Karine Bériault and Dr. Jim Bogart from the University of Guelph. The surveys took place on June 17, 2009, and daily from July 6 to July 10, 2009. On July 9, 2009, the salamander larval surveys were conducted at night, as it was noted by Dr. Jim Bogart that salamander larvae are sometimes easier to observe and collect during the night in June and July. The surveys were located at potential breeding habitats, which were identified as wetland features containing vernal pools/ponds or small remnants of standing water, with associated deciduous tree or shrub cover. The locations are shown as Larvae Monitoring Stations on Figure 15.

Finally, a road mortality survey was established based on comments on the EIR from the public, which identified the need to evaluate the effectiveness of wildlife crossings (i.e. culverts) by monitoring the incidence of wildlife mortality along Laird Road. Nighttime surveys were conducted twice a week from April 20 to June 18, 2009.

5.7.1 Call Count Surveys

Species Observations

Six amphibian species were recorded during evening herpetofauna surveys in 2009: American toad (*Bufo americanus*), northern spring peeper (*Pseudacris crucifer crucifer*), tetrapolid gray treefrog (*Hyla versicolor*), northern leopard frog (*Rana pipiens*), green frog (*Rana clamitans melanota*), and wood frogs (*Rana sylvatica*). Only one other anuran species is known from the area: western chorus frog (*Pseudacris triseriata* pop.2), which was recorded from Plot 6 in 2007, but has not been observed since. Appendix XI provides a comprehensive list of herpetofauna species observed by NRSI since 1998.

The number of species observed each year during call count surveys has increased over the years, as shown in Table 11. In 2009 the greatest number of species was recorded, as seven new stations were added to get a better representation of the study area, as well as to search for the western chorus frog.

Table 11. Number of Species Recorded From Call Counts

Year	# of Species
2006	0
2007	5
2008	4
2009	6

In order to compare species abundance over time and between stations, the maximum call code is used. The maximum call code is used to provide an estimate of abundance, as estimating numbers of individuals is not accurate. The three call codes are explained below as per the Marsh Monitoring protocol:

1. Calls can be counted; not simultaneous
2. Some simultaneous calls; yet distinguishable
3. Calls not distinguishable; overlapping (i.e. “full chorus”)

By comparing the number of stations that a species has been observed at and the maximum call code over time, increases or decreases in species abundance can be determined. The data is provided by station and species in Table 6 of the 2009 Terrestrial and Wetland Monitoring Report (Appendix IV). The following is a brief discussion of trends observed by species:

- The most abundant species is spring peeper. Spring peeper was recorded with a call code 3 at Plots 6, 12, and 16; it was the only species in 2009 that was recorded with this call code. It is also the most widely distributed anuran, being observed at 10 plots.
- American toad has been recorded from a different station each year. In 2009 it was recorded from only one plot (Plot 14). In 2008, American toad was recorded with a call code 3 at one station, but otherwise, it is found in small numbers.
- Tetraploid gray treefrog was first recorded in 2008. It was observed in the same plots in 2009, with the addition of a new plot.
- Northern leopard frog was newly observed from the call count surveys in 2009. It was recorded in three of the newly established plots. Although it had previously not been observed during call count surveys, northern leopard frog has been known from the site previously through other types of field work and observations.
- Green frog was observed from two stations in 2009; three individuals were recorded. In previous years it was recorded in even small numbers.
- Wood frog is the second most widely distributed species, being recorded at 6 different plots in 2009. It is also one of the more abundant species.
- American toad, green frog, and spring peeper have been recorded consistently over the last 3 years.

With regards to the plots:

- Plot 9 has the greatest diversity of species, with 6 different anurans recorded from this site over the years. In 2009, 4 species were recorded here, also the greatest number for one year.
- Plots 2, 7, 8, 13, and 15 had no species recorded in 2009. The first three plots have had species recorded in previous years; the latter two were new stations for 2009.

<u>Site Conditions</u>

Amphibians breed in several types of wetland habitat. All require the presence of water for some duration of the spring. Some species, such as spring peeper, western chorus frog, and wood frog, take advantage of temporary, seasonal pools created by spring rains and melting snow. The temporary pools dry up mid to late summer, by which time the larvae have metamorphosed into adults and moved to upland habitats. Some species of anurans, such as the leopard frog, green frog and bullfrog, require semi-permanent to permanent water bodies in order for the larvae to develop into adults, which can take up to 2 years.

Measured pH values ranged from 7.8 to 9.9 throughout the spring. The average pH values have gone up from 7.8 in 2006, to 8.8 in 2009. Whereas a pH value of 9 or more was not reached at any of the plots previously, this value was reached or surpassed approximately half the time in 2009. In fact, all plots (where water was present) had a pH value of 9 or higher on the final visit in June.

Anurans are known to prefer habitats that are pH neutral (pH 7) (Audubon International, 2000). When pH values decrease, becoming acidic, or increase, becoming alkaline, it can impact their survival. Seburn (1998) states that the northern leopard frog breeds successfully at a pH range of 8.5-9.5 and that fertilization of eggs is reduced at a pH of less than 6.5.

The pH values found during the monitoring period are within the normal range for southern Ontario. The recorded pH levels have not been recognized as having harmful effects on the presence of amphibian species. The pH levels recorded in the groundwater by Banks Environmental range between 7.61 and 8.36, with an average of 8.0 (Banks 2010). The surface water pH from Tributary A had a much greater range, though the values still fall within normal ranges (AECOM 2010).

5.7.2 Salamander Trap Survey

No salamander species were observed or trapped during salamander trap surveys. The memo addressing the salamander trap survey is appended to the 2009 Terrestrial and Wetland Monitoring Report (Appendix IV).

5.7.3 Salamander Larval Survey

No salamander larvae were found during the larval surveys. The full monitoring report is appended to the 2009 Terrestrial and Wetland Monitoring Report (Appendix IV).

5.7.4 Laird Road Wildlife Movement Survey

A total of 101 wildlife observations were made along Laird Road during mortality surveys. These observations included herpetofauna (frogs, toads and snakes) and mammals. Of the 101 observations, 77% were found dead, 22% were alive and none were injured. Amphibian species comprised 95% of these observations. American toad (35), northern leopard frog (33), northern spring peeper (16), unidentified anuran species (7), green frog (3), and wood frog (2) were all observed. The anuran species not identified to species were unidentifiable after being run over by vehicles.

In addition to amphibians, a dead eastern milksnake (*Lampropeltis t. triangulum*), eastern chipmunk (*Tamias striatus*) and two mouse species were recorded. The eastern milksnake is ranked as vulnerable provincially and is also considered a species of special concern by COSSARO and COSEWIC.

One dead salamander species was observed and collected on April 20, 2009. DNA extraction and analysis was performed at the University of Guelph by Dr. Jim Bogart. Genetic analysis of the tail clipping identified the salamander to be *Ambystoma laterale-*

(2) jeffersonianum; indicating a Jefferson salamander sperm donor within the area. Appendix XI lists all herpetofauna species known from the study area.

Observations of wildlife were generally quite dispersed along Laird Road; however, concentration areas were noted where natural features are present along both sides of the road, especially wetlands.

When feasible, direction of movement for each individual observed was recorded. Based on observations, 28% were moving north, 32% were moving south, while only 2% were noted to be moving east or west. In cases where carcasses were unidentifiable due to road mortality, direction of movement, unless quite obvious, was recorded as unknown (37%).

The amphibian breeding season generally begins in mid to late March for a number of amphibian species (i.e. Jefferson salamander, wood frog, northern spring peeper and western chorus frog) and tapers off in June for species such as green frog and northern leopard frog. In cases where wetlands are adjacent to busy roadways, there is often a correlation between increased amphibian road mortalities and peak breeding seasons.

Observations of amphibians along Laird Road were considerably higher in April than in June, which correlates with the fact that many of the amphibian species known to occur within the vicinity of the study area breed primarily in early to mid-spring.

The full monitoring report is appended to the 2009 Terrestrial and Wetland Monitoring Report (Appendix IV).

6.0 Trends and Effects

The monitoring data collected to date represents baseline data prior to construction of the business park. A review of trends is provided as information on the baseline data, but any trends are unrelated to the business park development. Rather, they would be related to natural variation in climate and other such conditions.

During pre-construction monitoring, some trends in groundwater levels were observed. It was noted that groundwater levels likely declined from the spring of 1997 to the fall of 2007 as a result of below-average precipitation in this period. The lowest observed groundwater elevations occurred in July and November 2007. Precipitation in 2007 was well below average and was the lowest observed from 1971 to 2009. As a result, groundwater levels continued to decline through to late November 2007. However, this trend was reversed during 2008 with groundwater elevations rising in response to above average annual precipitation. Groundwater elevations increased through the fall of 2008 in response to above-average monthly precipitation, resulting in a peak observed at many locations at the end of December. Groundwater elevations in 2009 were typical, except for a delayed mid-winter thaw that allowed elevations to decline through much of the winter until a February thaw, and a longer period of summer elevation decline that extended into November when precipitation reversed the decline.

During the pre-construction monitoring, no trends were observed for groundwater flows, temperatures or quality. Improved filtering of samples at the time of collection in 2009 resulted in reduced levels for a variety of the water quality parameters. This should not be considered a trend as the improvement is a result of the sampling methods used.

From the surface water baseline data for 2009, a single stream temperature exceedance of 22°C was recorded at Station 7 (Reach 14). No stream temperature exceedances of 24°C were recorded in 2009. Station 7 has had historically high temperatures compared to the other stations. This reach is wider with riparian vegetation composed of grasses not trees. Further, groundwater monitoring and modeling showed that this reach is a recharge area with limited to no groundwater inputs. The single occurrence of 0.5hr duration in a single reach requires no additional action.

In comparing the stream baseflow data from 2008 to 2009, no trends were observed in the minimum flows during this baseline monitoring period. However, the maximum flows measured were consistently higher in 2009 than in 2008.

The fish data from the pre-construction monitoring does not reveal any trends, other than to demonstrate natural variation in numbers of fish during baseline monitoring.

The benthic invertebrate data generally does not reveal trends during baseline monitoring, with the exception of some improvement in the quality of the benthic invertebrate community at Station BTH-003. At this station, the number of taxa, and the proportion of Ephemeroptera, Plecoptera and Trichoptera have increased, while the proportion of the dominant taxon has decreased.

The number of anuran amphibian species observed each year during call count surveys has increased over the years of baseline monitoring. None were observed in 2006, but 6 species were observed in 2009. During the intervening years, 4 to 5 species were observed. Although the northern leopard frog was newly observed from the call count surveys in 2009, it had previously been observed on the HCBP site during other types of surveys.

The average pH values have gone up from 7.8 in 2006, to 8.8 in 2009. Whereas a pH value of 9 or more was not reached at any of the plots previously, this value was reached or surpassed approximately half the time in 2009. Nevertheless, the pH values found during the monitoring period are within the normal range for southern Ontario, and have not been recognized as having harmful effects on the presence of amphibian species.

7.0 Recommended Actions

The trends during pre-construction monitoring that are noted above in Section 6.0 are provided for information purposes, and none are cause for concern and action. The pre-construction monitoring has been effective in providing substantial amounts of baseline data. The data collected to date is considered valid and reasonable, and will be useful for comparison to data collected during construction. No specific actions are recommended at this time.

8.0 Corrective Measures

There are no concerns or associated actions stemming from the 2009 monitoring results, nor are there any ongoing actions that require further guidance. Therefore, no corrective measures are required at this time.

9.0 Review of Future Monitoring Needs

Although some minor aspects of construction began in 2009, it is anticipated that 2010 will be the first year of monitoring during construction. The following recommendations are made with this in mind.

9.1 Groundwater

In general, the long-term groundwater monitoring program at the HCBP site should continue in 2010 as previously recommended on a quarterly basis. Groundwater samples should continue to be collected in 2010 from selected monitoring wells. Improvements to filtering of water samples have been successful in reducing the amount of sediment and should be continued as a standard practise.

Additional data loggers should be installed in selected monitoring wells and mini-piezometers that are expected to remain during and following site grading. This will improve the background dataset and the establishment of the influences of climate on groundwater elevations over the short-, medium-, and long-term.

Also during 2010, an additional pair of mini-piezometers should be installed in Tributary A near the northern property boundary in order to gain a better understanding of groundwater interactions with the stream in this area. This will help characterize the aquatic habitat in this part of Tributary A, and will improve interpretation of stream temperature data associated with the monitoring of Stormwater Management Pond 2.

9.2 Surface Water

The monitored temperature results from 2009 show that summer and fall water temperatures are suitable for brook trout habitat. Continuation of the monitoring program during and post construction should continue to ensure temperature targets are met. This monitoring will occur both within the stormwater ponds (as they are constructed) and the stream to identify the function of each mitigative element in the system (bottom draw, cooling trench, increased vegetative cover). Flow monitoring should also continue in 2010, with a flow monitoring component included at each SWM facility as they are built.

9.3 Fish

Quantitative fish sampling and a brook trout spawning survey should continue to occur in 2010 as per the Standard Operating Procedures for the Consolidated Monitoring Program (NRSI 2010).

9.4 Benthic Invertebrates

Benthic invertebrate monitoring should continue to occur in 2010 as per the Standard Operating Procedures for the Consolidated Monitoring Program (NRSI 2010).

9.5 Vegetation and Soils

Vegetation and Soils monitoring should continue in 2010 as per the Standard Operating Procedures for the Consolidated Monitoring Program (NRSI 2010).

9.6 Breeding Birds

Breeding Bird monitoring should continue in 2010 as per the Standard Operating Procedures for the Consolidated Monitoring Program (NRSI 2010).

9.7 Amphibians

The call count surveys should continue in 2010 as per the Standard Operating Procedures for the Consolidated Monitoring Program (NRSI 2010).

9.8 Salamanders

A more intensified salamander monitoring program was requested by the Ministry of Natural Resources (MNR). Therefore, in spring 2010, an extensive salamander monitoring program is being conducted by NRSI. The focus of the monitoring plan is to re-assess presence/absence of suitable breeding habitat for Jefferson salamander and determine presence/direction of any salamander movements to and from natural areas within the HCBP lands. The monitoring plan has been developed following extensive discussions involving NRSI, Ministry of Natural Resources, Guelph District, Dr. Jim Bogart from the University of Guelph and City staff. Results obtained from 2010 monitoring will be supplemented by findings from the 2009 surveys. A compilation of these results will inform the need for further salamander monitoring beyond the year 2010.

10.0 Conclusions and Recommendations

The 2009 monitoring year was successful in providing baseline monitoring data for the monitoring program. It is recommended that all monitoring components and the reporting process should continue in 2010 as per the Consolidated Monitoring Program.

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Table 12. List of Past Monitoring Reports

Title	Author	Date
Hanlon Creek Business Park Environmental Monitoring Program Pre-Construction (2006) Terrestrial and Wetland Monitoring	Natural Resource Solutions Inc.	November 2006
Hanlon Creek Business Park Pre-Construction Aquatic Monitoring 2006	Natural Resource Solutions Inc.	December 2007
Hanlon Creek Business Park Environmental Monitoring Program Pre-Construction Terrestrial and Wetland Monitoring (2007)	Natural Resource Solutions Inc.	December 2007
Hanlon Creek Business Park Pre-Construction Aquatic Monitoring 2007	Natural Resource Solutions Inc.	December 2007
Hanlon Creek Business Park Environmental Monitoring Program Pre-Construction Terrestrial and Wetland Monitoring (2008)	Natural Resource Solutions Inc.	January 2009
Hanlon Creek Business Park Pre-Construction Aquatic Monitoring 2008	Natural Resource Solutions Inc.	February 2009
Hanlon Creek Business Park Environmental Monitoring Program Pre-Construction Terrestrial and Wetland Monitoring (2009)	Natural Resource Solutions Inc.	March 2010
Hanlon Creek Business Park Pre-Construction Aquatic Monitoring 2009	Natural Resource Solutions Inc.	March 2010
Hanlon Creek Business Park City of Guelph Environmental Implementation Report Hydrogeology Report	Banks Groundwater Engineering Limited	May 2008
Hanlon Creek Business Park – 2008 Groundwater Monitoring Program Technical Memorandum	Banks Groundwater Engineering Limited	May 2009
Hanlon Creek Business Park – 2009 Groundwater Monitoring Program Technical Memorandum	Banks Groundwater Engineering Limited	February 2010
City of Guelph Hanlon Creek Flow and Temperature Monitoring Technical Memorandum	TSH (now AECOM)	February 2008
City of Guelph Hanlon Creek Tributary A Flow and Temperature Monitoring Technical Memorandum	TSH (now AECOM)	February 2009
City of Guelph 2009 Hanlon Creek Tributary A Surface Water Monitoring Report	TSH (now AECOM)	January 2010

APPENDIX I

GROUNDWATER MONITORING REPORT

Technical Memorandum

Banks Groundwater Engineering Limited
8 Sagewood Place, Guelph, Ontario N1G 3M6
519.829.4808 www.banksgroundwater.ca

25 February 2010

To: Peter Cartwright, General Manager, Economic Development & Tourism Services, City of Guelph

David Kemper, Managing Partner, Belmont Equity Partners Inc.

Bill Luffman, Director of Development, Cooper Construction Limited

Copies: Jim Riddell, Director of Community Design and Development Services, City of Guelph

Fred Natolochny, Supervisor of Resource Planning, Grand River Conservation Authority

From: Bill Banks, P.Eng., Principal – Senior Hydrogeologist

Re: Hanlon Creek Business Park – 2009 Groundwater Monitoring Program

1 Introduction

This Technical Memorandum presents the results of the second year of a long-term groundwater monitoring program for the Hanlon Creek Business Park (HCBP). The results of the first year were presented in a Technical Memorandum in May 2009. A Hydrogeology Report was completed by Banks Groundwater Engineering Limited in May 2008, as part of the Environmental Implementation Report (EIR), in support of the proposed HCBP. The Hydrogeology Report presented a recommended long-term groundwater monitoring program. This program was developed in recognition of the importance of establishing baseline groundwater conditions and to assess any changes in groundwater elevations and groundwater quality during and following development of the site. The monitoring program is also required to assess the performance of the stormwater management facilities once they are constructed and to observe seasonal trends in water levels in the core wetland. It is noted that this monitoring program is consistent with the recommendations of the Hanlon Creek State-of-the-Watershed Study Report (2003).

Baseline groundwater conditions were established during five years of on-site monitoring. The detailed results for the period spring 2003 to spring 2008 were presented in the Hydrogeology Report. Banks Groundwater Engineering is continuing to monitor groundwater in 35 on-site monitoring wells and 12 wetland mini-piezometers on a quarterly basis. To correspond to previous monitoring, the preferred monitoring periods are January, April, July and October. Data loggers have been installed to measure and record groundwater levels and temperatures on a more frequent basis in 22 selected monitoring wells and mini-piezometers. The installation of additional data loggers is planned. Groundwater samples are being collected from selected monitoring wells on an annual basis and analyzed for a representative list of groundwater quality parameters to augment the existing background water quality data.

It is not expected that development of this site will have any effect on local private water wells. It is expected that if any changes in groundwater elevations and groundwater quality during and following development of the site do occur, as a result of construction and post-construction activities, they will become apparent first in the on-site monitoring wells. Therefore, it was concluded that monitoring of local private wells was not required.

It is also noted that selected monitoring wells and mini-piezometers are currently being monitored for the purpose of establishing baseline data in advance of proposed adjacent land use activities (e.g. Mast-Snyder Gravel Pit). Changes related to climatic conditions are being observed in the on-site monitoring wells and mini-piezometers.

Prior to any site grading, the grading schedule will be reviewed to determine the potential for monitoring locations to be affected. Any monitoring stations located within the planned grading areas must be properly abandoned, in advance of grading, in accordance with Ontario Regulation 903, as recently amended, of the Ontario Water Resources Act by a licensed Water Well Technician. In some cases, existing monitoring wells can be maintained, with minor modifications or improvements, for continued monitoring. Several monitors will be replaced following grading and development of selected blocks.

The monitoring data has been compiled, plotted, and analyzed and the results are presented in this Technical Memorandum. Conclusions and recommendations related to the monitoring program are summarized.

2 Groundwater Monitoring

2.1 Groundwater Monitoring Background

Groundwater level monitoring was conducted at this site for more than five years in support of the evaluation of local hydrogeological conditions. The various stages of monitoring that have been completed are summarized in the EIR Hydrogeology Report. Since January 2007, groundwater levels have been monitored regularly at the HCBP site on a quarterly basis.

The locations of the groundwater monitoring stations are shown in Figure 1.

2.2 Groundwater Monitoring Stations Status

The status of each groundwater monitoring station is determined during each monitoring round. This includes all monitoring wells installed in 2003 and monitoring wells and mini-piezometers that were subsequently installed. The current condition of each station and other relevant attributes are described in Appendix A.

2.3 Groundwater Monitoring Data Collection and Compilation

The establishment of baseline groundwater conditions will continue until grading of the site is initiated. This will include monitoring of groundwater levels in selected monitoring wells and mini-piezometers (listed in Appendix A). In most cases this monitoring will continue to occur on a seasonal basis to establish variations in groundwater levels for each season at each station. In a selected number of monitors, groundwater levels will also continue to be recorded on a daily basis, or more frequent, using data loggers. This will assist in determining the relationships of groundwater levels, wetland levels, surface water flow, and precipitation. Groundwater samples were collected from selected monitoring wells and analyzed for selected chemical parameters in 2009. Sampling and analysis is to continue on an annual basis.

The 35 functioning monitoring wells and 12 mini-piezometers located across the HCBP site currently provide adequate groundwater monitoring locations. It was not considered necessary to replace destroyed and inaccessible monitoring wells and piezometers for the purpose of the analyses presented below.

Following each seasonal monitoring period, the data was recorded and entered into the groundwater level monitoring dataset. Data downloaded from each data logger was corrected for barometric pressure and then incorporated into the respective records within the groundwater level monitoring dataset. As the dataset is updated, tables and graphs are also updated to support on-going analysis of the groundwater monitoring results.

2.4 Groundwater Monitoring Results

The results of manual groundwater level measurements at the HCBP site up to October 2009 are summarized in tabular format in Appendix B. Selected monitoring station details are included with the monitoring data, which is presented as depth (in metres) to groundwater below current ground level and groundwater elevation (metres above mean sea level).

The groundwater elevation data for each monitoring station, based on the manual measurements, are presented in graphical format in Appendix C. The groundwater elevations from April 2003 to October 2009 present representative seasonal levels for most locations. As such, seasonal fluctuations are illustrated in the graphs, ranging from as little as 0.37 m, to as much as 2.01 m over this monitoring period. Monitoring well MW 123 is excluded from this comparison as it is completed in the deep bedrock aquifer and the groundwater levels are influenced by municipal well production.

Presented in Appendix D is a summary of vertical hydraulic gradient calculations, based on comparisons of shallow, intermediate and deep monitoring intervals, on selected dates. Graphs illustrating groundwater elevations and hydraulic gradients are included, with monitoring stations grouped in seven west-to-east profiles. These data and graphs confirm the downward hydraulic gradients (i.e. groundwater recharge conditions) in the upland portions of the site, and upward hydraulic gradients in the vicinity of, and within, the core wetland complex (i.e. groundwater discharge conditions). Groundwater discharge conditions have also been confirmed at the wetland adjacent to Downey Road, situated between Laird and Forestell Roads.

Given that climate is one of the most significant factors influencing groundwater elevations, available local climate data was compiled and is presented in graphical format in Appendix E. Groundwater elevations and temperatures recorded using data loggers in 22 groundwater monitoring stations are also presented for comparison with the climate data in Appendixes F, G, and H.

Groundwater samples were collected from selected monitoring wells in July 2003, April 2008, and April 2009. The samples were submitted to an accredited laboratory for analysis of selected chemical parameters. As indicated previously, this will provide a baseline of groundwater quality data prior to development of the site. The water quality data are presented in Appendix I.

3 Groundwater Characterization Update

3.1 Factors Influencing Fluctuations in Groundwater Elevations

There are a number of factors that influence groundwater levels at any given time and location, including:

- Precipitation
- Ambient air temperature and solar radiation (influencing snowmelt, evaporation and evapotranspiration)
- Vegetation
- Soils
- Geology
- Topography and associated drainage characteristics
- Land cover
- Local groundwater withdrawals and uses.

Each of these factors can influence the rate and spatial distribution of groundwater recharge. As such, it is important to account for these factors under the pre-development conditions in order to appreciate the causes of observed groundwater elevation changes. These changes also need to be evaluated relative to long-, medium-, and short-term influences. For the purposes of this evaluation, a long-term influence is considered for example to be lower-than-normal precipitation over several years, which have caused drought conditions in this area of Ontario historically and recently. For the purposes of this evaluation, medium-term influences are considered seasonal and short-term influences are event-related, such as spring thaw and periods of above-average or sustained rainfall.

Given that climate is one of the most significant factors influencing groundwater elevations, available local climate data was compiled and plotted to evaluate short-, medium-, and long-term variations and trends in precipitation and air temperature. A detailed evaluation of climate and fluctuations in groundwater elevations was presented in the EIR Hydrogeology Report.

Updated climate data is presented in graphical format in Appendix E. Graph E1 presents the total annual precipitation recorded at the Region of Waterloo International Airport Station (WMO ID 71368), for the period 1971 to 2009 inclusive. This station was selected due to its' proximity to the HCBP site and availability of data. Also illustrated in Graph E1 is a trend line depicting the annual cumulative departure from the average annual precipitation for this 39-year period, which is about 890 mm/year. This technique is helpful in illustrating periods of above- and below-average annual precipitation. An upward trend indicates sequential years of above-average precipitation (e.g. 1982 to 1988). A downward trend indicates a period of below-average precipitation (e.g. 1997 to 2007), possibly resulting in drought conditions. These longer-term trends can have a notable influence on groundwater levels. They need to be considered in the context of past, present, and future groundwater levels on-site due to the relatively shorter period (i.e. less than seven years) of groundwater monitoring that has been conducted at the HCBP site. The data presented in Graph E1 indicates that during the period 1997 to 2009 inclusive, the total annual precipitation for nine out of thirteen years was below the 39-year average. It is therefore interpreted that groundwater levels would have been elevated during the early to mid-1990's and likely declined from 1997 to 2007.

As indicated above, the groundwater monitoring program on-site began in April 2003. It is therefore useful to consider total monthly precipitation during this period (and shortly before) to evaluate medium-term influences on groundwater levels. Graph E2 presents the total monthly precipitation recorded at the Region of Waterloo International Airport Station, for the period January 2003 to December 2009 inclusive. Also illustrated in Graph E2 is a trend line depicting the monthly cumulative departure from the average monthly precipitation for this period, which has been updated with 2009 data to about 69 mm/month. Similar to the annual data, an upward trend indicates sequential months of above-average precipitation, which may cause increases in groundwater levels. A downward trend indicates a period of below-average precipitation, possibly resulting in a reduction in groundwater levels. On the basis of Graph E2, it would be expected that groundwater levels would be higher following several months of above average precipitation (e.g. October through December 2007, June through December 2008, and April through August 2009).

An alternative method to evaluate fluctuations in groundwater levels relative to monthly precipitation trends is to consider the monthly cumulative departure from normal monthly amounts. The normal amounts are based on the published 30-year record (i.e. from 1971 to 2000). The monthly observed precipitation from January 2003 to December 2009, the monthly normals, and the cumulative departure from the normal monthly precipitation are presented in Graph E3. This plot suggests that, due to a declining trend in precipitation from the spring of 2004 to the spring of 2008, groundwater levels would have declined during the same period, followed by an increase from the summer of 2008 to the summer of 2009, when monthly precipitation was greater.

These observations are further illustrated in Graph E4, which presents the preceding 18-month average monthly precipitation for the period from January 2003 to December 2009. This graph was developed with the understanding that the preceding 18 months of precipitation are likely the most influential on observed groundwater elevations. The cumulative departure from the 18-month average precipitation over this period also emphasizes the trends observed in Graph E2. One of the most notable recent trends is the increase in average precipitation beginning in the second half of 2008 and continuing to July 2009.

Short-term influences related to events are depicted by daily precipitation totals and ambient air temperature (i.e. maximum daily temperature). These data are presented in Graph E5, for the March 2007 to December 2009 monitoring period. To determine which events have an immediate influence on groundwater levels, total daily precipitation and air temperature are plotted together and compared with groundwater levels. Based on available data, the relationship of the above factors to observed fluctuations in groundwater elevations within the HCBP site was evaluated with direct reference to Graphs E2 to E5 and graphs of groundwater elevations observed at each monitoring station. This analysis is presented in the following sub-sections.

3.2 Observed Groundwater Elevations and Depths to Groundwater

The observed groundwater elevations for each monitoring station are summarized in tabular form in Appendix B, and presented as graphs in Appendixes C, F, G, and H. The observed groundwater elevations can be associated with the long-, medium-, and short-term factors discussed previously. The interpreted relationships are discussed below.

3.2.1 Long-Term

Previous analyses presented in last year's Technical Memorandum and the EIR Hydrogeology Report showed that it is likely groundwater levels declined from the spring of 1997 to the fall of 2007, based on the recorded precipitation for the period 1997 to 2007 inclusive. However, annual precipitation in 2003, 2006, and 2008 was above average. This appears to have influenced groundwater levels in the spring of 2004 and 2007, and the spring and fall of 2008, when groundwater elevations were among the highest observed between April 2003 and December 2009.

Evidence of the result of the longer trend of below average precipitation is provided by the groundwater levels in July and November 2007, when the lowest observed groundwater elevations occurred. Precipitation in 2007 was well below average and was the lowest observed from 1971 to 2009 (refer to Graph E1). As a result groundwater levels continued to decline through to late November 2007. However, this trend was reversed during 2008 with groundwater elevations rising in response to above-average annual precipitation.

3.2.2 Medium-Term

Previous analyses presented in last year's Technical Memorandum and the EIR Hydrogeology Report showed that monthly total precipitation and trends (depicted in Graphs E2 and E3) provide additional insight related to the observed high groundwater elevations observed in the spring of 2004, 2007, and 2008.

Elevated groundwater levels in April 2008 can be partially attributed to the above-average total monthly precipitation in October, November, and December 2007, followed by closer-to-normal precipitation amounts in January, February, and March 2008. Groundwater elevations increased through the fall of 2008 in response to above-average monthly precipitation, resulting in a peak observed at many locations at the end of December. Groundwater elevations declined through January 2009 as there was no thaw. However, a thaw in early February accompanied by about 38 mm of rainfall over two days caused another sharp rise in groundwater levels, which in many cases was above the subsequent spring levels. Groundwater levels then followed the typical overall decline starting in May, but extended through to mid-November, with two notable increases occurring in response to precipitation events in August and October. Precipitation events then caused a modest rise in levels through to the end of December.

3.2.3 Short-Term

The manual measuring and recording of groundwater levels across the HCBP site has been conducted on 21 occasions at most monitors, during various months and seasons, from April 2003 to October 2009. As a result, monitoring of groundwater levels may not have occurred at precisely the best time to observe the highest and lowest annual elevations. Fortunately however, groundwater levels were observed in selected monitors in the spring of 2003 and in most monitors in the spring of 2004, 2006, 2007, 2008, and 2009. Therefore, it is expected that these observations represent the influence of spring thaw and precipitation events, and as such are reasonably close to the highest for this monitoring period.

To evaluate the response to spring thaw and precipitation at selected groundwater monitors, data loggers were installed to record groundwater levels on a more frequent basis. Table 1 below lists the monitoring wells and mini-piezometers where 22 data loggers have been installed and when readings began (refer to Figure 1 for locations). These locations were selected to evaluate groundwater levels and to establish baseline conditions prior to development of the HCBP. For reference, the total daily precipitation and maximum daily air temperature recorded at the Region of Waterloo International Airport Station are presented in Graph E5, for the period March 2007 to December 2009.

Table 1: Monitoring Stations Equipped With Data Loggers

Monitoring Well	Data Logger Installed	Mini-Piezometer	Data Logger Installed
001	January 2008	1D	April 2009
003	March 2007	2D	January 2007
004	August 2009	4D	April 2009
005I	August 2009	7D	November 2007
006	August 2009	9D	March 2007
104	January 2008		
105	January 2008		
106	August 2009		
107	July 2008		
109	April 2009		
110	August 2009		
116A	January 2008		
117A	January 2008		
118A	July 2008		
119A	July 2008		
121A	July 2008		
122A	July 2008		

The EIR Hydrogeology Report presented a detailed evaluation of daily influences from March 2007 to April 2008. Last year's Technical Memorandum presented a detailed evaluation of climate influences on groundwater levels for January through December 2008. The following is noted for January through December 2009 in Graph E5:

- Snowfall through January was equivalent to about 30 mm of precipitation and remained until early February

- A thaw occurred from February 7 to 19, with about 38 mm of rainfall occurring from February 11 to 12, which was followed by a thaw from February 25 to 27, with about 21 mm of rainfall occurring during this period
- Total monthly precipitation for January and March were below normal amounts. Conversely, total monthly precipitation in February and from April through August was above normal amounts
- The gradual rise in maximum daily temperatures from early to mid-March is interpreted to have resulted in a relatively slow melting of the limited snow pack and ground frost, increasing the potential for groundwater recharge
- Maximum daily air temperatures remained above 0^{0}C from March 4 to December 9, 2009, with the exception of March 12 and April 7
- Monthly precipitation from April to August and in October 2009 was above average
- The total precipitation through 2009 was 853 mm, as compared to a 39-year average of about 890 mm.

These are considered to be the main factors influencing groundwater levels on-site during the 2009 interval. The most notable highest groundwater levels observed in monitors equipped with data loggers occurred during the February thaw. These levels were about equal to the spring 2008 levels, and in a few cases spiked for a short interval above these levels.

2009 Groundwater Level Monitoring at Downey Road PSW

Groundwater levels and temperatures are monitored at two stations at the Downey Road PSW. These include MW003, which is located on the north edge of the PSW, and mini-piezometer nest PZ-9, which is located in the centre of the PSW. The groundwater level and temperature observations for monitoring well MW003 and mini-piezometer PZ-9D are presented in graphical format in Appendix F.

Graph F1 presents the daily groundwater elevations (with occasional manual readings) recorded in monitor MW003, from March 2007 to January 2008. In late January 2008, the data logger was re-set to record groundwater levels and temperatures on an hourly basis. The EIR Hydrogeology Report presented a detailed evaluation of groundwater levels from March 2007 to April 2008, and last year's Technical Memorandum presented a detailed evaluation up to December 2008. The following is a summary of 2009 observations at this location.

During the winter and spring months of 2009, groundwater levels increased in direct response to maximum daily temperatures above 0^{0}C and corresponding periods of precipitation. The most significant rapid rise occurred in early February during the 16 days of thaw. This rise in groundwater levels began on February 7, the first day of the thaw, indicating a direct relationship. Throughout the remainder of 2009, groundwater elevations rose quickly in response to periods of significant rainfall, notably in March, April, May, July, August, October, and December.

The responses to precipitation events and spring thaw in this monitor demonstrate the local sensitivity of the shallow groundwater system, which is associated with the coarse-grained nature of the overburden deposits within and above the uppermost aquifer.

Two mini-piezometers were installed in the Downey Road PSW. PZ-9S was installed to a depth of about 0.5 m and PZ-9D to a depth of about 1.0 m. Graph F2 presents the groundwater elevations recorded in mini-piezometer PZ-9D, for the period March 2007 to October 2009. Groundwater levels for this pair of shallow and deeper mini-piezometers have illustrated the upward hydraulic gradient that exists in this PSW.

It is noted that responses to precipitation and temperature are apparent in PZ-9D in Graph F2, similar to MW003, confirming the infiltrative capacity of the medium- to coarse-grained deposits on this site and the inherent relationship of the wetlands to the shallow groundwater system. The groundwater elevations for MW003 and PZ-9D are combined in Graph F3, indicating similar trends in each monitor.

The upward hydraulic gradient is also evident when groundwater levels in MW003 are compared with levels in the adjacent PZ-9D, as presented in Graph F3.

2009 Groundwater Level Monitoring in the Core PSW

Groundwater level and temperature observations, for monitoring wells and mini-piezometers that are located in and adjacent to the Core PSW of the HCBP, are presented in graphical format in Appendix G. The graphs are presented in an order that corresponds to the north-to-south locations of the monitoring stations (refer to Figure 1).

The responses to maximum daily air temperatures and precipitation (when compared with Graph E5) are apparent in these plots. This confirms the infiltrative capacity of the medium- to coarse-grained deposits adjacent to the Core PSW and the inherent relationship of the wetlands to the shallow groundwater system. The hourly recording of groundwater levels at mini-piezometer locations also indicates subtle fluctuations during each 24-hour period, likely associated with diurnal cycles of evapotranspiration in the wetland. The range of groundwater levels in mini-piezometers is more subdued than other plots, which reflects the relatively constant groundwater elevations in the wetland area, with only minor perturbations observed relative to precipitation and/or temperature changes.

The observed relationship of rainfall and temperature, recorded at the Region of Waterloo International Airport Station, to the groundwater levels on-site continues to validate the use of this station's data for these analyses.

2009 Groundwater Level Monitoring at Perimeter Locations

Groundwater level and temperature observations, for monitoring wells that are located at perimeter locations around the HCBP site, are presented in graphical format in Appendix H. The graphs are presented in an order that corresponds to the north-to-south locations of the monitoring stations (refer to Figure 1).

The responses to precipitation and maximum daily air temperatures (when compared with Graph E5) are also apparent in these plots. Groundwater elevations vary more widely over the year in comparison to the Core PSW monitoring locations.

Groundwater Elevations

It is noted that, as expected, the greatest range in groundwater elevations occurs around the perimeter locations of the site where groundwater recharge to the medium- to coarse-grained deposits is most significant. The smallest fluctuations occur in and adjacent to the core wetland and Hanlon Creek Tributary 'A'. Shallow depths to groundwater and the occurrence of groundwater discharge to these surface water features naturally limit the range of groundwater elevations in these areas.

Depth to Groundwater

The smallest fluctuations occur in and adjacent to the core wetland and Hanlon Creek Tributary 'A'. Shallow depths to groundwater and the occurrence of groundwater discharge to these surface water features naturally limit the range in depths to groundwater in these areas. The greatest range in depths to groundwater occurs around the perimeter locations of the site where groundwater recharge to the medium- to coarse-grained deposits is most significant.

Groundwater Flow

The EIR Hydrogeology Report illustrated the horizontal direction of shallow groundwater flow is from southeast of the site, arcing towards the northern boundary of the site. The horizontal direction of groundwater flow coincides with the wetlands and creek, indicating that a portion of groundwater is discharging to this surface water system.

Also of interest is the vertical direction of groundwater flow. Presented in Appendix D is a summary of vertical hydraulic gradient calculations, based on comparisons of shallow, intermediate and deep monitoring intervals, on selected dates. Graphs illustrating groundwater elevations and hydraulic gradients are included, with monitoring stations grouped in seven west-to-east profiles. These data and graphs confirm the downward hydraulic gradients (i.e. groundwater recharge conditions) in the upland portions of the site, and upward hydraulic gradients in the vicinity of, and within, the core wetland complex (i.e. groundwater discharge conditions). Seasonal variations in vertical directions of groundwater flow are also observed in some monitoring well pairs. Groundwater discharge conditions have also been confirmed at the Downey Road PSW.

Groundwater Temperatures

Data loggers installed in either a monitoring well or mini-piezometer also records groundwater temperature. These data are illustrated in graphical format in Appendixes F, G, and H, following the groundwater elevation graphs. Seasonal variations and associated time lags are illustrated by these graphs.

As noted previously, groundwater level and temperature monitoring has been conducted using data loggers since 2007 at four PSW monitoring locations (i.e. MW003, PZ-9D, PZ-2D, and PZ-7D). These locations are representative of shallow groundwater conditions, although each location has somewhat different characteristics. The characteristics and factors that may influence groundwater temperatures are described as follows:

- MW003 – completed in the shallow water table aquifer; groundwater levels have ranged from 0.26 m above grade to 1.19 m below grade; located at the edge of an open agricultural field, adjacent to a provincially significant wetland (PSW); shallow groundwater temperature recorded is potentially influenced by cold air temperatures during winter months and by sunlight and standing water in wetland during summer months
- PZ-9D – relatively shallow (i.e. 1.0 m deep) mini-piezometer; groundwater levels have ranged from 0.62 m above grade to 0.75 m below grade; located in the PSW close to MW003; shallow groundwater temperature recorded is potentially influenced by cold air temperatures and frozen wetland during winter months and by sunlight and standing water in wetland during summer months
- PZ-2D – relatively shallow (i.e. 1.0 m deep) mini-piezometer; groundwater levels have ranged from 0.04 m above grade to 0.70 m below grade; located in a core wetland complex about 50 m east of Hanlon Creek Tributary ‘A’; shallow groundwater temperature recorded is potentially influenced by cold air temperatures during winter months and moderated by trees providing shade during summer months
- PZ-7D – relatively shallow (i.e. 1.0 m deep) mini-piezometer; groundwater levels have ranged from 0.01 m to 0.25 m above grade; located in a core wetland complex in the eastern tributary of Hanlon Creek Tributary ‘A’; shallow groundwater temperature recorded is potentially influenced by cold air temperatures during winter months and moderated by trees providing shade during summer months

Temperatures recorded from March 2007 to October 2009 at these locations range from a low of about 3^0C to a high of about 15^0C. However, the temperature ranges differed as follows for each location:

- MW003 – ranged from about 6^0C in March to about 12^0C in late-October/early-November
- PZ-9D – ranged from about 3^0C in March to just below 15^0C in late-August/early-September
- PZ-2D – ranged from just below 3^0C in late-March/early April to just below 14^0C in late-August/early-September
- PZ-7D – ranged from just below 5^0C in late-March/early April to about 12^0C from late-July through early-October

The temperature range of groundwater at greater depths in this general area tends to fluctuate in a narrower range, typically between 5 and 10^0C. It is therefore apparent that the temperatures in the shallower groundwater regime in the vicinity of these four monitors are influenced by seasonal variations in air temperature and solar radiation. These data are interpreted to be representative of the temperature of groundwater discharging to the wetlands and creeks in these locations.

The temperatures recorded in the remaining monitoring stations starting in 2008 and 2009, also reflect shallow groundwater temperatures near the central wetland complex and around the perimeter of the site. Although the 2009 monitoring is limited for some stations, temperature ranges and the timing of higher and lower temperatures are similar in most monitors. The highest observed groundwater temperatures are evident in monitors where the groundwater elevation is close to surface during summer months, particularly the monitors located in open fields. These monitors also exhibit the lowest groundwater temperatures during the late winter and early spring, when melting snow and frost infiltrate to the shallow groundwater system.

3.3 Relevance to Site Development and Stormwater Management

The observed minimum and maximum depths to shallow groundwater (i.e. water table) are presented in Appendix B, for the 2003 to 2009 monitoring period. These observations indicate specific locations where there may be limitations to lot-level stormwater infiltration facilities. As noted previously, the greatest range in depths to groundwater occurs around the perimeter locations of the site where groundwater recharge to the medium- to coarse-grained deposits is most significant. It is interpreted that it is in these areas where the groundwater elevations in the spring of 1997 would have been up to 0.5 m above those observed in April 2004, April 2007, and April 2008. Therefore, allowance should be made for this potential high groundwater elevation during the design of stormwater infiltration facilities, at the Site Plan Approval stage. The design should be in accordance with the Ministry of the Environment Stormwater Management Planning and Design Manual 2003, thus allowing adequate separation between the bottom of the infiltration system and the high water table elevation.

The site will be graded for development purposes. It will therefore be necessary to consider the estimated depth to groundwater based on proposed site grading to further evaluate potential locations for lot-level stormwater infiltration facilities. Continued monitoring of groundwater levels at all functioning monitoring well locations is required until grading of the site begins to support these evaluations, which will be required as part of the Site Plan Approval process.

3.4 Groundwater Quality

Groundwater samples were first collected in 2003 from 23 selected monitoring wells, and then from 33 selected monitoring wells in 2008 and 2009. The groundwater quality data are summarized in Appendix I. The data were compared to the Ontario Drinking Water Quality Standards (ODWQS), Ontario Regulation 169/03. Concentrations that exceeded the ODWQS are indicated on the tables. The groundwater can be characterized as basic (i.e. pH>7) and, based on the reported calcium and magnesium concentrations, as hard.

In general, the concentrations of the parameters analyzed were below the applicable ODWQS criteria, with the following exceptions (refer to Appendix I for specific exceedances and Figure 1 for well locations):

- Nitrate (as N) concentrations exceeded the ODWQS of 10.0 mg/L on at least one occasion in five monitoring wells
- Aluminum concentrations exceeded the ODWQS of 0.1 mg/L on at least one occasion in 23 monitoring wells
- Cadmium concentrations exceeded the ODWQS of 0.005 mg/L on at least one occasion in 11 monitoring wells
- Iron concentrations exceeded the ODWQS of 0.3 mg/L on at least one occasion in 29 monitoring wells

- Lead concentrations exceeded the ODWQS of 0.010 mg/L on at least one occasion in 21 monitoring wells
- Manganese concentrations exceeded the ODWQS of 0.05 mg/L on at least one occasion in 31 monitoring wells
- Sodium concentrations exceeded the ODWQS of 20 mg/L on at least one occasion in 18 monitoring wells
- Hardness concentrations exceeded the ODWQS of 100 mg/L in all monitoring wells.

The ODWQS for nitrate is health-related and the concentrations above this level in five monitoring wells can be attributed to the agricultural use of this site and the application of nutrients. Nitrate was also elevated above normal levels in five other monitoring wells. The elimination of nutrients applied to crops would be expected to reduce levels of nitrate. Such changes have been observed in other areas of Guelph.

The ODWQS for aluminum is an operational guideline for drinking water supplies and the elevated levels detected may be attributed to monitoring wells that are not developed to a sediment-free condition. Improved filtering of samples at the time of collection in 2009 resulted in reduced levels in all monitors.

The ODWQS for lead is a standard for drinking water supplies and the elevated levels detected may be attributed to monitoring wells that are not developed to a sediment-free condition. Improved filtering of samples at the time of collection in 2009 resulted in reduced levels in all monitors.

The ODWQS for iron and manganese is an aesthetic objective and the elevated levels are typical of groundwater in this area of Ontario. Improved filtering of samples at the time of collection in 2009 resulted in reduced levels in all monitors.

The ODWQS for sodium is a health-related parameter for people on sodium-restricted diets. Elevated levels of sodium and chloride are often associated with the application of road salt for de-icing purposes. The levels of chloride do not exceed the ODWQS of 250 mg/L in any of the monitors; however, the level of chloride was elevated above normal levels in many of the monitors where sodium was elevated. The source of the elevated sodium and chloride occurring in some of the monitoring wells, including one of the bedrock wells, can likely be attributed to road salting along the Hanlon Expressway, Downey Road, and possibly Forestell Road.

The ODWQS for hardness is an aesthetic objective and the elevated levels observed in all monitoring wells are typical of groundwater in this area of Ontario.

Colour, turbidity, total dissolved solids, and DOC exceeded the respective ODWQS concentrations in most of the monitoring wells. This observation is typical for monitoring wells that are not developed to a sediment-free condition. Improved filtering of samples at the time of collection in 2009 resulted in reduced levels of some parameters.

3.5 Long-Term Groundwater Monitoring Program

The long-term groundwater monitoring program at the HCBP site should continue as previously recommended on a quarterly basis. Additional data loggers should be installed in selected monitoring wells and mini-piezometers that are expected to remain during and following site grading. This will improve the background dataset and the establishment of the influences of climate on groundwater elevations over the short-, medium-, and long-term. Groundwater samples should continue to be collected on an annual basis from selected monitoring wells. Improvements to filtering of water samples have been successful in reducing the amount of sediment and should be continued as a standard practise.

4 Summary

The on-going monitoring of groundwater levels has provided an updated characterization of the hydrogeological conditions across the HCBP site and surrounding area, including the local occurrence and movement of groundwater in relation to the on-site wetlands and Hanlon Creek Tributary 'A'. The following is a summary of conclusions and recommendations related to the groundwater monitoring program.

- A long-term groundwater monitoring program is required to assess any changes in groundwater elevations and groundwater quality during and following development of the site. The monitoring program is also required to assess the performance of the stormwater management facilities once they are constructed and to observe seasonal trends in water levels in the core wetland. It is therefore recommended that initially groundwater levels continue to be monitored on a quarterly basis at a minimum in all available monitoring wells and mini-piezometers, before and where possible during grading of the site. To correspond to previous monitoring, the preferred monitoring periods would continue to be January, April, July and October. Groundwater samples should be collected from all available monitoring wells prior to grading of any part of the site to augment the existing background water quality data.
- Prior to any site grading, the grading schedule should be reviewed to determine the potential for monitoring locations to be affected. Any monitoring stations located within the planned grading areas must be properly abandoned, in advance of grading, in accordance with Ontario Regulation 903, as recently amended, of the Ontario Water Resources Act, by a licensed Water Well Technician.
- In some cases, existing monitoring wells can be maintained, with minor modifications or improvements, for continued monitoring. Several monitors must be replaced following grading and development of selected blocks. The proposed locations for long-term monitoring of groundwater levels and quality were identified in the EIR Hydrogeology Report, including existing monitors that are expected to be maintained or abandoned, and proposed future monitoring locations.
- Groundwater level and temperature monitoring using data loggers is recommended for many, if not all, of the monitoring wells over the long-term. By utilizing this technology, the frequency of monitoring can be increased significantly and trends in groundwater level changes can be detected sooner and with improved accuracy.
- It is recommended that the monitoring data continue to be compiled, plotted, and analyzed on an annual basis by a qualified professional engineer or geoscientist. The results should be presented in a Technical Memorandum that is submitted to the City of Guelph on an annual basis, for the purpose of review, acceptance, and response to recommendations. Recommendations related to the monitoring program, including any proposed modifications, would be included. The GRCA should also receive a copy for review and comment in relation to maintenance of groundwater levels across the site, but with particular emphasis on the Provincially Significant Wetlands and Hanlon Creek Tributary 'A'. In the event of unexpected changes in groundwater elevations or quality, the frequency of monitoring, sampling, and reporting would be evaluated and revised as required. These monitoring recommendations are consistent with the Hanlon Creek State-of-the-Watershed Study Report (2003).

Respectfully submitted,
Banks Groundwater Engineering Limited

Original signed by:
William D. Banks, P.Eng.
Principal – Senior Hydrogeologist

The Figure, Tables and Graphs referenced in this technical memorandum are appended under the following headings:

Groundwater Monitoring Stations Figure

Appendix A: Current Groundwater Monitoring Network

Appendix B: Groundwater Level Monitoring Data 2003 – 2009

Appendix C: Groundwater Monitoring Graphs 2003 – 2009

Appendix D: Vertical Hydraulic Gradients 2003 – 2009

Appendix E: Climate Monitoring

Appendix F: Downey Road PSW Groundwater Monitoring

Appendix G: HCBP Core PSW Groundwater Monitoring

Appendix H: HCBP Perimeter Groundwater Monitoring

Appendix I: Groundwater Quality Monitoring Data

Groundwater Monitoring Stations Figure

Hanlon Creek Business Park

City of Guelph

Groundwater Monitoring Program

Banks Groundwater Engineering Limited

Legend

- Wetland
- Surface Water
- Project Boundary
- Monitoring Well
- Mini-Piezometer

Disclaimer: This Figure is for illustrative purposes only and is to be considered in conjunction with the Hydrogeology Report.

Digital Mapping Source: Airphoto (2006) used under license from the Corporation of the City of Guelph.

Map Projection: UTM Zone 17, NAD83

January 2008

Scale: 1:10,000 (@ 11x17")

0 100 200 300 400 500 Meters

Figure 1

Study Area and Monitoring Locations

NRSI_0726P_Fig1_StudyAreaMonitoringSites_10K_28Nov07_NJB

Appendix A: Current Groundwater Monitoring Network

Hanlon Creek Business Park - Groundwater Monitoring Program

Monitoring Well and Mini-Piezometer Condition Summary - 27 October 2009

Monitoring Well Number	Type *	Nominal Well Diameter (mm)	Protective Casing Size/Diameter (mm)	Condition of Monitor & Protective Casing	Waterra Tubing In Place	Monitoring Started	Most Recent Monitoring	Data Logger Installed
001	S	50	100	Functioning; square protective casing in good condition	Yes	Apr-03	Oct-09	Jan-08
002	S	50	100	Functioning; square protective casing not secure in ground, monitor broken at ground level with limited to no access	No	Apr-03	Oct-08	--
003	S	50	100	Functioning; square protective casing in good condition	Yes	Apr-03	Oct-09	Mar-07
004	S	50	100	Functioning; square protective casing in good condition	Yes	Apr-03	Oct-09	Aug-09
005 (S)	S	13	100	Functioning; S & I monitors inside same square protective casing; in good condition	No	Apr-03	Oct-09	--
005 (I)	I	50	100	Functioning; S & I monitors inside same square protective casing; in good condition	Yes	Apr-03	Oct-09	Aug-09
006	S	50	100	Functioning; square protective casing in good condition	No	Apr-03	Oct-09	Aug-09
101	S	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-09	--
102	S	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-09	--
103	S	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-09	--
104	S	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-09	Jan-08
105	S	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-09	Jan-08
106	S	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-09	Aug-09
107	S	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-09	Jul-08
108	S	50	100	Inaccessible; square protective casing & monitor bent at ground surface; monitor crimped	Yes	Jun-03	Apr-04	--
109	S	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-09	Apr-09
110	I	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-09	Aug-09
111	D	50	150	Functioning; 150mm dia. cap, well casing & lock in good condition; flowing on some occasions requiring temporary extension on monitor for accurate water level reading	No	Sep-03	Oct-09	--
112	D	50	150	Functioning; 150mm dia. cap, well casing & lock in good condition	Yes	Sep-03	Oct-09	--
113	D	50	150	Functioning; 150mm dia. cap, well casing & lock in good condition	No	Sep-03	Oct-09	--
114	D	50	150	Functioning; 150mm dia. cap, well casing & lock in good condition	Yes	Sep-03	Oct-09	--
115	I	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-09	--
115A	S	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-09	--
116	I	50	150	Functioning; square protective casing in good condition	No	Jun-03	Oct-09	--
116A	S	50	150	Functioning; square protective casing in good condition	No	Jun-03	Oct-09	Jan-08
117	I	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-09	--
117A	S	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-09	Jan-08
118	I	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-09	--
118A	S	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-09	Jul-08
119	I	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-09	--
119A	S	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-09	Jul-08
120	I	50	Removed	Square protective casing & top of monitor removed by vandals	No	Jun-03	Apr-04	--
120A	S	50	Removed	Square protective casing & top of monitor removed by vandals	No	Jun-03	Apr-04	--
121	I	50	100	Functioning; square protective casing in good condition	Yes	Jun-03	Oct-09	--
121A	S	50	100	Functioning; square protective casing removed & monitor repaired; locking well cap installed	No	Jun-03	Oct-09	Jul-08
122	I	50	100	Functioning; square protective casing in good condition	Yes	Sep-03	Oct-09	--
122A	S	50	100	Functioning; square protective casing in good condition	Yes	Sep-03	Oct-09	Jul-08
123	D	50	100	Functioning; round protective casing, & well tag in good condition	No	Oct-05	Oct-09	--
Mini-Piezometer Number	**Type ****	**Nominal Piezometer Diameter (mm)**	**Protective Casing Size/Diameter (mm)**	**Condition of Mini-Piezometer**	**Waterra Tubing In Place**	**Monitoring Started**	**Most Recent Monitoring**	**Data Logger Installed**
1S	SP	20	n/a	Functioning	No	Dec-06	Oct-09	--
1D	DP	20	n/a	Functioning	No	Dec-06	Oct-09	Apr-09
2S	SP	20	n/a	Functioning	No	Dec-06	Oct-09	--
2D	DP	20	n/a	Functioning	No	Dec-06	Oct-09	Jan-07
4S	SP	20	n/a	Functioning	No	Dec-06	Oct-09	--
4D	DP	20	n/a	Functioning	No	Dec-06	Oct-09	Apr-09
6S	SP	20	n/a	Removed by vandals	No	Dec-06	Jul-07	--
6D	DP	20	n/a	Removed by vandals	No	Dec-06	Jul-07	--
7S	SP	20	n/a	Functioning - PVC pipe	No	Dec-06	Oct-09	--
7D	DP	20	n/a	Functioning - PVC pipe	No	Dec-06	Oct-09	Nov-07
8S	SP	20	n/a	Functioning	No	Dec-06	Oct-09	--
8D	DP	20	n/a	Functioning	No	Dec-06	Oct-09	--
9S	SP	20	n/a	Functioning	No	Mar-07	Oct-09	--
9D	DP	20	n/a	Functioning	No	Mar-07	Oct-09	Mar-07

* S=shallow (overburden); I=intermediate (overburden); D=deep (bedrock)
** SP=shallow piezometer (1.0m); DP=deeper piezometer (1.5m)

Appendix B: Groundwater Level Monitoring Data 2003 – 2009

Hanlon Creek Business Park - Groundwater Monitoring Program 2008/2009

Monitoring Well Elevation Data

Monitoring Well Number	Type	Northing	Easting	Ground Elevation (m)	Top of Well Elevation (m)	Depth to Top of Screen (m)	Depth to Groundwater (m) Apr 23-25/03	Groundwater Elevation (m) Apr 23-25/03	Depth to Groundwater (m) Jul 7/03	Groundwater Elevation (m) Jul 7/03	Depth to Groundwater (m) Sep 3-9/03	Groundwater Elevation (m) Sep 3-9/03	Depth to Groundwater (m) Oct 8/03	Groundwater Elevation (m) Oct 8/03	Depth to Groundwater (m) Nov 6/03	Groundwater Elevation (m) Nov 6/03
001	S	4815738	563019	324.80	325.68	4.00	0.67	324.13			0.84	323.96	0.89	323.91	0.76	324.04
002	S	4815264	563116	327.26	328.06	2.20	1.38	325.88			1.87	325.39	damaged	damaged	damaged	damaged
003	S	4814814	562436	326.61	327.784	2.10	0.79	325.82			1.00	325.61	0.96	325.65	0.62	325.99
004	S	4814286	562532	330.43	331.22	5.10	4.44	325.99			4.71	325.72	4.82	325.61	4.75	325.68
005 (S)	S	4814708	564015	336.53	337.21	3.00	6.17	330.36			6.74	329.78	n/a	n/a	n/a	n/a
005 (I)	I	4814708	564015	336.53	337.12	10.80	9.58	326.95			9.60	326.92	9.66	326.86	9.67	326.86
006	S	4815051	563955	334.70	335.57	7.50	7.58	327.12			7.73	326.97	7.74	326.96	7.70	327.00
101	S	4816126	562590	321.70	322.47	4.00			4.05	317.65	4.12	317.58	3.96	317.74	3.52	318.18
102	S	4815860	562163	320.66	321.42	3.00			1.57	319.10	1.75	318.91	1.41	319.26	0.84	319.83
103	S	4815933	562895	323.85	324.76	2.20			1.14	322.71	1.22	322.63	1.05	322.81	0.65	323.21
104	S	4815648	562401	322.04	322.61	2.30			1.24	320.80	1.21	320.83	0.86	321.18	0.53	321.51
105	S	4815489	562700	323.87	324.61	2.70			1.25	322.62	1.27	322.60	1.12	322.75	1.03	322.84
106	S	4815478	563458	328.65	329.38	4.00			2.73	325.92	2.86	325.78	2.77	325.88	2.42	326.23
107	S	4815143	563540	327.44	328.07	1.90			0.98	326.46	1.13	326.31	1.07	326.37	0.80	326.63
108	S	4814607	562867	330.33	330.92	5.00			4.11	326.22	4.27	326.06	4.30	326.03	4.12	326.21
109	S	4814444	563116	331.70	332.39	7.20			5.23	326.46	5.41	326.29	5.48	326.22	5.39	326.31
110	I	4814502	563532	339.59	340.38	14.80			12.89	326.70	13.06	326.53	13.14	326.44	13.12	326.47
111	D	4815365	562710	324.20	324.90	18.90			n/a	n/a	-0.40	324.60	-0.41	324.61	-0.54	324.74
112	D	4814288	562531	330.44	331.18	28.00			n/a	n/a	4.97	325.47	5.11	325.33	4.95	325.49
113	D	4814478	563532	339.85	340.66	40.80			n/a	n/a	14.43	325.42	14.48	325.37	14.40	325.45
114	D	4814640	564115	338.68	339.54	34.10			n/a	n/a	12.86	325.82	12.94	325.74	12.90	325.79
115	I	4815311	562313	323.12	323.76	7.10			n/a	n/a	0.11	323.02	0.03	323.10	-0.02	323.14
115A	S	4815309	562312	323.10	323.77	1.60			0.64	322.45	0.66	322.44	0.29	322.81	0.16	322.93
116	I	4816139	562305	318.75	319.60	9.80			3.83	314.91	3.89	314.86	3.69	315.06	3.21	315.54
116A	S	4816139	562311	318.67	319.48	1.50			0.51	318.16	0.74	317.92	n/a	n/a	0.15	318.52
117	I	4815889	562525	321.21	321.83	7.10			3.07	318.14	3.11	318.09	2.96	318.24	2.63	318.58
117A	S	4815885	562527	321.25	322.08	2.00			1.30	319.95	1.28	319.97	1.21	320.04	0.98	320.26
118	I	4815685	562921	324.02	324.77	7.30			0.59	323.43	0.84	323.18	0.73	323.30	0.45	323.58
118A	S	4815689	562926	323.97	324.61	2.10			0.72	323.25	0.81	323.16	0.69	323.28	0.55	323.41
119	I	4815279	562960	325.88	326.86	6.00			1.16	324.72	1.12	324.76	0.86	325.02	0.62	325.26
119A	S	4815280	562965	325.88	326.92	2.80			1.11	324.77	1.11	324.77	0.85	325.03	0.61	325.27
120	I	4814948	563249	327.38	328.80	7.20			0.35	327.04	0.47	326.91	0.36	327.02	0.09	327.29
120A	S	4814941	563244	327.38	328.12	2.50			1.06	326.33	1.19	326.19	1.08	326.30	0.80	326.59
121	I	4814817	563395	327.44	328.02	8.80			1.55	325.89	1.72	325.72	1.74	325.71	1.58	325.86
121A	S	4814817	563396	328.09	328.44	2.70			1.47	326.61	1.64	326.44	1.67	326.42	1.52	326.57
122	I	4814929	562960	326.79	327.50	5.80			n/a	n/a	0.87	325.93	0.81	325.98	0.69	326.11
122A	S	4814931	562959	326.81	327.51	2.80			n/a	n/a	1.01	325.81	0.96	325.86	0.85	325.97
123	VD	4815368	562710	324.08	324.83	49.00			n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

S=Shallow; I=Intermediate; D=Deep (Bedrock)

Hanlon Creek Business Park - Groundwater Monitoring Program 2008/2009

Monitoring Well Elevation Data

Monitoring Well Number	Depth to Groundwater (m) Apr 13/04	Groundwater Elevation (m) Apr 13/04	Depth to Groundwater (m) Nov 8/05	Groundwater Elevation (m) Nov 8/05	Depth to Groundwater (m) Nov 11/05	Groundwater Elevation (m) Nov 11/05	Depth to Groundwater (m) Apr 26/06	Groundwater Elevation (m) Apr 26/06	Depth to Groundwater (m) Dec 20/06	Groundwater Elevation (m) Dec 20/06	Depth to Groundwater (m) Feb 1/07	Groundwater Elevation (m) Feb 1/07	Depth to Groundwater (m) Apr 27/07	Groundwater Elevation (m) Apr 27/07
001	0.43	324.37	0.98	323.82			0.54	324.27	0.47	324.33	0.56	324.24	0.47	324.33
002	damaged	damaged	damaged	damaged	damaged	damaged	damaged	damaged	damaged	damaged	damaged	damaged	damaged	damaged
003	0.05	326.56			1.01	325.60	0.13	326.48	0.24	326.37	0.28	326.33	0.04	326.57
004	3.18	327.25			4.86	325.57	3.68	326.75	3.87	326.56	3.78	326.65	3.40	327.03
005 (S)	n/a	n/a			n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
005 (I)	8.33	328.19			n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
006	6.54	328.16			7.61	327.09	6.83	327.88	6.94	327.77	6.85	327.85	6.43	328.27
101	3.46	318.24	4.26	317.44			3.70	318.00	3.61	318.09	3.86	317.84	3.69	318.01
102	0.92	319.75	2.26	318.40			0.95	319.71	0.98	319.68	1.08	319.58	0.92	319.74
103	0.40	323.45	1.29	322.56			0.56	323.29	0.53	323.32	0.76	323.09	0.52	323.33
104	0.63	321.41	1.07	320.97			0.53	321.51	0.68	321.36	0.79	321.25	0.55	321.49
105	1.03	322.84	1.12	322.75			1.02	322.85	1.07	322.80	1.11	322.76	0.94	322.93
106	2.00	326.64			2.75	325.90	2.17	326.47	2.16	326.48	2.23	326.42	1.99	326.66
107	0.07	327.37	1.07	326.37			0.39	327.05	0.45	326.99	0.48	326.96	not accessible	not accessible
108	3.06	327.27	damaged	damaged			damaged	damaged	damaged	damaged	damaged	damaged	damaged	damaged
109	4.09	327.61			5.41	326.29	4.46	327.24	4.67	327.03	4.52	327.18	4.14	327.56
110	11.74	327.85			12.99	326.60	12.07	327.52	12.31	327.28	12.11	327.48	11.69	327.90
111	n/a	n/a	-0.36	324.56			overflowing	overflowing	overflowing	overflowing	overflowing	overflowing	overflowing	overflowing
112	3.64	326.79			5.15	325.29	3.82	326.62	4.22	326.22	4.19	326.25	3.95	326.49
113	13.33	326.51			14.38	325.47	13.65	326.20	13.66	326.19	13.53	326.32	13.12	326.73
114	11.72	326.96			12.85	325.83	12.09	326.59	12.20	326.48	11.96	326.72	11.64	327.04
115	0.19	322.93	0.46	322.66			0.15	322.97	frozen	frozen	frozen	frozen	0.36	322.77
115A	0.16	322.93	0.26	322.84			0.11	322.99	0.19	322.90	0.19	322.90	0.05	323.05
116	2.97	315.78	4.03	314.71			3.02	315.73	3.07	315.68	3.35	315.39	3.03	315.71
116A	0.15	318.52	0.63	318.04			0.17	318.50	0.26	318.41	0.32	318.35	0.16	318.50
117	2.70	318.51	3.34	317.87			2.88	318.33	2.91	318.30	3.03	318.17	3.02	318.19
117A	1.05	320.20	1.25	320.00			1.01	320.24	1.06	320.19	1.17	320.08	0.79	320.45
118	0.57	323.45	0.88	323.14			0.67	323.35	0.60	323.42	0.73	323.29	0.59	323.43
118A	0.47	323.50	0.77	323.20			0.60	323.37	0.64	323.33	0.69	323.28	0.52	323.45
119	0.65	325.24	0.92	324.96			0.58	325.30	0.63	325.25	0.66	325.22	0.51	325.37
119A	0.64	325.25	0.92	324.96			0.58	325.30	0.62	325.26	0.65	325.23	0.70	325.19
120	-0.19	327.57			destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed
120A	0.52	326.87			destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed
121	0.83	326.61			1.61	325.83	0.95	326.49	1.06	326.38	0.94	326.51	1.06	326.38
121A	0.78	327.30			damaged	damaged	damaged	damaged	damaged	damaged	damaged	damaged	damaged	damaged
122	0.48	326.31			0.90	325.89	0.55	326.24	0.60	326.19	0.59	326.20	0.49	326.30
122A	0.68	326.13			0.78	326.03	0.75	326.06	0.71	326.10	0.79	326.03	0.72	326.10
123	n/a	n/a	16.36	307.72	14.21	309.88	17.53	306.55	n/a	n/a	n/a	n/a	18.26	305.83

Hanlon Creek Business Park - Groundwater Monitoring Program 2008/2009

Monitoring Well Elevation Data

Monitoring Well Number	Depth to Groundwater (m) Jul 25/07	Groundwater Elevation (m) Jul 25/07	Depth to Groundwater (m) Nov 2/07	Groundwater Elevation (m) Nov 2/07	Depth to Groundwater (m) Jan 25, 29/08	Groundwater Elevation (m) Jan 25, 29/08	Depth to Groundwater (m) Apr 22-25/08	Groundwater Elevation (m) Apr 22-25/08	Depth to Groundwater (m) Jul 23-28/08	Groundwater Elevation (m) Jul 23-28/08	Depth to Groundwater (m) Oct 24-28/08	Groundwater Elevation (m) Oct 24-28/08
001	0.93	323.87	1.13	323.67	0.51	324.29	0.38	324.42	0.59	324.22	0.77	324.034
002	1.93	325.33	1.99	325.27	1.31	325.95	1.25	326.01	1.35	325.91	1.43	325.83
003	0.72	325.89	1.13	325.48	0.44	326.17	0.03	326.58	0.39	326.22	0.69	325.924
004	4.24	326.19	4.91	325.52	4.21	326.22	2.90	327.53	3.94	326.49	4.40	326.03
005 (S)	moist/dry	moist/dry	dry	dry	6.43	330.10	6.33	330.20	6.20	330.33	6.47	330.05
005 (I)	8.65	327.88	9.37	327.16	9.24	327.29	7.91	328.62	8.40	328.13	8.83	327.70
006	6.96	327.74	7.59	327.11	7.24	327.46	6.16	328.54	6.65	328.05	7.08	327.62
101	4.16	317.54	4.35	317.35	3.61	318.09	3.21	318.49	3.91	317.79	3.93	317.77
102	1.94	318.72	2.36	318.30	0.92	319.74	0.77	319.89	0.48	320.18	1.51	319.15
103	1.41	322.44	1.45	322.40	0.52	323.33	0.41	323.44	0.80	323.05	1.06	322.79
104	1.45	320.59	1.34	320.70	0.58	321.46	0.61	321.43	0.74	321.30	0.90	321.139
105	1.39	322.48	1.25	322.62	1.10	322.77	1.05	322.82	1.10	322.77	1.15	322.717
106	2.58	326.07	2.89	325.76	2.26	326.39	1.82	326.83	2.15	326.50	2.46	326.19
107	0.73	326.71	1.15	326.29	0.66	326.78	-0.08	327.52	0.29	327.145	0.69	326.745
108	n/a	n/a	damaged	damaged	damaged	damaged	damaged	damaged	damaged	damaged	damaged	damaged
109	4.82	326.88	5.41	326.29	4.99	326.71	3.79	327.91	4.60	327.10	4.96	326.74
110	12.29	327.30	12.96	326.63	12.70	326.89	11.39	328.20	12.06	327.53	12.45	327.14
111	-0.83	325.03	-0.47	324.67	-0.98	325.18	-1.73	325.93	-0.85	325.05	-0.66	324.86
112	4.67	325.77	5.09	325.35	4.47	325.97	3.37	327.07	4.18	326.26	4.63	325.81
113	13.75	326.10	14.30	325.55	13.96	325.89	12.90	326.95	13.59	326.26	13.97	325.88
114	12.03	326.65	12.64	326.04	12.39	326.29	11.25	327.43	11.81	326.87	12.23	326.45
115	-0.02	323.14	-0.07	323.19	frozen	frozen	-0.64	323.76	-0.64	323.76	-0.32	323.45
115A	1.12	321.97	0.75	322.34	0.28	322.81	0.27	322.82	-0.01	323.10	0.35	322.74
116	4.12	314.63	4.34	314.41	3.40	315.35	2.75	316.00	4.12	314.63	3.91	314.84
116A	1.09	317.58	1.11	317.56	0.20	318.47	0.18	318.49	0.40	318.27	0.46	318.208
117	3.16	318.05	3.17	318.04	2.66	318.55	2.37	318.84	3.15	318.06	2.96	318.25
117A	1.42	319.83	1.32	319.93	1.12	320.13	1.00	320.25	1.21	320.04	1.15	320.099
118	0.69	323.33	0.68	323.34	0.36	323.66	0.27	323.75	0.53	323.49	0.59	323.43
118A	0.98	322.99	0.93	323.04	0.66	323.31	0.64	323.33	0.71	323.26	0.76	323.204
119	1.16	324.72	1.03	324.85	0.73	325.15	0.66	325.22	0.53	325.35	0.70	325.18
119A	1.15	324.73	1.01	324.87	0.71	325.17	0.64	325.24	0.53	325.35	0.69	325.196
120	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed
120A	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed
121	1.09	326.35	1.63	325.81	1.29	326.15	0.73	326.71	0.94	326.50	1.15	326.29
121A	1.10	326.99	1.63	326.46	1.51	326.58	0.79	327.30	0.96	327.13	1.15	326.935
122	0.72	326.07	0.83	325.96	0.65	326.14	0.49	326.30	0.49	326.30	0.66	326.13
122A	0.88	325.93	0.97	325.84	0.83	325.98	0.69	326.12	0.69	326.12	0.82	325.991
123	18.95	305.14	19.54	304.55	13.56	310.53	12.45	311.64	15.98	308.11	17.12	306.97

Hanlon Creek Business Park - Groundwater Monitoring Program 2008/2009

Monitoring Well Elevation Data

Monitoring Well Number	Depth to Groundwater (m) Jan 2, 3/09	Groundwater Elevation (m) Jan 2, 3/09	Depth to Groundwater (m) Apr 27-29/09	Groundwater Elevation (m) Apr 27-29/09	Depth to Groundwater (m) May 20/09	Groundwater Elevation (m) May 20/09	Depth to Groundwater (m) Jul 29/09	Groundwater Elevation (m) Jul 29/09	Depth to Groundwater (m) Aug 27/09	Groundwater Elevation (m) Aug 27/09	Depth to Groundwater (m) Oct 26, 27/09	Groundwater Elevation (m) Oct 26, 27/09
001	0.40	324.404	0.37	324.434	0.46	324.339	0.60	324.201			0.70	324.099
002	not available	not available	not available	not available	not available	not available	not available	not available			not available	not available
003	0.05	326.561	-0.03	326.644			0.31	326.304			0.60	326.014
004	3.56	326.87	3.14	327.29			3.89	326.54	4.04	326.39	4.35	326.08
005 (S)	6.01	330.52	6.42	330.11			6.46	330.07	6.45	330.08	dry	dry
005 (I)	8.71	327.82	7.71	328.82			8.15	328.38	8.29	328.24	8.67	327.85
006	6.71	327.99	6.04	328.66			6.49	328.21	6.58	328.12	6.95	327.76
101	3.05	318.65	3.18	318.52					4.08	317.62	3.82	317.88
102	0.53	320.13	0.53	320.13					1.49	319.17	1.32	319.34
103	0.30	323.55	0.34	323.51					0.95	322.90	1.05	322.80
104	0.49	321.549	0.43	321.609	0.71	321.329			0.90	321.139	0.87	321.174
105	1.03	322.835	0.94	322.930	1.07	322.795	1.08	322.785			1.08	322.788
106	1.88	326.77	1.72	326.93			2.17	326.48	2.20	326.45	2.37	326.28
107	0.19	327.245	-0.32	327.760			0.30	327.140			0.59	326.850
108	damaged	damaged	damaged	damaged	damaged	damaged	damaged	damaged			damaged	damaged
109	4.39	327.31	3.83	327.871			4.49	327.211			4.87	326.831
110	12.16	327.43	11.36	328.23			11.89	327.70	12.04	327.55	12.34	327.25
111	-0.85	325.05	nm				-1.02	325.22			-0.53	324.73
112	3.90	326.54	3.65	326.79			4.20	326.24			4.89	325.55
113	13.68	326.17	12.98	326.87			13.43	326.42			14.01	325.84
114	12.00	326.68	11.25	327.43			11.61	327.07			12.19	326.49
115	frozen	frozen	-0.64	323.76					-0.43	323.55	-0.38	323.50
115A	0.17	322.92	0.00	323.09					0.36	322.73	0.18	322.91
116	not available	not available	2.80	315.95	3.17	315.58			4.49	314.26	3.70	315.05
116A	0.10	318.568	0.14	318.528	0.32	318.348			0.40	318.268	0.48	318.183
117	2.36	318.85	2.42	318.79	2.68	318.53			3.39	317.82	2.88	318.33
117A	0.88	320.366	0.89	320.356	1.09	320.156			1.25	319.996	1.16	320.091
118	0.33	323.69	0.28	323.74	0.43	323.59	0.48	323.54			0.54	323.48
118A	0.49	323.481	0.47	323.501	0.81	323.156	0.67	323.298			0.72	323.251
119	0.61	325.27	0.46	325.42	0.66	325.22	0.63	325.25			0.64	325.24
119A	0.60	325.285	0.46	325.418	0.64	325.243	0.61	325.268			0.62	325.258
120	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed			destroyed	destroyed
120A	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed	destroyed			destroyed	destroyed
121	0.91	326.53	0.70	326.74			0.87	326.57			1.06	326.38
121A	0.94	327.145	0.75	327.335			0.90	327.190			1.08	327.010
122	0.51	326.28	0.41	326.38	0.49	326.30	0.53	326.26			0.60	326.19
122A	0.71	326.109	0.64	326.174	0.70	326.114	0.73	326.084			0.79	326.029
123	16.99	307.10	16.87	307.22							17.14	306.95

Hanlon Creek Business Park - Groundwater Monitoring Program 2008/2009
Piezometer Groundwater Elevation Data

Piezometer Well Number	Type	Ground Elevation (m amsl)	Pipe Stickup on April 22/08 (m)	Depth to Groundwater (m)* Dec 20/06	Groundwater Elevation (m) Dec. 20/06	Depth to Groundwater (m) Jan 23/07	Groundwater Elevation (m) Jan 23/07	Depth to Groundwater (m) Apr 27/07	Groundwater Elevation (m) Apr 27/07	Depth to Groundwater (m) May 28/07	Groundwater Elevation (m) May 28/07	Depth to Groundwater (m) Jul 25, 26/07	Groundwater Elevation (m) Jul 25, 26/07
PZ-1	S	327.40	0.15	0.80	326.60	frozen		-0.09	327.49			-0.03	327.43
PZ-1	D	327.40	0.15	0.13	327.27	0.20	327.20	flowing	flowing			0.10	327.30
PZ-2	S	326.20	0.15	0.35	325.85	0.12	326.08	-0.04	326.24			0.56	325.64
PZ-2	D	326.20	0.15	0.96	325.24	0.14	326.06	0.09	326.11			0.47	325.73
PZ-4	S	322.30	0.15	0.52	321.78	frozen		0.00	322.30			0.20	322.10
PZ-4	D	322.30	0.15	-0.09	322.39	frozen		flowing	flowing			0.29	322.01
PZ-7	S	321.40	1.04	0.27	321.13	-0.01	321.41	n/a	n/a			n/a	n/a
PZ-7	D	321.40	1.04	0.09	321.31	0.00	321.40	n/a	n/a			n/a	n/a
PZ-8	S	318.50	0.20	-0.03	318.53	-0.02	318.52	-0.10	318.60			0.31	318.19
PZ-8	D	318.50	0.13	-0.03	318.53	-0.02	318.52	flowing	flowing			0.30	318.20
PZ-9	S	326.15	0.68	n/a	n/a	n/a	n/a	n/a	n/a	-0.28	326.43		
PZ-9	D	326.15	0.59	n/a	n/a	n/a	n/a	n/a	n/a	-0.25	326.40		

* Depth to Groundwater in metres below ground level

Hanlon Creek Business Park - Groundwater Monitoring Program 2008/2009
Piezometer Groundwater Elevation Data

Piezometer Well Number	Depth to Groundwater (m) Aug 2/07	Groundwater Elevation (m) Aug 2/07	Depth to Groundwater (m) Aug 17/07	Groundwater Elevation (m) Aug 17/07	Depth to Groundwater (m) Oct 1/07	Groundwater Elevation (m) Oct 1/07	Depth to Groundwater (m) Nov 2/07	Groundwater Elevation (m) Nov 2/07	Depth to Groundwater (m) Jan 25/08	Groundwater Elevation (m) Jan 25/08	Depth to Groundwater (m) Apr 25/08	Groundwater Elevation (m) Apr 25/08
PZ-1							0.34	327.06	0.26	327.14	-0.03	327.43
PZ-1							0.57	326.83	0.20	327.20	-0.14	327.54
PZ-2			0.63	325.57			0.36	325.84	0.23	325.97	-0.03	326.23
PZ-2			0.54	325.66			0.39	325.81	0.21	325.99	0.04	326.16
PZ-4							0.13	322.17	frozen		0.02	322.28
PZ-4							0.12	322.18	frozen		-0.06	322.36
PZ-7	0.01	321.39			-0.01	321.41	-0.06	321.46	-0.08	321.48	-0.08	321.48
PZ-7	0.01	321.39			-0.01	321.41	-0.07	321.47	-0.04	321.44	-0.09	321.49
PZ-8							0.38	318.12	-0.17	318.67	-0.08	318.58
PZ-8							0.36	318.14	frozen		-0.10	318.60
PZ-9			dry	dry			dry	dry	frozen		-0.38	326.53
PZ-9			0.400	325.75			0.660	325.49	frozen		-0.415	326.56

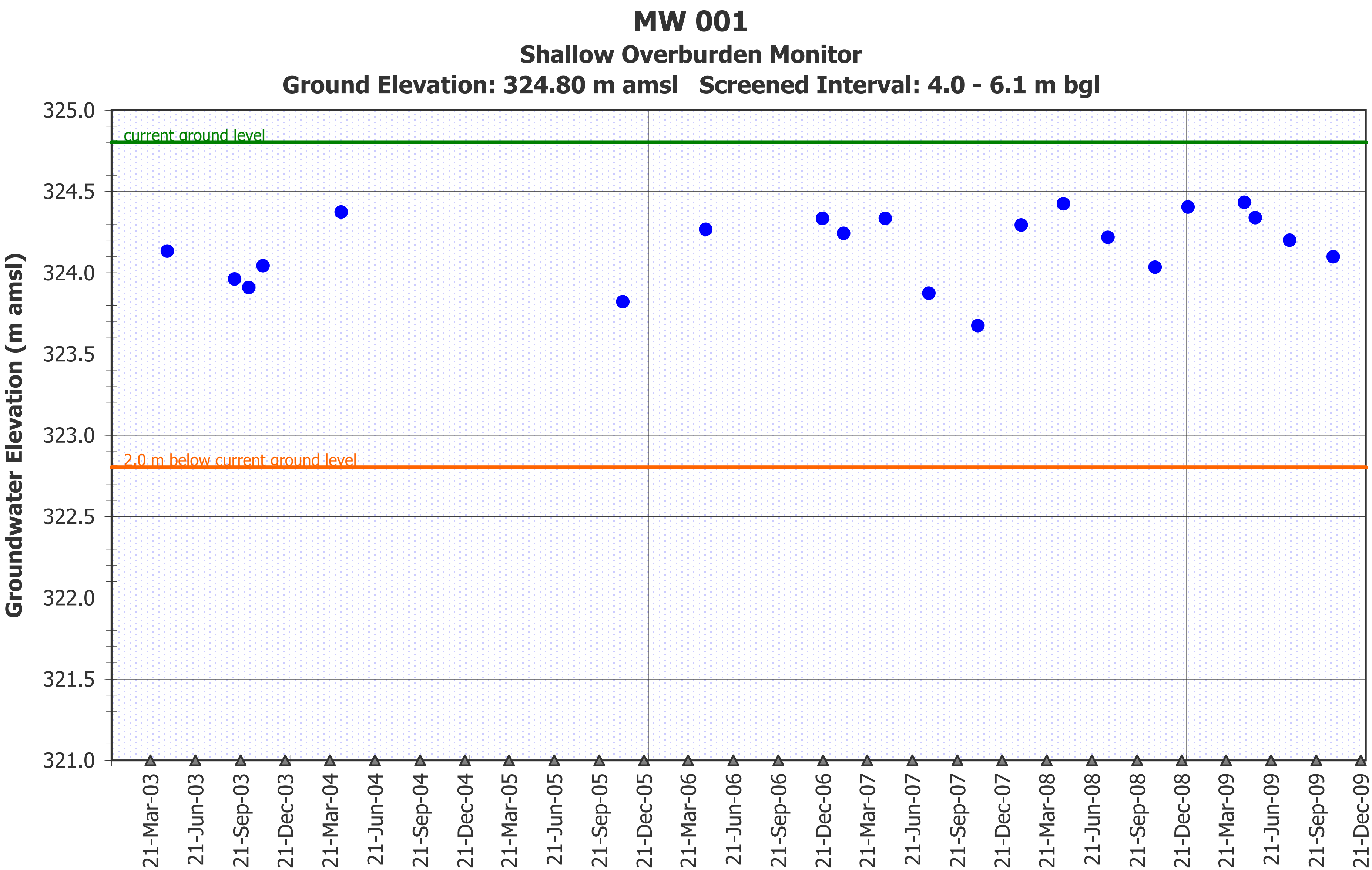
Hanlon Creek Business Park - Groundwater Monitoring Program 2008/2009
Piezometer Groundwater Elevation Data

Piezometer Well Number	Depth to Groundwater (m) Jul 23/08	Groundwater Elevation (m) Jul 23/08	Depth to Groundwater (m) Oct 28/08	Groundwater Elevation (m) Oct 28/08	Depth to Groundwater (m) Jan 2, 3/09	Groundwater Elevation (m) Jan 2, 3/09	Depth to Groundwater (m) Apr 13/09	Groundwater Elevation (m) Apr 13/09	Depth to Groundwater (m) May 20/09	Groundwater Elevation (m) May 20/09	Depth to Groundwater (m) Jul 29/09	Groundwater Elevation (m) Jul 29/09
PZ-1	-0.10	327.50	0.00	327.40	frozen		-0.05	327.45			-0.01	327.41
PZ-1	-0.07	327.47	0.10	327.30	frozen		-0.13	327.53			-0.08	327.48
PZ-2	-0.02	326.22	0.19	326.01	frozen				-0.03	326.23	0.00	326.20
PZ-2	0.10	326.10	0.21	325.99	0.05	326.15			0.04	326.16	0.06	326.14
PZ-4	0.02	322.28	0.05	322.25	frozen		-0.02	322.32				
PZ-4	-0.05	322.35	-0.02	322.32	frozen		-0.14	322.44				
PZ-7	-0.07	321.47	-0.13	321.53	frozen				-0.08	321.48		
PZ-7	-0.08	321.48	-0.13	321.53	-0.13	321.53			-0.09	321.49		
PZ-8	0.05	318.45	0.01	318.49	frozen				-0.05	318.55		
PZ-8	0.05	318.45	0.16	318.34	frozen				-0.07	318.57		
PZ-9	-0.13	326.28	0.19	325.96	frozen		-0.42	326.57			-0.24	326.39
PZ-9	-0.08	326.23	0.23	325.92	frozen		-0.47	326.61			-0.16	326.31

Hanlon Creek Business Park - Groundwater Monitoring Progr
Piezometer Groundwater Elevation Data

Piezometer Well Number	Depth to Groundwater (m) Aug 27/09	Groundwater Elevation (m) Aug 27/09	Depth to Groundwater (m) Oct 26, 27/09	Groundwater Elevation (m) Oct 26, 27/09
PZ-1			0.05	327.35
PZ-1			0.08	327.32
PZ-2			0.14	326.06
PZ-2			0.14	326.062
PZ-4	0.04	322.26	0.03	322.27
PZ-4	0.01	322.29	-0.06	322.36
PZ-7	-0.06	321.46	-0.11	321.51
PZ-7	-0.07	321.47	-0.11	321.51
PZ-8	0.10	318.40	0.04	318.46
PZ-8	0.09	318.41	0.03	318.47
PZ-9			0.05	326.10
PZ-9			0.125	326.02

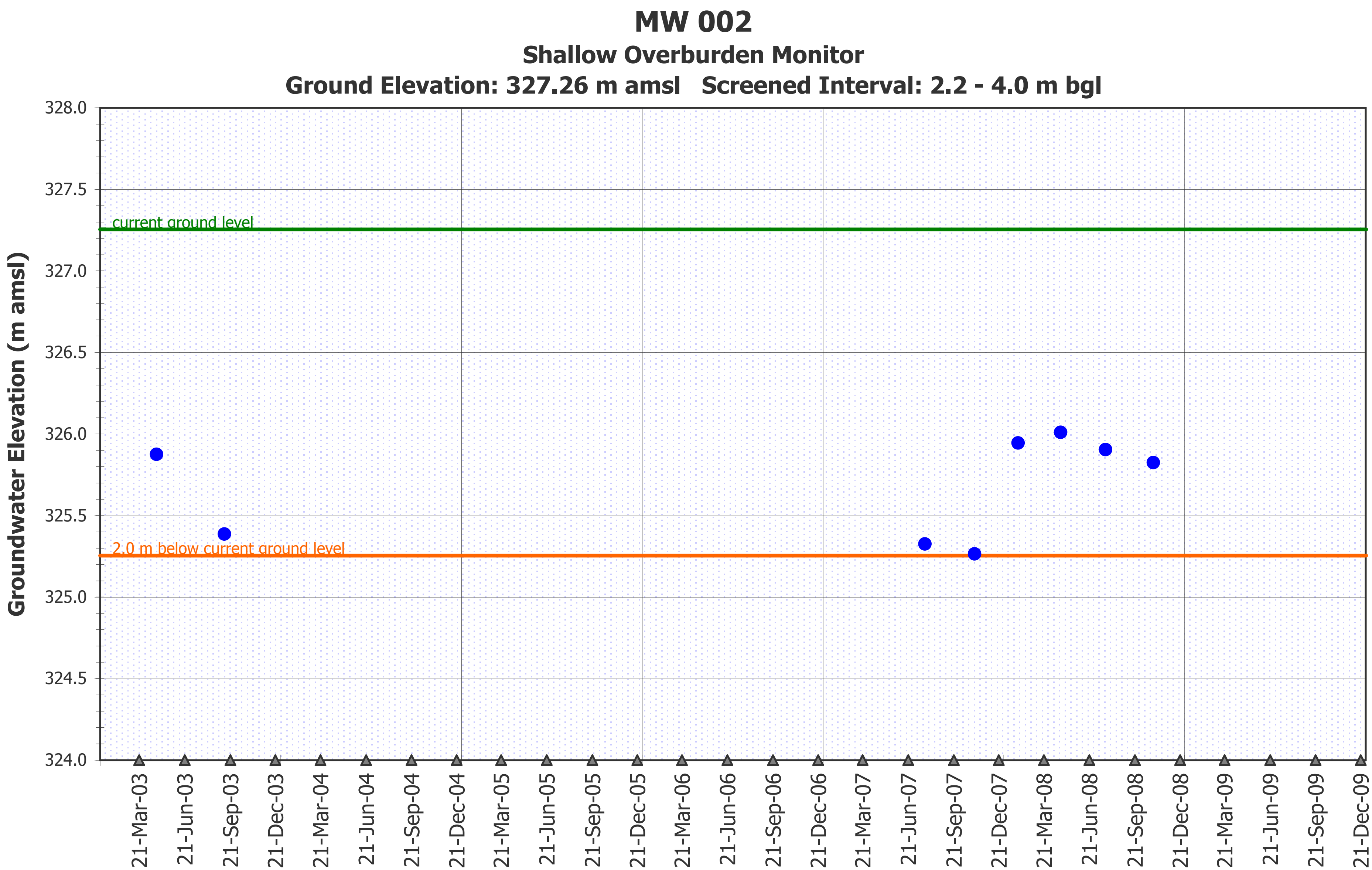
Appendix C: Groundwater Monitoring Graphs 2003 – 2009



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

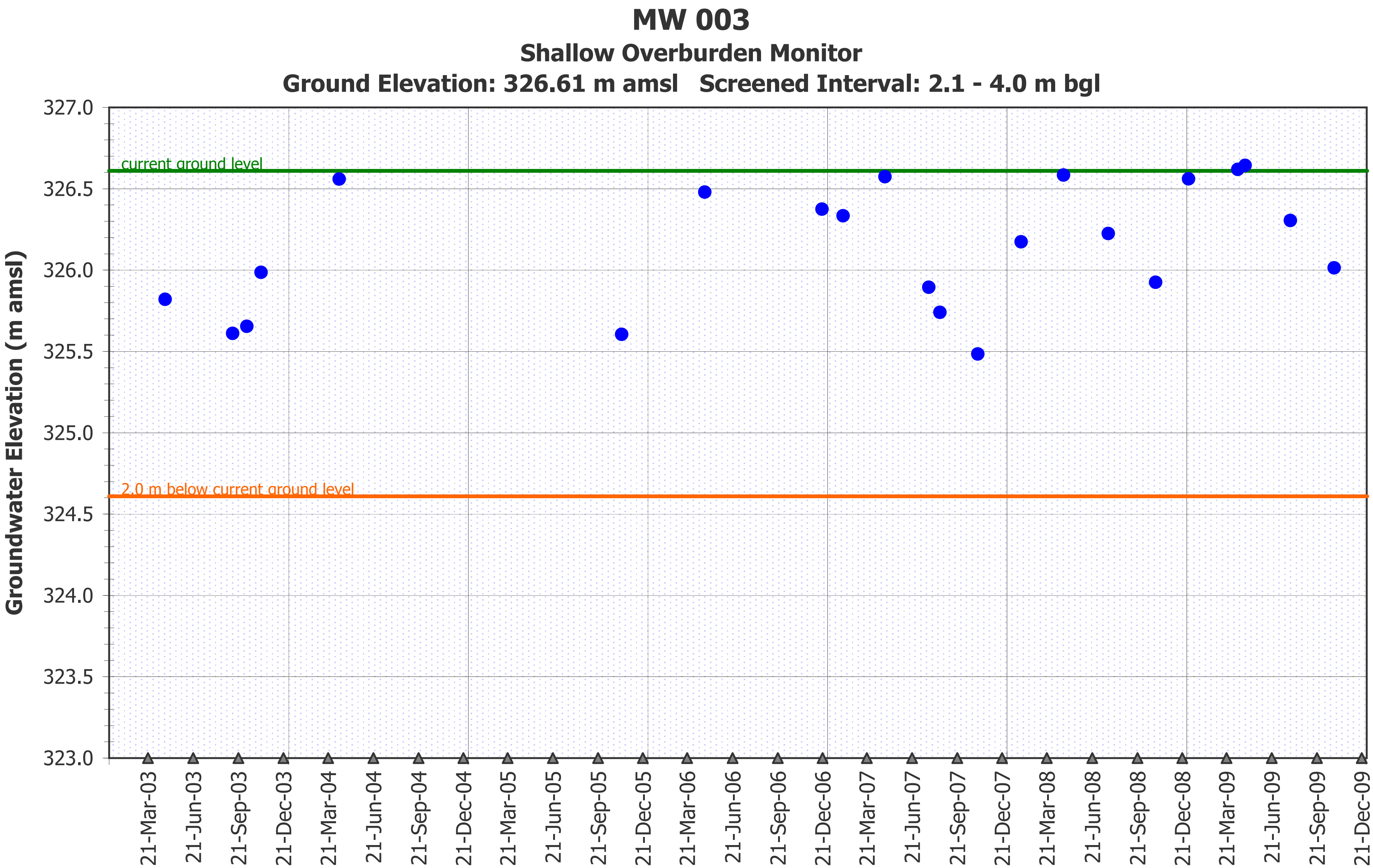
December 2009 **Graph C 1**



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph C 2**



Banks Groundwater Engineering Limited

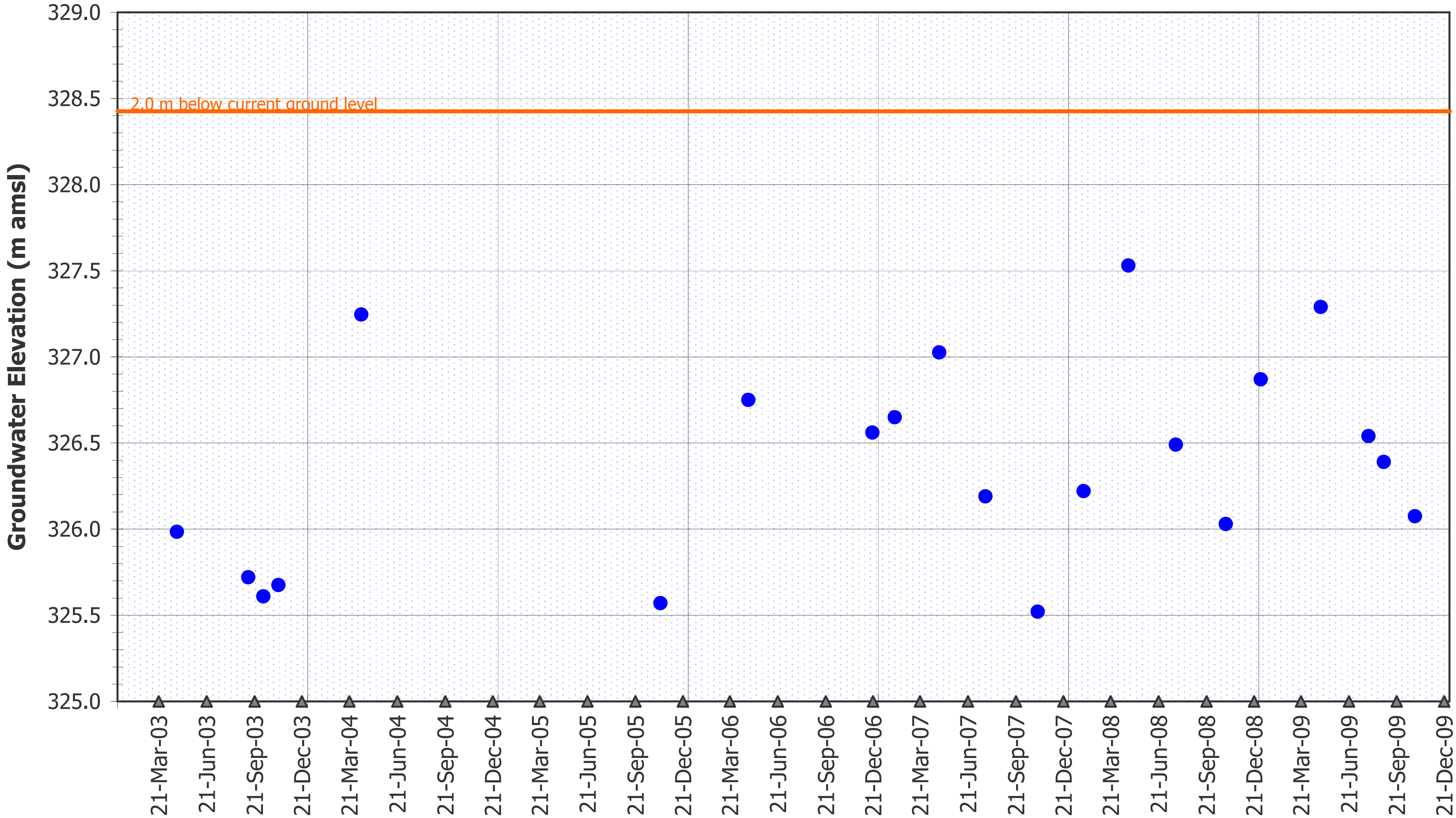
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph C 3**

MW 004

Shallow Overburden Monitor

Ground Elevation: 330.43 m amsl   Screened Interval: 5.1 - 7.0 m bgl



Banks Groundwater Engineering Limited

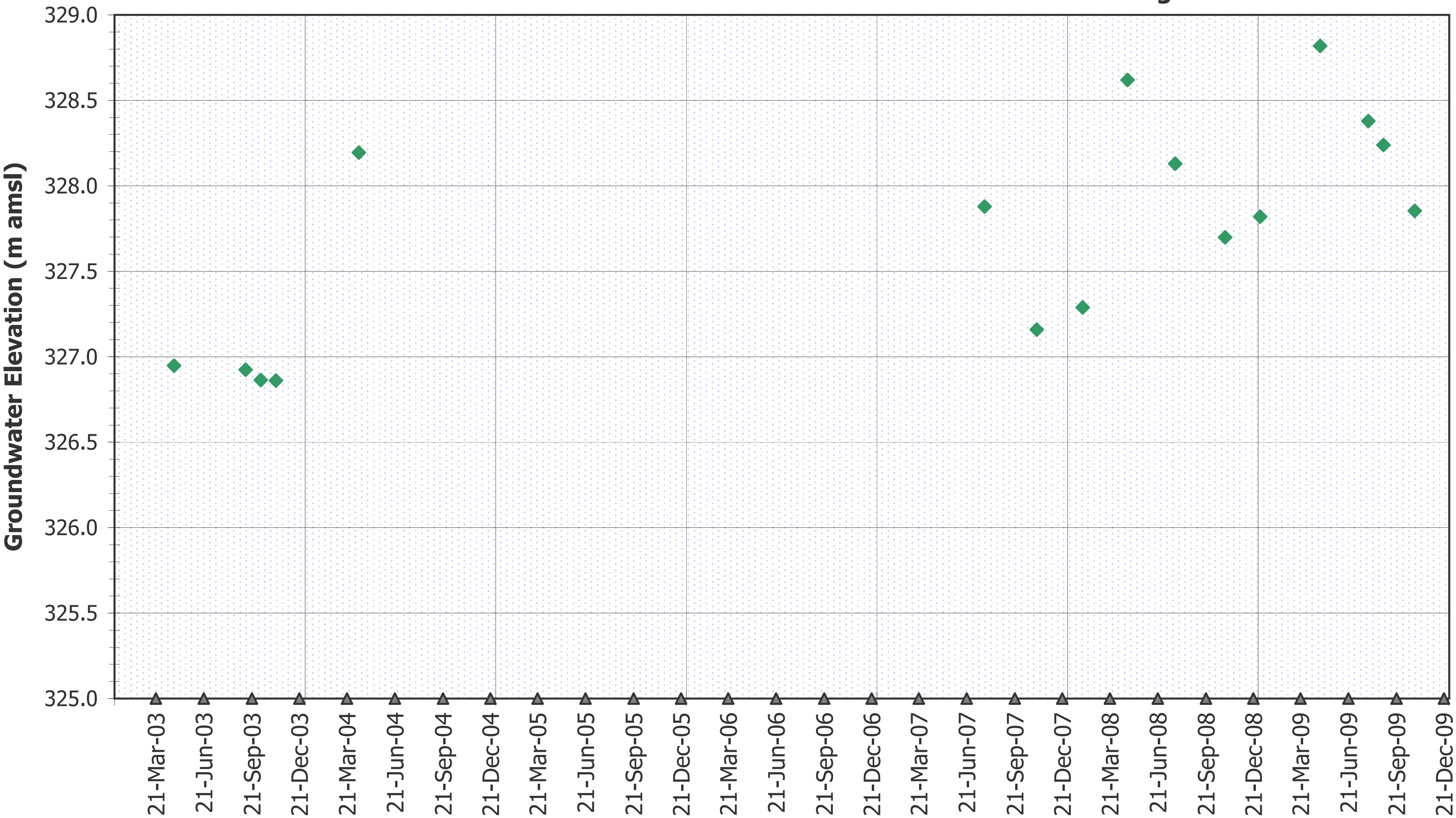
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph C 4**

MW 005I

Intermediate Overburden Monitor

Ground Elevation: 336.53 m amsl   Screened Interval: 10.8 - 12.0 m bgl



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

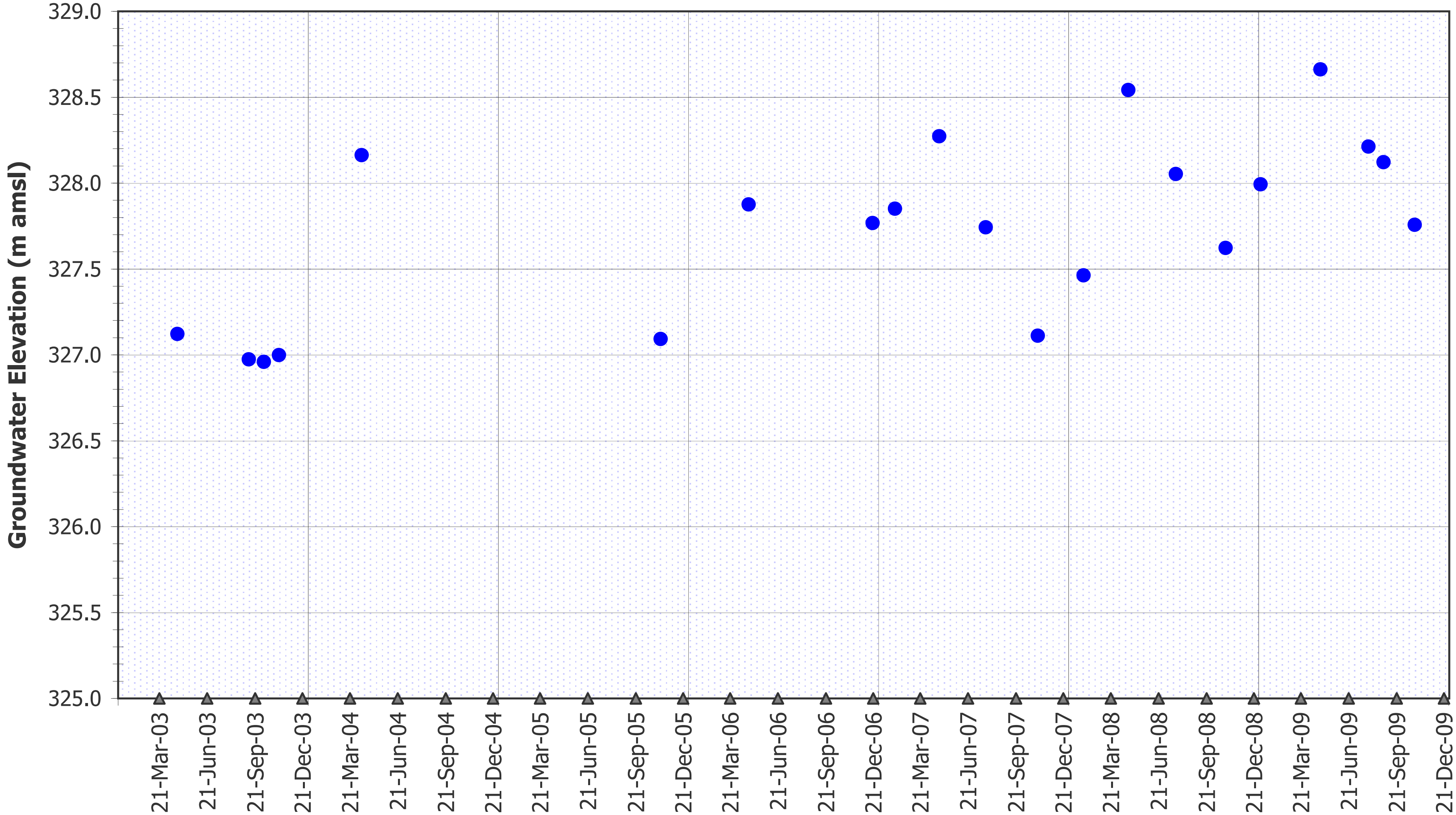
December 2009

Graph C 5

MW 006

Shallow Overburden Monitor

Ground Elevation: 334.70 m amsl   Screened Interval: 7.5 - 9.0 m bgl



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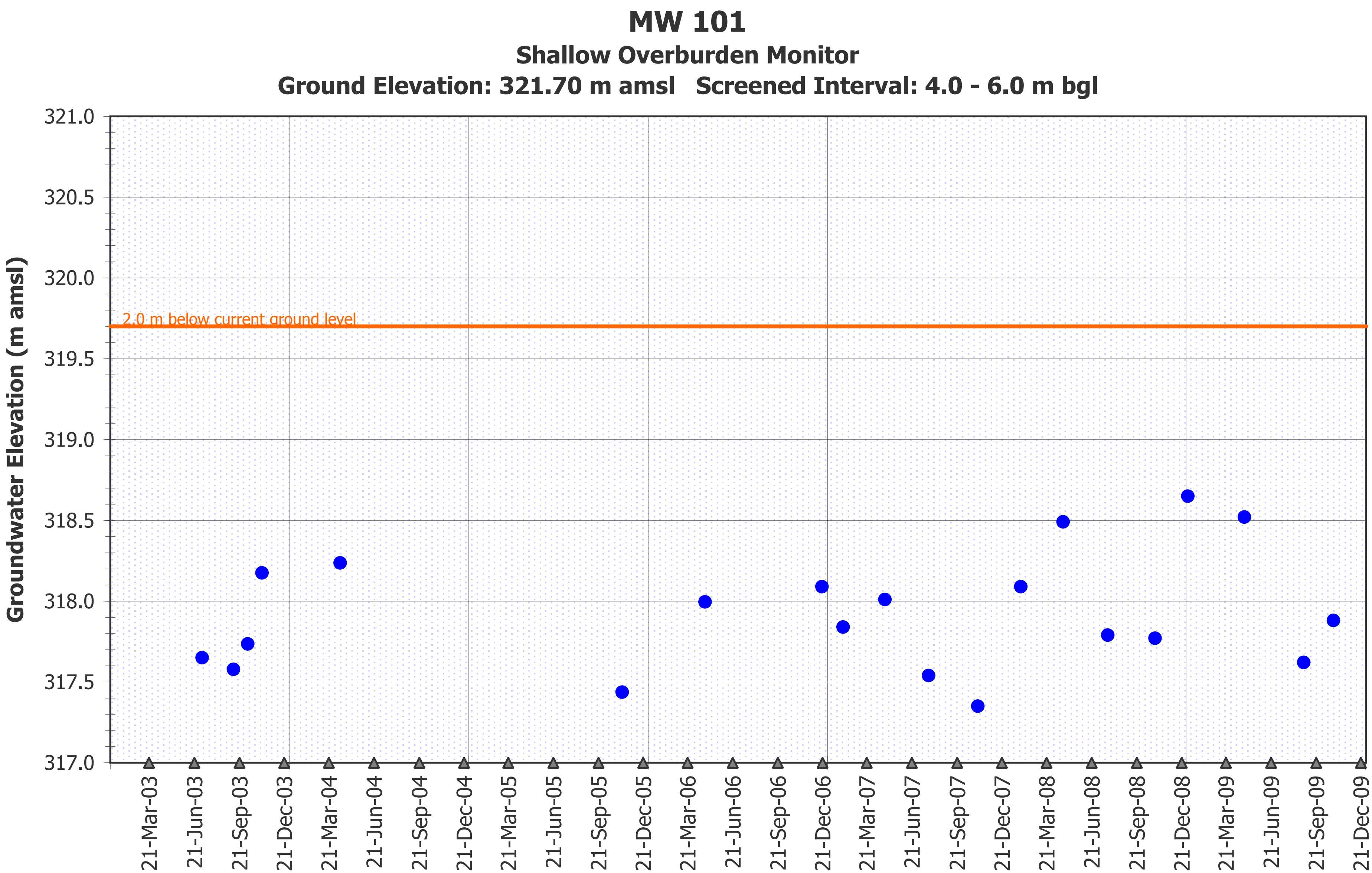
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009

Graph C 6


MW 101
Shallow Overburden Monitor
Ground Elevation: 321.70 m amsl   Screened Interval: 4.0 - 6.0 m bgl
Groundwater Elevation (m amsl)
2.0 m below current ground level
321.0
320.5
320.0
319.5
319.0
318.5
318.0
317.5
317.0
21-Mar-03
21-Jun-03
21-Sep-03
21-Dec-03
21-Mar-04
21-Jun-04
21-Sep-04
21-Dec-04
21-Mar-05
21-Jun-05
21-Sep-05
21-Dec-05
21-Mar-06
21-Jun-06
21-Sep-06
21-Dec-06
21-Mar-07
21-Jun-07
21-Sep-07
21-Dec-07
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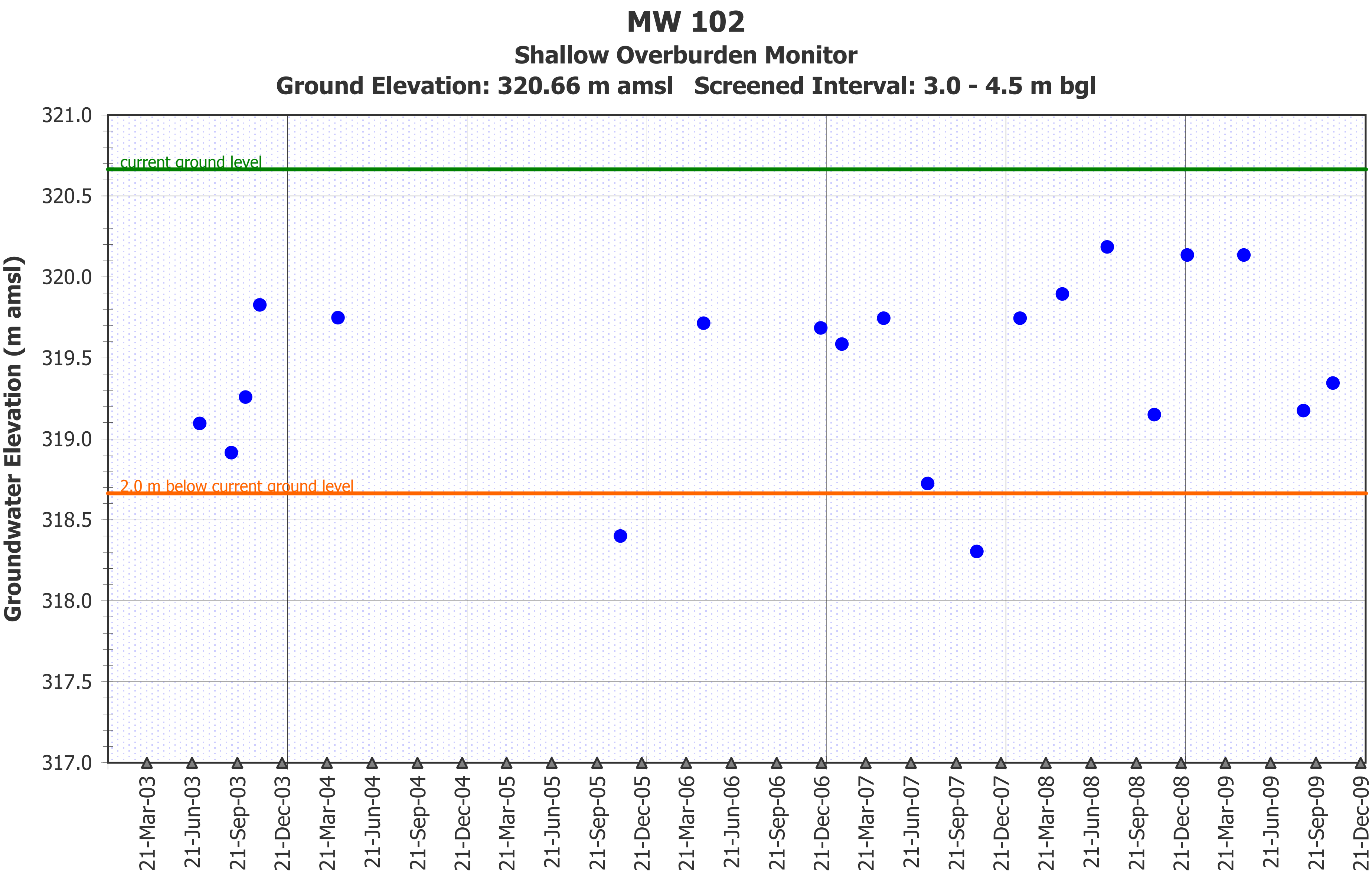
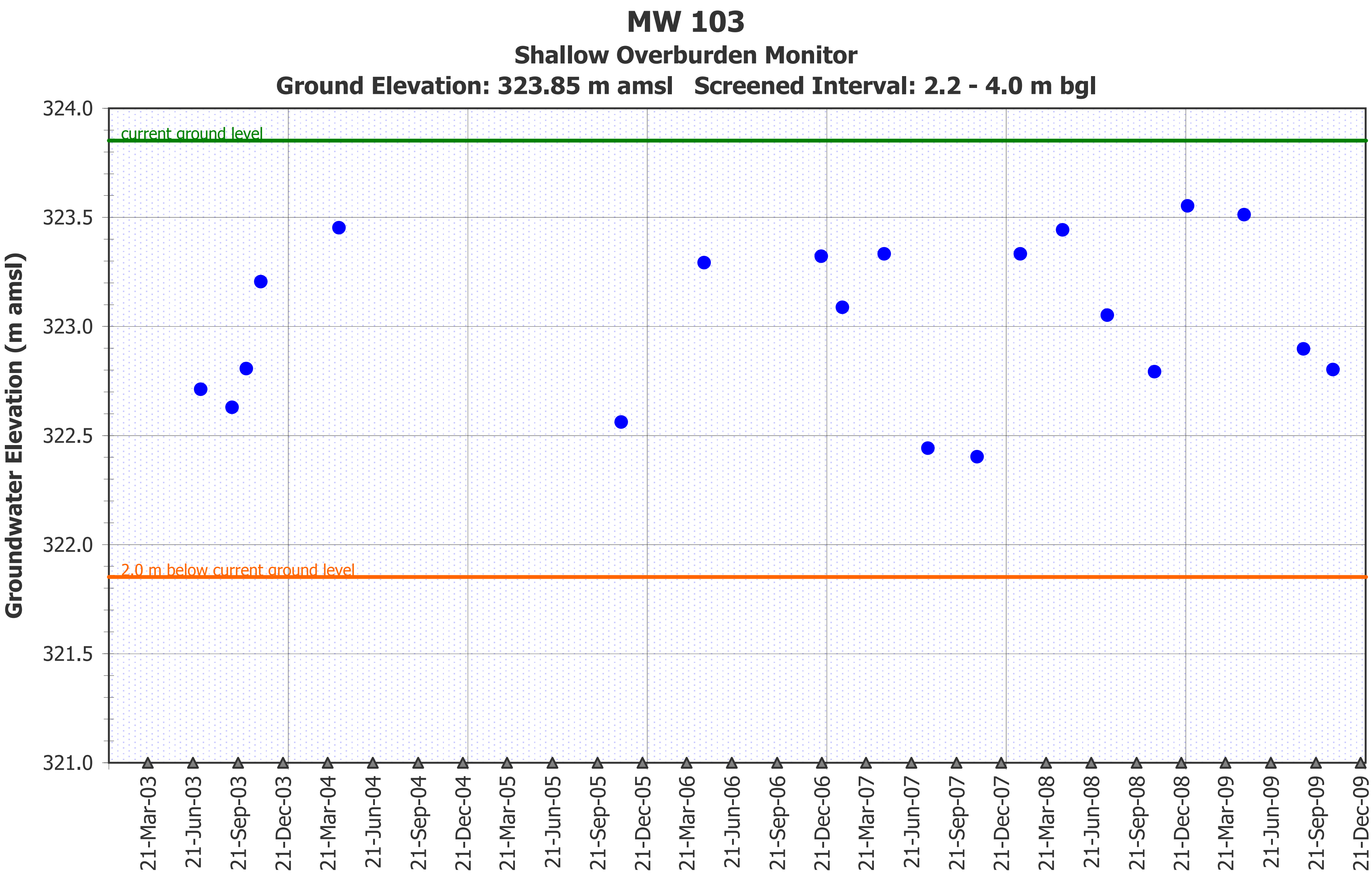
21-Mar-09
21-Jun-09
21-Sep-09
21-Dec-09



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

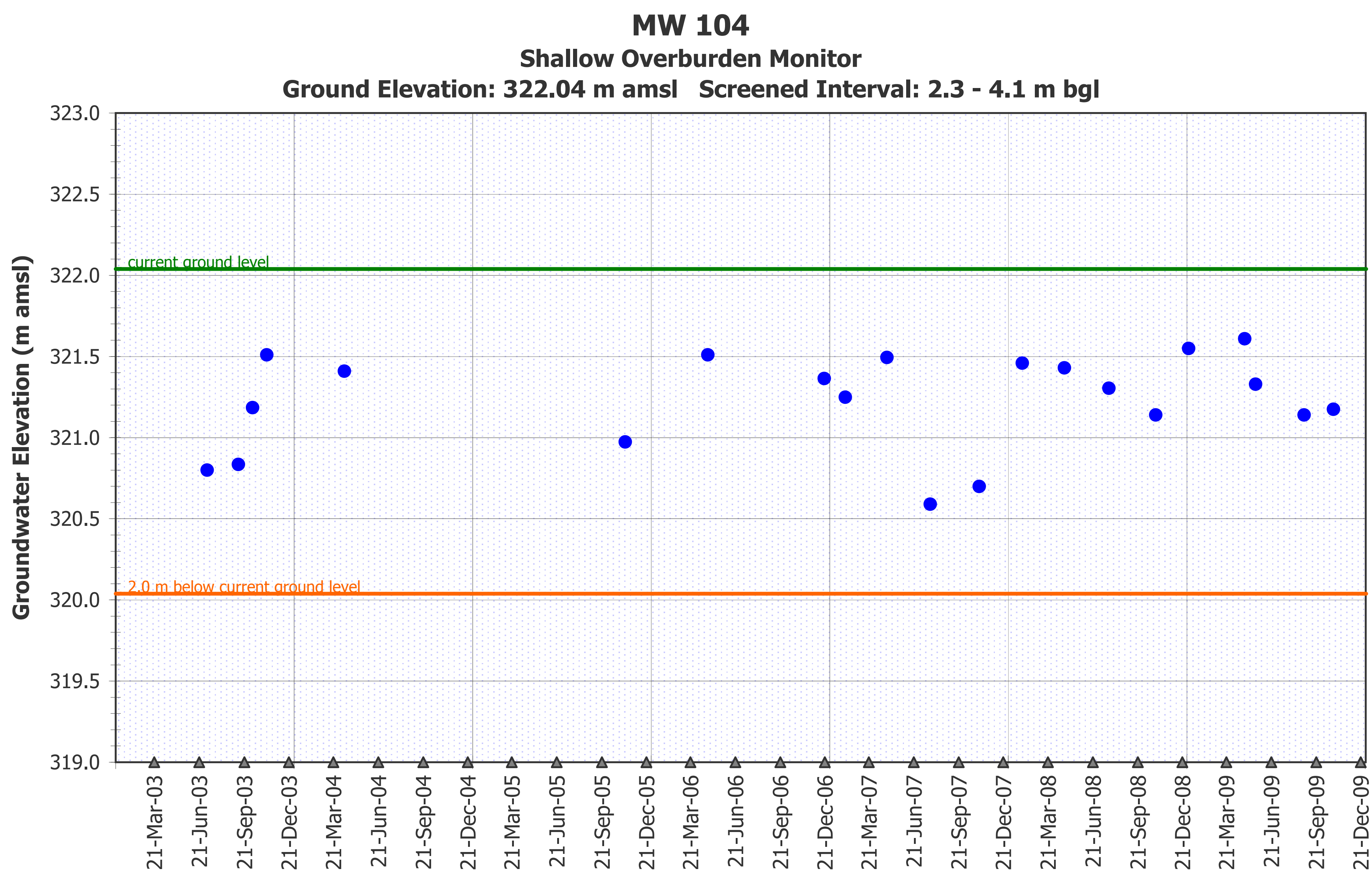
December 2009 **Graph C 8**



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

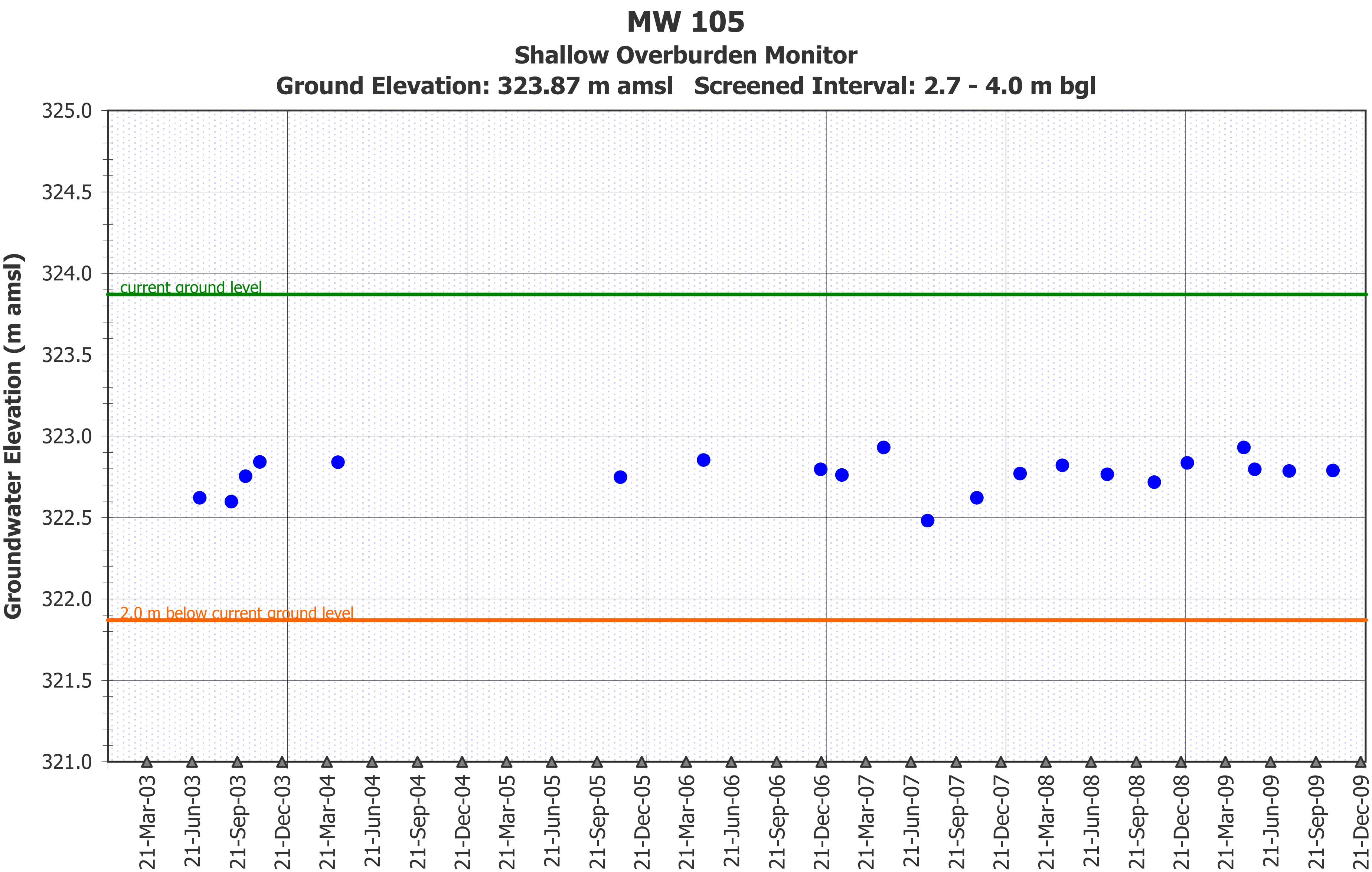
December 2009 **Graph C 9**



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph C 10**


MW 105
Shallow Overburden Monitor
Ground Elevation: 323.87 m amsl   Screened Interval: 2.7 - 4.0 m bgl
Groundwater Elevation (m amsl)
325.0
324.5
324.0
323.5
323.0
322.5
322.0
321.5
321.0
current ground level
2.0 m below current ground level
21-Mar-03
21-Jun-03
21-Sep-03
21-Dec-03
21-Mar-04
21-Jun-04
21-Sep-04
21-Dec-04
21-Mar-05
21-Jun-05
21-Sep-05
21-Dec-05
21-Mar-06
21-Jun-06
21-Sep-06
21-Dec-06
21-Mar-07
21-Jun-07
21-Sep-07
21-Dec-07
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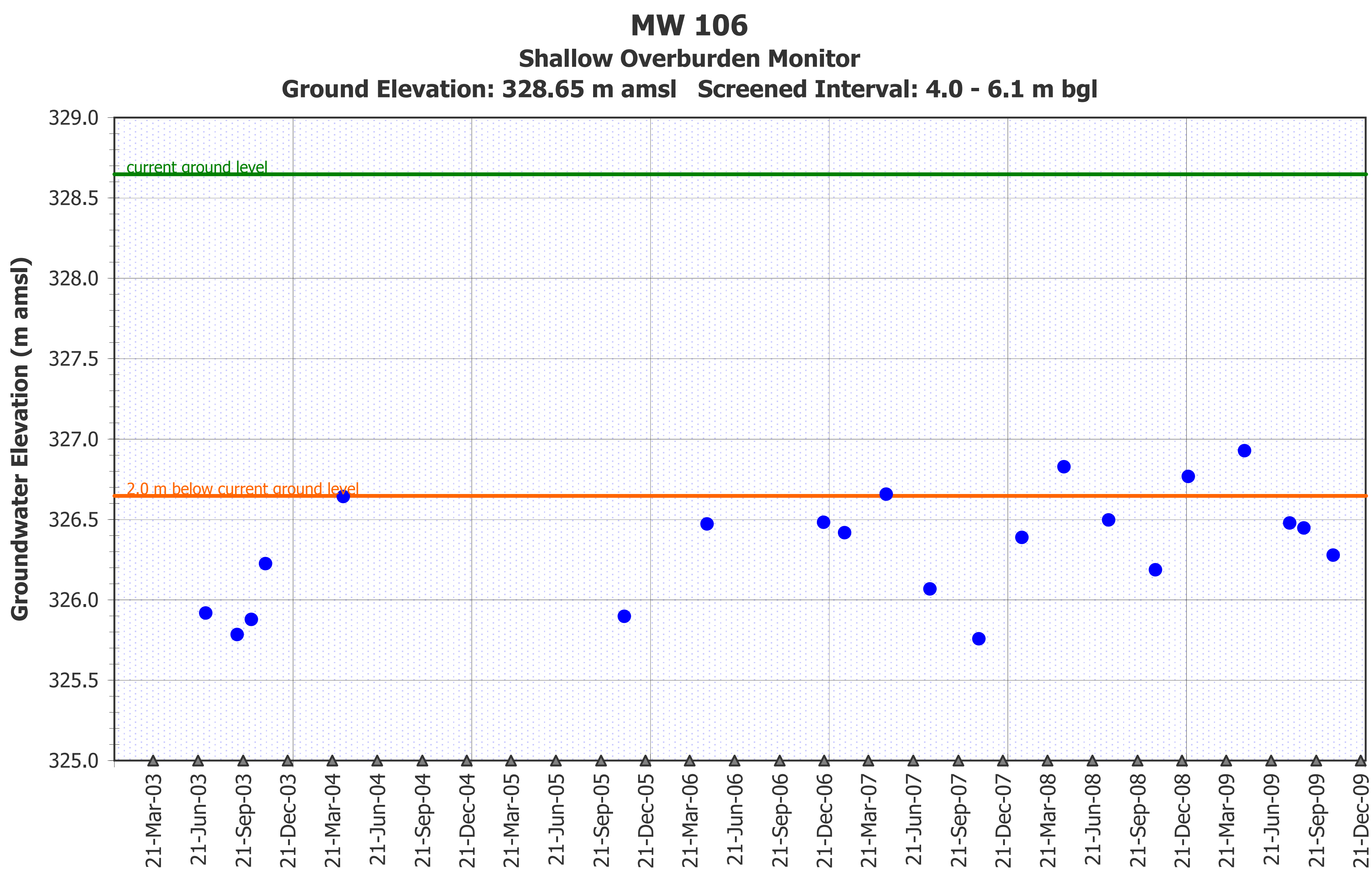
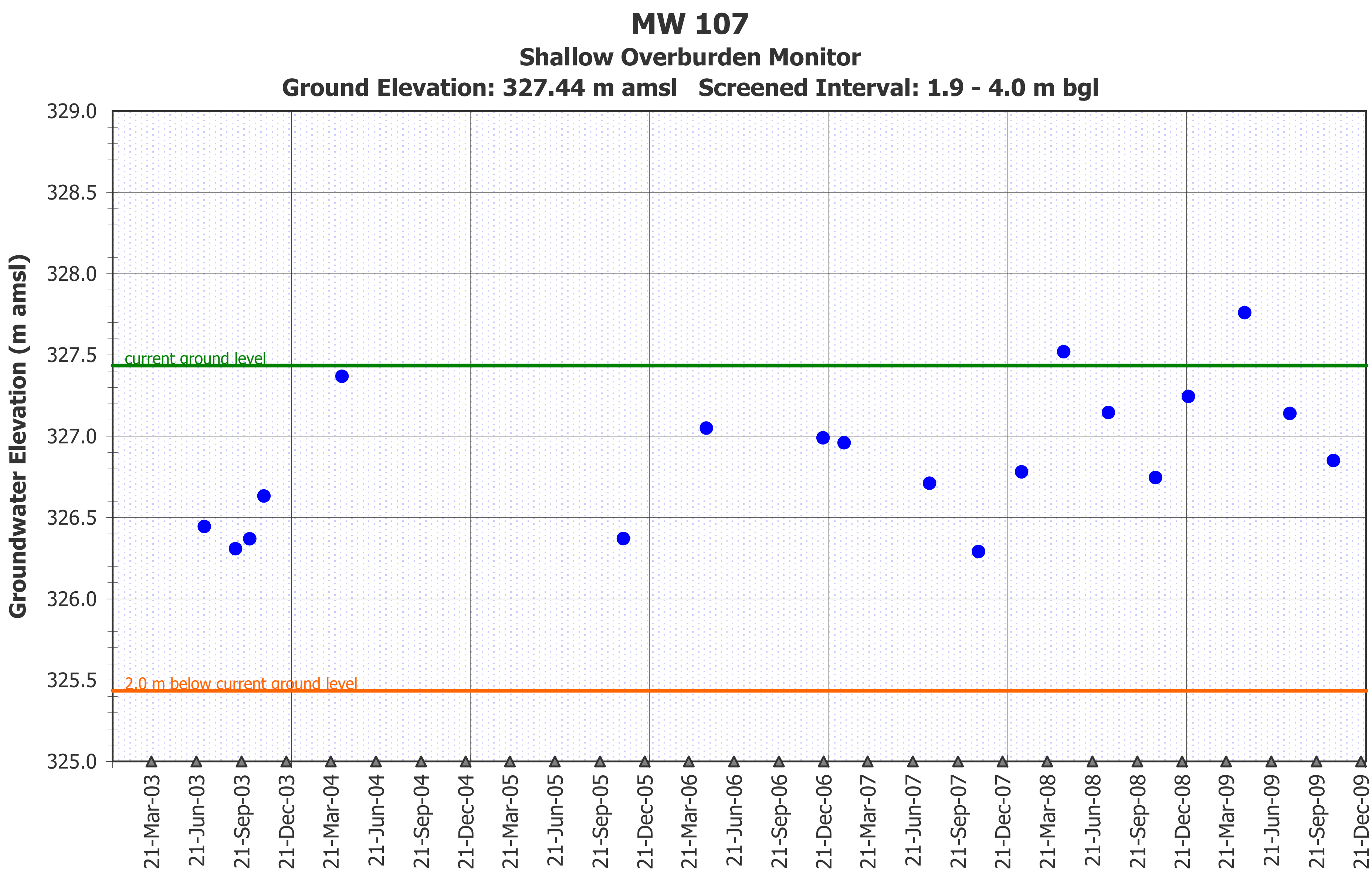
21-Sep-09
21-Dec-09



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

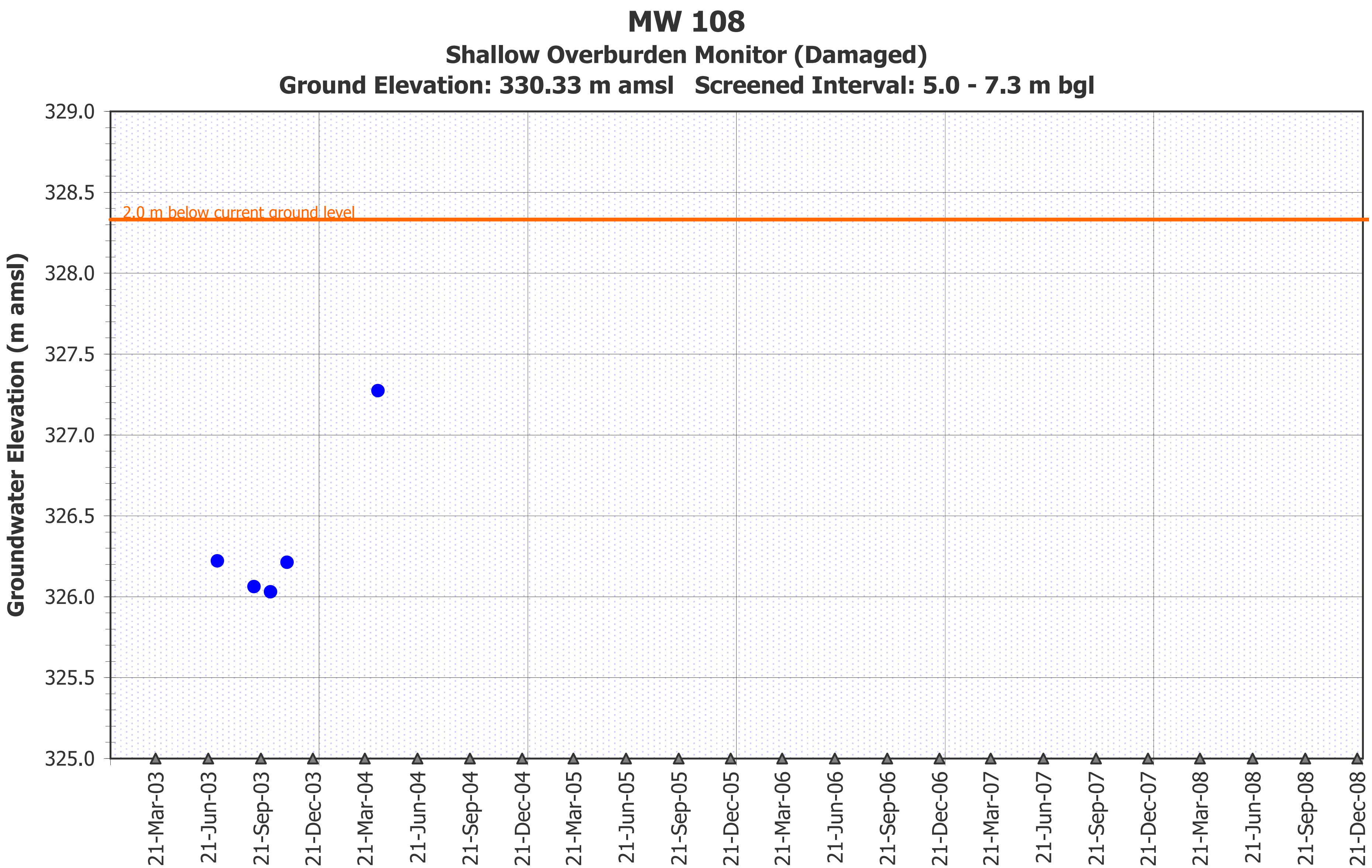
December 2009 **Graph C 12**



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph C 13**

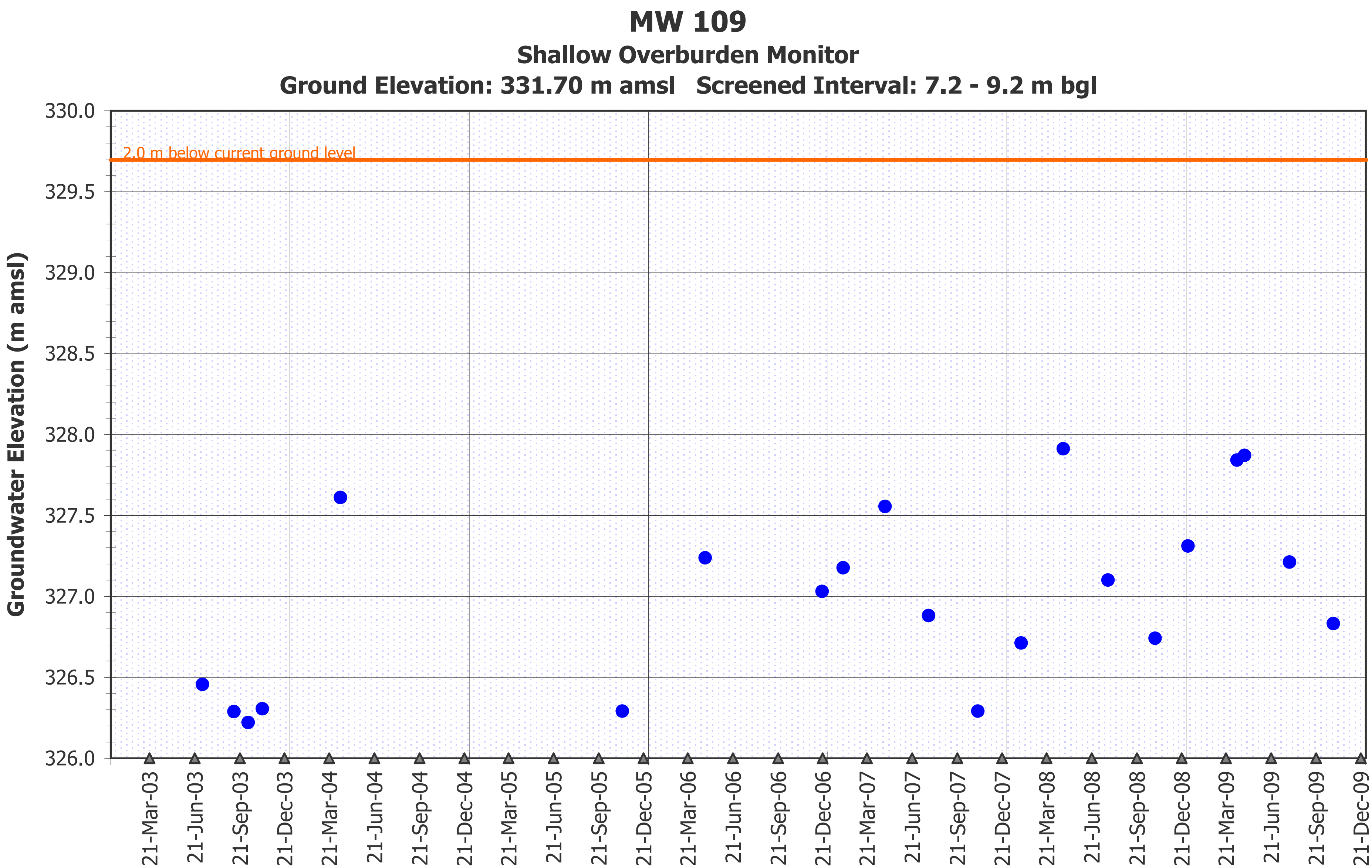


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009

Graph C 14



Banks Groundwater Engineering Limited

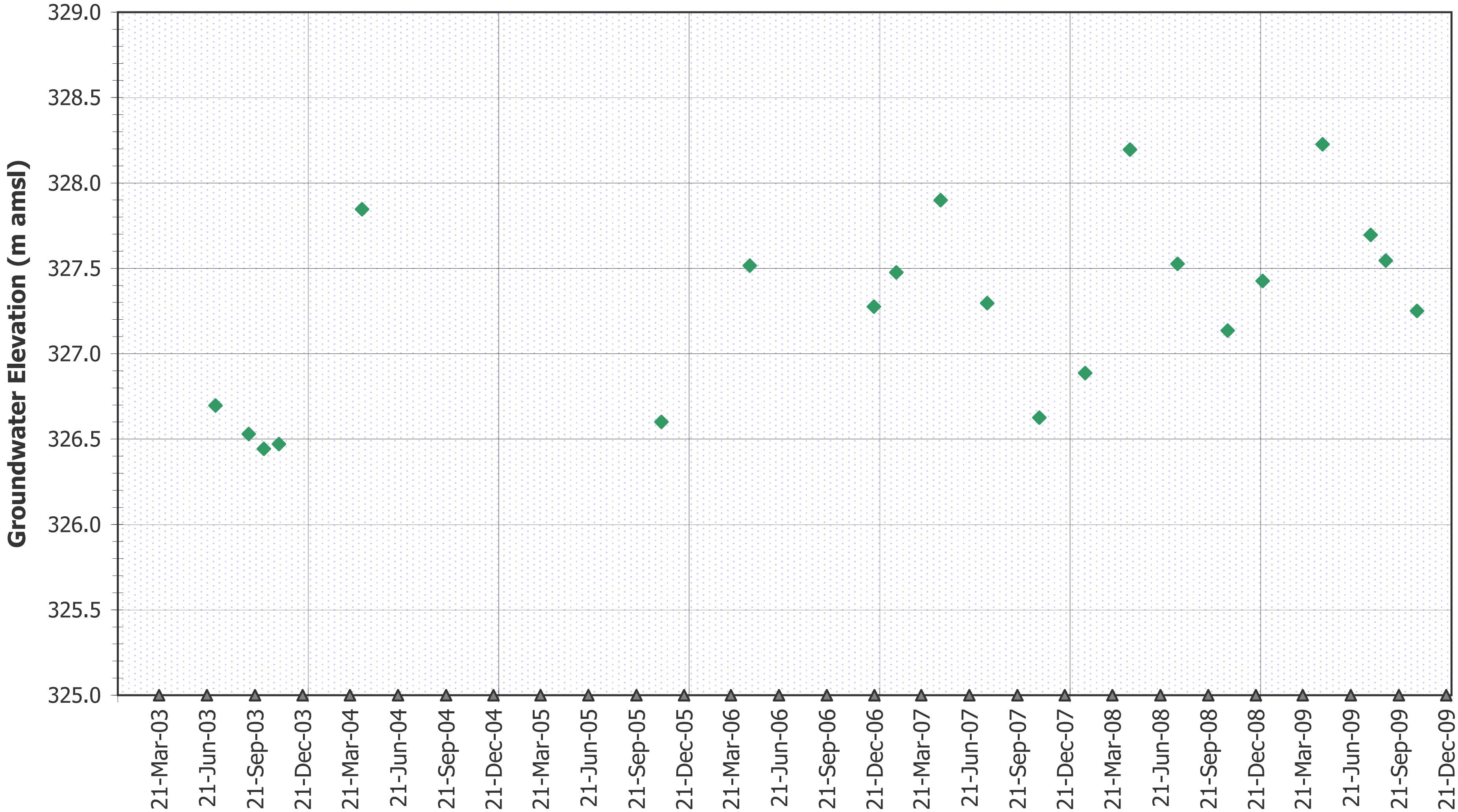
Hanlon Creek Business Park - Groundwater Monitoring Program

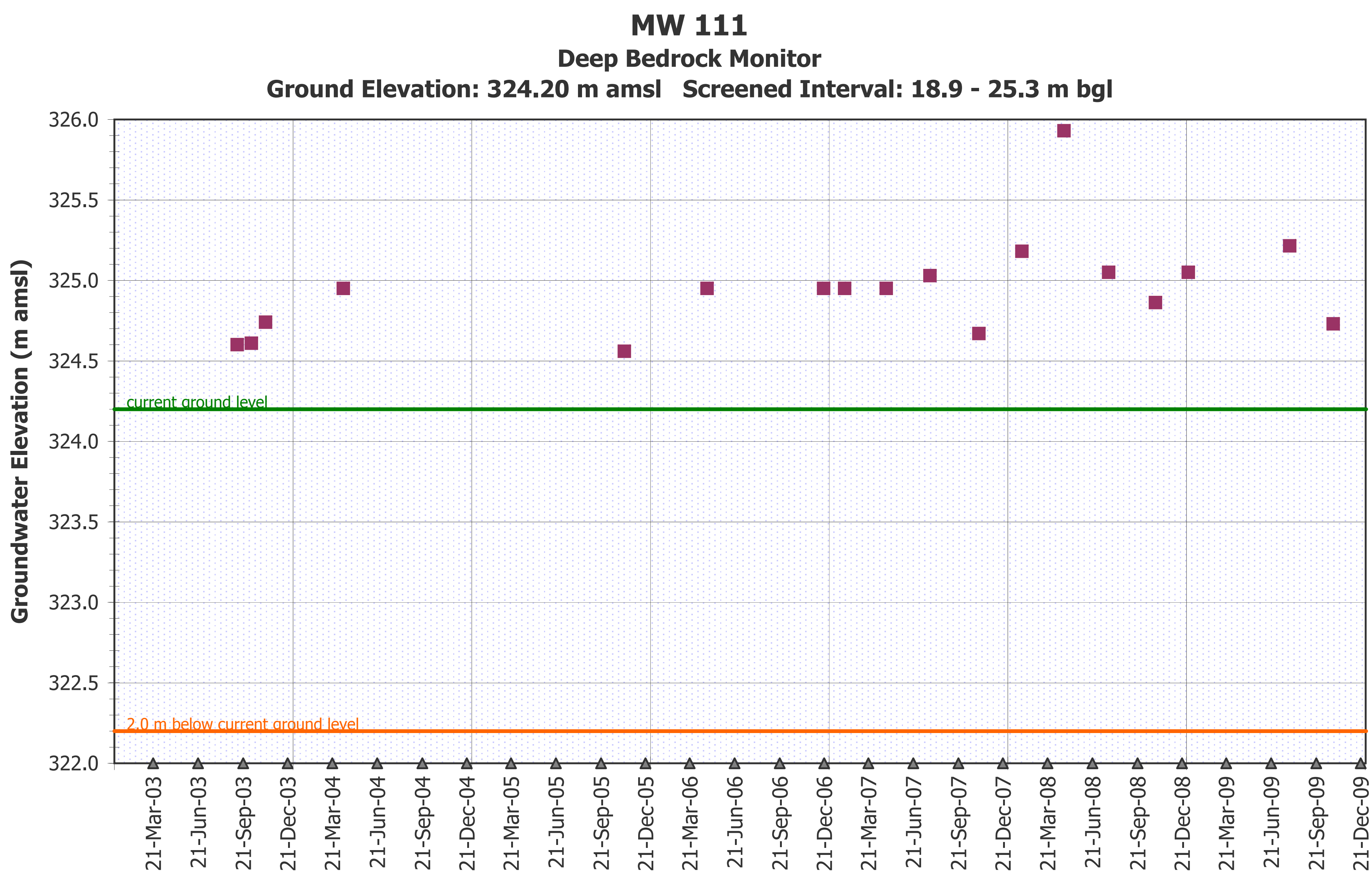
December 2009 **Graph C 15**

MW 110

Intermediate Overburden Monitor

Ground Elevation: 339.59 m amsl   Screened Interval: 14.8 - 16.8 m bgl

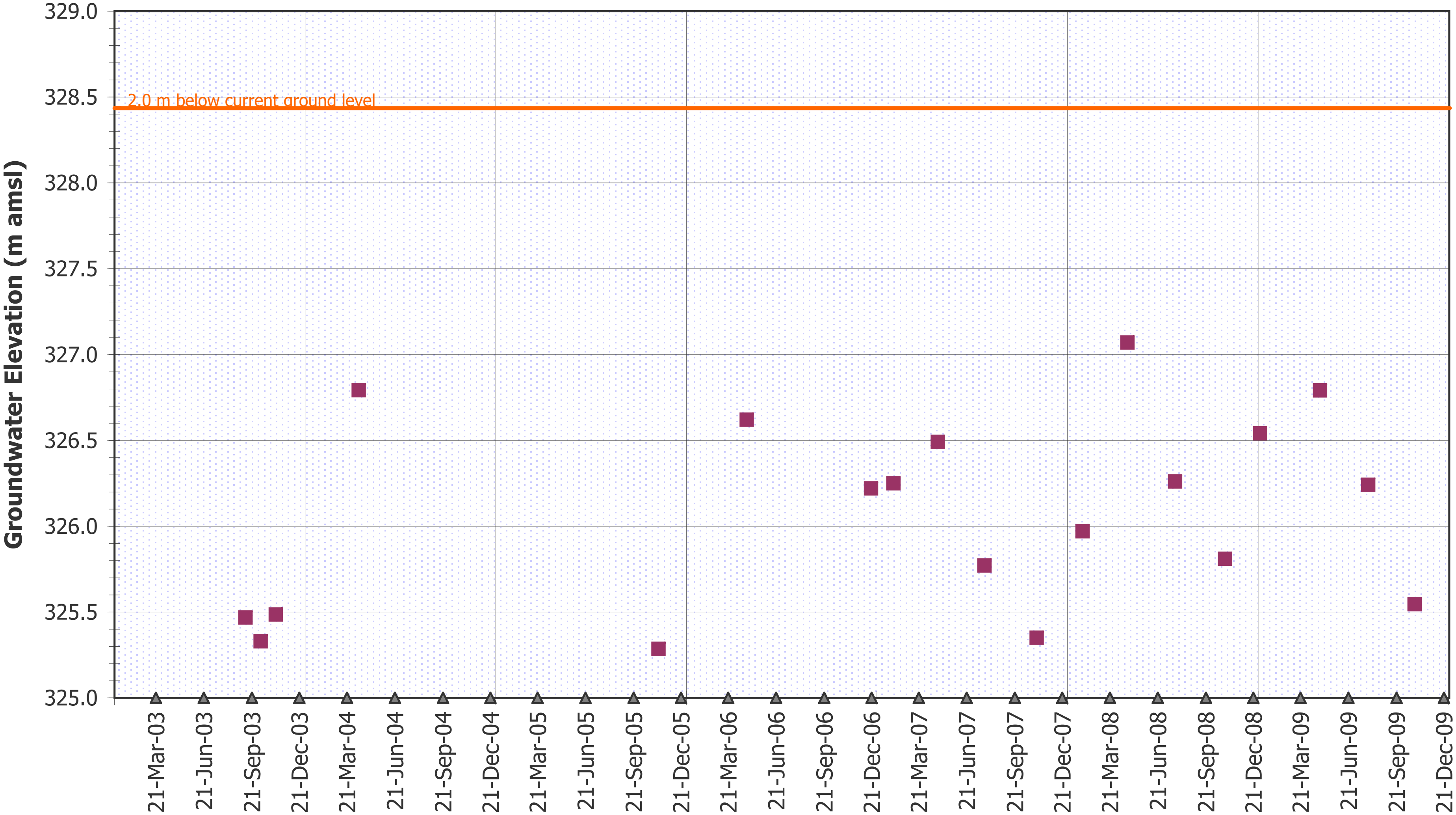



MW 111
Deep Bedrock Monitor
Ground Elevation: 324.20 m amsl Screened Interval: 18.9 - 25.3 m bgl
Groundwater Elevation (m amsl)
326.0
325.5
325.0
324.5
324.0
323.5
323.0
322.5
322.0
current ground level
2.0 m below current ground level
21-Mar-03
21-Jun-03
21-Sep-03
21-Dec-03
21-Mar-04
21-Jun-04
21-Sep-04
21-Dec-04
21-Mar-05
21-Jun-05
21-Sep-05
21-Dec-05
21-Mar-06
21-Jun-06
21-Sep-06
21-Dec-06
21-Mar-07
21-Jun-07
21-Sep-07
21-Dec-07
21-Mar-08
21-Jun-08
21-Sep-08
21-Dec-08
21-Mar-09
21-Jun-09
21-Sep-09
21-Dec-09

MW 112

Deep Bedrock Monitor

Ground Elevation: 330.44 m amsl   Screened Interval: 28.0 - 32.3 m bgl

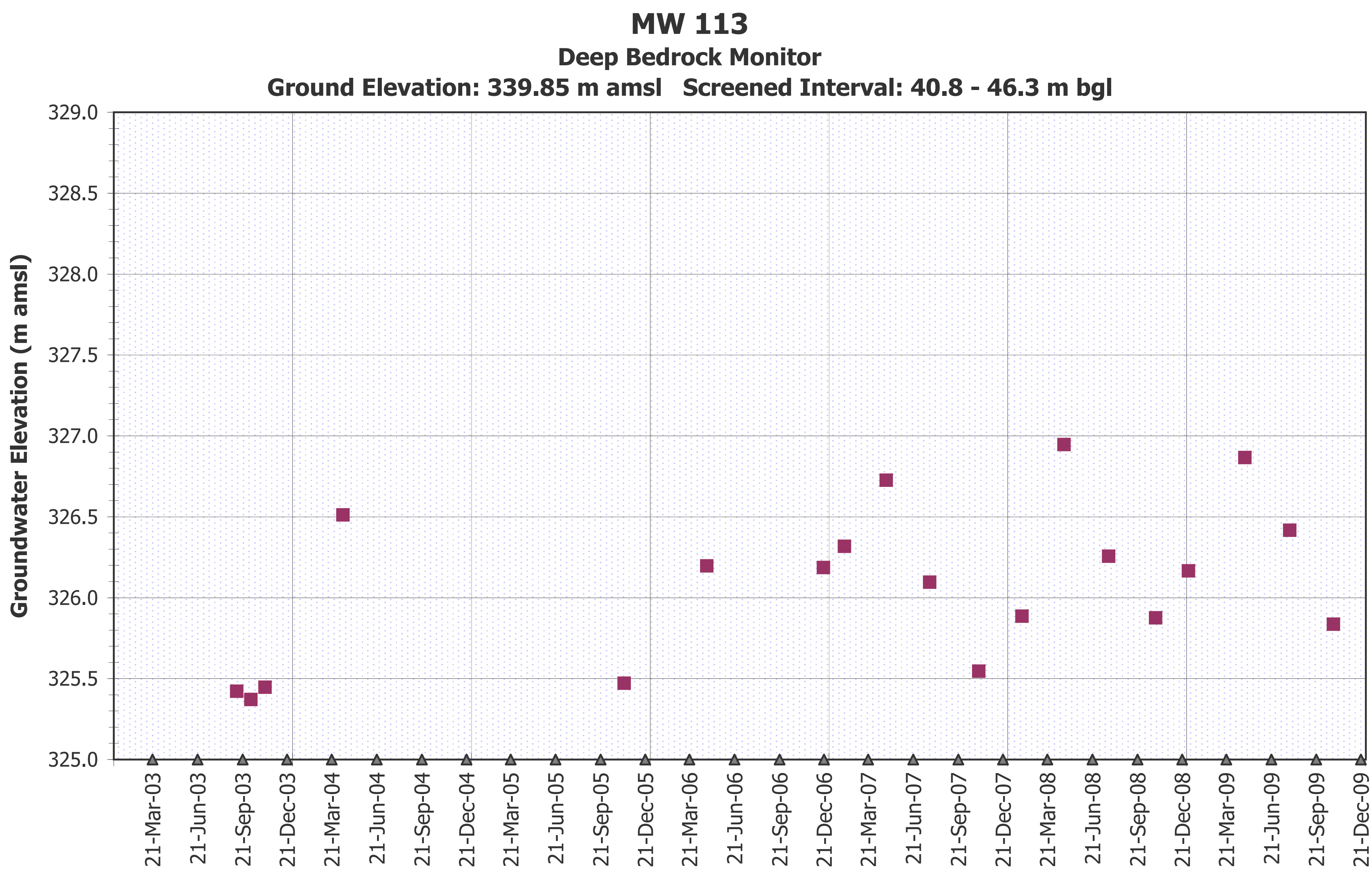


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009

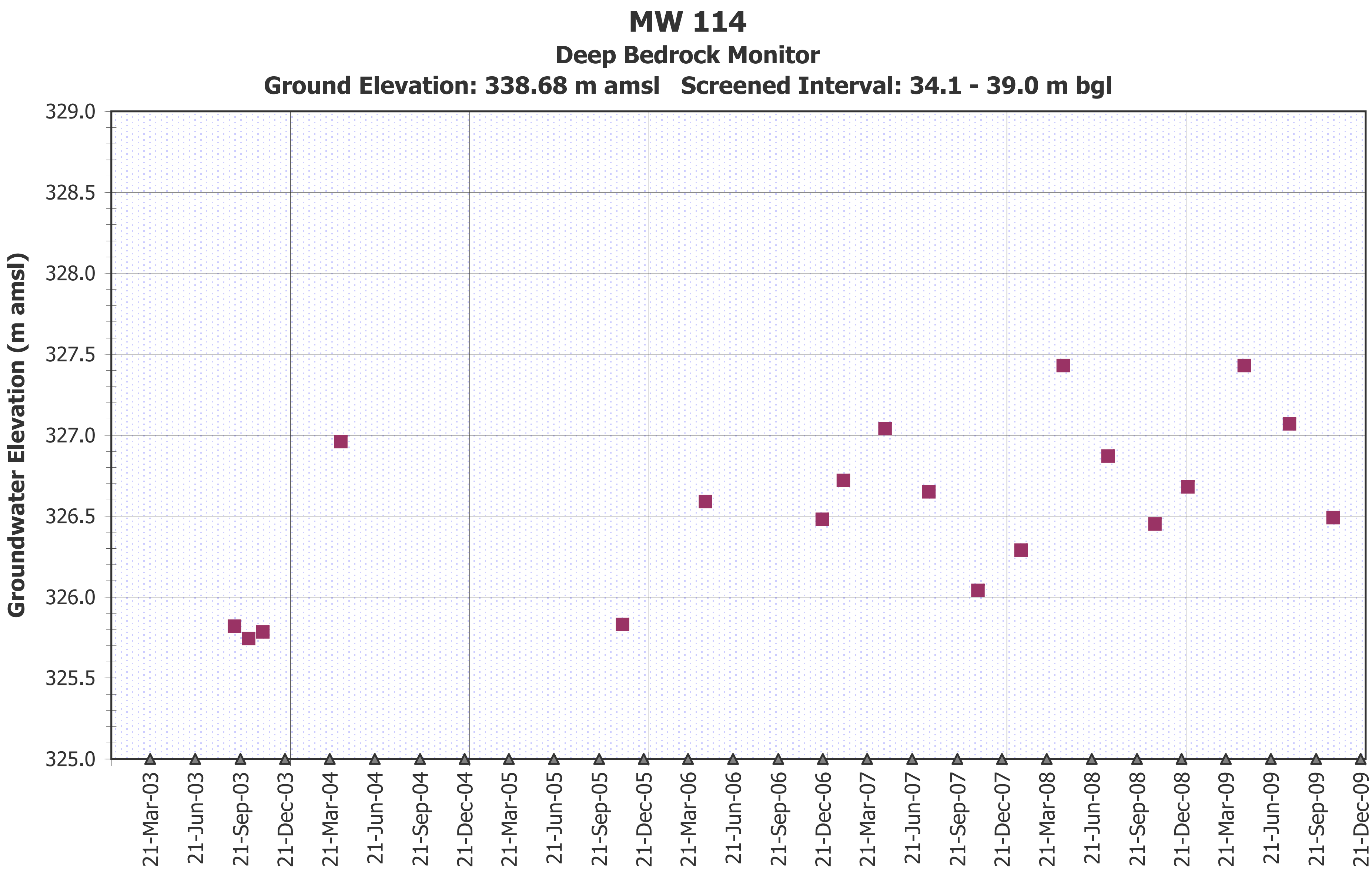
Graph C 18

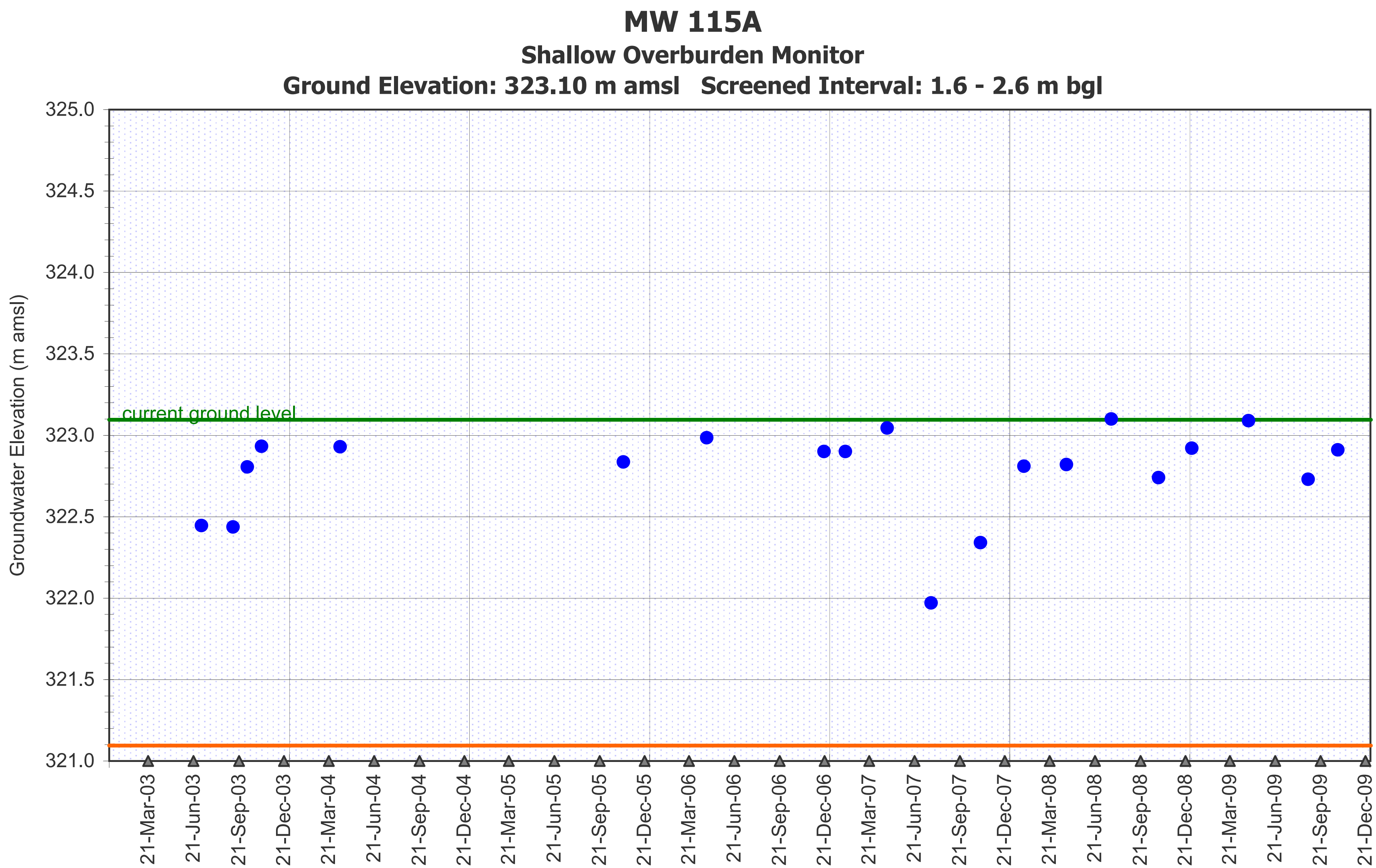


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph C 19**

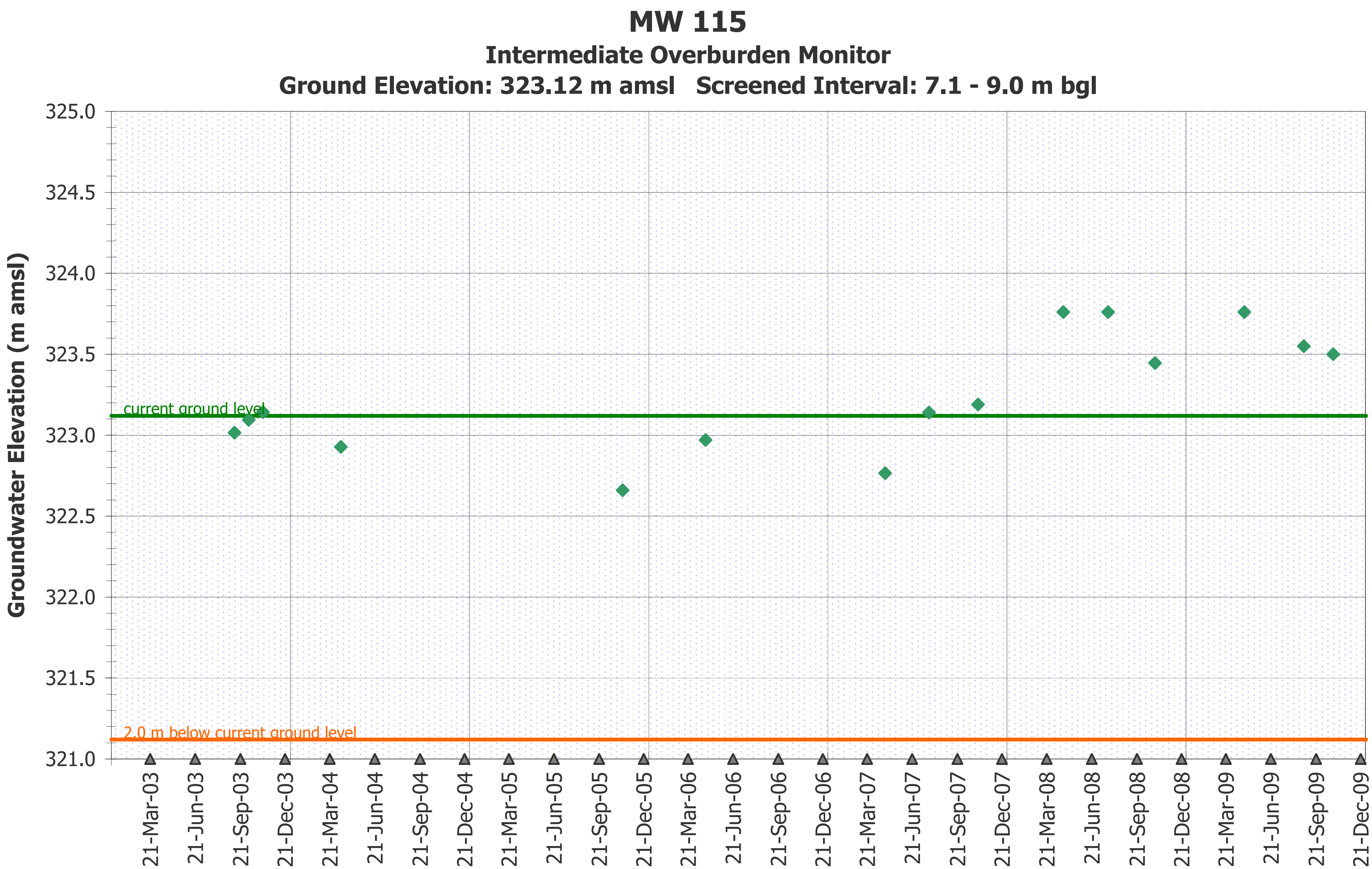

MW 114
Deep Bedrock Monitor
Ground Elevation: 338.68 m amsl   Screened Interval: 34.1 - 39.0 m bgl
Groundwater Elevation (m amsl)
329.0
328.5
328.0
327.5
327.0
326.5
326.0
325.5
325.0
21-Mar-03
21-Jun-03
21-Sep-03
21-Dec-03
21-Mar-04
21-Jun-04
21-Sep-04
21-Dec-04
21-Mar-05
21-Jun-05
21-Sep-05
21-Dec-05
21-Mar-06
21-Jun-06
21-Sep-06
21-Dec-06
21-Mar-07
21-Jun-07
21-Sep-07
21-Dec-07
21-Mar-08
21-Jun-08
21-Sep-08
21-Dec-08
21-Mar-09
21-Jun-09
21-Sep-09
21-Dec-09



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

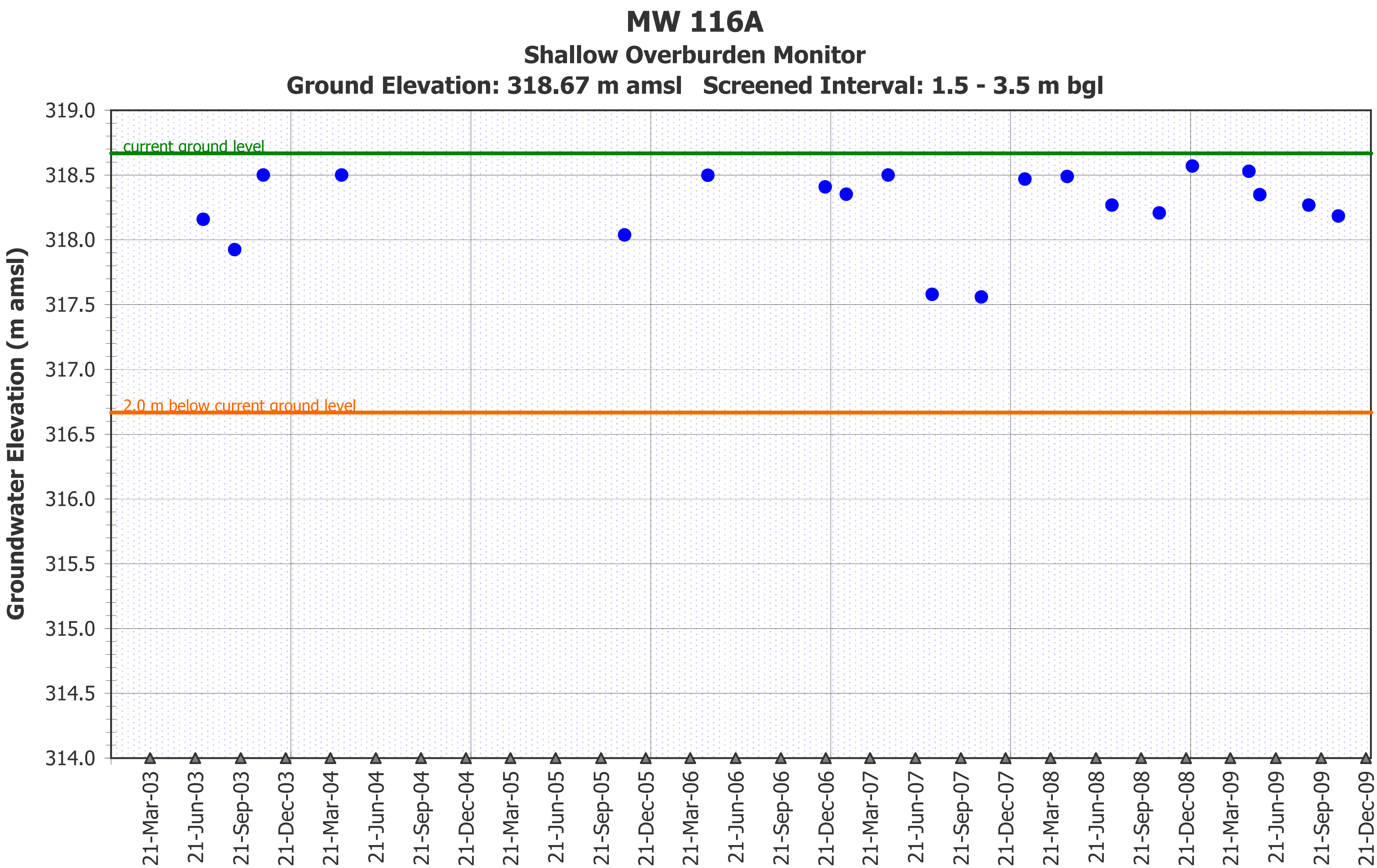
December 2009 **Graph C 21**



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

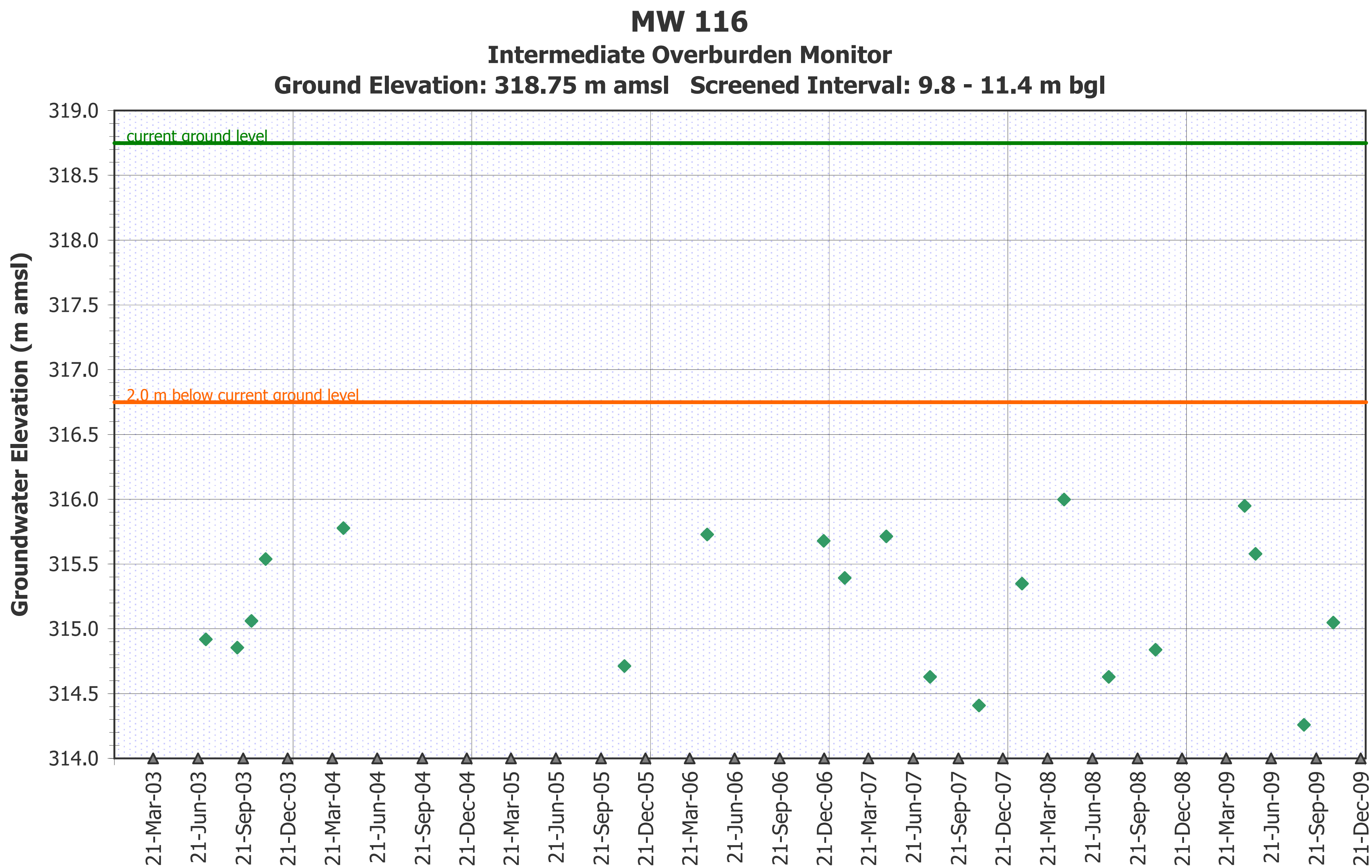
December 2009 **Graph C 22**



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph C 23**

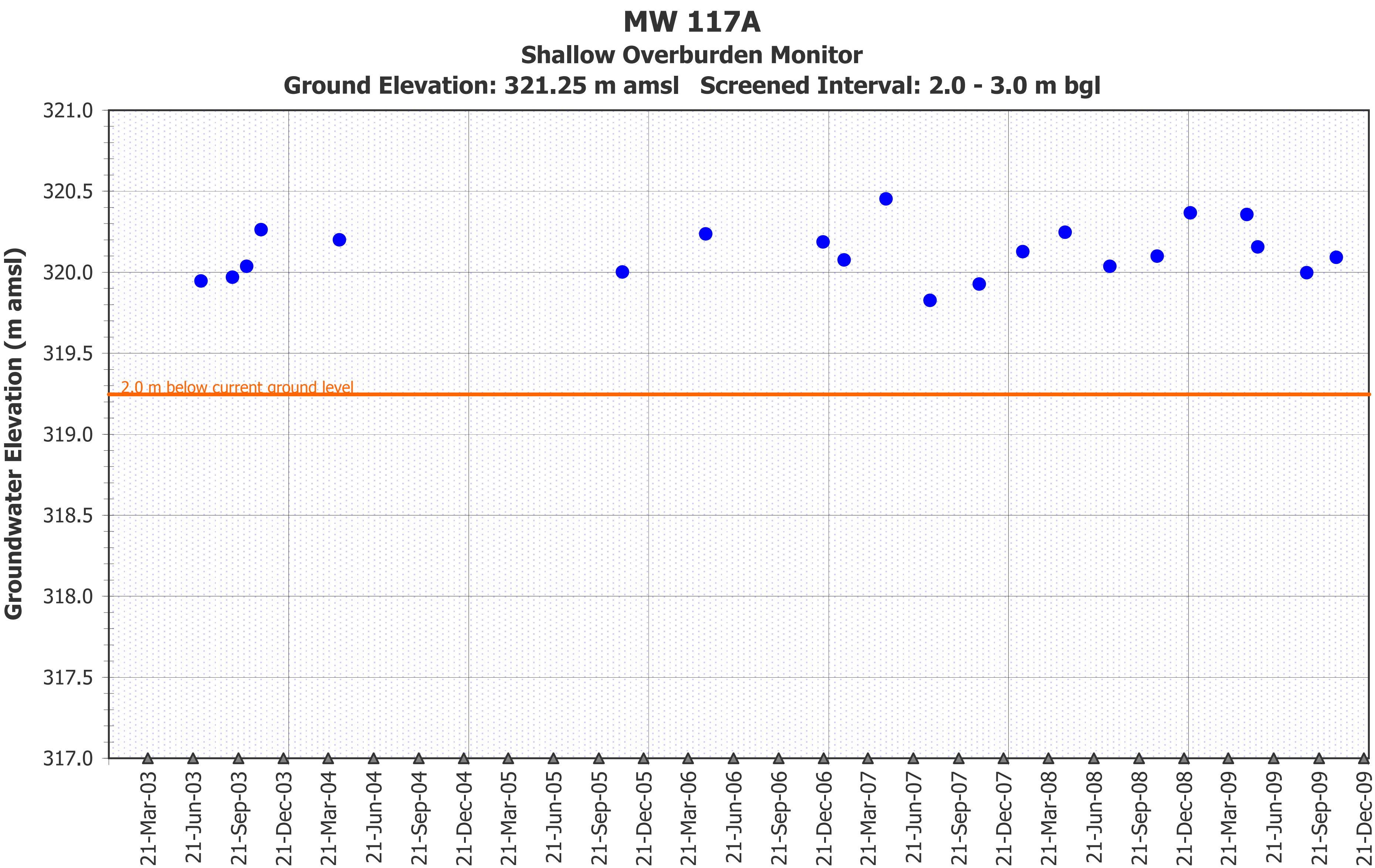


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009

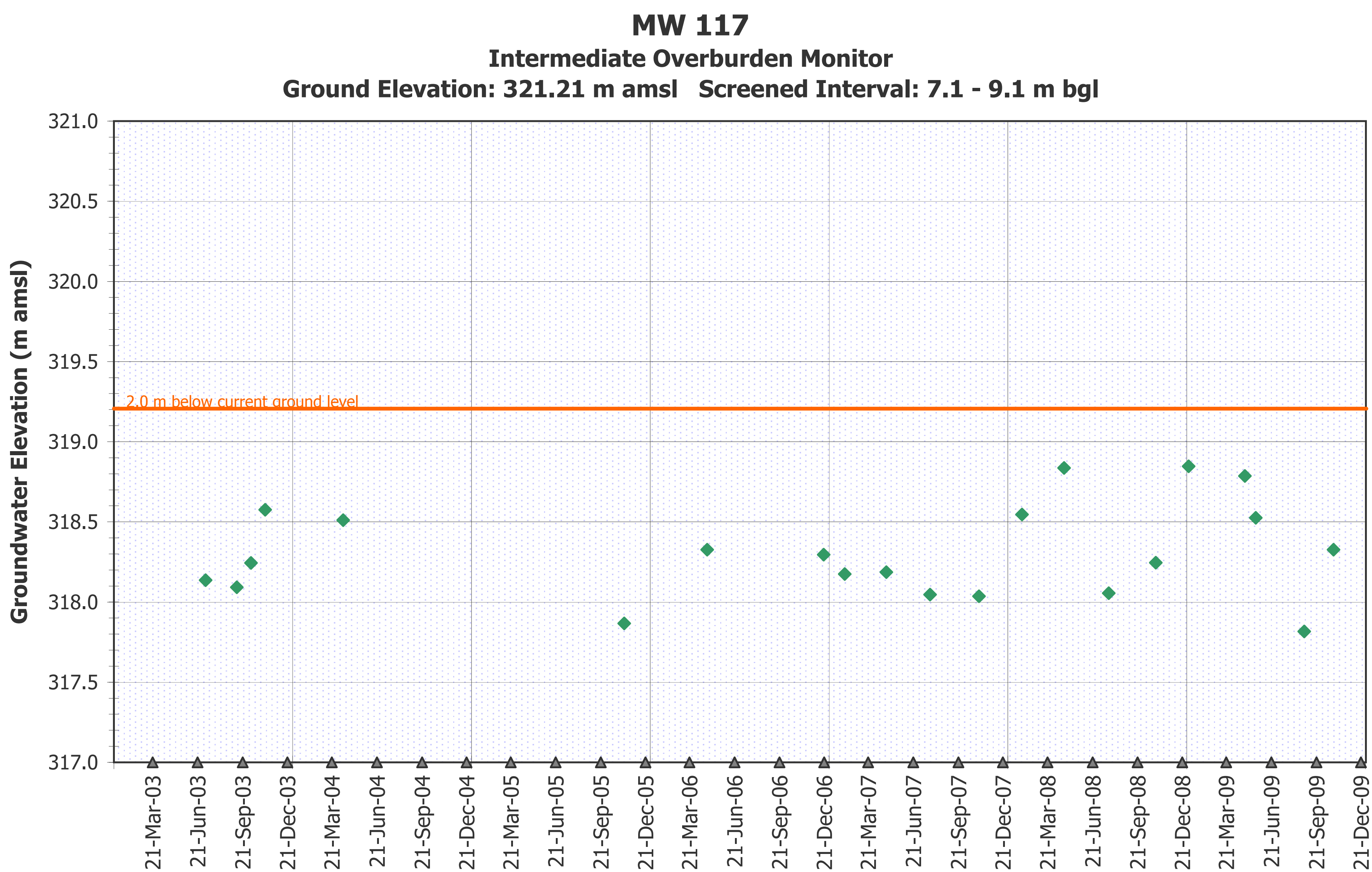
Graph C 24



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

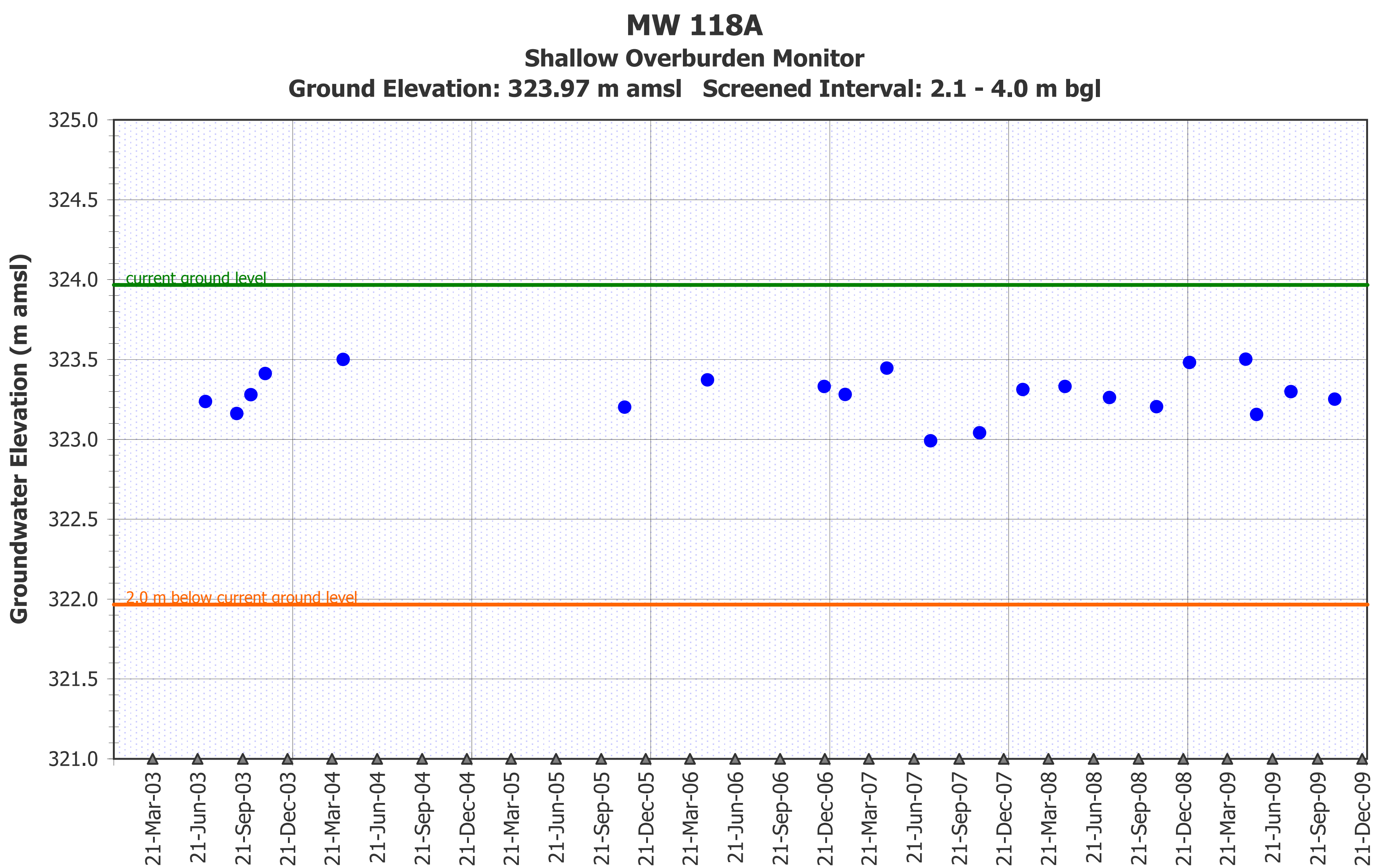
December 2009 **Graph C 25**



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

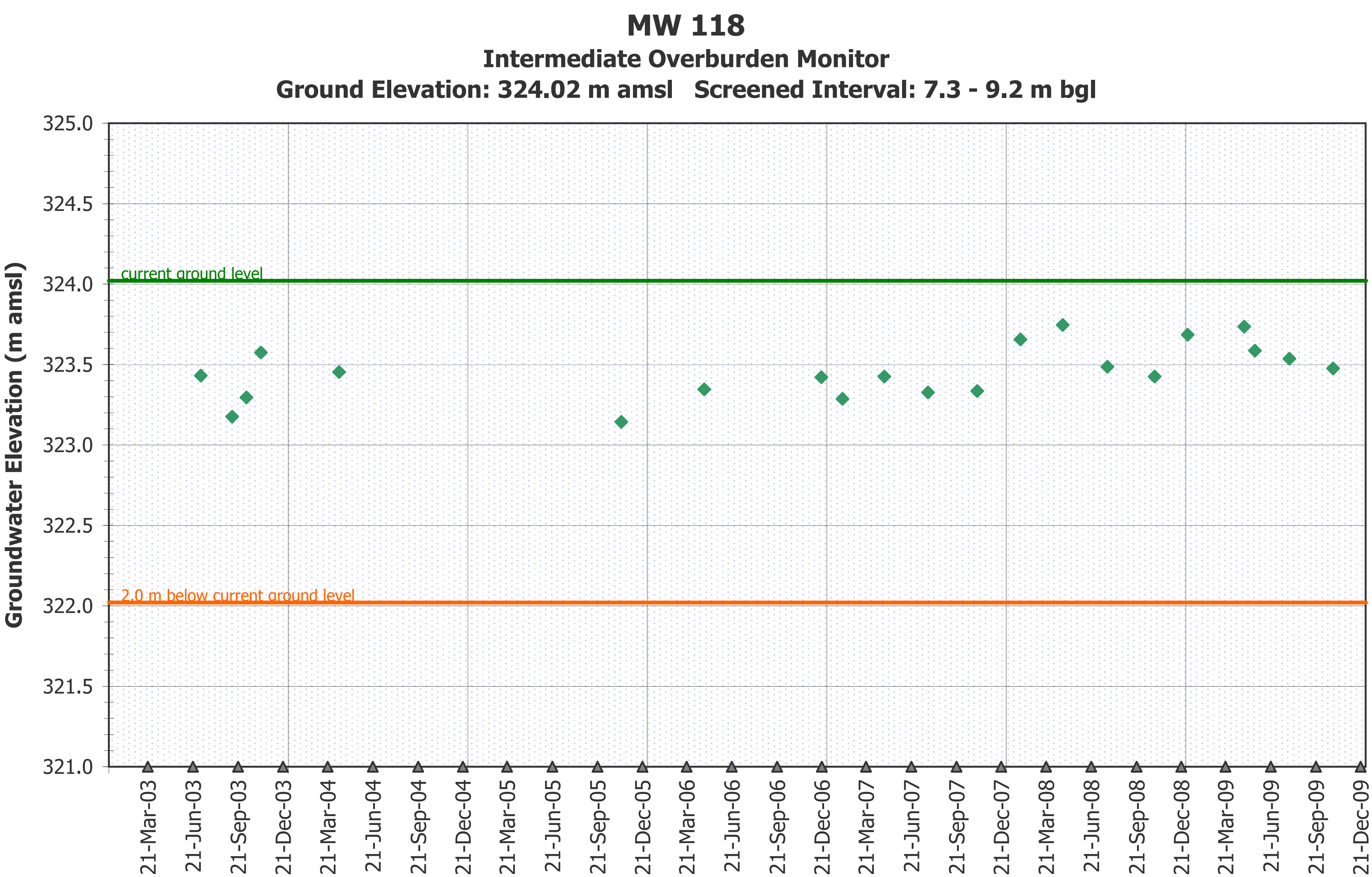
December 2009 **Graph C 26**

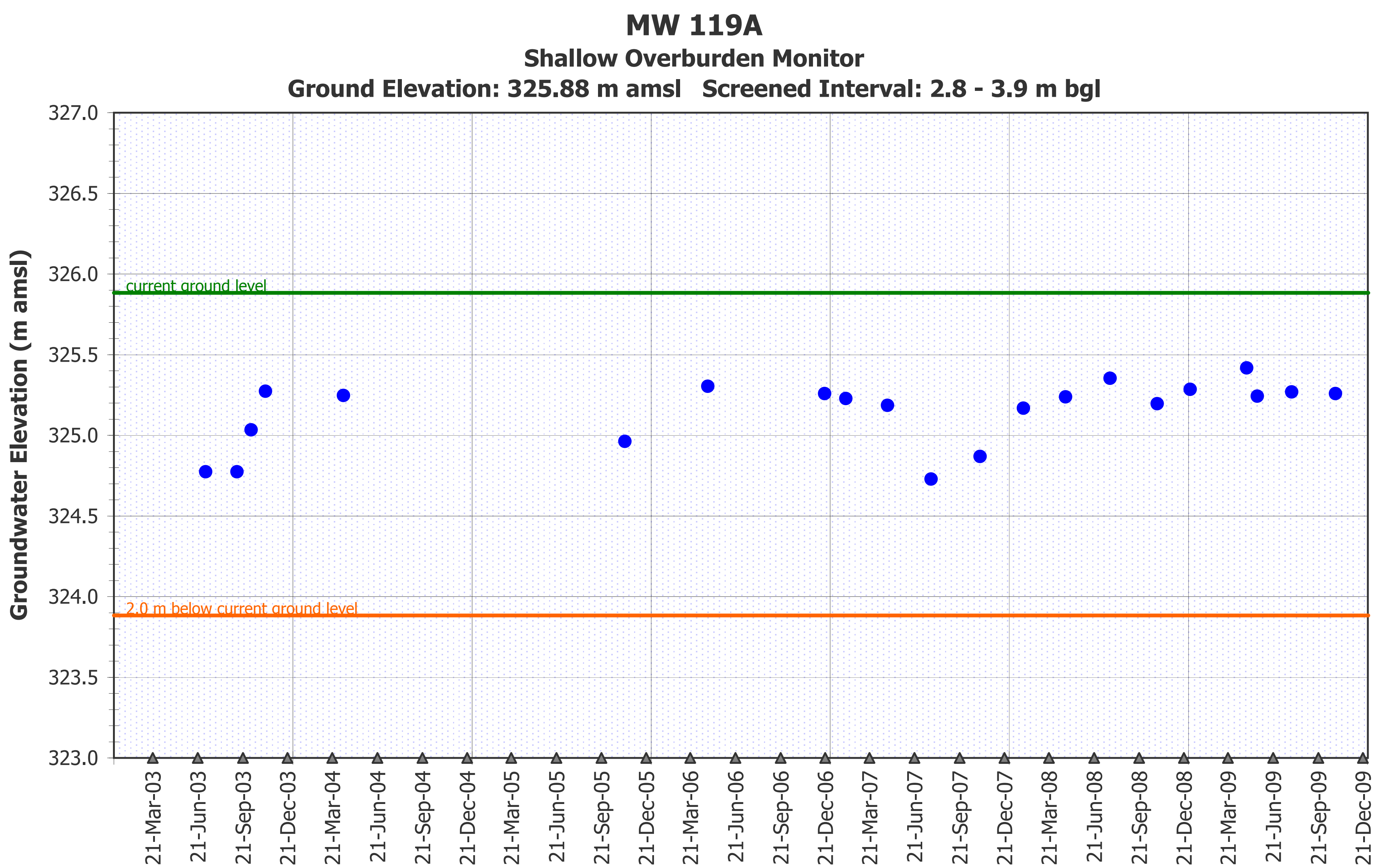


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph C 27**


MW 118
Intermediate Overburden Monitor
Ground Elevation: 324.02 m amsl   Screened Interval: 7.3 - 9.2 m bgl
Groundwater Elevation (m amsl)
current ground level
2.0 m below current ground level
325.0
324.5
324.0
323.5
323.0
322.5
322.0
321.5
321.0
21-Mar-03
21-Jun-03
21-Sep-03
21-Dec-03
21-Mar-04
21-Jun-04
21-Sep-04
21-Dec-04
21-Mar-05
21-Jun-05
21-Sep-05
21-Dec-05
21-Mar-06
21-Jun-06
21-Sep-06
21-Dec-06
21-Mar-07
21-Jun-07
21-Sep-07
21-Dec-07
21-Mar-08
21-Jun-08
21-Sep-08
21-Dec-08
21-Mar-09
21-Jun-09
21-Sep-09
21-Dec-09



Banks Groundwater Engineering Limited

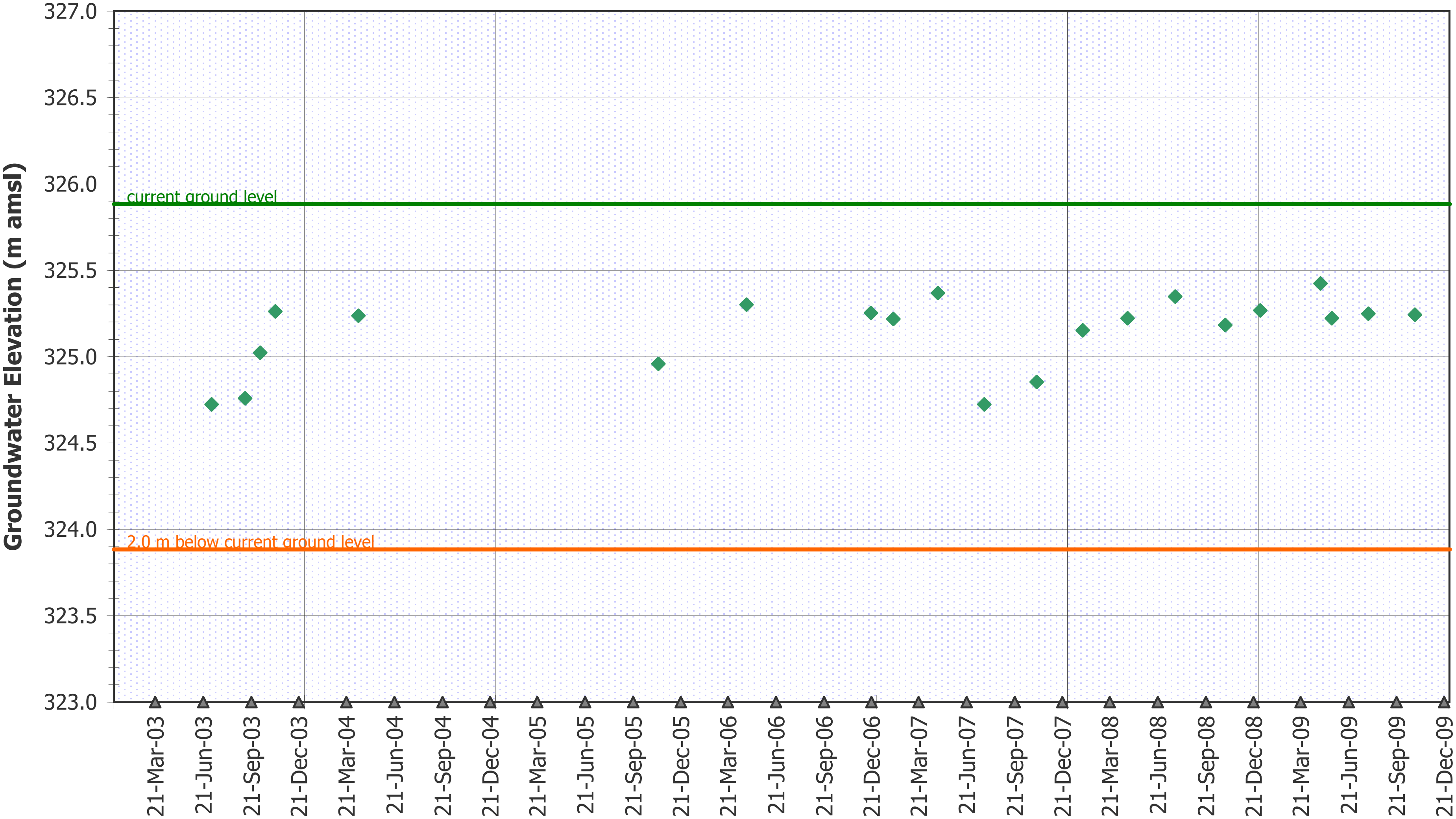
Hanlon Creek Business Park - Groundwater Monitoring Program

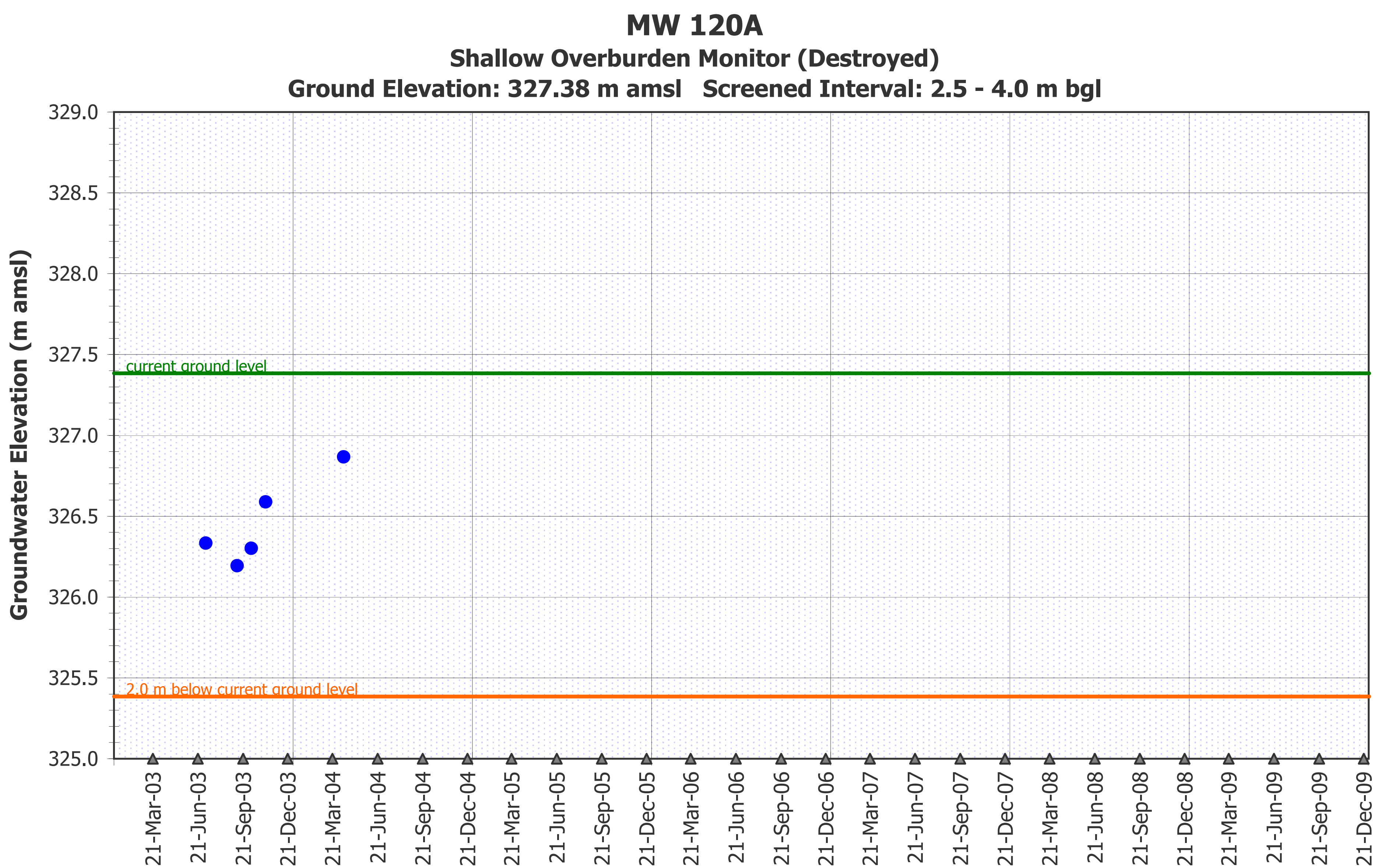
December 2009 **Graph C 29**

MW 119

Intermediate Overburden Monitor

Ground Elevation: 325.88 m amsl   Screened Interval: 6.0 - 8.0 m bgl

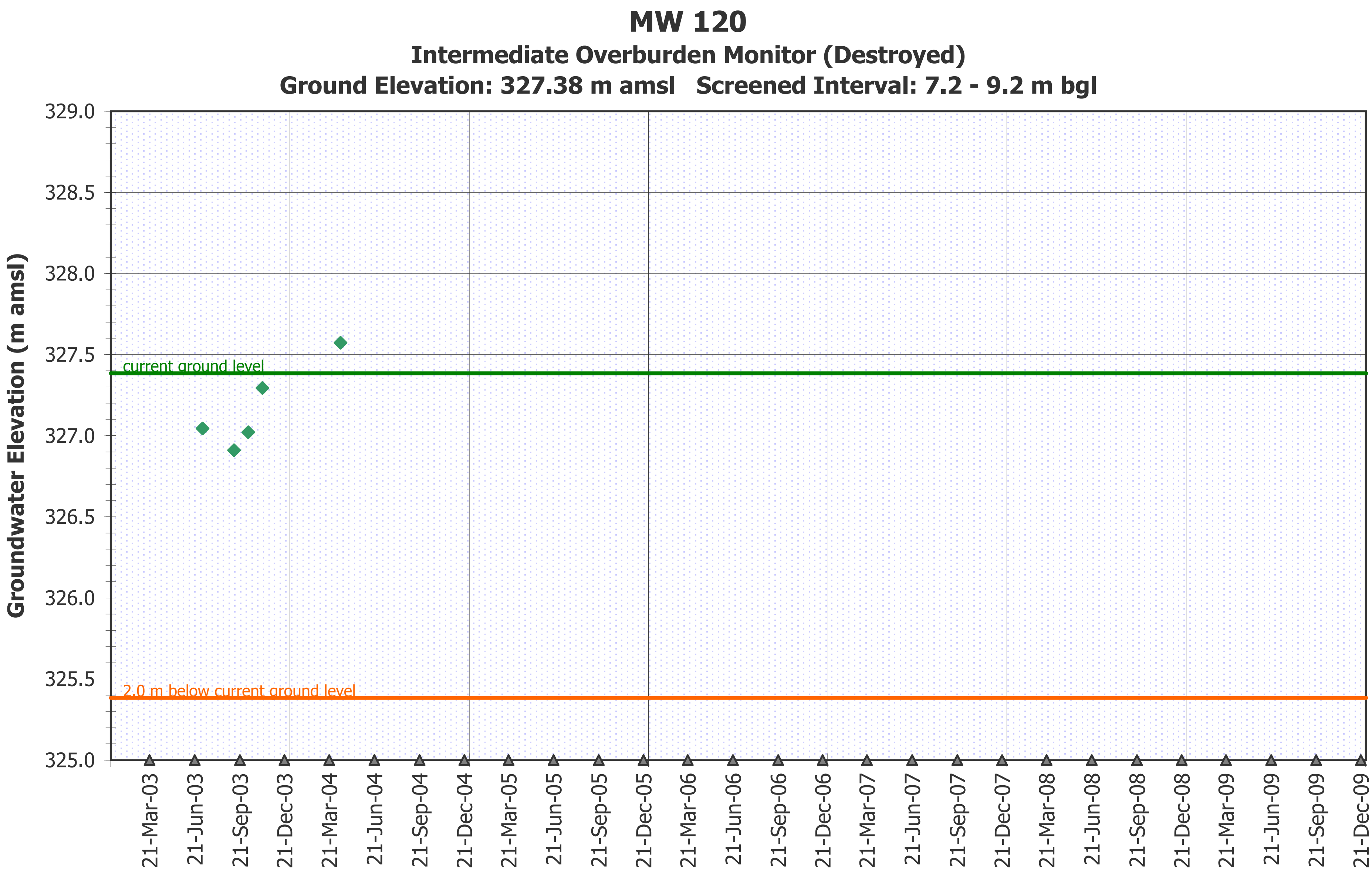


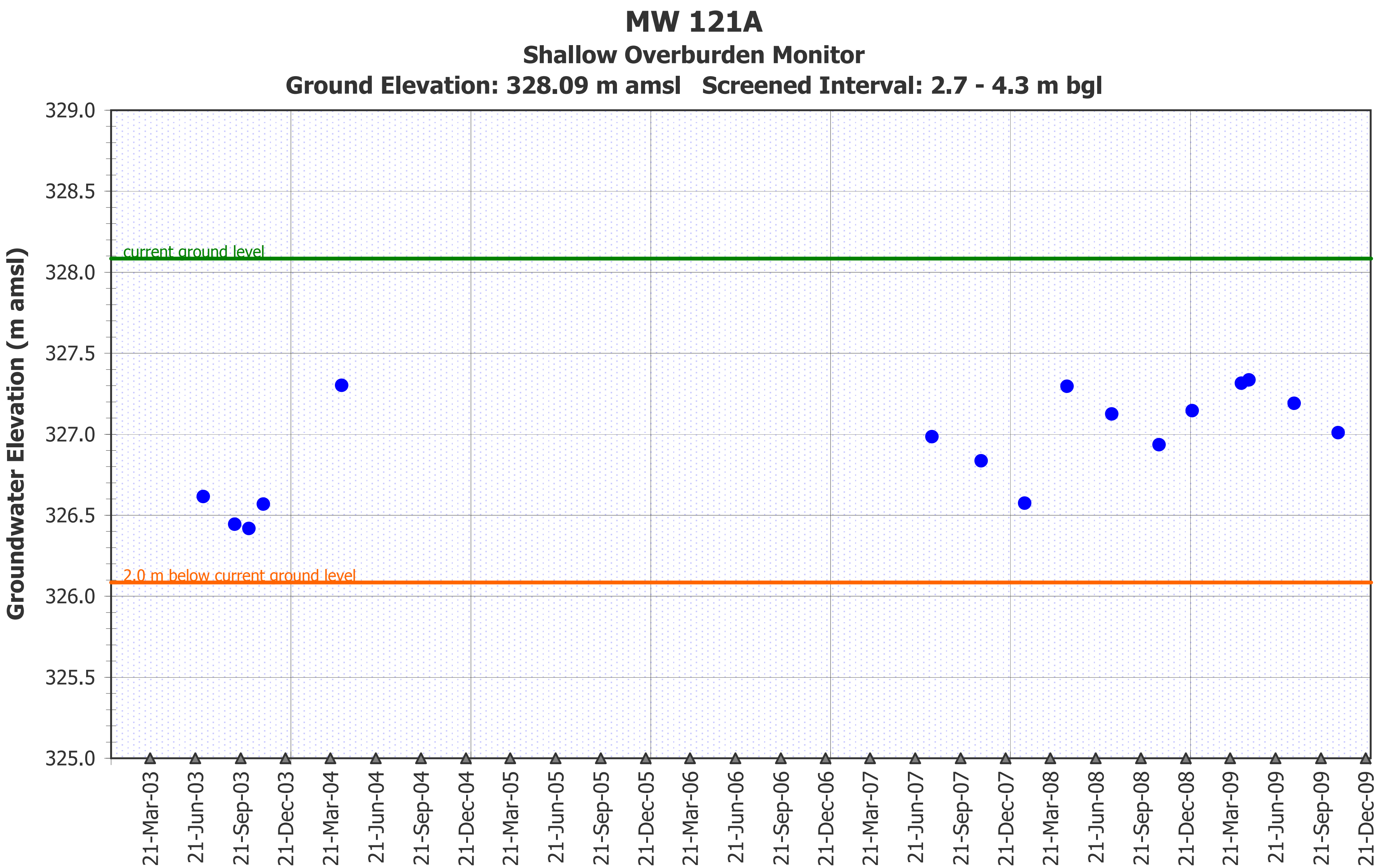


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph C 31**

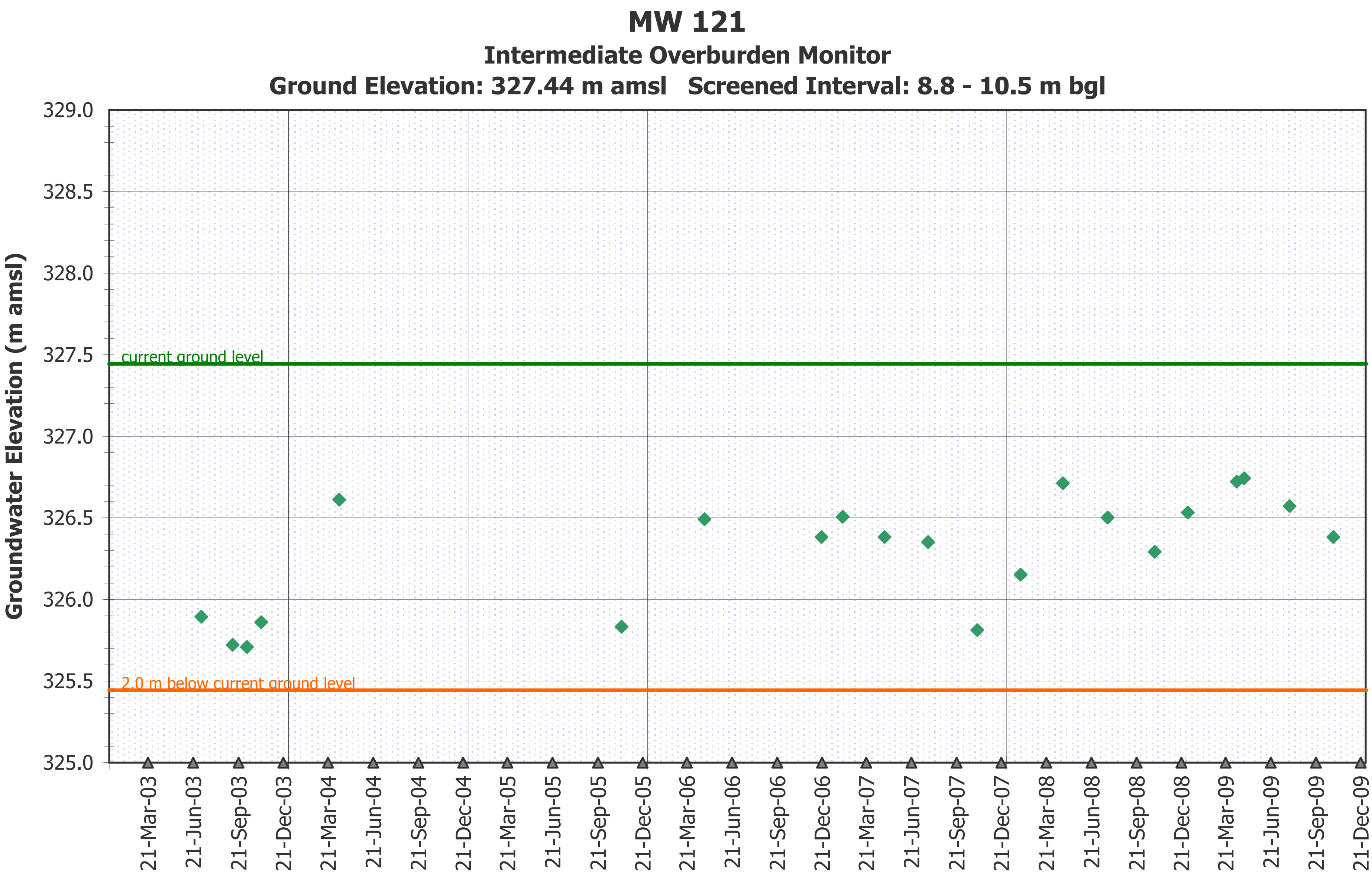

MW 120
Intermediate Overburden Monitor (Destroyed)
Ground Elevation: 327.38 m amsl Screened Interval: 7.2 - 9.2 m bgl
Groundwater Elevation (m amsl)
329.0
328.5
328.0
327.5
327.0
326.5
326.0
325.5
325.0
current ground level
2.0 m below current ground level
21-Mar-03
21-Jun-03
21-Sep-03
21-Dec-03
21-Mar-04
21-Jun-04
21-Sep-04
21-Dec-04
21-Mar-05
21-Jun-05
21-Sep-05
21-Dec-05
21-Mar-06
21-Jun-06
21-Sep-06
21-Dec-06
21-Mar-07
21-Jun-07
21-Sep-07
21-Dec-07
21-Mar-08
21-Jun-08
21-Sep-08
21-Dec-08
21-Mar-09
21-Jun-09
21-Sep-09
21-Dec-09



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

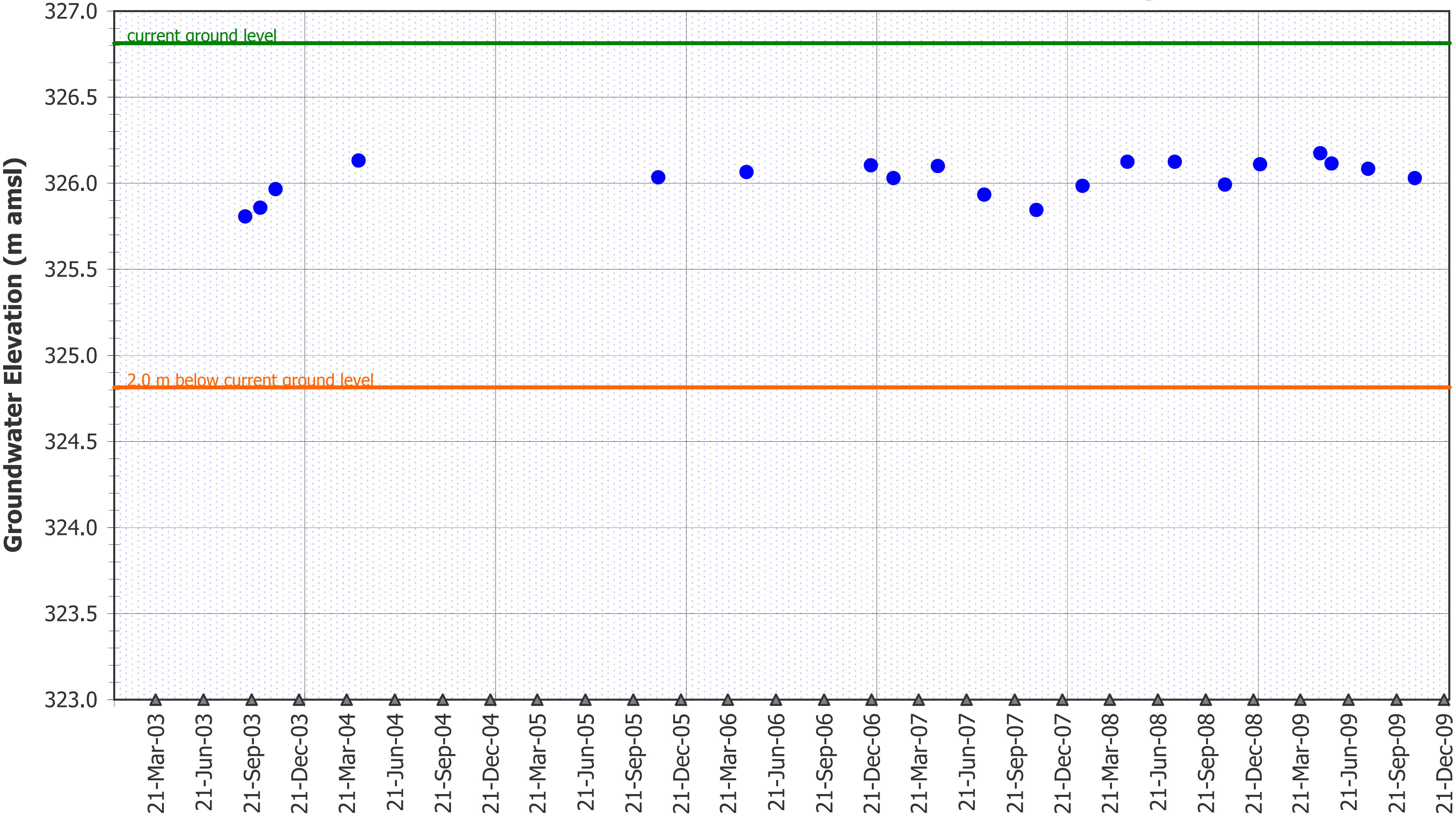
December 2009 **Graph C 33**


MW 121
Intermediate Overburden Monitor
Ground Elevation: 327.44 m amsl   Screened Interval: 8.8 - 10.5 m bgl
Groundwater Elevation (m amsl)
current ground level
2.0 m below current ground level
329.0
328.5
328.0
327.5
327.0
326.5
326.0
325.5
325.0
21-Mar-03
21-Jun-03
21-Sep-03
21-Dec-03
21-Mar-04
21-Jun-04
21-Sep-04
21-Dec-04
21-Mar-05
21-Jun-05
21-Sep-05
21-Dec-05
21-Mar-06
21-Jun-06
21-Sep-06
21-Dec-06
21-Mar-07
21-Jun-07
21-Sep-07
21-Dec-07
21-Mar-08
21-Jun-08
21-Sep-08
21-Dec-08
21-Mar-09
21-Jun-09
21-Sep-09
21-Dec-09

MW 122A

Shallow Overburden Monitor

Ground Elevation: 326.81 m amsl   Screened Interval: 2.8 - 3.8 m bgl

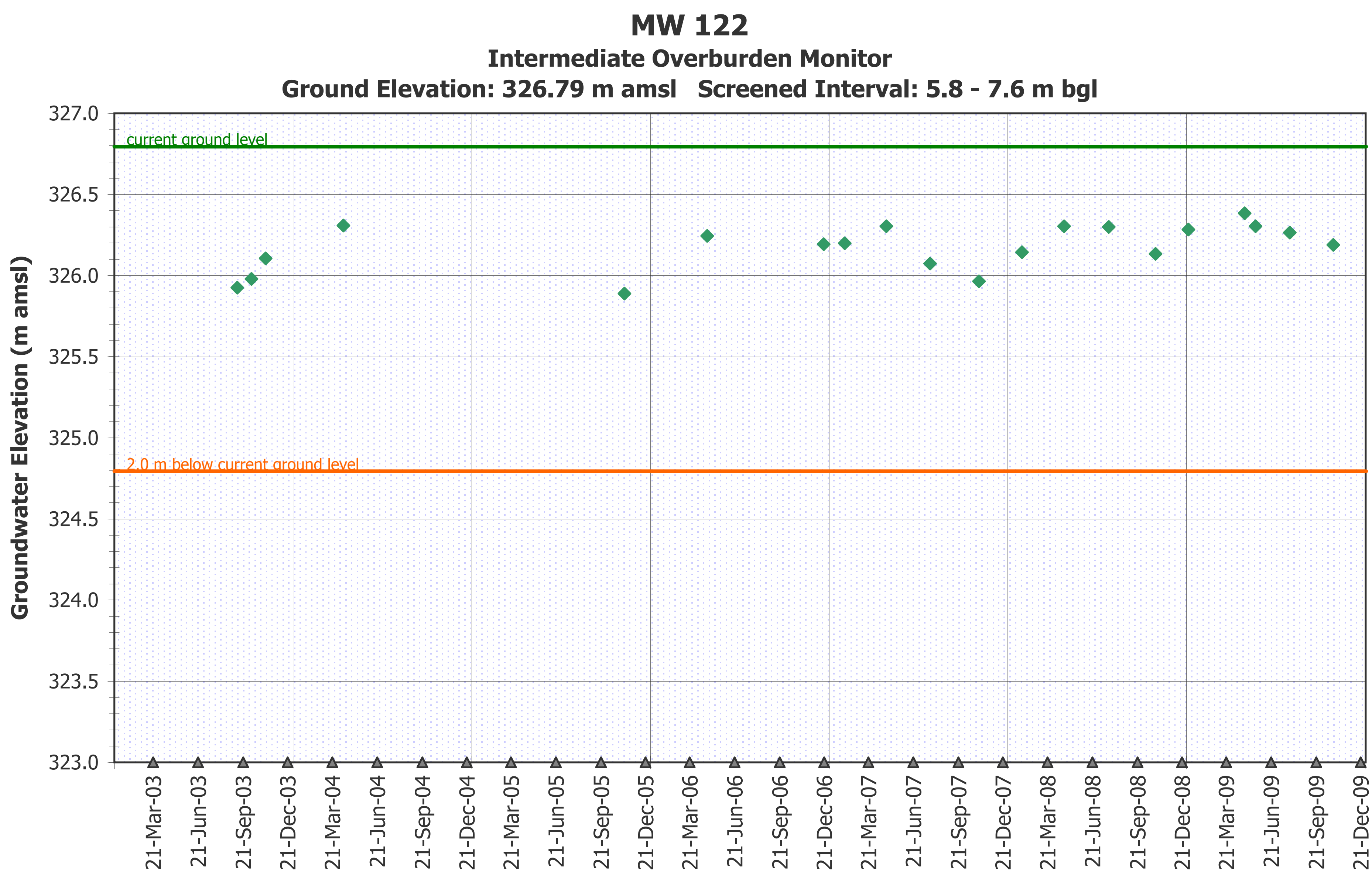


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009

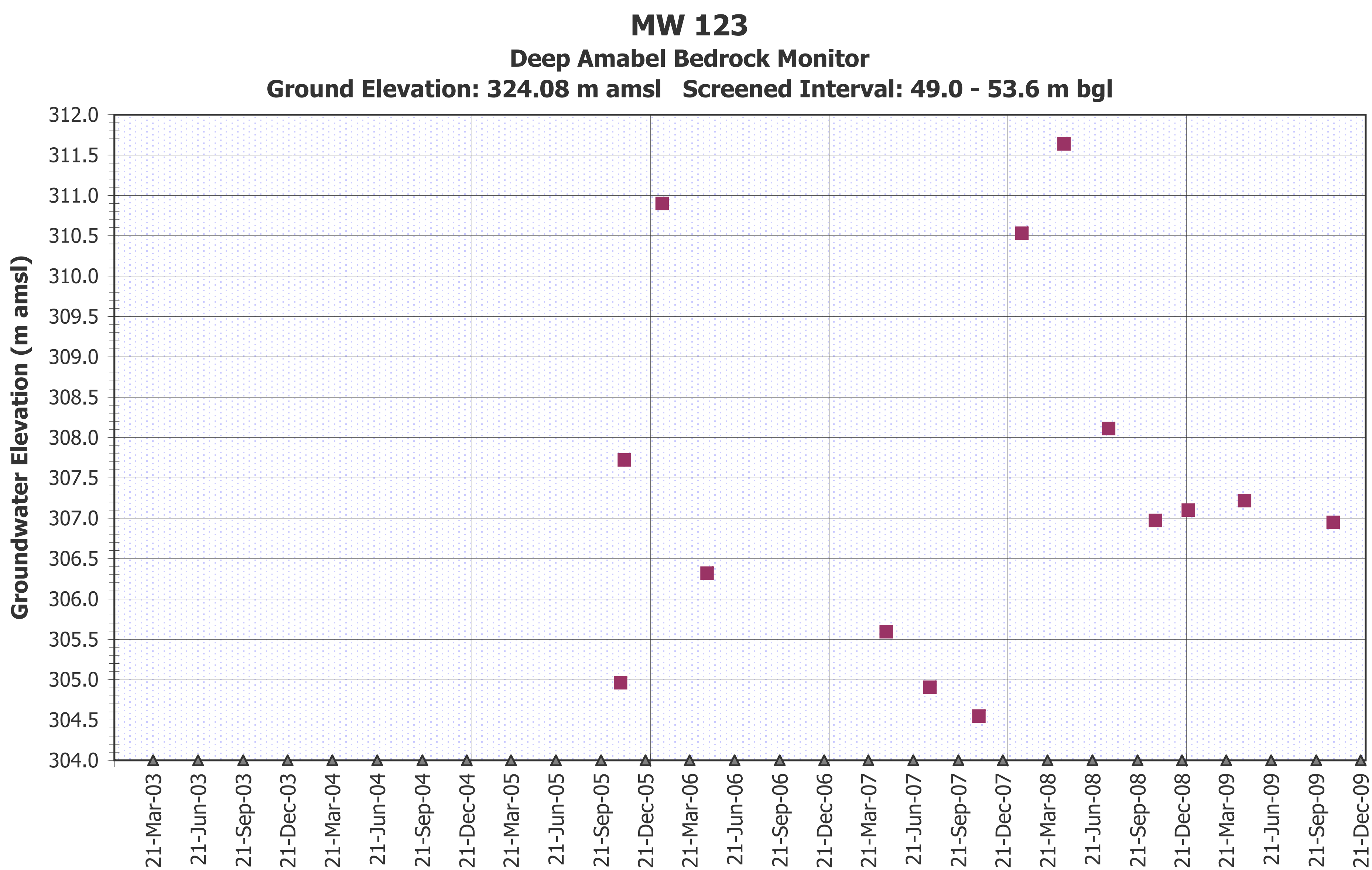
Graph C 35



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

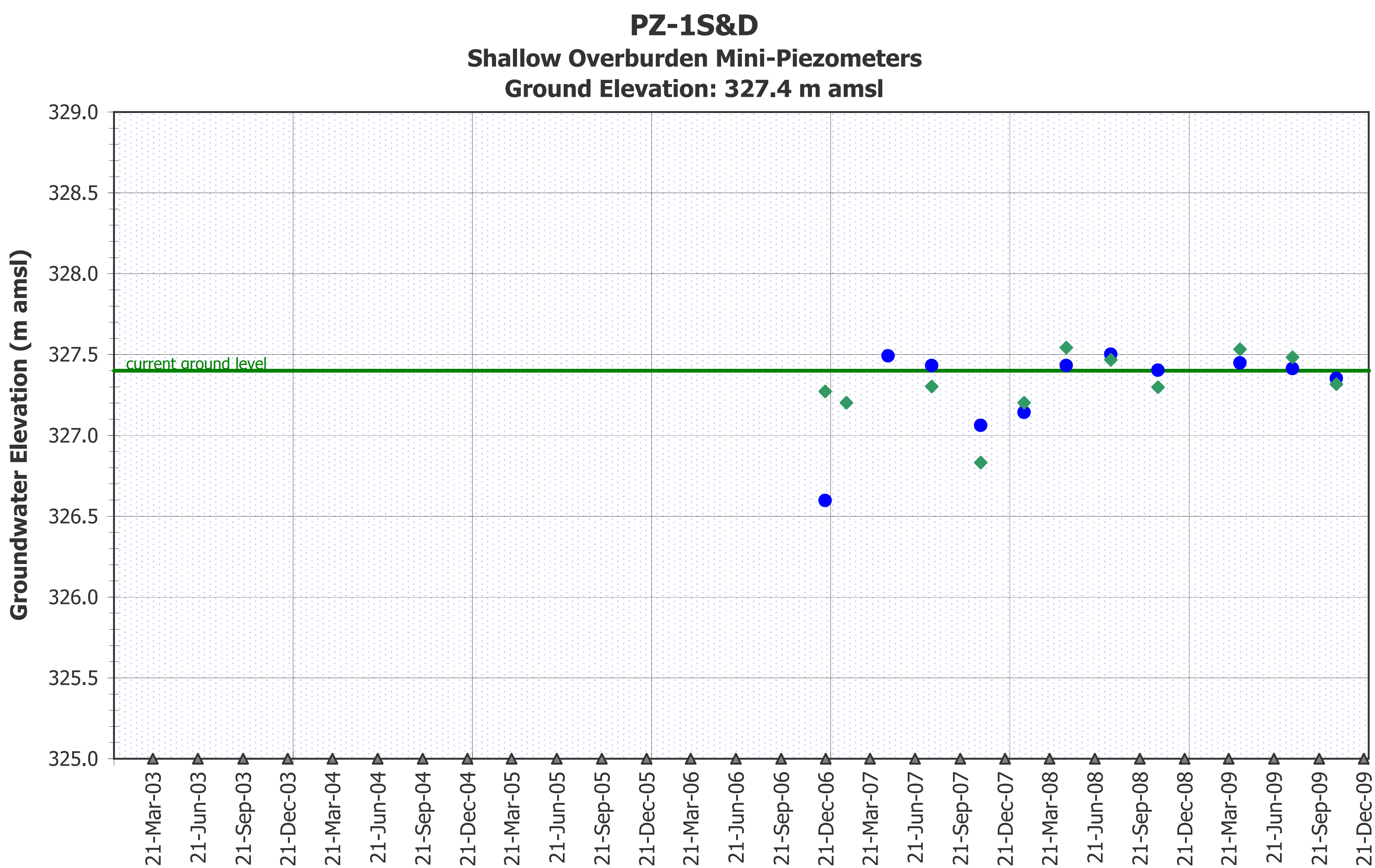
December 2009 **Graph C 36**

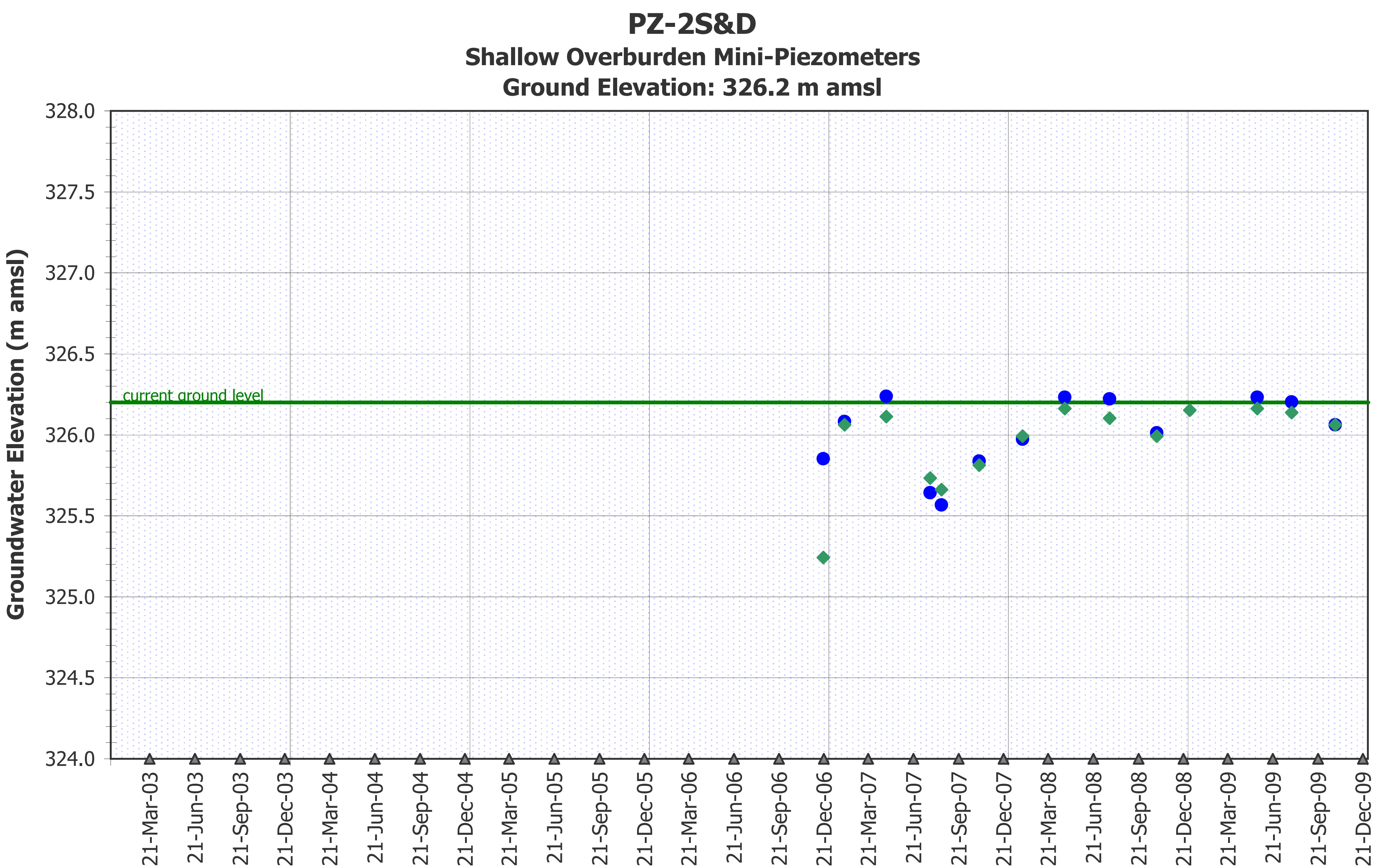


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph C 37**

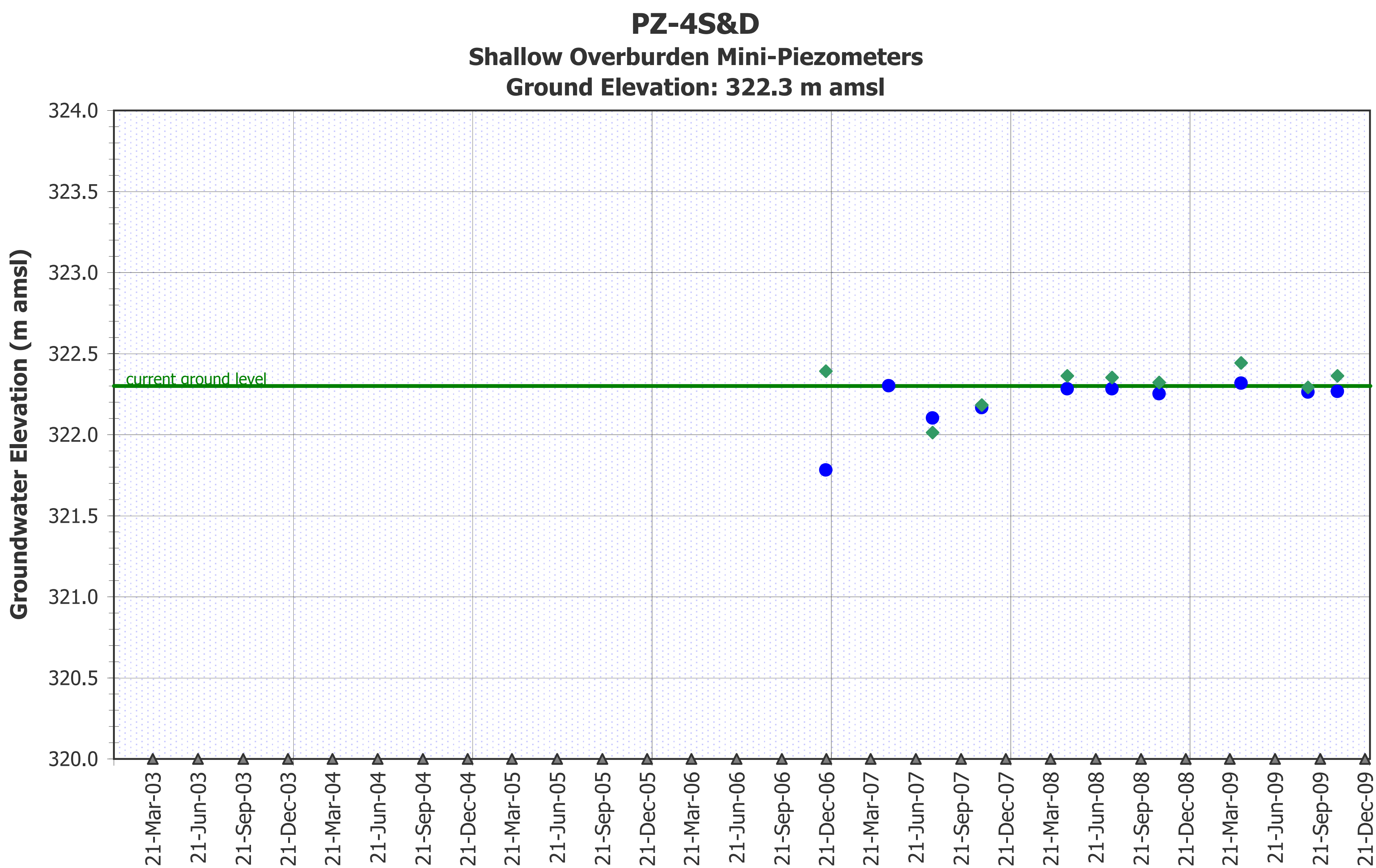

PZ-1S&D
Shallow Overburden Mini-Piezometers
Ground Elevation: 327.4 m amsl
Groundwater Elevation (m amsl)
329.0
328.5
328.0
327.5
327.0
326.5
326.0
325.5
325.0
current ground level
21-Mar-03
21-Jun-03
21-Sep-03
21-Dec-03
21-Mar-04
21-Jun-04
21-Sep-04
21-Dec-04
21-Mar-05
21-Jun-05
21-Sep-05
21-Dec-05
21-Mar-06
21-Jun-06
21-Sep-06
21-Dec-06
21-Mar-07
21-Jun-07
21-Sep-07
21-Dec-07
21-Mar-08
21-Jun-08
21-Sep-08
21-Dec-08
21-Mar-09
21-Jun-09
21-Sep-09
21-Dec-09



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph C 39**



Banks Groundwater Engineering Limited

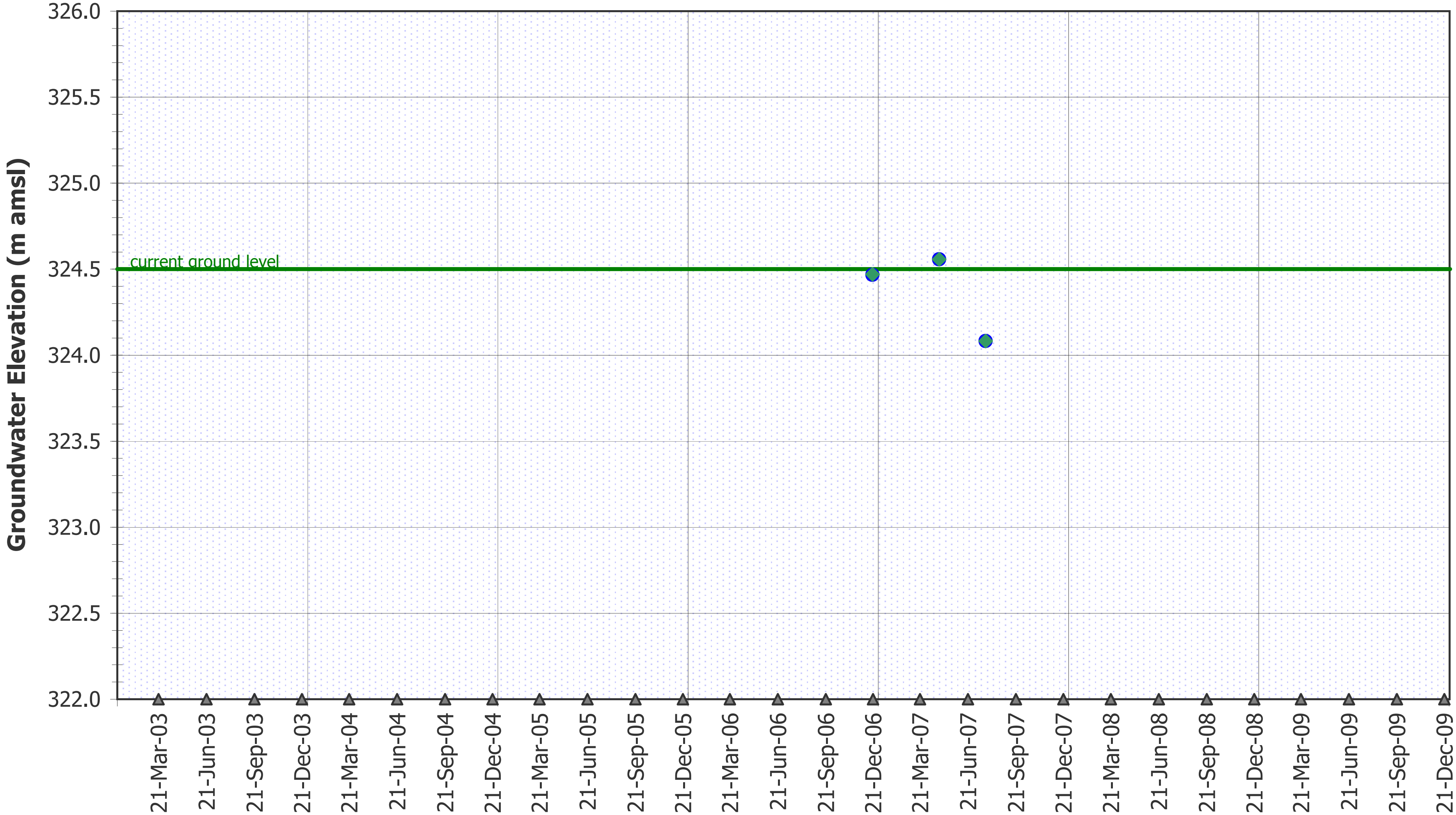
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph C 40**

PZ-6S&D

Shallow Overburden Mini-Piezometers (Removed)

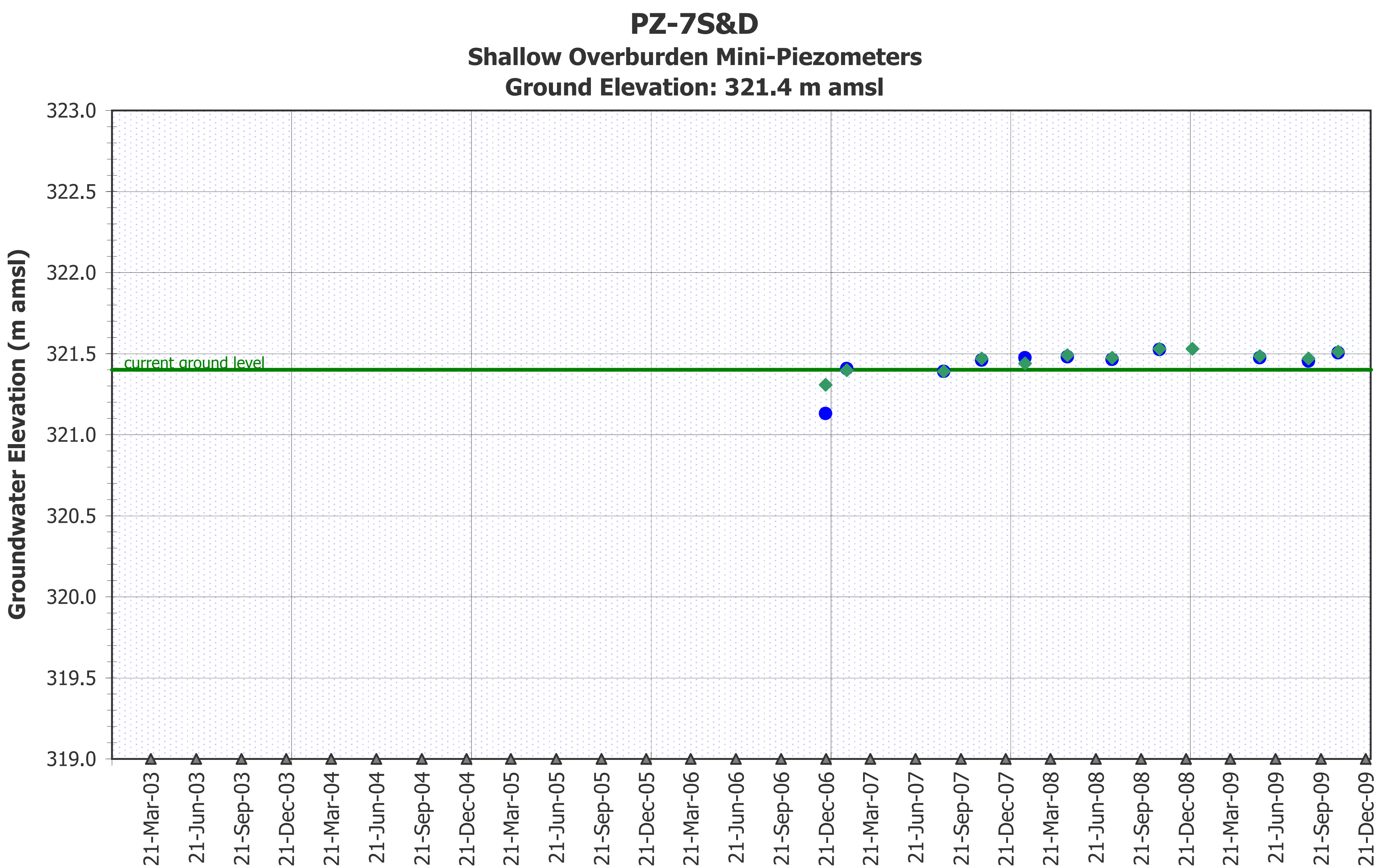
Ground Elevation: 324.5 m amsl



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

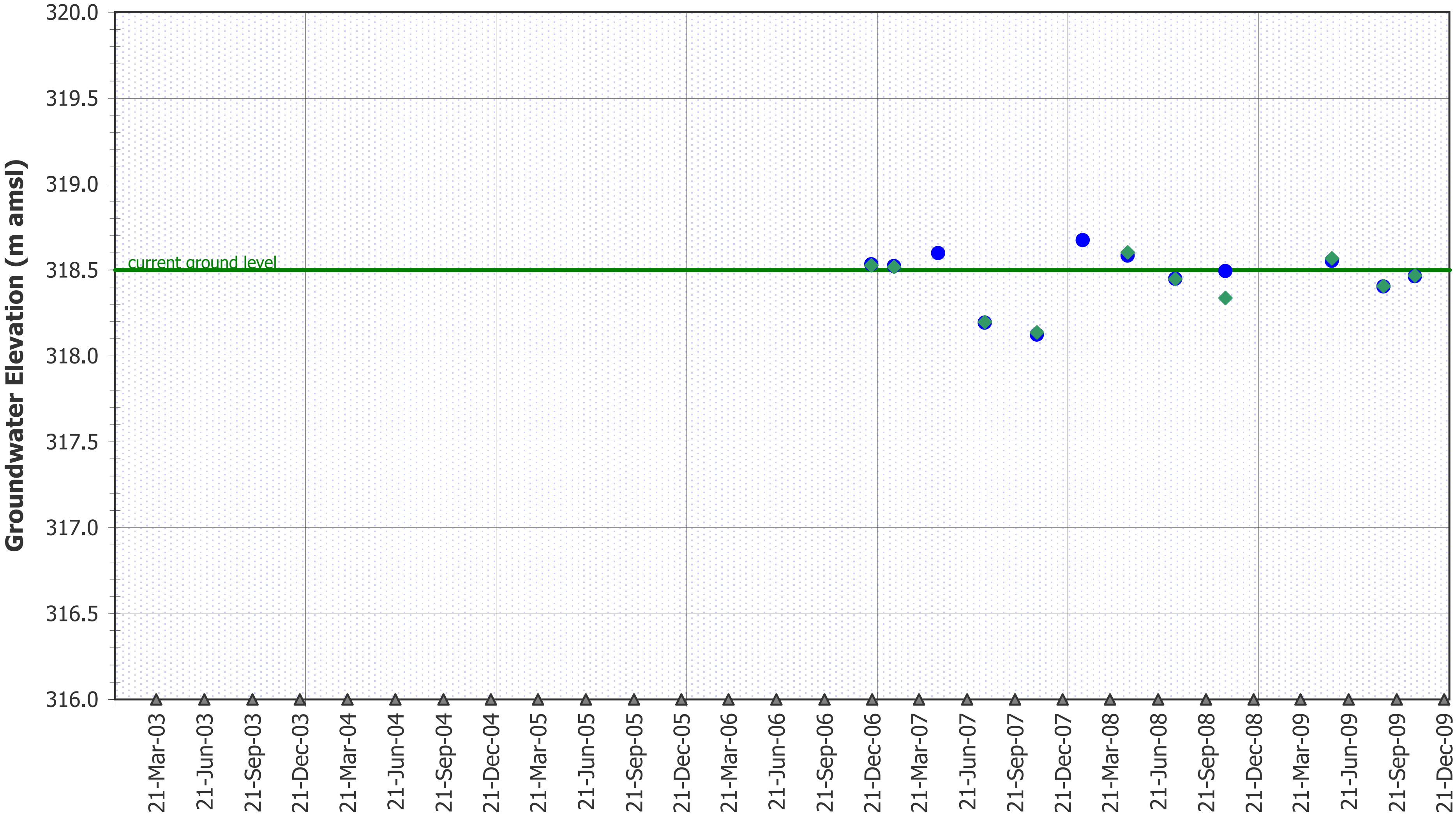
December 2009 **Graph C 41**


PZ-7S&D
Shallow Overburden Mini-Piezometers
Ground Elevation: 321.4 m amsl
Groundwater Elevation (m amsl)
323.0
322.5
322.0
321.5
321.0
320.5
320.0
319.5
319.0
current ground level
21-Mar-03
21-Jun-03
21-Sep-03
21-Dec-03
21-Mar-04
21-Jun-04
21-Sep-04
21-Dec-04
21-Mar-05
21-Jun-05
21-Sep-05
21-Dec-05
21-Mar-06
21-Jun-06
21-Sep-06
21-Dec-06
21-Mar-07
21-Jun-07
21-Sep-07
21-Dec-07
21-Mar-08
21-Jun-08
21-Sep-08
21-Dec-08
21-Mar-09
21-Jun-09
21-Sep-09
21-Dec-09

PZ-8S&D

Shallow Overburden Mini-Piezometers

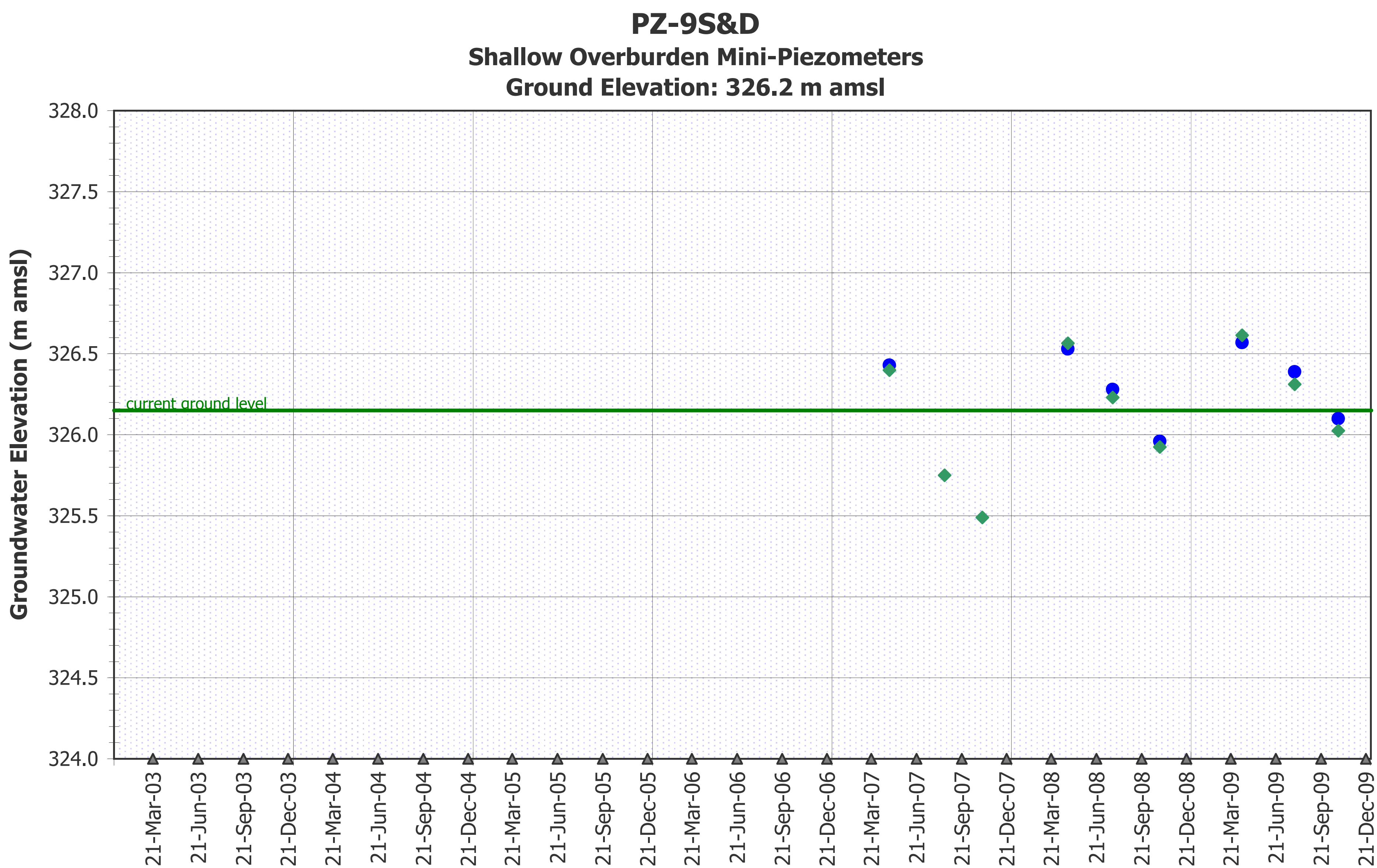
Ground Elevation: 318.5 m amsl



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph C 43**


PZ-9S&D
Shallow Overburden Mini-Piezometers
Ground Elevation: 326.2 m amsl
Groundwater Elevation (m amsl)
328.0
327.5
327.0
326.5
326.0
325.5
325.0
324.5
324.0
current ground level
21-Mar-03
21-Jun-03
21-Sep-03
21-Dec-03
21-Mar-04
21-Jun-04
21-Sep-04
21-Dec-04
21-Mar-05
21-Jun-05
21-Sep-05
21-Dec-05
21-Mar-06
21-Jun-06
21-Sep-06
21-Dec-06
21-Mar-07
21-Jun-07
21-Sep-07
21-Dec-07
21-Mar-08
21-Jun-08
21-Sep-08
21-Dec-08
21-Mar-09
21-Jun-09
21-Sep-09
21-Dec-09

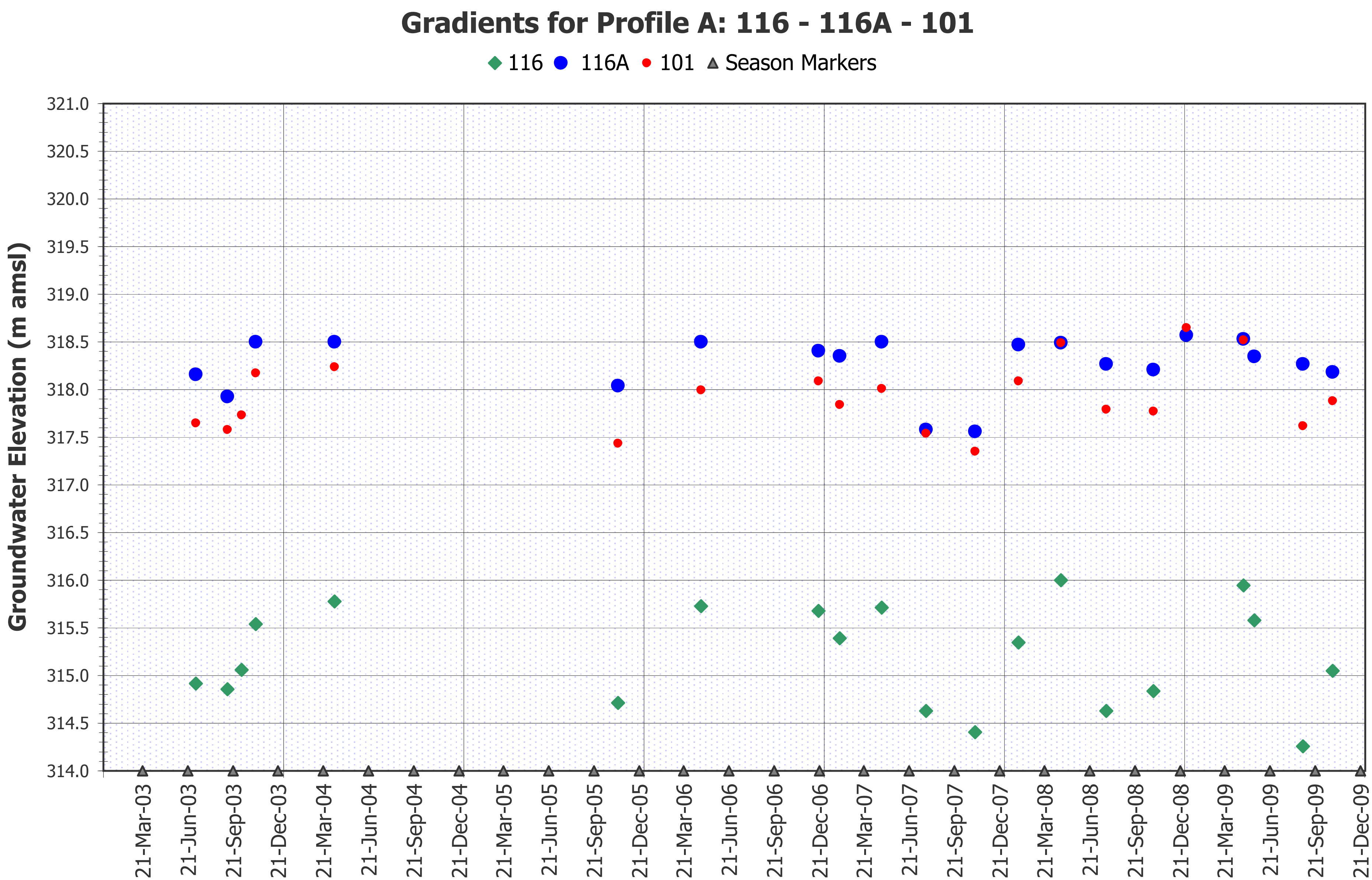
Appendix D: Vertical Hydraulic Gradients 2003 – 2009

Hanlon Creek Business Park -Groundwater Monitoring Program

Vertical Hydraulic Gradient Data - 2003 Monitoring Wells

Monitoring Well Number	Type	Groundwater Elevations (m amsl)												Compare w/ MW for Gradient Calc.	Mid-Point of Screen Elevation (m)	Vertical Hydraulic Gradient I (-ve = up)												
		Sep-03	Apr-07	Jul-07	Nov-07	Jan-08	Apr-08	Jul-08	Oct-08	Jan-09	Apr-09	Jul-09	Oct-09			Sep-03	Apr-07	Jul-07	Nov-07	Jan-08	Apr-08	Jul-08	Oct-08	Jan-09	Apr-09	Jul-09	Oct-09	average I
001	S	323.96	324.33	323.87	323.67	324.29	324.42	324.22	324.03	324.40	324.43	324.20	324.10	118	319.75	0.20	0.23	0.14	0.08	0.16	0.17	0.18	0.15	0.18	0.18	0.17	0.16	0.17
002	S	325.39	damaged	325.33	325.27	325.95	325.01	325.91	325.83					119	324.16	0.12	n/a	0.11	0.08	0.15	-0.04	0.11	0.12					0.09
003	S	325.61	326.57	325.89	325.48	326.17	326.58	326.22	325.92	326.56	326.64	326.30	326.01	122	323.56	-0.09	0.08	-0.05	-0.14	0.01	0.08	-0.02	-0.06	0.08	0.08	0.01	-0.29	-0.03
004	S	325.72	327.03	326.19	325.52	326.22	327.53	326.49	326.03	326.87	327.29	326.54	326.08	112	324.38	0.01	0.02	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.02	0.01
005 (S)	S	329.78	n/a	moist/dry	dry	330.10	330.20	330.33	330.05	330.52	330.11	330.07		005(I)	331.23	0.47	n/a	n/a	n/a	0.46	0.26	0.36	0.39	n/a	0.21	0.28		0.35
005 (I)	I	326.92	n/a	327.88	327.16	327.29	328.62	328.13	327.70	327.82	328.82	328.38	327.85	114	325.13	0.05	n/a	0.05	0.05	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.05
006	S	326.97	328.27	327.74	327.11	327.46	328.54	328.05	327.62	327.99	328.66	328.21	327.76	121	326.45	0.14	0.22	0.16	0.15	0.15	0.21	0.18	0.15	0.17	0.22	0.19	0.29	0.19
101	S	317.58	318.01	317.54	317.35	318.09	318.49	317.79	317.77	318.65	318.52	317.62	317.88	116	316.70	0.32	0.27	0.34	0.34	0.32	0.29	0.37	0.34		0.30	0.39	0.33	0.33
102	S	318.91	319.74	318.72	318.30	319.74	319.89	320.18	319.15	320.13	320.13	319.17	319.34	117	316.91	0.22	0.41	0.18	0.07	0.31	0.28	0.56	0.24	0.34	0.35	0.36	0.27	0.30
103	S	322.63	323.33	322.44	322.40	323.33	323.44	323.05	322.79	323.55	323.51	322.90	322.80	117	320.75	0.59	0.67	0.57	0.57	0.63	0.60	0.65	0.59	0.62	0.62	0.66	0.59	0.61
104	S	320.83	321.49	320.59	320.70	321.46	321.43	321.30	321.14	321.55	321.61	321.14	321.17	118	318.84	-0.76	-0.63	-0.89	-0.86	-0.72	-0.76	-0.71	-0.75	-0.70	-0.69		-0.75	-0.75
105	S	322.60	322.93	322.48	322.62	322.77	322.82	322.77	322.72	322.84	322.93	322.79	322.79	111	320.52	-0.11	-0.11	-0.14	-0.11	-0.13	-0.17	-0.12	-0.12	-0.12		-0.13	-0.11	-0.12
106	S	325.78	326.66	326.07	325.76	326.39	326.83	326.50	326.19	326.77	326.93	326.48	326.28	119	323.60	0.22	0.27	0.29	0.19	0.26	0.34	0.24	0.21	0.32	0.32	0.26	0.22	0.26
107	S	326.31	n/a	326.71	326.29	326.78	327.52	327.15	326.75	327.25	327.76	327.14	326.85	119	324.49	0.28	n/a	0.35	0.26	0.29	0.41	0.32	0.28	0.35	0.42	0.34	0.29	0.33
109	S	326.29	327.56	326.88	326.29	326.71	327.91	327.10	326.74	327.31	327.87	327.21	326.83	113	323.50	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.04	0.04	0.03	0.04	0.03
110	I	326.53	327.90	327.30	326.63	326.89	328.20	327.53	327.14	327.43	328.23	327.70	327.25	113	323.79	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04
111	D	324.60	324.95	325.03	324.67	325.18	325.93	325.05	324.86	325.05		325.22	324.73	105	302.10	-0.11	-0.11	-0.14	-0.11	-0.13	-0.17	-0.12	-0.12	-0.12		-0.13	-0.11	-0.12
112	D	325.47	326.49	325.77	325.35	325.97	327.07	326.26	325.81	326.54	326.79	326.24	325.55	004	300.29	0.01	0.02	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.02	0.01
113	D	325.42	326.73	326.10	325.55	325.89	326.95	326.26	325.88	326.17	326.87	326.42	325.84	110	296.30	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04
114	D	325.82	327.04	326.65	326.04	326.29	327.43	326.87	326.45	326.68	327.43	327.07	326.49	005(I)	302.13	0.05	n/a	0.05	0.05	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.05
115	I	323.02	322.77	323.14	323.19	frozen	323.76	323.76	323.45		323.76	323.55	323.50	115A	315.07	-0.10	0.05	-0.20	-0.14	n/a	-0.16	-0.11	-0.12		-0.11	-0.14	-0.10	-0.11
115A	S	322.44	323.05	321.97	322.34	322.81	322.82	323.10	322.74	322.92	323.09	322.73	322.91	115	321.00	-0.10	0.05	-0.20	-0.14	n/a	-0.16	-0.11	-0.12		-0.11	-0.14	-0.10	-0.11
116	I	314.86	315.71	314.63	314.41	315.35	316.00	314.63	314.84		315.95	314.26	315.05	116A	308.15	0.38	0.35	0.37	0.39	0.39	0.31	0.45	0.42		0.32	0.50	0.39	0.39
116A	S	317.92	318.50	317.58	317.56	318.47	318.49	318.27	318.21	318.57	318.53	318.27	318.18	116	316.17	0.38	0.35	0.37	0.39	0.39	0.31	0.45	0.42		0.32	0.50	0.39	0.39
117	I	318.09	318.19	318.05	318.04	318.55	318.84	318.06	318.25	318.85	318.79	317.82	318.33	117A	313.11	0.33	0.40	0.32	0.34	0.28	0.25	0.35	0.33	0.27	0.28	0.39	0.31	0.32
117A	S	319.97	320.45	319.83	319.93	320.13	320.25	320.04	320.10	320.37	320.36	320.00	320.09	117	318.75	0.33	0.40	0.32	0.34	0.28	0.25	0.35	0.33	0.27	0.28	0.39	0.31	0.32
118	I	323.18	323.43	323.33	323.34	323.66	323.75	323.49	323.43	323.69	323.74	323.54	323.48	118A	315.77	-0.003	0.004	-0.07	-0.06	-0.07	-0.08	-0.04	-0.04	-0.04	-0.05	-0.05	-0.04	-0.04
118A	S	323.16	323.45	322.99	323.04	323.31	323.33	323.26	323.20	323.48	323.50	323.30	323.25	118	320.92	-0.003	0.004	-0.07	-0.06	-0.07	-0.08	-0.04	-0.04	-0.04	-0.05	-0.05	-0.04	-0.04
119	I	324.76	325.37	324.72	324.85	325.15	325.22	325.35	325.18	325.27	325.42	325.25	325.24	119A	318.88	0.00	-0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	0.01	0.00	-0.00
119A	S	324.77	325.19	324.73	324.87	325.17	325.24	325.35	325.20	325.29	325.42	325.27	325.26	119	322.53	0.00	-0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	0.01	0.00	-0.00
121	I	325.72	326.38	326.35	325.81	326.15	326.71	326.50	326.29	326.53	326.74	326.57	325.26	121A	317.79	0.11	n/a	0.09	0.15	0.06	0.09	0.09	0.09	0.09	0.09	0.09	0.17	0.10
121A	S	326.44	damaged	326.99	326.84	326.58	327.30	327.13	326.94	327.15	327.34	327.19	326.38	121	324.59	0.11	n/a	0.09	0.15	0.06	0.09	0.09	0.09	0.09	0.09	0.09	0.17	0.10
122	I	325.93	326.30	326.07	325.96	326.14	326.30	326.30	326.13	326.28	326.38	326.26	327.01	122A	320.09	-0.03	-0.06	-0.04	-0.04	-0.05	-0.05	-0.05	-0.04	-0.05	-0.06	-0.05	-0.24	-0.06
122A	S	325.81	326.10	325.93	325.84	325.98	326.12	326.12	325.99	326.11	326.17	326.08	326.19	122	323.51	-0.03	-0.06	-0.04	-0.04	-0.05	-0.05	-0.05	-0.04	-0.05	-0.06	-0.05	-0.24	-0.06
123	VD	n/a	305.83	305.14	304.55	310.53	311.64	308.11	306.97		307.22		326.03	111	272.78	n/a	0.65	0.68	0.69	0.50	0.49	0.58	0.61				-0.04	0.52

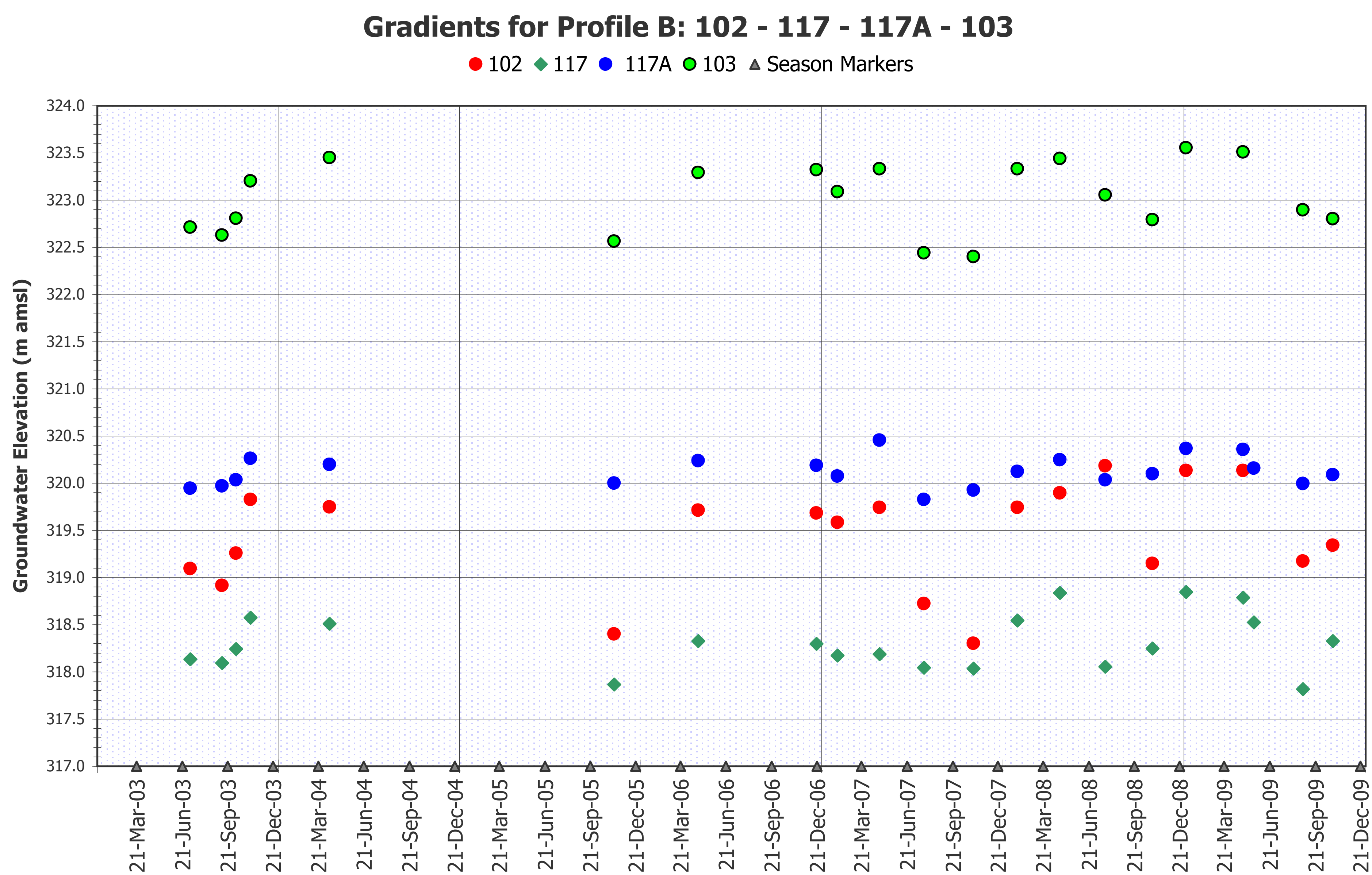
S=Shallow; I=Intermediate; D=Deep (Bedrock)



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph D 1**



Banks Groundwater Engineering Limited

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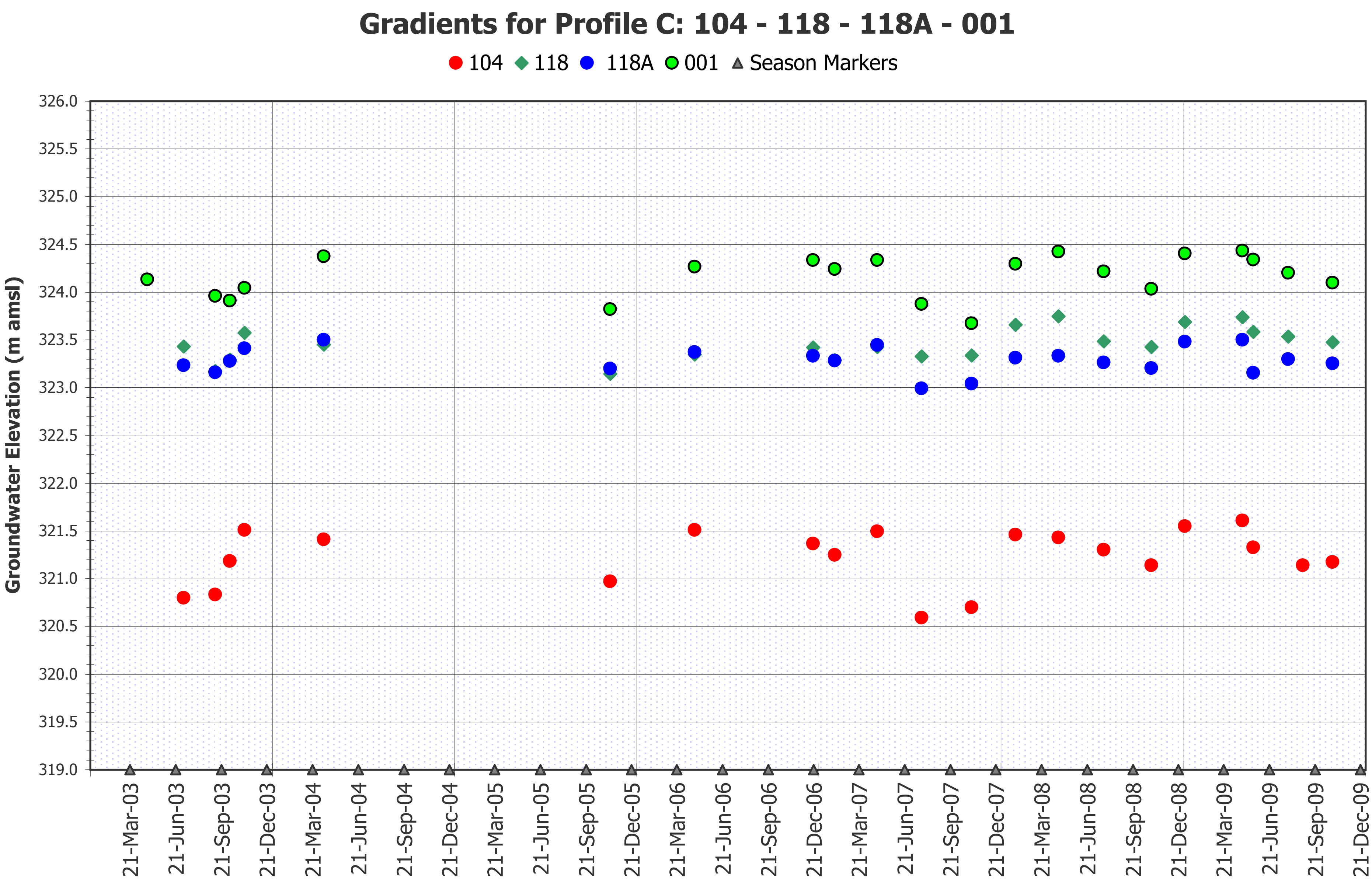
December 2009 **Graph D 2**



Banks Groundwater Engineering Limited

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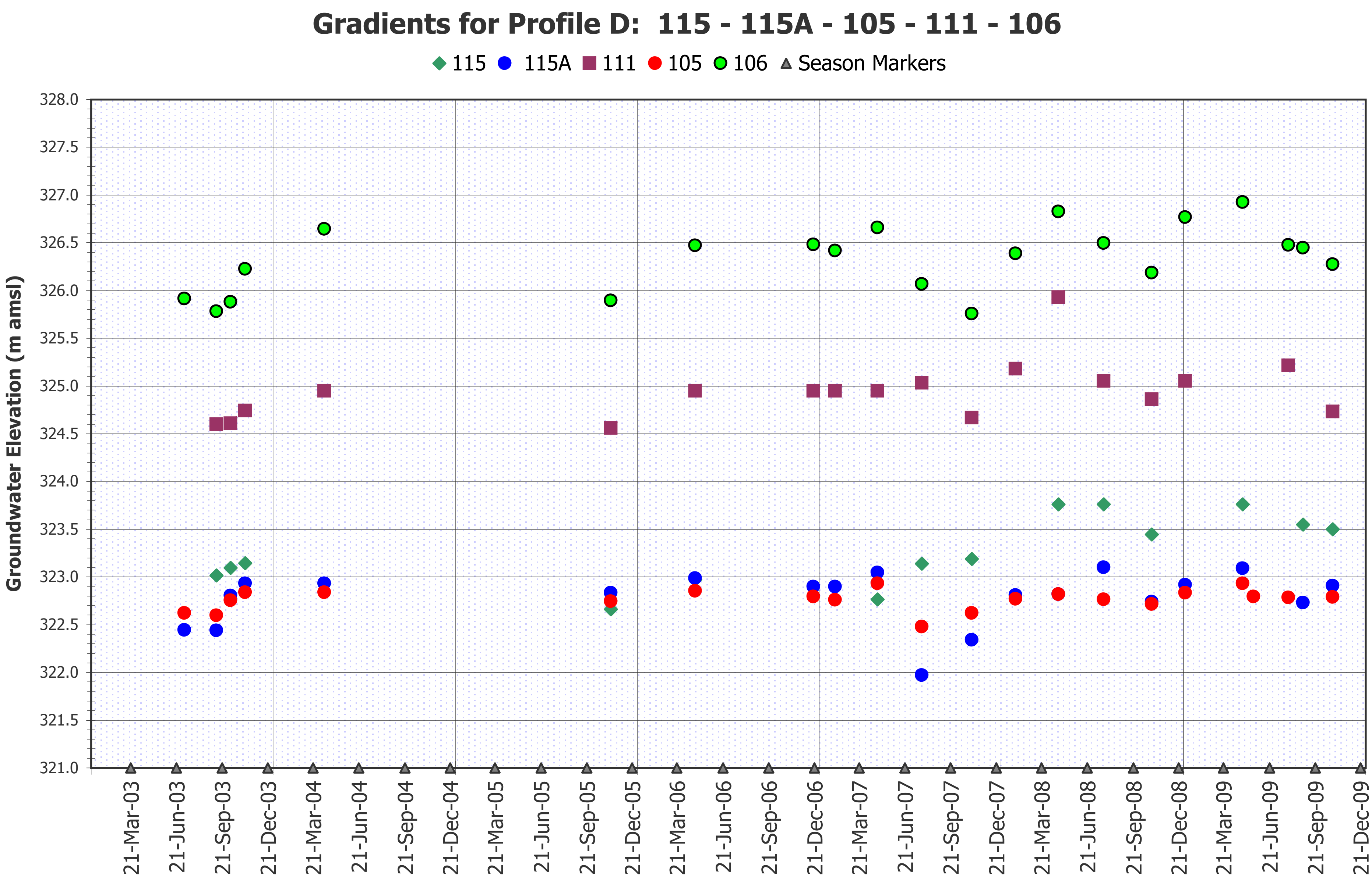
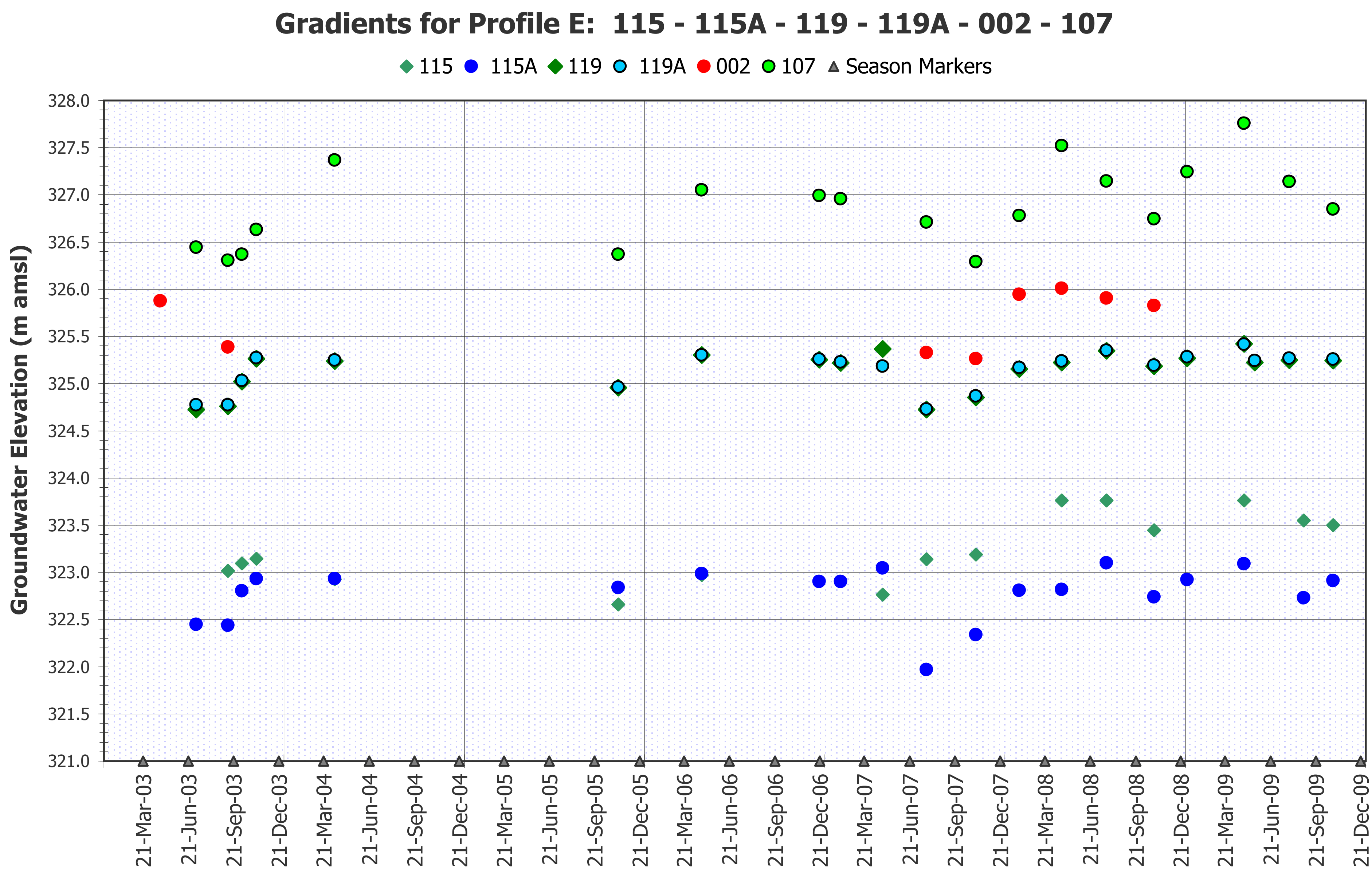
December 2009 **Graph D 3**



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

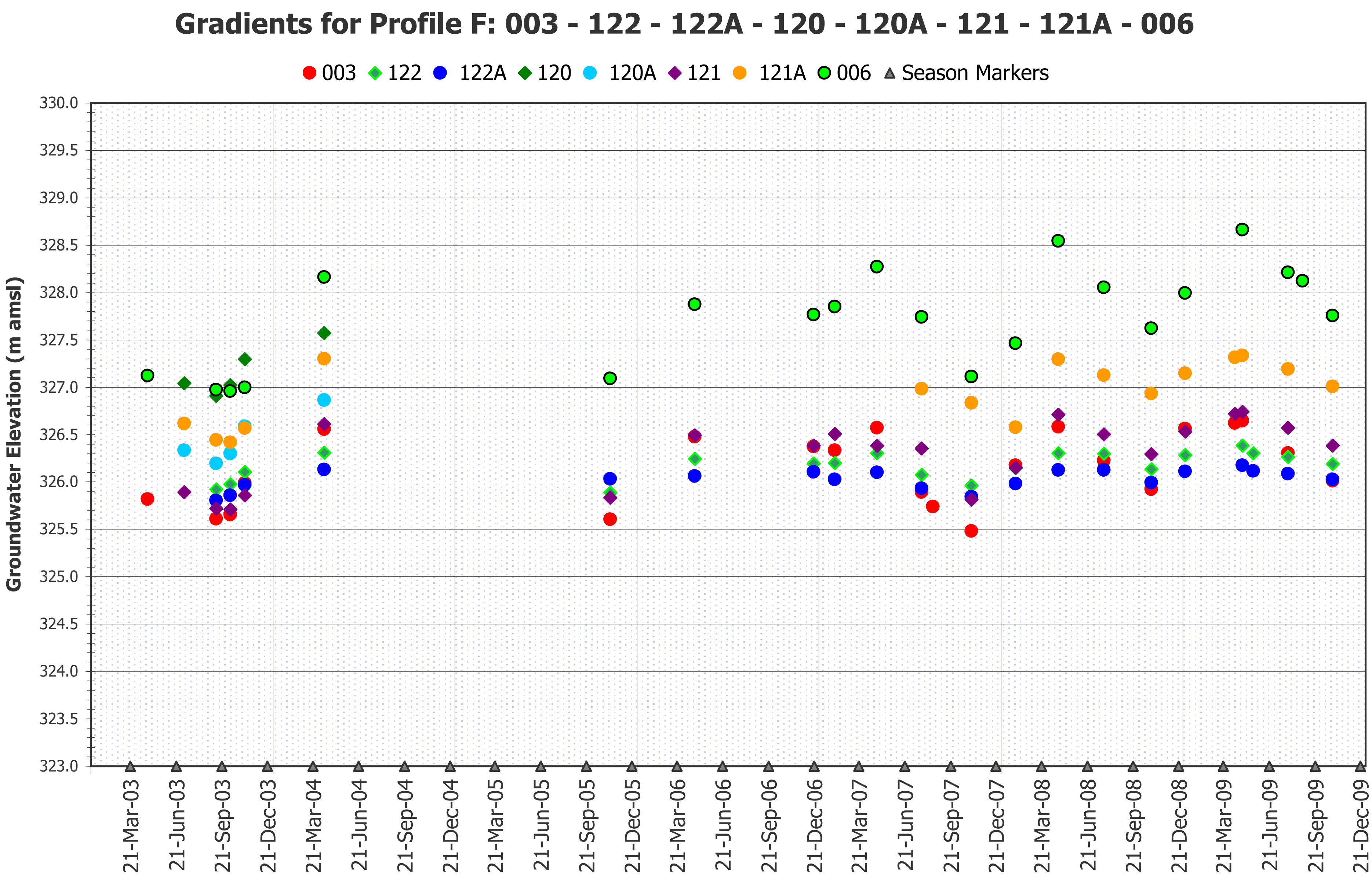
December 2009 **Graph D 4**



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

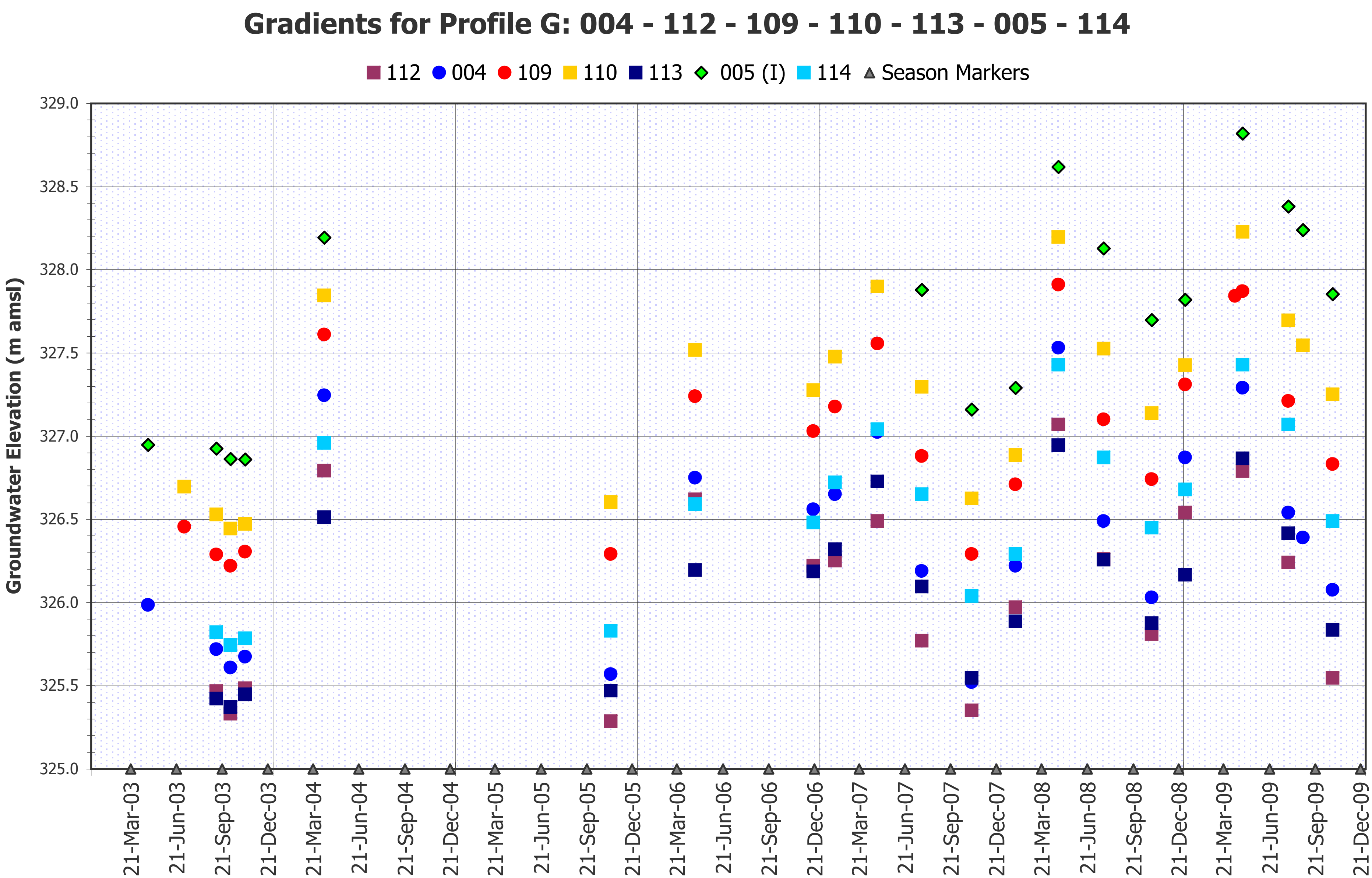
December 2009 **Graph D 5**



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

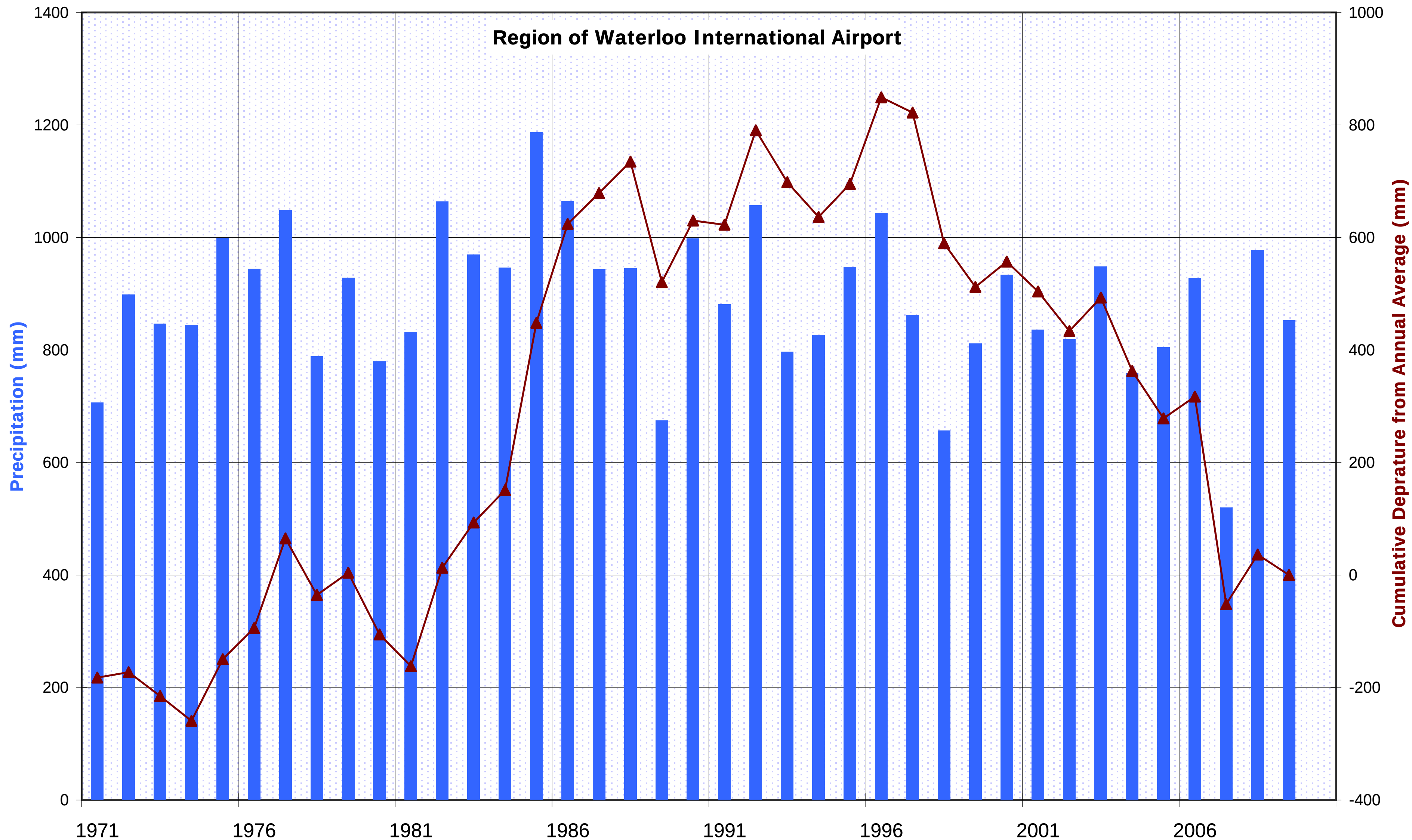
December 2009 **Graph D 6**



Gradients for Profile G: 004 - 112 - 109 - 110 - 113 - 005 - 114
112
004
109
110
113
005 (I)
114
Season Markers
Groundwater Elevation (m amsl)
329.0
328.5
328.0
327.5
327.0
326.5
326.0
325.5
325.0
21-Mar-03
21-Jun-03
21-Sep-03
21-Dec-03
21-Mar-04
21-Jun-04
21-Sep-04
21-Dec-04
21-Mar-05
21-Jun-05
21-Sep-05
21-Dec-05
21-Mar-06
21-Jun-06
21-Sep-06
21-Dec-06
21-Mar-07
21-Jun-07
21-Sep-07
21-Dec-07
21-Mar-08
21-Jun-08
21-Sep-08
21-Dec-08
21-Mar-09
21-Jun-09
21-Sep-09
21-Dec-09

Appendix E: Climate Monitoring

Annual Precipitation & Cumulative Departure from Annual Average - 1971 to 2009

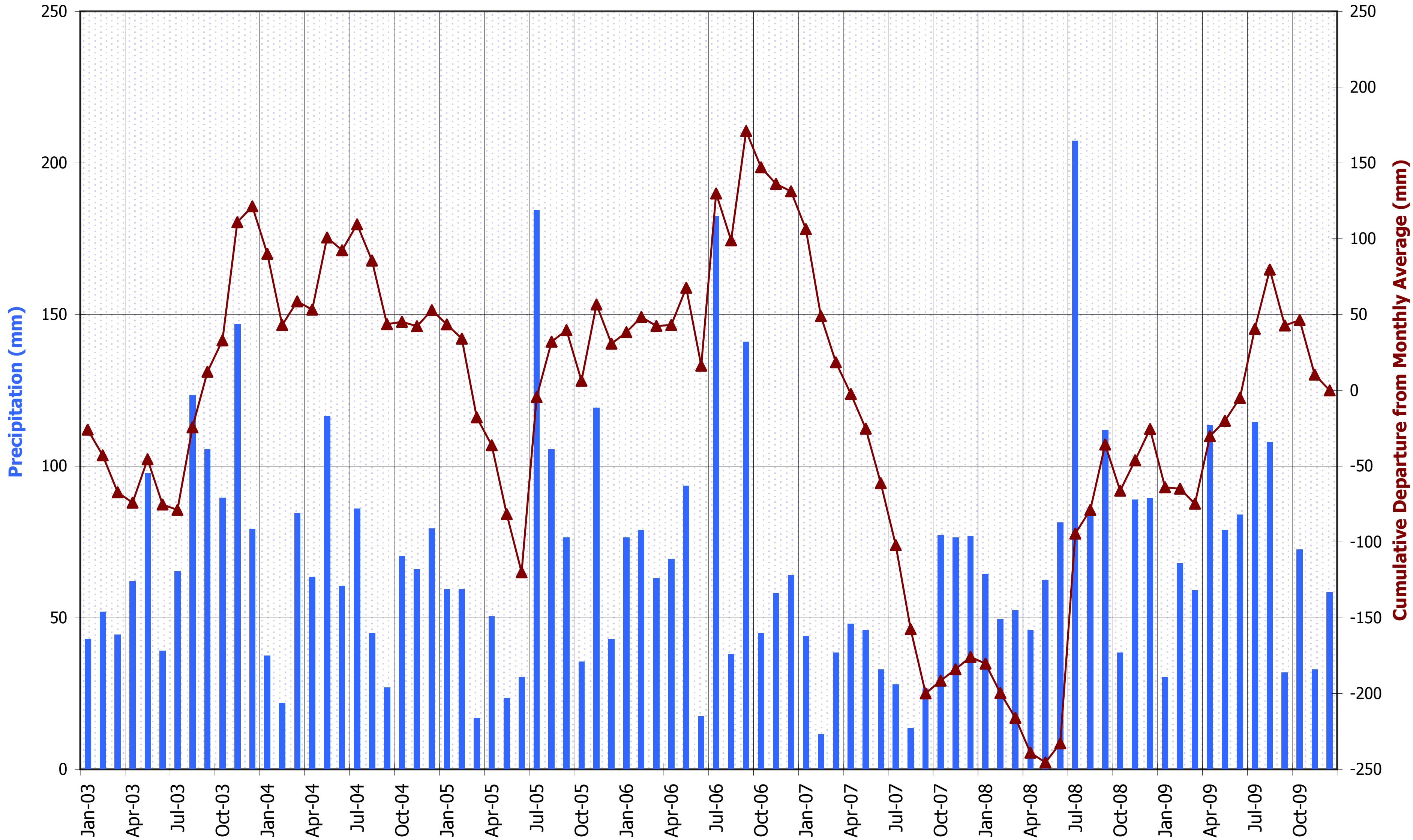


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph E 1**

Monthly Precipitation & Cumulative Departure from Monthly Average - 2003 to 2009



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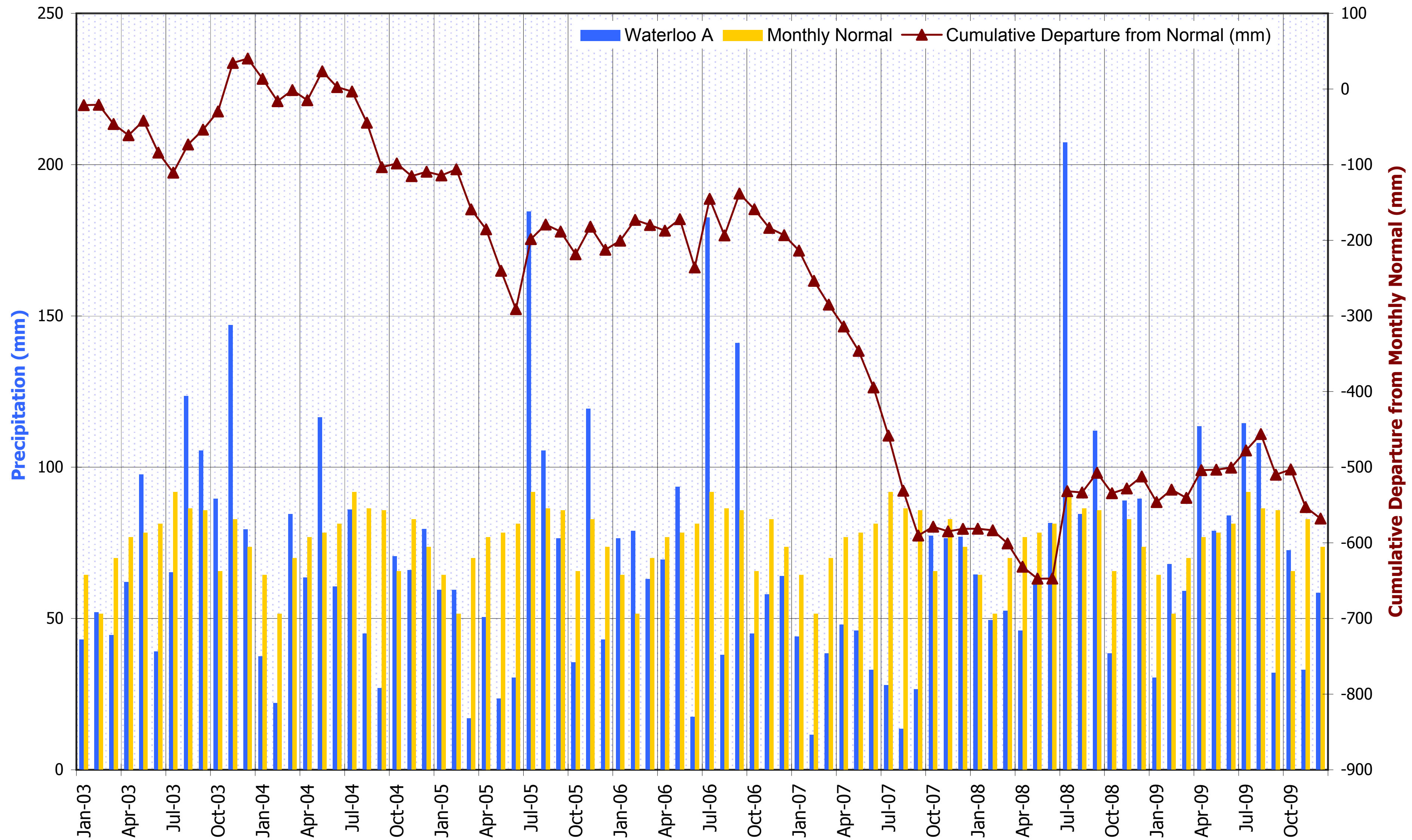
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph E 2**

Monthly Precipitation & Cumulative Departure from Monthly Normal - 2003 to 2009

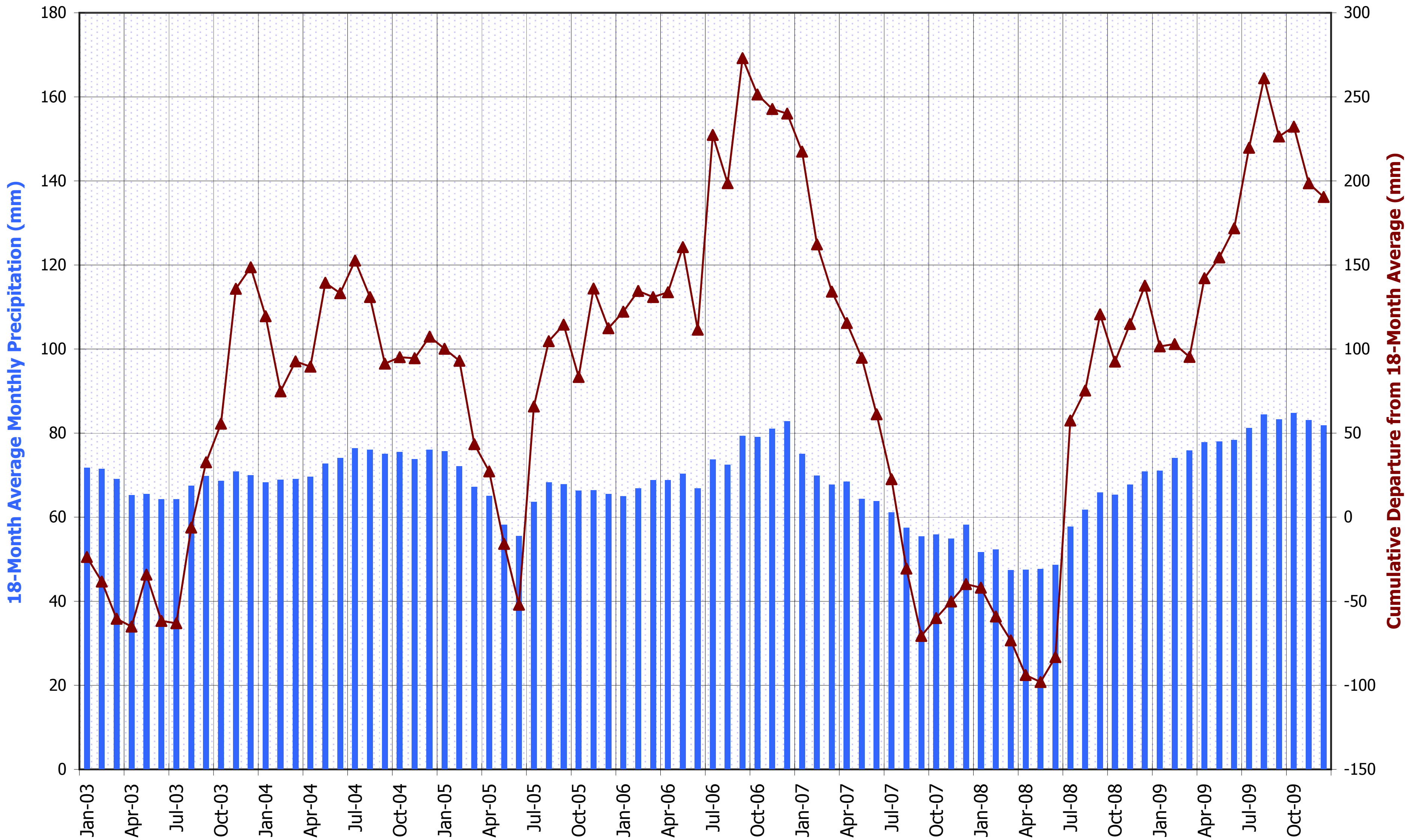


Banks Groundwater Engineering Limited

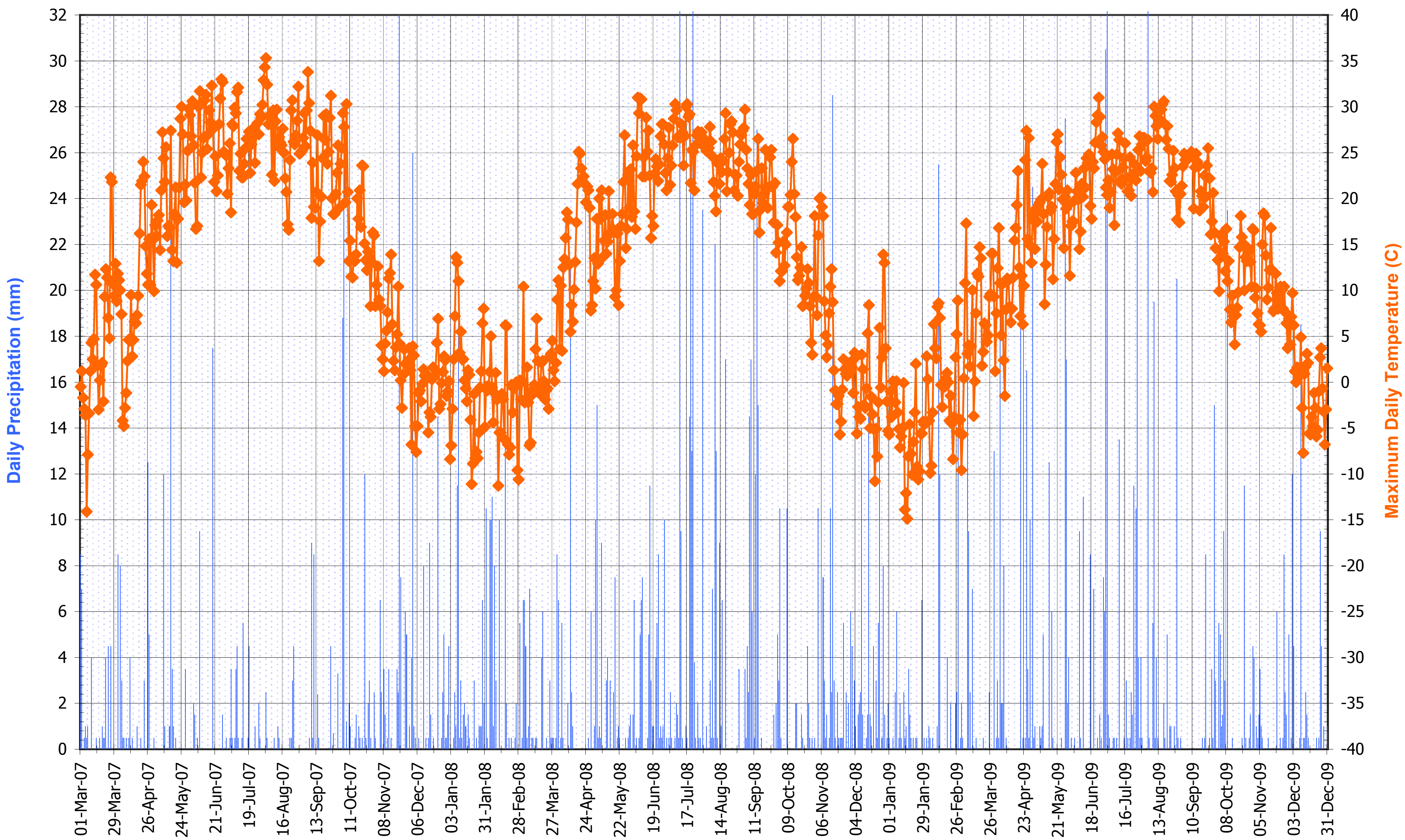
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph E 3**

18-Month Average Monthly Precipitation & Cumulative Departure from 18-Month Average - 2003 to 2009



Daily Precipitation & Maximum Daily Temperature: Waterloo International Airport (March 07 to December 09)



Banks Groundwater Engineering Limited

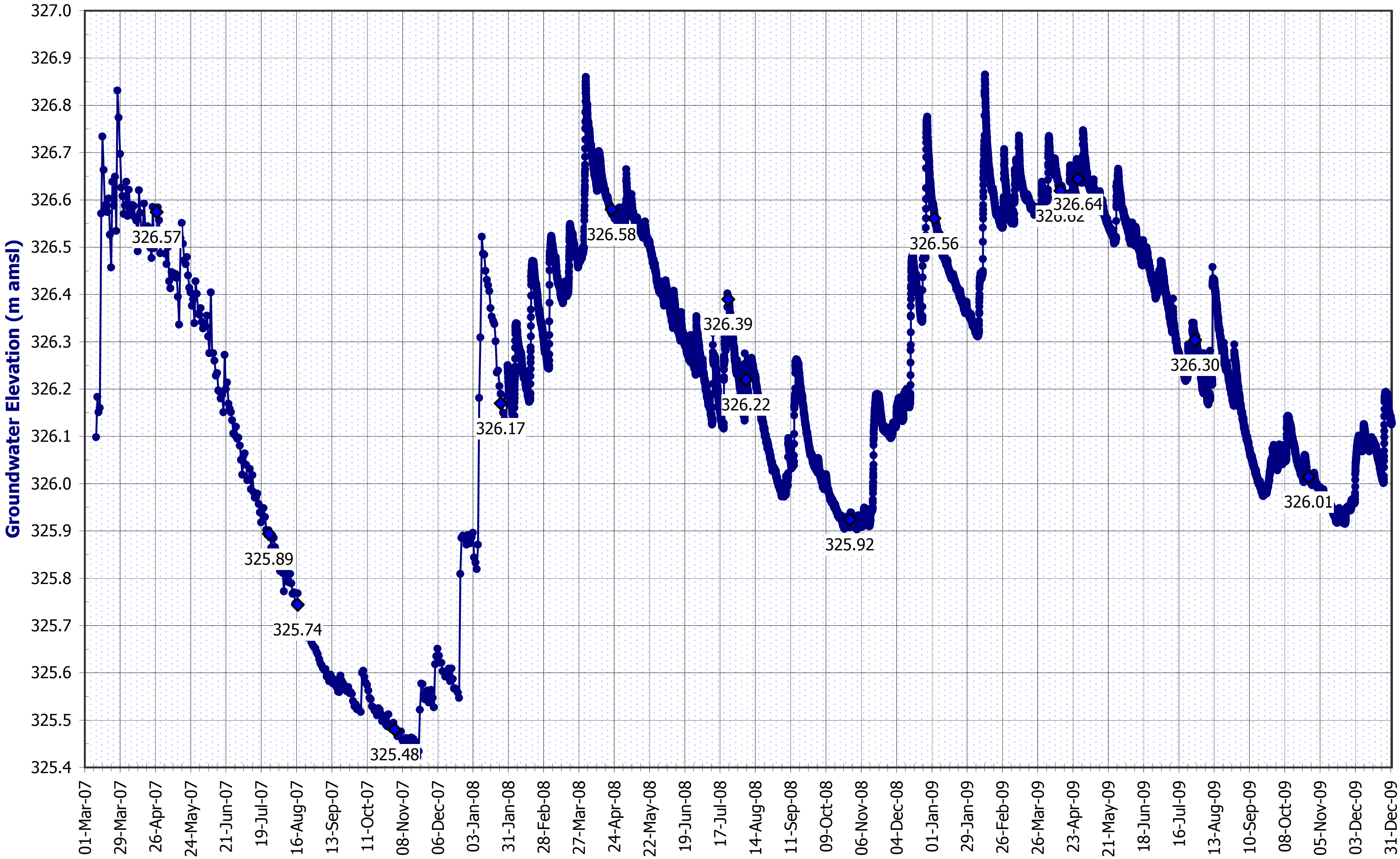
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009

Graph E 5

Appendix F: Downey Road PSW Groundwater Monitoring

Groundwater Elevation: MW003 (March 07 to December 09)

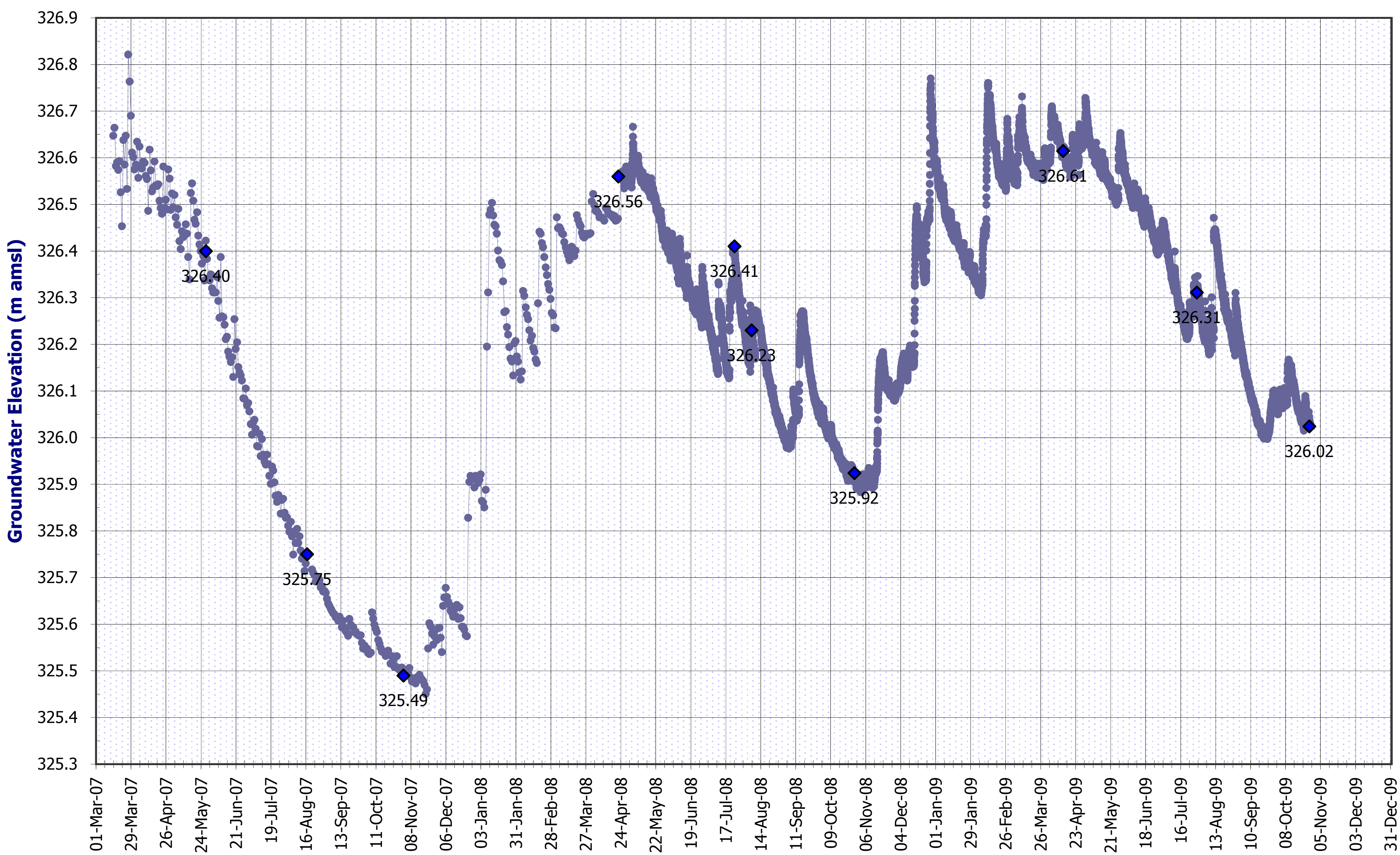


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph F 1**

Groundwater Elevation: PZ-9D (March 07 to October 09)

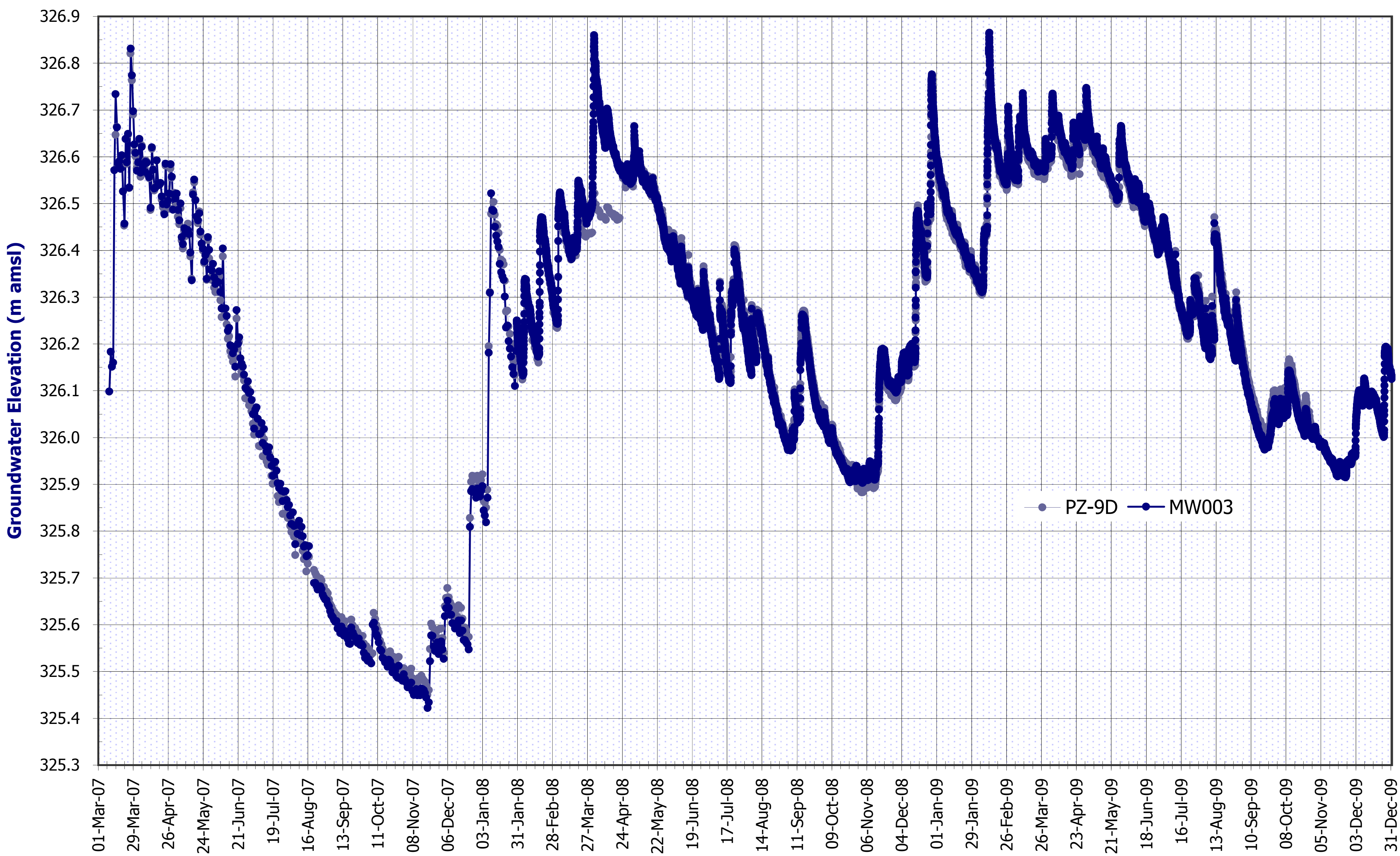


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph F 2**

Groundwater Elevation: MW003 & PZ-9D (March 07 to December 09)

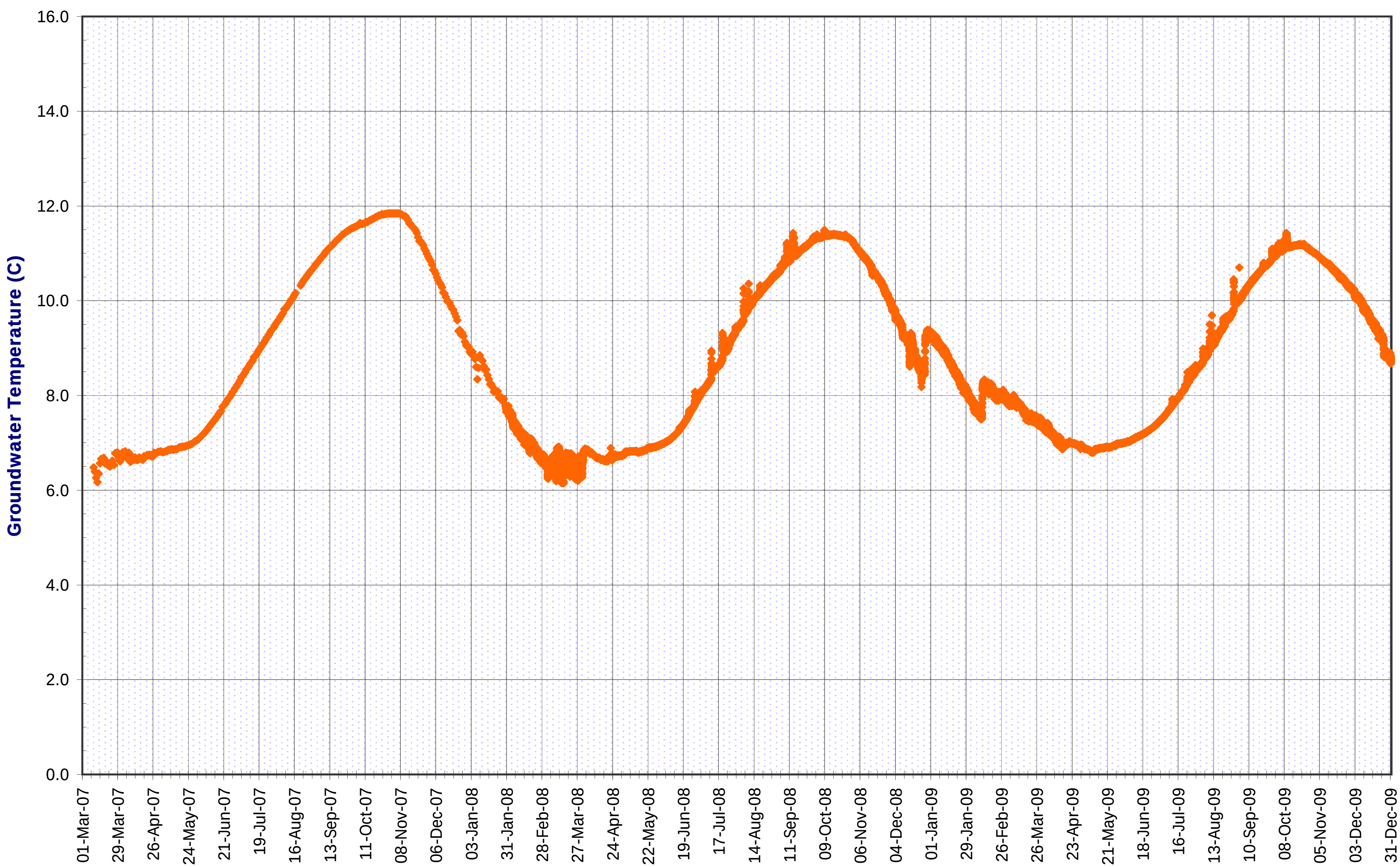


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph F 3**

Groundwater Temperature: MW003 (March 07 to December 09)

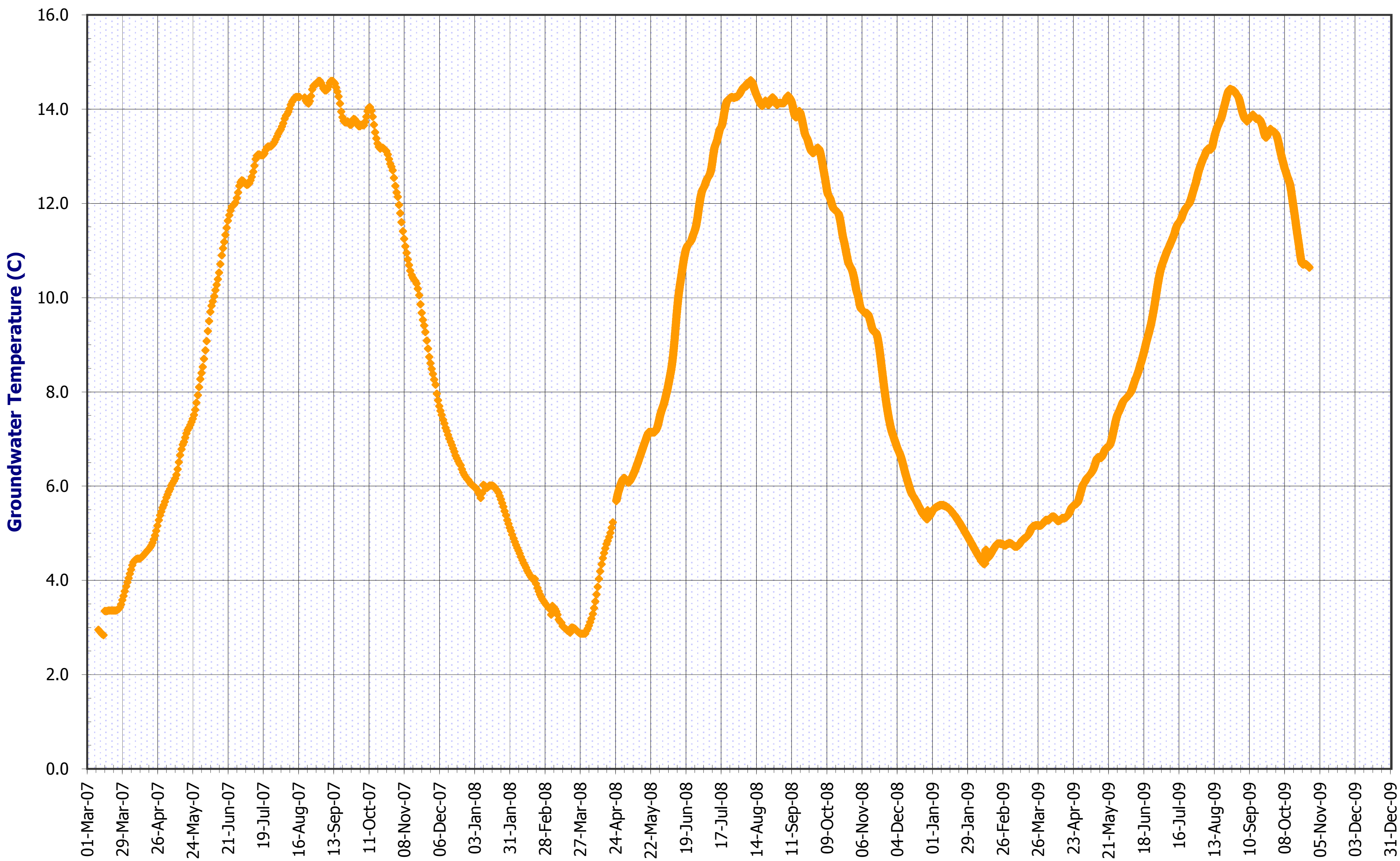


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph F 1a**

Groundwater Temperature: PZ-9D (March 07 to October 09)

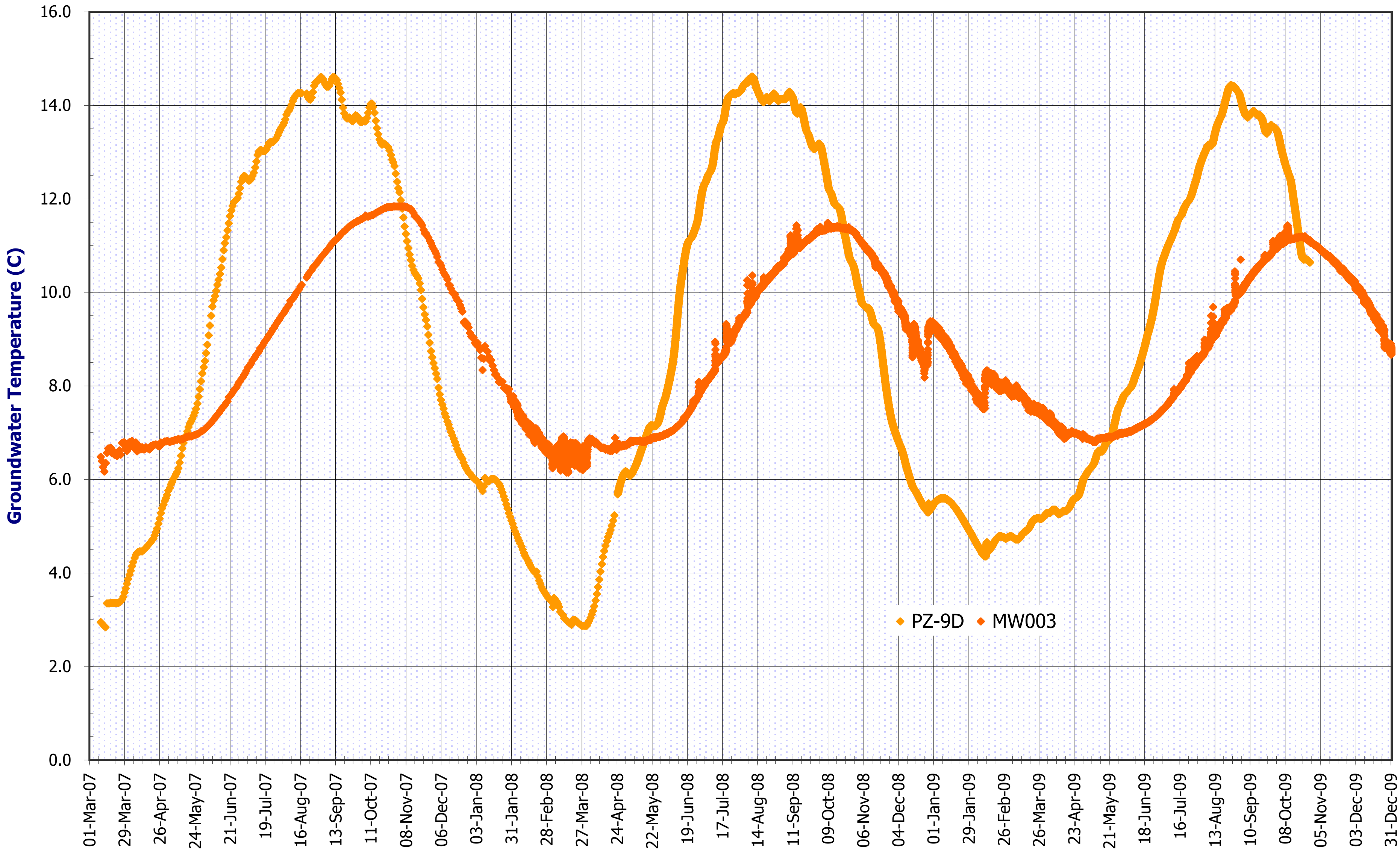


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph F 2a**

Groundwater Temperature: MW003 & PZ-9D (March 07 to December 09)

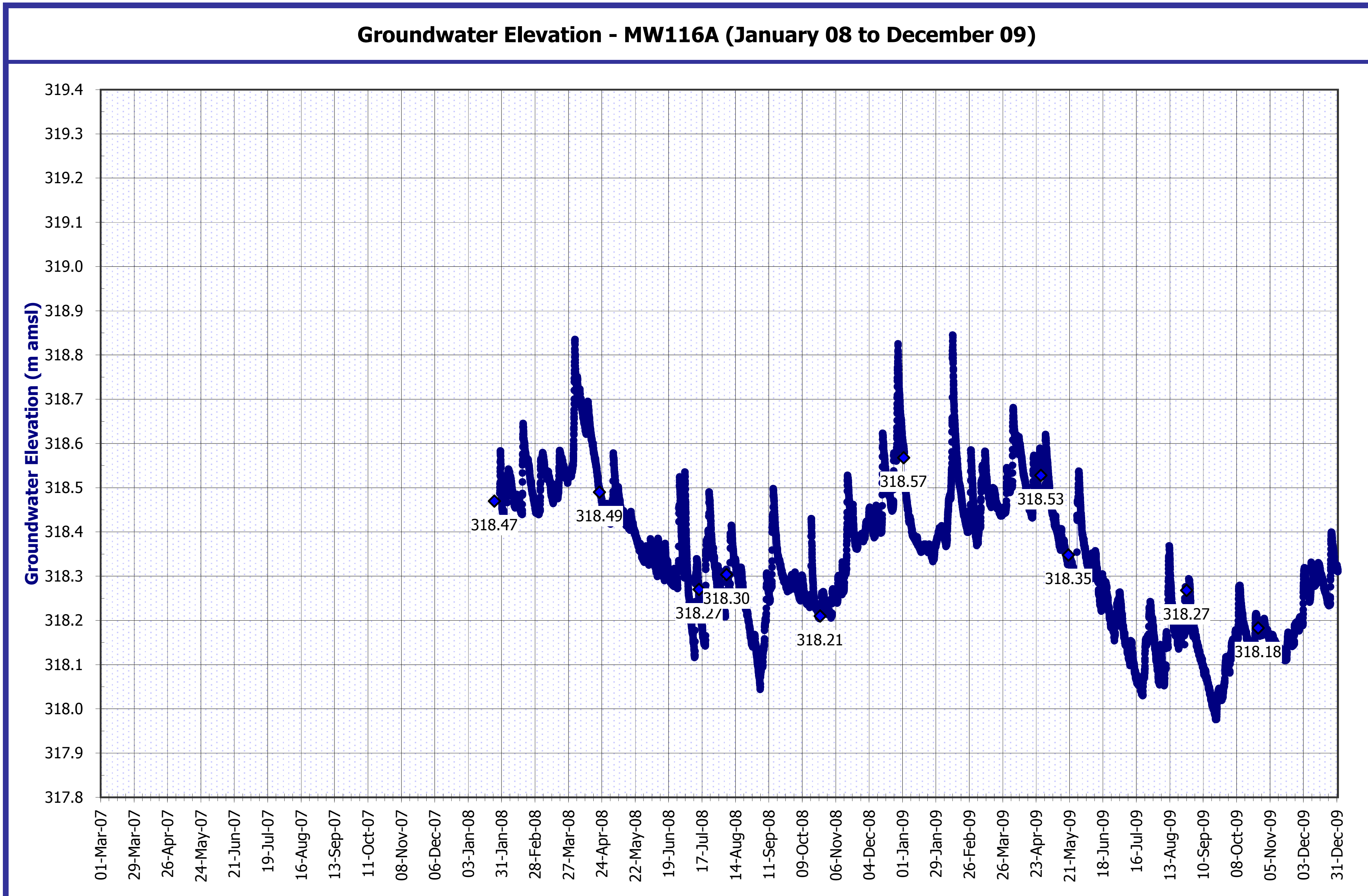


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph F 3a**

Appendix G: HCBP Core PSW Groundwater Monitoring

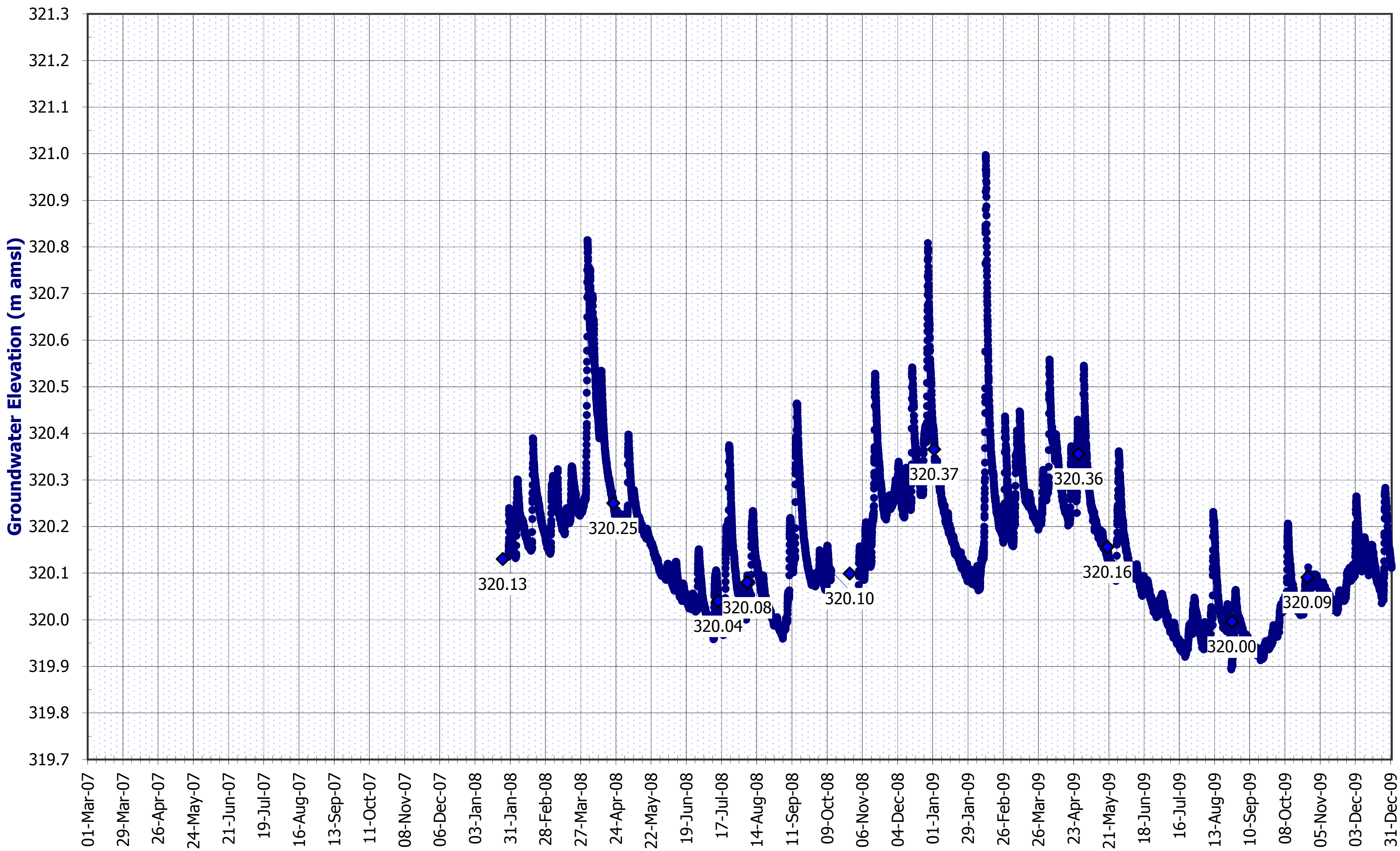


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 1**

Groundwater Elevation - MW117A (January 08 to December 09)

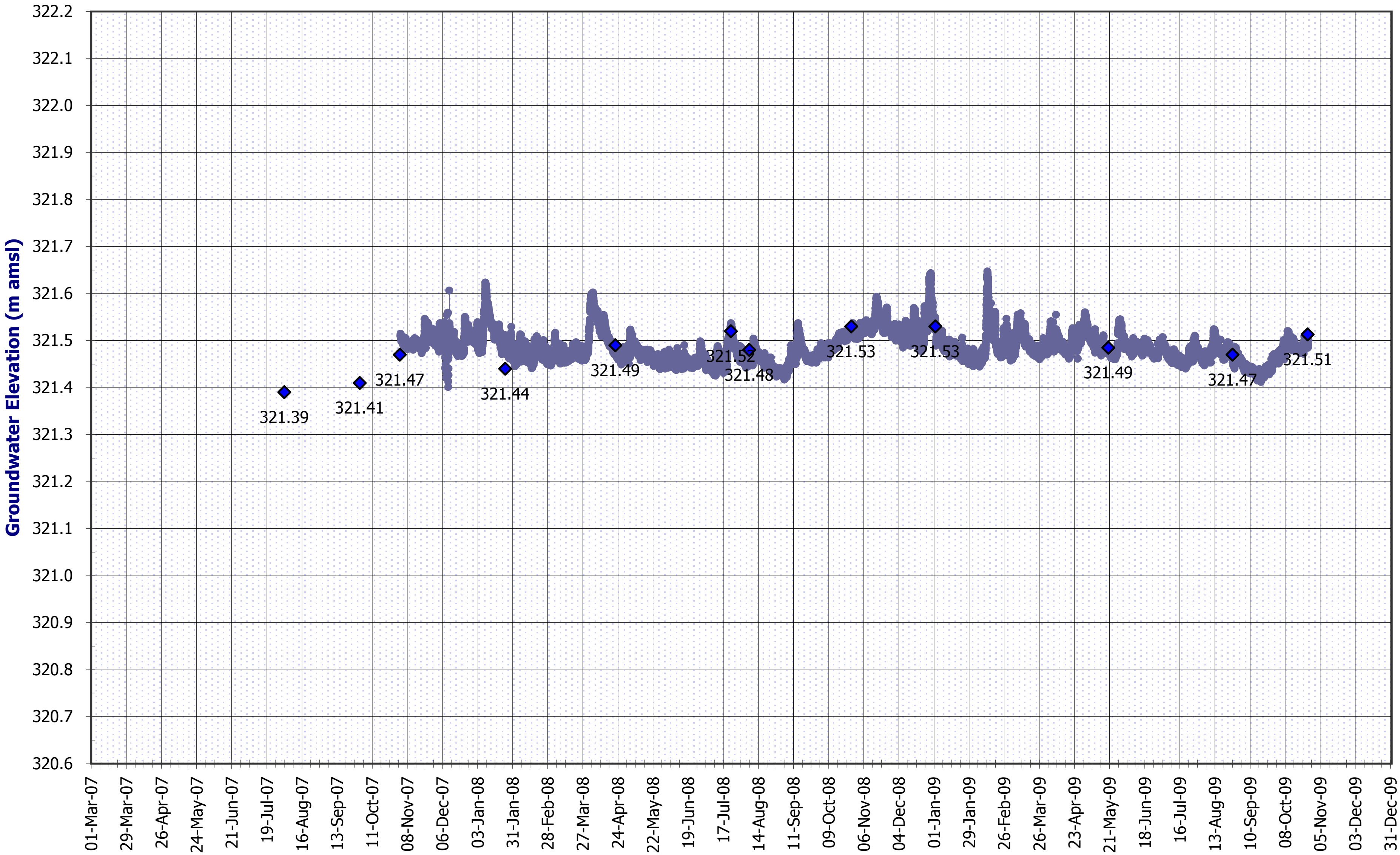


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 2**

Groundwater Elevation: PZ-7D (August 07 to October 09)

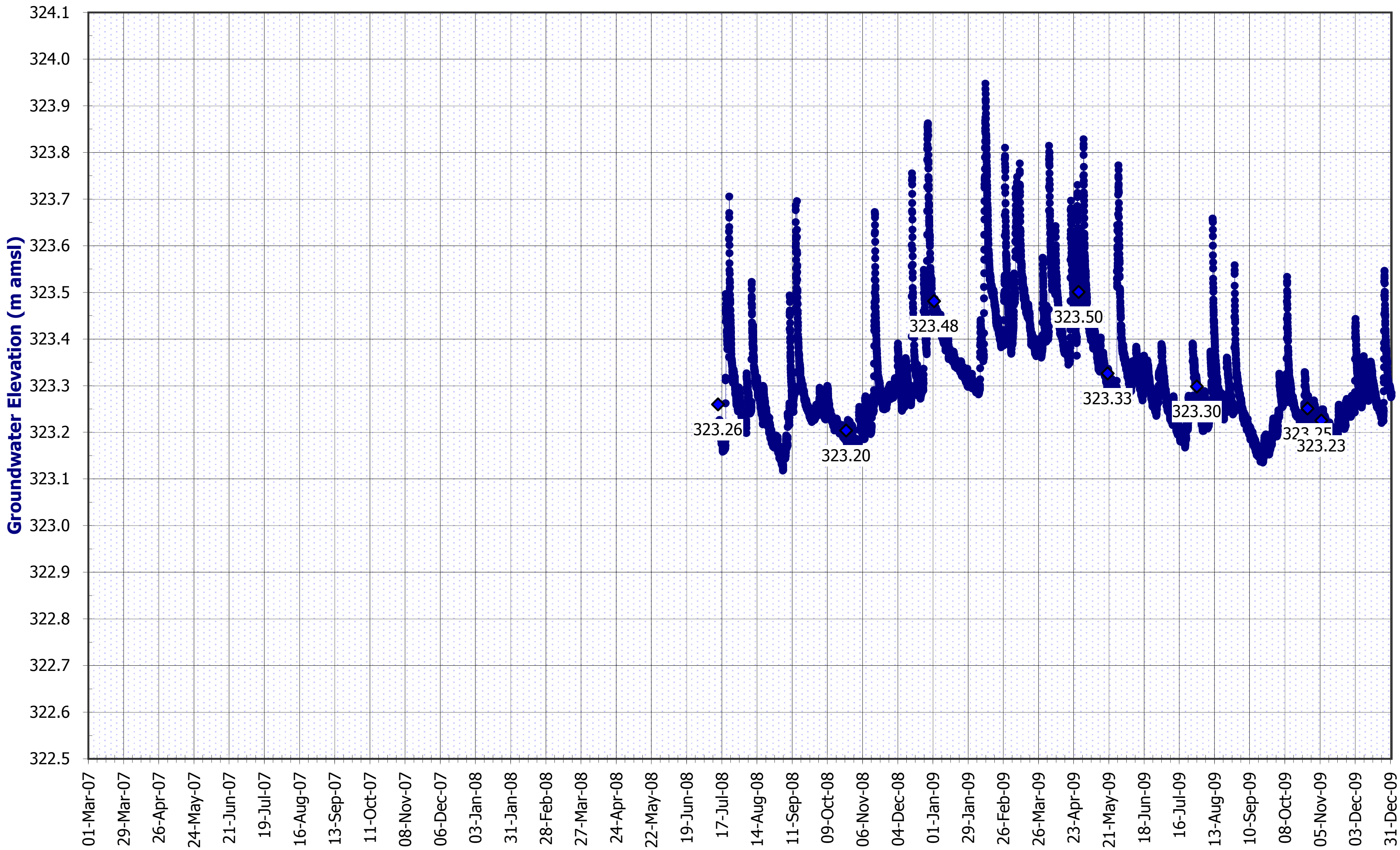


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 3**

Groundwater Elevation - MW118A (July 08 to December 09)

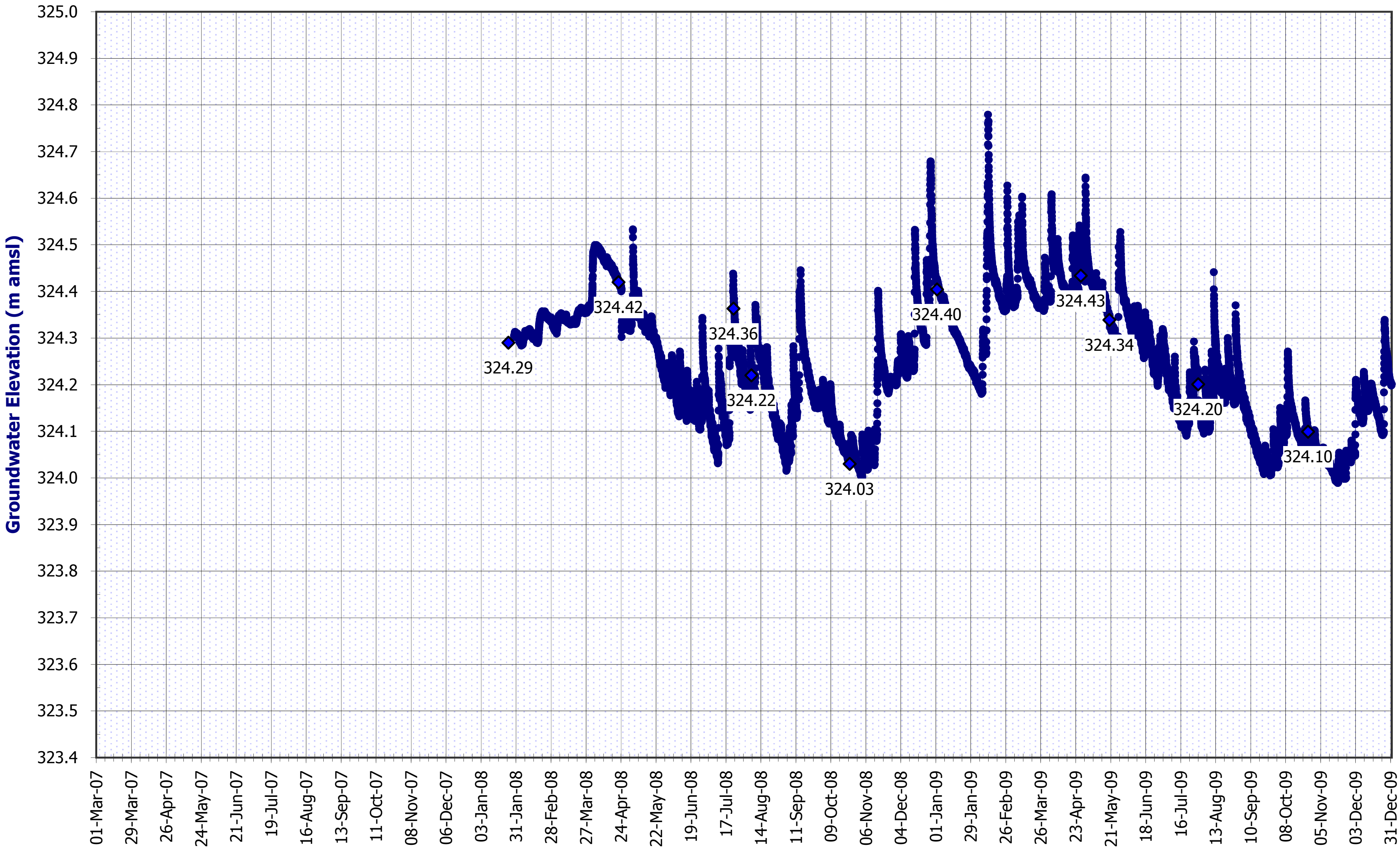


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 4**

Groundwater Elevation: MW001 (January 08 to December 09)

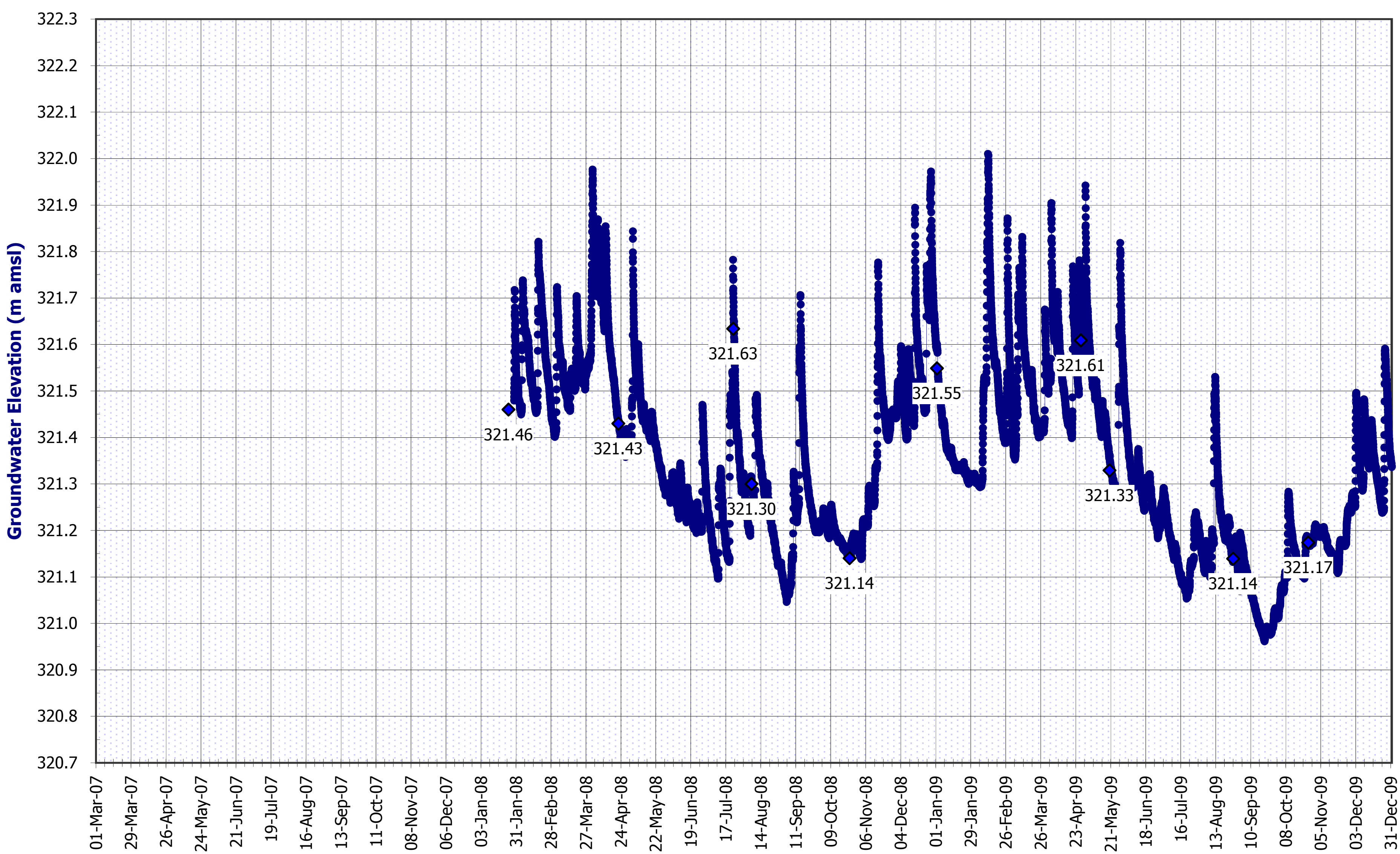


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 5**

Groundwater Elevation - MW104 (January 08 to December 09)

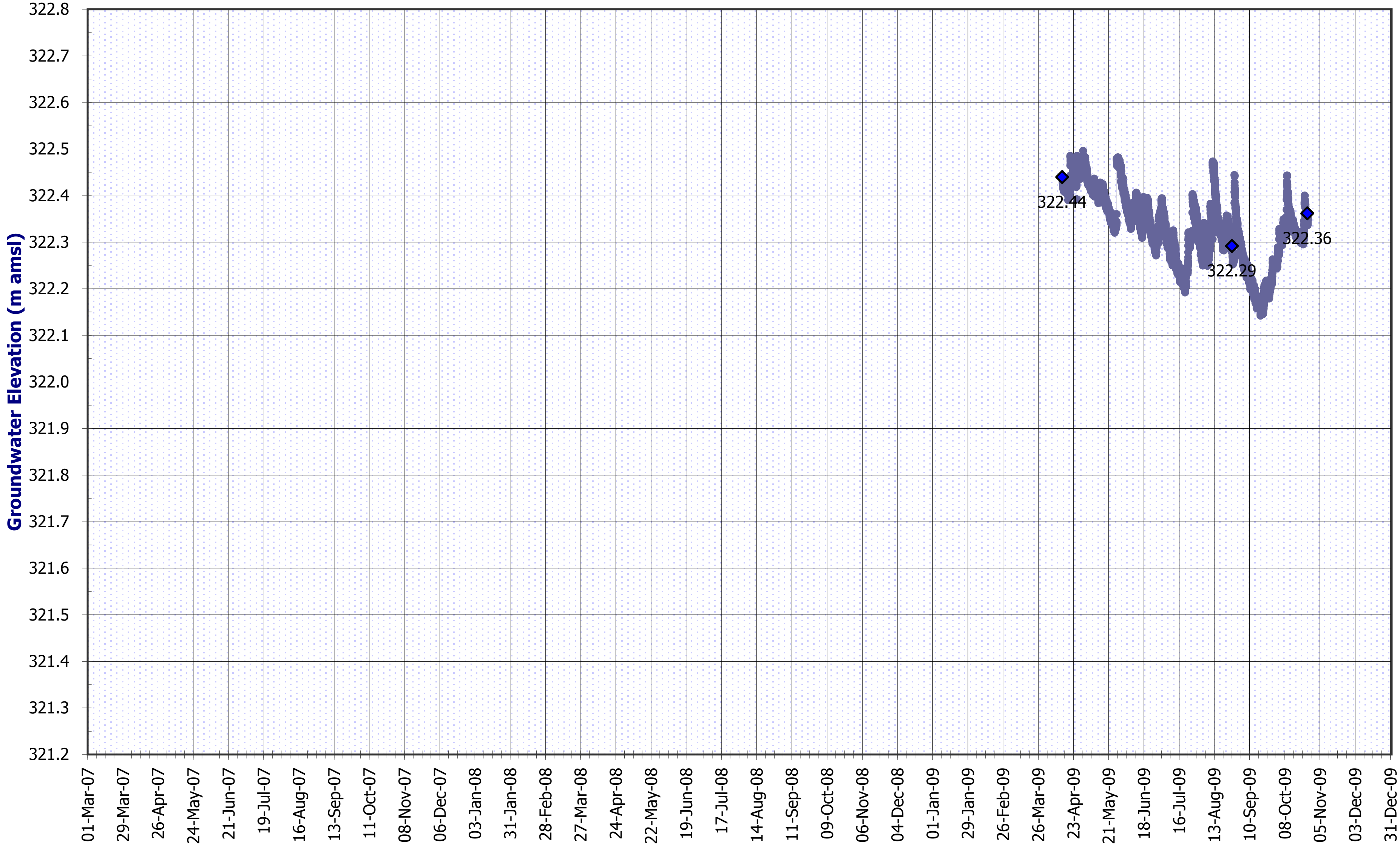


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 6**

Groundwater Elevation - PZ-4D (April 09 to October 09)



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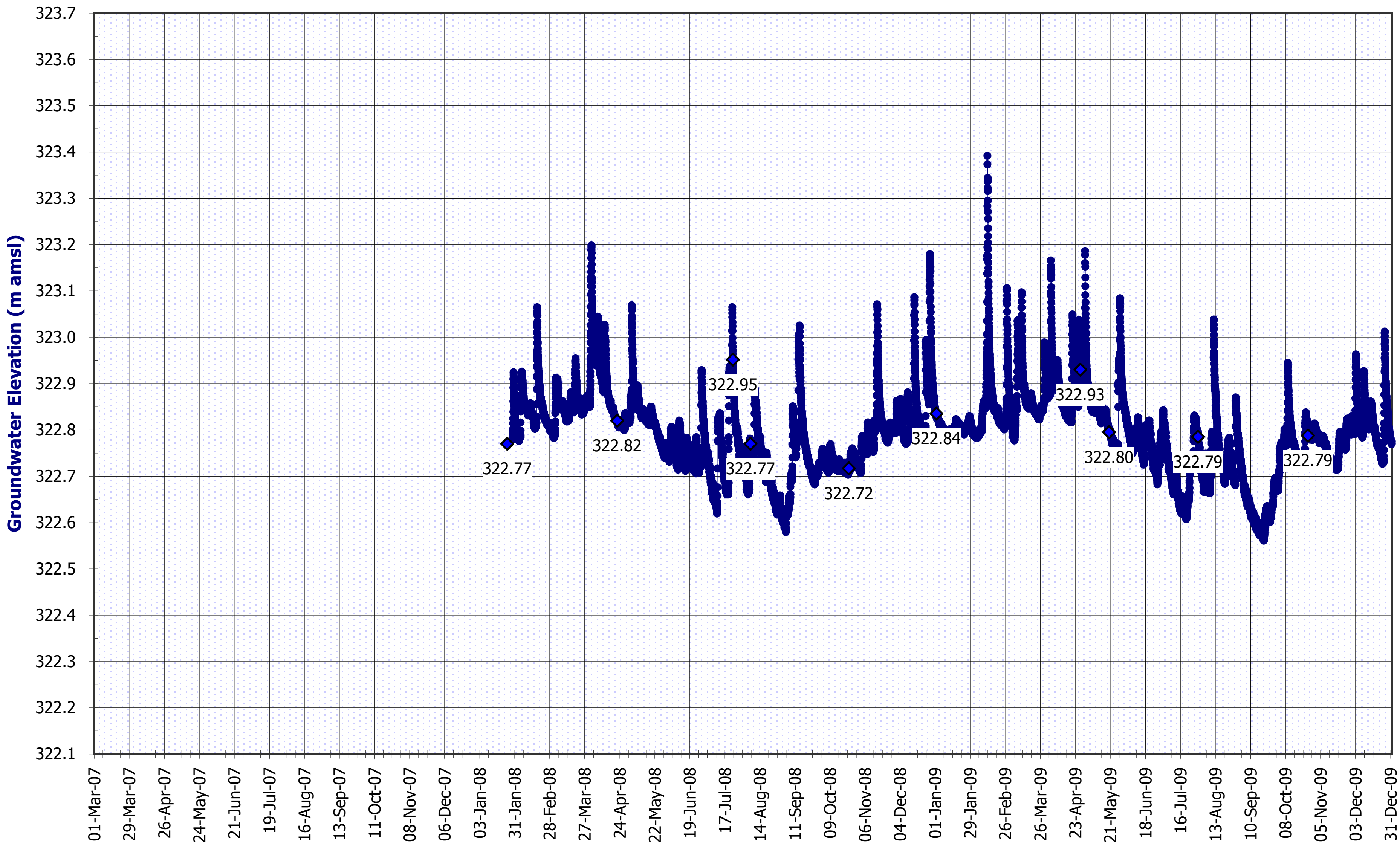
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 7**

Groundwater Elevation - MW105 (January 08 to December 09)

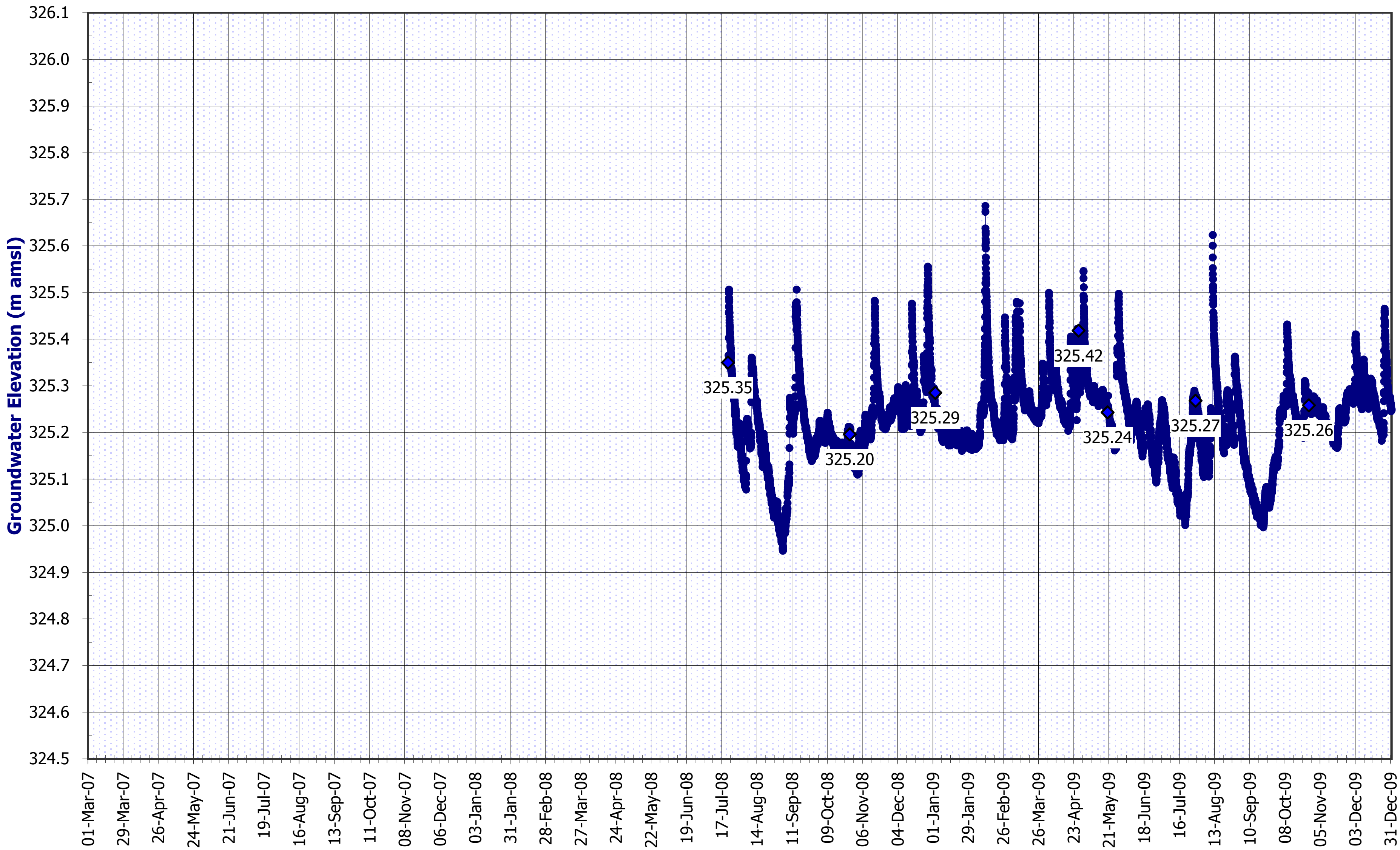


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 8**

Groundwater Elevation - MW119A (July 08 to December 09)

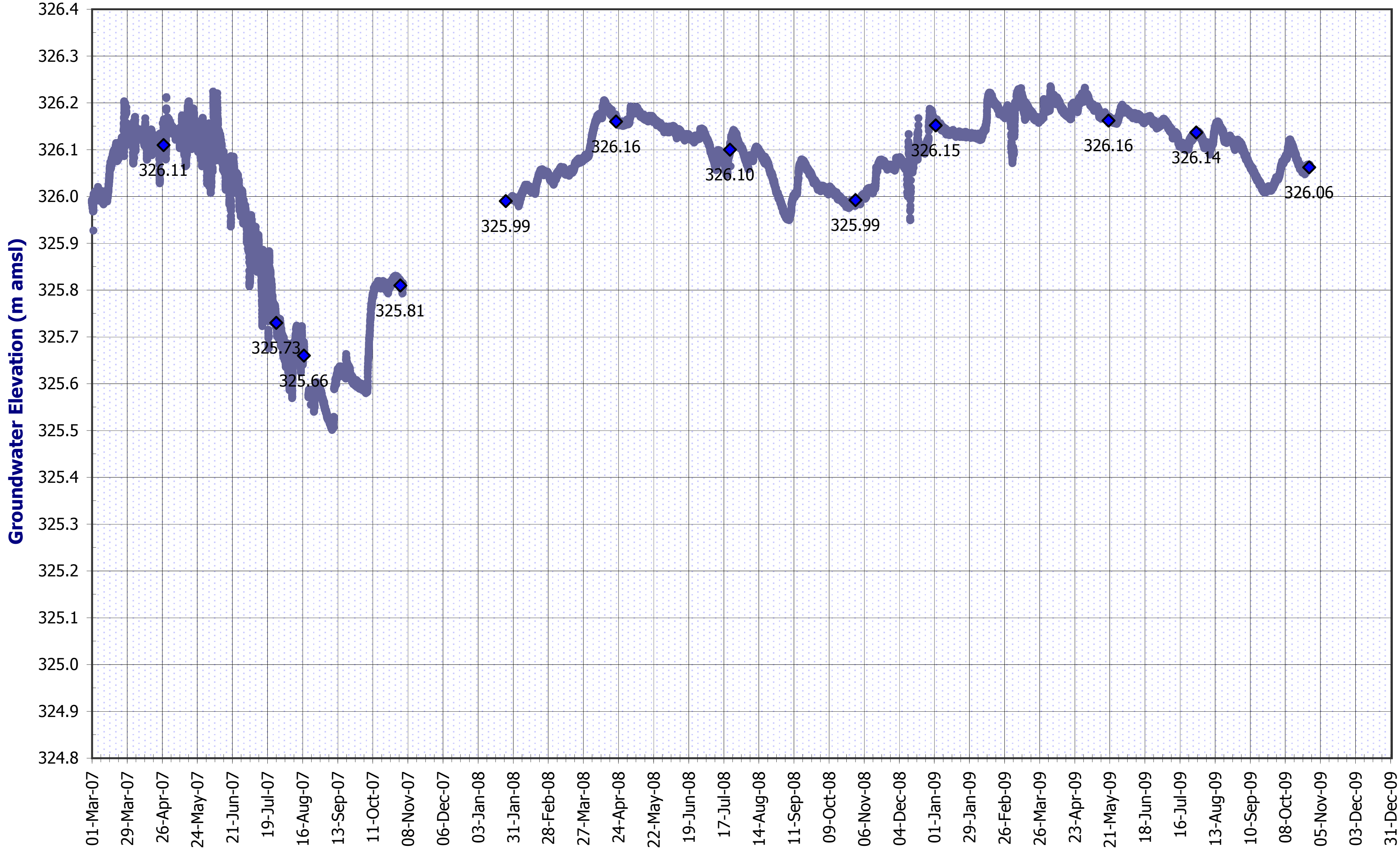


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 9**

Groundwater Elevation: PZ-2D (March 07 to October 09)

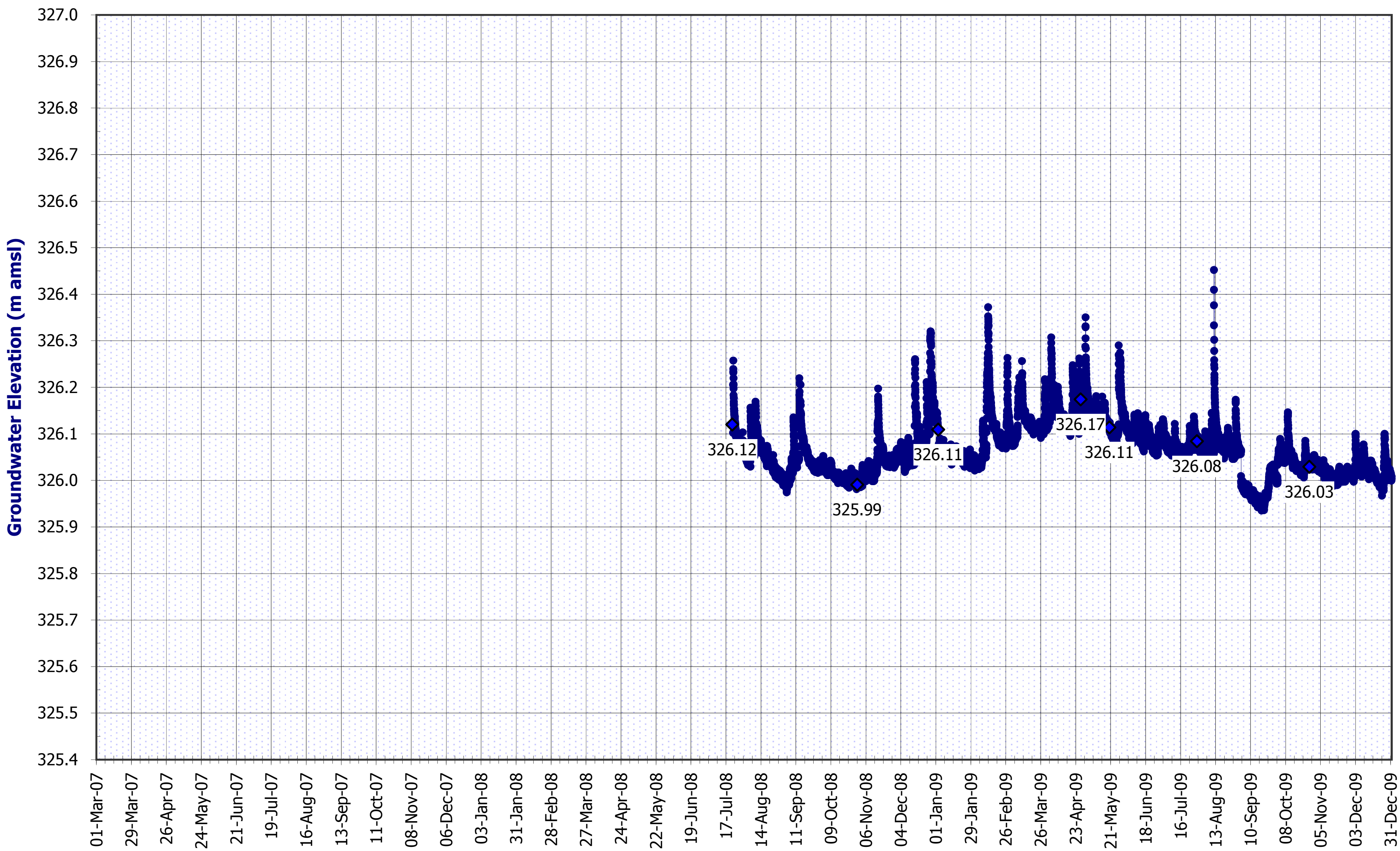


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 10**

Groundwater Elevation - MW122A (July 08 to December 09)

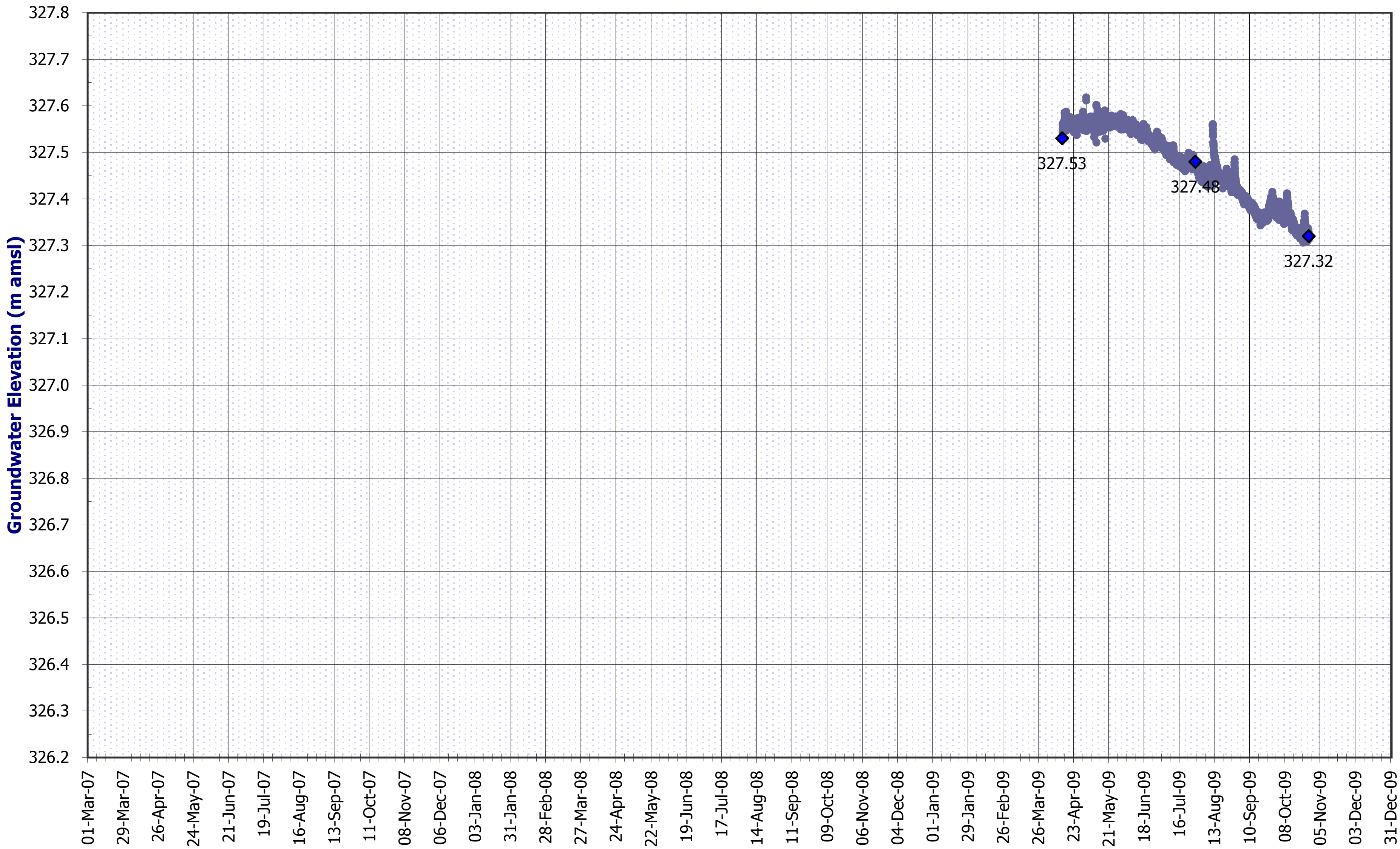


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 11**

Groundwater Elevation - PZ-1D (April 09 to October 09)

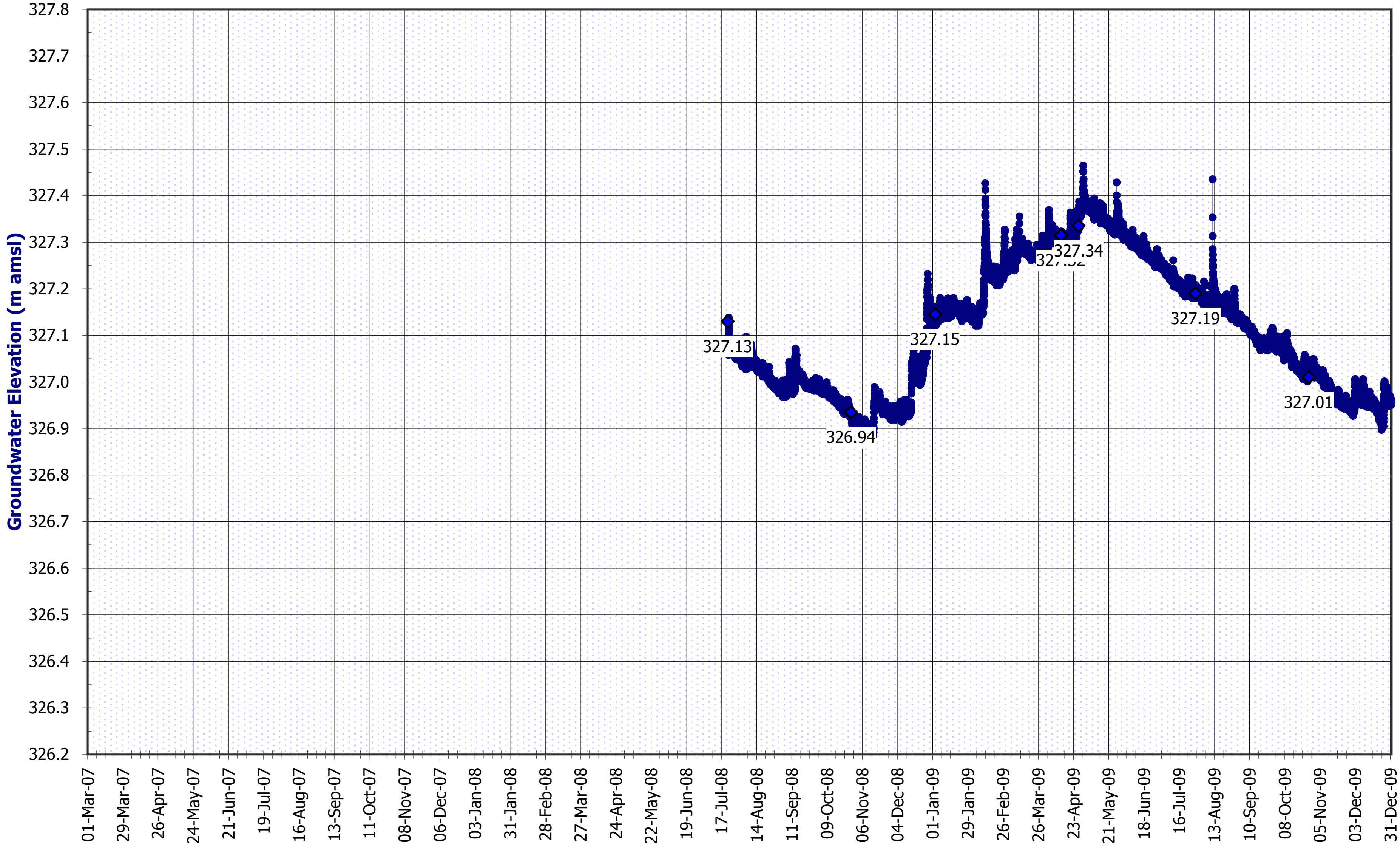


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 12**

Groundwater Elevation - MW121A (July 08 to December 09)

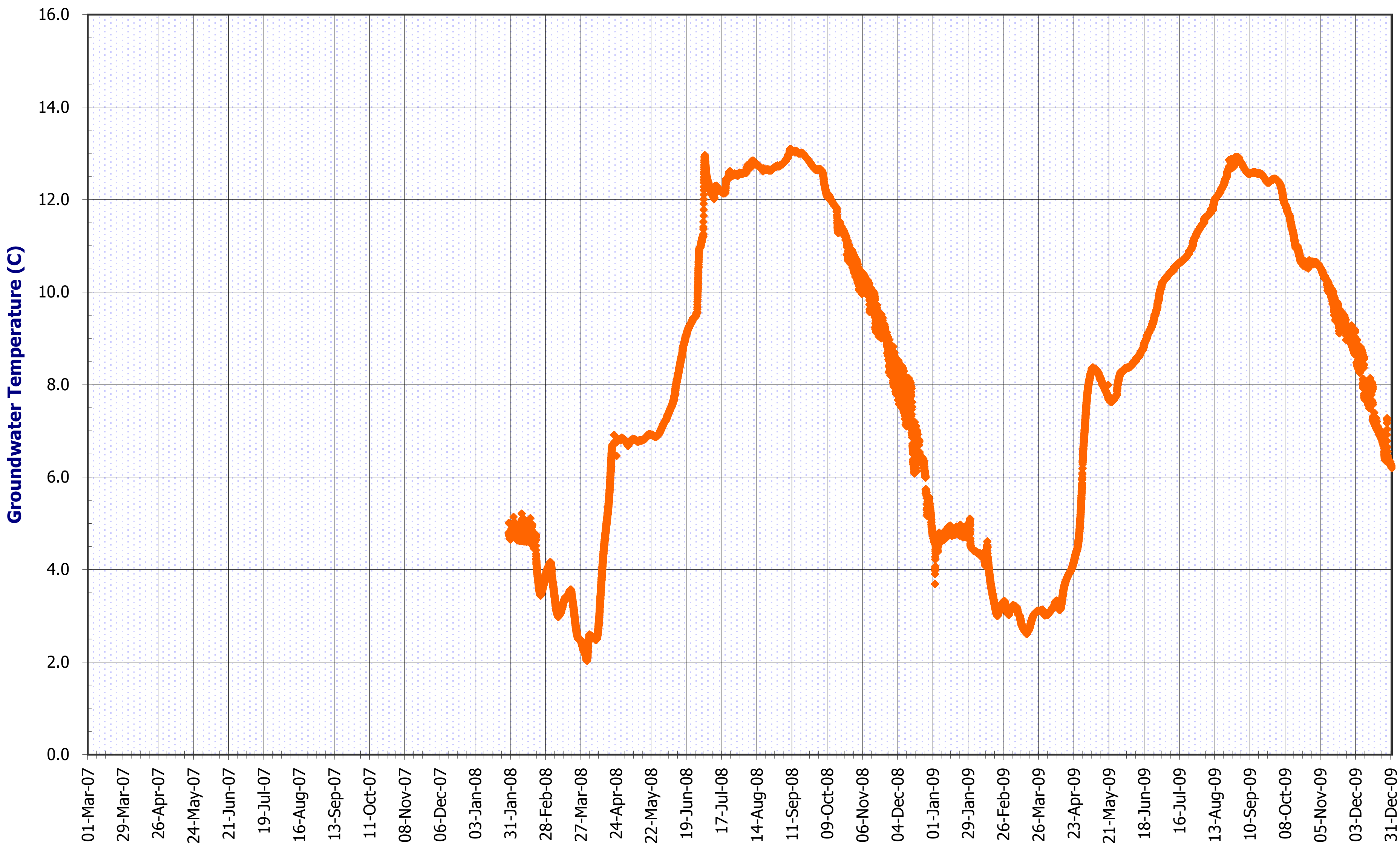


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 13**

Groundwater Temperature - MW116A (January 08 to December 09)

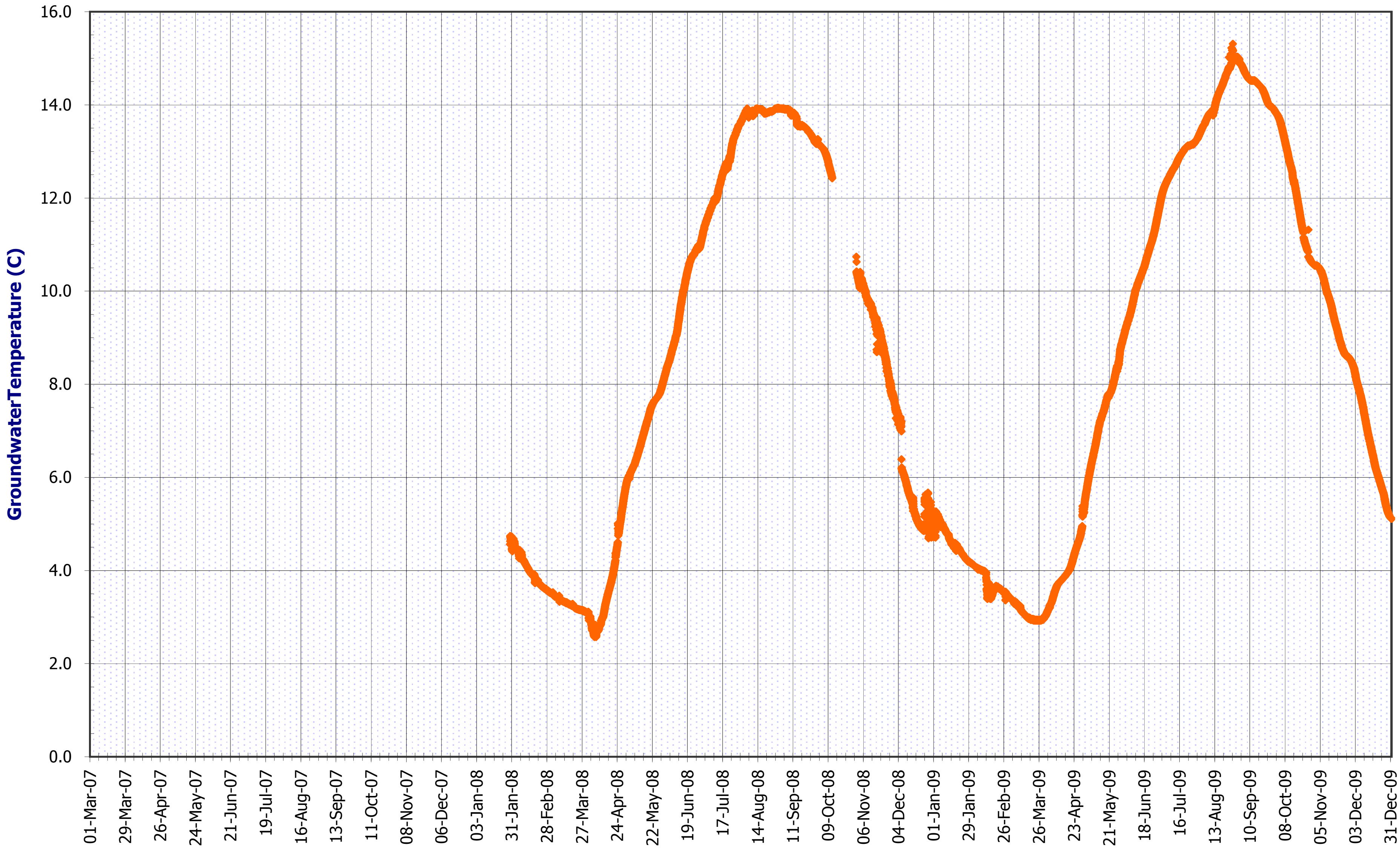


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 1a**

Groundwater Temperature - MW117A (January 08 to December 09)

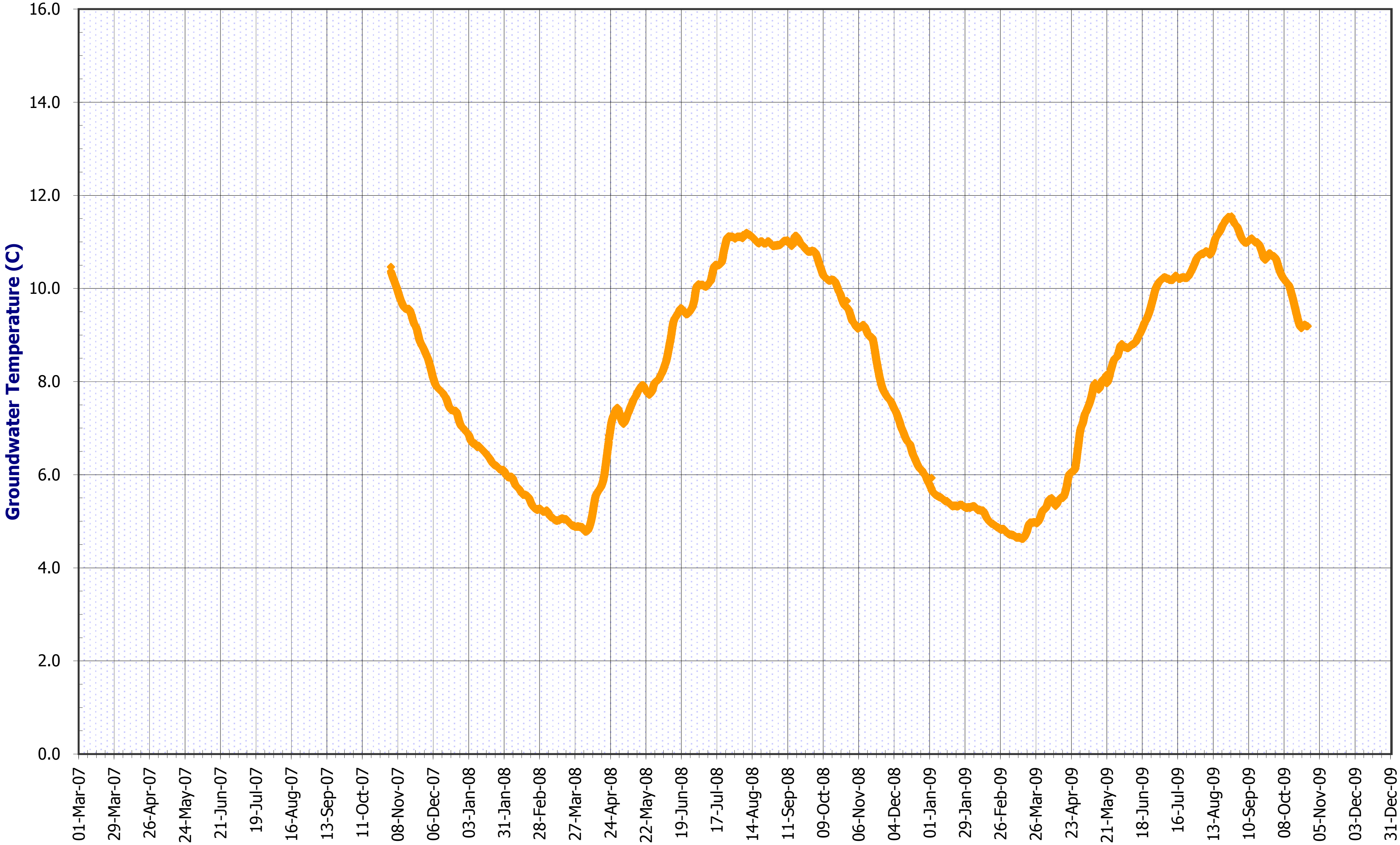


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 2a**

Groundwater Temperature: PZ-7D (August 07 to October 09)

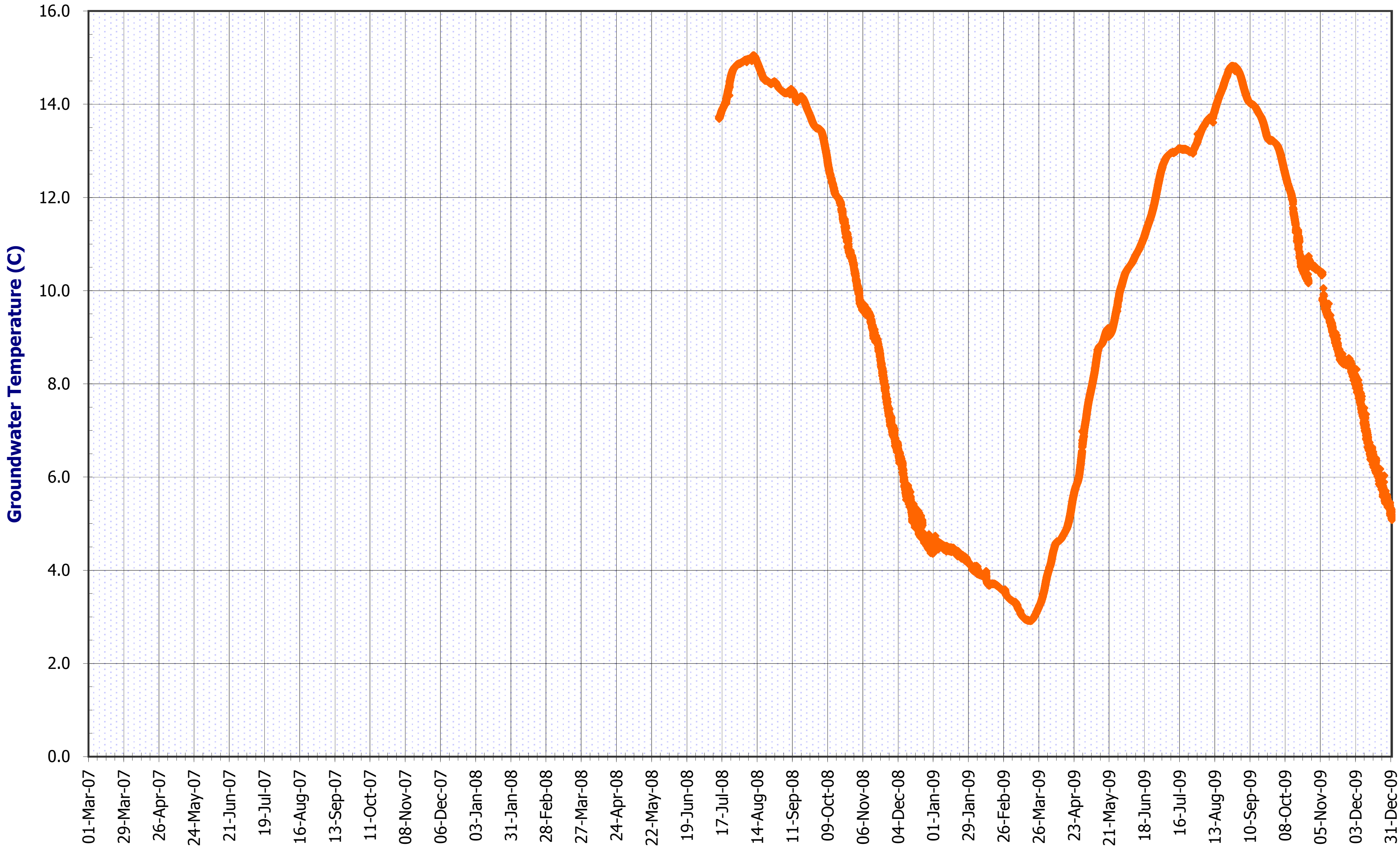


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 3a**

Groundwater Temperature - MW118A (July 08 to December 09)

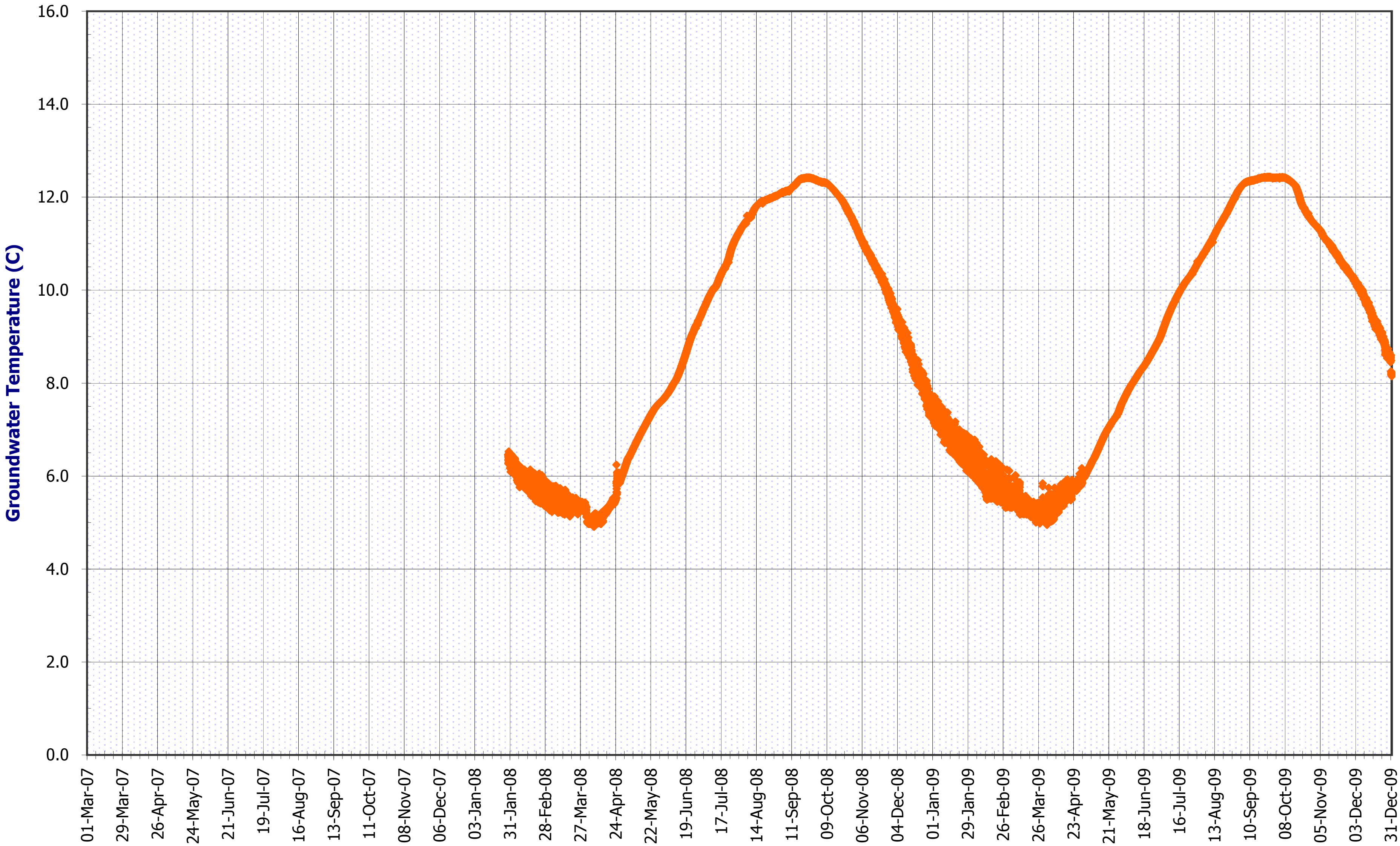


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 4a**

Groundwater Temperature: MW001 (January 08 to December 09)

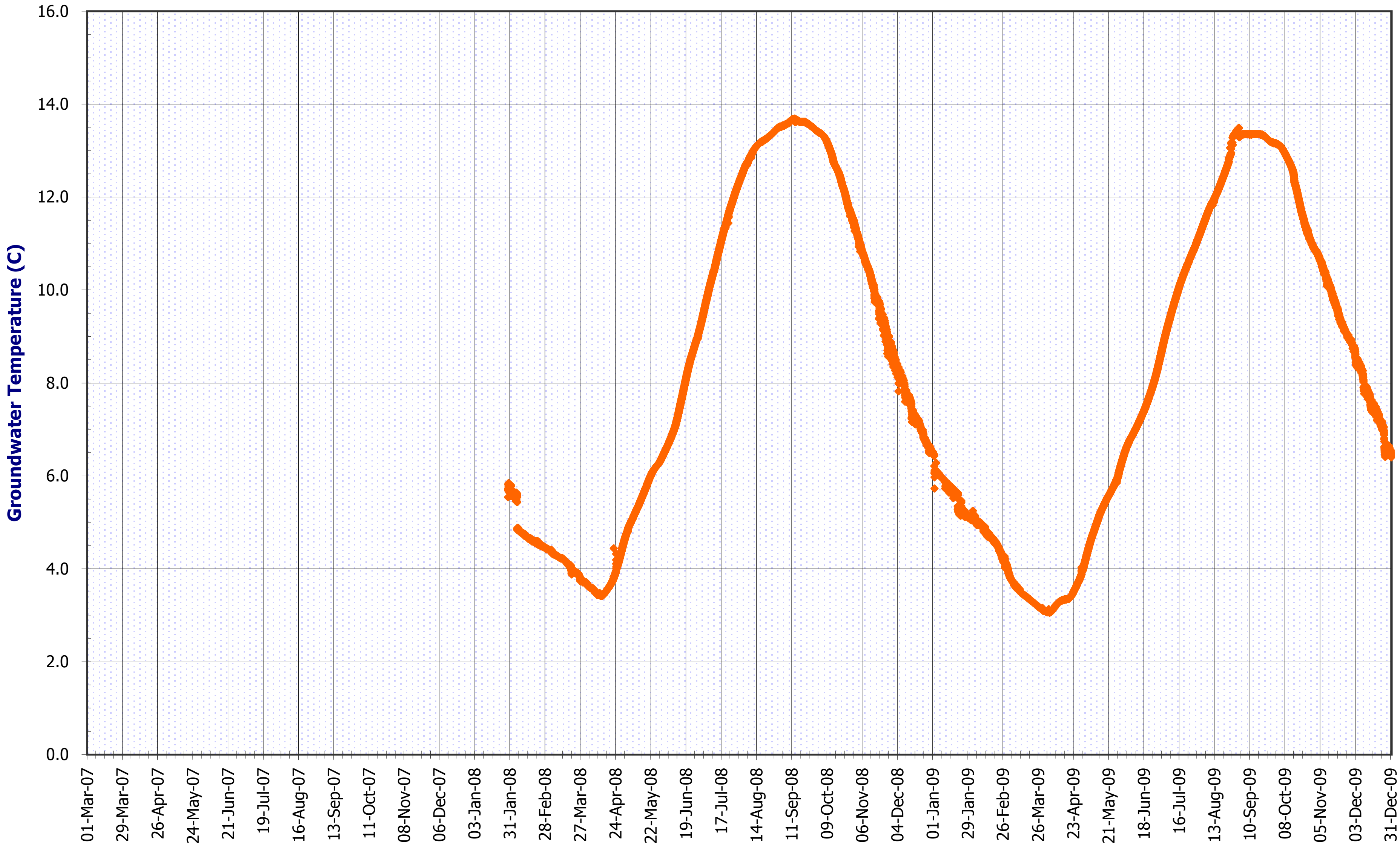


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 5a**

Groundwater Temperature - MW104 (January 08 to December 09)

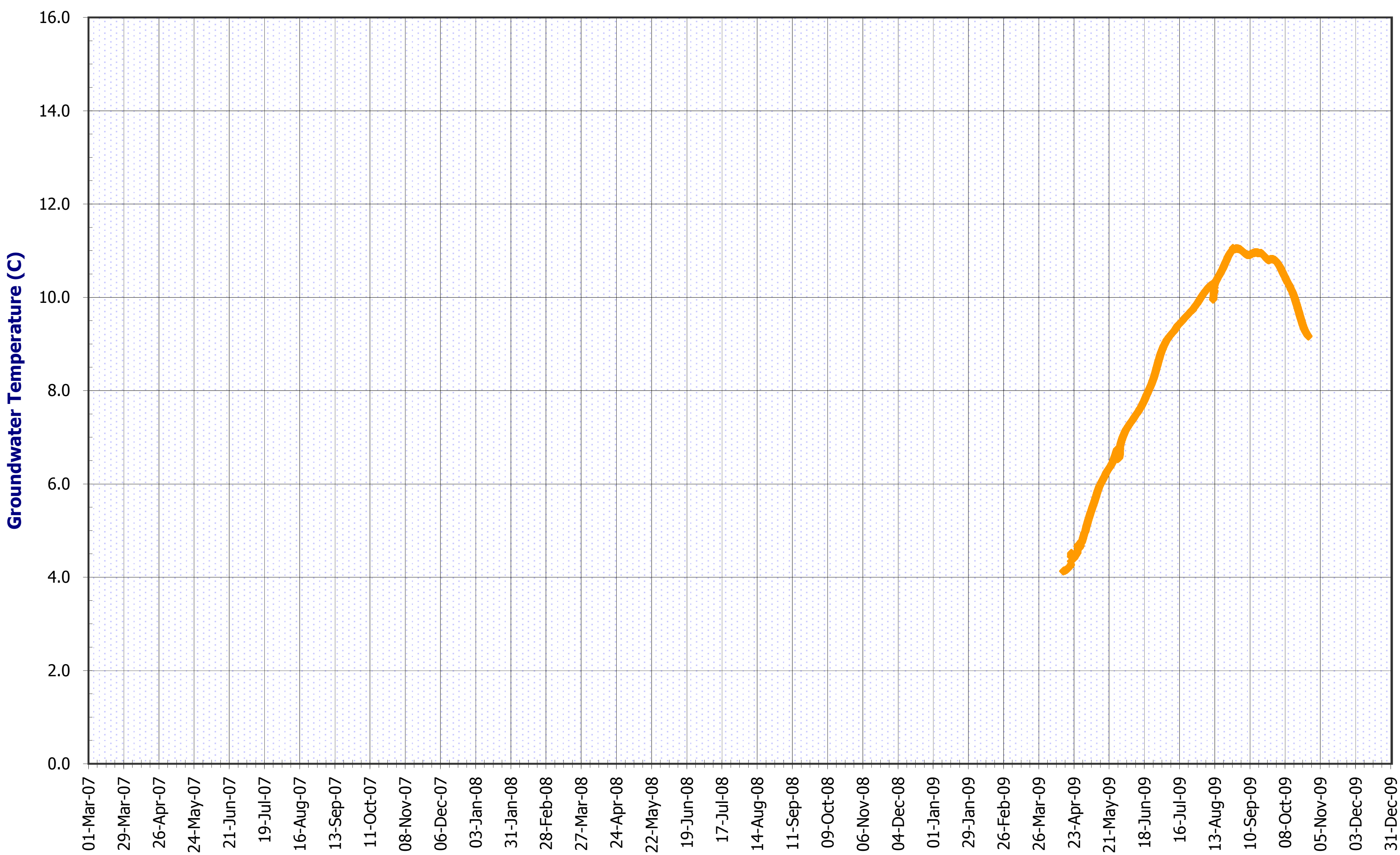


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 6a**

Groundwater Temperature - PZ-4D (April 09 to October 09)

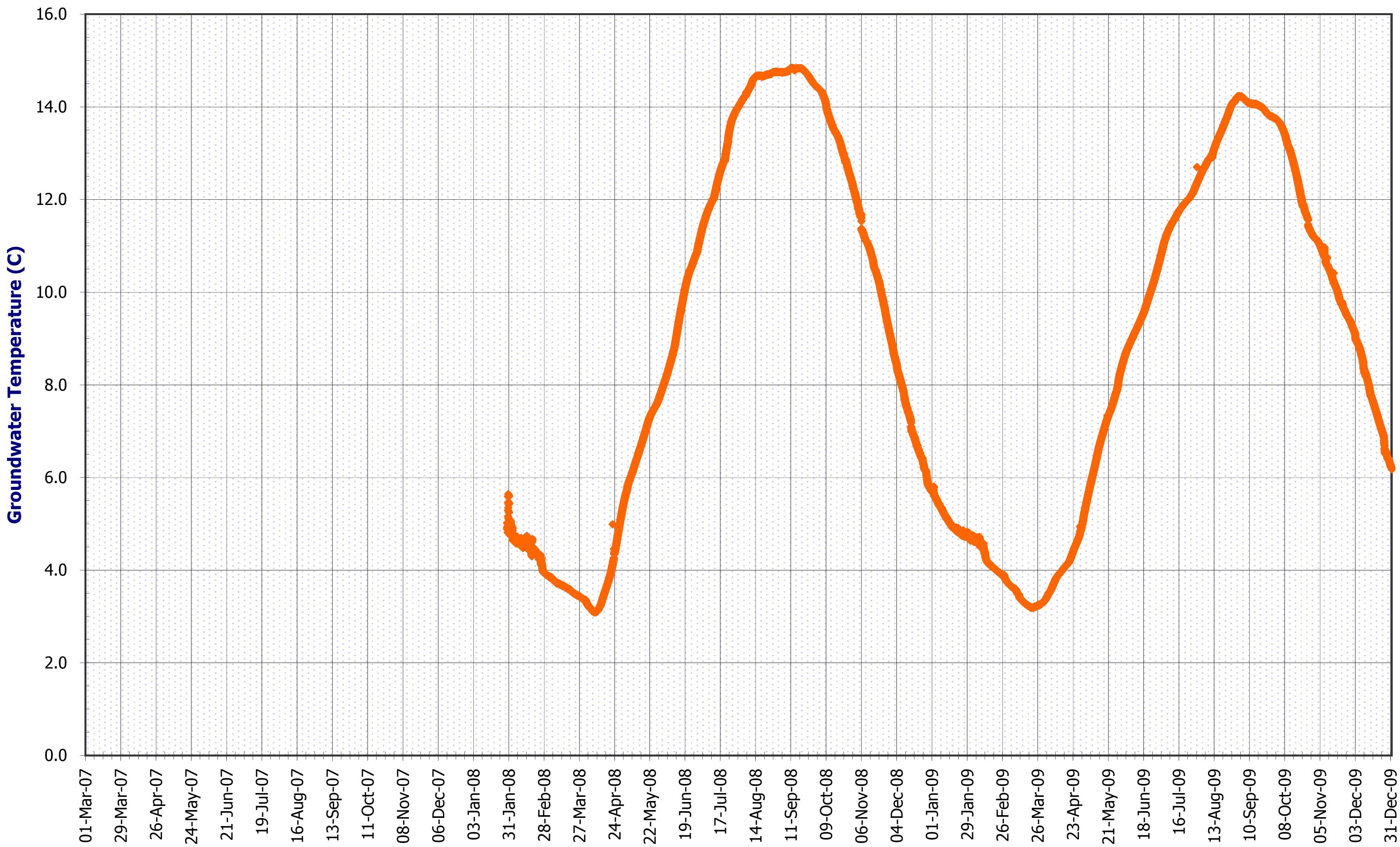


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 7a**

Groundwater Temperature - MW105 (January 08 to December 09)

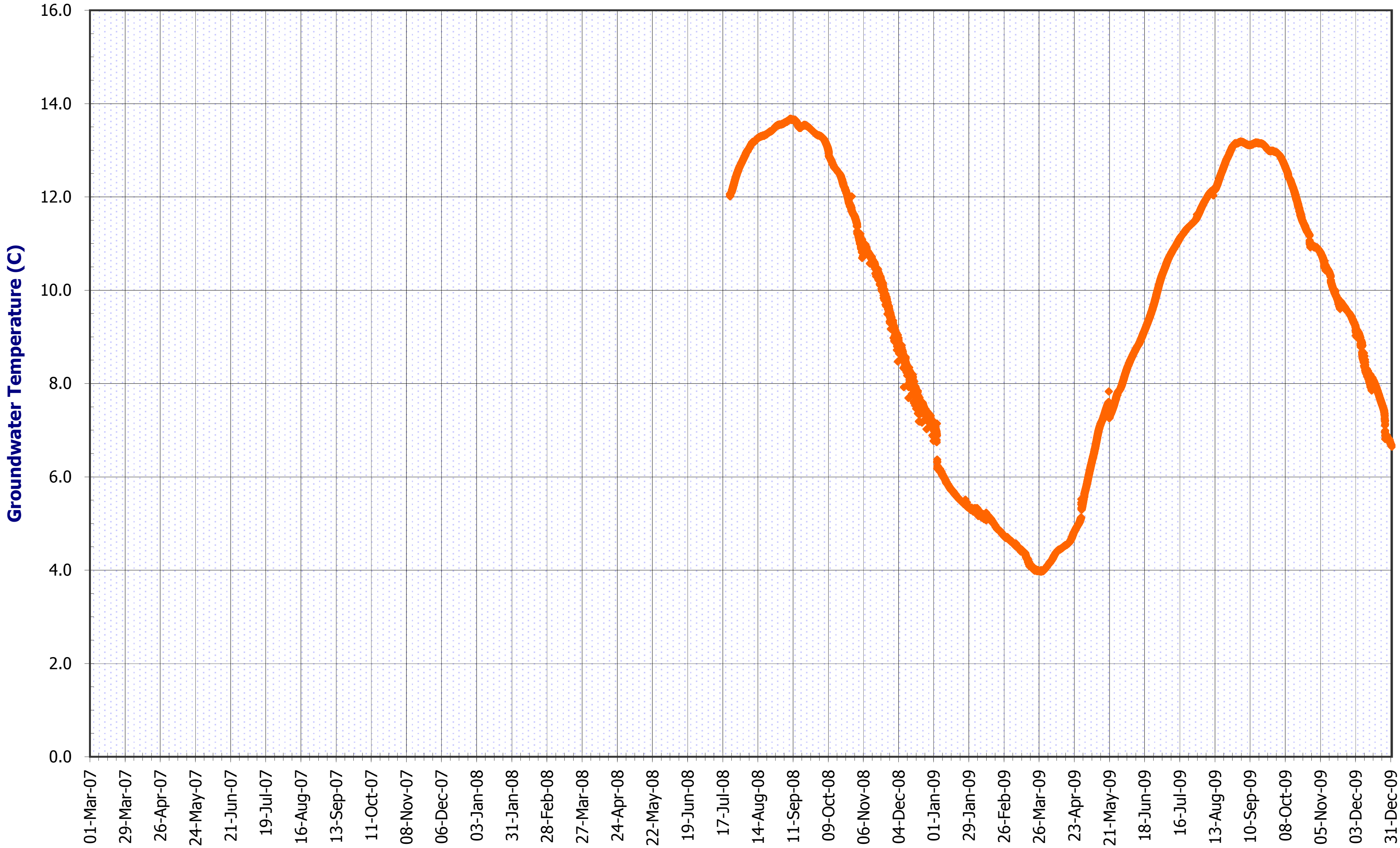


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 8a**

Groundwater Temperature - MW119A (July 08 to December 09)

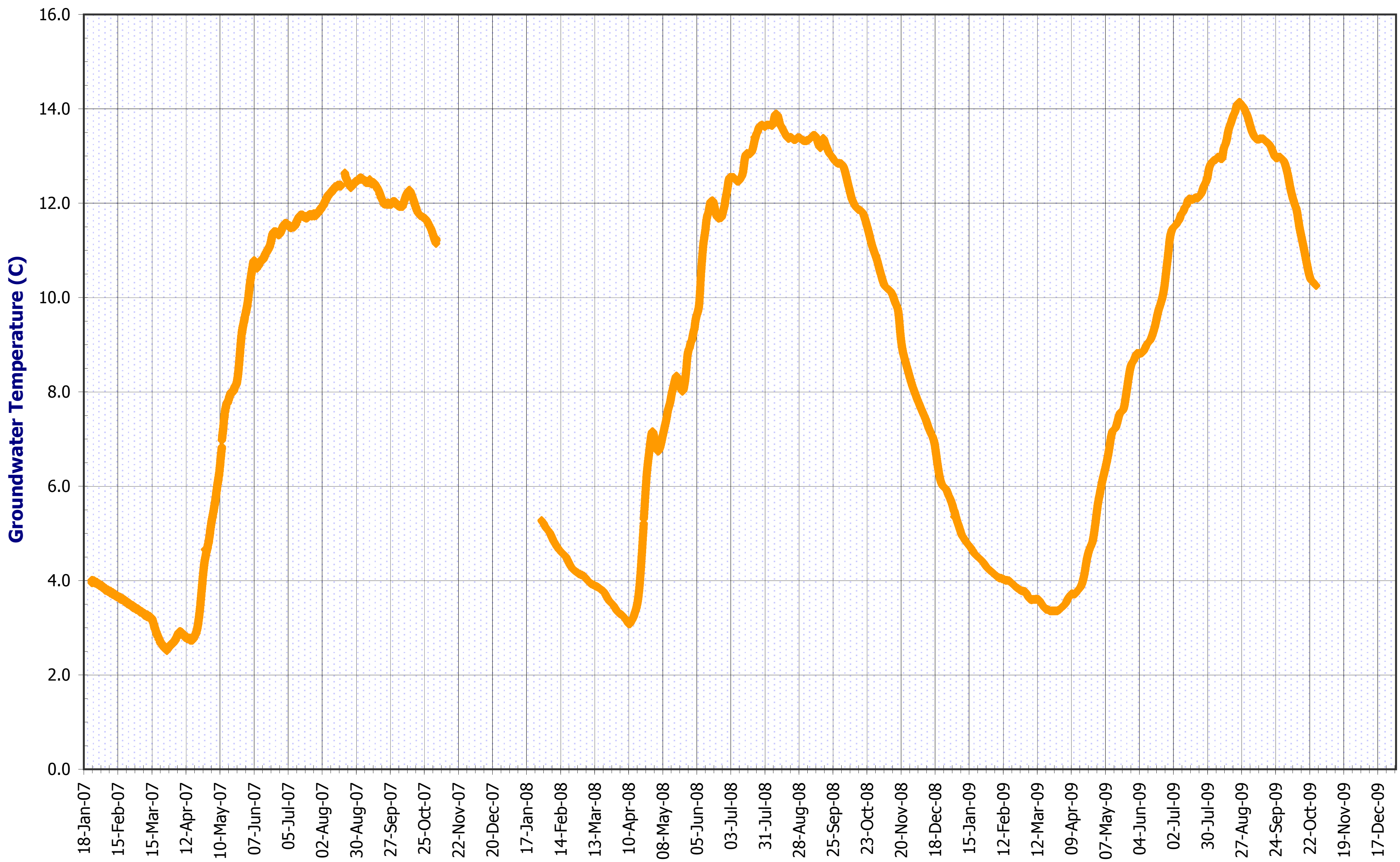


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 9a**

Groundwater Temperature: PZ-2D (January 07 to October 09)

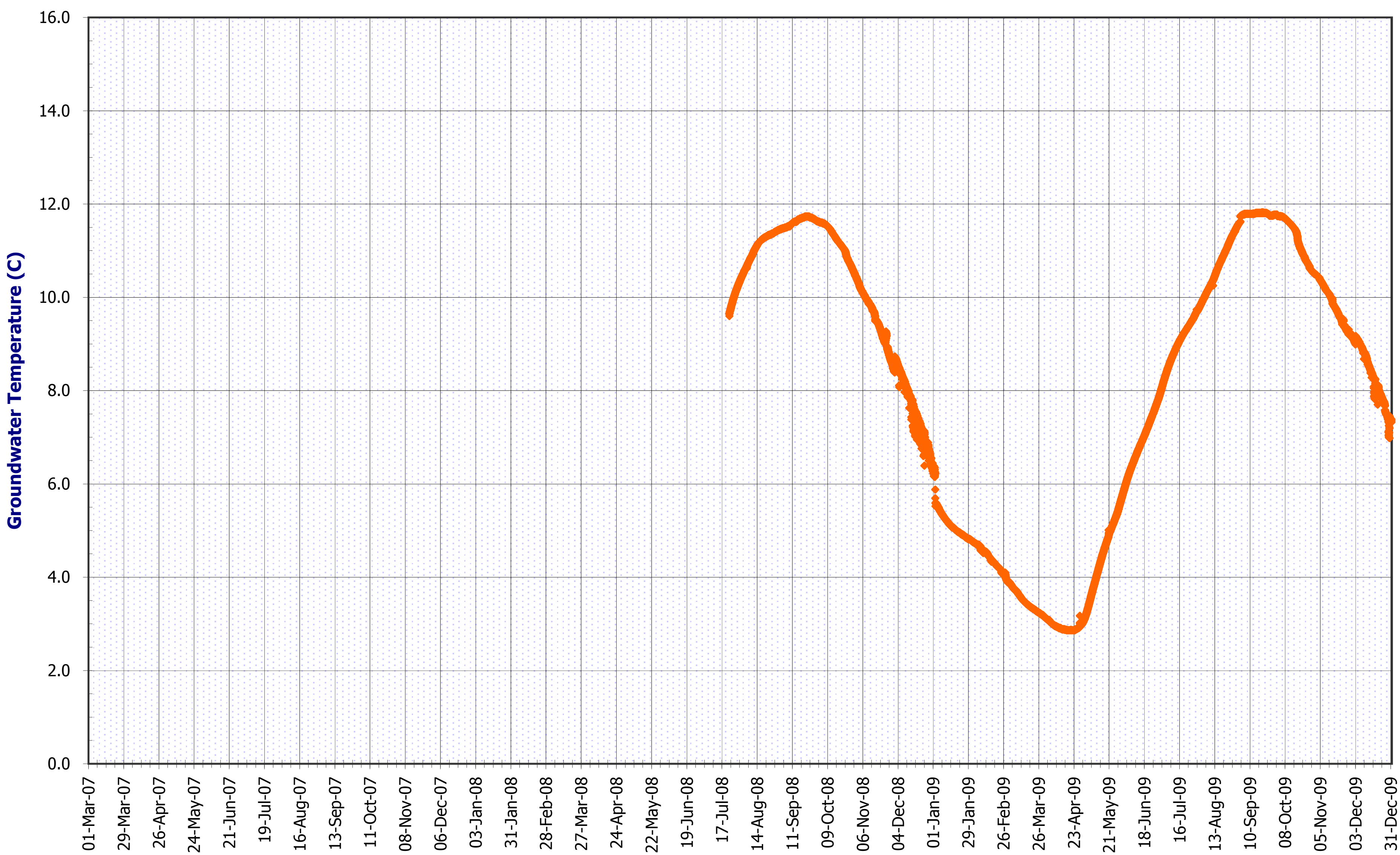


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 10a**

Groundwater Temperature - MW122A (July 08 to December 09)

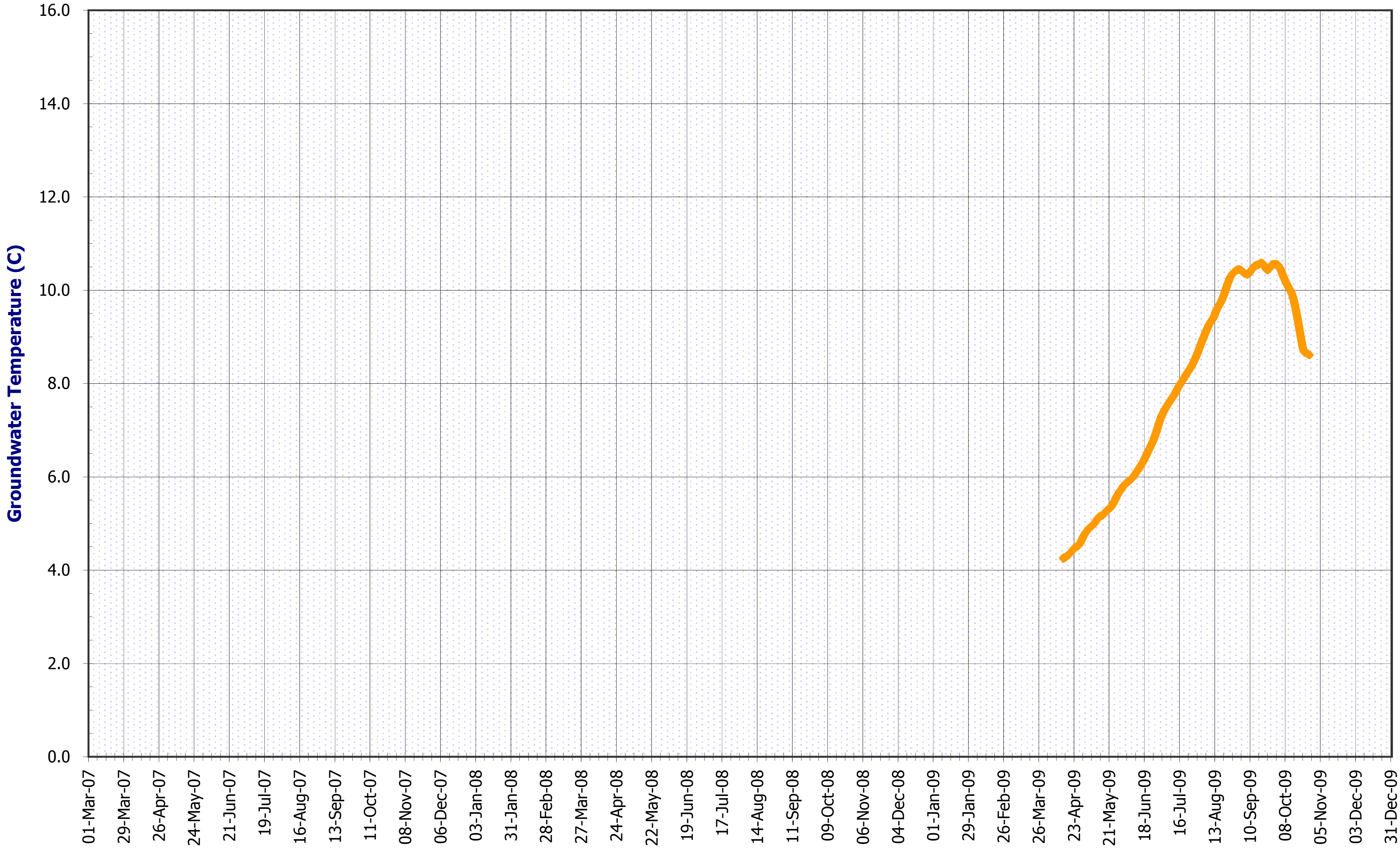


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 11a**

Groundwater Temperature - PZ-1D (April 09 to October 09)

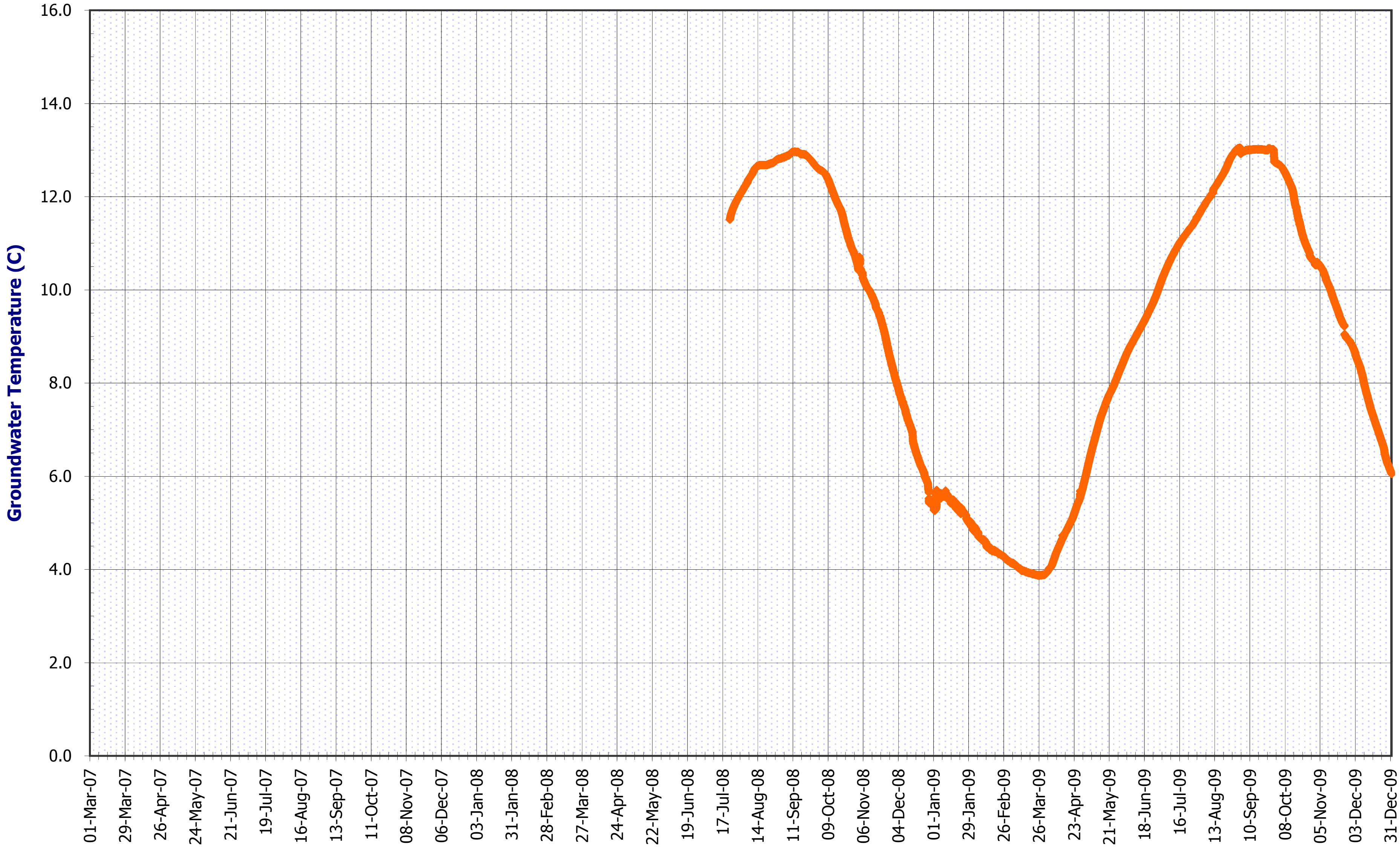


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph G 12a**

Groundwater Temperature - MW121A (July 08 to December 09)



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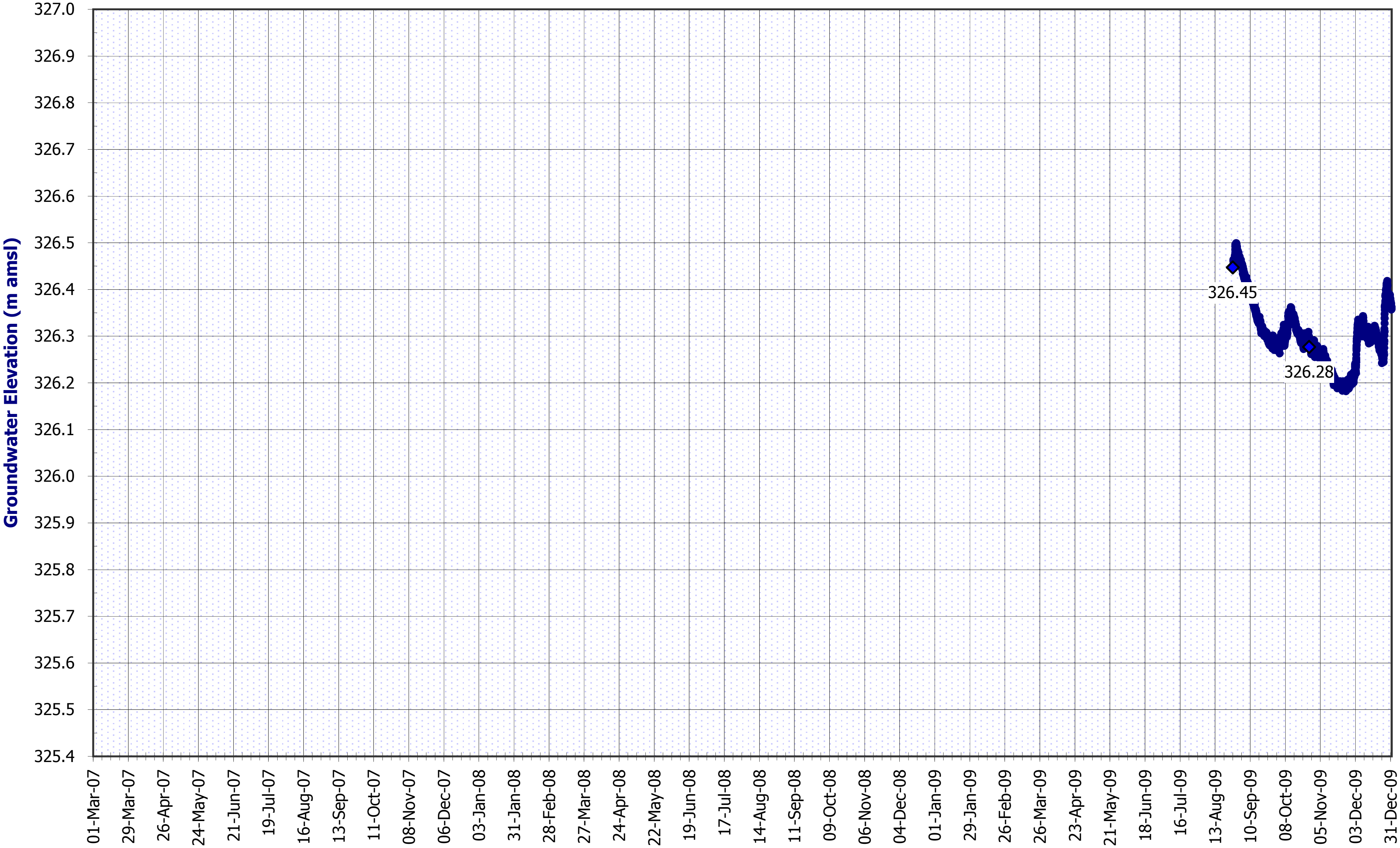
December 2009 **Graph G 13a**

Appendix H: HCBP Perimeter Groundwater Monitoring

Groundwater Elevation - MW106 (August 09 to December 09)



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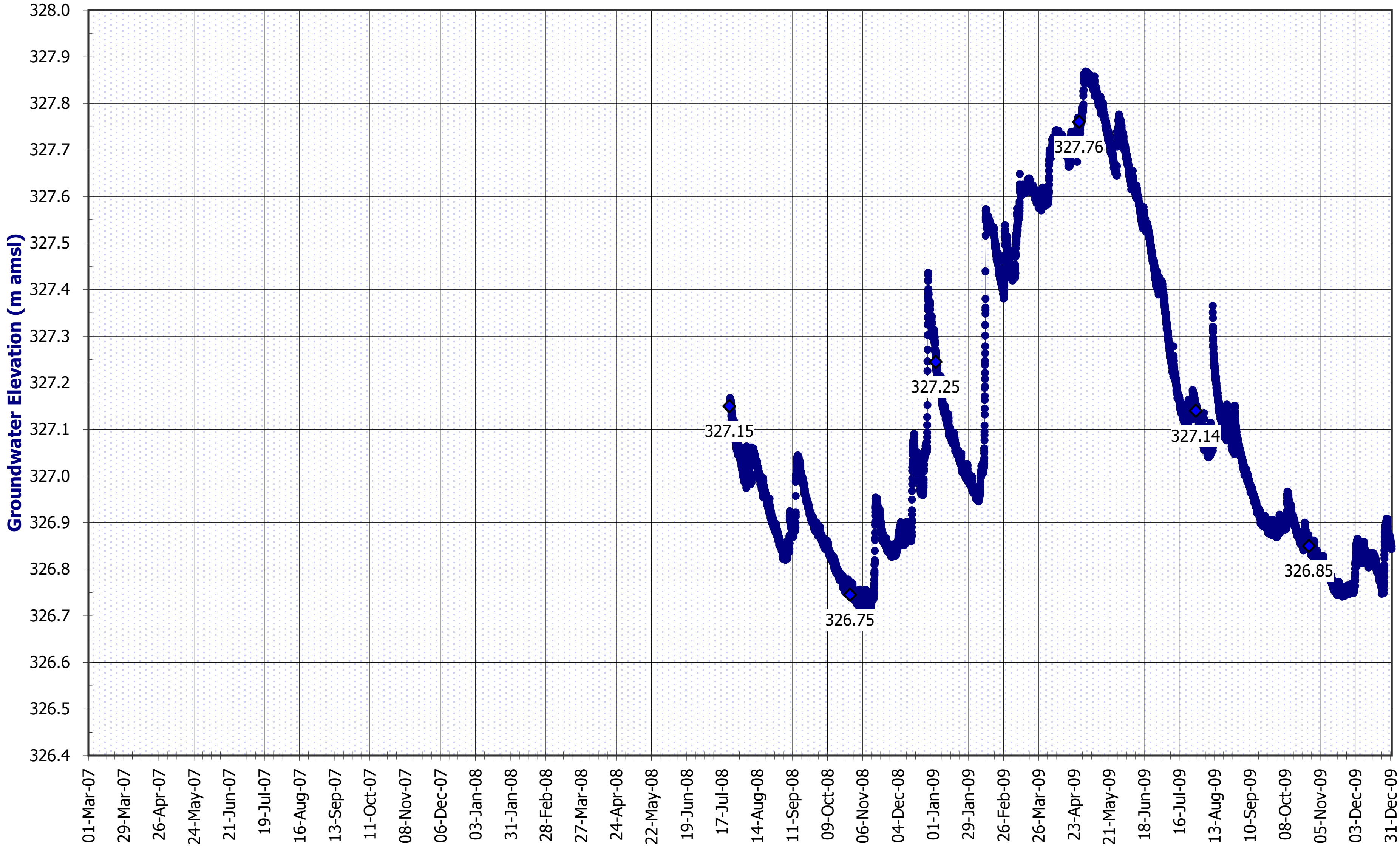
December 2009 **Graph H 1**

Groundwater Elevation - MW107 (July 08 to December 09)



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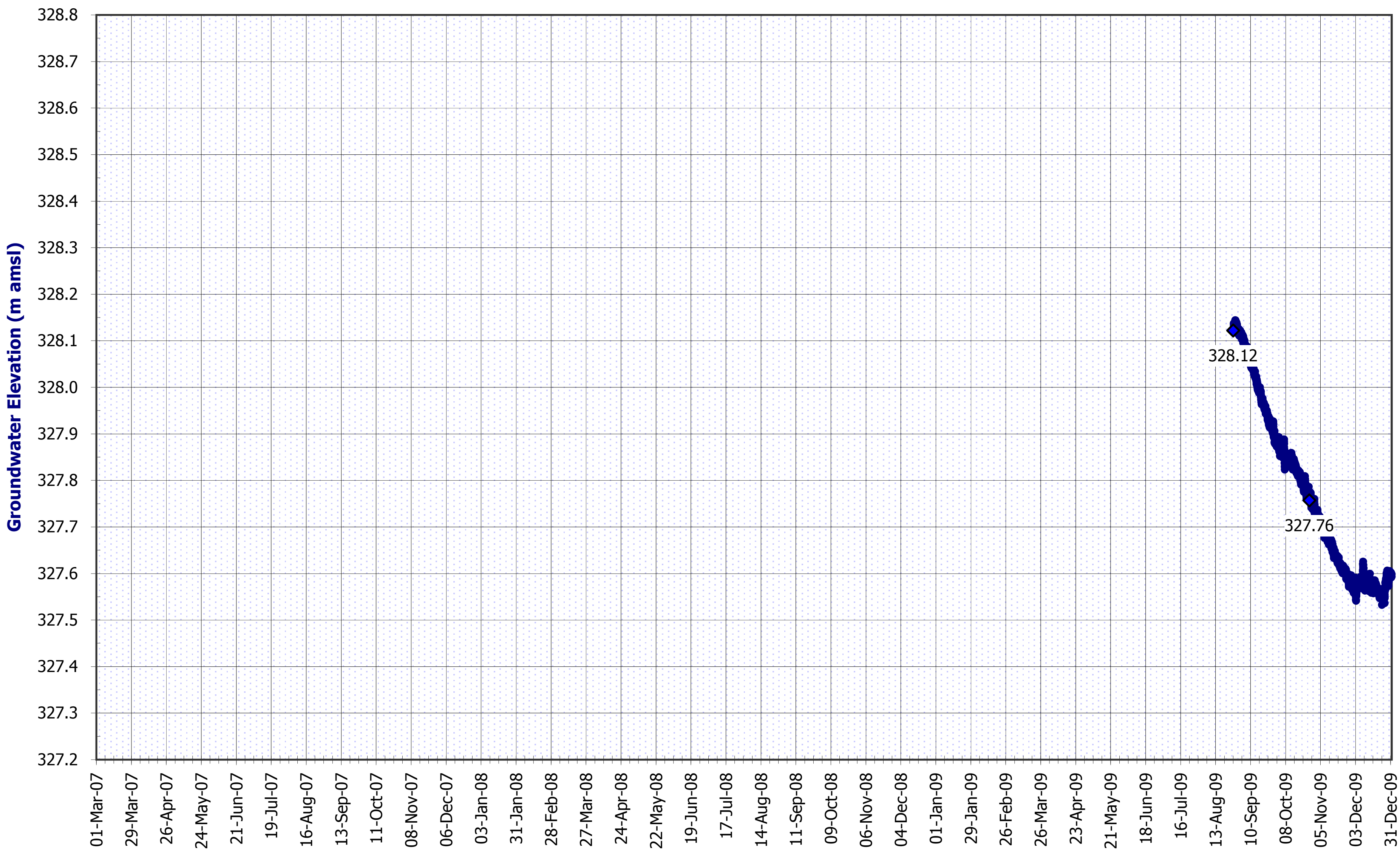
December 2009 **Graph H 2**

Groundwater Elevation - MW006 (August 09 to December 09)



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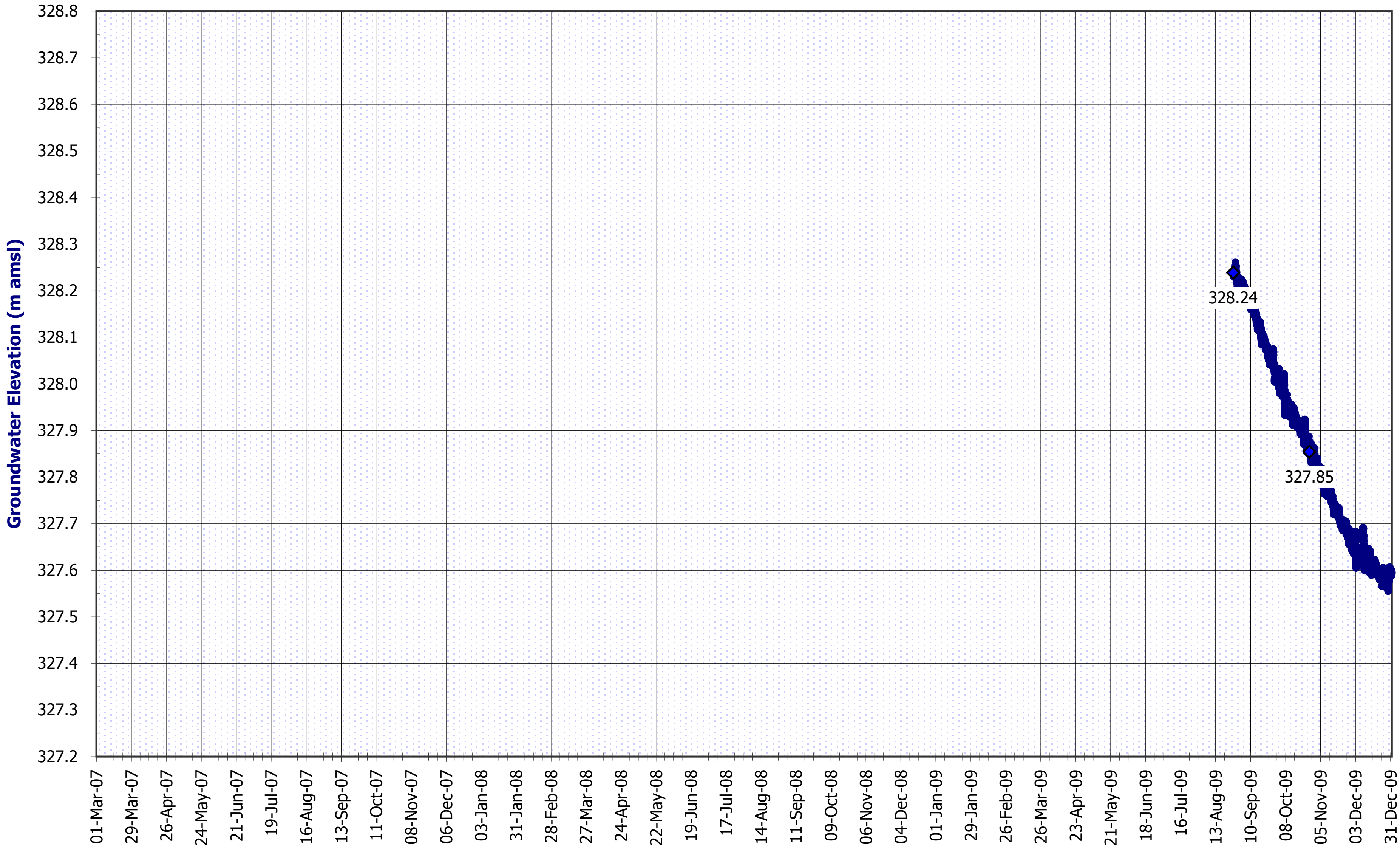
December 2009 **Graph H 3**

Groundwater Elevation - MW005I (August 09 to December 09)



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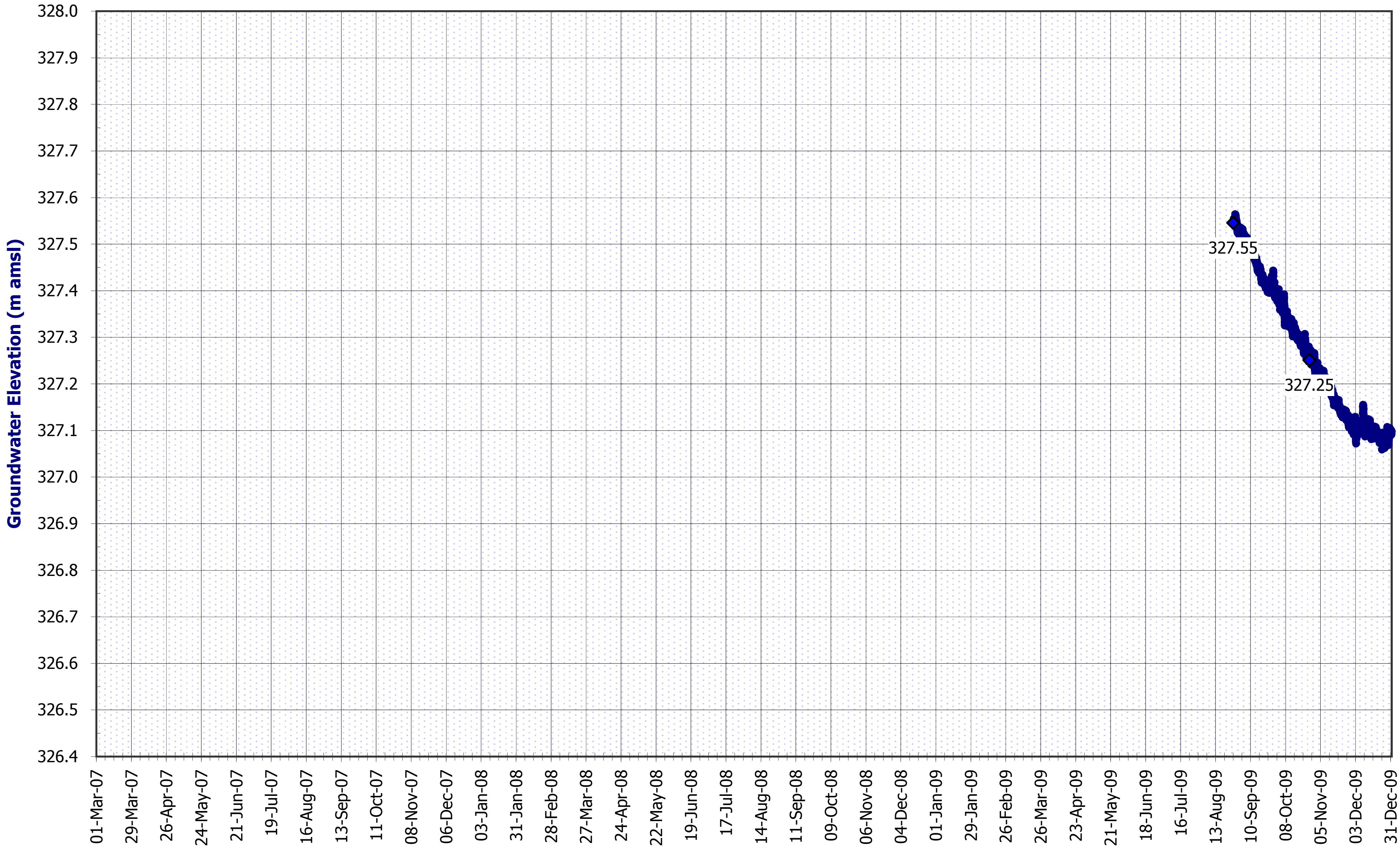
December 2009 **Graph H 4**

Groundwater Elevation - MW110 (August 09 to December 09)



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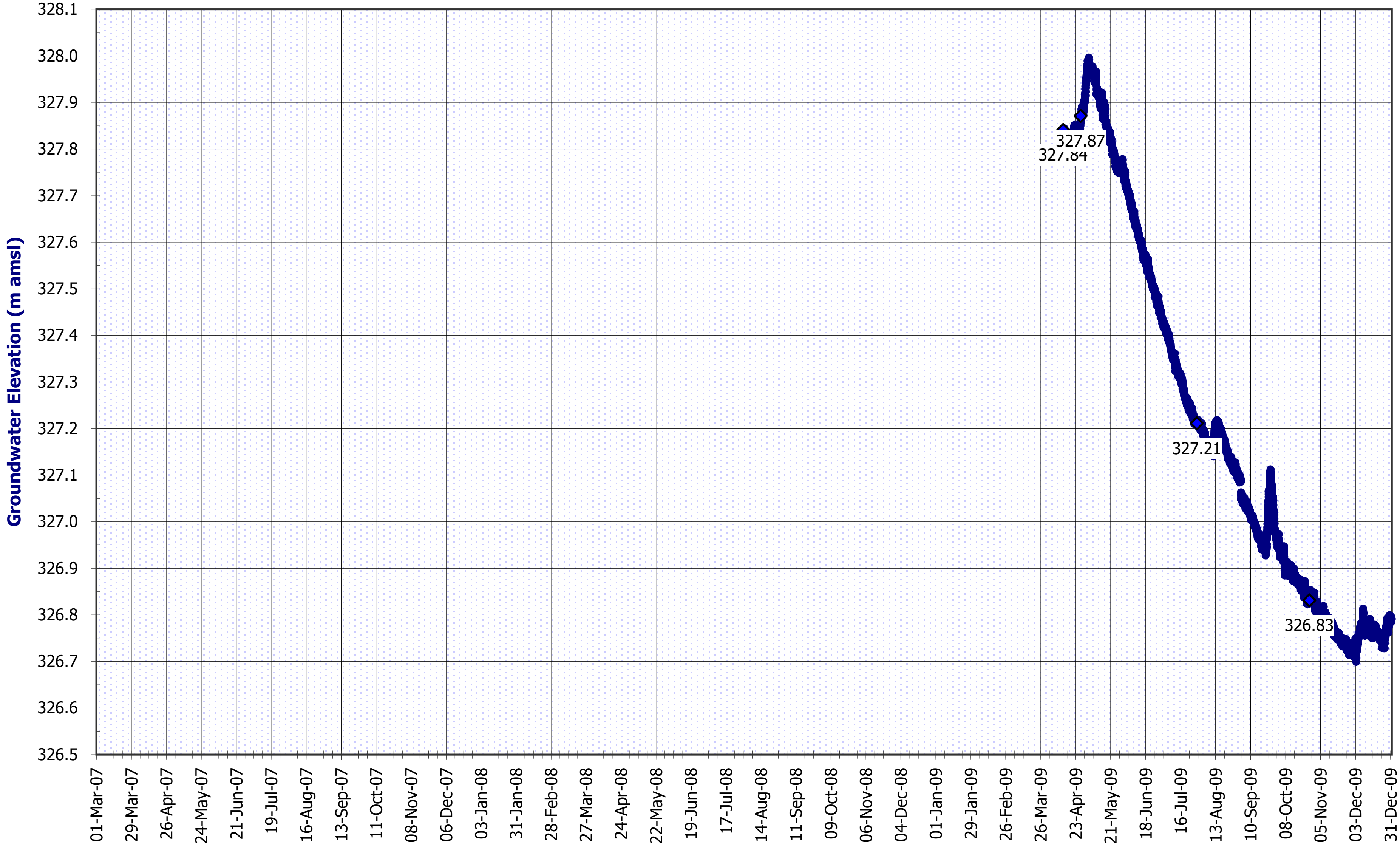
December 2009 **Graph H 5**

Groundwater Elevation - MW109 (April 09 to December 09)



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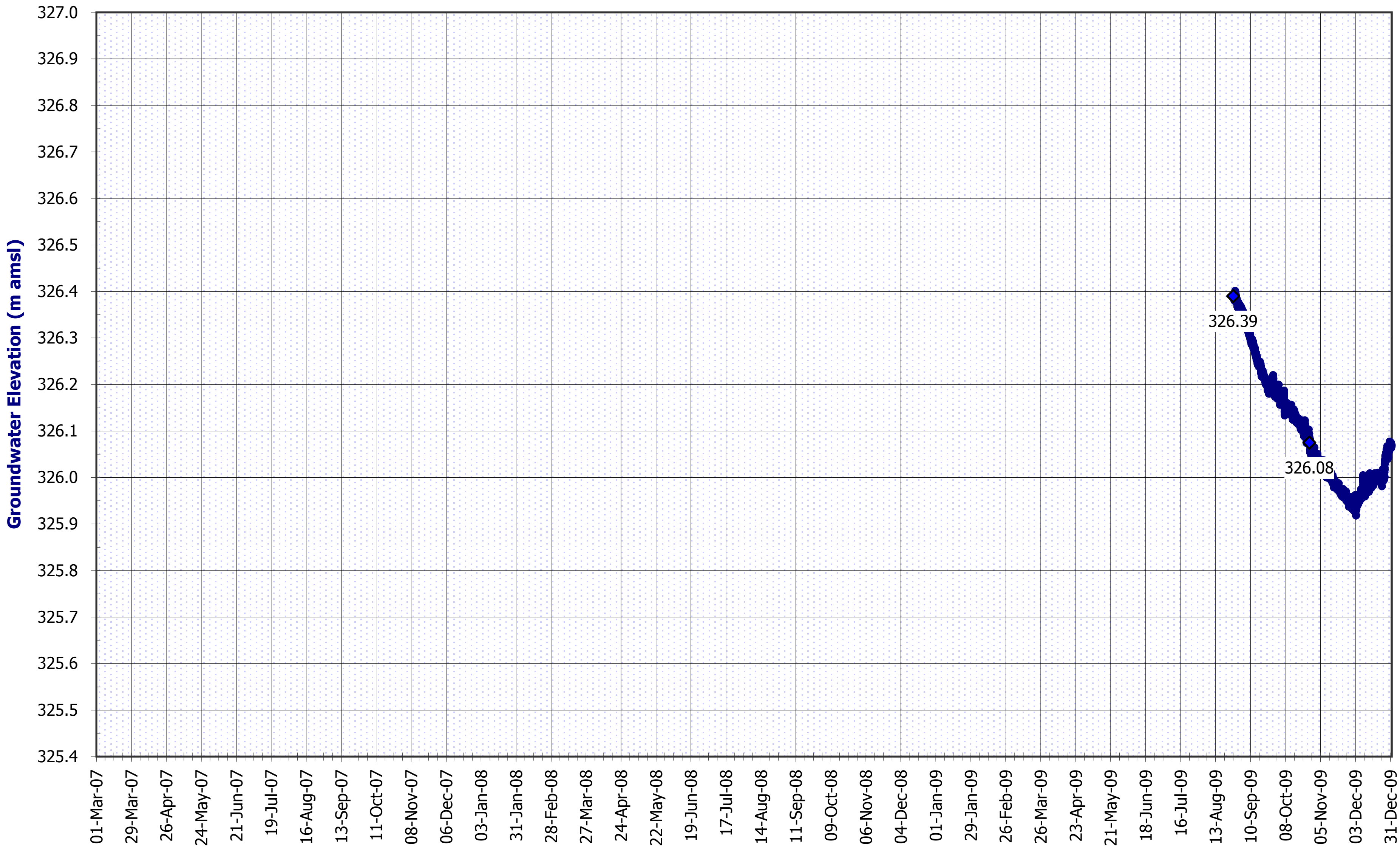
December 2009 **Graph H 6**

Groundwater Elevation - MW004 (August 09 to December 09)



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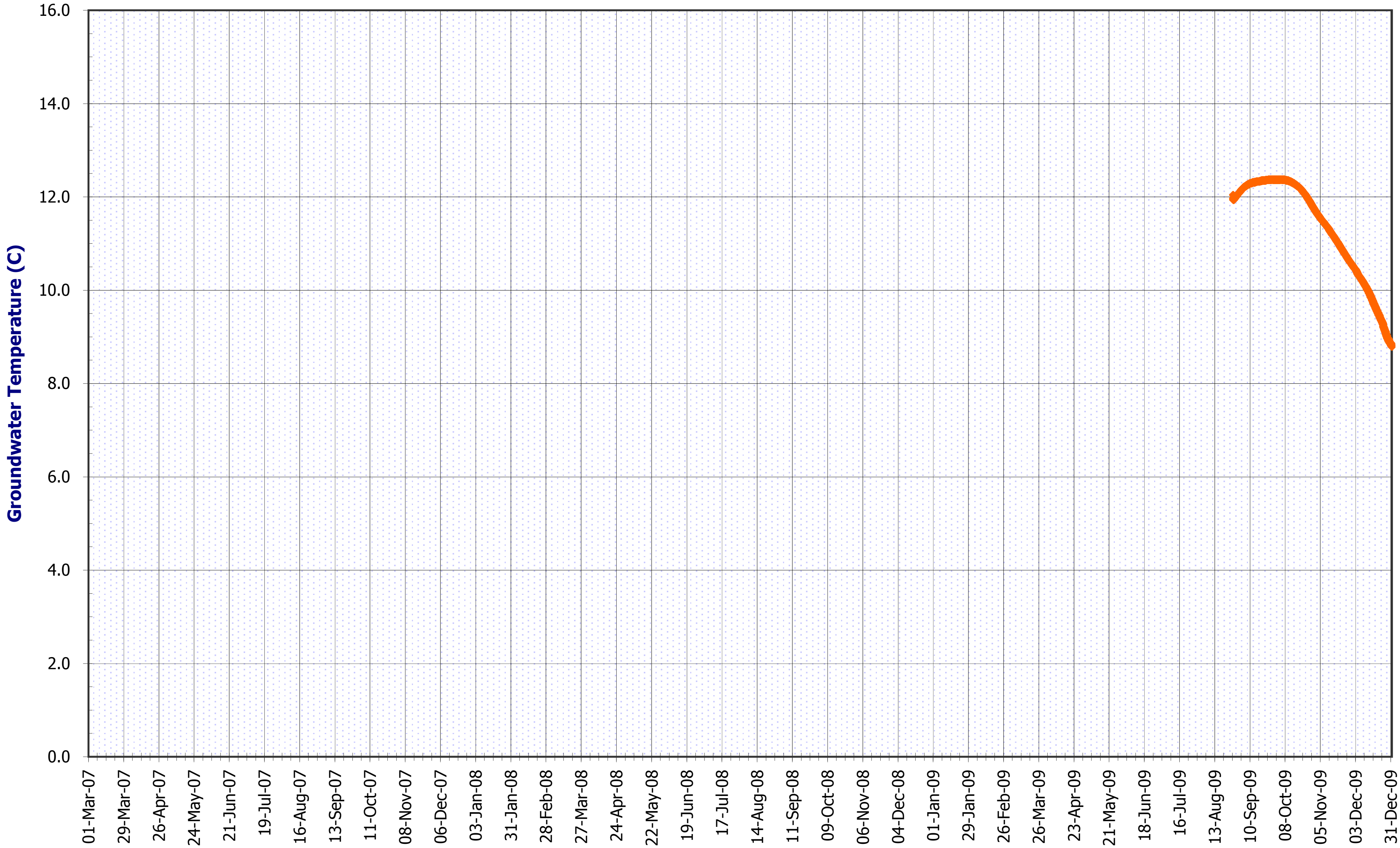
December 2009 **Graph H 7**

Groundwater Temperature - MW106 (August 09 to December 09)



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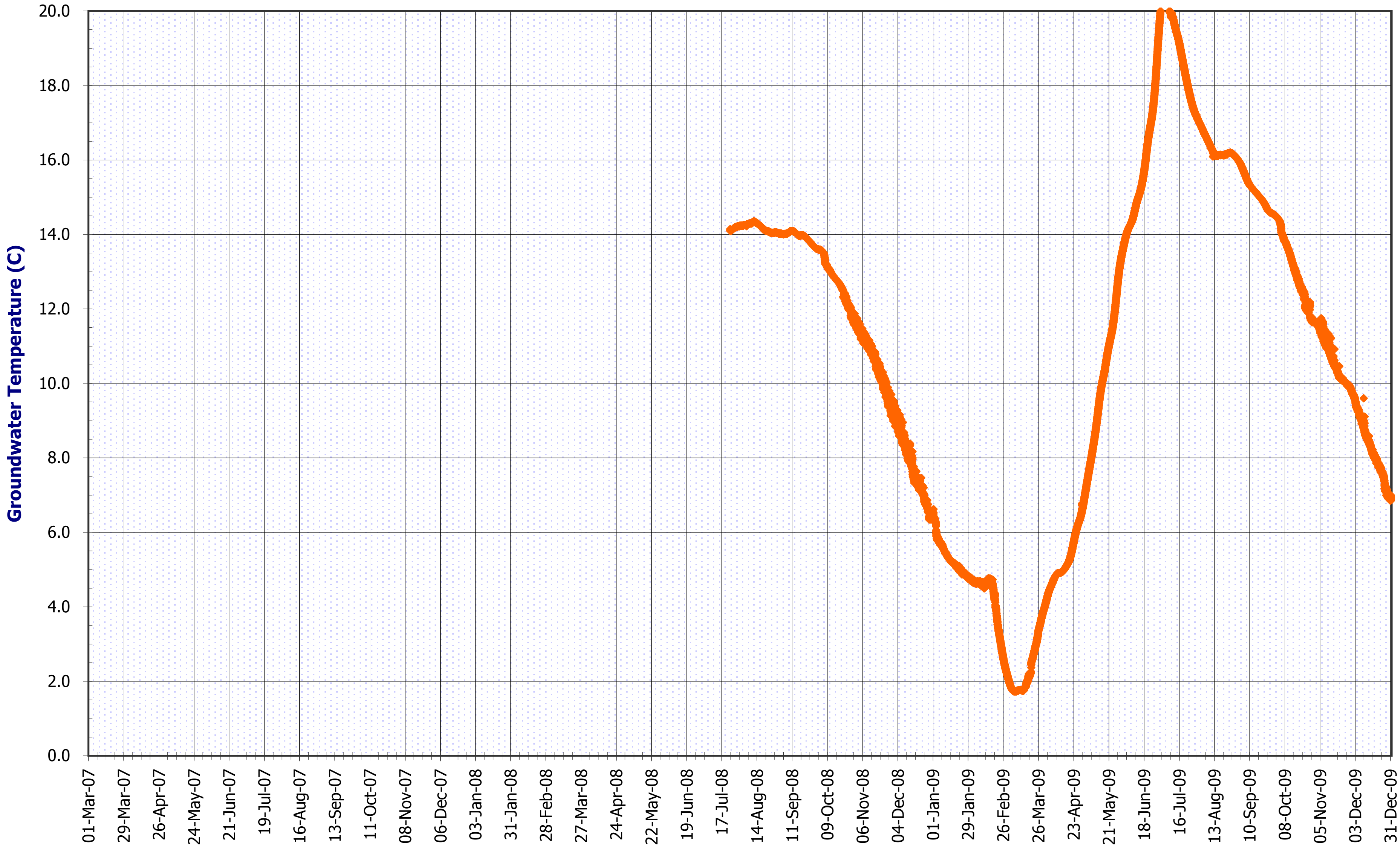
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph H 1a**

Groundwater Temperature - MW107 (July 08 to December 09)



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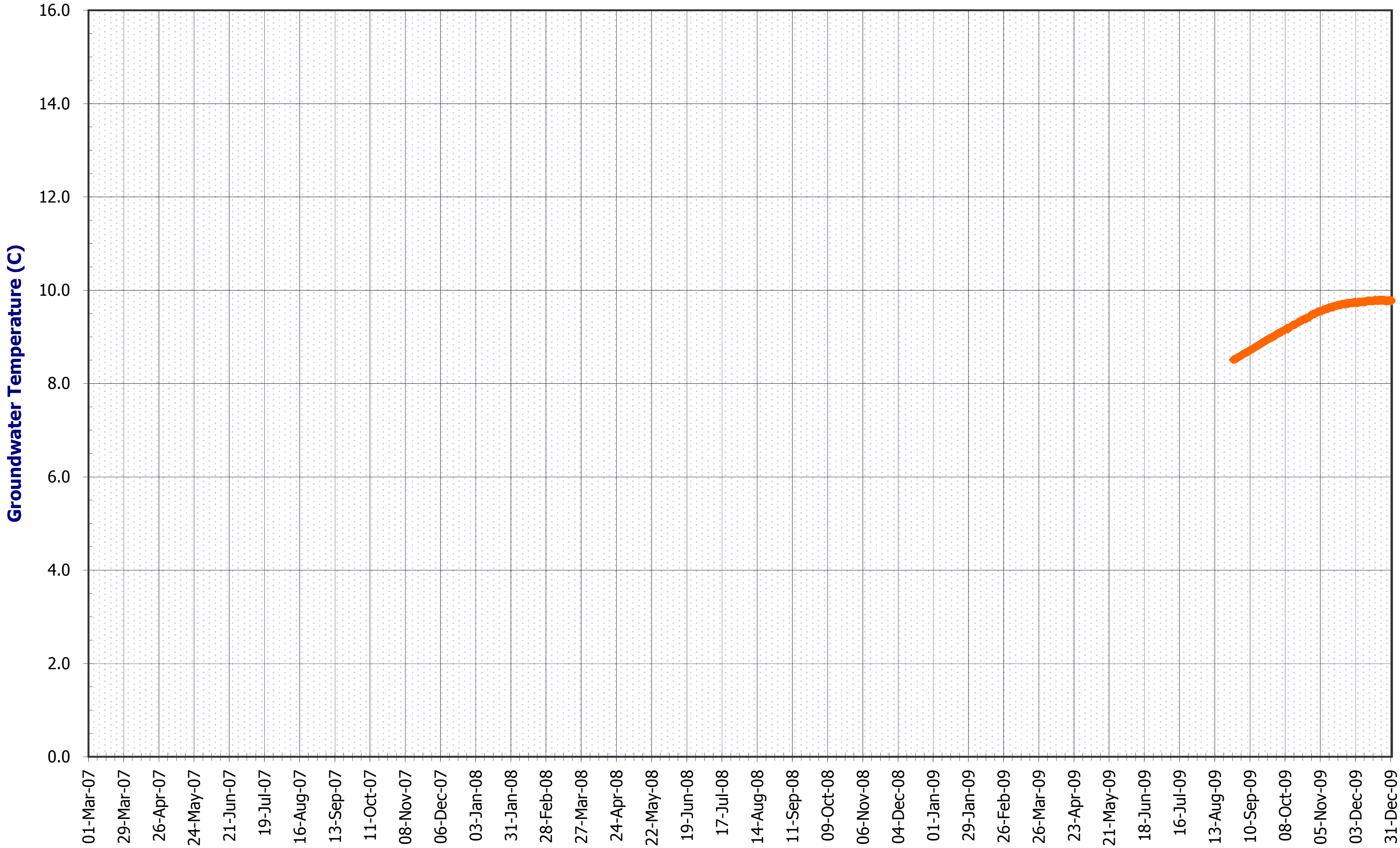
December 2009 **Graph H 2a**

Groundwater Temperature - MW006 (August 09 to December 09)



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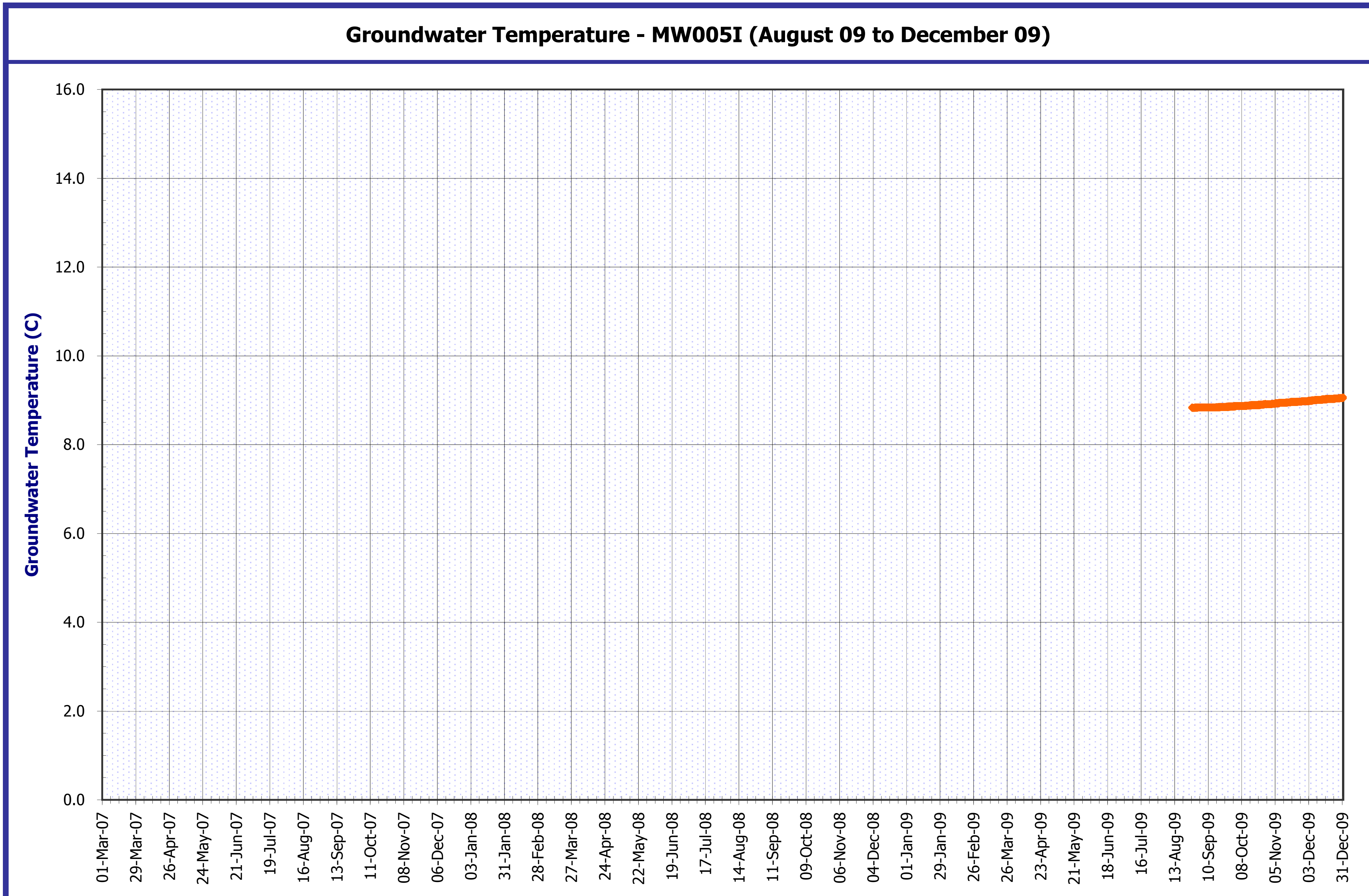
December 2009 **Graph H 3a**



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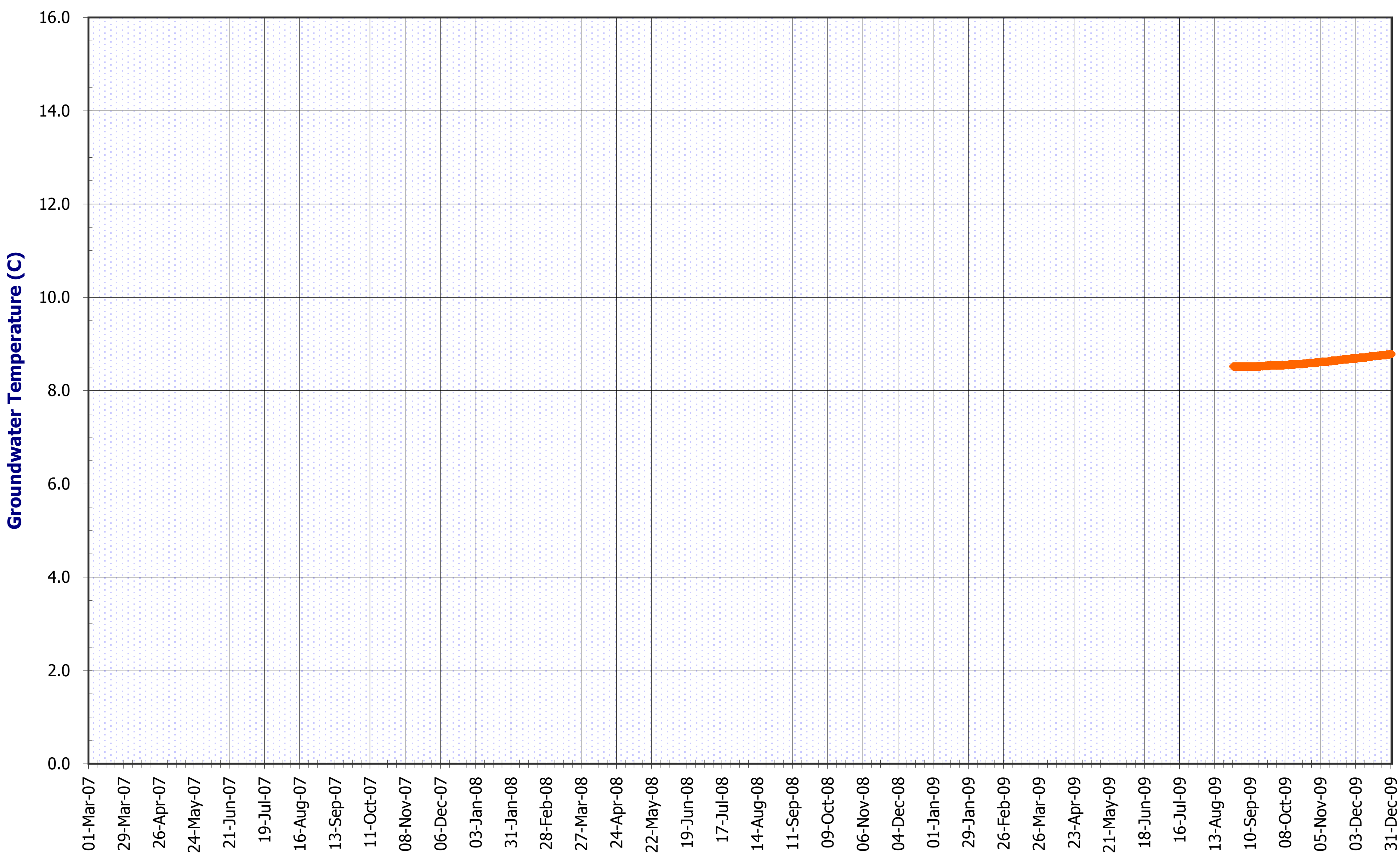
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph H 4a**

Groundwater Temperature - MW110 (August 09 to December 09)



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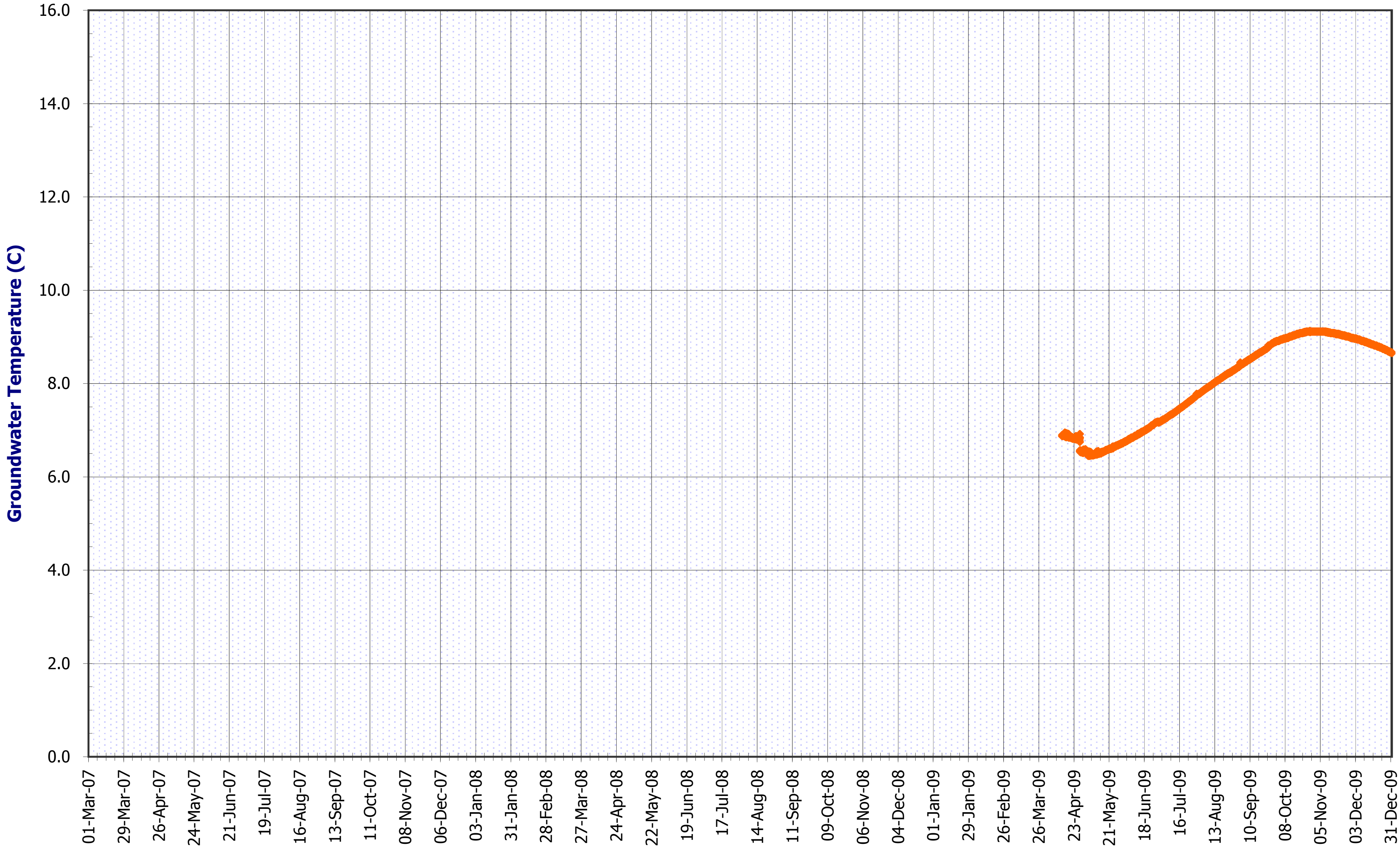
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph H 5a**

Groundwater Temperature - MW109 (April 09 to December 09)



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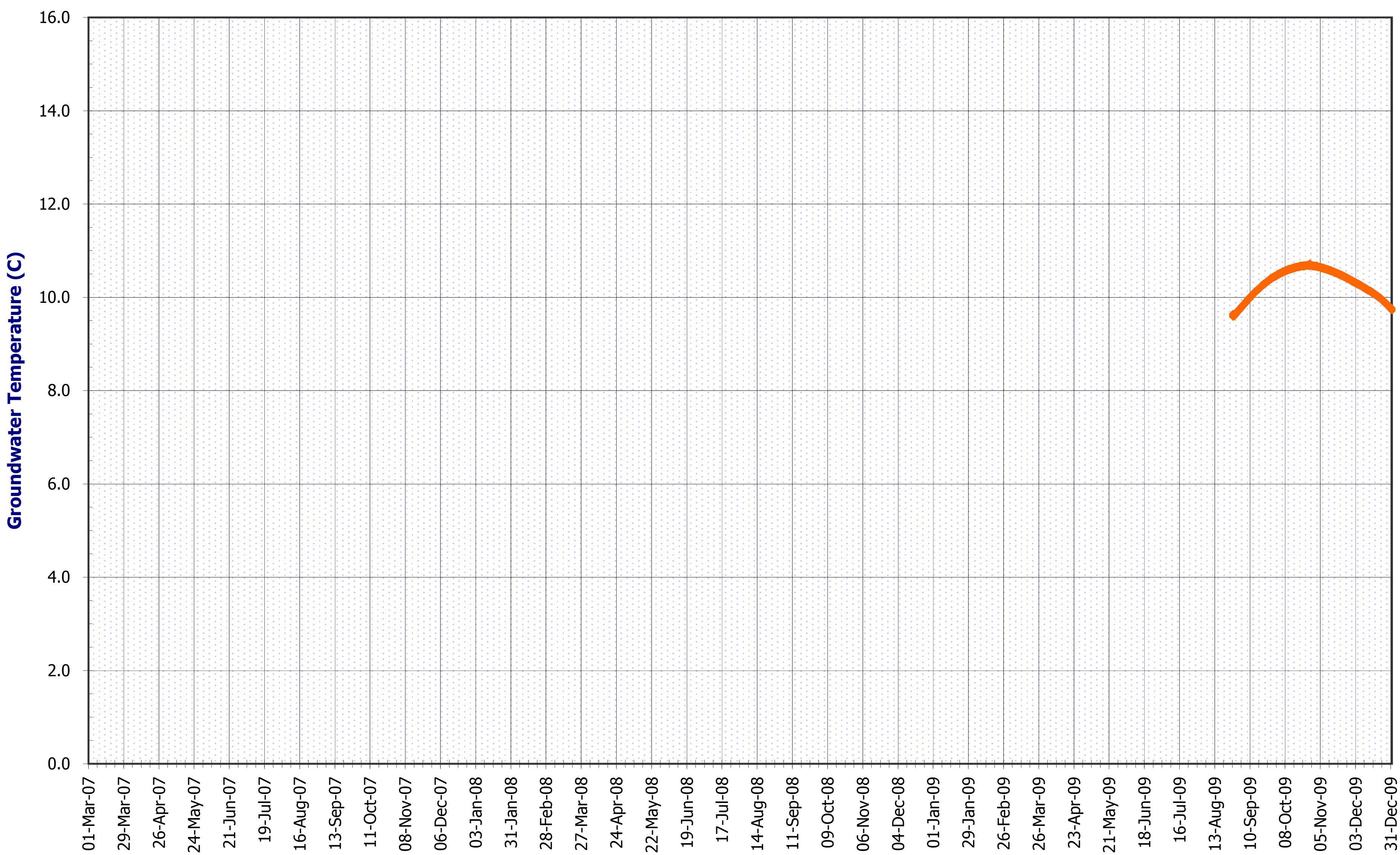
Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph H 6a**

Groundwater Temperature - MW004 (August 09 to December 09)



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Hanlon Creek Business Park - Groundwater Monitoring Program

December 2009 **Graph H 7a**

Appendix I: Groundwater Quality Monitoring Data

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter	ODWQS	RDL		Monitoring Wells 001			003			004			005-I		
			2003	2008/2009	2003	2008	2009	2003	2008	2009	2003	2008	2009	2003	2008	2009
Anions	Chloride (mg/L)	250	2.0	0.10	ns	221	245	ns	37.6	37.4	63.0	48.9	55.3	190	163	182
	Fluoride (mg/L)	1.5	0.10	0.05	ns	0.08	<0.05	ns	<0.05	<0.05	<0.10	0.08	<0.05	0.10	<0.05	<0.05
	Nitrate as N (mg/L)	10.0	0.10	0.05	ns	4.88	3.93	ns	11.9	7.79	19.0	10.7	12	6.80	6.95	4.71
	Nitrite as N (mg/L)	1.0	0.10	0.05	ns	<0.05	<0.05	ns	<0.05	<0.05	<0.10	<0.05	<0.05	<0.30	<0.05	<0.05
	Phosphate-P (ortho) (mg/L)		0.30	0.10	ns	<0.10	<0.10	ns	<0.10	<0.10	<0.30	<0.10	<0.10	<0.30	<0.10	<0.10
	Sulphate (mg/L)	500	2.0	0.10	ns	28.4	24	ns	18.0	16.3	25.0	20.3	21.4	20.0	18.4	17.2
Metals	Aluminum (mg/L)	0.1	0.01	0.004	ns	0.063	<0.004	ns	2.56	<0.004	<0.01	0.648	0.009	<0.01	1.09	<0.004
	Antimony (mg/L)	0.006	0.005	0.006	ns	<0.006	<0.006	ns	<0.006	<0.006	<0.005	<0.006	<0.006	<0.005	<0.006	<0.006
	Arsenic (mg/L)	0.025	0.001	0.003	ns	<0.003	<0.003	ns	0.010	<0.003	0.001	0.005	<0.003	<0.001	<0.003	<0.003
	Barium (mg/L)	1.0	0.01	0.002	ns	0.627	0.108	ns	0.312	0.057	0.15	0.371	0.126	0.10	0.366	0.095
	Beryllium (mg/L)		0.001	0.001	ns	<0.001	<0.001	ns	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	ns	<0.002	<0.002	ns	<0.002	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	ns	0.015	0.012	ns	0.016	<0.010	<0.05	0.016	0.013	<0.05	0.015	<0.010
	Cadmium (mg/L)	0.005	0.0001	0.002	ns	0.006	<0.002	ns	0.010	<0.002	<0.0001	0.011	<0.002	<0.0001	0.020	<0.002
	Calcium (mg/L)	200	0.5	0.05	ns	86.2	95.7	ns	87.2	86.6	130	92.5	119	110	83.6	103
	Chromium (mg/L)	0.05	0.001	0.003	ns	0.016	0.004	ns	0.006	<0.003	0.004	0.004	0.004	0.004	0.012	0.006
	Cobalt (mg/L)		0.0008	0.001	ns	0.008	<0.001	ns	0.027	<0.001	<0.0008	0.017	<0.001	<0.0008	0.028	<0.001
	Copper (mg/L)	1.0	0.001	0.003	ns	0.004	<0.003	ns	0.082	<0.003	0.002	0.009	0.003	0.005	0.058	<0.003
	Iron (mg/L)	0.3	0.05	0.010	ns	0.63	<0.010	ns	3.20	<0.010	0.13	0.592	<0.010	0.12	<0.010	<0.010
	Lead (mg/L)	0.010	0.001	0.002	ns	<0.001	<0.002	ns	0.325	<0.002	<0.001	0.002	<0.002	<0.001	0.082	<0.002
	Magnesium (mg/L)		0.5	0.05	ns	27.3	28.9	ns	24.3	27.3	36	25	32.2	44	27	31.9
	Manganese (mg/L)	0.05	0.001	0.002	ns	4.87	<0.002	ns	3.53	<0.002	0.012	3.38	<0.002	0.046	3.74	<0.002
	Molybdenum (mg/L)		0.001	0.002	ns	<0.002	<0.002	ns	<0.002	<0.002	<0.001	<0.002	<0.002	0.004	<0.002	<0.002
	Nickel (mg/L)		0.002	0.003	ns	0.028	<0.003	ns	<0.003	<0.003	<0.002	<0.003	<0.003	0.004	0.022	<0.003
	Phosphorus (mg/L)		0.05	0.05	ns	0.13	<0.05	ns	0.97	<0.05	<0.05	0.16	<0.05	<0.05	0.18	<0.05
	Potassium (mg/L)		0.5	0.05	ns	3.07	1.73	ns	2.24	1.79	15	10.3	13.4	3.4	2.26	1.48
	Selenium (mg/L)	0.01	0.005	0.004	ns	<0.004	<0.004	ns	0.006	<0.004	<0.005	<0.004	<0.004	<0.005	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	ns	<0.0001	<0.002	ns	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.0001	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	ns	127	105	ns	14	17.4	24	18.6	22.3	73	84.6	87.5
	Strontium (mg/L)		0.001	0.005	ns	1.91	0.113	ns	0.994	0.094	0.16	1.98	0.138	0.19	1.69	0.117
	Thallium (mg/L)		0.0003	0.006	ns	<0.0003	<0.006	ns	<0.006	<0.006	0.0004	<0.006	<0.006	0.0008	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	ns	<0.002	<0.002	ns	<0.002	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	ns	0.005	<0.002	ns	0.016	<0.002	<0.002	0.009	<0.002	<0.002	0.005	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	ns	0.002	<0.002	ns	<0.002	<0.002	<0.005	<0.002	<0.002	<0.005	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	ns	0.002	<0.002	ns	0.007	<0.002	0.009	<0.002	<0.002	0.009	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	ns	0.309	0.023	ns	1.19	0.011	0.018	0.835	0.042	0.013	1.32	0.02
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	ns	299	275	ns	252	262	320	293	326	290	306	261
	Bicarbonate (CaCO3) (mg/L)		10	5	ns	299	275	ns	252	262	319	293	326	289	306	261
	Carbonate (CaCO3) (mg/L)		10	5	ns	<5	<5	ns	<5	<5	<10	<5	<5	<10	<5	<5
	Colour (TCU)	5	1	5	ns	<5	<5	ns	<5	<5	27	<5	<5	16	<5	<5
	Total Organic Carbon			0.5	ns	36.6	1.4	ns	2.6	4.2	na	1.0	2	na	9.9	5.4
	DOC (mg/L)	5	0.7	0.5	ns	1.4	1.5	ns	2.6	1.9	1.3	1.0	2	<0.7	0.8	3.9
	Hardness (CaCO3) (mg/L)	100	10	10	ns	328	358	ns	318	329	473	334	430	456	320	389
	Ammonia as N (mg/L)		0.05	0.02	ns	<0.02	<0.02	ns	<0.02	<0.02	<0.05	0.17	<0.02	<0.05	<0.02	<0.02
	Conductivity (us/cm)		3	2	ns	1160	1290	ns	658	667	950	739	897	1100	1050	1110
	pH ()	8.5	0.1	N/A	ns	7.84	8.18	ns	8.14	7.90	7.3	8.11	7.83	7.5	7.82	8.01
Calculated Values	Anion sum (meq/L)		0.01		ns	12.2	13.2	ns	7.33	7.19	10.1	8.43		12.1	11.6	
	Cation sum (meq/L)		0.01		ns	12.1	11.8	ns	7.02	7.37	10.9	7.76		12.4	10.1	
	% Difference (%)		0.01	0.1	ns	0.1	5.7	ns	2.1	1.2	7.93	4.1	2.7	2.62	6.8	2.5
	Langelier Index ()		0.0001		ns	0.94	1.28	ns	1.18	0.98	-0.17	1.24	1.28	-0.10	0.92	1.59
	Saturation pH (pH units)		0.01		ns	6.9	6.9	ns	6.96	6.92	7.47	6.87	6.55	7.60	6.9	6.42
	Silica (mg/L)			0.05	ns	10.6	3.79	ns	8.30	3.60	20.2	9.64	4.37	12.9	11.4	8.94

	Parameter	006			101			102			103			104		
		2003	2008	2009	2003	2008	2009	2003	2008	2009	2003	2008	2009	2003	2008	2009
Anions	Chloride (mg/L)	ns	22.9	36.8	ns	82.5	101	ns	46.3	39.9	ns	143	173	ns	49.9	47.1
	Fluoride (mg/L)	ns	0.06	<0.05	ns	0.10	0.08	ns	0.09	<0.05	ns	0.16	<0.05	ns	0.19	<0.05
	Nitrate as N (mg/L)	ns	2.36	5.83	ns	2.57	2.03	ns	<0.05	0.05	ns	0.27	0.14	ns	<0.05	<0.05
	Nitrite as N (mg/L)	ns	<0.05	<0.05	ns	<0.05	<0.05	ns	<0.05	<0.05	ns	<0.05	<0.05	ns	<0.05	<0.05
	Phosphate-P (ortho) (mg/L)	ns	<0.10	<0.10	ns	<0.10	<0.10	ns	<0.10	<0.10	ns	<0.10	<0.10	ns	<0.10	<0.10
	Sulphate (mg/L)	ns	9.85	13.8	ns	23.2	22.3	ns	38.7	25.6	ns	37.0	18.5	ns	89.4	20.7
Metals	Aluminum (mg/L)	ns	0.067	<0.004	ns	0.048	<0.004	ns	0.037	0.022	ns	3.29	0.009	ns	0.630	0.005
	Antimony (mg/L)	ns	<0.006	<0.006	ns	<0.006	<0.006	ns	<0.006	<0.006	ns	<0.006	<0.006	ns	<0.006	<0.006
	Arsenic (mg/L)	ns	0.005	<0.003	ns	<0.003	<0.003	ns	0.003	<0.003	ns	0.028	<0.003	ns	0.013	<0.003
	Barium (mg/L)	ns	0.480	0.043	ns	0.558	0.043	ns	0.332	0.056	ns	0.232	0.097	ns	0.368	0.095
	Beryllium (mg/L)	ns	<0.001	<0.001	ns	<0.001	<0.001	ns	<0.001	<0.001	ns	<0.001	<0.001	ns	<0.001	<0.001
	Bismuth (mg/L)	ns	<0.002	<0.002	ns	<0.002	<0.002	ns	<0.002	<0.002	ns	<0.002	<0.002	ns	<0.002	<0.002
	Boron (mg/L)	ns	0.016	<0.010	ns	0.012	0.011	ns	0.012	0.011	ns	0.012	0.014	ns	0.016	<0.010
	Cadmium (mg/L)	ns	0.008	<0.002	ns	0.001	<0.002	ns	0.0012	<0.002	ns	0.0015	<0.002	ns	0.0049	<0.002
	Calcium (mg/L)	ns	67.5	78.3	ns	76.2	83.5	ns	83.7	85.1	ns	91.2	109	ns	97.8	91.4
	Chromium (mg/L)	ns	<0.003	<0.003	ns	0.013	<0.003	ns	0.013	<0.003	ns	0.025	0.003	ns	0.006	<0.003
	Cobalt (mg/L)	ns	0.008	<0.001	ns	0.006	<0.001	ns	0.015	<0.001	ns	0.013	<0.001	ns	0.022	<0.001
	Copper (mg/L)	ns	<0.003	<0.003	ns	<0.003	<0.003	ns	0.005	<0.003	ns	0.097	0.005	ns	0.167	<0.003
	Iron (mg/L)	ns	<0.010	<0.010	ns	0.40	<0.010	ns	4.65	0.684	ns	11.0	0.109	ns	12.2	1.12
	Lead (mg/L)	ns	<0.002	<0.002	ns	<0.001	<0.002	ns	<0.001	<0.002	ns	0.149	<0.002	ns	0.014	<0.002
	Magnesium (mg/L)	ns	22.4	24.5	ns	24.4	27	ns	24.9	26.9	ns	27.4	34.2	ns	30.4	28.8
	Manganese (mg/L)	ns	2.50	<0.002	ns	4.13	<0.002	ns	4.26	0.152	ns	1.52	0.103	ns	3.25	0.196
	Molybdenum (mg/L)	ns	<0.002	<0.002	ns	<0.002	<0.002	ns	0.003	<0.002	ns	<0.002	<0.002	ns	<0.002	<0.002
	Nickel (mg/L)	ns	<0.003	<0.003	ns	0.009	<0.003	ns	0.022	<0.003	ns	0.020	<0.003	ns	0.036	<0.003
	Phosphorus (mg/L)	ns	<0.05	<0.05	ns	0.03	<0.05	ns	1.07	0.02	ns	2.43	0.02	ns	2.11	0.03
	Potassium (mg/L)	ns	1.11	0.81	ns	2.46	1.41	ns	2.12	1.01	ns	1.96	1.18	ns	1.72	0.67
	Selenium (mg/L)	ns	<0.004	<0.004	ns	<0.004	<0.004	ns	<0.004	<0.004	ns	<0.004	<0.004	ns	<0.004	<0.004
	Silver (mg/L)	ns	<0.002	<0.002	ns	<0.0001	<0.002	ns	<0.0001	<0.002	ns	<0.0001	<0.002	ns	<0.0001	<0.002
	Sodium (mg/L)	ns	16	24.9	ns	53.9	53.5	ns	39.5	35	ns	90.4	98.4	ns	18.9	19.6
	Strontium (mg/L)	ns	2.13	0.073	ns	1.79	0.11	ns	1.89	0.13	ns	0.741	0.126	ns	1.6	0.117
	Thallium (mg/L)	ns	<0.006	<0.006	ns	<0.0003	<0.006	ns	<0.0003	<0.006	ns	<0.0003	<0.006	ns	<0.0003	<0.006
	Tin (mg/L)	ns	<0.002	<0.002	ns	<0.002	<0.002	ns	<0.002	<0.002	ns	<0.002	<0.002	ns	<0.002	<0.002
	Titanium (mg/L)	ns	0.004	<0.002	ns	0.004	<0.002	ns	0.003	<0.002	ns	0.046	<0.002	ns	0.003	<0.002
	Uranium (mg/L)	ns	<0.002	<0.002	ns	<0.002	<0.002	ns	0.003	<0.002	ns	0.003	<0.002	ns	<0.002	<0.002
	Vanadium (mg/L)	ns	<0.002	<0.002	ns	<0.002	<0.002	ns	<0.002	<0.002	ns	0.047	<0.002	ns	<0.002	<0.002
	Zinc (mg/L)	ns	0.498	0.008	ns	0.015	0.01	ns	0.08	0.042	ns	0.983	0.013	ns	0.46	0.016
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	ns	264	251	ns	275	285	ns	307	300	ns	325	381	ns	259	297
	Bicarbonate (CaCO3) (mg/L)	ns	264	251	ns	275	285	ns	307	300	ns	325	381	ns	259	297
	Carbonate (CaCO3) (mg/L)	ns	<5	<5	ns	<5	<5	ns	<5	<5	ns	<5	<5	ns	<5	<5
	Colour (TCU)	ns	<5	<5	ns	<5	<5	ns	<5	<5	ns	20	34	ns	10	27
	Total Organic Carbon	ns	1.2	1.6	ns	12.4	5.4	ns	19.7	3	ns	22.2	7.8	ns	22.6	11.9
	DOC (mg/L)	ns	1.2	1.5	ns	1.5	4.8	ns	2.9	3	ns	9.0	7.5	ns	6.9	11.1
	Hardness (CaCO3) (mg/L)	ns	261	296	ns	291	320	ns	312	323	ns	341	413	ns	369	347
	Ammonia as N (mg/L)	ns	1.05	<0.02	ns	<0.02	<0.02	ns	<0.02	<0.02	ns	<0.02	<0.02	ns	<0.02	0.09
	Conductivity (us/cm)	ns	547	642	ns	775	823	ns	695	728	ns	1010	1240	ns	731	717
	pH ()	ns	8.13	8.18	ns	7.89	8.13	ns	8.01	8.19	ns	7.61	7.83	ns	7.67	7.97
Calculated Values	Anion sum (meq/L)	ns	6.3	6.76	ns	7.6	9.16	ns	7.25		ns	10.3		ns	7.61	
	Cation sum (meq/L)	ns	6.01	7.03	ns	8.22	8.75	ns	8		ns	10.8		ns	8.25	
	% Difference (%)	ns	2.4	1.9	ns	3.9	2.3	ns	4.9	2.2	ns	2.5	1.3	ns	4	0.7
	Langelier Index ()	ns	1.14	1.19	ns	0.93	1.23	ns	1.13	1.32	ns	0.79	1.14	ns	0.76	1.12
	Saturation pH (pH units)	ns	6.99	6.99	ns	6.96	6.9	ns	6.88	6.87	ns	6.82	6.69	ns	6.91	6.85
	Silica (mg/L)	ns	8.53	3.56	ns	11.0	4.33	ns	9.93	3.82	ns	9.87	4.31	ns	12.0	4.65

Exceeds ODWQS

* ODWQS: Ontario Drinking Water Quality Standards, RDL: Reported Detection Limit, ns: not sampled, na: not analyzed

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter	ODWQS	RDL		Monitoring Wells 105			106			107			109			110			111			112			113			114		
			2003	2008/2009	2003	2008	2009	2003	2008	2009	2003	2008	2009	2003	2008	2009	2003	2008	2009	2003	2008	2009	2003	2008	2009	2003	2008	2009	2003	2008	2009
Anions	Chloride (mg/L)	250	2.0	0.10	ns	25.6	39.6	ns	182	288	ns	63.4	69.1	ns	86.6	113	91.0	75.8	78.3	3.00	1.27	1.23	<2.0	1.88	1.92	2.30	0.88	0.82	5.40	0.55	0.42
	Fluoride (mg/L)	1.5	0.10	0.05	ns	0.26	0.22	ns	0.05	<0.05	ns	0.06	<0.05	ns	0.06	<0.05	0.10	0.06	<0.05	0.71	1.08	1.22	0.67	0.73	0.8	0.68	1.33	1.4	0.82	0.77	0.81
	Nitrate as N (mg/L)	10.0	0.10	0.05	ns	<0.05	<0.05	ns	5.20	1.94	ns	2.42	1.43	ns	5.69	5.53	7.70	7.48	5.38	<0.10	<0.05	<0.05	<0.10	<0.05	<0.05	<0.10	<0.05	<0.05	0.13	<0.05	<0.05
	Nitrite as N (mg/L)	1.0	0.10	0.05	ns	<0.05	<0.05	ns	<0.05	1	ns	<0.05	<0.05	ns	<0.05	<0.05	<0.10	<0.05	<0.05	<0.10	<0.05	<0.05	<0.10	<0.05	<0.05	<0.10	<0.05	<0.05	<0.10	<0.05	<0.05
	Phosphate-P (ortho) (mg/L)		0.30	0.10	ns	<0.10	<0.10	ns	<0.10	<0.10	ns	<0.10	<0.10	ns	<0.10	<0.10	<0.30	<0.10	<0.10	<0.30	<0.10	<0.10	<0.30	<0.10	<0.10	<0.30	<0.10	0.37	<0.30	<0.10	0.64
	Sulphate (mg/L)	500	2.0	0.10	ns	17.5	20.3	ns	26.5	24.4	ns	18.2	11	ns	21.8	22.5	27.0	19.5	18.5	27.0	21.1	21	15.0	16.4	18.1	34.0	19.5	20.3	70.0	4.54	4.73
Metals	Aluminum (mg/L)	0.1	0.01	0.004	ns	1.31	0.013	ns	1.90	<0.004	ns	1.16	0.108	ns	1.65	<0.004	<0.01	0.981	<0.004	0.210	0.614	<0.004	<0.01	0.041	0.005	<0.01	0.145	0.011	<0.01	0.046	0.004
	Antimony (mg/L)	0.006	0.005	0.006	ns	<0.006	<0.006	ns	<0.006	<0.006	ns	<0.006	<0.006	ns	<0.006	<0.006	<0.005	<0.006	<0.006	<0.005	<0.006	<0.006	<0.005	<0.006	<0.006	<0.005	<0.006	<0.006	<0.005	<0.006	<0.006
	Arsenic (mg/L)	0.025	0.001	0.003	ns	0.011	<0.003	ns	0.009	<0.003	ns	<0.003	<0.003	ns	0.007	<0.003	<0.001	<0.003	<0.003	0.004	0.004	<0.003	0.003	0.004	0.005	0.005	<0.003	<0.003	0.001	0.008	0.008
	Barium (mg/L)	1.0	0.01	0.002	ns	0.173	0.088	ns	0.275	0.091	ns	0.429	0.081	ns	0.309	0.094	0.10	0.126	0.086	0.08	0.093	0.067	0.01	0.038	0.041	0.09	0.082	0.082	0.08	0.050	0.056
	Beryllium (mg/L)		0.001	0.001	ns	<0.001	<0.001	ns	<0.001	<0.001	ns	<0.001	<0.001	ns	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	ns	<0.002	<0.002	ns	<0.002	<0.002	ns	<0.002	<0.002	ns	<0.002	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	ns	0.014	<0.010	ns	0.021	0.013	ns	<0.010	<0.010	ns	0.016	0.011	0.10	0.010	<0.010	0.06	0.016	0.019	<0.05	0.037	0.039	<0.05	<0.010	<0.010	<0.05	0.016	0.017
	Cadmium (mg/L)	0.005	0.0001	0.002	ns	<0.002	<0.002	ns	0.008	<0.002	ns	0.0039	<0.002	ns	0.014	<0.002	<0.0001	0.002	<0.002	<0.0001	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.0001	<0.002	<0.002
	Calcium (mg/L)	200	0.5	0.05	ns	69.7	84.5	ns	85.4	85.3	ns	76.4	84.5	ns	94.8	112	91.0	81.6	91.5	53.0	43.3	57.8	28.0	22.9	32	59.0	51.6	59.9	25.0	40.8	49.5
	Chromium (mg/L)	0.05	0.001	0.003	ns	0.004	<0.003	ns	0.009	0.003	ns	0.012	<0.003	ns	0.006	0.004	0.003	0.008	0.004	0.002	<0.003	<0.003	0.002	<0.003	<0.003	0.002	<0.003	<0.003	0.002	<0.003	<0.003
	Cobalt (mg/L)		0.0008	0.001	ns	0.003	<0.001	ns	0.027	<0.001	ns	0.013	<0.001	ns	0.034	<0.001	<0.0008	0.017	<0.001	<0.0008	<0.001	<0.001	<0.0008	<0.001	<0.001	0.0018	<0.001	<0.001	0.0016	<0.001	<0.001
	Copper (mg/L)	1.0	0.001	0.003	ns	0.028	<0.003	ns	0.060	<0.003	ns	0.075	0.003	ns	0.058	<0.003	0.001	0.026	<0.003	<0.001	<0.003	<0.003	<0.001	<0.003	<0.003	<0.001	<0.003	<0.003	<0.001	<0.003	<0.003
	Iron (mg/L)	0.3	0.05	0.010	ns	4.09	<0.010	ns	3.92	<0.010	ns	2.58	<0.010	ns	2.12	<0.010	0.06	3.71	<0.010	0.27	1.55	0.023	<0.05	0.149	0.12	0.07	0.400	0.162	0.06	1.32	1.09
	Lead (mg/L)	0.010	0.001	0.002	ns	0.066	<0.002	ns	0.126	<0.002	ns	0.091	<0.002	ns	0.21	<0.002	<0.001	0.129	<0.002	<0.001	0.008	<0.002	<0.001	<0.002	<0.002	<0.001	0.035	<0.002	<0.001	<0.002	<0.002
	Magnesium (mg/L)		0.5	0.05	ns	25.2	29.2	ns	24.4	24.6	ns	23.4	26.7	ns	27.2	32.4	29	25.7	28.3	23	20.8	25.1	22	22.7	27.9	22	21	23.6	18	20.3	23.1
	Manganese (mg/L)	0.05	0.001	0.002	ns	1.47	<0.002	ns	5.00	0.006	ns	1.50	0.067	ns	3.74	<0.002	0.075	0.843	<0.002	0.024	0.051	0.006	0.034	0.039	0.031	0.029	0.028	0.004	0.097	0.004	0.003
	Molybdenum (mg/L)		0.001	0.002	ns	<0.002	<0.002	ns	<0.002	0.002	ns	<0.002	<0.002	ns	<0.002	<0.002	0.006	<0.002	<0.002	0.002	<0.002	<0.002	0.005	0.004	0.004	0.001	<0.002	<0.002	0.016	0.002	0.002
	Nickel (mg/L)		0.002	0.003	ns	<0.003	<0.003	ns	0.025	<0.003	ns	0.056	<0.003	ns	<0.003	<0.003	0.002	0.010	<0.003	<0.002	<0.003	<0.003	<0.002	<0.003	<0.003	<0.002	<0.003	<0.003	0.003	<0.003	<0.003
	Phosphorus (mg/L)		0.05	0.05	ns	1.41	<0.05	ns	3.94	<0.05	ns	0.54	<0.05	ns	1.69	<0.05	<0.05	0.36	<0.05	<0.05	0.16	<0.05	<0.05	0.06	0.05	<0.05	0.07	<0.05	<0.05	0.05	0.06
	Potassium (mg/L)		0.5	0.05	ns	1.11	0.74	ns	2.44	1.63	ns	1.76	1.33	ns	2.36	1.61	2.7	2.87	1.92	1.2	0.84	1.41	0.9	0.96	0.81	1.0	1.06	0.94	1.0	1	0.83
	Selenium (mg/L)	0.01	0.005	0.004	ns	<0.004	<0.004	ns	<0.004	<0.004	ns	<0.004	<0.004	ns	<0.004	<0.004	<0.005	<0.004	<0.004	<0.005	<0.004	<0.004	<0.005	<0.004	<0.004	<0.005	<0.004	<0.004	<0.005	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	ns	<0.002	<0.002	ns	<0.002	<0.002	ns	0.0001	<0.002	ns	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.0001	<0.002	<0.002
	Sodium (mg/L)	20	0.5	0.05	ns	18.9	21.8	ns	99.9	151	ns	35.1	36.2	ns	30.9	39	27	34.4	34.4	5.2	10.2	3.8	11	12.1	12.5	4.2	3.64	3	34	6.55	5.08
	Strontium (mg/L)		0.001	0.005	ns	0.653	0.129	ns	1.26	0.117	ns	0.247	0.091	ns	1.12	0.123	0.19	0.234	0.115	0.16	0.205	0.134	0.38	0.426	0.361	0.30	0.193	0.172	16	0.361	0.289
	Thallium (mg/L)		0.0003	0.006	ns	<0.006	<0.006	ns	<0.006	<0.006	ns	<0.0003	<0.006	ns	<0.006	<0.006	<0.0003	<0.006	<0.006	<0.0003	<0.006	<0.006	<0.0003	<0.006	<0.006	<0.0003	<0.006	<0.006	<0.0003	<0.006	<0.006
	Tin (mg/L)		0.001	0.002	ns	<0.002	<0.002	ns	<0.002	<0.002	ns	<0.002	<0.002	ns	<0.002	<0.002	0.006	0.002	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	ns	0.015	<0.002	ns	0.021	<0.002	ns	0.073	<0.002	ns	0.019	<0.002	<0.002	0.067	<0.002	0.009	0.034	<0.002	<0.002	<0.002	<0.002	<0.002	0.009	<0.002	<0.002	0.002	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	ns	<0.002	<0.002	ns	<0.002	<0.002	ns	<0.002	<0.002	ns	<0.002	<0.002	<0.005	<0.002	<0.002	<0.005	0.004	<0.002	<0.005	<0.002	<0.002	<0.005	<0.002	<0.002	<0.005	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	ns	0.004	<0.002	ns	0.006	<0.002	ns	0.01	<0.002	ns	0.004	<0.002	0.008	0.004	<0.002	0.004	<0.002	<0.002	0.004	<0.002	<0.002	0.005	<0.002	<0.002	0.005	<0.002	<0.002
	Zinc (mg/L)	5	0.003	0.005	ns	0.201	0.028	ns	1.06	0.014	ns	0.669	0.231	ns	1.15	0.019	0.011	0.521	0.021	0.008	0.015	<0.005	0.004	0.015	0.009	0.006	0.008	0.019	0.007	0.014	0.007
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	ns	281	290	ns	263	277	ns	262	279	ns	279	279	270	277	266	240	225	218	200	185	193	240	228	234	220	226	222
	Bicarbonate (CaCO3) (mg/L)		10	5	ns	267	290	ns	263	277	ns	262	279	ns	279	279	269	277	266	239	225	213	199	185	193	239	228	234	220	226	222
	Carbonate (CaCO3) (mg/L)		10	5	ns	14	<5	ns	<5	<5	ns	<5	<5	ns	<5	<5	<10	<5	<5	<10	<5	5	<10	<5	<5	<10	<5	<5	<10	<5	<5
	Colour (TCU)	5	1	5	ns	<5	<5	ns	<5	<5	ns	<5	<5	ns	<5	<5	<1	<5	<5	65	<5	<5	79	<5	<5	4	<5	<5	85	<5	<5
	Total Organic Carbon			0.5	ns	1.1	1.9	ns	1.4	1.3	ns	5.4	2.7	ns	1.2	3.2	na	2.9	1.3	na	1.5	0.7	na	0.6	0.7	na	0.7	0.6	na	1.2	1.1
	DOC (mg/L)	5	0.7	0.5	ns	1.1	2.2	ns	1.4	1.3	ns	2.6	2.8	ns	1.2	2.4	<0.7	1.0	1.1	540	0.8	0.6	46.0	0.5	0.7	56.0	0.6	0.7	51.0	1.2	1.2
	Hardness (CaCO3) (mg/L)	100	10	10	ns	278	331	ns	314	314	ns	287	321	ns	349	413	347	310	345	227	194	248	161	151	195	238	215	247	137	185	219
	Ammonia as N (mg/L)		0.05	0.02	ns	<0.02	<0.02	ns	<0.02	<0.02	ns	<0.02	<0.02	ns	0.15	<0.02	<0.05	<0.02	<0.02	0.08	<0.02	<0.02	0.33	0.37	0.07	0.06	<0.02	<0.02	0.15	0.67	0.45
	Conductivity (us/cm)		3	2	ns	585	684	ns	1070	1380	ns	671	733	ns	579	899	860	758	817	450	416	437	380	358	379	480	402	450	530	383	413
	pH ()	8.5	0.1	N/A	ns	8.31	8.06	ns	7.99	8.13	ns	7.89	8.15	ns	8.03	7.83	7.7	7.93	7.89	7.8	8.09	8.34	7.7	8.13	8.21	7.8	8.05	8.12	7.2	8.07	8.1
Calculated Values	Anion sum (meq/L)		0.01		ns	6.71	7.34	ns	11.3	14.4	ns	6.72	7.86	ns	8.88		9.08	8.62		5.49	4.97	4.83	4.41	4.09		5.62	4.99		6.06	4.63	
	Cation sum (meq/L)		0.01		ns	6.4	7.59	ns	10.7	12.9	ns	7.31	8.02	ns	8.38		8.17	7.76		4.80	4.33	5.15	3.73	3.58		4.97	4.49		4.24	4.06	
	% Difference (%)		0.01	0.1	ns	2.3	1.6	ns	2.9	5.5	ns	4.2	1	ns	2.9	1.8	-10.55	5.3	0.8	-13.41	6.9	3.2	-16.71	6.7	1.9	-12.28	5.3	0.4	-35.34	6.5	1
	Langelier Index ()		0.0001		ns	1.34	1.18	ns	1.02	1.18	ns	0.91	1.24	ns	1.16	1.19	0.02	1	1.15	-0.10	0.90	1.24	-0.54	0.75	1.09	-0.06	0.91	1.18	-1.07	0.86	1.09
	Saturation pH (pH units)		0.01		ns	6.97	6.88	ns	6.97	6.95	ns	6.98	6.91	ns	6.87	6.64	7.68	6.93	6.74	7.90	7.19	7.1	8.24	7.38	7.12	7.86	7.14	6.94	8.27	7.21	7.01
	Silica (mg/L)			0.05	ns	14.3	5.14	ns	10.5	3.69	ns	10.6	3.15	ns	11.3	4.6	11.3	11.5	4.65	18.4	18.4	7.86	12.8	14.7	6.56	18.0	18.5	7.96	11.3	17.3	7.38

Exceeds ODWQS

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

	Parameter	ODWQS	RDL		Monitoring Wells 115			115A			116			116A			117			117A			118			118A		
			2003	2008/2009	2003	2008	2009	2003	2008	2009	2003	2008	2009	2003	2008	2009	2003	2008	2009	2003	2008	2009	2003	2008	2009	2003	2008	2009
Anions	Chloride (mg/L)	250	2.0	0.10	6.80	2.33	2.42	150	237	156	68.0	27.2	31.3	15.0	13.1	9.23	8.10	17.3	17.5	35.0	31.8	41.2	6.40	0.44	12	220	137	217
	Fluoride (mg/L)	1.5	0.10	0.05	0.34	0.38	0.38	<0.10	0.05	<0.05	<0.10	0.15	0.11	<0.10	0.12	<0.05	0.13	0.16	<0.05	0.12	0.23	<0.05	0.50	0.59	0.53	0.11	0.06	<0.05
	Nitrate as N (mg/L)	10.0	0.10	0.05	<0.10	<0.05	<0.05	9.10	2.12	1.3	2.30	0.12	0.08	0.54	0.10	<0.05	<0.10	0.11	<0.05	3.30	0.88	0.51	<0.10	0.11	0.28	11.0	4.02	3.82
	Nitrite as N (mg/L)	1.0	0.10	0.05	<0.10	<0.05	<0.05	<0.10	<0.05	<0.05	0.45	<0.05	<0.05	<0.10	<0.05	<0.05	<0.10	<0.05	<0.05	0.23	<0.05	<0.05	<0.10	0.08	<0.05	<0.30	<0.05	<0.05
	Phosphate-P (ortho) (mg/L)		0.30	0.10	<0.30	<0.10	<0.10	<0.30	<0.10	<0.10	<0.30	<0.10	<0.10	<0.30	<0.10	<0.10	<0.30	<0.10	<0.10	<0.30	<0.10	<0.10	<0.30	<0.10	<0.10	<0.30	<0.10	<0.10
	Sulphate (mg/L)	500	2.0	0.10	45.0	30.9	32.1	29.0	22.7	14.8	57.0	33.6	24.1	57.0	25.4	8.82	35.0	37.8	34.3	40.0	20.2	24.3	20.0	12.7	11.2	23.0	25.8	20.7
Metals	Aluminum (mg/L)	0.1	0.01	0.004	<0.01	0.031	0.004	<0.01	2.41	0.012	<0.01	3.20	0.006	<0.01	1.84	<0.004	<0.01	0.02	<0.004	<0.01	2.04	<0.004	<0.01	0.035	0.344	<0.01	1.20	<0.004
	Antimony (mg/L)	0.006	0.005	0.006	<0.005	<0.006	<0.006	<0.005	<0.006	<0.006	<0.005	<0.006	<0.006	<0.005	<0.006	<0.006	<0.005	<0.006	<0.006	<0.005	<0.006	<0.006	<0.005	<0.006	<0.006	<0.005	<0.006	<0.006
	Arsenic (mg/L)	0.025	0.001	0.003	<0.001	0.013	0.005	<0.001	0.013	<0.003	0.001	0.004	<0.003	0.002	0.007	<0.003	0.001	<0.003	<0.003	<0.001	0.004	<0.003	0.003	0.004	0.006	<0.001	0.003	<0.003
	Barium (mg/L)	1.0	0.01	0.002	0.12	0.957	0.113	0.08	0.191	0.057	0.06	0.170	0.039	0.04	0.122	0.031	0.10	0.970	0.114	0.12	0.387	0.092	0.15	1.190	0.137	0.10	0.938	0.093
	Beryllium (mg/L)		0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Bismuth (mg/L)		0.001	0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.002
	Boron (mg/L)	5.0	0.05	0.010	0.11	0.020	0.012	<0.05	0.018	<0.010	0.09	0.011	0.013	<0.05	0.011	<0.010	<0.05	0.013	0.012	<0.05	0.014	<0.010	<0.05	0.018	0.023	<0.05	0.013	0.01
	Cadmium (mg/L)	0.005	0.0001	0.002	<0.0001	<0.002	<0.002	<0.0001	0.007	<0.002	<0.0001	0.0027	<0.002	<0.0001	0.002	<0.002	<0.0001	0.0006	<0.002	<0.0001	0.0025	<0.002	<0.0001	0.0012	<0.002	<0.0001	0.0154	<0.002
	Calcium (mg/L)	200	0.5	0.05	63.0	52.7	57.4	110	109	93.4	94.0	81.1	90.6	84.0	74.6	84.8	79.0	79.9	79.4	90.0	70.8	78.4	46.0	38.3	47.3	100	89.7	102
	Chromium (mg/L)	0.05	0.001	0.003	0.002	<0.003	<0.003	0.004	0.010	0.003	0.003	0.015	<0.003	0.003	0.012	<0.003	0.003	0.014	<0.003	0.003	0.018	<0.003	0.003	0.013	<0.003	0.004	0.014	0.003
	Cobalt (mg/L)		0.0008	0.001	<0.0008	0.009	<0.001	<0.0008	0.023	<0.001	0.0008	0.012	<0.001	<0.0008	0.012	<0.001	<0.0008	0.020	<0.001	<0.0008	0.016	<0.001	<0.0008	0.017	0.004	<0.0008	0.003	<0.001
	Copper (mg/L)	1.0	0.001	0.003	<0.001	<0.003	<0.003	0.001	0.082	<0.003	0.002	0.057	<0.003	0.002	0.136	<0.003	0.001	0.003	<0.003	0.002	0.070	<0.003	<0.001	<0.003	0.006	0.002	0.115	<0.003
	Iron (mg/L)	0.3	0.05	0.010	<0.05	3.25	0.176	0.08	3.68	<0.010	0.06	7.45	<0.010	0.05	5.07	0.265	<0.05	1.61	0.532	0.06	2.47	<0.010	<0.05	5.6	1.06	0.09	2.35	<0.010
	Lead (mg/L)	0.010	0.001	0.002	<0.001	<0.002	<0.002	<0.001	0.208	<0.002	<0.001	0.114	<0.002	<0.001	0.154	<0.002	<0.001	<0.001	<0.002	<0.001	0.591	<0.002	<0.001	0.001	0.027	<0.001	0.032	<0.002
	Magnesium (mg/L)		0.5	0.05	21	22.6	24.2	28	29.8	26.5	34	25.7	27.5	22	22.5	24.7	24	27.4	28.3	27	23.7	27.3	25	25.6	26.2	29	27.2	31
	Manganese (mg/L)	0.05	0.001	0.002	0.047	4.94	0.01	<0.001	3.19	0.002	0.14	1.66	0.002	0.021	1.11	0.078	0.097	4.08	0.046	0.013	2.09	<0.002	0.003	4.87	0.191	0.003	3.3	<0.002
	Molybdenum (mg/L)		0.001	0.002	0.009	0.002	<0.002	<0.001	<0.002	<0.002	0.009	<0.002	<0.002	0.003	<0.002	<0.002	0.004	<0.002	<0.002	<0.001	<0.002	<0.002	0.009	<0.002	<0.002	0.001	<0.002	<0.002
	Nickel (mg/L)		0.002	0.003	<0.002	0.013	<0.003	<0.002	0.003	<0.003	0.002	0.017	<0.003	<0.002	0.030	<0.003	0.002	0.037	<0.003	<0.002	0.023	<0.003	<0.002	0.038	<0.003	<0.002	0.066	<0.003
	Phosphorus (mg/L)		0.05	0.05	<0.05	0.1	<0.05	<0.05	9.2	<0.05	<0.05	0.97	<0.05	<0.05	0.6	<0.05	<0.05	0.04	0.03	<0.05	2.03	0.03	<0.05	0.03	<0.05	<0.05	1.03	<0.05
	Potassium (mg/L)		0.5	0.05	2.2	2.04	1.17	1.4	1.68	0.94	2.7	1.58	1.57	1.0	0.9	0.69	1.5	2.27	0.83	1.2	1.28	0.77	2.0	1.67	1.04	2.3	2.52	1.67
	Selenium (mg/L)	0.01	0.005	0.004	<0.005	<0.004	<0.004	<0.005	<0.004	<0.004	<0.005	<0.004	<0.004	<0.005	<0.004	<0.004	<0.005	<0.004	<0.004	<0.005	<0.004	<0.004	<0.005	<0.004	<0.004	<0.005	<0.004	<0.004
	Silver (mg/L)		0.0001	0.002	<0.0001	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.0001	<0.0001	<0.002	<0.0001	<0.0001	<0.002	<0.0001	<0.0001	<0.002	<0.0001	0.0002	<0.002	<0.0001	<0.0001	<0.002	<0.0001	0.0003	<0.002
	Sodium (mg/L)	20	0.5	0.05	7.6	4.56	4.54	53	79.7	111	25	13	16.5	5.8	7.69	7.97	5.5	6.27	7.16	18	15.4	18.7	11	6.41	11.9	110	80.7	105
	Strontium (mg/L)		0.001	0.005	0.25	2.41	0.123	0.16	1.16	0.114	0.21	0.419	0.106	0.12	0.467	0.095	0.17	2.04	0.117	0.15	0.765	0.103	0.28	1.97	0.265	0.14	0.94	0.11
	Thallium (mg/L)		0.0003	0.006	<0.0003	<0.006	<0.006	<0.0003	<0.006	<0.006	<0.0003	<0.0003	<0.006	<0.0003	<0.0003	<0.006	<0.0003	<0.0003	<0.006	<0.0003	<0.0003	<0.006	<0.0003	<0.0003	<0.006	<0.0003	<0.0003	<0.006
	Tin (mg/L)		0.001	0.002	0.001	<0.002	<0.002	<0.001	<0.002	<0.002	0.002	<0.002	<0.002	<0.001	<0.002	<0.002	0.001	<0.002	<0.002	<0.001	<0.002	<0.002	0.001	<0.002	<0.002	<0.001	<0.002	<0.002
	Titanium (mg/L)		0.002	0.002	<0.002	0.003	<0.002	<0.002	0.019	<0.002	<0.002	0.081	<0.002	<0.002	0.059	<0.002	<0.002	0.003	<0.002	<0.002	0.022	<0.002	<0.002	0.003	0.026	<0.002	0.004	<0.002
	Uranium (mg/L)	0.02	0.005	0.002	<0.005	0.004	<0.002	<0.005	<0.002	<0.002	<0.005	0.002	<0.002	<0.005	<0.002	<0.002	<0.005	0.006	<0.002	<0.005	0.002	<0.002	<0.005	0.01	<0.002	<0.005	<0.002	<0.002
	Vanadium (mg/L)		0.001	0.002	0.008	<0.002	<0.002	0.009	0.011	<0.002	0.009	0.023	<0.002	0.008	0.021	<0.002	0.010	<0.002	<0.002	0.009	0.013	<0.002	0.010	<0.002	<0.002	0.009	0.004	<0.002
	Zinc (mg/L)	5	0.003	0.005	0.025	0.055	0.005	0.011	0.49	0.007	0.019	0.649	0.020	0.031	0.467	0.012	0.004	0.038	0.009	0.012	0.328	0.016	0.018	0.067	0.114	0.011	2.14	0.086
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	230	214	206	270	251	351	280	276	298	250	262	268	280	271	264	280	243	255	230	237	208	270	296	282
	Bicarbonate (CaCO3) (mg/L)		10	5	229	200	206	269	251	351	279	276	268	249	262	268	279	271	264	279	243	255	228	237	203	269	296	282
	Carbonate (CaCO3) (mg/L)		10	5	<10	14	<5	<10	<5	<5	<10	<5	<5	<10	<5	<5	<10	<5	<5	<10	<5	<5	<10	<5	5	<10	<5	<5
	Colour (TCU)	5	1	5	15	<5	<5	<1	<5	<5	18	<5	<5	11	<5	<5	14	<5	<5	11	5	<5	14	<5	<5	<1	<5	<5
	Total Organic Carbon			0.5	na	0.8	12.9	na	3.8	2	na	6.3	7.5	na	8.2	3.1	na	34.2	7.9	na	15.7	2.5	na	6.1	1.8	na	27.5	5.9
	DOC (mg/L)	5	0.7	0.5	2.2	0.8	12.3	1.3	3.8	2	6.6	2.4	4.4	1.9	3.0	3.1	2.5	1.6	6.9	1.7	3.0	2.2	1.8	0.8	1.2	0.8	4.8	6
	Hardness (CaCO3) (mg/L)	100	10	10	244	225	243	390	395	342	375	308	339	300	279	313	296	312	315	336	274	308	218	201	226	369	336	382
	Ammonia as N (mg/L)		0.05	0.02	0.07	<0.02	<0.02	<0.05	<0.02	<0.02	<0.05	<0.02	<0.02	<0.05	<0.02	<0.02	<0.05	<0.02	<0.02	<0.05	<0.02	<0.02	0.13	0.26	0.16	<0.05	<0.02	<0.02
	Conductivity (us/cm)		3	2	470	425	441	1000	1160	1130	830	604	624	600	526	524	570	563	602	730	551	645	400	388	439	1300	935	1220
	pH ()	8.5	0.1	N/A	7.7	8.32	8.21	7.5	8.27	8.02	7.6	7.66	7.84	7.5	7.63	7.98	7.6	7.83	8.06	7.5	7.78	8.08	7.9	8.2	8.35	7.5	7.92	8.04
Calculated Values	Anion sum (meq/L)		0.01		5.75	4.99	4.86	10.9	12.3	11.8	8.87	6.1	6.76	6.65	5.29	5.80	6.57	5.82		7.66	5.46		5.23	4.28	4.75	12.9	9.64	12.5
	Cation sum (meq/L)		0.01		5.26	4.74	5.08	10.1	11.4	11.7	8.65	6.77	7.54	6.28	5.93	6.63	6.20	6.57		7.53	6.18		4.89	4.35	5.07	12.2	10.3	12.2
	% Difference (%)		0.01	0.1	-8.90	2.6	2.3	-7.13	3.9	0.5	-2.51	5.2	5.5	-5.72	5.7	6.6	-5.79	6.1	1	-1.71	6.3	1.3	-6.72	0.8	3.2	-5.18	3.2	0.9
	Langelier Index ()		0.0001		-0.15	1.17	1.08	-0.13	1.38	1.21	-0.06	0.73	0.94	-0.21	0.63	1.07	-0.07	0.9	1.12	-0.04	0.74	1.12	-0.06	1.05	1.19	-0.18	1.03	1.18
	Saturation pH (pH units)		0.01		7.85	7.15	7.13	7.63	6.89	6.81	7.66	6.93	6.90	7.71	7.0	6.91	7.68	6.93	6.94	7.65	7.04	6.96	7.97	7.15	7.16	7.69	6.89	6.86
	Silica (mg/L)			0.05	6.67	17.6	8.38	10.6	6.41	3.25	10.5	9.79	3.99	7.90	8.38	3.41	14.2	15.9	7.48	12.5	9.9	3.94	15.8	19.4	8.8	10.9	8.08	3.78

Exceeds ODWQS

Hanlon Creek Business Park - Groundwater Monitoring Program

Groundwater Quality

					Monitoring Wells																							
	Parameter	ODWQS	RDL		119			119A			121			121A			122			122A			123			max	min	average
			2003	2008/2009	2003	2008	2009	2003	2008	2009	2003	2008	2009	2003	2008	2009	2003	2008	2009	2003	2008	2009	2003	2008	2009			
Anions	Chloride (mg/L)	250	2.0	0.10	32.0	28.7	28.9	30.0	19.3	23.1	52.0	45.2	105	38.0	62.7	48.5	44.0	63.6	66.1	32.0	48.7	41.9	ns	4.22	3.86	288	0.42	60.2
	Fluoride (mg/L)	1.5	0.10	0.05	<0.10	0.05	<0.05	<0.10	0.06	<0.05	<0.10	0.08	<0.05	<0.10	0.06	<0.05	<0.10	0.05	<0.05	<0.10	<0.05	<0.05	ns	1.22	1.39	1.4	<0.05	0.39
	Nitrate as N (mg/L)	10.0	0.10	0.05	0.25	<0.05	<0.05	<0.10	<0.05	<0.05	2.40	3.00	4.45	10.0	4.62	2.85	7.80	11.6	8.71	9.10	4.53	3.79	ns	<0.05	<0.05	19.0	<0.05	4.25
	Nitrite as N (mg/L)	1.0	0.10	0.05	0.19	<0.05	<0.05	<0.10	<0.05	<0.05	0.26	<0.05	<0.05	<0.10	<0.05	<0.05	0.26	<0.05	<0.05	<0.10	<0.05	<0.05	ns	<0.05	<0.05	1	<0.05	0.54
	Phosphate-P (ortho) (mg/L)		0.30	0.10	<0.30	<0.10	<0.10	<0.30	<0.10	<0.10	<0.30	<0.10	<0.10	<0.30	<0.10	<0.10	<0.30	<0.10	<0.10	<0.30	<0.10	<0.10	ns	<0.10	<0.10	<0.30	<0.10	-
	Sulphate (mg/L)	500	2.0	0.10	96.0	67.7	61.8	81.0	25.5	15.7	55.0	41.5	15.8	27.0	16.3	41.6	63.0	22.1	22.7	20.0	16.2	16.2	ns	21.7	22.1	89.4	4.54	23.9
Metals	Aluminum (mg/L)	0.1	0.01	0.004	<0.01	1.06	0.01	<0.01	1.74	0.004	<0.01	0.533	<0.004	<0.01	4.19	1.48	<0.01	0.831	0.004	<0.01	0.964	0.004	ns	0.02	0.009	4.19	<0.01	0.73
	Antimony (mg/L)	0.006	0.005	0.006	<0.005	<0.006	<0.006	<0.005	<0.006	<0.006	<0.005	<0.006	<0.006	<0.005	<0.006	<0.006	<0.005	<0.006	<0.006	<0.005	<0.006	<0.006	ns	<0.006	<0.006	<0.006	<0.005	<0.006
	Arsenic (mg/L)	0.025	0.001	0.003	0.002	0.01	<0.003	0.002	0.008	<0.003	<0.001	<0.003	<0.003	<0.001	<0.003	0.005	<0.001	<0.003	<0.003	<0.001	<0.003	<0.003	ns	0.009	0.005	0.028	<0.001	0.008
	Barium (mg/L)	1.0	0.01	0.002	0.07	0.169	0.048	0.09	0.339	0.06	0.10	0.325	0.064	0.09	0.310	0.163	0.09	0.156	0.093	0.07	0.089	0.049	ns	0.067	0.076	1.190	0.031	0.214
	Beryllium (mg/L)		0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	ns	<0.001	<0.001	<0.001	<0.001	-
	Bismuth (mg/L)		0.001	0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.002	ns	<0.002	<0.002	<0.002	<0.001	-
	Boron (mg/L)	5.0	0.05	0.010	0.11	0.018	0.011	<0.05	0.013	<0.010	0.17	0.012	0.011	<0.05	<0.010	<0.010	0.05	<0.010	<0.010	<0.05	<0.010	<0.010	ns	0.02	0.017	0.060	<0.010	0.016
	Cadmium (mg/L)	0.005	0.0001	0.002	<0.0001	<0.002	<0.002	<0.0001	0.006	<0.002	<0.0001	0.0043	<0.002	<0.0001	0.0071	<0.002	<0.0001	<0.002	<0.002	<0.0001	<0.002	<0.002	ns	<0.002	<0.002	0.020	<0.0001	0.006
	Calcium (mg/L)	200	0.5	0.05	110	94.4	98.2	110	89.0	94.1	77.0	84.9	92.9	95.0	83.3	89.3	89.0	85.4	101	92.0	72.3	79.7	ns	45.9	56.6	119	22.9	77.9
	Chromium (mg/L)	0.05	0.001	0.003	0.003	0.004	<0.003	0.005	0.004	<0.003	0.003	0.010	0.004	0.003	0.023	0.011	0.003	0.006	0.003	0.003	0.004	<0.003	ns	<0.003	<0.003	0.025	0.002	0.009
	Cobalt (mg/L)		0.0008	0.001	0.0009	0.008	<0.001	<0.0008	0.010	<0.001	0.0011	0.010	<0.001	<0.0008	0.042	0.003	<0.0008	0.005	<0.001	<0.0008	0.003	<0.001	ns	<0.001	<0.001	0.0419	<0.0008	0.014
	Copper (mg/L)	1.0	0.001	0.003	0.002	<0.003	<0.003	0.002	0.007	<0.003	0.002	0.016	<0.003	0.001	0.134	0.017	0.001	0.015	<0.003	0.001	0.036	<0.003	ns	<0.003	<0.003	0.167	<0.001	0.049
	Iron (mg/L)	0.3	0.05	0.010	0.08	10.1	1.02	0.08	8.68	0.259	<0.05	5.16	<0.010	0.07	11.8	5.44	0.06	2.54	<0.010	0.07	1.86	<0.010	ns	0.113	0.1	12.2	<0.010	2.908
	Lead (mg/L)	0.010	0.001	0.002	<0.001	0.02	<0.002	<0.001	0.044	<0.002	<0.001	0.017	<0.002	<0.001	0.528	0.079	<0.001	0.06	<0.002	<0.001	0.091	<0.002	ns	<0.002	<0.002	0.591	<0.001	0.123
	Magnesium (mg/L)		0.5	0.05	31	29.3	30.7	35	26.6	28.6	26	28.9	27.4	25	23.8	31.8	28	26.8	30.6	26	22.6	24.6	ns	26.5	28.7	34.2	20.3	26.5
	Manganese (mg/L)	0.05	0.001	0.002	0.16	3.75	0.124	0.20	5.2	0.573	0.29	2.61	<0.002	0.020	3.14	0.721	0.14	0.864	<0.002	<0.001	0.399	<0.002	ns	0.004	0.003	5.2	<0.001	1.65
	Molybdenum (mg/L)		0.001	0.002	0.010	<0.002	<0.002	0.009	<0.002	<0.002	0.014	<0.002	<0.002	<0.001	<0.002	<0.002	0.006	<0.002	<0.002	<0.001	<0.002	<0.002	ns	0.003	<0.002	0.004	<0.001	0.003
	Nickel (mg/L)		0.002	0.003	0.005	<0.003	<0.003	<0.002	<0.003	0.005	0.003	0.010	<0.003	<0.002	0.036	0.003	<0.002	<0.003	<0.003	<0.002	<0.003	<0.003	ns	<0.003	<0.003	0.066	<0.002	0.024
	Phosphorus (mg/L)		0.05	0.05	<0.05	1.74	<0.05	<0.05	0.21	<0.05	<0.05	2.78	<0.05	<0.05	1.02	<0.05	<0.05	0.86	<0.05	<0.05	0.68	<0.05	ns	<0.05	<0.05	9.2	0.02	0.97
	Potassium (mg/L)		0.5	0.05	1.9	1.64	0.99	2.5	1.6	1.05	2.2	2.03	1.52	4.3	3.89	1.36	1.5	1.79	1.29	1.5	1.31	0.9	ns	1.42	1.24	13.4	0.67	1.82
	Selenium (mg/L)	0.01	0.005	0.004	<0.005	0.005	<0.004	<0.005	0.005	<0.004	<0.005	<0.004	<0.004	<0.005	<0.004	<0.004	<0.005	<0.004	<0.004	<0.005	<0.004	<0.004	ns	<0.004	<0.004	0.006	0.005	0.005
	Silver (mg/L)		0.0001	0.002	<0.0001	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.0001	<0.0001	<0.002	<0.0001	0.0001	<0.002	<0.0001	<0.002	<0.002	<0.0001	<0.002	<0.002	ns	<0.002	<0.002	0.0003	0.0001	0.0002
	Sodium (mg/L)	20	0.5	0.05	21	8.52	7.79	12	6.23	7.56	24	13.4	38.8	18	30.2	12.1	27	19.4	20.6	15	17.9	15.3	ns	4.6	4.13	151	3	32.7
	Strontium (mg/L)		0.001	0.005	0.73	2	0.12	0.21	2.17	0.087	0.22	1.04	0.108	0.13	0.469	0.318	0.20	0.407	0.111	0.14	0.222	0.089	ns	0.547	0.448	2.410	0.073	0.619
	Thallium (mg/L)		0.0003	0.006	<0.0003	<0.006	<0.006	<0.0003	<0.006	<0.006	<0.0003	<0.0003	<0.006	<0.0003	<0.0003	<0.006	<0.0003	<0.006	<0.006	<0.0003	<0.006	<0.006	ns	<0.006	<0.006	<0.006	<0.0003	-
	Tin (mg/L)		0.001	0.002	0.008	<0.002	<0.002	0.002	<0.002	<0.002	0.008	<0.002	<0.002	<0.001	<0.002	<0.002	0.003	<0.002	<0.002	0.003	<0.002	<0.002	ns	<0.002	<0.002	0.002	<0.001	0.002
	Titanium (mg/L)		0.002	0.002	<0.002	0.029	<0.002	<0.002	0.005	<0.002	<0.002	0.004	<0.002	<0.002	0.062	0.045	<0.002	0.015	<0.002	<0.002	0.018	<0.002	ns	<0.002	<0.002	0.081	<0.002	0.022
	Uranium (mg/L)	0.02	0.005	0.002	<0.005	<0.002	<0.002	0.006	0.002	<0.002	<0.005	<0.002	<0.002	<0.005	<0.002	<0.002	<0.005	<0.002	<0.002	<0.005	<0.002	<0.002	ns	<0.002	<0.002	0.01	<0.002	0.004
	Vanadium (mg/L)		0.001	0.002	0.010	0.007	<0.002	0.013	0.007	<0.002	0.008	0.003	<0.002	0.009	0.012	0.007	0.009	0.005	<0.002	0.010	0.008	<0.002	ns	<0.002	<0.002	0.047	<0.002	0.010
	Zinc (mg/L)	5	0.003	0.005	0.011	0.217	0.013	0.014	0.519	0.035	0.010	0.434	0.017	0.028	1.79	0.272	0.019	0.229	0.037	0.005	0.212	0.007	ns	0.023	0.007	2.14	0.005	0.276
Wet Chemistry	Alkalinity (CaCO3) (mg/L)	500	10	5	300	296	298	350	312	303	250	259	273	280	266	244	270	267	255	280	247	242	ns	235	223	381	185	266
	Bicarbonate (CaCO3) (mg/L)		10	5	299	278	298	349	294	303	249	259	273	279	266	244	269	267	255	279	247	242	ns	235	223	381	185	265
	Carbonate (CaCO3) (mg/L)		10	5	<10	18	<5	<10	18	<5	<10	<5	<5	<10	<5	<5	<10	<5	<5	<10	<5	<5	ns	<5	<5	18	5	12
	Colour (TCU)	5	1	5	19	8	13	28	10	10	22	<5	<5	23	<5	<5	27	<5	<5	79	<5	<5	ns	<5	<5	65	5	20
	Total Organic Carbon			0.5	na	4.9	9.8	na	5.1	5.5	na	9.4	5.6	na	9.4	2.5	na	3.5	5.6	na	8.2	1.4	ns	0.5	1.8	36.6	0.5	6.4
	DOC (mg/L)	5	0.7	0.5	3.1	4.9	9.6	7.3	5.1	5.4	2.1	1.2	1.9	1.1	1.9	0.7	2.1	0.9	4.9	0.9	1.7	1.3	ns	0.5	1.6	540	0.5	10.9
	Hardness (CaCO3) (mg/L)	100	10	10	402	356	372	419	332	353	299	331	345	340	306	354	338	324	378	337	274	300	ns	224	260	430	151	306
	Ammonia as N (mg/L)		0.05	0.02	<0.05	0.21	<0.02	<0.05	<0.02	<0.02	<0.05	0.15	<0.02	<0.05	0.25	<0.02	<0.05	<0.02	<0.02	<0.05	<0.02	<0.02	ns	<0.02	<0.02	1.05	<0.02	0.30
	Conductivity (us/cm)		3	2	800	676	722	850	611	646	720	643	845	770	694	684	780	695	773	720	597	637	ns	399	464	1380	358	705
	pH ()	8.5	0.1	N/A	7.4	8.36	7.95	7.4	8.35	8.05	7.6	7.76	7.87	7.5	7.73	7.88	7.7	8	7.88	7.5	7.99	8.04	ns	8.2	8.28	8.36	7.61	8.0
Calculated Values	Anion sum (meq/L)		0.01		8.92	8.14	8.06	9.54	7.32	7.04	7.78	6.69		7.95	6.89		8.51	8.42		7.57	6.97		ns	5.27	5.03	14.4	4.09	7.57
	Cation sum (meq/L)		0.01		9.01	7.55	7.79	8.96	6.94	7.4	7.09	7.26		7.69	7.55		7.96	7.36		7.42	6.28		ns	4.7	5.39	12.9	3.58	7.48
	% Difference (%)		0.01	0.1	1.00	3.8	1.7	-6.27	2.6	2.5	-9.28	4.1	2.6	-3.32	4.6	2.1	-6.68	6.8	2.6	-2.00	5.2	0.4	ns	5.7	3.5	6.9	-35.34	2.44
	Langelier Index ()		0.0001		-0.17	1.52	1.13	-0.10	1.5	1.22	-0.17	0.83	1.14	-0.12	0.78	1.12	0.02	1.08	1.16	-0.13	0.96	1.2	ns	1.09	1.21	1.59	-0.1	1.04
	Saturation pH (pH units)		0.01		7.57	6.84	6.82	7.50	6.85	6.83	7.77	6.93	6.73	7.62	6.95	6.76	7.68	6.92	6.72	7.63	7.03	6.84	ns	7.11	7.07	7.9	6.42	6.94
	Silica (mg/L)			0.05	11.1	10.3	3.94	11.9	6.42	2.47	10.1	13.4	3.77	11.0	8.03	5.73	11.4	12.1	4.82	11.1	8.42	3.29	ns	15.6	6.59	19.4	2.47	8.5

Exceeds ODWQS

APPENDIX II

SURFACE WATER MONITORING REPORT

City of Guelph

2009 Hanlon Creek Tributary A Surface Water Monitoring Report

Statement of Qualifications and Limitations

The attached Report (the “Report”) has been prepared by AECOM Canada Ltd. (“Consultant”) for the benefit of the client (“Client”) in accordance with the agreement between Consultant and Client, including the scope of work detailed therein (the “Agreement”).

The information, data, recommendations and conclusions contained in the Report:

- are subject to the scope, schedule, and other constraints and limitations in the Agreement and the qualifications contained in the Report (the “Limitations”)
- represent Consultant’s professional judgement in light of the Limitations and industry standards for the preparation of similar reports
- may be based on information provided to Consultant which has not been independently verified
- have not been updated since the date of issuance of the Report and their accuracy is limited to the time period and circumstances in which they were collected, processed, made or issued
- must be read as a whole and sections thereof should not be read out of such context
- were prepared for the specific purposes described in the Report and the Agreement
- in the case of subsurface, environmental or geotechnical conditions, may be based on limited testing and on the assumption that such conditions are uniform and not variable either geographically or over time

Unless expressly stated to the contrary in the Report or the Agreement, Consultant:

- shall not be responsible for any events or circumstances that may have occurred since the date on which the Report was prepared or for any inaccuracies contained in information that was provided to Consultant
- agrees that the Report represents its professional judgement as described above for the specific purpose described in the Report and the Agreement, but Consultant makes no other representations with respect to the Report or any part thereof
- in the case of subsurface, environmental or geotechnical conditions, is not responsible for variability in such conditions geographically or over time

The Report is to be treated as confidential and may not be used or relied upon by third parties, except:

- as agreed by Consultant and Client
- as required by law
- for use by governmental reviewing agencies

Any use of this Report is subject to this Statement of Qualifications and Limitations. Any damages arising from improper use of the Report or parts thereof shall be borne by the party making such use.

This Statement of Qualifications and Limitations is attached to and forms part of the Report.

AECOM
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Kitchener, ON, Canada N2G 4Y9 519 886 1697 fax
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January 28, 2010

Mr. Peter Cartwright
Manager of Economic Development Services
City of Guelph
City Hall, 1 Carden Street
Guelph, Ontario, Canada N1H

Dear Mr. Cartwright:

Project No: **60118430**

Regarding: **2009 Hanlon Creek Tributary A Surface Water Monitoring Report**

We are pleased to provide a pdf copy of our 2009 Hanlon Creek Tributary A Surface Water Monitoring Report. If you have any questions or comments regarding this report, please contact the undersigned.

Sincerely,
AECOM Canada Ltd.

Nicole S. Weber, M.Sc., Ph.D., P.Eng.
Senior Project Manager - Water Resources, Water
Nicole.Weber@aecom.com

NW:as
Encl.

Distribution List

# of Hard Copies	PDF Required	Association / Company Name
0	Y	City of Guelph
0	Y	Natural Resource Solutions Inc.

AECOM Signatures

Report Prepared By:

Adrienne Sones, B.Eng
Water Resources EIT

Report Reviewed By:

Nicole S. Weber, M.Sc., Ph.D., P.Eng.
Senior Project Manager - Water Resources, Water

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1. Introduction

In anticipation of construction at the Hanlon Creek Business Park, AECOM was retained by the City of Guelph in 2003 to establish and carry out a monitoring program at Hanlon Creek Tributary A to identify pre-construction flow and temperature characteristics. This memorandum summarizes the results of the monitoring program completed in 2009.

2. Background

In 2003-2004 monitoring data was reported in separate memoranda to the City at the time of sampling and in the consolidated EIS prepared by Natural Resource Solutions Inc. (NRSI) for the Hanlon Creek Business Park in 2004. Monitoring continued in 2006 and 2007 with continuous temperature measurements at 6 stations between the outlet of the online pond (Road A) and 150m upstream of Laird Road from May-December 2006 and August-December 2007. Depth and velocity were continuously measured at the Laird Road culvert from May-December 2006 and October-December 2007. Depth measurements were included at monitoring Station 5 from October-December 2006 and August-December 2007. Sampling completed in 2006-2007 was summarized in a technical memorandum, submitted to the City of Guelph in February 2008.

The 2008 monitoring plan included temperature monitoring at the previous 6 stations along Tributary A and an additional temperature monitoring station (Station 7) located near the outlet of the existing SWM pond which is to be Pond 2. This additional station provides background information to identify the temperature impacts of proposed Ponds 1 and 2. Depth and velocity were monitored at the Laird Road culvert and water depth was monitored at Station 5. Through June-September 2008, sites were visited monthly to download data, perform maintenance, and collect baseflow measurements and water quality parameters (DO, pH, specific conductivity) at all stations. The flow/velocity instrument stopped logging data was removed December 3, 2008. 2008 monitoring results were presented in a memorandum to the City of Guelph, dated February 3, 2009.

The 2009 monitoring plan included temperature monitoring at the 7 stations monitored in 2008. These monitoring locations are shown in **Figure 1.** Temperature monitoring consisted of logging temperature readings every 15 and 30 minutes at the 7 site locations. Temperature loggers deployed during winter months were set at a 30 minute interval to ensure adequate memory would be available throughout the winter months. Loggers re-deployed during later months were set at a 15 minute interval. A continuous level/temp logger (at station 5) was installed in 2008 and remained within the stream throughout 2009. In addition, depth and velocity monitoring equipment was installed on May 6, 2009 at the Laird Road culvert.

During May-October 2009, sites were visited monthly to download data, perform maintenance, and collect baseflow measurements and water quality parameters (DO, pH, specific conductivity) at all stations. The flow/velocity instrument stopped logging data November 22nd due to battery failure and was removed from the culvert December 14, 2009. The remainder of the data loggers continue to collect continuous data at 30 minute intervals and were last downloaded December 14, 2009. Monitoring reports from 2009 site visits are included in **Appendix A**.

During the 2009 sampling year, winter stream conditions, equipment malfunctions, and the disappearance of monitoring equipment caused data gaps from some of the stations files. **Table 1** outlines time periods and monitoring parameters unavailable for the associated station. Additionally, weather data from the Elora Research Station made available online by the University of Guelph has been used in data analysis. Data gaps in the weather data are also included in **Table 1** below.

Table 1: Data Gaps in Logger Files

Station	Parameter	Temperature Data Gaps
1	Temperature	May 6 – May 29,
2	Temperature	None
3	Temperature	None
4	Temperature	February 27 – April 2, May 6 – May 29, July 15 – August 24
5	Temperature/Level	July 15 – August 24
6	Temperature	April 2- June 17, July 28 – August 15
7	Temperature	June 4 – June 17
Elora Research Station	Air Temperature, Rainfall	March 29 – May 3

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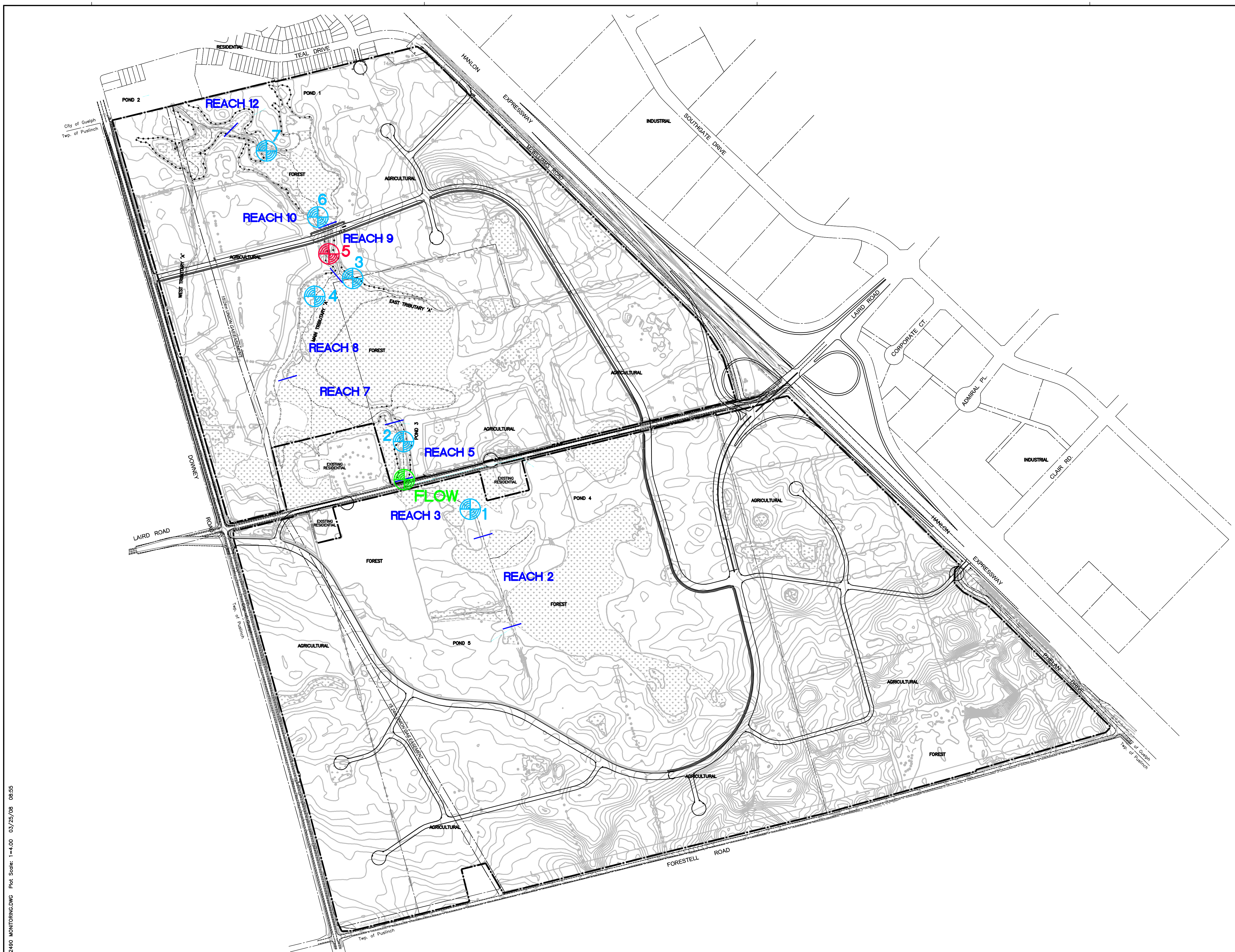

LEGEND

- Property line
- Existing Contours
- Floodline (not surveyed)
- Floodline (surveyed)
- Wetland
- Existing Watercourse
- Existing Treeline
- Temperature Monitoring Station
- Temperature and Level Monitoring Station
- Flow Monitoring Station
- Proposed Stormwater Management Pond

SCALE BAR

20 0 100 200

No.	DATE	BY	ISSUES / REVISIONS
1	01/10/09	RC	ADDED SITE 7

AECOM

AECOM Canada Ltd.
72 Victoria St S., Suite 202, Kitchener, Ontario, Canada N2G 4Y9
T519.886.2160 F519.886.1697

ALL DIMENSIONS AND INFORMATION SHALL BE CHECKED AND VERIFIED ON THE JOB AND ANY DISCREPANCIES MUST BE REPORTED TO THE CONSULTANT BEFORE COMMENCING THE WORK. DRAWINGS ARE NOT TO BE SCALED.

CLIENT:

CITY OF Guelph
Making a Difference

PROJECT:

HANLON CREEK BUSINESS PARK

GUELPH, ONTARIO

DRAWING:

EXISTING CONDITIONS

DRAWN BY: DM	CHECKED BY: RFC	PROJECT No.: 21872-01
DESIGNED BY: DM	APPROVED BY: RT	DRAWING No. 1
SCALE: AS SHOWN	DATE: JAN/09	

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3. Temperature Monitoring

The locations of the temperature monitoring stations for 2009 are shown in **Figure 1**. Station 1 is located approximately 150 m upstream of Laird Road in a partially forested area. The stream then passes through an open area and under Laird Road. Station 2 is located approximately 100 m downstream of Laird Road. The stream passes through a cedar wetland in which Station 4 is located. Station 3 is located in the same cedar wetland on a tributary of the main branch of the creek. Station 5 is located approximately 50 m downstream of the confluence of the main branch and the tributary and above the online pond and farm vehicle creek crossing. Station 6 is located at the outlet of the online pond. Station 7 is located at the downstream end of the study site, approximately 150 m upstream of Teal Drive.

The temperature loggers (HOBO Pendant Temp/Light Logger) were placed in the creek secured to a steel stake driven into the substrate. Temperature data was collected in maximum 30 minute intervals.

A plot of the continuous temperature monitoring throughout the entire year is included in **Figure 2**. Monthly plots of stream and hourly air temperature data from the Elora Research Station are included in **Appendix B**. These plots show the daily pattern of temperature variation with temperatures increasing during the day and decreasing at night.

During sub-zero air temperatures in the winter months, Stations 1 and 7 show no daily variation in temperature and therefore may have been frozen; Station 2 also intermittently exhibits this trend. Stations 2, 5 and 6 show the greatest fluctuation in daily temperatures during winter months (when Station 2 does not show a freezing trend). Stations 3 and 4 show very similar trends and maintain the highest temperatures, generally above 1.5°C, with lower diurnal fluctuations.

During summer months the stations which are more exposed (Station 7) and have a wider flow channel with lesser depths (Stations 2 and 6) show the highest daily variation in temperature as there is greater opportunity for solar radiation impact. Station 3 during the summer shows the lowest temperatures and daily temperature variation indicating groundwater inputs. Station 4 shows a similar trend but reaching higher daily temperatures and showing a much greater variation in the diurnal trends.

Further investigation of groundwater monitoring levels and temperatures (provided by Banks Groundwater) provides a better understanding of seasonal surface water temperature variations. The higher temperatures noted at Stations 3 and 4 during the winter may indicate these stations are more influenced by groundwater, as groundwater temperatures are typically above 3°C. **Appendix D** includes mapping of groundwater monitoring locations, and groundwater level and temperature data from stations which may influence surface water conditions at Stations 3 and 4. This noted trend at Stations 3 and 4 changes during the summer when the influence of groundwater is more apparent at Station 3. Groundwater monitoring data shows the water table in proximity to Station 4 to fluctuate more than the water table upstream of Station 3, with water table levels highest in January and lowest in September. Decreases in groundwater tables at Station 4 may explain why groundwater influences at Station 4 are less apparent during summer months. **Table 2** provides a summary of groundwater monitoring data collected from monitoring locations in proximity to Stations 3 and 4.

Table 2 - Summer Temperature Summary

Groundwater Monitoring Station	Downstream Surface Water Monitoring Station	Monitoring Period	Est. Temperature Variation (°C)	Est. Water Table Variation (m)	Est. Diff. Water Table Variation (m)
MW-104	4	Jan. ’08 – Oct. ‘09	3 – 13.5	320.96 – 322.02	1.06
PZ-4D	4	Apr. ’09 – Oct ‘09	4 – 13	322.5 – 322.15	0.35
MW-118A	3	Oct. ’08 – Oct. ‘09	3 – 15	323.1 – 323.95	0.85
PZ-7D	3	Aug. ’07 – Oct. 09	5 – 11.5	321.4 – 321.65	0.25

The ability of a stream to support a cold water fish species is often defined by the temperatures though summer (July and August) and autumn (mid October – end of November) months. The 2009 Hanlon Business Park Stream Temperature Impact Report (AECOM, 2009) provided a summary of reach based statistical stream temperature modeling results for future mitigated site conditions. This summary included target daily averages, maximums, minimums, the number of hours target temperatures were exceeded and exceedance frequencies during both the summer and autumn. A comparison summary of overall modeled existing and future mitigated conditions of average temperature conditions throughout the creek were also included in the modeling report. The same statistical analysis applied to the HSP-F modeling results has been applied to the 2009 data and is included in **Table 3** and **Table 4** where sufficient is data available.

Note that the Hanlon Creek Business Park Stream Temperature Impact Report recommends:

1. Any single temperature exceedance of 22°C should be analyzed in an annual temperature and flow monitoring report, including an investigative of the cause of the exceedance and recommendations for adaptive management measures as warranted. The investigation should consider the frequency, duration and spatial distribution of the exceedance.
2. Any single temperature exceedance of 24°C should trigger an investigation commencing within 2 weeks of the monthly review of data that identified such an exceedance. This investigation should consider the frequency, duration and spatial distribution of the exceedance, seek to identify the cause of the temperature exceedance, and provide recommendations for adaptive management measures as warranted. If adaptive management measures are warranted, the design and implementation of selected measures should be completed as soon as possible. At the latest, the selected measures should be implemented in the year following the exceedance of 24°C.

No exceedances of 24°C were recorded in 2009. A single occurrence of 22°C was recorded at Station 7 (Reach 14). This station has had historically high temperatures compared to the other stations. This reach is wider with riparian vegetation composed of grasses not trees. Further, groundwater monitoring and modeling shows that this is a reach is a recharge area with limited to no groundwater inputs. The single occurrence of 0.5hr duration in a single reach requires no additional action.

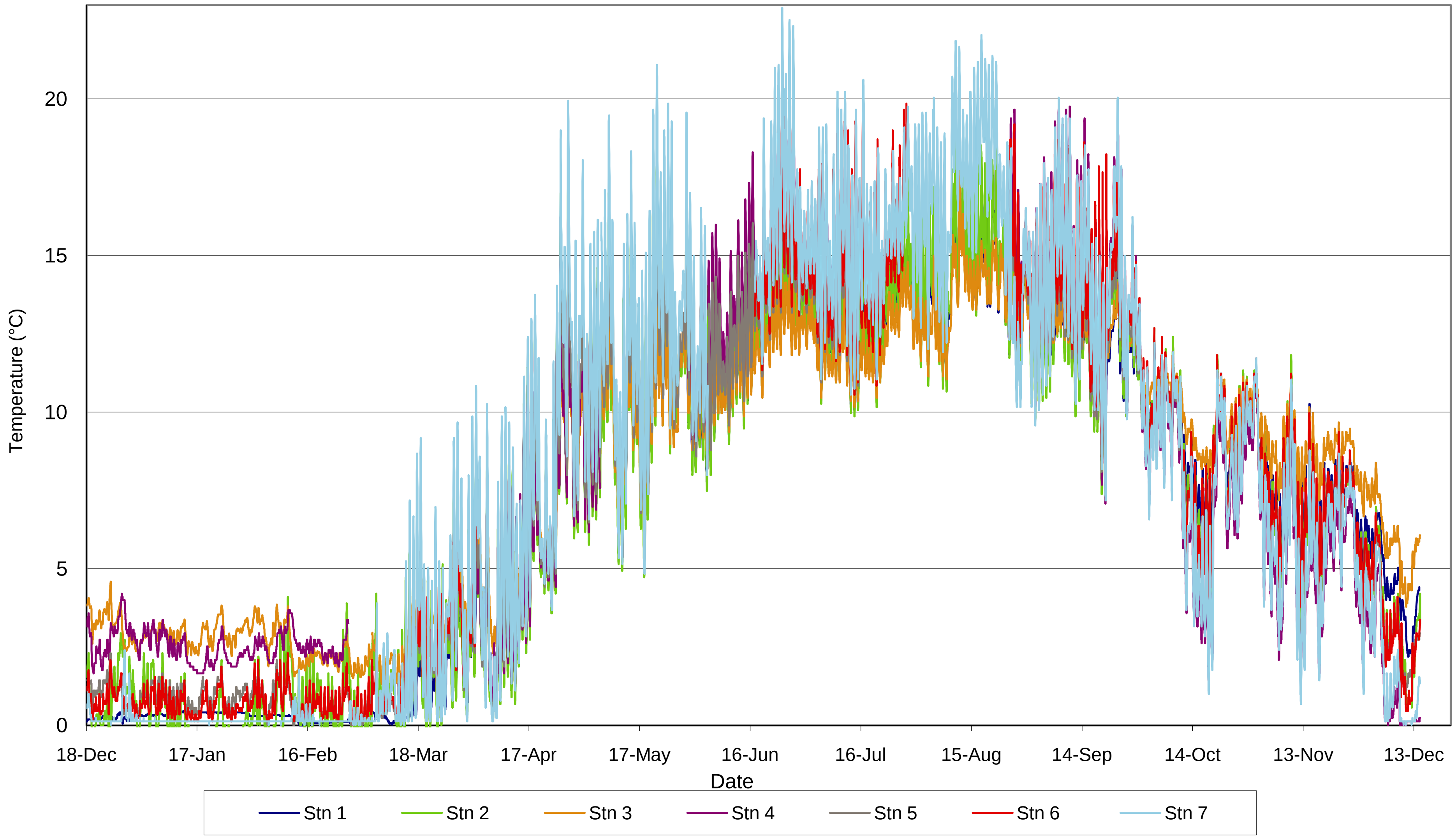


Figure 2 - Hanlon Creek Temperature Monitoring –June –December 2008

Table 3 - Summer Temperature Summary

Stn	Summer (July-August) average maximum	Summer July-August) average	Summer (July-August) average minimum	Maximum 3-day mean	Maximum 7-day mean	Maximum 7-day mean of daily maximums	Hours over 19°C	Percent of Time over 19°C	Frequency of Exceedance over 19°C (Days/yr)	Average Duration of Event Over 19°C (h)	Hours over 22°C	Percent of Time over 22°C	Frequency of Exceedance over 22°C (Days/yr)	Average Duration of Event Over 22°C (h)	Hours over 24°C	Percent of Time over 24°C	Frequency of 24°C Exceedance (Days/yr)	Average Duration of Event Over 24°C (h)
1	15.5	13.8	12.6	13.2	12.8	14.8	0	0.00	0	0	0	0.00	0	0	0	0	0	0
2	16.1	13.9	12.5	13.3	12.8	15.1	0	0.00	0	0	0	0.00	0	0	0	0	0	0
3	13.9	13.0	12.2	0.0	0.0	12.3	0	0.00	0	0	0	0.00	0	0	0	0	0	0
4	17.2*	15.0*	13.1*	n/a	n/a	n/a	11.75*	2.15*	3*	3.9*	0*	0.00*	0*	0*	0*	0*	0*	0*
5	15.2*	13.7*	12.7*	n/a	n/a	n/a	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*
6	17.4*	14.5*	12.3*	n/a	n/a	n/a	11.75*	2.15*	6*	2.0*	0*	0*	0*	0*	0*	0*	0*	0*
7	18.6	16.1	13.8	15.4	14.8	17.8	187	12.57	29	6.2	0.5	0.03%	1	0.5	0	0	0	0

*Data is based on temperature data available July 1-15 and August 24-31, n=21 days

Table 4 - Fall Temperature Summary

	Mid October to End of November				November Only			
Stn	**Max Temp. (°C)**	**Frequency of 11°C Exceedance (days/year)**	**Hours Over 11°C**	**Average Hrs. Over 11°C per Event**	**Max Temp. (°C)**	**Frequency of 11°C Exceedance (days/year)**	**Hours Over 11°C**	**Average Hrs. Over 11°C per Event**
1	11.2	3	8.5	2.8	11.1	1	2.5	2.5
2	11.8	7	24.0	4.3	11.8	1	5.8	5.8
3	11.6	6	35.0	5.8	11.1	1	3.5	3.5
4	11.4	1	3.5	3.5	10.4	1	0.0	0.0
5	11.4	2	6.8	3.4	10.7	0	0.0	0.0
6	11.8	5	23.5	4.7	11.2	1	3.3	3.3
7	11.7	5	22	4.4	11.0	1	2.0	2.0

A method described in Stoneman and Jones (1996) to determine the temperature regime of each station is based on a comparison of water and air temperature at 16:00 each day during summer months when air temperatures exceed 25°C. This analysis was applied to historical temperature monitoring data. A nomograph is then used to classify results based upon water thermal characteristics. **Table 5** below shows the results associated with each station within Hanlon Creek, associated classification plots of each station are included in **Appendix C**. Station 6 is the only station classified as a warmwater thermal regime. The lack of canopy cover at the farm vehicle crossing and the increase in water surface area at the online pond between Stations 5 and 6 likely allows enough solar radiation penetration to the water surface to allow the creek to warm above the targets.

Table 5 - Temperature Classification Summary

Stn	2009	2008	2007	2006	Overall
1	Cool	Cool	Cold	Cold	Cool/Cold
2	Cool	Cool	Cool	Cool	Cool
3	Cold	Cold	Cold	Cold	Cold
4	n/a	Cool	Cold	Cool	Cool
5	n/a	Cold	Cool	Cool	Cool
6	Warm	Cool	Warm	Warm	Warm
7	Cool	Cool	n/a	n/a	Cool

4. Flow Monitoring

In 2009 two flow measurement stations were installed along Hanlon Creek. The first, a depth-velocity meter (ISCO 2100) was installed on the downstream end of the 1200mm culvert crossing Laird Road from May 6th -November 22nd 2009. Although field staff cleared sediment from the culvert during each field visit, mobile organic sediments covered the meter several times during the 2009 season (July 27–August 19, September 7-October 19, November 17–November 22). A debris jam accumulated downstream of the Laird Road culvert during the 2009 monitoring season and is thought to have increased sedimentation at the culvert. During site visits on sediment depth measurements were recorded at the Laird Road station. By applying a factor of sedimentation or sediment removal between site visits and using the continuous level information, a continuous flow area through the culvert was calculated and with the velocity data produced continuous flow data through the culvert. This flow data is presented in **Figure 3.**

A depth logger (HOBO Water Level) was installed at station 5 on May 6th, 2009. This logger disappeared from site sometime at the end of July and was replaced August 24th. Therefore data from July 15th to August 24th is missing from this location. When the logger was replaced, the initial of logger location could not be confirmed and therefore water level readings associated with the replaced of the logger were increased by 0.053 m to coincide the existing data set.

Six flow measurements were taken between May 6 and October 21st 2009 at station 5. These values were used to develop a stage (level) - discharge relationship and establish a 2009 rating curve for Station 5 shown in **Figure 4**. The stage-discharge measurements recorded in 2009 did not fit to the rating curve developed in 2008. This may be a result of instream channel adjustments which have altered the stage-discharge relationship at station 5. The rating curve which includes all flow measurements at station 5 taken from 2007-2009 is shown in **Figure 5**.

A plot showing the creek flow at Station 5 and Laird Rd as well as precipitation data collected at the Elora Research Station, for the 2009 monitoring period is shown in **Figure 5**. The flow at Laird Road, for the period where the records overlap, is on average about 65% of the flow at Station 5.This is consistent with 2007and 2008 flow data. The additional flow at Station 5 can be attributed to local groundwater and tributary flow contributions.

In addition to the continuous flow monitoring and flow measurements at station 5, six baseflow measurements for each Station 1,2,3,4 and 7 were taken on between May 6 and November 21, 2009, using a Flow Tracker 6300 - Acoustic Doppler Velocity Meter. These results are presented in **Table 6** and shown graphically in **Figure 6**. Low water levels and a meandering channel at Station 6 typically make it difficult to perform an accurate flow measurement at this location therefore, baseflow measurements were not often taken at this location. A comparison of 2008 and 2009 baseflow are shown in **Table 7.** Continuation of the baseflow monitoring program will provide sufficient data for trends analysis.

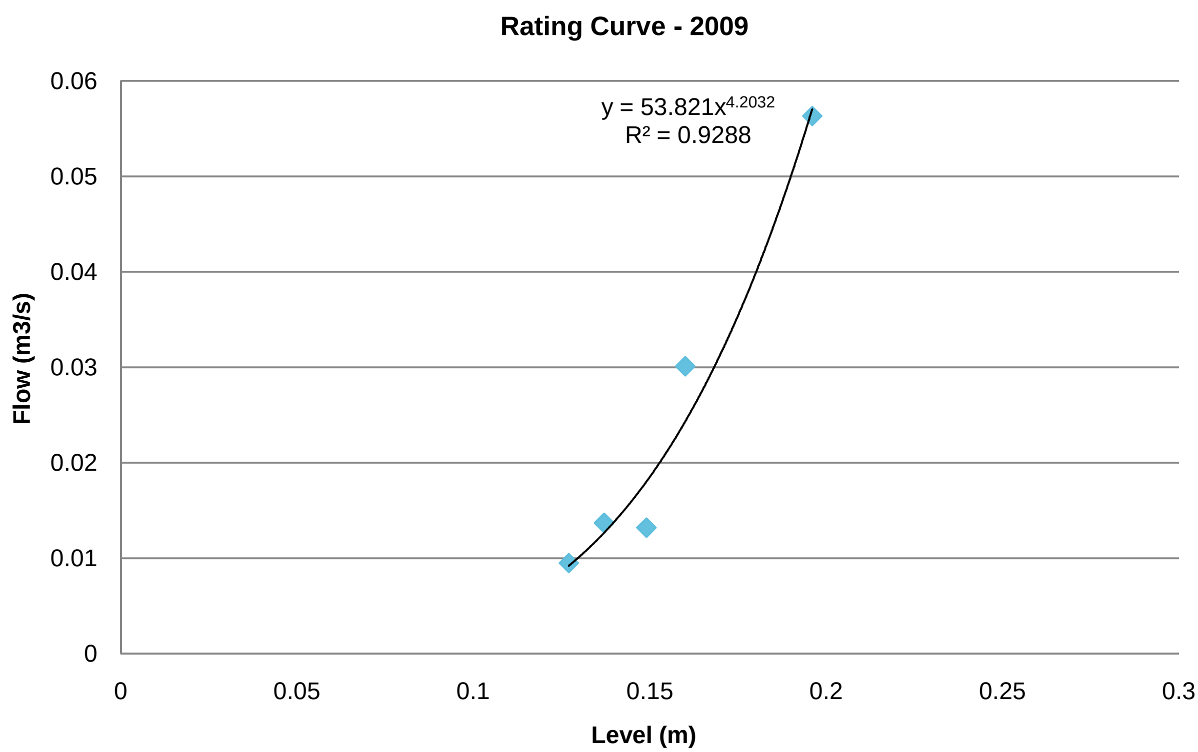


Figure 3 - Stage-Discharge relationship used to calculate flow at Station 5 for 2009

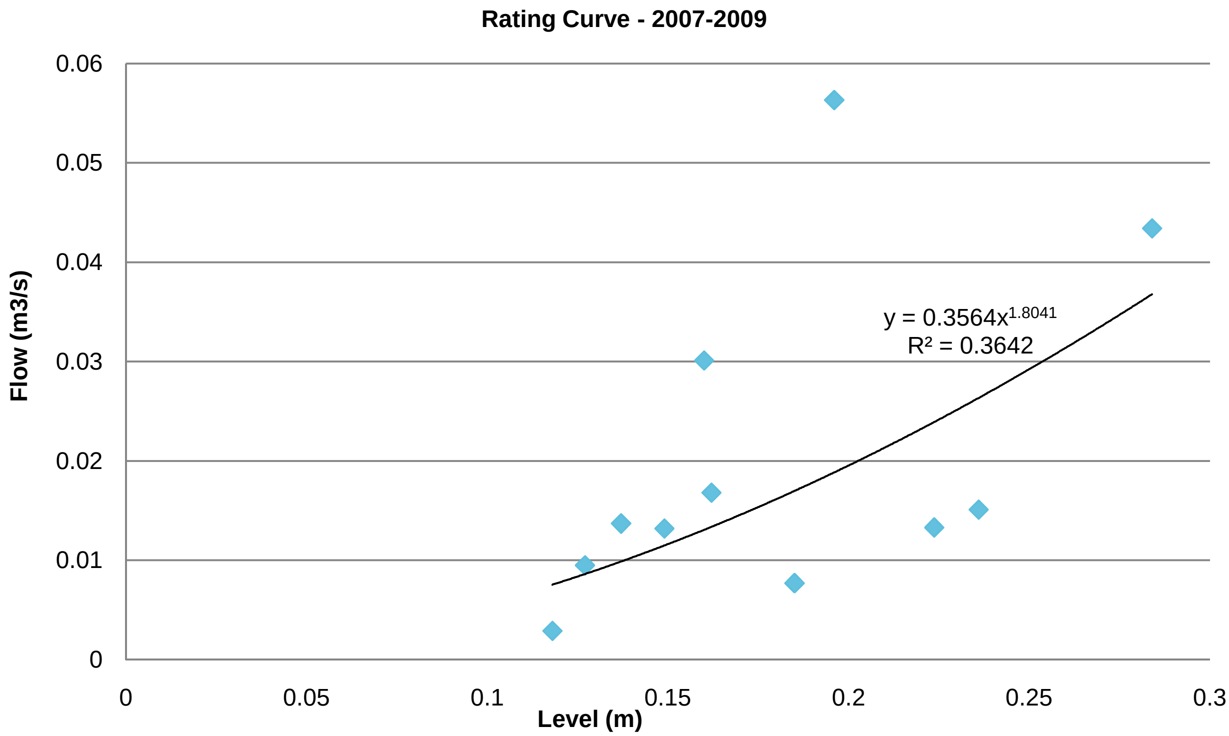


Figure 4 - Stage-Discharge relationship 2007-2009

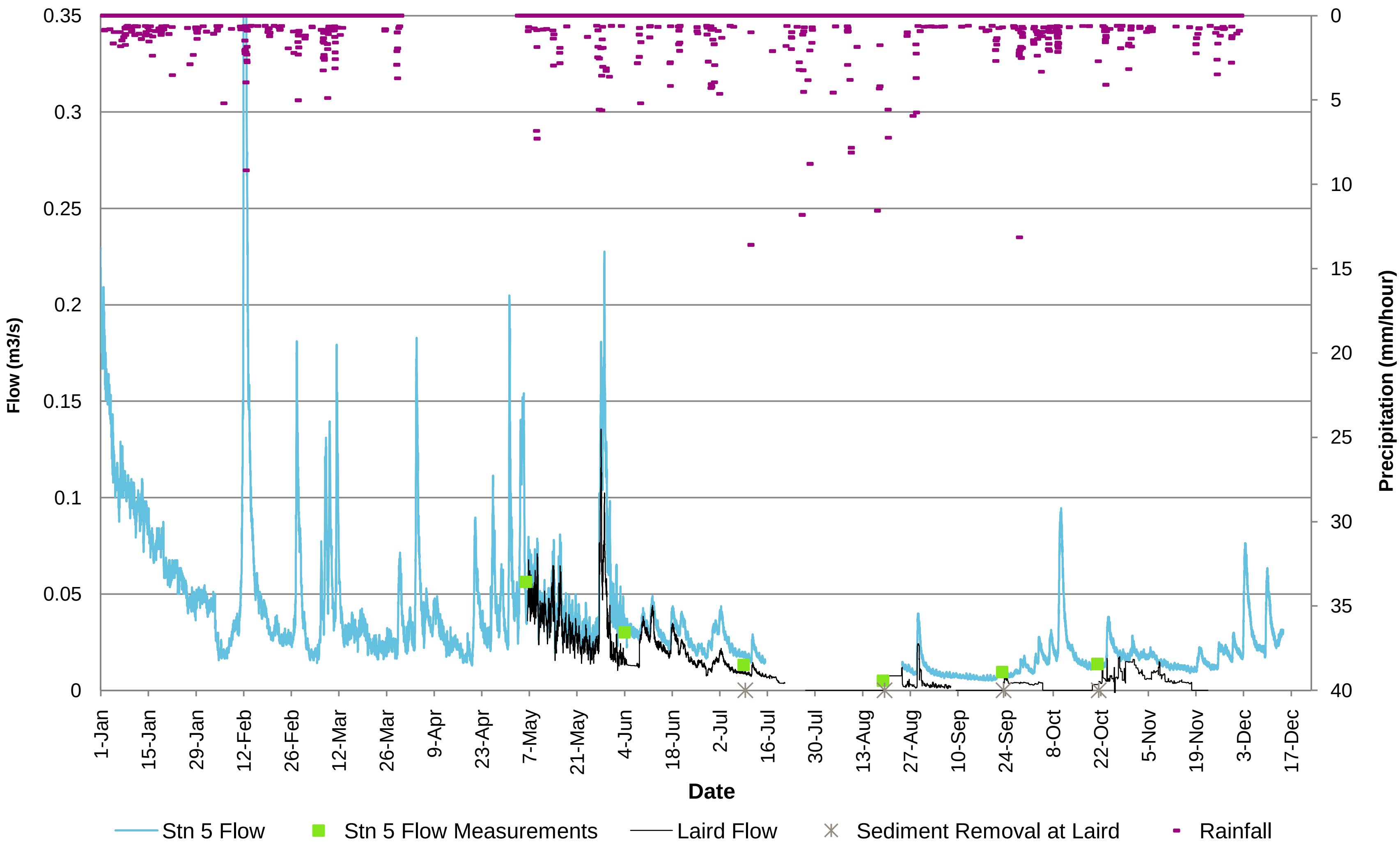


Figure 5 - Laird Rd Station and Station 5 Flow and Precipitation – June 2008 to December 2008

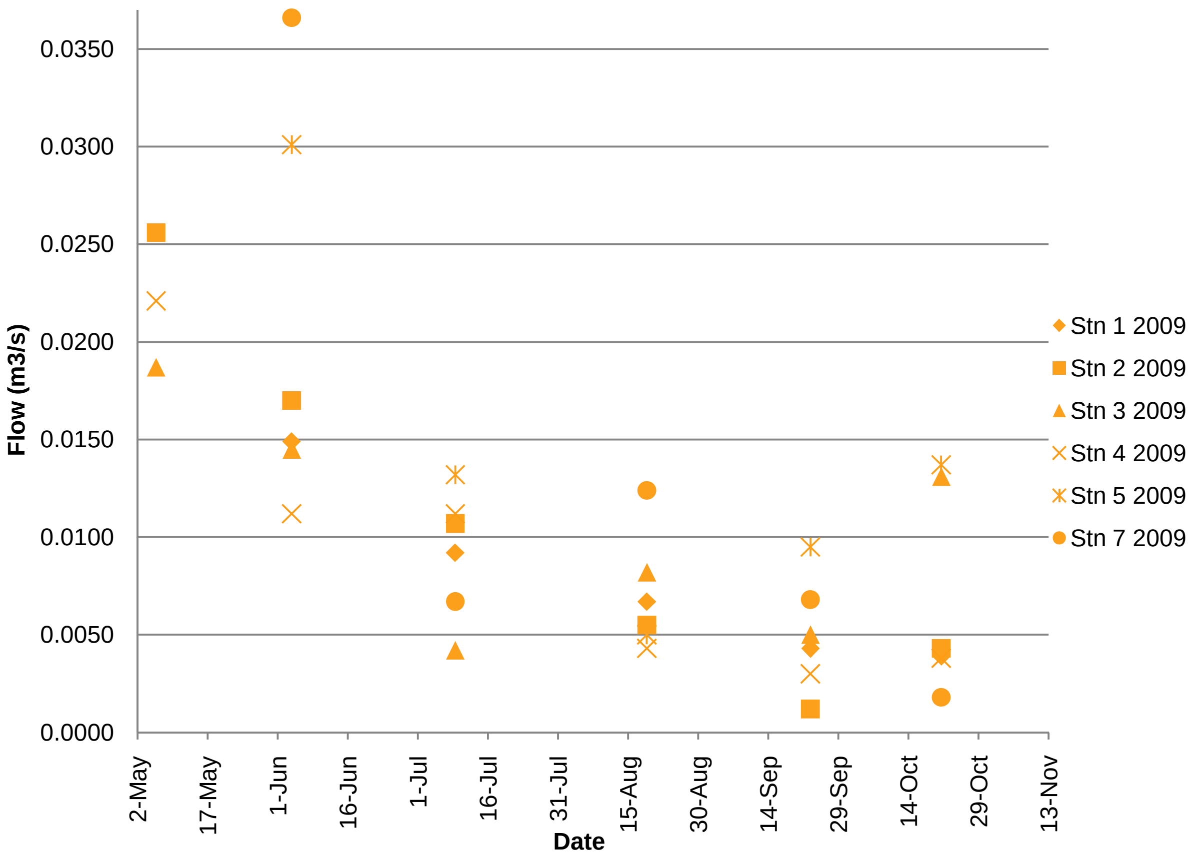


Figure 6 - Hanlon Tributary A Baseflow Measurements – 2009

Table 6 - Hanlon Creek Baseflow Monitoring – May 2009 to October 2009

Stn	6-May-09	4-Jun-09	15-Jul-09	19-Aug-09	23-Sep-09	21-Oct-09
1	n/a	0.0149	0.0092	0.0067	0.0043	0.0039
2	0.0256	0.017	0.0107	0.0055	0.0012	0.0043
3	0.0187	0.0145	0.0042	0.0082	0.005	0.0131
4	0.0221	0.0112	0.0112	0.0043	0.003	0.0038
5	0.0563	0.0301	0.0132	0.005	0.0095	0.0137
6	n/a	n/a	0.0075	n/a	n/a	0.0137
7	0.0538	0.0366	0.0067	0.0124	0.0068	0.0018

Table 7 - Hanlon Creek Baseflow Monitoring – 2008-2009 Summary

Stn	2008 Min	2009 Min	2008 Max	2009 Max	2008 Average	2009 Average
1	0.0035	0.0039	0.0113	0.0149	0.0060	0.0078
2	0.0027	0.0012	0.0107	0.0256	0.0093	0.0107
3	0.0038	0.0042	0.0094	0.0187	0.0085	0.0106
4	0.0021	0.0030	0.0100	0.0221	0.0090	0.0093
5	0.0077	0.0050	0.0168	0.0563	0.0205	0.0213
6	n/a	n/a	n/a	n/a	n/a	n/a
7	0.0009	0.0018	0.0121	0.0538	0.0158	0.0197

5. Water Quality Data

During each field visit an YSI multi-parameter probe (600R) was used to collect dissolved oxygen, pH, and specific conductivity conditions at each site. These results are shown graphically in **Figure7 -9.** All water quality data collected are within normal ranges.

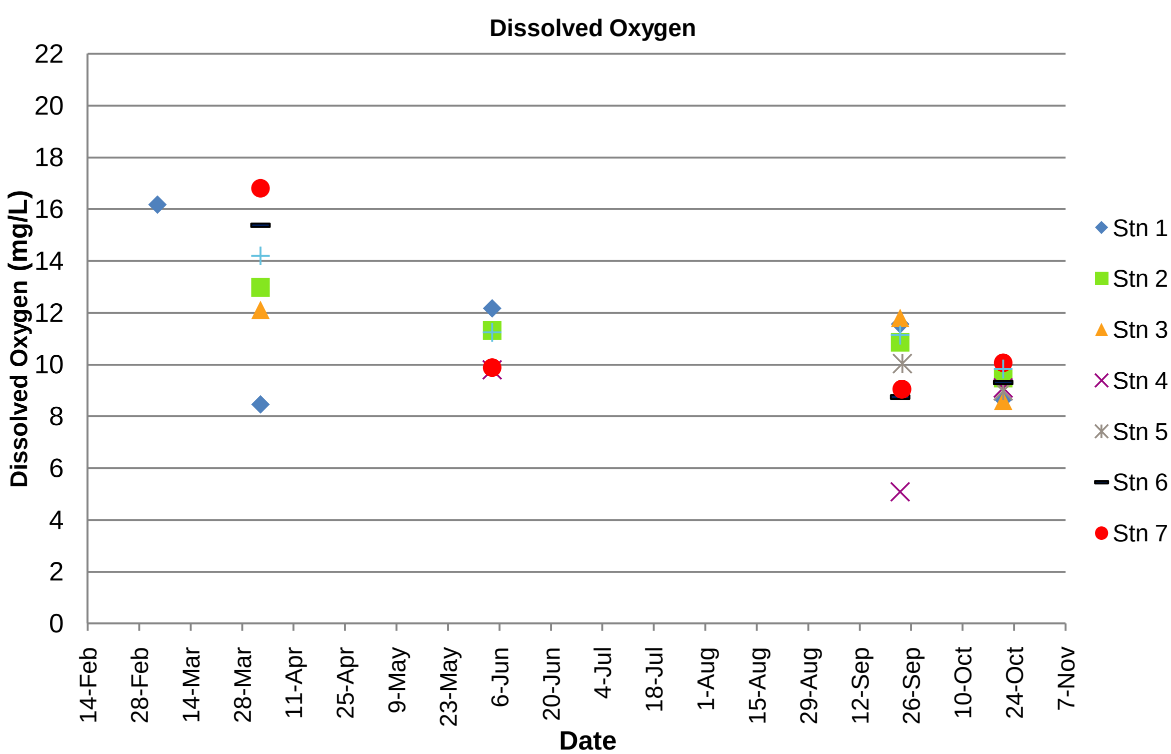


Figure 7 - YSI Dissolved Oxygen Readings

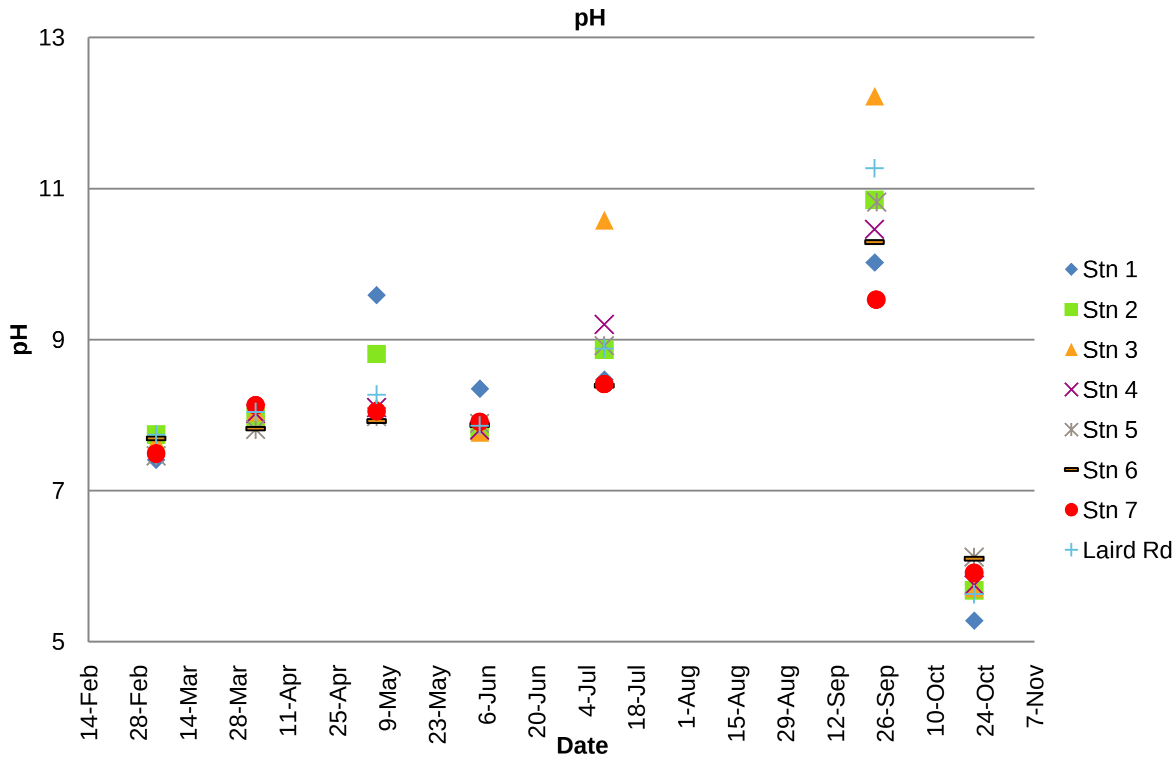


Figure 8 - YSI pH Readings

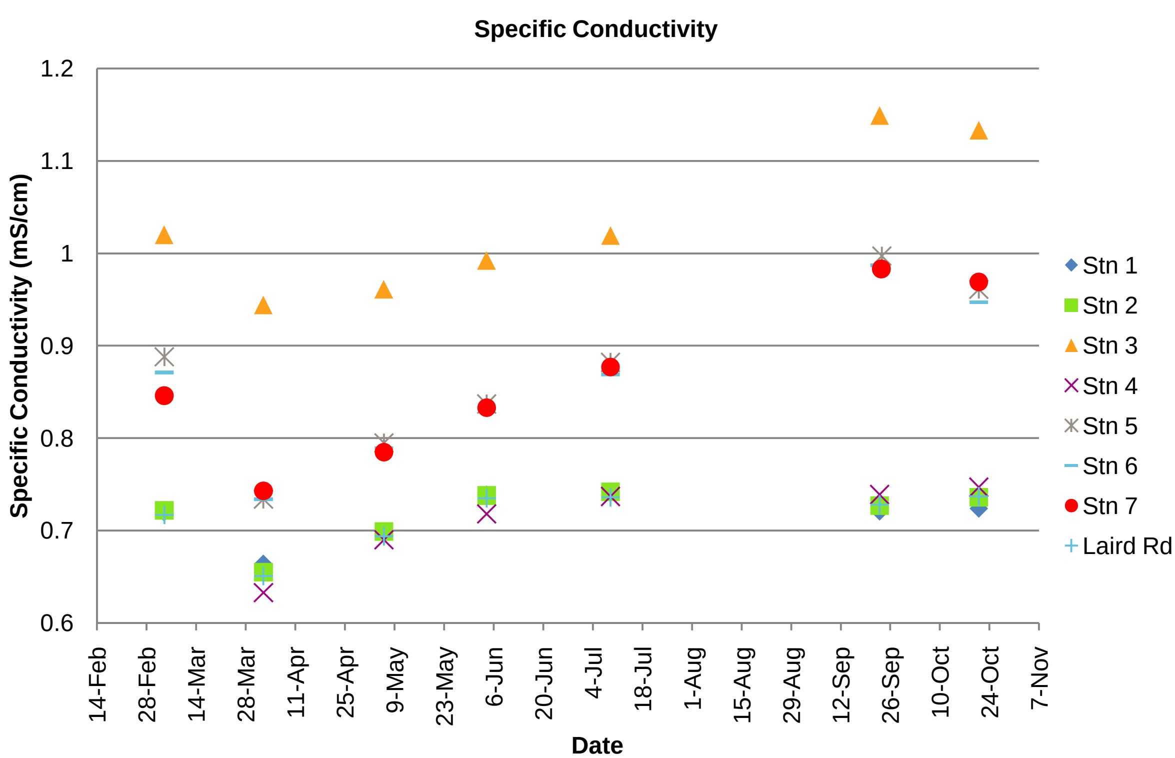


Figure 9 - YSI Specific Conductivity Readings

6. Conclusions and Recommendations

The monitored temperature results from 2009 shows that summer and fall water temperatures are suitable for brook trout habitat. Continuation of the monitoring program during and post construction should continue to ensure temperature targets are met. This monitoring will occur both within the stormwater ponds and the stream to identify the function of each mitigative element in the system (bottom draw, cooling trench, increased vegetative cover). Results of this program should be annually reported to ensure the recommended adaptive management approach is meeting the intended targets. Flow monitoring should also continue in future monitoring initiatives, with a flow monitoring component included at each SWM facility.

7. References

AECOM. 2009. Hanlon Creek Business Park Stream Temperature Impact Report Continuous Modeling with HSP-F.

Grand River Conservation Authority. 1998. Grand River Fisheries Management Plan.

Natural Resource Solutions Inc. 2004. Hanlon Creek Business Park Consolidated Environmental Impact Study.

Stoneman, C.L. and Jones, M.L. 1996. A simple method to classify stream thermal stability with single observations of daily maximum water and air temperatures. ***North American Journal of Fisheries Management*** 16: 728-737

Appendix A

2009 Hanlon Creek Monitoring Report

- **Monitoring Reports**

AECOM
202 – 72 Victoria Street South, Kitchener, ON, Canada N2G 4Y9
T 519.886.2160 F 519.886.1697 www.aecom.com

Sampling Report

Client: City of Guelph
Project: Hanlon Creek Monitoring
Project Number: 110141
Sampling Date: 05 March 2009

Distribution: file

Weather, General Conditions and notes
Site: Hanlon Stn 1

Time: 11:00

Field Crew: Adrienne Sones /John So

Weather: Sunny, 3°C

Photos: U/S, D/S, Across

Flow Tracker filename: none

Measured Flow: none

Logged YSI sample: Yes

Downloaded Temp Logger: No

Other Comments:

Photograph 1 ↑
Upstream View of Temperature Logger Stake

Photograph 2 ↑
Upstream View of Temperature Logger Stake

Photograph 3 🡑
Downstream View of Temperature Logger Stake

Weather, General Conditions and notes

Site: Hanlon Stn 2

Time: 11:10

Field Crew: Adrienne Sones /John So

Weather: Sunny, 3°C

Photos: U/S, D/S, Across

Flow Tracker filename: none

Measured Flow: none

Logged YSI sample: Yes

Downloaded Temp Logger: No

Other Comments:

Photograph 4 ↑
Across Stream View of Temperature Logger Stake

Photograph 5 ↑
Downstream View

Photograph 6 ↑
Upstream View of Temperature Logger Stake

Photograph 7 ↑
Upstream View of Temperature Logger Stake

Photograph 8 ↑
Ice at Temperature Logger

Weather, General Conditions and notes

Site: Laird Road (Flow)

Time: 11:20

Field Crew: Adrienne Sones /John So

Weather: Sunny, 3°C

Photos: U/S, D/S, Across

Flow Tracker filename: None

Measured Flow: None

Logged YSI sample: Yes

Downloaded ATM Logger: No

Other Comments:

Photograph 9 ↑
Downstream View, Right of Culvert

Photograph 10 ↑
Downstream View from Culvert

Photograph 11 ↑
Downstream View from Culvert

Weather, General Conditions and notes

Site: Hanlon Stn 3

Time: 11:50

Field Crew: Adrienne Sones /John So

Weather: Cloudy, 3°C

Flow Tracker filename: none

Measured Flow: none

Logged YSI sample: Yes

Downloaded Temp Logger: No

AECOM

Photos: U/S, D/S, Across

Other Comments:

- Attempted to download temp. logger but data did not transfer to the shuttle

Photograph 12 ↑
Upstream View

Photograph 13 ↑
Bank Conditions

Photograph 14 ↑
Downstream of Culvert

Photograph 15 ↑
Downstream of Station

Weather, General Conditions and notes

Site: Hanlon Stn 4

Time:

Field Crew: Adrienne Sones /John So

Weather: Cloudy, 3°C

Photos: U/S, D/S, Across

Flow Tracker filename: none

Measured Flow: none

Logged YSI sample: No

Downloaded Temp Logger: No

Other Comments:

- Approximately at least 20cm of ice at Stn 4

Photograph 16 ↑
Downstream View

Photograph 17 ↑
Upstream View

Photograph 18 ↑
Temperature Logger Stake

Photograph 19 ↑
Ice Near bank at Temperature Logger Stake

Weather, General Conditions and notes

Site: Hanlon Stn 5

Time: 12:10

Field Crew: AS / JS

Weather: Cloudy, 3°C

Photos: U/S, D/S, Across

Flow Tracker filename: none

Measured Flow: none

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments:

Photograph 20 🡅
Upstream View

Photograph 21 🡅
Across Stream View

Photograph 22 🡅
Taking YSI reading at Temperature Logger Stake

Photograph 23 🡅
Downstream View

Weather, General Conditions and notes

Site: Hanlon Stn 6

Time: 12:20

Field Crew: Adrienne Sones /John So

Weather: Cloudy, 3°C

Photos: U/S, D/S, Across

Flow Tracker filename: none

Measured Flow: none

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments:

Photograph 24 ↑
Upstream View

Photograph 25 ↑
Downstream View of Temperature Logger Stake

Photograph 26 ↑
Temperature Logger Stake

Weather, General Conditions and notes

Site: Hanlon Stn 7

Time: 12:40

Field Crew: Adrienne Sones /John So

Weather: Cloudy, 3°C

Photos: U/S, D/S, Across

Flow Tracker filename: none

Measured Flow: none

Logged YSI sample: Yes

Downloaded Temp Logger: No

Other Comments:

Photograph 27🡅
Upstream View

Photograph 28 🡅
Downstream View

Photograph 29🡅
Temperature Logger Stake

Photograph 30 🡅
Reading YSI at Opening in Ice

JS:as

AECOM
202 – 72 Victoria Street South, Kitchener, ON, Canada N2G 4Y9
T 519.886.2160 F 519.886.1697 www.aecom.com

Sampling Report

Client: City of Guelph
Project: Hanlon Creek Monitoring
Project Number: 110141
Sampling Date: April 2, 2009

Distribution: file

Weather, General Conditions and notes

Site: Hanlon Stn 1

Time: 14:15

Field Crew: Adrienne Sones/John So

Weather: Sunny, warm (7-8°C), no wind

Photos: U/S, D/S, Across

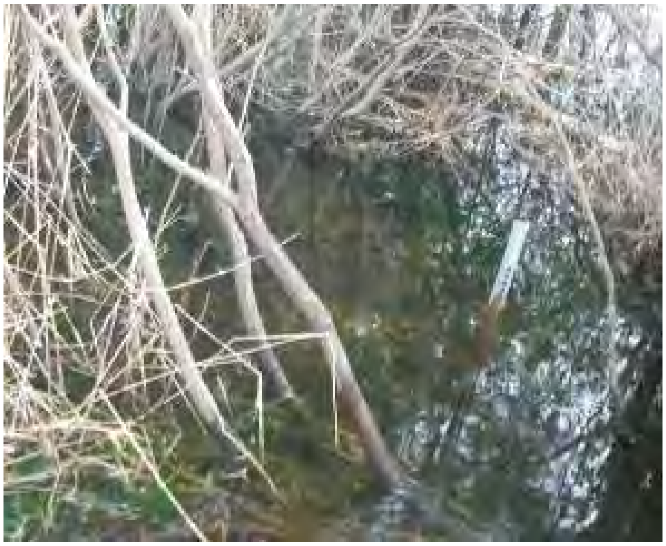
Flow Tracker filename: none

Measured Flow: none

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments: Green algae noted, see photos



Photograph 1 ↑
Upstream at temperature station

Photograph 2 ↑
Downstream

Photograph 3 ↑
Algae downstream

Photograph 4 ↑
Algae downstream

Weather, General Conditions and notes

Site: Hanlon Stn 2

Time: 14:25

Field Crew: Adrienne Sones/John So

Weather: Sunny, warm (7-8°C), no wind

Photos: U/S, D/S, Across

Flow Tracker filename: none

Measured Flow: none

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments: none

Photograph 5 ↑
Downstream

Photograph 6 ↑
Logger Station

Photograph 7 ↑
Across

Weather, General Conditions and notes

Site: Laird Road (Flow)

Time: 15:00

Field Crew: Adrienne Sones/John So

Weather: Sunny, warm (7-8°C), no wind

Photos: U/S, D/S, Across

Flow Tracker filename: none

Measured Flow: none

Logged YSI sample: Yes

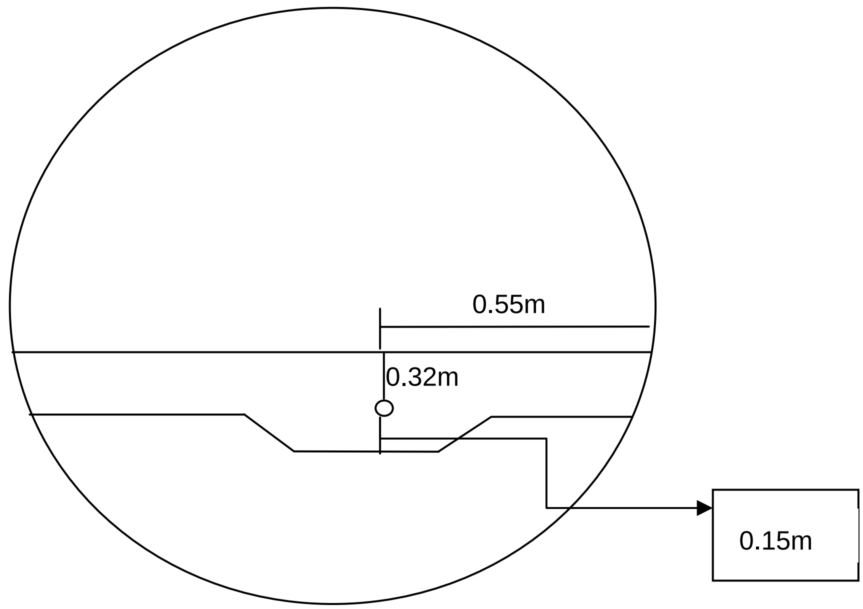
Downloaded Temp Logger: No

Other Comments:

- Attempted to install level velocity meter. Lid on box broke and equipment returned to office for repair
- Algae noted, see photos

Distance from Left edge of Culvert (m)	Bottom of Culvert to top of Sediment (m)
0	0.15
0.1	0.15
0.2	0.24
0.3	0.35

0.4	0.39
At sensor	0.45
0.5	0.48
0.6	0.49
0.7	0.49
0.8	0.13
0.9	0.17
1.0	0.18
1.1	0.14
1.2	0.15



Photograph 8 ↑
Downstream of Culvert

Photograph 9 ↑
Downstream of Culvert

Photograph 10 ↑
Algae to the right of culvert

Weather, General Conditions and notes

Site: Hanlon Stn 3

Time: 16:10

Field Crew: Adrienne Sones/John So

Weather: Sunny, warm (7-8°C), no wind

Photos: U/S, D/S, Across

Flow Tracker filename: none

Measured Flow: none

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments: Replaced logger 11807 (Hobo Temp Pro V.2) with UA 001-08 (Hobo Pendant)

Photograph 11 ↑
Upstream

Photograph 12 ↑
Downstream

Photograph 13 ↑
Across

Weather, General Conditions and notes

Site: Hanlon Stn 4

Time: 16:15

Field Crew: Adrienne Sones/John So

Weather: Sunny, warm (7-8°C), no wind

Photos: U/S, D/S, Across

Flow Tracker filename: none

Measured Flow: none

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments: none

Photograph 14 ↑
Upstream

Photograph 15 ↑
Downstream

Photograph 16 ↑
Across

Weather, General Conditions and notes

Site: Hanlon Stn 5

Time: 16:20

Field Crew: Adrienne Sones/John So

Weather: partly cloudy, warm (7-8°C), no wind

Photos: U/S, D/S, Across

Flow Tracker filename: none

Measured Flow: none

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments: none

Photograph 17 ↑
Upstream

Photograph 18 ↑
Downstream

Photograph 19 ↑
Across

Weather, General Conditions and notes

Site: Hanlon Stn 6

Time: 16:50

Field Crew: Adrienne Sones/John So

Weather: partly cloudy, warm (7-8°C), no wind

Photos: U/S, D/S, Across

Flow Tracker filename:

Measured Flow: none

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments: none

Photograph 20 ↑
Upstream

Photograph 21 ↑
Downstream

Photograph 22 ↑
Across

Weather, General Conditions and notes

Site: Hanlon Stn 7

Time: 17:00

Field Crew: Adrienne Sones/John So

Weather: partly cloudy, warm (7-8°C), no wind

Photos: U/S, D/S, Across, sink hole noted near SWM pond

Flow Tracker filename: none

Measured Flow: none

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments: Sink hole noted near SWM pond, see photos

Photograph 23 ↑
Upstream

Photograph 24 ↑
Downstream

Photograph 25 ↑
Across

Photograph 26 ↑
Sink hole south of pathway near SWM pond

Photograph 27 ↑
Sink hole south of pathway near SWM pond

Photograph 28 ↑
Sink hole south of pathway near SWM pond

AS
Encl.

AECOM

AECOM
202 – 72 Victoria Street South, Kitchener, ON, Canada N2G 4Y9
T 519.886.2160 F 519.886.1697 www.aecom.com

Sampling Report

Client:	City of Guelph
Project:	Hanlon Creek Monitoring
Project Number:	110141
Sampling Date:	06 May 2009

Distribution: file

Weather, General Conditions and notes

Site: Hanlon Stn 1

Time: 8:27

Field Crew: Adrienne Sones /Kyle Woeller

Weather: Sunny, 11°C, no wind

Photos: U/S, D/S, Across

Flow Tracker filename: No flow measurement, flow over banks.

Measured Flow: None

Logged YSI sample: yes

Downloaded Temp Logger: yes

Other Comments: None

Photograph 1 🡩
Upstream

Photograph 2 🡩
Downstream

Photograph 3 🡩
Across stream

Weather, General Conditions and notes

Site: Hanlon Stn 2

Time: 8:40

Field Crew: Adrienne Sones /Kyle Woeller

Weather: Sunny, 11°C, no wind

Photos: U/S, D/S, Across

Flow Tracker filename: HAN20605

Measured Flow: Q= 0.0256 m^3/s

Logged YSI sample: yes

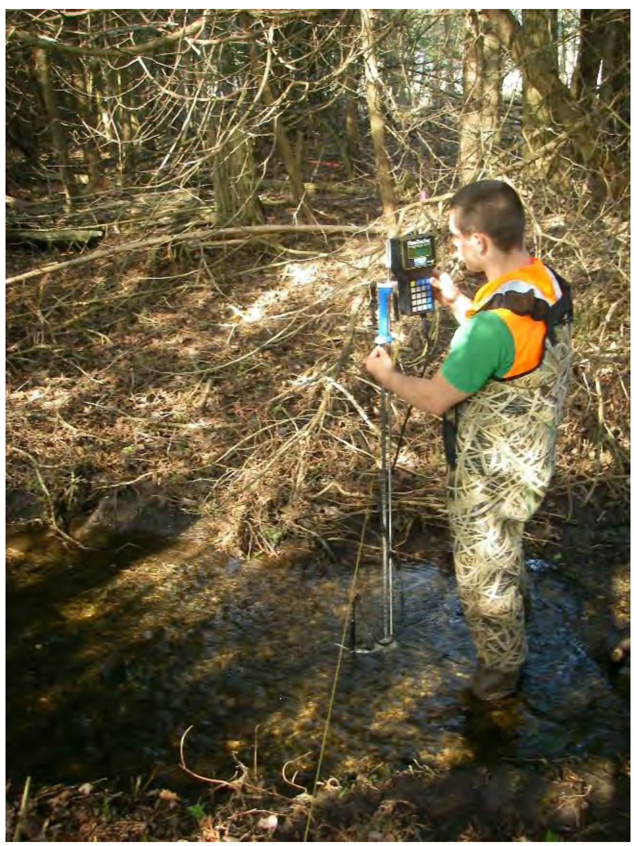
Downloaded Temp Logger: yes

Other Comments: None

Distance from Edge (m)	Water Depth (m)
0	0.03
0.1	0.06
0.2	0.07
0.3	0.08
0.4	0.09
0.5	0.10
0.6	0.09
0.7	0.08
0.8	0.10
0.9	0.11
1.0	0.10
1.1	0.09

Photograph 1 ↑
Upstream

Photograph 2 ↑
Downstream



Photograph 3 ↑
Across stream measuring flow rate

Weather, General Conditions and notes

Site: Laird Road (Flow)

Time: 9:40

Field Crew: Adrienne Sones /Kyle Woeller

Weather: Sunny, 13°C, no wind

Photos: D/S

Flow Tracker filename: No flow measurement, flow over banks.

Measured Flow: None

Logged YSI sample: no

Downloaded Temp Logger: no

Other Comments:

- Green algae present at culvert.
- Installed area/velocity meter.

Distance from Edge of Culvert (m)	Depth of Sediment (m)	Water Depth (m)
0.0	0.28	0.19
0.1	0.35	0.20
0.2	0.13	0.35
0.3	0.36	0.40
0.4	0.09	0.45
0.5	0.20	0.45
0.6	0.03	0.47
0.7	0.09	0.39
0.8	0.12	0.38
0.9	0.14	0.34
1.0	0.08	0.36
1.1	0.07	0.37

Photograph 1 ↑
Downstream

Photograph 2 ↑
Downstream algae, right of culvert

Photograph 3 ↑
Downstream algae, left of culvert

Weather, General Conditions and notes

Site: Hanlon Stn 3

Time: 10:26

Field Crew: Adrienne Sones /Kyle Woeller

Weather: Sunny, 18°C, no wind

Photos: U/S, D/S, Across

Flow Tracker filename: HAN30605

Measured Flow: Q= 0.0187 m^3/s

Logged YSI sample: yes

Downloaded Temp Logger: yes

Other Comments: None

Distance from Edge (m)	Water Depth (m)
0.1	0.18
0.2	0.20
0.3	0.23
0.4	0.23
0.5	0.26
0.6	0.26
0.7	0.23
0.8	0.14
0.9	0.09

Photograph 1 🡩
Downstream

Photograph 2 🡩
Upstream

Photograph 3 🡩
Across stream

Weather, General Conditions and notes

Site: Hanlon Stn 4

Time: 11:15

Field Crew: Adrienne Sones /Kyle Woeller

Weather: Sunny, 18°C, no wind

Photos: U/S, D/S, Across

Flow Tracker filename: HAN40605

Measured Flow: Q= 0.0221 m^3/s

Logged YSI sample: yes

Downloaded Temp Logger: yes

Other Comments: None

Distance from Edge (m)	Water Depth (m)
0.0	N/A
0.8	0.24
1.0	0.30
1.2	0.27
1.4	0.30
1.6	0.25
1.8	0.22
2.0	0.23
2.2	0.21
2.4	0.23
2.6	0.22
2.8	0.22
3.0	0.18
3.2	0.16
3.4	0.16
3.6	0.13
4.1	0.12

Photograph 1 🡅
Upstream

Photograph 2 🡅
Downstream

Photograph 3 🡅
Across stream

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Weather, General Conditions and notes

Site: Hanlon Stn 5

Time: 12:00

Field Crew: Adrienne Sones /Kyle Woeller

Weather: Sunny with clouds, 18°C, no wind

Photos: U/S, D/S, Across

Flow Tracker filename: HAN50605

Measured Flow: Q= 0.0563 m^3/s

Logged YSI sample: yes

Downloaded Temp Logger: yes

Other Comments:

- Stake was found removed from ground but was replaced (see photo).
- Fish were observed (10-15cm in length).

Distance from Stake (m)	Water Depth (m)
0.0	0.12
0.1	0.12
0.2	0.11
0.3	0.12
0.4	0.12
0.5	0.12
0.6	0.13
0.7	0.12
0.8	0.11
0.9	0.10
1.0	0.09
1.1	0.10
1.2	0.10
1.3	0.08

Photograph 1 ↑
Upstream

Photograph 2 ↑
Downstream

Photograph 3 ↑
Across stream

Photograph 4 ↑
Relocated stake

Weather, General Conditions and notes

Site: Hanlon Stn 6

Time: 12:50

Field Crew: Adrienne Sones /Kyle Woeller

Weather: Sunny with clouds, 18°C, no wind

Photos: U/S, D/S, Across, U/S pond

Flow Tracker filename: N/A

Measured Flow: None

Logged YSI sample: yes

Downloaded Temp Logger: yes

Other Comments:
Upstream pond depth
- 15 cm of water
- 73 cm total depth

Photograph 1 ↑
Downstream left of pond

Photograph 2 ↑
Downstream right of pond

Photograph 3 ↑
Upstream pond, measuring depth

Weather, General Conditions and notes

Site: Hanlon Stn 7

Time: 14:00

Field Crew: Adrienne Sones /Kyle Woeller

Weather: Cloudy, 20°C, light breeze

Photos: U/S, D/S, Across

Flow Tracker filename: HAN70605

Measured Flow: Q= 0.0538 m^3/s

Logged YSI sample: yes

Downloaded Temp Logger: yes

Other Comments:

- Lots of fish and frogs were observed in creek.
- Sinkhole found south of path at the south end of the SWM pond (roughly 9.5m in length by 3.7m in width). Sinkhole is roughly 0.9m deep with a submerged pipe inlet (0.4m diameter) located at north end. Round stone located around end of inlet.

Distance from Stake (m)	Water Depth (m)
0.0	0.09
0.1	0.16
0.2	0.19
0.3	0.22
0.4	0.24
0.5	0.26
0.6	0.29
0.7	0.30
0.8	0.30
0.9	0.30
1.0	0.31
1.1	0.32
1.2	0.32
1.3	0.32
1.4	0.32

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Photograph 1 ↑
Sinkhole, south of SWM pond

Photograph 2 ↑
Downstream

Photograph 3 ↑
Across stream, measuring flow rate

KW:as

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Sampling Report

Client: City of Guelph
Project: Hanlon Creek Monitoring
Project Number: 110141
Sampling Date: 04 June 2009

Distribution: file

Weather, General Conditions and notes

Site: Hanlon Stn 1

Time: 8:30

Field Crew: Adrienne Sones /Kyle Woeller

Weather: Sunny, warm, 13°C

Photos: U/S, D/S, Across

Flow Tracker filename: HAN10406

Measured Flow: Q= 0.0149 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments:

- Water in channel exceeded measurable area.
- Stagnant water to left (roughly 1m - see photos).

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.10	0.30	0.15
0.20	0.32	0.18
0.30	0.32	0.22
0.40	0.32	0.22
0.50	0.32	0.23
0.60	0.32	0.22
0.70	0.26	0.24
0.80	0.28	0.22
0.90	0.32	0.21
1.00	0.34	0.17
1.10	0.35	0.15
1.20	0.36	0.14
1.30	0.24	0.14

Photograph 1 ↑
Upstream View of Temperature Logger Stake

Photograph 2 ↑
Downstream View of Flow Measurment

Photograph 3 ↑
Across Stream View of Flow Measurement

Weather, General Conditions and notes

Site: Hanlon Stn 2

Time: 9:45

Field Crew: Adrienne Sones /Kyle Woeller

Weather: Sunny, warm, 17°C

Photos: U/S, D/S, Across

Flow Tracker filename: HAN20406

Measured Flow: Q= 0.0170 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments:

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.10	0.00	0.04
0.20	0.00	0.04
0.30	0.00	0.06
0.40	0.00	0.06
0.50	0.00	0.07
0.60	0.00	0.07
0.70	0.00	0.10
0.80	0.00	0.08
0.90	0.00	0.09
1.00	0.00	0.08
1.10	0.00	0.07

Photograph 4 ↑
Upstream View

Photograph 5 ↑
Downstream View

Photograph 6 ↑
Across Stream View

Weather, General Conditions and notes

Site: Laird Road (Flow)

Time: 10:20

Field Crew: Adrienne Sones /Kyle Woeller

Weather: Sunny, warm, 18°C

Photos: U/S, D/S, Across

Flow Tracker filename: None

Measured Flow: None

Logged YSI sample: Yes

Downloaded ATM Logger: Yes

Other Comments:

- Downloaded ISCO

Distance from Edge of Culvert (m)	Sediment Depth (m)	Water Depth (m)
0.00	0.15	0.16
0.10	0.23	0.17
0.20	0.28	0.21
0.30	0.53	0.31
0.40	0.33	0.32
0.50	0.26	0.33
0.60	0.17	0.33
0.70	0.30	0.31
0.80	0.32	0.30
0.90	0.16	0.31
1.00	0.15	0.29
1.10	0.14	0.27
1.20	0.12	0.26
0.45 (@ level logger)	0.34	0.28

Photograph 7 ↑
Downstream View from Culvert

Photograph 8 ↑
Downstream View, Right of Culvert

Photograph 9 ↑
Downstream View, Left of Culvert

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Weather, General Conditions and notes

Site: Hanlon Stn 3

Time: 13:00

Field Crew: Adrienne Sones /Kyle Woeller

Weather: Sunny, warm, 20°C, no wind

Photos: U/S, D/S, Across

Flow Tracker filename: HAN30406

Measured Flow: Q= 0.0145 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments:

- DO on YSI would not stabilize
- Calibration did not fix - discard DO reading

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.10	0.00	0.20
0.20	0.00	0.20
0.30	0.00	0.20
0.40	0.00	0.24
0.50	0.00	0.21
0.60	0.00	0.18

Photograph 10 ↑
Upstream View

Photograph 11 ↑
Downstream View

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Photograph 12 ↑
Across Stream View, Taking Flow Measurement

Weather, General Conditions and notes

Site: Hanlon Stn 4

Time: 13:45

Field Crew: Adrienne Sones /Kyle Woeller

Weather: Sunny, 20°C

Photos: U/S, D/S, Across

Flow Tracker filename: HAN40406

Measured Flow: Q= 0.0112 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments:

- Calibrated DO on YSI

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.00	0.00	0.17
0.10	0.00	0.16
0.20	0.00	0.20
0.30	0.00	0.22
0.40	0.00	0.25
0.50	0.00	0.26
0.60	0.00	0.25
0.70	0.00	0.25
0.80	0.00	0.16
0.90	0.00	0.18
1.00	0.00	0.14
1.10	0.00	0.18
1.20	0.00	0.18
1.30	0.00	0.18
1.40	0.00	0.15
1.50	0.00	0.12
1.60	0.00	0.12

Photograph 13 ↑
Upstream View

Photograph 14 ↑
Downstream View

Photograph 15 ↑
Across Stream View, Taking Flow Measurement

Weather, General Conditions and notes

Site: Hanlon Stn 5

Time: 14:50

Field Crew: Adrienne Sones /Kyle Woeller

Weather: Sunny, warm, 23°C, no wind

Photos: U/S, D/S, Across

Flow Tracker filename: HAN50406

Measured Flow: Q= 0.0301 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments:
- Discard DO reading (incorrect)
- Downloaded level logger

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.10	0.00	0.12
0.20	0.00	0.10
0.30	0.00	0.09
0.40	0.00	0.10
0.50	0.00	0.11
0.60	0.00	0.10
0.70	0.00	0.10
0.80	0.00	0.10
0.90	0.00	0.09
1.00	0.00	0.08
1.10	0.00	0.06
1.20	0.00	0.06
1.30	0.00	0.06

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Photograph 16 🡹
Upstream View

Photograph 17 🡹
Downstream View

Photograph 18 🡹
Across Stream View, Taking Flow Measurement

Weather, General Conditions and notes

Site: Hanlon Stn 6

Time: 15:30

Field Crew: Adrienne Sones /Kyle Woeller

Weather: Sunny, warm, 23°C

Photos: U/S, D/S, Across

Flow Tracker filename: None

Measured Flow: None

Logged YSI sample: Yes

Downloaded Temp Logger: No

Other Comments:

- Discard DO reading (incorrect)
- Temperature logger was missing from site

Weather, General Conditions and notes

Site: Hanlon Stn 7

Time: 11:00

Field Crew: AS / KW

Weather: Sunny, warm, 18°C

Photos: U/S, D/S, Across

Flow Tracker filename: HAN70406

Measured Flow: Q= 0.0366 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments:

- Battery in temperature logger needs replacement

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.10	0.00	0.20
0.20	0.00	0.22
0.30	0.00	0.24
0.40	0.00	0.26
0.50	0.00	0.28
0.60	0.00	0.28
0.70	0.00	0.28
0.80	0.00	0.29
0.90	0.00	0.29
1.00	0.00	0.30
1.10	0.00	0.30
1.20	0.00	0.29
1.30	0.00	0.30
1.40	0.00	0.26
1.50	0.00	0.24

Photograph 19 ↑
Upstream View

Photograph 20 ↑
Downstream View

Photograph 21 ↑
Across Stream View

KW:as

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Sampling Report

Client: City of Guelph
Project: Hanlon Creek Monitoring
Project Number: 110141
Sampling Date: 09 July 2009

Distribution: file

Weather, General Conditions and notes

Site: Hanlon Stn 1

Time: 9:55

Field Crew: John So /Kyle Woeller

Weather: Sunny, warm

Photos: U/S, D/S, Across

Flow Tracker filename: HAN10907

Measured Flow: Q= 0.0092 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: No

Other Comments:

- DO measurement not accurate (discard)
- GPS location tracked

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.10	0.27	0.22
0.20	0.26	0.24
0.30	0.25	0.24
0.40	0.24	0.20
0.50	0.28	0.19
0.60	0.30	0.20
0.70	0.34	0.16
0.80	0.30	0.18
0.90	0.30	0.18
1.00	0.33	0.13
1.10	0.29	0.12
1.20	0.25	0.08
1.30	0.20	0.08

Photograph 1 ↑
Upstream View of Temperature Logger Stake

Photograph 2 ↑
Downstream View

Photograph 3 ↑
Across Stream View

Weather, General Conditions and notes

Site: Hanlon Stn 2

Time: 10:38

Field Crew: JS / KW

Weather: Sunny, light wind, 17°C

Photos: U/S, D/S, Across

Flow Tracker filename: HAN20907

Measured Flow: Q= 0.0107 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: No

Other Comments:

- DO measurement not accurate (discard)
- GPS location tracked

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.10	0.00	0.02
0.20	0.00	0.04
0.30	0.00	0.05
0.40	0.00	0.05
0.50	0.00	0.04
0.60	0.00	0.07
0.70	0.00	0.07
0.80	0.00	0.08
0.90	0.00	0.08
1.00	0.00	0.05
1.10	0.00	0.06
1.20	0.00	0.04

Photograph 4 ↑
Upstream View

Photograph 5 ↑
Downstream View

Photograph 6 ↑
Across Stream View, Taking Flow Measurement

Weather, General Conditions and notes

Site: Laird Road (Flow)

Time: 11:20

Field Crew: JS / KW

Weather: Sunny, light wind, 18°C

Photos: U/S, D/S, Across

Flow Tracker filename: None

Measured Flow: None

Logged YSI sample: Yes

Downloaded ATM Logger: Yes

Other Comments:

- Downloaded ISCO
- DO measurement not accurate (discard)
- Both batteries fully charged @ 6 volts
- GPS location tracked

Before Clearing Sediment Around Level Logger

Distance from Edge of Culvert (m)	Sediment Depth (m)	Water Depth (m)
0.00	0.15	0.09
0.10	0.20	0.11
0.20	0.19	0.14
0.30	0.24	0.16
0.40	0.20	0.23
0.50	0.14	0.23
0.60	0.15	0.24
0.70	0.14	0.23
0.80	0.12	0.22
0.90	0.12	0.23
1.00	0.14	0.20
1.10	0.13	0.20
1.20	0.14	0.16

After Clearing Sediment Around Level Logger

Distance from Edge of Culvert (m)	Sediment Depth (m)	Water Depth (m)
0.00	0.15	0.10
0.10	0.20	0.11
0.20	0.20	0.14
0.30	0.22	0.19
0.40	0.26	0.25
0.50	0.23	0.29
0.60	0.10	0.31
0.70	0.02	0.31
0.80	0.19	0.23
0.90	0.17	0.23
1.00	0.15	0.22

1.10	0.13	0.22
1.20	0.27	0.20

Photograph 7 🡡
Downstream View from Culvert

Photograph 8 🡡
Downstream View of Culvert

Photograph 9 🡡
Upstream View of Culvert

Photograph 10 🡡
Across Stream View of Culvert

Weather, General Conditions and notes

Site: Hanlon Stn 3

Time: 13:36

Field Crew: JS / KW

Weather: Sunny, warm, few clouds

Photos: U/S, D/S, Across

Flow Tracker filename: HAN30907

Measured Flow: Q= 0.0042 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: No

Other Comments:

- DO measurement not accurate (discard)
- GPS location tracked

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.10	0.08	0.06
0.20	0.08	0.10
0.30	0.14	0.12
0.40	0.13	0.12
0.50	0.07	0.14
0.60	0.00	0.15

Photograph 11 ↑
Upstream View

Photograph 12 ↑
Downstream View

Photograph 13 ↑
Across Stream View

Weather, General Conditions and notes

Site: Hanlon Stn 4

Time: 14:05

Field Crew: JS / KW

Weather: Sunny, light wind, 18°C

Photos: U/S, D/S, Across

Flow Tracker filename: HAN40907

Measured Flow: Q= 0.0112 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: No

Other Comments:

- DO measurement not accurate (discard)
- GPS location tracked

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.00	0.00	0.00
0.20	0.11	0.13
0.40	0.27	0.15
0.60	0.25	0.14
0.80	0.21	0.14
1.00	0.17	0.16
1.20	0.24	0.11
1.40	0.19	0.17
1.60	0.17	0.14
1.80	0.12	0.13
2.00	0.14	0.11
2.20	0.24	0.12
2.40	0.22	0.16

Photograph 14 ↑
Upstream View

Photograph 15 ↑
Across Stream View, Taking Water Sample

Photograph 16 ↑
Downstream View

Weather, General Conditions and notes

Site: Hanlon Stn 5

Time: 14:44

Field Crew: JS / KW

Weather: Sunny, light wind, 18°C

Photos: U/S, D/S, Across

Flow Tracker filename: HAN50907

Measured Flow: Q= 0.0132 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: No

Other Comments:

- DO measurement not accurate (discard)
- GPS location tracked
- Possible relocation of temp logger due to future construction

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.1	0.0	0.09
0.2	0.0	0.09
0.3	0.0	0.08
0.4	0.0	0.05
0.5	0.0	0.05
0.6	0.0	0.06
0.7	0.0	0.04
0.8	0.0	0.04
0.9	0.0	0.04
1.0	0.0	0.04

Photograph 17 ↑
Upstream View

Photograph 18 ↑
Downstream View

Photograph 19 ↑
Across Stream View

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Weather, General Conditions and notes

Site: Hanlon Stn 6

Time: 15:30

Field Crew: AS / KW

Weather: Sunny, warm, 23°C

Photos: U/S, D/S, Across

Flow Tracker filename: None

Measured Flow: Q= 0.0075 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: No

Other Comments:

- Discard DO reading (incorrect)
- Temperature logger was moved approx. 20m downstream of original location
- New GPS location tracked

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.10	0.00	0.07
0.20	0.00	0.08
0.30	0.00	0.08
0.40	0.00	0.09
0.50	0.00	0.10
0.60	0.00	0.08
0.70	0.00	0.10
0.80	0.00	0.10
0.90	0.00	0.10
1.00	0.00	0.10
1.10	0.00	0.10

Photograph 20 🡅
Upstream View of New Temp Logger Location

Photograph 21 🡅
Across Stream View of New Temp Logger Location

Photograph 22 🡅
Across Stream View of New Temp Logger Location

Photograph 23 🡅
Across Stream View of New Temp Logger Location

Photograph 24 🡅
Taking Flow Measurement, 6m Upstream of New Temp Logger Location

Photograph 25 🡅
Upstream View, Taking Flow Measurement, 6m Upstream of New Temp Logger Location

Photograph 26 🡅
Downstream View, Taking Flow Measurement, 6m Upstream of New Temp Logger Location

Photograph 27 🡅
Upstream View, 6m Upstream of New Temp Logger Location

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Weather, General Conditions and notes

Site: Hanlon Stn 7

Time: 12:03

Field Crew: JS / KW

Weather: Sunny, warm

Photos: U/S, D/S, Across

Flow Tracker filename: HAN70907

Measured Flow: Q= 0.0067 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: No

Other Comments:

- DO measurement not accurate (discard)
- GPS location tracked

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.1	0.00	0.08
0.2	0.05	0.13
0.3	0.05	0.14
0.4	0.05	0.14
0.5	0.01	0.18
0.6	0.02	0.18
0.7	0.03	0.15
0.8	0.00	0.15
0.9	0.01	0.14
1.0	0.00	0.16
1.1	0.00	0.10
1.2	0.00	0.15

Photograph 28 🡅
Upstream View

Photograph 29🡅
Downstream View of Temp Logger

Photograph 30 ↑
Across Stream View

KW

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Sampling Report

Client: City of Guelph
Project: Hanlon Creek Monitoring
Project Number: 110141
Sampling Date: August 19, 2009

Distribution: file

Weather, General Conditions and notes

Site: Hanlon Stn 1

Time: 8:24 am

Field Crew: Rayna Carmichael / Adrienne Sones

Weather: Overcast

Photos: U/S, D/S, Across

Flow Tracker filename: HAN11908

Measured Flow: Q= 0.0067 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments:

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.1	0.36	0.04
0.2	0.37	0.05
0.3	0.34	0.10
0.4	0.36	0.10
0.5	0.36	0.08
0.6	0.36	0.10
0.7	0.33	0.10
0.8	0.36	0.09
0.9	0.37	0.09
1.0	0.36	0.08
1.1	0.36	0.08
1.2	0.39	0.06

1.3	0.33	0.08
1.4	0.00	0.00

Photograph 1 ↑
Upstream

Photograph 2 ↑
Downstream

Photograph 3 ↑

Across

Weather, General Conditions and notes

Site: Hanlon Stn 2

Time: 9:30 am

Field Crew: Rayna Carmichael / Adrienne Sones

Weather: Overcast

Photos: U/S, D/S, Across

Flow Tracker filename: HAN21908

Measured Flow: Q= 0.0055 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments:
NRSI upper limit stake has been removed from soil and is broken.

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.1		0.02
0.2		0.03
0.3		0.05
0.4		0.04
0.5		0.05
0.6		0.06
0.7		0.06
0.8		0.06
0.9		0.06
1.0		0.06
1.1		0.05
1.2		0.05
1.3		0.02

Photograph 1 ↑
Upstream

Photograph 2 ↑
Downstream

Photograph 3 ↑
Across

Weather, General Conditions and notes

Site: Laird Road (Flow)

Flow Tracker filename: None

Time: 10:00 am

Field Crew: Rayna Carmichael / Adrienne Sones

Weather: Sun and Cloud

Photos: U/S, D/S, Across

Measured Flow: None

Logged YSI sample: Yes

Downloaded Area/Velocity meter: No

Other Comments:

Before Sediment Removal

Distance from Edge of Culvert (m)	Sediment Depth (m)	Water Depth (m)
0.1	0.16	0.08
0.2	0.27	0.10
0.3	0.42	0.11
0.4	0.46	0.12
0.5	0.44	0.14
0.6	0.40	0.15
0.7	0.43	0.16
0.8	0.40	0.16
0.9	0.46	0.14
1.0	0.44	0.12
1.1	0.46	0.12
1.2	0.23	0.12
1.3	0.17	0.13

After Sediment Removal

Distance from Edge of Culvert (m)	Sediment Depth (m)	Water Depth (m)
0.00	0.14	0.08
0.10	0.22	0.10
0.20	0.41	0.15
0.30	0.29	0.18
0.40	0.34	0.18
0.50	0.31	0.21
0.60	0.36	0.24
0.70	0.37	0.20
0.80	0.36	0.23
0.90	0.39	0.22
1.00	0.39	0.17
1.10	0.18	0.17
1.20	0.13	0.17

Photograph 1 ↑
Downstream

Photograph 2 ↑
Velocity meter in culvert

Weather, General Conditions and notes

Site: Hanlon Stn 3

Time: 12:40 pm

Field Crew: Rayna Carmichael / Adrienne Sones

Weather: Sunny

Photos: U/S, D/S, Across

Flow Tracker filename:

Measured Flow: Q= 0.0082 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments:

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.0	0.10	0.01
0.1	0.14	0.06
0.2	0.09	0.09
0.3	0.04	0.16
0.4	0.08	0.14
0.5	0.09	0.13

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0.6	0.06	0.12
0.7	0.08	0.12
0.8	0.06	0.12
0.9		0.15
1.0		

Photograph 1 ↑
Upstream

Photograph 2 ↑
Downstream

Photograph 3 ↑
Across

Weather, General Conditions and notes

Site: Hanlon Stn 4

Time: 1:30 pm

Field Crew: Rayna Carmichael / Adrienne Sones

Weather: Sun

Photos: U/S, D/S, Across

Flow Tracker filename: HAN41908

Measured Flow: Q= 0.0043 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: No

Other Comments:
Temp logger is missing.

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.0	0.23	0.00
0.1	0.18	0.04
0.2	0.17	0.04
0.3	0.21	0.04
0.4	0.19	0.06
0.5	0.18	0.08
0.6	0.10	0.16
0.7	0.06	0.22
0.8	0.06	0.22
0.9	0.06	0.24
1.0	0.00	0.30
1.1	0.00	0.30
1.2	0.00	0.27
1.3	0.00	0.28

Photograph 1 ↑
Upstream

Photograph 2 ↑
Downstream

Photograph 3 ↑
Across

Weather, General Conditions and notes

Site: Hanlon Stn 5

Time: 2:30 pm

Field Crew: Rayna Carmichael / Adrienne Sones

Weather: Hot and Sunny

Flow Tracker filename: HAN51908

Measured Flow: Q= 0.0050 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: No

Other Comments:

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Photos: U/S, D/S, Across

Level logger not at station, angle iron and wooden stakes (for flow measurement) removed.

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.0	0	0.10
0.1	0	0.10
0.2	0	0.10
0.3	0	0.11
0.4	0	0.09
0.5	0	0.11
0.6	0	0.10
0.7	0	0.09
0.8	0	0.09
0.9	0	0.07
1.0	0	0.05
1.1	0	

Photograph 1 ↑
Upstream

Photograph 2 ↑
Downstream

Photograph 3 ↑
Across

Weather, General Conditions and notes

Site: Hanlon Stn 6

Time: 3:00 pm

Field Crew: Rayna Carmichael / Adrienne Sones

Weather: Sunny and Hot

Photos: U/S, D/S, Across

Flow Tracker filename: None, low flow

Measured Flow: None

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments:
DO not accurate.
Logger was out of water with stake bent, returned logger to office

Photograph 1 ↑
Upstream

Photograph 2 ↑
Downstream

Photograph 3 ↑
Across

Weather, General Conditions and notes

Site: Hanlon Stn 7

Time: 10:30 am

Field Crew: Rayna Carmichael / Adrienne Sones

Flow Tracker filename: HAN71908

Measured Flow: Q= 0.124 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Weather: Sunny

Other Comments:

Photos: U/S, D/S, Across

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.0		0.00
0.1		0.18
0.2		0.27
0.3		0.29
0.4		0.27
0.5		0.28
0.6		0.27
0.7		0.28
0.8		0.27
0.9		0.26
1.0		0.26
1.1		0.25
1.2		0.25
1.3		0.21
1.4		0.20
1.5		0.19
1.6		0.11
1.7		0.09

Photograph 1 ↑
Upstream

Photograph 2 ↑
Downstream

Photograph 3 ↑
Across

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Sampling Report

Client: City of Guelph
Project: Hanlon Creek Monitoring
Project Number: 110141
Sampling Date: August 24, 2009

Distribution: file

Weather, General Conditions and notes
Site: Hanlon Stn 4

Time: 2:50

Field Crew: Adrienne Sones and John So

Weather: Sunny, hot (25°C)

Photos: none

Flow Tracker filename: n/a

Logged YSI sample: **no**

Downloaded Temp Logger: **no**

Other Comments: Installed new pendant logger Serial Number: 2389966

Weather, General Conditions and notes
Site: Hanlon Stn 5

Time: 3:00

Field Crew: Adrienne Sones, John So

Weather: Sunny, hot (25°C)

Photos: U/S, D/S, Across

Logged YSI sample: **no**

Downloaded Temp Logger: **no**

Other Comments: Installed new depth/temp logger Serial number: 1028563, water depth measured at 10.0cm

Photograph 1 🡅
Upstream

Photograph 2 🡅
Downstream

Photograph 3 🡅
Logger site

Weather, General Conditions and notes

Site: Hanlon Stn 6

Time: 3:10

Field Crew: Adrienne Sones, John So

Weather: Sunny, hot (25°C)

Photos: U/S, D/S, Across

Logged YSI sample: yes/**no**

Downloaded Temp Logger: yes/**no**

Other Comments: Installed temp logger, serial number: 2319910

Photograph 4🡅
Upstream

Photograph 4🡅
Downstream

Photograph 6 🡅
Across

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Sampling Report

Client: City of Guelph
Project: Hanlon Creek Monitoring
Project Number: 110141
Sampling Date: September 23, 2009

Distribution: file

Weather, General Conditions and notes

Site: Hanlon Stn 1

Time: 8:20 AM

Field Crew: Adrienne Sones / Peter Dekker

Weather: Cloudy, warm, 18°C

Photos: U/S, D/S, Across

Flow Tracker filename: HAN12309

Measured Flow: Q= 0.0043 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments:

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.0	0.00	0.00
0.05	0.00	0.09
0.1	0.10	0.16
0.2	0.30	0.10
0.3	0.34	0.07
0.4	0.36	0.04
0.5	0.35	0.05
0.6	0.34	0.06
0.7	0.33	0.06
0.8	0.32	0.06
0.9	0.36	0.05
1.0	0.35	0.07
1.1	0.34	0.06
1.2	0.32	0.06

1.3	0.27	0.07
1.4	0.21	0.05

Photograph 1 ↑
Upstream View, Temperature Logger Location

Photograph 2 ↑
Downstream View, Taking Flow Measurement

Photograph 3 ↑
Across Stream View, Taking Flow Measurement

Weather, General Conditions and notes
Site: Hanlon Stn 2

Time: 9:45 AM

Field Crew: Adrienne Sones / Peter Dekker

Weather: Cloudy, warm, 18°C

Photos: U/S, D/S, Across

Flow Tracker filename: HAN22309

Measured Flow: Q= 0.0012 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments: Temp logger # 2010705 had low battery; replaced with # 2246235
Log jam noted upstream (see photos), creating a backwater effect that may affect sedimentation in Laird Road Culvert

Distance from Edge of Creek (m)	Water Depth (m)
0.0	0.0
0.1	0.02
0.2	
0.3	
0.4	
0.5	
0.6	0.04
0.7	
0.8	
0.9	
1.0	
1.1	
1.2	
1.28	

Photograph 1 ↑
Upstream View

Photograph 2 ↑
Downstream View

Photograph 3 ↑
Across Stream View, Taking Flow Measurement

Weather, General Conditions and notes

Site: Laird Road (Flow)

Time: 10:25 AM

Field Crew: Adrienne Sones / Peter Dekker

Weather: Cloudy, warm, 20°C

Photos: Culvert Opening, Across Stream

Flow Tracker filename: none

Measured Flow: Q= m^3/s

Logged YSI sample: Yes

Downloaded ATM Logger: Yes

Other Comments: Meter was covered completely with sediment

Distance from Edge of Culvert (m)	Sediment Depth (m)	Water Depth (m)
0.0	0.00	0.07
0.1	0.38	0.10

0.2	0.36	0.12
0.3	0.42	0.13
0.4	0.40	0.13
0.5	0.47	0.14
0.6	0.48	0.10
0.7	0.43	0.10
0.8	0.46	0.10
0.9	0.41	0.10
1.0	0.42	0.11
1.1	0.14	0.05
1.2	0.00	0.07
(moved sediment)		
0.0	0.00	0.11
0.1	0.20	0.13
0.2	0.31	0.19
0.3	0.30	.018
0.4	0.35	0.17
0.5	0.35	0.18
0.6	0.36	0.19
0.7	0.36	0.20
0.8	0.35	0.20
0.9	0.32	0.20
1.0	0.16	0.17
1.1	0.12	0.14
1.2	0.14	0.07

Photograph 1 ↑
Culvert Outlet, Taking YSI Sample

Photograph 2 ↑
Across Stream View

Weather, General Conditions and notes

Site: Hanlon Stn 3

Time: 1:15 PM

Field Crew: Adrienne Sones / Peter Dekker

Weather: Cloudy with sun, warm, 22°C

Photos: U/S, D/S, Across

Flow Tracker filename: HAN32309

Measured Flow: Q= 0.0050 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments:

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.0	0.04	0.08
0.1	0.08	0.05
0.2	0.06	0.09
0.3	0.02	0.14
0.4	0.04	0.14
0.5	0.08	0.12
0.6	0.09	0.11
0.7	0.10	0.10
0.8	0.03	0.09
0.9	0	0

Photograph 1 ↑
Upstream View

Photograph 2 ↑
Downstream View

Photograph 3 🡅
Across Stream View, Taking Flow Measurement

Weather, General Conditions and notes

Site: Hanlon Stn 4

Time: 2:10 PM

Field Crew: Adrienne Sones / Peter Dekker

Weather: Sunny with clouds, 22°C

Photos: U/S, D/S, Across

Flow Tracker filename: HAN42309

Measured Flow: Q= 0.0030 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments: Low, slow flow

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.0	0.18	0.08
0.1	0.15	0.07

0.2	0.13	0.07
0.3	0.14	0.06
0.4	0.11	0.11
0.5	0.17	0.14
0.6	0.16	0.16
0.7	0.15	0.17
0.8	0.12	0.22
0.9	0.13	0.21
1.0	0.15	0.21
1.1	0.17	0.21
1.2	0.19	0.20
1.3	0.11	0.19
1.4	0.00	0.22

Photograph 1 🡅
Upstream View, Temperature Logger Location

Photograph 2 🡅
Downstream View, Taking Flow Measurement

Photograph 3 ↑
Across Stream View

Weather, General Conditions and notes

Site: Hanlon Stn 5

Time: 3:10 PM

Field Crew: Adrienne Sones / Peter Dekker

Weather: Cloudy with sun, a few rain drops, 20°C

Photos: U/S, D/S, Across

Flow Tracker filename: HAN52309

Measured Flow: Q= 0.0095 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments:

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.0		0.08

0.1		0.08
0.2		0.08
0.3		0.08
0.4		0.07
0.5		0.06
0.6		0.07
0.7		0.05
0.8		0.05
0.9		0.04
1.0		0.03
1.1		0.02
1.2		0.04
1.3		0.02
1.35		0.00

Photograph 1 ↑
Upstream View, Taking Flow Measurement

Photograph 2 ↑
Downstream View

Photograph 3 ↑
Across Stream View, Taking Flow Measurement

Weather, General Conditions and notes
Site: Hanlon Stn 6

Time: 3:40 PM

Field Crew: Adrienne Sones / Peter Dekker

Weather: Cloudy with sun, windy, 20°C

Photos: U/S, D/S, Across

Flow Tracker filename: none

Measured Flow: Q= m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments: Low flow does not allow accurate flow measurement.

Photograph 1 ↑
Upstream View

Photograph 2 ↑
Downstream View, Taking YSI Measurement

Photograph 3 ↑
Across Stream View

/eather, General Conditions and notes

ite: Hanlon Stn 7

ime: 11:10 AM

ield Crew: Adrienne Sones / Peter Dekker

/eather: Cloudy, windy, warm, 18°C

hotos: U/S, D/S, Across

Flow Tracker filename: HAN72309

Measured Flow: Q= 0.0068 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: yes/no

Other Comments: Some sediment observed in channel, approximately 5 cm average.

Distance from Edge of Creek (m)	Water Depth (m)
0.0	0.00
0.1	0.10

0.2	0.10
0.3	0.14
0.4	0.15
0.5	0.20
0.6	0.22
0.7	0.22
0.8	0.25
0.9	0.24
1.0	0.23
1.1	0.23
1.2	0.23
1.3	0.22
1.4	0.22
1.5	0.18
1.6	0.18
1.7	0.12
1.8	0.06

Photograph 1 ↑
Upstream View

Photograph 2 ↑
Downstream View

Photograph 3 ↑
Across Stream View, Taking Flow Measurement

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Sampling Report

Client: City of Guelph
Project: Hanlon Creek Monitoring
Project Number: 110141
Sampling Date: October 21, 2009

Distribution: file

Weather, General Conditions and notes

Site: Hanlon Stn 1

Time: 8:15 AM

Field Crew: Adrienne Sones / Peter Dekker

Weather: Cloudy, warm, 15°C

Photos: U/S, D/S, Across

Flow Tracker filename: HAN11021

Measured Flow: Q= 0.0039 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments: Battery level in logger OK.

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.0	0	0.09
0.1	0.3	0.09
0.2	0.24	0.18
0.3	.033	0.11
0.4	0.35	0.09
0.5	0.36	0.10
0.6	0.29	0.12
0.7	0.36	0.08
0.8	0.34	0.10
0.9	0.35	0.11
1.0	0.35	0.06
1.1	0.35	0.06
1.2	0.35	0.06
1.3	0.37	0.04
1.4	0.23	0.07

1.5	0.13	0.03

Photograph 1 ↑
Upstream View, Temperature Logger Location

Photograph 2 ↑
Downstream View, Taking Flow Measurement

Photograph 3 ↑
Across Stream View, Taking Flow Measurements

Weather, General Conditions and notes

Site: Hanlon Stn 2

Time: 9:15 AM

Field Crew: Adrienne Sones / Peter Dekker

Weather: Cloudy, warm, 15°C

Photos: none

Flow Tracker filename: HAN21021

Measured Flow: Q= 0.0043 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments: Logger battery level OK.

Distance from Edge of Creek (m)	Water Depth (m)
0.0	0
0.1	0.04
0.2	0.05
0.3	0.06
0.4	0.07
0.5	0.07
0.6	0.07
0.7	0.08
0.8	0.08
0.9	0.08
1.0	0.08
1.1	0.08
1.2	0.07
1.35	0.04

Weather, General Conditions and notes

Site: Laird Road (Flow)

Time: 10:05 AM

Field Crew: Adrienne Sones / Peter Dekker

Weather: Cloudy, warm, 15°C

Photos: Culvert Opening, Across Stream, Downstream View

Logged YSI sample: Yes

Downloaded ATM Logger: Yes

Other Comments: Meter was covered completely with sediment. Battery 48%

BEFORE REMOVING SEDIMENT FROM CULVERT		
Distance from Edge of Culvert (m)	Sediment Depth (m)	Water Depth (m)

0.0	0.18	0.08
0.1	0.14	0.18
0.2	0.25	0.19
0.3	0.43	0.13
0.4	0.16	0.18
0.5	0.45	0.19
0.6	0.46	0.16
0.7	0.52	0.14
0.8	0.47	0.14
0.9	0.48	0.12
1.0	0.21	0.11
1.1	0.26	0.11
1.2	0.15	0.14
AFTER REMOVING SEDIMENT FROM CULVERT		
0.0	0.17	0.09
0.1	0.16	0.11
0.2	0.28	0.23
0.3	0.27	0.28
0.4	0.27	0.27
0.5	0.27	0.37
0.6	0.28	0.34
0.7	0.25	0.37
0.8	0.35	0.28
0.9	0.36	0.25
1.0	0.17	0.21
1.1	0.20	0.14
1.2	0.09	0.14

Photograph 1 🡅
Culvert Opening

Photograph 2 🡅
Across Stream View

Photograph 3 🡅
Downstream View

Weather, General Conditions and notes

Site: Hanlon Stn 3

Time: 1:00 PM

Field Crew: Adrienne Sones / Peter Dekker

Flow Tracker filename: HAN31021

Measured Flow: Q= 0.131 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Weather: Cloudy, cool (12°C)

Other Comments: Battery level OK.

Photos: U/S, D/S, Across

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.0	0.07	0.10
0.1	0.15	0.06
0.2	0.10	0.09
0.3	0.04	0.15
0.4	0.04	0.19
0.5	0.05	0.19
0.6	0.08	0.20
0.7	0.06	0.20
0.8	0.06	0.18
0.9	0.06	0.16
0.95	0.00	0.09

Photograph 1 ↑
Upstream View

Photograph 2 ↑
Downstream View

Photograph 3 ↑
Across Stream View, Taking Flow Measurement

Weather, General Conditions and notes

Site: Hanlon Stn 4

Time: 1:40 PM

Field Crew: Adrienne Sones / Peter Dekker

Weather: Cool, cloudy, light rain (12°C)

Photos: U/S, D/S, Across

Flow Tracker filename: HAN42110

Measured Flow: Q= 0.0038 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments:

Distance from Edge of Creek (m)	Sediment Depth (m)	Water Depth (m)
0.0	0.10	0.09
0.1	0.13	0.08

0.2	0.15	0.08
0.3	0.13	0.10
0.4	0.11	0.13
0.5	0.10	0.15
0.6	0.07	0.17
0.7	0.09	0.16
0.8	0.06	0.19
0.9	0.13	0.17
1.0	0.08	0.22
1.1	0.07	0.23
1.2	0.09	0.21

Photograph 1 ↑
Upstream View, Temperature Logger Location

Photograph 2 ↑
Downstream View, Taking Flow Measurement

Photograph 3 ↑
Across Stream View, Taking Flow Measurement

Weather, General Conditions and notes

Site: Hanlon Stn 5

Time: 2:12 PM

Field Crew: Adrienne Sones / Peter Dekker

Weather: Cool, cloudy

Photos: U/S, D/S, Across

Flow Tracker filename: HAN52110

Measured Flow: Q= 0.0137 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments:

Distance from Edge of Creek (m)	Water Depth (m)
0.0	0.11
0.1	0.09
0.2	0.10
0.3	0.10
0.4	0.10
0.5	0.08
0.6	0.09
0.7	0.07
0.8	0.09
0.9	0.08
1.0	0.07
1.1	0.06
1.2	0.02

Photograph 1 ↑
Upstream View

Photograph 2 ↑
Downstream View

Photograph 3 ↑
Across Stream View, Taking Flow Measurement

Weather, General Conditions and notes

Site: Hanlon Stn 6

Time: 2:40 PM

Field Crew: Adrienne Sones / Peter Dekker

Weather: Cloudy, cool

Photos: U/S, D/S, Across

Flow Tracker filename: none

Logged YSI sample: Yes

Downloaded Temp Logger: Yes

Other Comments: Logger battery level OK

Photograph 1 ↑
Upstream View

Photograph 2 ↑
Downstream View

Photograph 3 ↑
Across Stream View, Taking YSI Measurement

Weather, General Conditions and notes

Site: Hanlon Stn 7

Time: 11:00 AM

Field Crew: Adrienne Sones / Peter Dekker

Weather: Cloudy, light rain

Photos: U/S, D/S, Across

Flow Tracker filename: HAN71021

Measured Flow: Q= 0.0078 m^3/s

Logged YSI sample: Yes

Downloaded Temp Logger: yes/no

Other Comments: Battery level OK

Distance from Edge of Creek (m)	Water Depth (m)
0.0	0.07
0.1	0.11
0.2	0.10
0.3	0.13
0.4	0.15
0.5	0.16
0.6	0.15
0.7	0.17
0.8	0.17
0.9	0.17
1.0	0.16
1.1	0.25
1.2	0.22
1.3	0.20
1.4	0.18
1.5	0.15
1.6	0.11

Photograph 1 🡅
Upstream View

Photograph 2 🡅
Downstream View

Photograph 3 🡅
Across Stream View, Taking Flow Measurement

AS:pd

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Sampling Report

Client: City of Guelph
Project: Hanlon Creek Monitoring
Project Number: 110141
Sampling Date: December 14/15, 2009

Distribution: file

Weather, General Conditions and notes	
Site: Hanlon Stations 1, 2, 3, 4, 5, 6, & 7, & Laird Road Time: 2:00 – 4:00 PM / 8:00 – 10:00 AM Field Crew: Adrienne Sones / Peter Dekker Weather: Cold (0°C) Photos: U/S, D/S, Across	Flow Tracker filename: N/A Measured Flow: Q= N/A m^3/s Logged YSI sample: No Downloaded Temp Loggers: Yes (all sites) Other Comments: In field to remove, re-program, and re-install temperature loggers for winter months. Logger sample interval adjusted from 15 minutes to 30 minutes. Batteries were changed in loggers at stations 1,2,3,7.

Upstream view of Station 1

Downstream view of Station 1

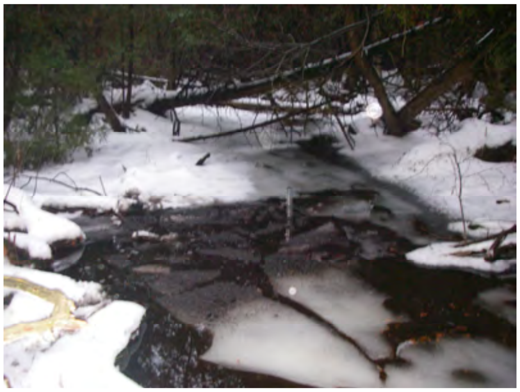
Upstream view of Station 2

Downstream view of Station 2

Laird Road Culvert

Upstream view of Station 3

Downstream view of Station 3



Upstream view of Station 4

Downstream view of Station 4

Upstream view of Station 5

Downstream view of Station 5

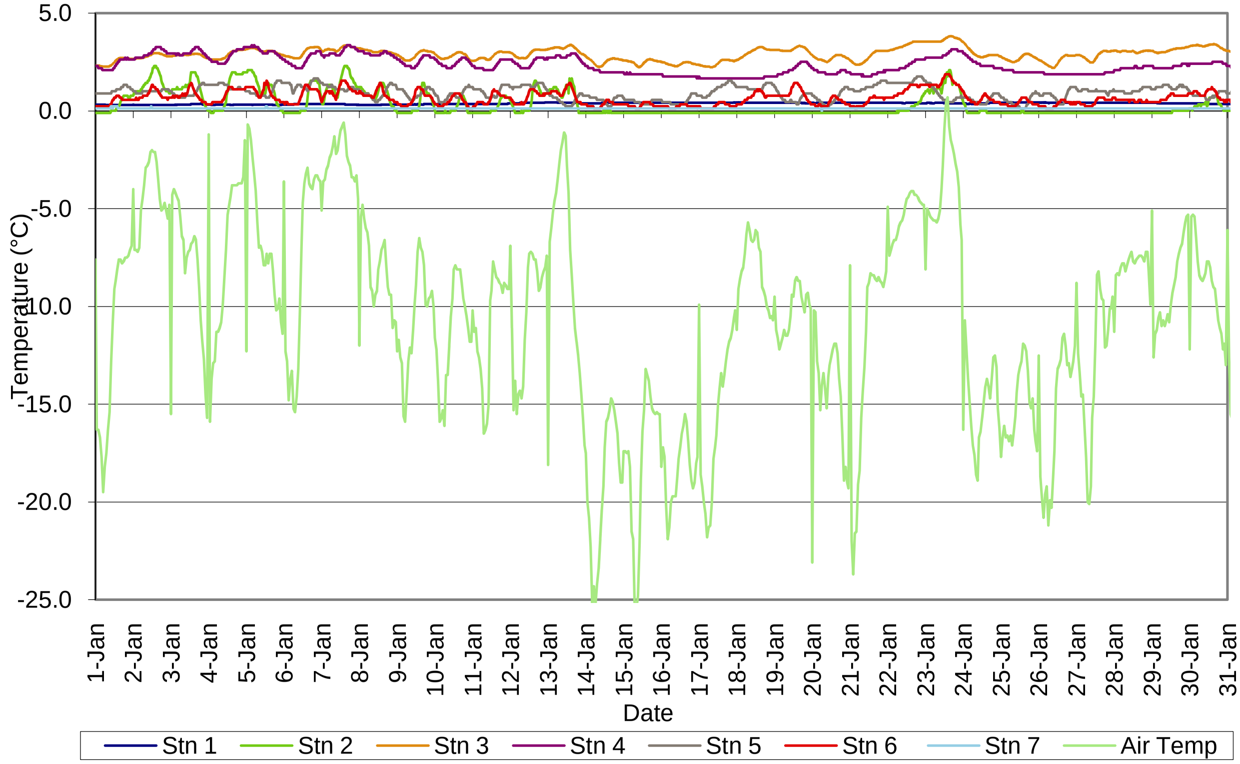
Station 6

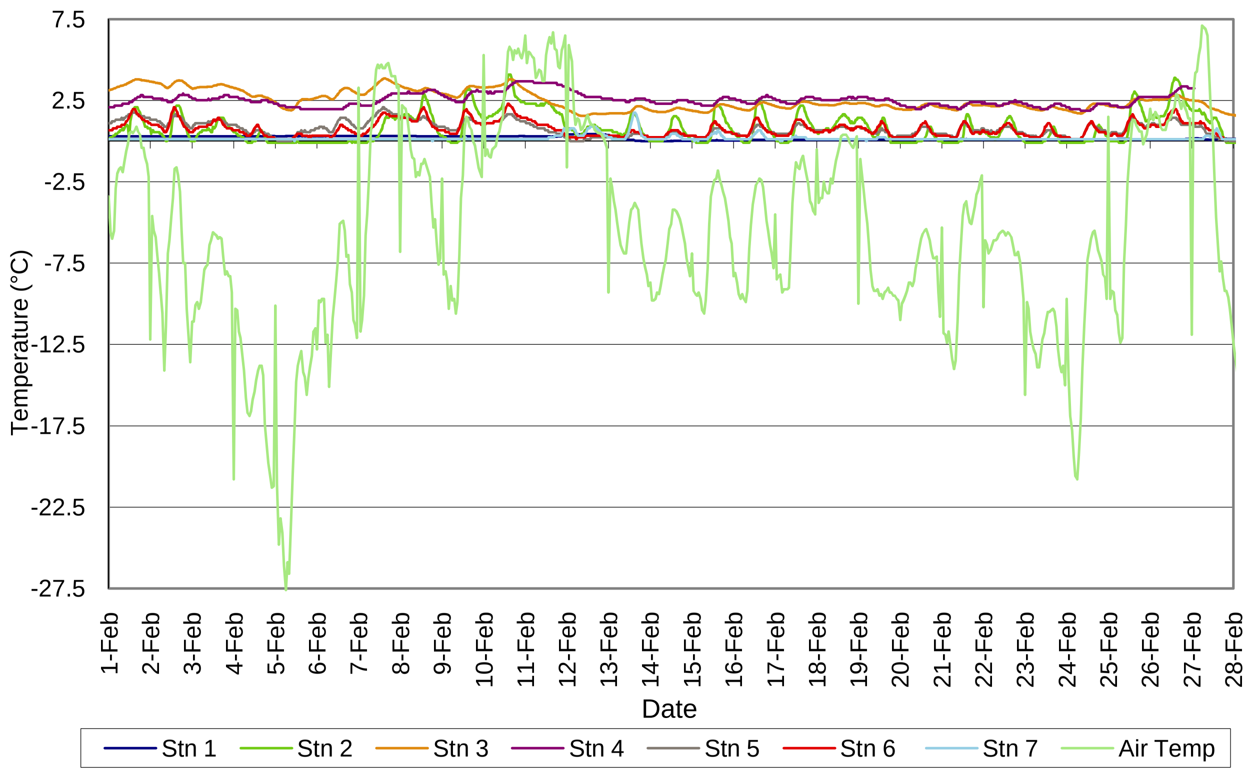
Upstream view of Station 5

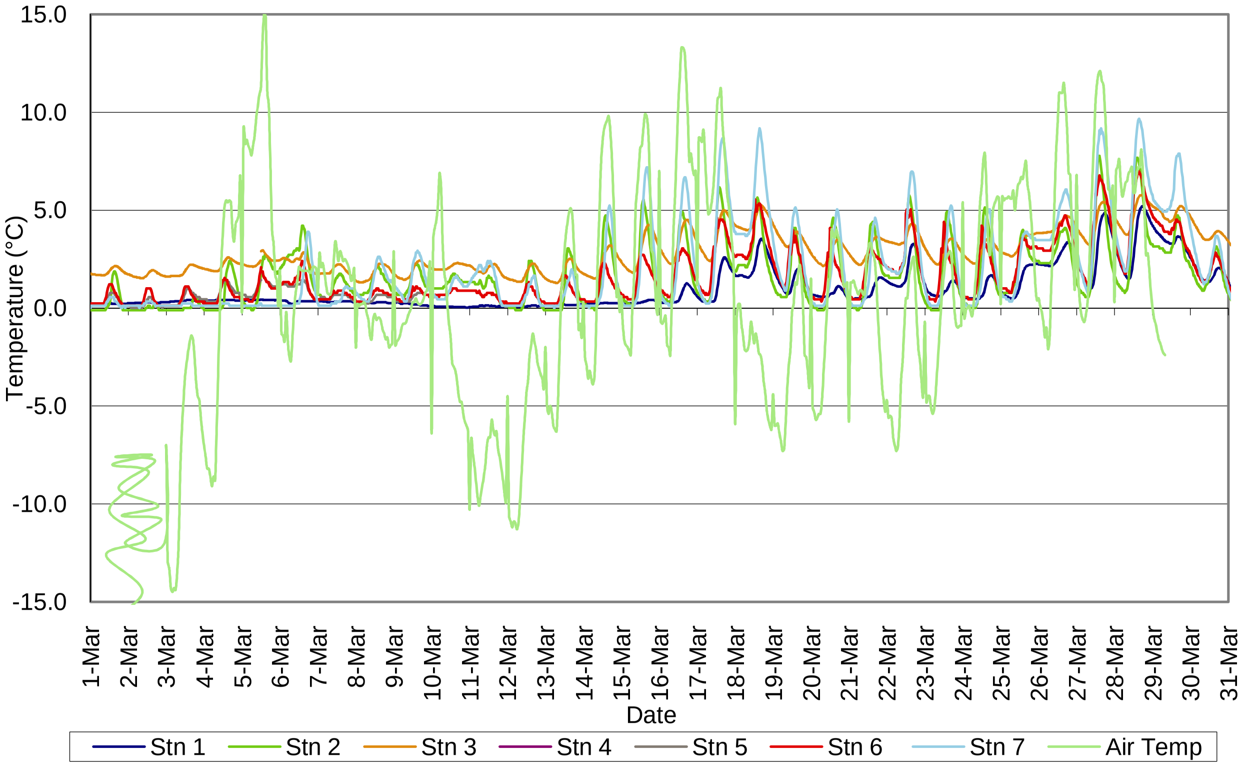
Upstream view of Station 7

Downstream view of Station 7

Appendix B Hanlon Creek Monthly Temperature Plots 2009



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-10.0
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Temperature (°C)
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2-Mar
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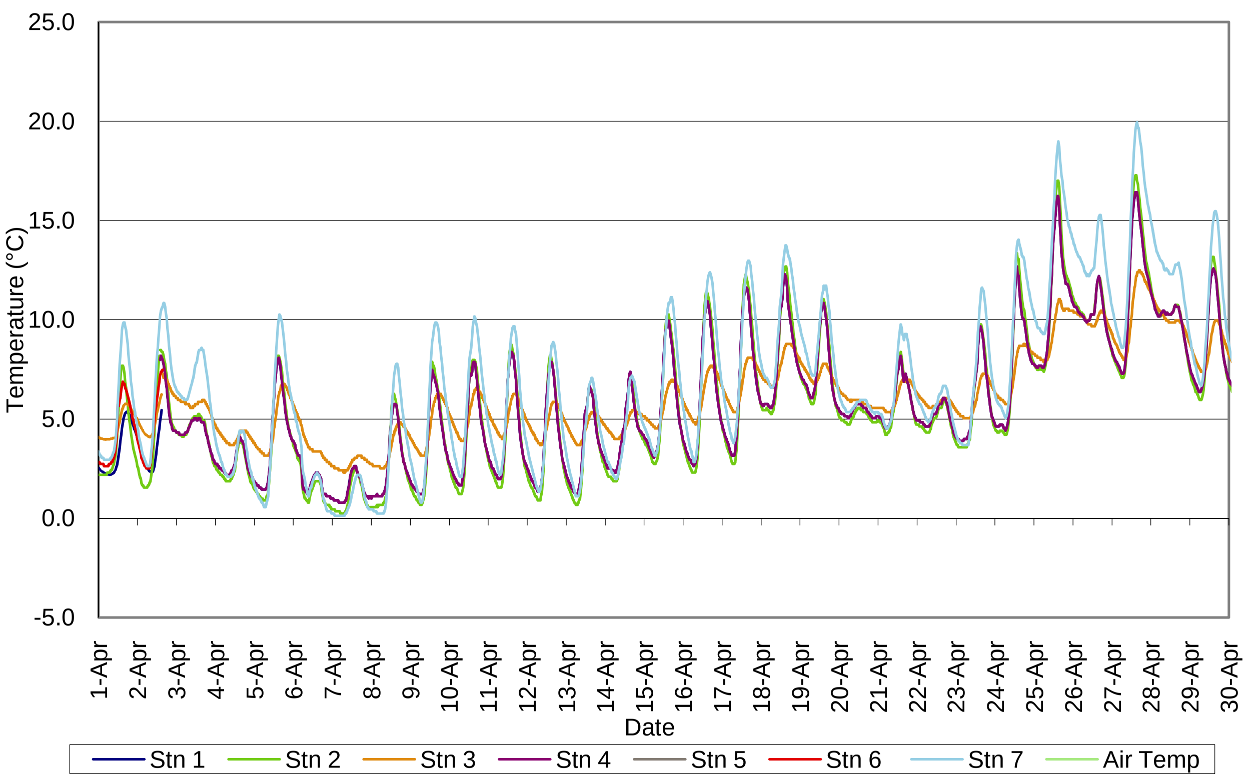
4-Mar
5-Mar
6-Mar
7-Mar
8-Mar
9-Mar
10-Mar
11-Mar
12-Mar
13-Mar
14-Mar
15-Mar
16-Mar
17-Mar
18-Mar
19-Mar
20-Mar
21-Mar
22-Mar
23-Mar
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
30-Mar
31-Mar
Date
Stn 1
Stn 2
Stn 3
Stn 4
Stn 5
Stn 6
Stn 7
Air Temp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20.0
15.0
10.0
5.0
0.0
-5.0
Temperature (°C)
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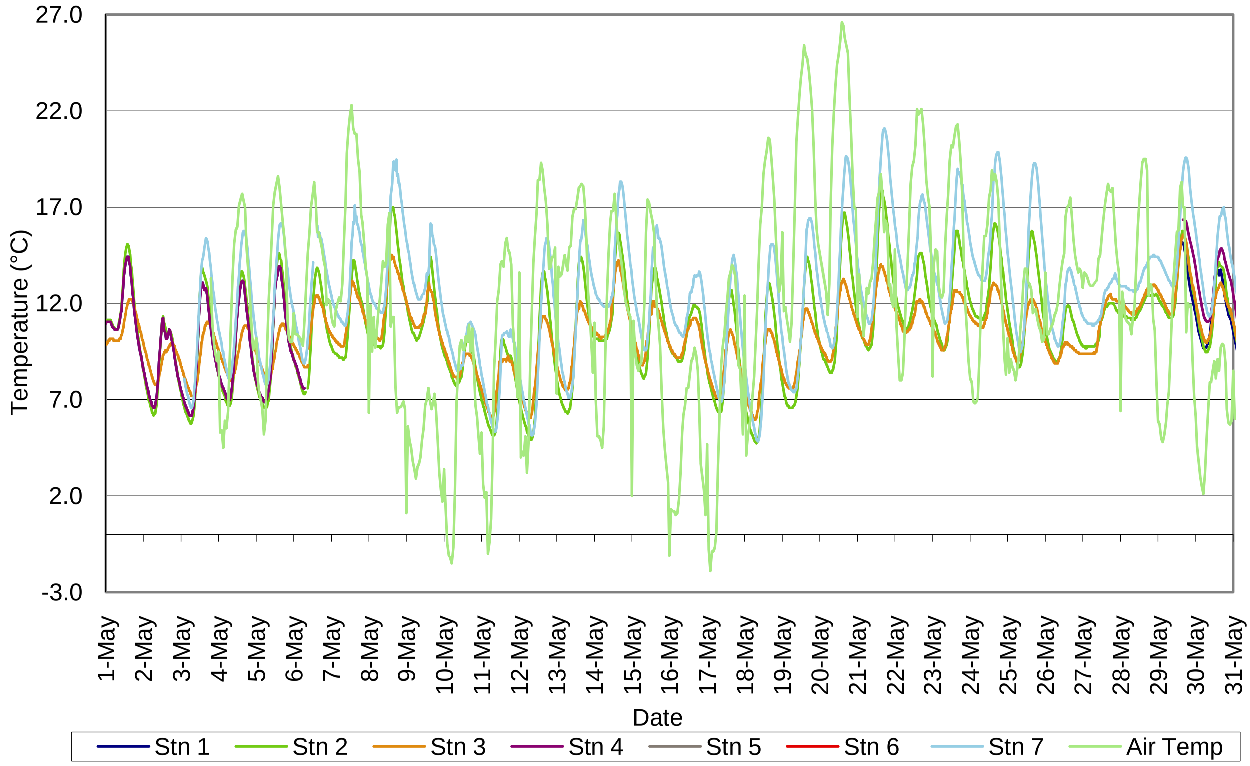
2-Apr
3-Apr
4-Apr
5-Apr
6-Apr
7-Apr
8-Apr
9-Apr
10-Apr
11-Apr
12-Apr
13-Apr
14-Apr
15-Apr
16-Apr
17-Apr
18-Apr
19-Apr
20-Apr
21-Apr
22-Apr
23-Apr
24-Apr
25-Apr
26-Apr
27-Apr
28-Apr
29-Apr
30-Apr
Date
Stn 1
Stn 2
Stn 3
Stn 4
Stn 5
Stn 6
Stn 7
Air Temp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12.0
7.0
2.0
-3.0
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3-May
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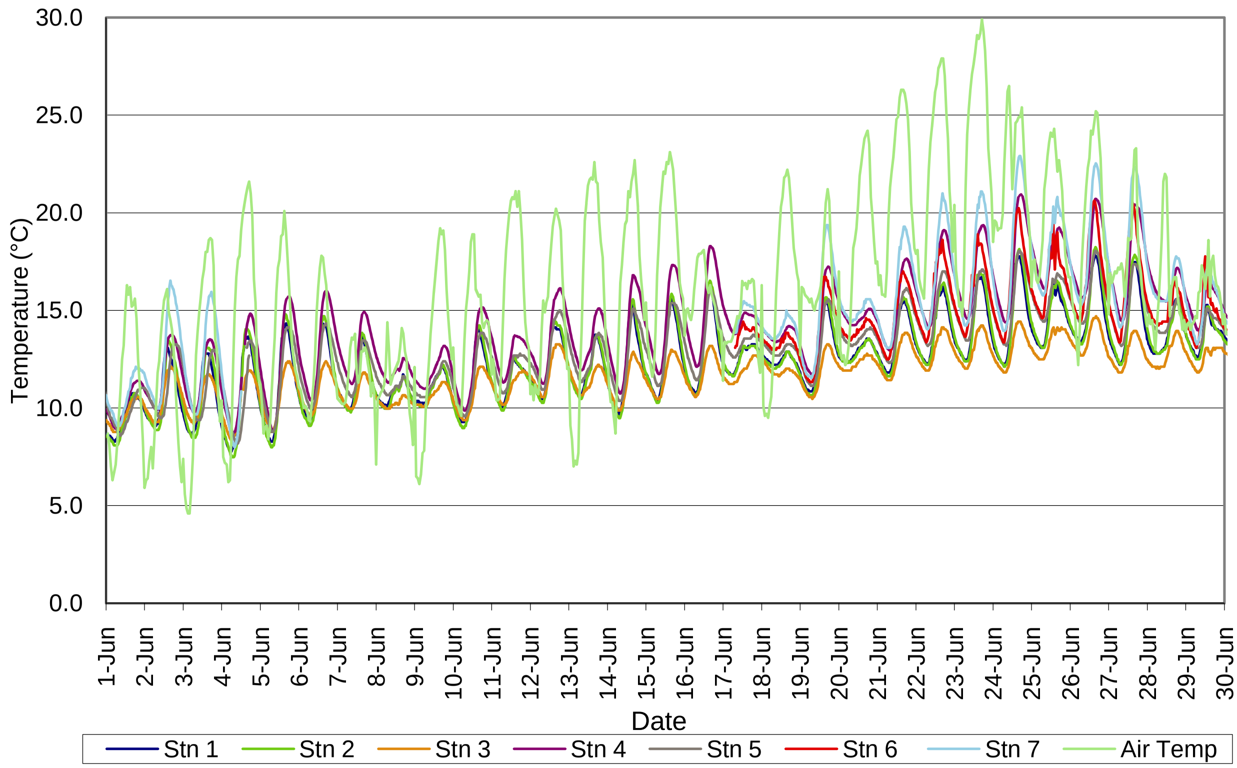
7-May
8-May
9-May
10-May
11-May
12-May
13-May
14-May
15-May
16-May
17-May
18-May
19-May
20-May
21-May
22-May
23-May
24-May
25-May
26-May
27-May
28-May
29-May
30-May
31-May
Date
Stn 1
Stn 2
Stn 3
Stn 4
Stn 5
Stn 6
Stn 7
Air Temp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10.0
5.0
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2-Jun
3-Jun
4-Jun
5-Jun
6-Jun
7-Jun
8-Jun
9-Jun
10-Jun
11-Jun
12-Jun
13-Jun
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17-Jun
18-Jun
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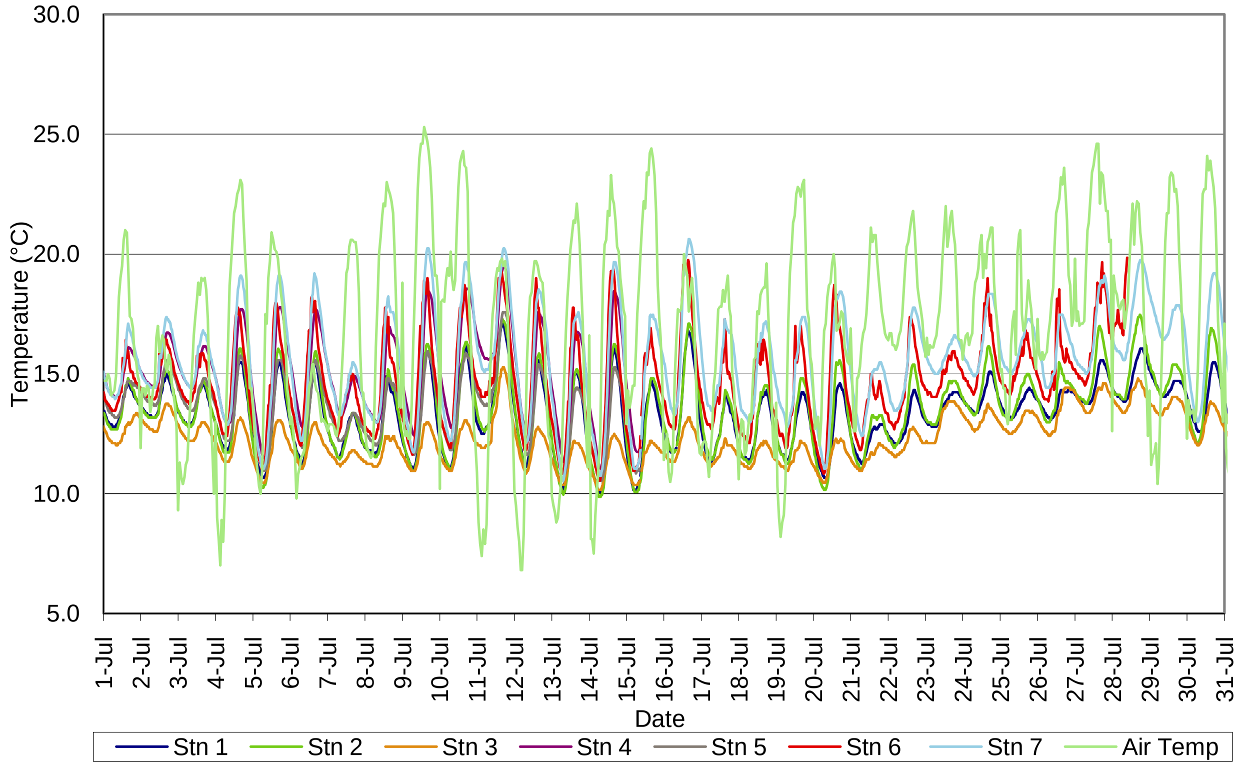
22-Jun
23-Jun
24-Jun
25-Jun
26-Jun
27-Jun
28-Jun
29-Jun
30-Jun
Date
Stn 1
Stn 2
Stn 3
Stn 4
Stn 5
Stn 6
Stn 7
Air Temp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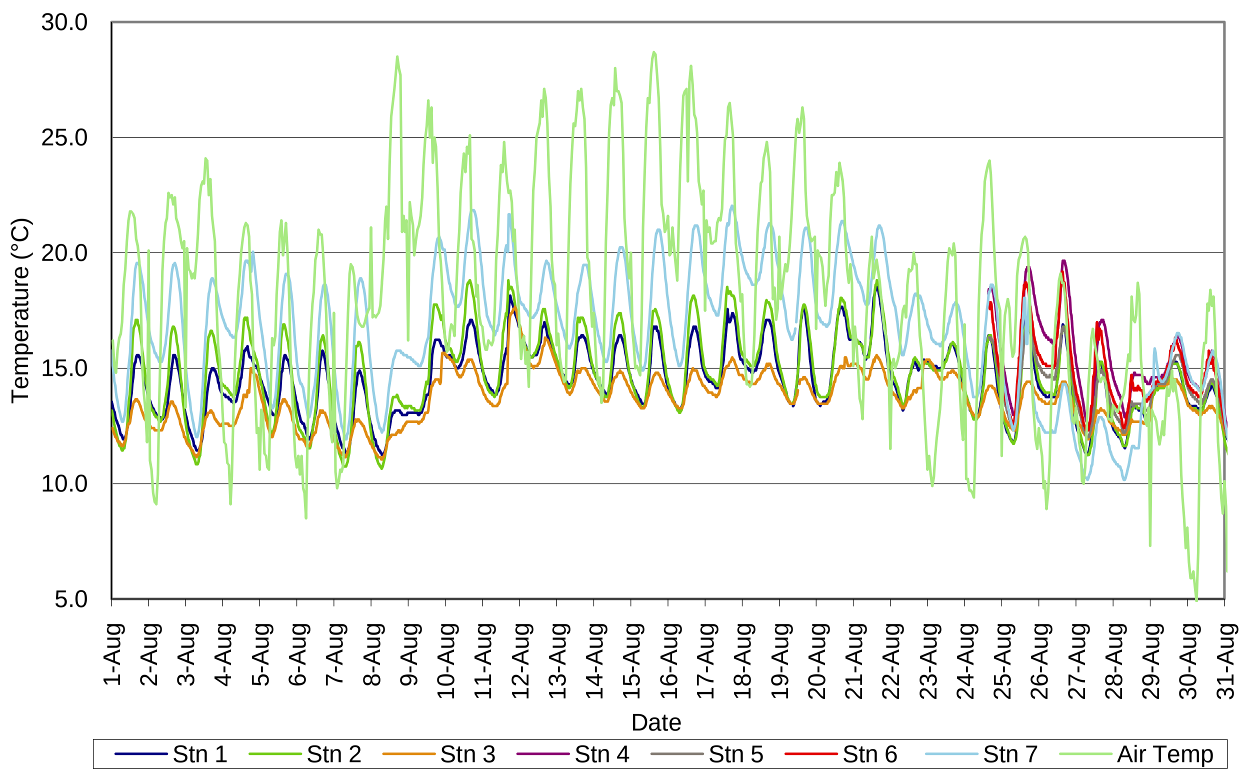
20.0
15.0
10.0
5.0
1-Jul 2-Jul 3-Jul 4-Jul 5-Jul 6-Jul 7-Jul 8-Jul 9-Jul 10-Jul 11-Jul 12-Jul 13-Jul 14-Jul 15-Jul 16-Jul 17-Jul 18-Jul 19-Jul 20-Jul 21-Jul 22-Jul 23-Jul 24-Jul 25-Jul 26-Jul 27-Jul 28-Jul 29-Jul 30-Jul 31-Jul
Date
Stn 1
Stn 2
Stn 3
Stn 4
Stn 5
Stn 6
Stn 7
Air Temp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20.0
15.0
10.0
5.0
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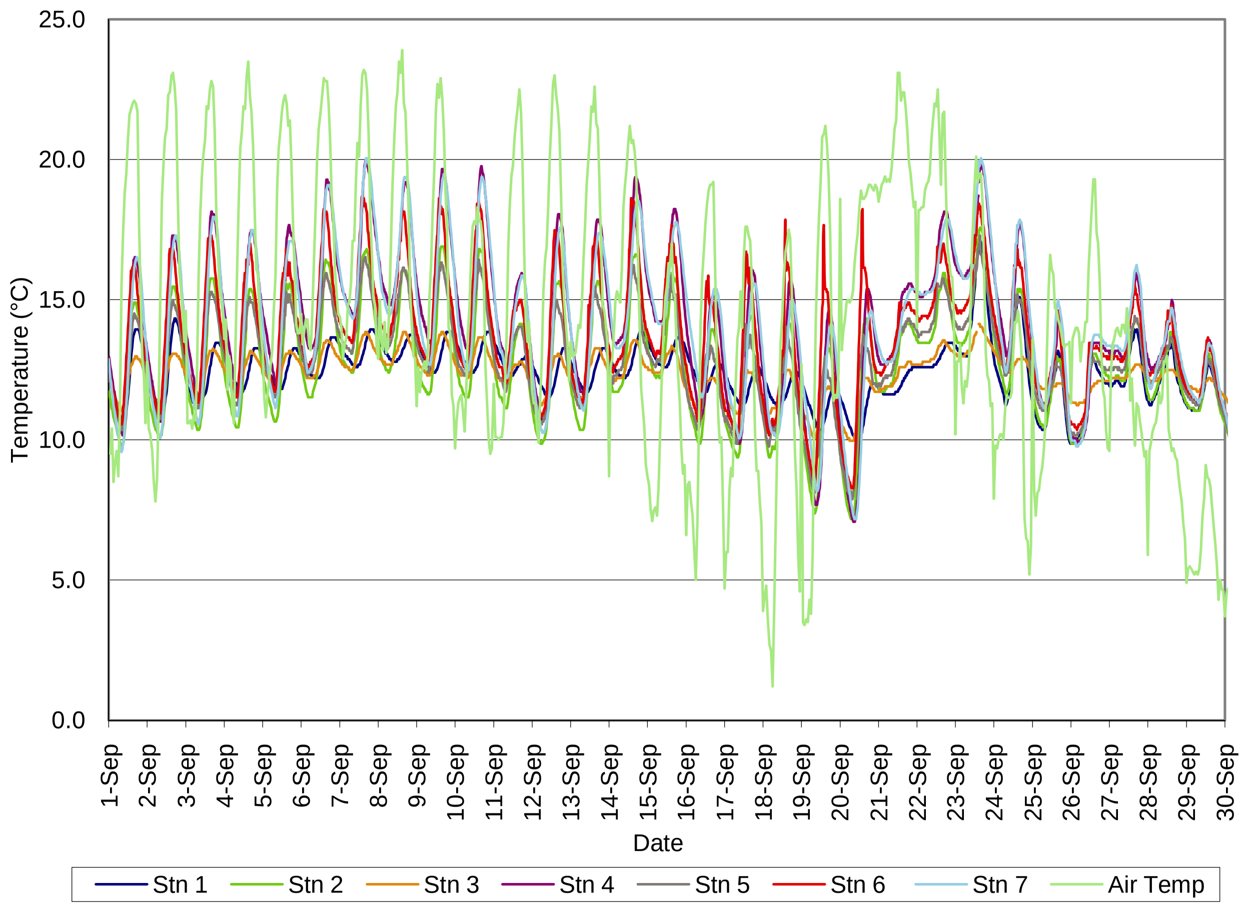
Date
Stn 1
Stn 2
Stn 3
Stn 4
Stn 5
Stn 6
Stn 7
Air Temp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0.0
Temperature (°C)
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3-Sep
4-Sep
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6-Sep
7-Sep
8-Sep
9-Sep
10-Sep
11-Sep
12-Sep
13-Sep
14-Sep
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16-Sep
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18-Sep
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21-Sep
22-Sep
23-Sep
24-Sep
25-Sep
26-Sep
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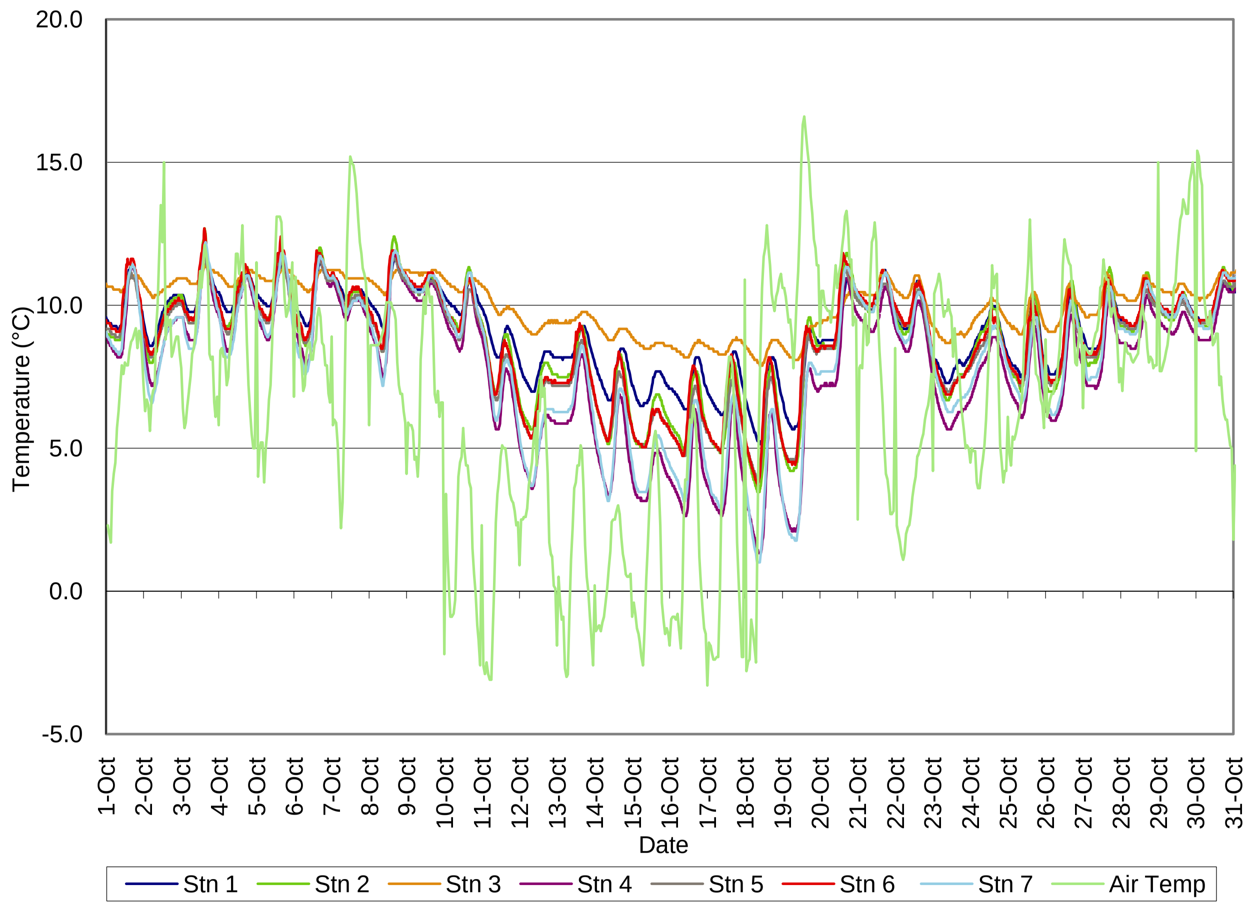
29-Sep
30-Sep
Date
Stn 1
Stn 2
Stn 3
Stn 4
Stn 5
Stn 6
Stn 7
Air Temp


Temperature (°C)
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0.0
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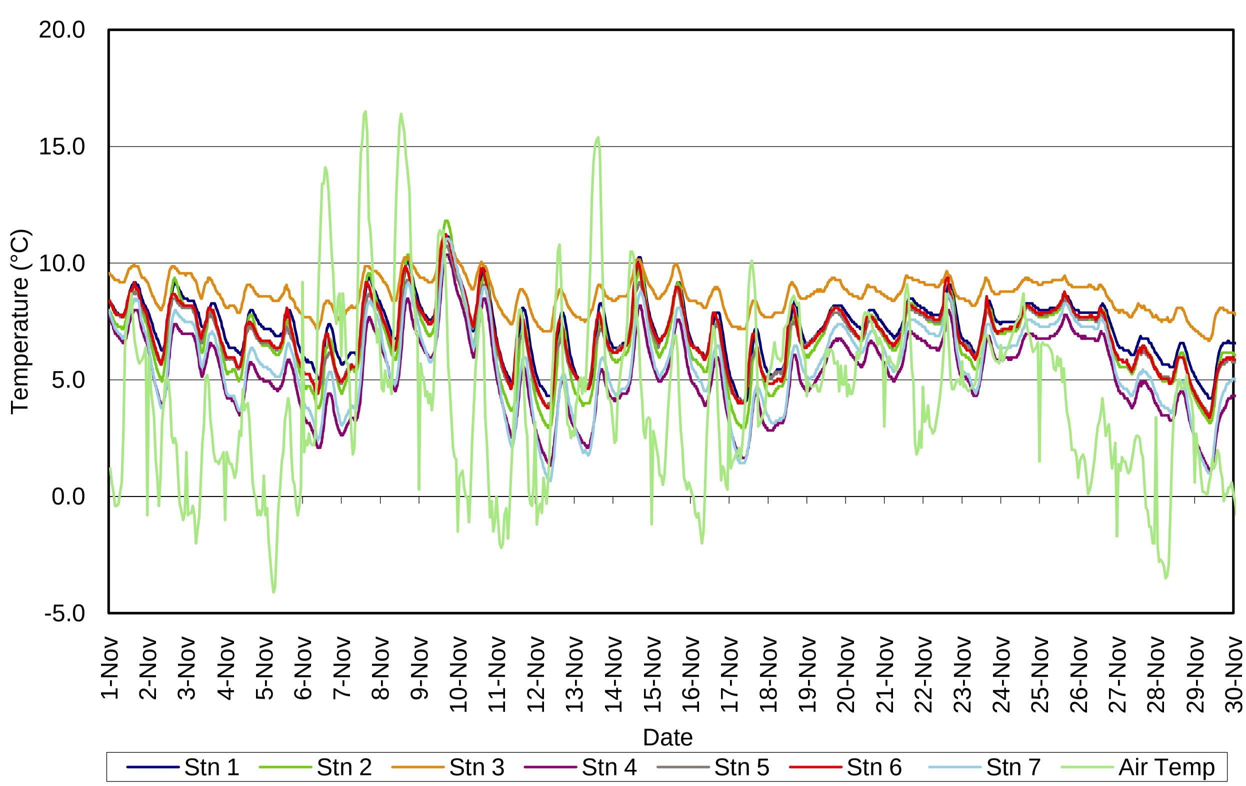
13-Oct
14-Oct
15-Oct
16-Oct
17-Oct
18-Oct
19-Oct
20-Oct
21-Oct
22-Oct
23-Oct
24-Oct
25-Oct
26-Oct
27-Oct
28-Oct
29-Oct
30-Oct
31-Oct
Date
Stn 1
Stn 2
Stn 3
Stn 4
Stn 5
Stn 6
Stn 7
Air Temp


Temperature (°C)
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3-Nov
4-Nov
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7-Nov
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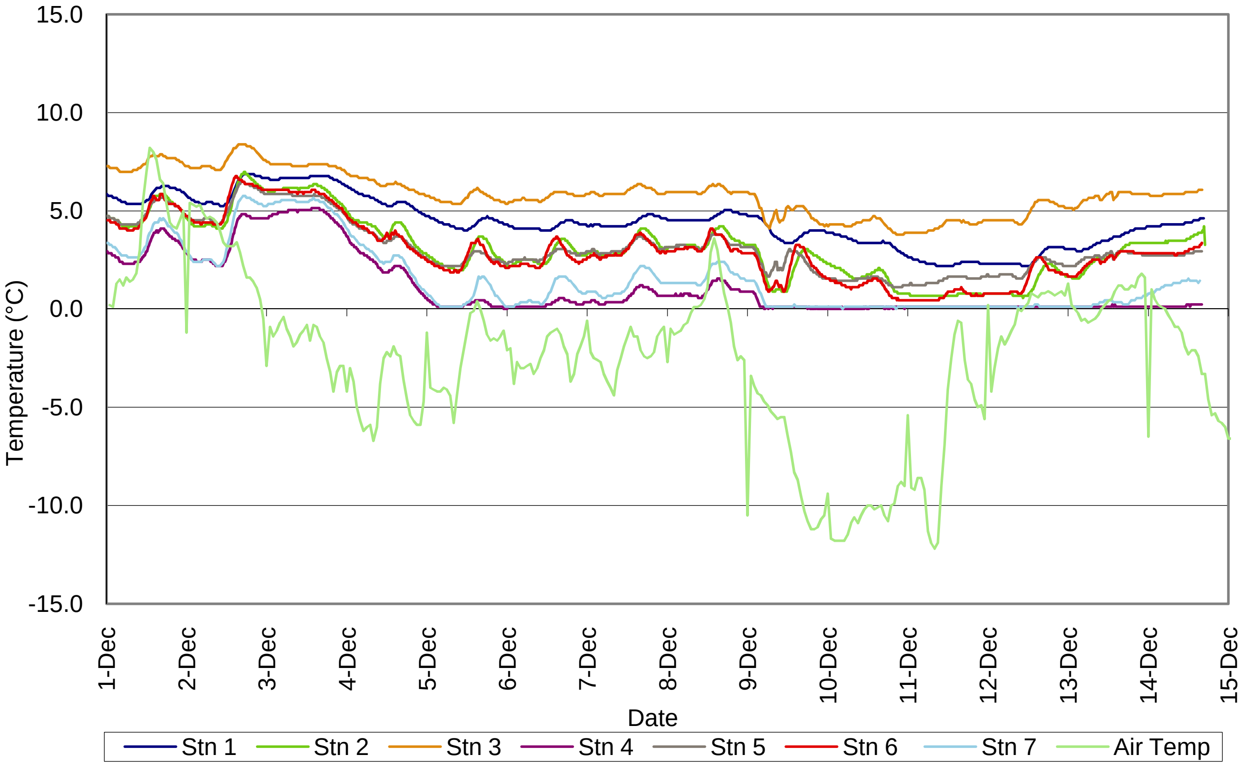
9-Nov
10-Nov
11-Nov
12-Nov
13-Nov
14-Nov
15-Nov
16-Nov
17-Nov
18-Nov
19-Nov
20-Nov
21-Nov
22-Nov
23-Nov
24-Nov
25-Nov
26-Nov
27-Nov
28-Nov
29-Nov
30-Nov
Date
Stn 1
Stn 2
Stn 3
Stn 4
Stn 5
Stn 6
Stn 7
Air Temp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10.0
5.0
0.0
-5.0
-10.0
-15.0
Temperature (°C)
1-Dec
2-Dec
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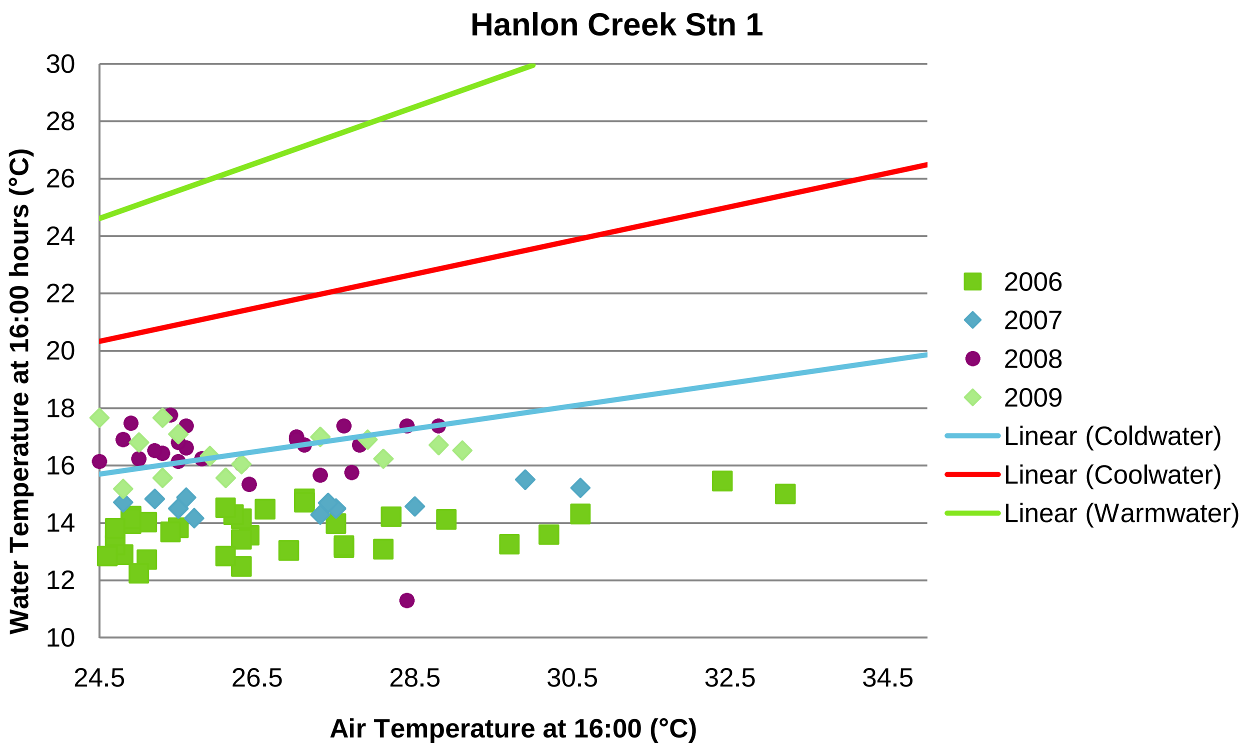
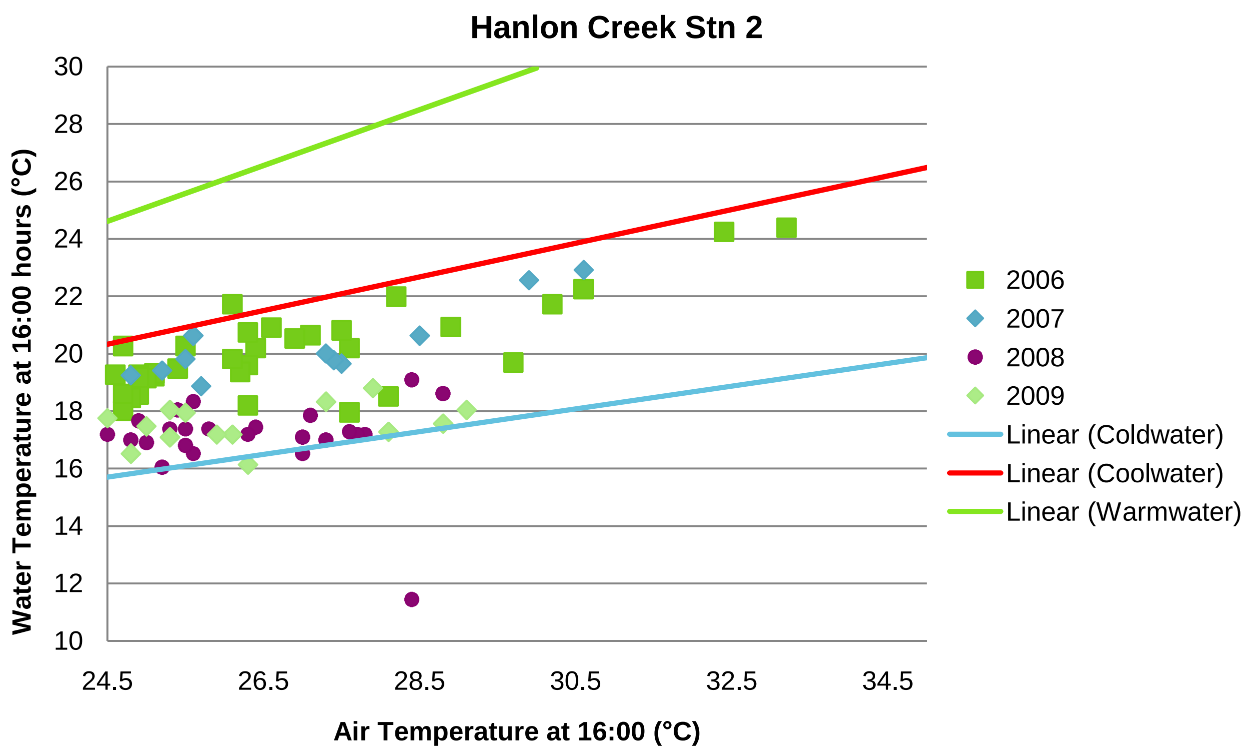
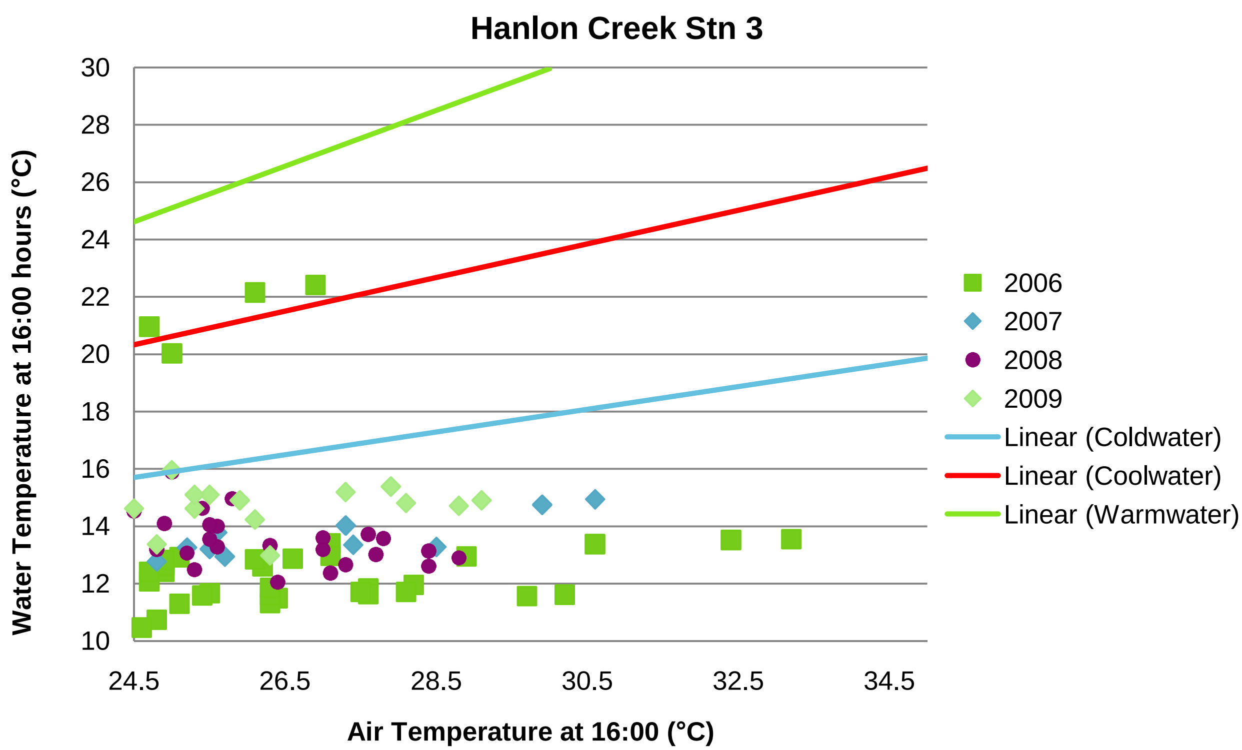
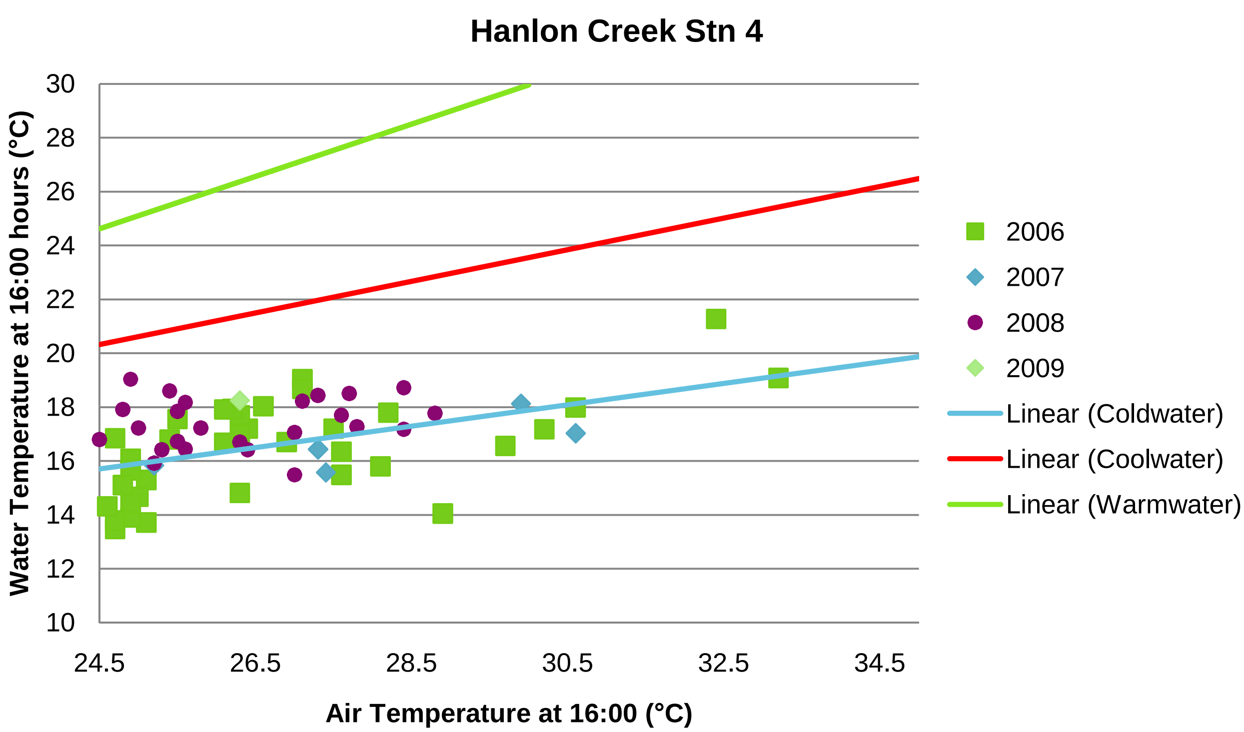
4-Dec
5-Dec
6-Dec
7-Dec
8-Dec
9-Dec
10-Dec
11-Dec
12-Dec
13-Dec
14-Dec
15-Dec
Date
Stn 1
Stn 2
Stn 3
Stn 4
Stn 5
Stn 6
Stn 7
Air Temp

Appendix C Thermal Regime Classification






Hanlon Creek Stn 3
Water Temperature at 16:00 hours (°C)
30
28
26
24
22
20
18
16
14
12
10
24.5
26.5
28.5
30.5
32.5
34.5
Air Temperature at 16:00 (°C)
2006
2007
2008
2009
Linear (Coldwater)
Linear (Coolwater)
Linear (Warmwater)


Hanlon Creek Stn 4
Water Temperature at 16:00 hours (°C)
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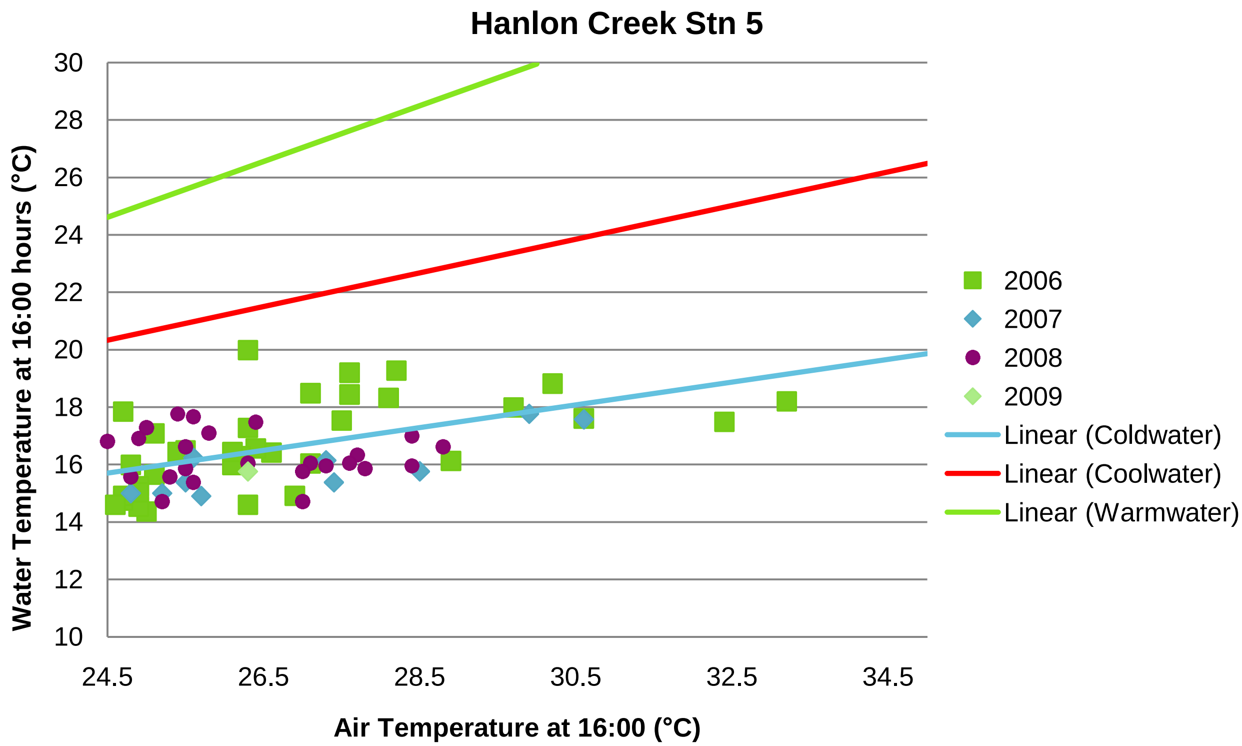
28
26
24
22
20
18
16
14
12
10
24.5
26.5
28.5
30.5
32.5
34.5
Air Temperature at 16:00 (°C)
2006
2007
2008
2009
Linear (Coldwater)
Linear (Coolwater)
Linear (Warmwater)


Hanlon Creek Stn 5
Water Temperature at 16:00 hours (°C)
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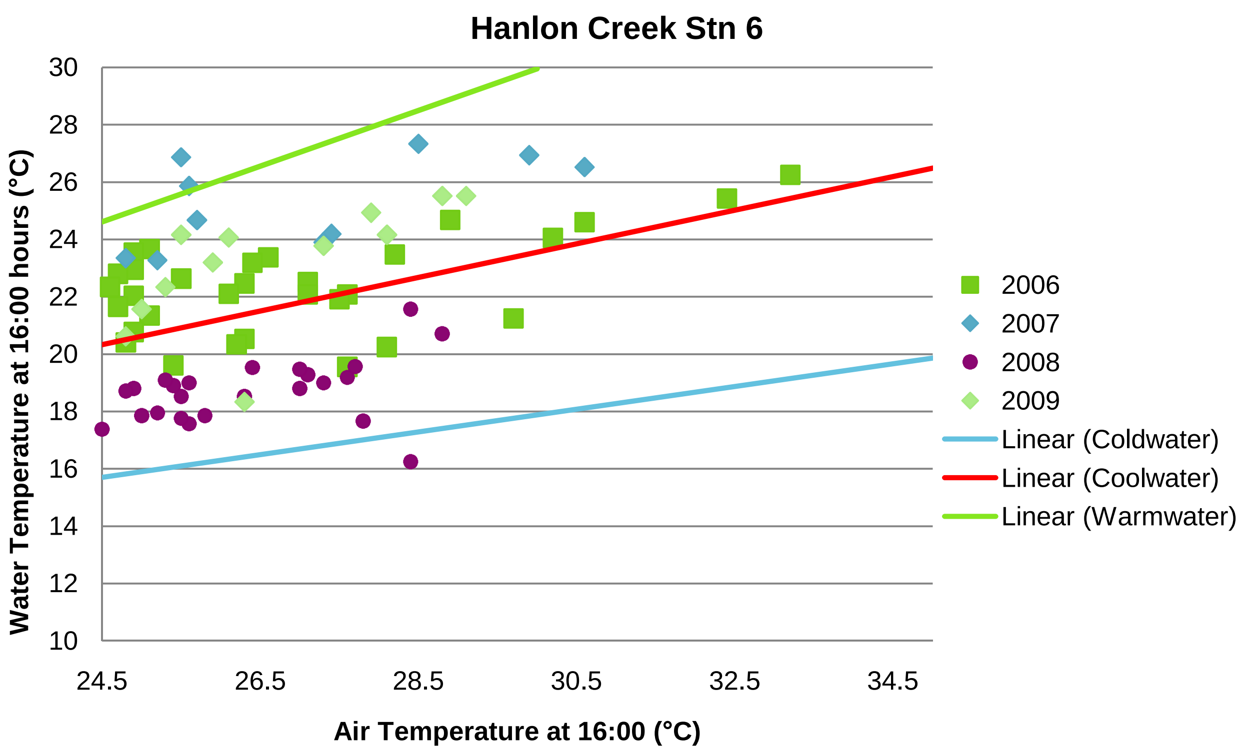
28
26
24
22
20
18
16
14
12
10
24.5
26.5
28.5
30.5
32.5
34.5
Air Temperature at 16:00 (°C)
2006
2007
2008
2009
Linear (Coldwater)
Linear (Coolwater)
Linear (Warmwater)


Hanlon Creek Stn 6
Water Temperature at 16:00 hours (°C)
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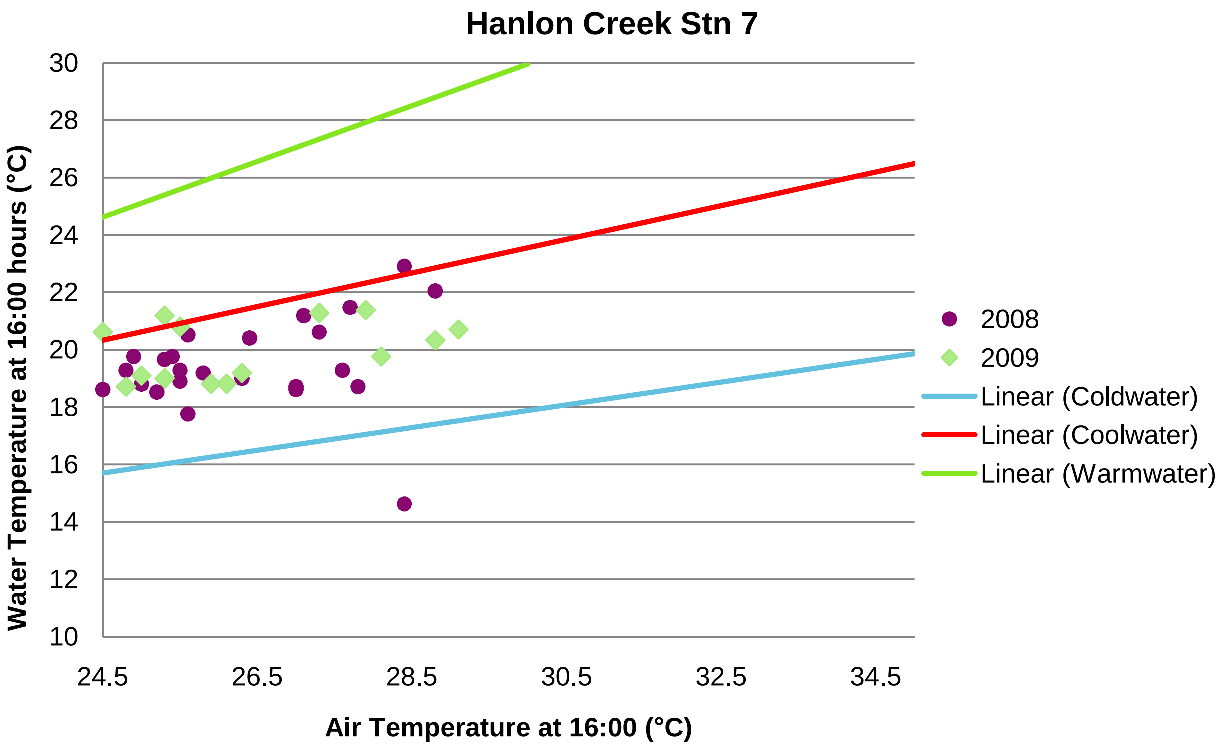
28
26
24
22
20
18
16
14
12
10
24.5
26.5
28.5
30.5
32.5
34.5
Air Temperature at 16:00 (°C)
2006
2007
2008
2009
Linear (Coldwater)
Linear (Coolwater)
Linear (Warmwater)


Hanlon Creek Stn 7
Water Temperature at 16:00 hours (°C)
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28
26
24
22
20
18
16
14
12
10
24.5
26.5
28.5
30.5
32.5
34.5
Air Temperature at 16:00 (°C)
2008
2009
Linear (Coldwater)
Linear (Coolwater)
Linear (Warmwater)

Appendix D

Groundwater Monitoring Results

NRSI_0726P_Fig1_StudyAreaMonitoringSites_10K_28Nov07_NJB

Hanlon Creek Business Park

City of Guelph

Environmental Implementation Report

Hydrogeology

Banks Groundwater Engineering Limited

Legend

- Wetland
- Surface Water
- Project Boundary
- Monitoring Well
- Mini-Piezometer

Disclaimer: This Figure is for illustrative purposes only and is to be considered in conjunction with the Hydrogeology Report.

Digital Mapping Source: Airphoto (2006) used under license from the Corporation of the City of Guelph.

Map Projection: UTM Zone 17, NAD83

December, 2007

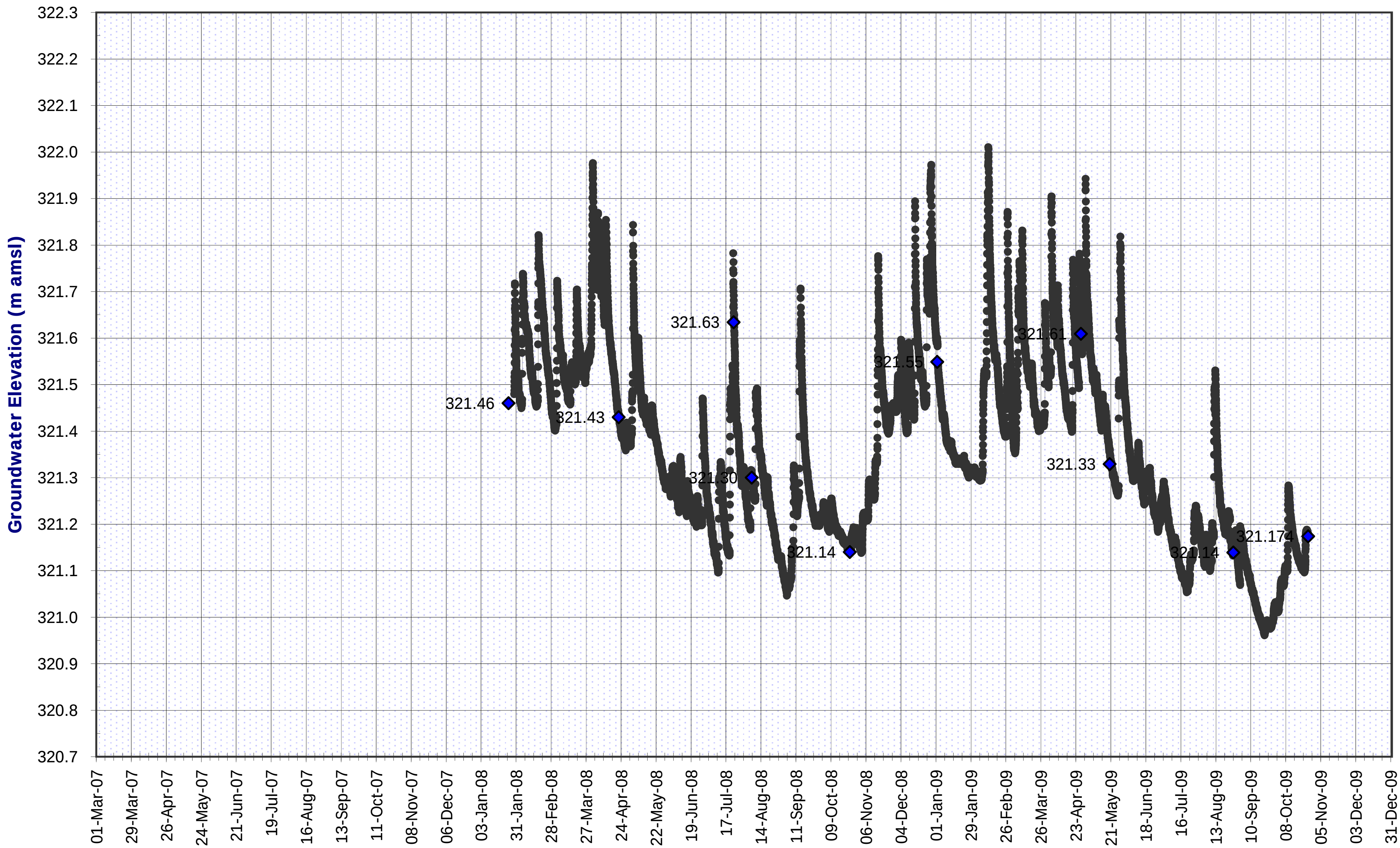
Scale: 1:10,000 (@ 11x17")

0 100 200 300 400 500 Meters

Figure 1

Study Area and Monitoring Locations

Groundwater Elevation - MW104 (January 08 to October 09)

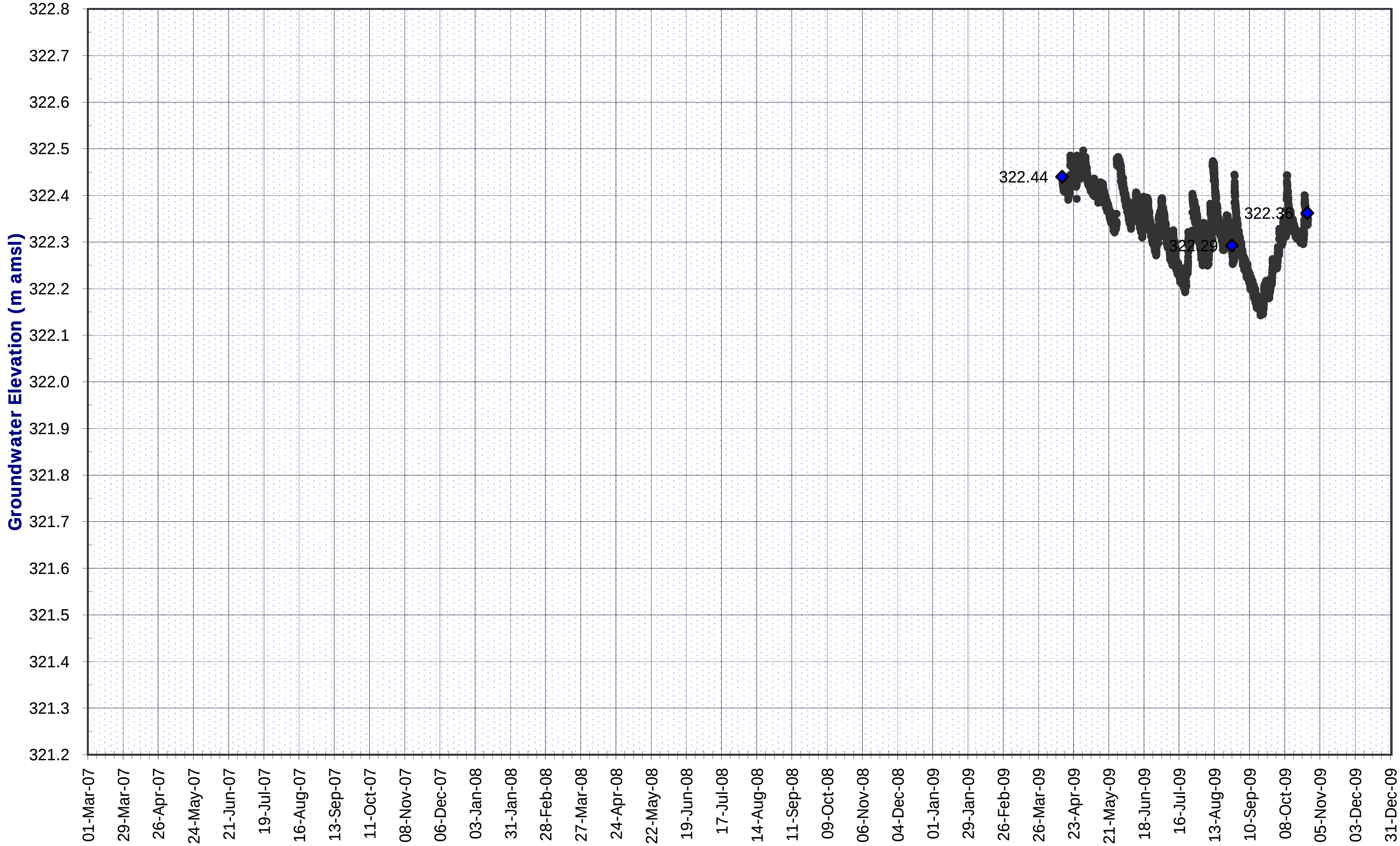


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

October 2009 **Graph E 12**

Groundwater Elevation - PZ-4D (April 09 to October 09)

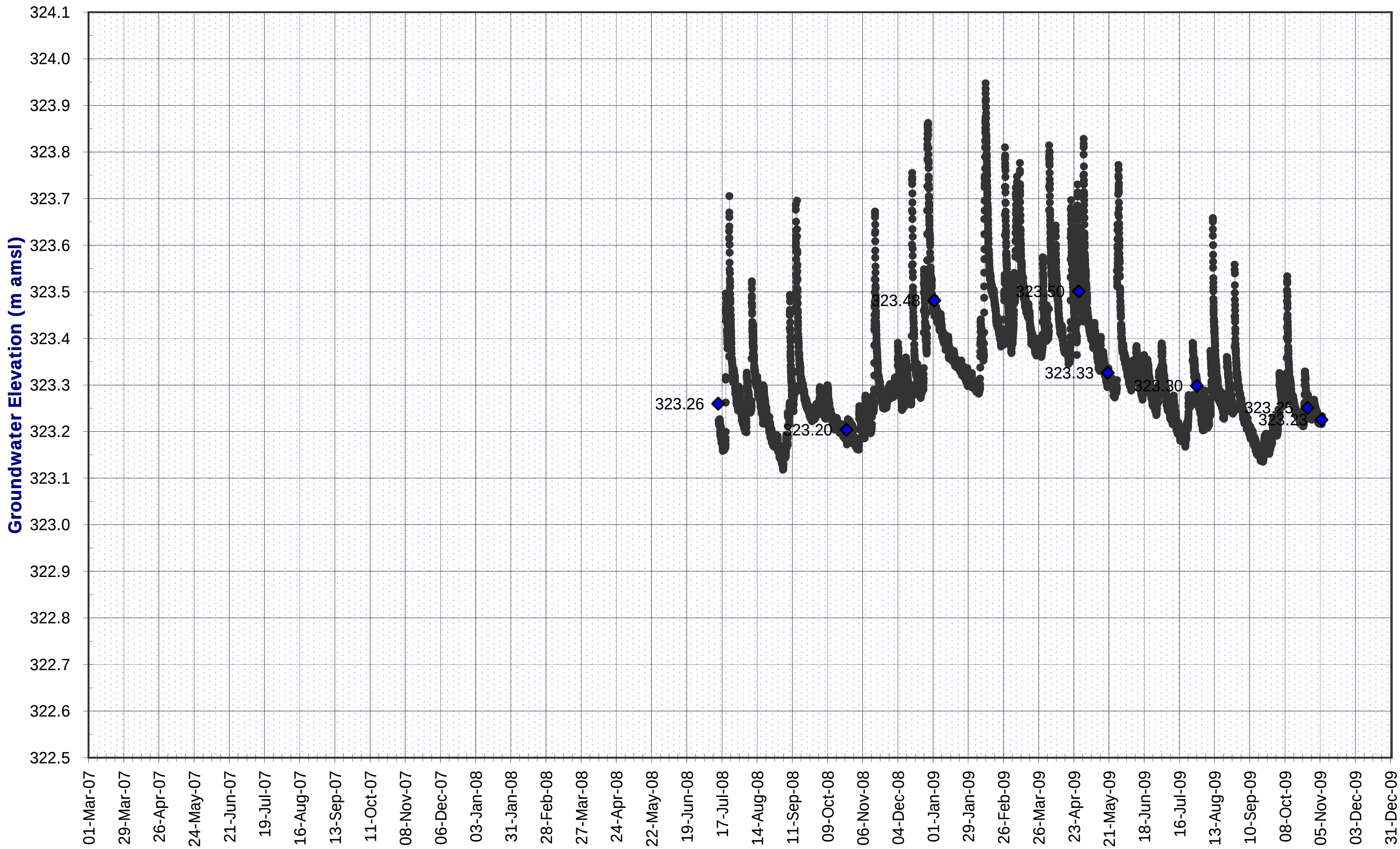


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

October 2009 **Graph E 22**

Groundwater Elevation - MW118A (October 08 to October 09)

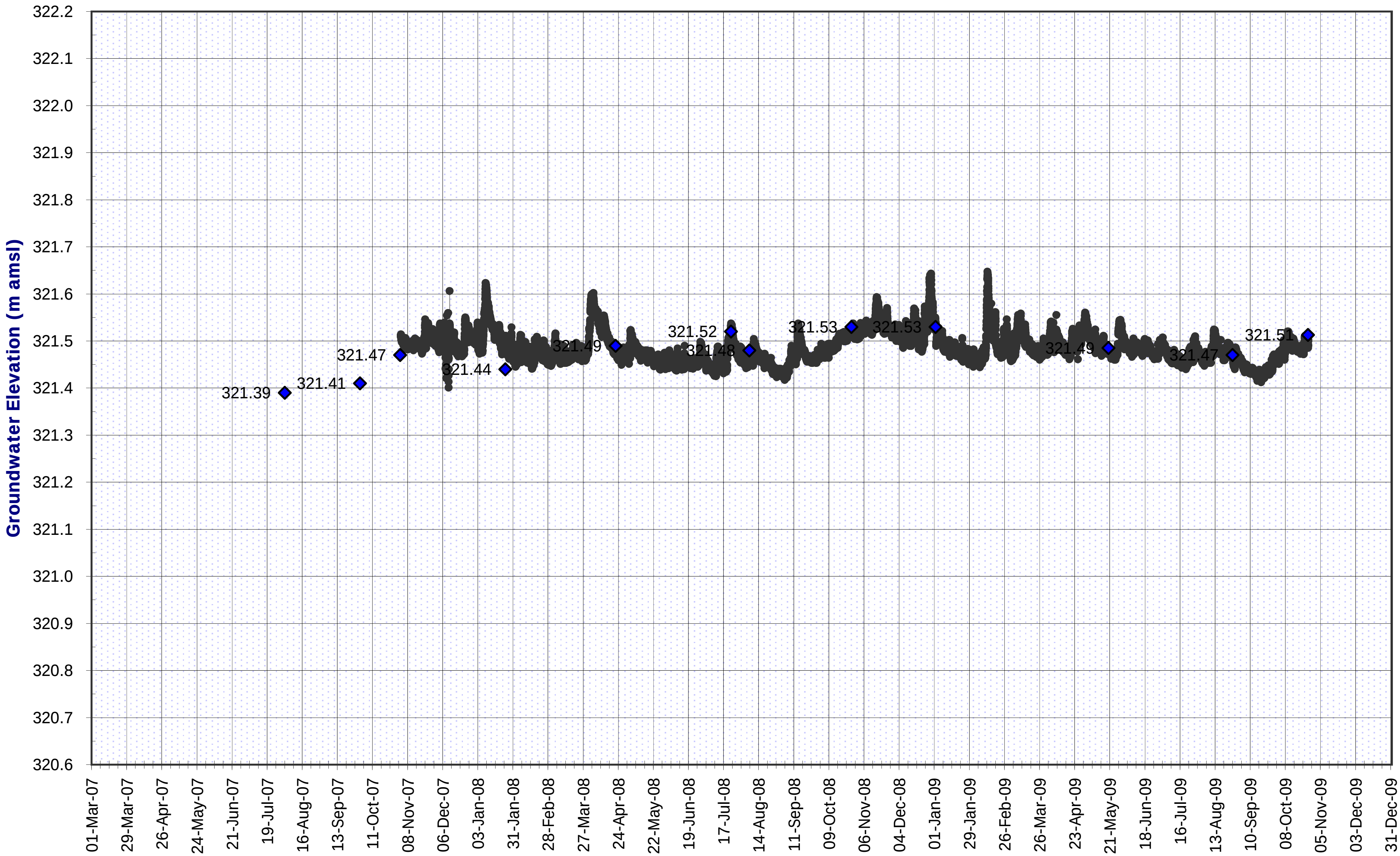


Banks Groundwater Engineering Limited

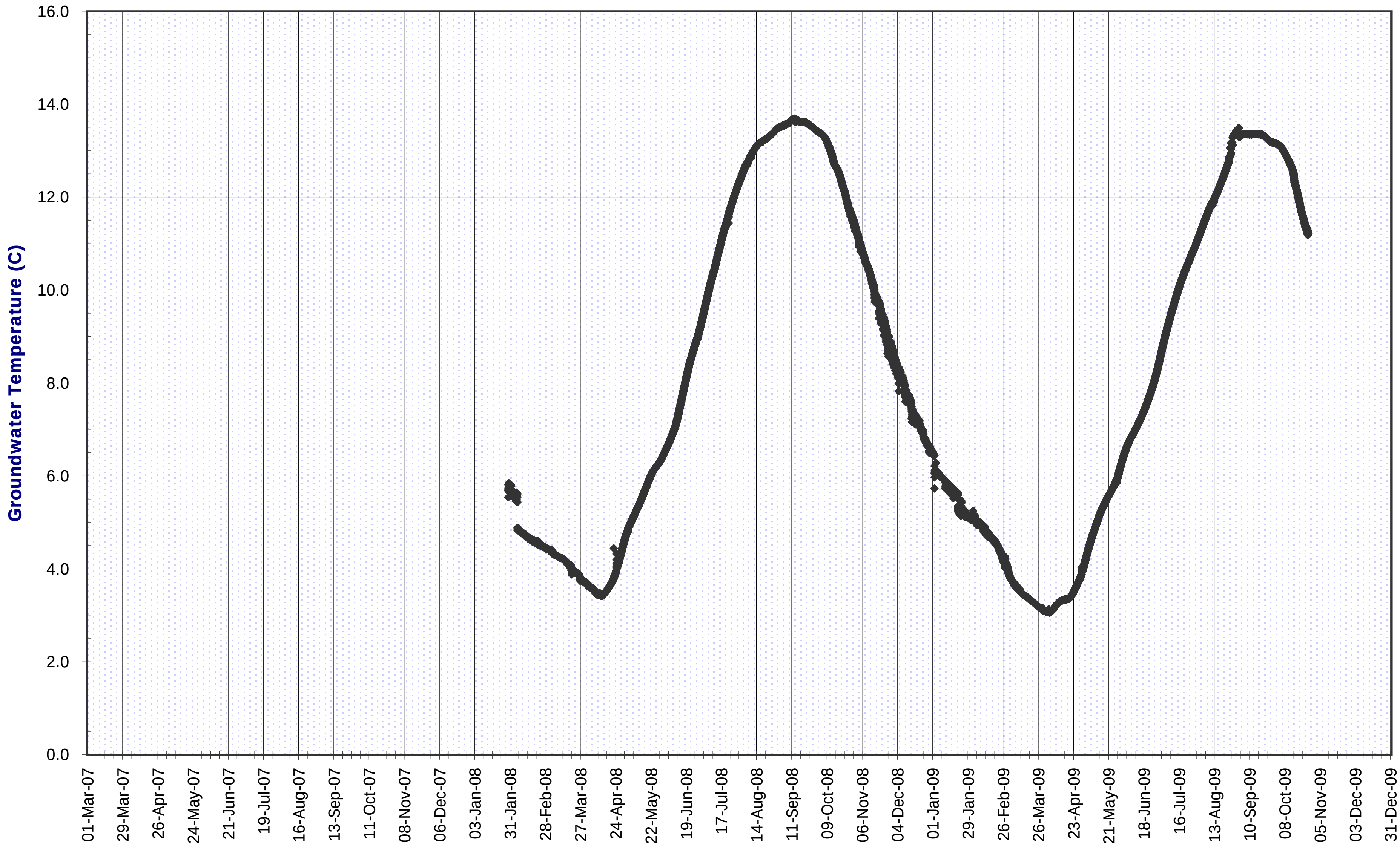
Hanlon Creek Business Park - Groundwater Monitoring Program

October 2009 **Graph E 17**

Groundwater Elevation: PZ-7D (August 07 to October 09)



Groundwater Temperature - MW104 (January 08 to October 09)

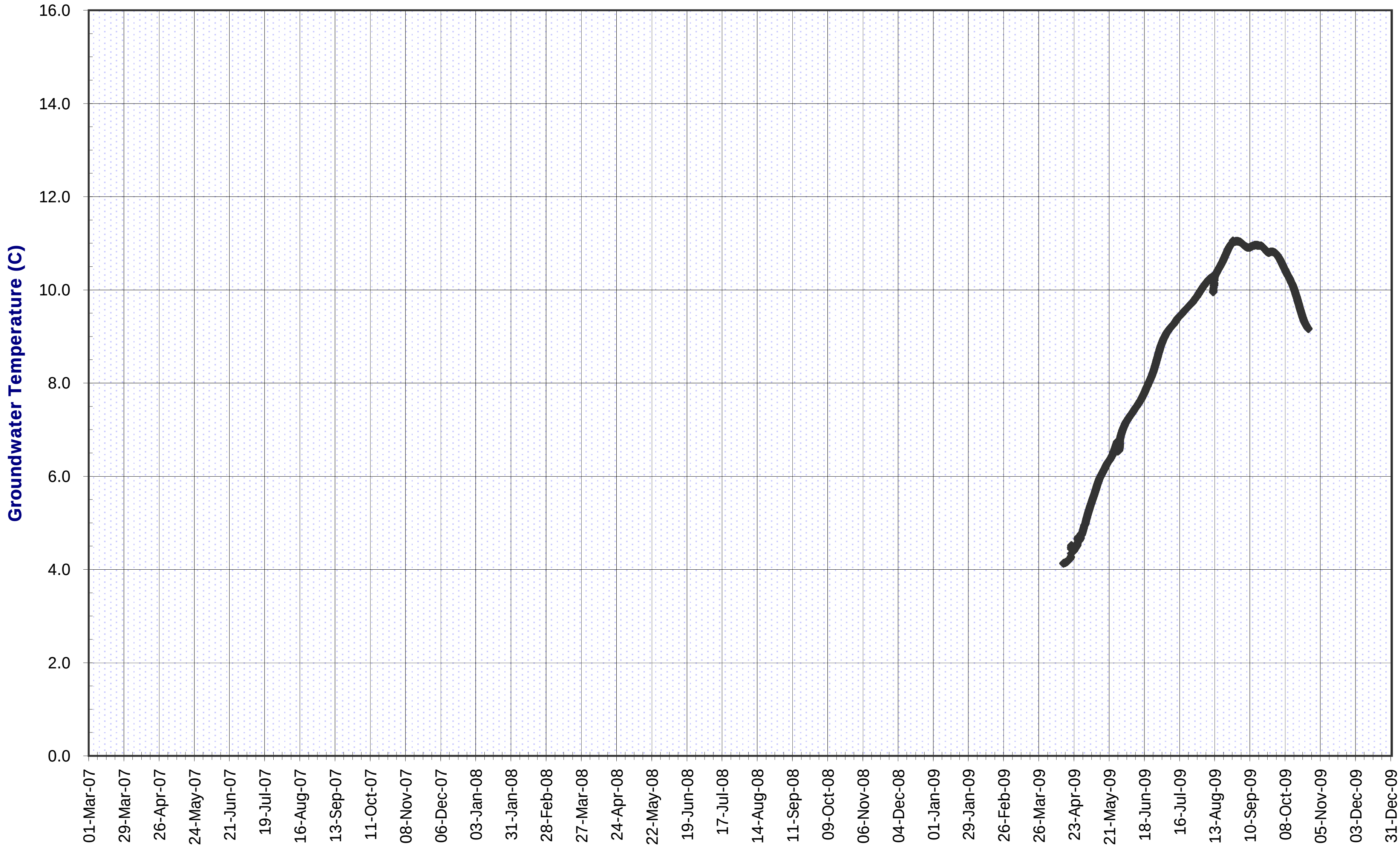


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

October 2009 **Graph E 12a**

Groundwater Temperature - PZ-4D (April 09 to October 09)

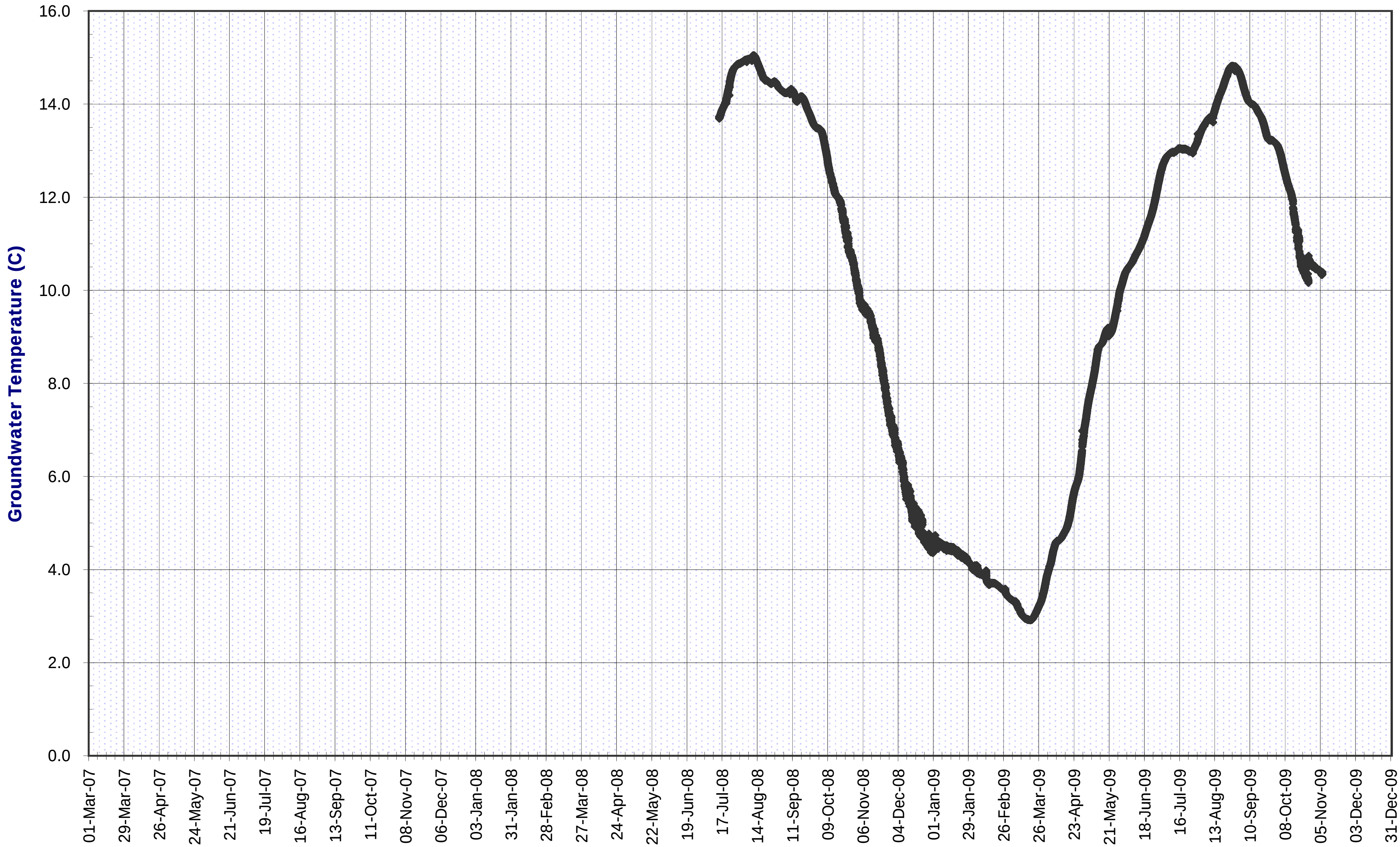


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

October 2009 **Graph E 22a**

Groundwater Temperature - MW118A (July 08 to October 09)

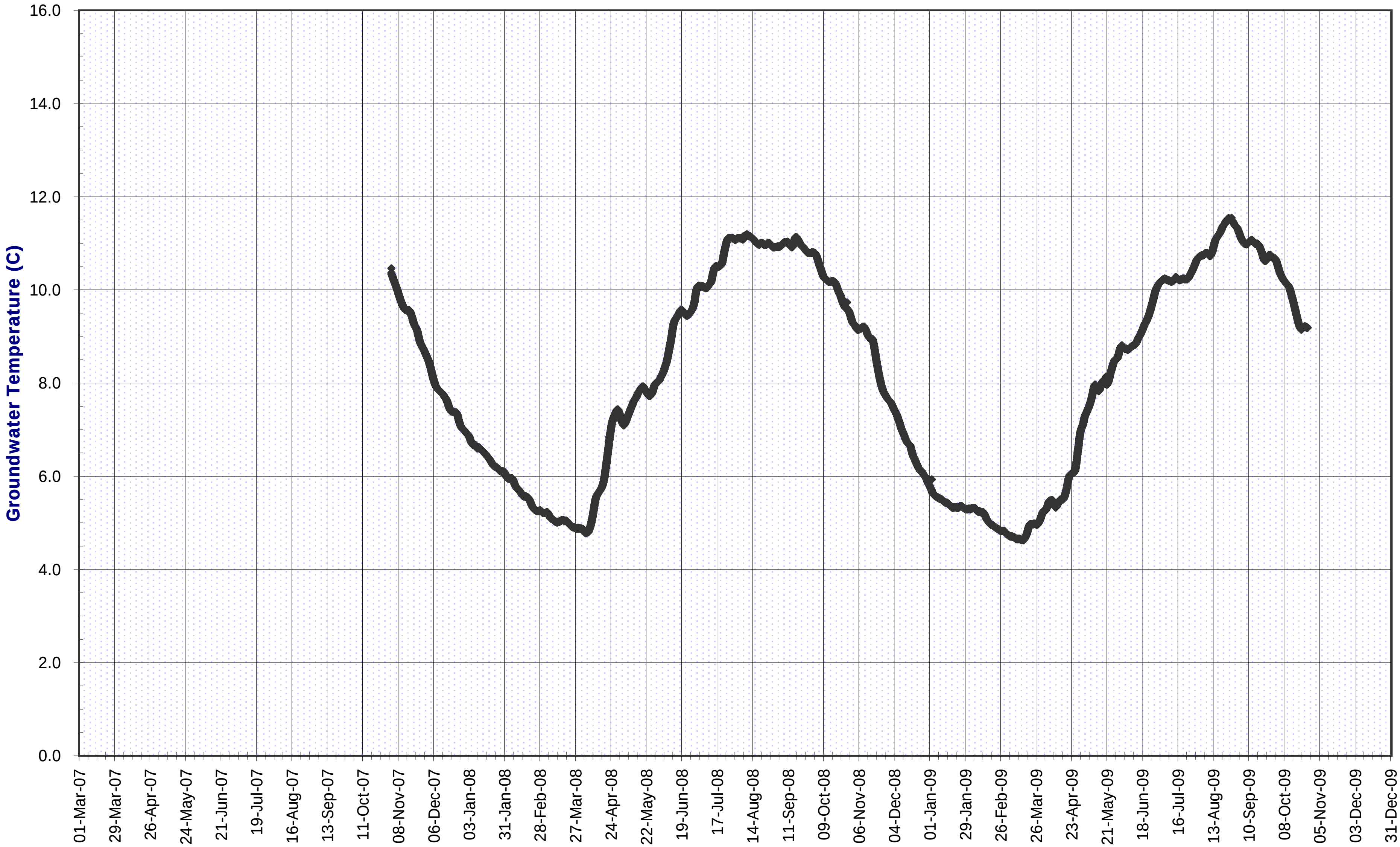


Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

October 2009 **Graph E 17a**

Groundwater Temperature: PZ-7D (August 07 to October 09)



Banks Groundwater Engineering Limited

Hanlon Creek Business Park - Groundwater Monitoring Program

October 2009 **Graph E 10a**

APPENDIX III

AQUATIC MONITORING REPORT

DRAFT

Hanlon Creek Business Park
Pre-Construction Aquatic Monitoring
2009

Prepared for:
City of Guelph
Economic Development Services
65 Delhi Street
Guelph, ON

Project No. 682H

Date: April 2010

NATURAL RESOURCE SOLUTIONS INC.
Aquatic, Terrestrial and Wetland Biologists

DRAFT
Hanlon Creek Business Park
Pre-Construction Aquatic Monitoring 2009

Project Team:

Staff	Role
Andrew Schiedel	Aquatic Biologist – Project Manager
Deanna Calhoun	Aquatic Biologist
Gina Van Wieren	Aquatic Biologist

Report submitted on April 29, 2010

Andrew Schiedel, B.A.
Project Manager/Aquatic Biologist

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1.0 Introduction

The need for aquatic monitoring for the Hanlon Creek Business Park development was identified in the *Hanlon Creek Business Park Consolidated Environmental Impact Study* (NRSI 2004), which recommended benthic invertebrate sampling and fish sampling on a more frequent basis than the 5-year cycle of the state-of-the-watershed monitoring (Hanlon Creek Watershed Plan 1993). Monitoring of aquatic habitat was also recommended in the conditions for the Draft Plan approval of the Hanlon Creek Business Park as set by the Ontario Municipal Board (2006). Specifically, Draft Plan Condition #12 requires that thermal impact of stormwater management ponds be monitored.

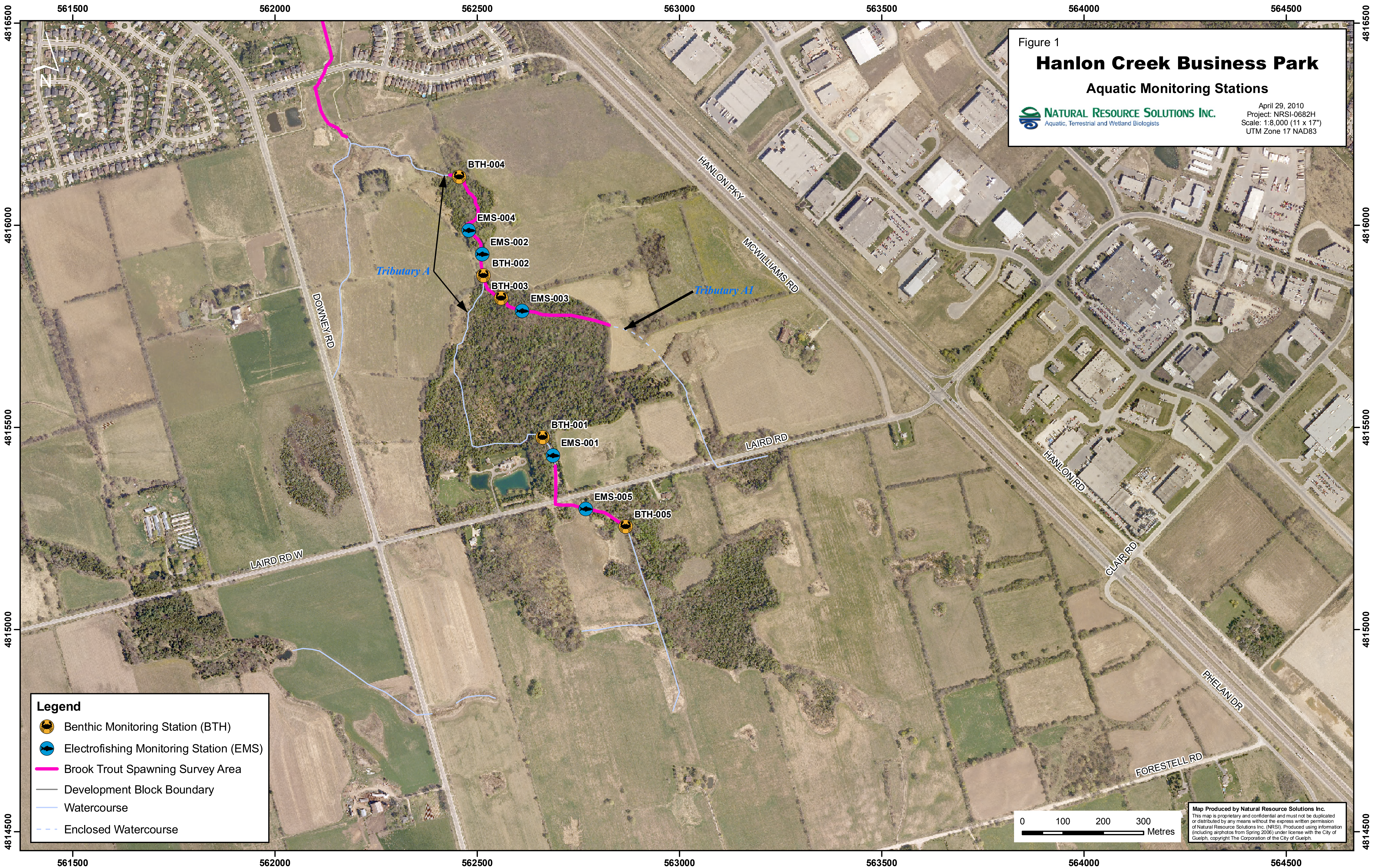
A multi-disciplinary monitoring program was developed for the Hanlon Creek Business Park development to achieve a variety of objectives, including objectives that do not directly deal with the aquatic habitat. The overall monitoring program includes terrestrial features, hydrogeology, surface water flows, surface water temperatures, benthic invertebrates and fish. The complete monitoring program, including responsibilities and timelines, is provided in the HCBP Consolidated Monitoring Program (NRSI 2010).

This monitoring report deals with the benthic invertebrate and fish communities. The aquatic monitoring components were implemented prior to construction to establish an adequate baseline data set against which development conditions can be compared. The pre-construction data now includes the years 2006, 2007, 2008, and 2009. Data has been collected at 5 stations (3 stations prior to 2009). One of the stations coincides with the aforementioned state-of-the-watershed fish sampling station. Some limited construction activities began in 2009. The most substantial work that could affect the stream was the tree clearing in the vicinity of the Road A crossing, but this is not expected to have an impact on the monitoring results. For this reason 2009 is considered pre-construction monitoring.

2.0 Study Area

Hanlon Creek Business Park is located in the south end of the City of Guelph. As shown on Figure 1, the project area is bounded to the east by Hanlon Expressway, to the north by the Kortright IV subdivision, to the west by Downey Road and to the south by Forestell Road. Laird Road runs parallel to Forestell Road, dividing the project area into north and south sections. The project area comprises forested areas and swamp/marsh pockets, as well as lands to be developed. The project area also includes a system of tributary streams that is part of the Hanlon Creek watershed. These streams are the subject of the aquatic monitoring. The watercourses are shown on Figure 1.

The aquatic monitoring program is being conducted primarily in the northern portion (Phase I) of the business park development, north of Laird Road. The interest in this location is based on the historic presence of brook trout *(Salvelinus fontinalis)* in the coldwater habitat provided by Tributary A1, and Tributary A north of Laird Road. One of the stations added for 2009 is south of Laird Road, situated downstream of the planned outlet of Stormwater Management Pond 4.



NRSI_0682H_Fig1_AquaticMonitoring_8K_2010_04_29_SWM

3.0 Methods

A total of 3 sampling sites in the northern portion of the subject property were selected during the 2006 field season. The same sites were sampled again in 2007, 2008 and 2009. Two sites were added in 2009 to expand the monitoring program. At each site, there is a benthic macroinvertebrate sampling station (BTH) and a quantitative fish sampling stations (EMS).

- Site 1 (BTH-001 and EMS-001) is located on Tributary A approximately 150m downstream of Laird Road.
- Site 2 (BTH-002 and EMS-002) is located on Tributary A immediately downstream of the confluence with Tributary A1.
- Site 3 (BTH-003 and EMS-003) is located on Tributary A1.
- Site 4 (BTH-004 and EMS-004) is located on Tributary A downstream of the Road A crossing.
- Site 5 (BTH-005 and EMS-005) is located on Tributary A upstream/south of Laird Road

Fish sampling and benthic macroinvertebrate collection were conducted at each site, but they occurred in separate areas of the stream to facilitate collection of both parameters on the same day (Figure 1).

The original selection of stations was based in part on historic knowledge of brook trout inhabitance. The stations were also positioned to help locate sources of future impacts, should any occur. Attention was given to the recommendation in the Ontario Stream Assessment Protocol (Stanfield 2005) to establish the upstream and downstream extents of a site at a crossover point of the thalweg (concentration of flow). The specific sections of stream were selected to represent the habitat types in the vicinity of each station, and were a minimum of 30m of stream length.

3.1 Benthic Macroinvertebrate Community

There are a number of advantages in sampling benthic macroinvertebrates for water quality monitoring:

- They reflect local aquatic conditions as a result of their limited mobility;
- They integrate all the surrounding parameters of their environment into one easily assessable sampling unit;
- They integrate the physical and chemical aspects of water quality over annual time periods due to their short life spans (approximately 1 year); and
- They may indicate the probable cause of impairment because many benthic macroinvertebrate species have known environmental sensitivities and/or tolerances.

3.1.1 Benthic Macroinvertebrate Sampling

Sampling for the benthic macroinvertebrate monitoring took place on September 17 and 18, 2009. It employed the sampling methodology from the Ontario Benthos Biomonitoring Network (OBBN) protocols (Jones et al 2005). Most of the following procedures are taken from those protocols. Some of the specimen processing procedures are not covered by the OBBN protocols.

According to OBBN, a total of 3 subsamples are collected at each station in stream habitats: 2 from riffles, and 1 from a pool. Where riffle and pool habitats are not clearly defined (as is the case at some of the subject stations) pools and riffles can be functionally defined as slow/deep and fast/shallow sections. For wadable streams, the OBBN protocol employs a Travelling Transect Kick and Sweep method. For each subsample, a total of at least 10 linear metres of transect must be sampled in approximately 3 minutes. For small streams such as those in this study, this requires that several transects be positioned in the same riffle or pool in order to sample 10 metres of transect. Beginning at one bank and moving across the transects, the substrate is disturbed to a depth of approximately 5cm by vigorously kicking the substrate. A 500-µm-mesh D-net is held downstream of and close to the disturbed area by the person sampling. The net is held on or close to the bottom, and is swept back and forth so that dislodged macroinvertebrates will be carried into the net. In areas of slow current, the sweeping motion is important for collecting the macroinvertebrates into the net. A stopwatch is used to time the sampling.

When sampling is complete, the net is rinsed and the sample is placed in plastic jars. The sample is then preserved with a 10% concentration of buffered formalin and sent to a professional taxonomist for identification. For 2009, samples were sent to Richard Bland Associates in London, Ontario. Samples are identified to the lowest practical taxonomic level. Subsampling is conducted by randomly dipping a small portion of the sample from a container until at least 200 organisms are obtained. After reaching the 200th organism, the portion being sampled is completed in order to facilitate measurement of the proportion of the total sample that is subsampled and identified. The subsample proportion is determined by measuring the total sample weight/volume before identification and the remaining sample weight/volume after identification. The difference between those 2 measurements represents the portion sampled, which is recorded as a percentage of the total sample. While the OBBN protocol requires that a minimum of 100 organisms be collected, 200 organisms per subsample are collected to provide a robust sample for this program's use of the Percent Model Affinity analysis.

The OBBN data form was used to record habitat information at the benthic macroinvertebrate sampling stations. The form includes both measured and visually estimated parameters, and facilitates comparison with other years provided the estimated parameters are treated as approximations.

3.1.2 Benthic Macroinvertebrate Data Analysis

Analysis was performed using the Percent Model Affinity (PMA) method developed in New York State by Novak and Bode (1992). This method was adapted for southern Ontario by Dr. David Barton (1996) of the University of Waterloo.

In his 1996 paper, Dr. Barton sampled over 200 streams in southern Ontario, 69 of which were used as the reference streams for the model community. Instead of using the 7 groupings originally used by Novak and Bode (1992), Dr. Barton compared the use of model communities at the order, family, genus, and 'lowest practical' taxonomic levels. He found that there was an improvement with increasing taxonomic resolution, particularly between the family and genus levels. He also analyzed seasonal differences (Barton 1996). Since 1996, Dr. Barton has continued to update his model community information.

The model communities used for analysis in this study are based on recent values from Dr. Barton for streams with mud and cobble/gravel substrates sampled in August (Barton 2007). The model community for mud substrates was used for BTH-001, BTH-003, BTH-004 and BTH-005, and the model community for cobble/gravel substrates was used for BTH-002. The family level of taxonomic resolution was used because many of the macroinvertebrates are very small in August and September, making it difficult or impossible to identify some of the specimens beyond their family.

The equation used to determine the percent similarity of community (PSC) is as follows:

$$PSC = 100 - 0.5 \Sigma \left| a - b \right|$$

Where: a is the model community value for a taxonomic group expressed as a percentage of the organisms in the model community; and

b is the percentage of the same taxonomic group in a sample from the stream being studied.

The sample PSC value is calculated by summing the absolute differences between the family model values and the families in the sample, multiplying the sum by 0.5 and subtracting this number from 100 (Novak and Bode 1992). The sample PSC value is then compared to the critical PSC value for the chosen model community.

Each critical PSC value is effectively a lower confidence limit of the mean for the expected community. It is essentially a statistical one-tailed t-test comparing a single observation with the mean of the sample, where the P-Value = 0.05 (Zar 1999)). The critical PSC values were provided by Dr. Barton along with the model community data (Barton 2007).

This index does not assign a degree of impairment or non-impairment. Rather, significant impact at a sample site is determined when the calculated sample PSC value is less than the critical PSC value. Significant impact implies that the sample community is statistically significantly different from the model community. A determination of no significant impact occurs when the calculated sample PSC value is greater than the critical PSC value (Barton 1996).

The PMA analysis was conducted for each station with the 3 subsamples (riffles and pool) combined into one sample, which is the intention of the OBBN protocol.

In addition to PMA analysis, three other indices were calculated to provide additional insight into the water quality conditions at the sampling sites. They were:

- the number of taxa present in each sample (taxa richness),
- the percentage of individuals in each sample belonging to the taxonomic groups Ephemeroptera, Plecoptera, and Tricoptera (EPT richness), and
- the percentage of individuals in each sample that were the dominant taxon (% dominant taxon).

3.2 Fish Community

NRSI biologists conducted quantitative fish sampling at the 5 stations to provide population estimates that can be compared over the years of monitoring.

3.2.1 Fish Community Sampling

Fish sampling was conducted on August 17, 25 and 26 and September 8, 2009 using a depletion sampling method that is outlined in the Ontario Stream Assessment Protocol (Stanfield 2005). At each quantitative station, the chosen stream length was isolated from the rest of the stream using block nets. The block nets were small seine nets with a mesh size similar to the mesh on the dip net used with the electrofisher. The rope across the bottom of the net was weighted to keep it against the bottom of the channel, and the top of the net was a floating line. The nets were tied to trees or woody material, or secured on metal T-bar posts.

A 2-person electrofishing crew conducted multiple passes of the enclosed area using a Halltech Model 1 backpack electrofisher set to a pulsating frequency of 60Hz, and an electric potential of 300 to 400 volts. Once collected, the fish were identified, measured on site, and released outside of the sampling area. This process was repeated until the number of individuals caught exhibited a downward trend, or a minimum of three times. The number of individual fish, and minimum and maximum lengths were recorded for each species. The water quality conditions, electrofisher settings, and number of shocking seconds for each pass were recorded. An effort was made to keep the sampling effort the same for each pass with respect to shocking seconds and netting technique.

Habitat information for the stations included classifications of adjacent lands, and basic visual estimates of macrohabitats (riffles, pools, etc.), instream vegetation, instream cover and overhead canopy shading. These habitat parameters provide a basic description of the conditions and help to understand the fish data. This information is intended to help interpret the fish community data for the quantitative stations. Because the focus of the monitoring is on the fish community, they are approximate and not intended for detailed comparison among years of monitoring.

A brook trout spawning survey was carried out during the spawning season. Two site visits were conducted on October 14 and 21, 2009 to document redds and observe any brook trout exhibiting spawning behaviour. The survey was conducted in several locations:

- Tributary A in the vicinity of Teal Drive (October 14 only);
- Tributary A between the swamp downstream of the proposed Road A crossing and the confluence with Tributary A1;
- Tributary A in the vicinity of Laird Road (October 21 only); and
- Tributary A1 between the confluence with Tributary A and the outlet of the agricultural tile drain that is the source of much of the flow in Tributary A1

3.2.2 Fish Community Data Analysis

The analysis of the data for the three sampling stations provides estimates of the population of the fish at each station. Biomass was not calculated in 2009 because the mass data for the fish was not sufficiently accurate. A simple method for these calculations uses a regression of the data, which is plotted on a 2-dimensional graph with the catch from an individual fishing (1 pass) on the y-axis and the previous total catch (sum of previous passes) on the x-axis. This method is described by Zippen

(1958) in the context of trapping small mammals. This calculation assumes a constant probability of capture with each fishing pass. However, this method is generally considered inferior because it does not give valid estimates of the standard error of the estimated population size.

A better method employs maximum likelihood estimates, as described by Schnute (1983). This method calculates the probability of capture, and this probability can be either constant or variable. A study by Peterson et al (2004) showed that constant probability may not be an accurate assumption for electrofishing depletion sampling for salmonids, particularly for sampling larger watercourses. For 2009, the variable probability of capture was used for 4 of the 5 stations. This required a minimum of 4 passes at each station. The data collected at Station EMS-004 was limited to 3 passes, because only 1 fish was captured in the third pass and the data exhibited a consistent downward trend. This data is well suited to the regression method.

A computer software package called *Removal Sampling 2* by Pisces Conservation Ltd. was used to perform the calculations using the maximum likelihood – variable probability methods. The regression calculation was performed in *Microsoft Excel.* The estimated population calculations were carried out separately for each station, and estimates were made for all species combined. Capture of brook trout warrants a separate estimate, but none were captured in 2009.

4.0 Results and Discussion

4.1 Benthic Macroinvertebrate Sampling

4.1.1 Habitat and Sampling Conditions

Station BTH-001 is situated within a white cedar – hardwood mixed swamp as defined in the Ecological Land Classification for Southern Ontario Guide (ELC, Lee et al. 1998). This swamp extends up to 100m to the west, but an agricultural field occupies land within 50m to the southeast of the station. The station is composed of runs, riffles, and pools. The channel has no vegetation or algae within the station, but woody material and detritus are present. The overhead canopy provides 75 to 100% shade. The sampling conditions are summarized in Table 1.

Table 1. Benthic Invertebrate Sampling Conditions for Station BTH-001

Date	September 18, 2009		
Time	1010hrs		
Air Temperature (°C)	15		
Water Temperature (°C)	11		
Dissolved Oxygen (ppm)	10.04		
Conductivity (µS/cm)	714		
	Riffle 1	**Pool**	**Riffle 2**
Wetted Width (m)	1.7	0.6	1.8
Maximum Depth (m)	0.05	0.14	0.06
Maximum Hydraulic Head (mm)	5	10	10
Dominant Substrate	Gravel	Silt	Gravel
Second Dominant Substrate	Cobble	Sand	Silt
Total Transect Length (m)	10.2	9.6	10.8
Kick & Sweep Sampling Time (min:sec)	3:19	2:49	3:00
Number of Jars to Retain Sample	1	2	1

Station BTH-002 is situated within a white cedar – hardwood mixed swamp (Lee et al. 1998). The station is composed of riffles, pools, and runs. Some emergent aquatic plants are present in the channel, as are woody material and detritus. The overhead canopy provides 50 to 74% shade. The vegetative community adjacent to the stream on each side is scrubland from 1.5 to 10m from the water's edge, and mainly the white cedar – hardwood mixed swamp from 10 to 30m from the water's edge. On the west side of the station, the swamp continues from 30 to 100m from the water's edge. Meadow is present in this proximity on the east side of the stream. The sampling conditions are summarized in Table 2.

Table 2. Benthic Invertebrate Sampling Conditions for Station BTH-002

Date	September 17, 2009		
Time	1300		
Air Temperature (°C)	19		
Water Temperature (°C)	13		
Dissolved Oxygen (ppm)	12.54		
Conductivity (µS/cm)	1050		
	Riffle 1	**Pool**	**Riffle 2**
Wetted Width (m)	1.0	2.75	2.0
Maximum Depth (m)	0.09	0.11	0.10
Maximum Hydraulic Head (mm)	10	0	10
Dominant Substrate	Cobble	Cobble	Cobble
Second Dominant Substrate	Gravel	Gravel	Gravel
Total Transect Length (m)	10.0	11.0	10.0
Kick & Sweep Sampling Time (min:sec)	2:38	3:01	3:00
Number of Jars to Retain Sample	1	1	1

Station BTH-003 is situated within a white cedar – hardwood mixed swamp (Lee et al. 1998). Habitat in the station includes flats, runs and shallow pools. There is a limited amount of emergent vegetation in the channel, but an abundance of woody material and detritus. Fallen logs and branches add complexity to the instream habitat. The overhead canopy provides 75 to 100% shade over the station. The vegetative community adjacent to the stream is the white cedar – hardwood mixed swamp on the west side of the station and in the proximity of 1.5 to 10m from the water's edge on the east side. Meadow (fallow agricultural land) is found further to the east. The sampling conditions are summarized in Table 3.

Table 3. Benthic Invertebrate Sampling Conditions for Station BTH-003

Date	September 17, 2009		
Time	1430hrs		
Air Temperature (°C)	18		
Water Temperature (°C)	12.6		
Dissolved Oxygen (ppm)	11.08		
Conductivity (μS/cm)	1141		
	Riffle 1	**Pool**	**Riffle 2**
Wetted Width (m)	1.2	1.2	1.0
Maximum Depth (m)	0.16	0.17	0.16
Maximum Hydraulic Head (mm)	0	0	0
Dominant Substrate	Silt	Silt	Silt
Second Dominant Substrate	Silt	Silt	Silt
Total Transect Length (m)	9.6	9.6	10.9
Kick & Sweep Sampling Time (min:sec)	2:09	2:15	2:53
Number of Jars to Retain Sample	1	1	2

BTH-004 is situated in a white cedar – hardwood mixed swamp (Lee et al. 1998). Habitat in the station includes flats, runs and shallow pools. No aquatic vegetation is present in the channel, but there is abundant detritus and woody material. Fallen logs and branches add complexity to the instream habitat. The overhead canopy provides 75 to 100% shade over the station. The vegetative community adjacent to the stream is the white cedar – hardwood mixed swamp on the east side of the station. To the west, the swamp extends approximately 30m, beyond which is a section of mineral meadow marsh and fallow agricultural land. The sampling conditions are summarized in Table 4.

Table 4. Benthic Invertebrate Sampling Conditions for Station BTH-004

Date	September 17, 2009		
Time	1045hrs		
Air Temperature (°C)	15		
Water Temperature (°C)	12.1		
Dissolved Oxygen (ppm)	8.7		
Conductivity (µS/cm)	1014		
	Riffle 1	**Pool**	**Riffle 2**
Wetted Width (m)	1.6	1.5 to 2.0	2.0
Maximum Depth (m)	0.07	0.19	0.10
Maximum Hydraulic Head (mm)	5	0	5
Dominant Substrate	Sand	Sand	Sand
Second Dominant Substrate	Silt	Silt	Silt
Total Transect Length (m)	9.6	9.0	10.0
Kick & Sweep Sampling Time (min:sec)	1:53	2:05	2:29
Number of Jars to Retain Sample	2	1	1

BTH-005 is situated in a fresh – moist poplar deciduous forest. Smaller areas of reed canary grass mineral meadow marsh and willow mineral thicket swamp communities occur from 10 to 30m to the southwest of the channel (Lee et al. 1998). Fallow agricultural land occurs further southeast, and Laird Road is approximately 30m to the north. Instream habitat in the station is characterized by flats and runs with limited emergent vegetation, floating duckweed (*Lemna* sp.), abundant detritus and variable amounts of woody material. Although the habitat is variable within the station, the sample areas could not be defined as riffles or pools. Therefore, the samples are simply referred to as Samples 1 to 3. The sampling conditions are summarized in Table 5.

Table 5. Benthic Invertebrate Sampling Conditions for Station BTH-005

Date	September 18, 2009		
Time	1200hrs		
Air Temperature (°C)	16		
Water Temperature (°C)	12.6		
Dissolved Oxygen (ppm)	12.3		
Conductivity (µS/cm)	712		
	Sample 1	**Sample 2**	**Sample 3**
Wetted Width (m)	0.7	1.2	1.1
Maximum Depth (m)	0.13	0.22	0.08
Maximum Hydraulic Head (mm)	5	10	0
Dominant Substrate	Silt	Silt	Silt
Second Dominant Substrate	Silt	Silt	Silt
Total Transect Length (m)	9.8	9.6	9.9
Kick & Sweep Sampling Time (min:sec)	Approx. 3:00	Approx. 3:00	2:40
Number of Jars to Retain Sample	2	2	2

4.1.2 Benthic Macroinvertebrate Community Data

The identification and enumeration of benthic macroinvertebrates are summarized in tabular format in Appendix I.

The Percent Model Affinity (PMA) index calculation generates Percent Similar Community (PSC) values, which are summarized in Table 6. Values that are higher than the critical PSC value indicate no impact, while values that are lower than the critical PSC value indicate impact. The impact determinations for 2006, 2007 and 2008 are given along with the 2009 results for comparison.

Table 6. Percent Similar Community Values and Impact Determination

Stn.	2006 Result	2007 Result	2008 Result	2009 Critical PSC	2009 Sample PSC	2009 Result
BTH – 001	No Impact	No Impact	No Impact	42.12	55.04	No Impact
BTH – 002	Impact	No Impact	Impact	50.70	42.58	Impact
BTH – 003	No Impact	No Impact	No Impact	42.12	57.51	No Impact
BTH – 004	-	-	-	42.12	54.14	No Impact
BTH - 005	-	-	-	42.12	48.08	No Impact

The additional indices that were calculated include taxonomic richness, EPT richness, and % dominant taxon. These results are summarized in Tables 7 and 8 and shown on Figures 2, 3 and 4. The results are discussed by station in the text that follows.

Table 7. Benthic Invertebrate Metrics for Stations BTH-001, BTH-002 and BTH-003

	BTH-001				BTH-002				BTH-003			
Year	2006	2007	2008	2009	2006	2007	2008	2009	2006	2007	2008	2009
Taxon. Richnes.	40	42	38	38	47	42	39	32	21	28	30	35
% EPTs	21.3	25.0	41.8	37.2	42.9	16.4	44.4	48.8	6.9	16.3	25.4	22.2
% Dom't Taxon	27.8	19.4	25.5	20.5	18.5	32.0	20.2	19.1	66.3	37.2	42.4	30.7

Table 8. Benthic Invertebrate Metrics for Stations BTH-004 and BTH-005

	BTH-004	BTH-005
Year	2009	2009
Taxonomic Richness	39	42
% EPTs	12.5	14.8
% Dominant Taxon	29.0	22.5

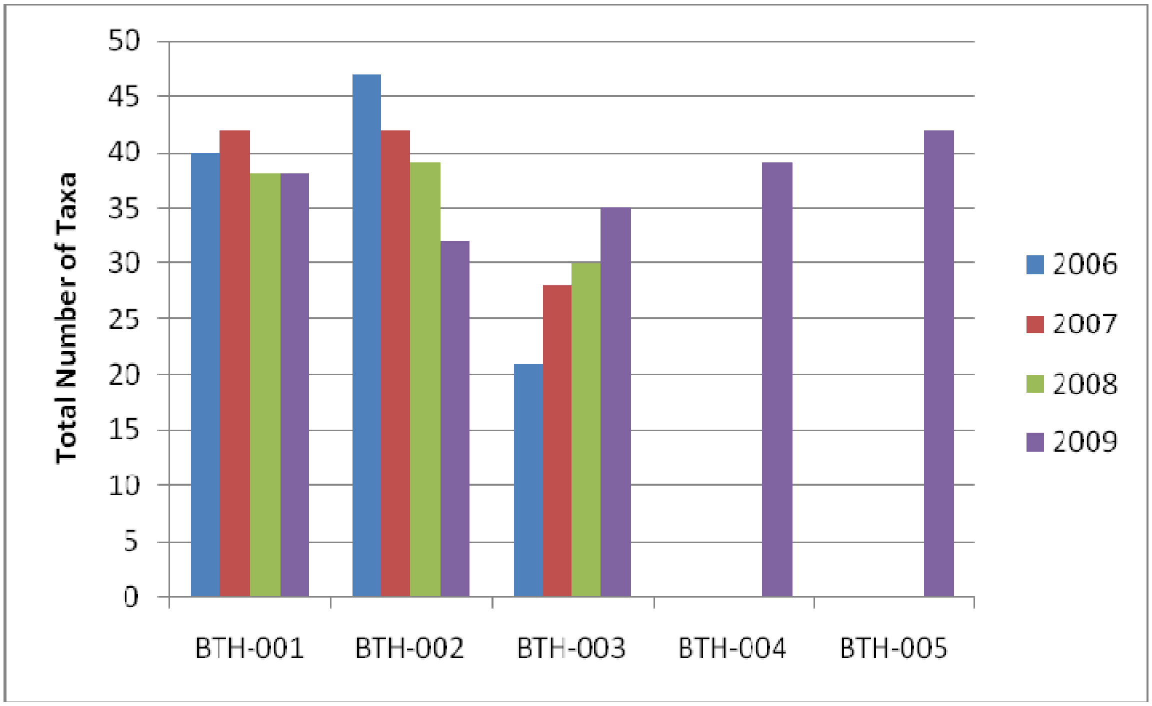


Figure 2. Benthic Invertebrate Taxonomic Richness for the Years 2006 to 2009

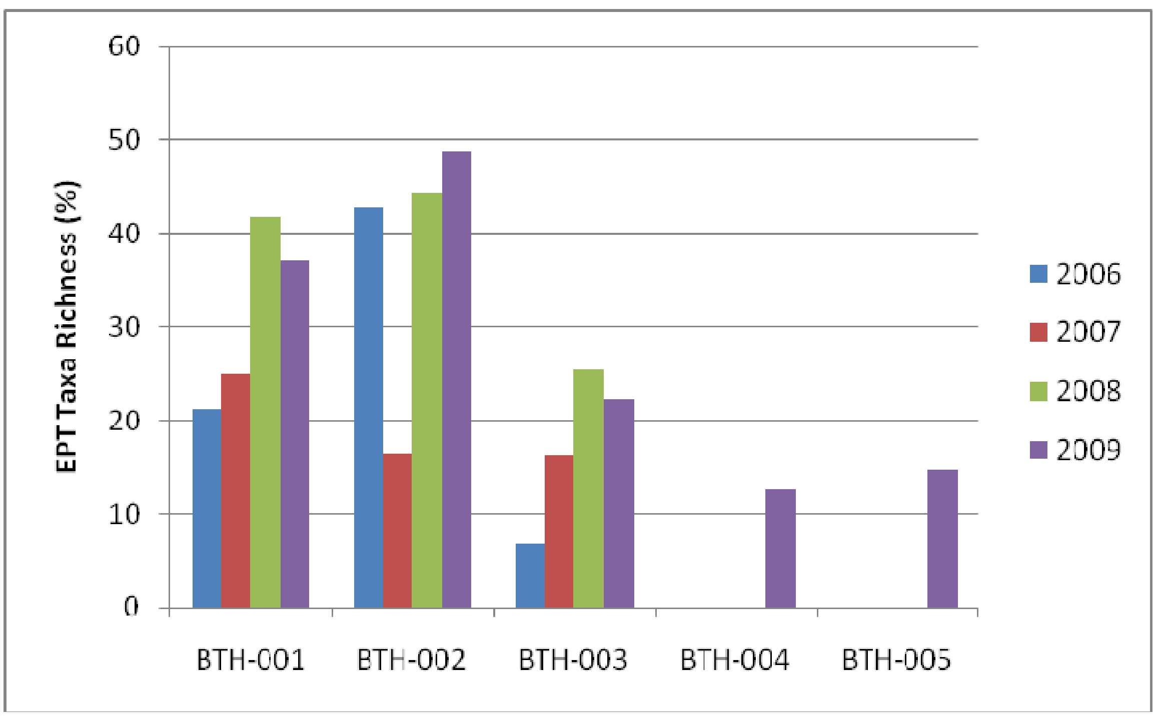


Figure 3. Benthic Invertebrate EPT Taxa Richness for the Years 2006 to 2009

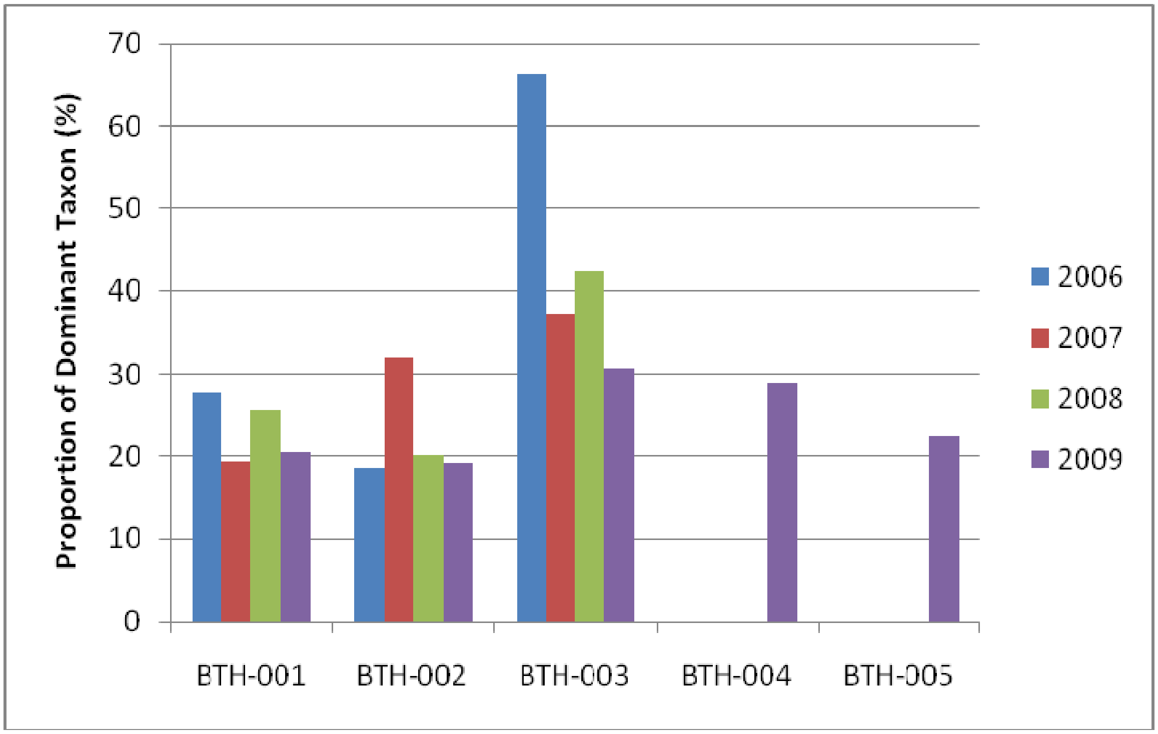


Figure 4. Benthic Invertebrate Proportion of Dominant Taxon, Years 2006 to 2009

<u>BTH-001</u>

Generally, a higher number of taxa present in a sample reflects more diverse habitat and/or better water quality. Taxonomic richness has remained very similar at station BTH-001 throughout the 4 years of pre-construction monitoring. The number of taxa has varied from 38 to 42.

The percentage of Ephemeroptera, Plecoptera, and Trichoptera (EPT richness) is based on the premise that EPT taxa are less tolerant of pollution. Therefore, a higher EPT richness value suggests better water quality and/or habitat conditions. The EPT richness for 2008 and 2009 stand out as being higher than the results for 2006 and 2007.

The dominant taxon in 2009 was *Diplectrona modesta*, a caddisfly (Trichopteran) of the family Hydropsychidae. Caddisflies of the family Hydropsychidae frequently represent a large proportion of benthic invertebrates in streams of various sizes, flow velocities and water temperatures (Thorp and Covich 2001). Caddisflies of the genus *Diplectrona* are found in habitats of erosional headwater streams (Merritt and Cummins 1978). The conditions at station BTH-001 are consistent with this habitat description. This species represented 20.5% of the individuals in the sample. This is a similar percentage to previous years, and the dominant taxon is the same taxon that was dominant in the 2008 data. There was a change in dominant taxon at this station from 2007 to 2008. In 2006 and 2007, the dominant taxon was *Micropsectra* spp., a true fly (Dipteran) of the family Chironomidae.

The PMA index continued to show “no impact” in 2009. Aside from some expected natural variation, the overall results suggest that habitat and water quality conditions at station BTH-001 have generally remained consistent during pre-construction monitoring for the years 2006 to 2009.

<u>BTH-002</u>
At station BTH-002, taxonomic richness was 32 in 2009. This is a continuation of a general decline in this metric, which started at 47 taxa in 2006.

The EPT richness was 48.8% in 2009. This is similar to most years of pre-construction monitoring, with the exception of 2007 when this value was much lower (16.4%).

The dominant taxon at station BTH-002 in 2009 was *Cheumatopsyche* spp., a genus of caddisflies (Trichopterans) of the family Hydropsychidae. Caddisflies of the family Hydropsychidae frequently represent a large proportion of benthic invertebrates in streams of various sizes, flow velocities and water temperatures (Thorp and Covich 2001). Caddisflies of the genus *Cheumatopsyche* are widely distributed in lotic-erosional habitats, particularly warmer streams and rivers. They collectors that feed by filtering, consuming mainly algae and detritus (Merritt and Cummins 1978). This genus represented 19.1% of the individuals in the sample. This quantitative result for % dominant taxon is typical for this station over the years of monitoring, with the year 2007 having the most variable result. However, the dominant taxonomic group has changed twice during pre-construction monitoring. In 2006, the dominant group was the genus *Sialis* of the order Megaoptera and family Sialidae. In 2007 and 2008, the dominant group was the genus *Micropsectra* of the order Diptera and family Chironomidae.

The 2008 PMA index returned a result of “impact”. This is the same result as in 2006 and 2008. Only in 2007 did the PMA index indicate “no impact”. Since the PMA index has only two categories for the results, natural variation could realistically vary the result in this way. The predominance of the “impact” result should not be construed to mean station BTH-002 is in poorer condition than the other stations. Recall that this station is the only station that uses the cobble/gravel model community for PMA index. Because of this difference, comparison among stations using the PMA index is not valid. The monitoring program is intended to provide temporal comparison within stations.

BTH-003

Taxonomic richness at station BTH-003 was 35 in 2009. There has been a general increase in this metric, which was at its lowest (21) in 2006.

The EPT richness was 22.2% in 2009. The results have been variable over the years. The lowest result was 6.9% in 2006, and the highest was 25.4% in 2008.

The dominant taxon in 2009 was *Micropsectra* spp., a genus of the order Diptera, family Chironomidae, and subfamily Chironominae. It has been dominant throughout all 4 years of pre-construction monitoring. They represented 30.7% of the sample in 2009, the lowest value of all the years of pre-construction monitoring. The highest value occurred in 2006 when the genus *Micropsectra* represented 66.3% of individuals in the sample. Such a high percentage can impact the overall diversity, but it may also increase the numbers of organisms at a station. *Micropsectra* are collector-gatherers that are widespread throughout North America. There are 20 or more species and they generally live in lentic environments or depositional lotic systems (Merritt and Cummins 1978). The preference of *Micropsectra* spp. for depositional areas explains their abundance at station BTH-003, because this station is in a slow-flowing area with abundant detritus and silt substrates.

The PMA analysis continued to show “no impact” in 2009. Overall, the results suggest that habitat and/or water quality conditions at station BTH-003 have generally improved throughout the 4 years of pre-construction monitoring.

BTH-004

This station was sampled for the first time in 2009. Taxonomic richness at Station BTH-004 was 39 in 2009, which is typical for the benthic monitoring stations at the HCBP.

The EPT richness was 12.5% - lower than most results at other stations during pre-construction monitoring.

The dominant taxon was *Caecidotea* spp., a genus of the order Isopoda and family Asellidae. They represented 29% of the sample in 2009. Isopods are Crustaceans. Some species of *Caecidotea* are cave-dwelling or are associated with groundwater (Smithsonian National Museum of Natural History 2009).

<u>BTH-005</u>
This station was sampled for the first time in 2009. Taxonomic richness at Station BTH-005 was 42 in 2009, which is typical for the benthic monitoring stations at the HCBP. The EPT richness was 14.8% - lower than most results at other stations during pre-construction monitoring.

The dominant taxon was *Caecidotea* spp., a genus of the order Isopoda and family Asellidae. They represented 22.5% of the sample in 2009. Isopods are Crustaceans. Some species of *Caecidotea* are cave-dwelling or are associated with groundwater (Smithsonian National Museum of Natural History 2009).

4.2 Fish Sampling

4.2.1 Habitat Conditions

<u>Station EMS-001</u> starts and ends within a riffle feature, and pools and runs are present throughout the station. Substrates consist of cobble, grave, pebbles and sand within the riffle sections, and sand, silt and detritus in pools. Habitats within the sampling station consist of riffle, pool, woody debris, undercut banks, and overhanging vegetation. The surrounding land use is classified as a White Cedar Mineral Mixed Swamp Ecosite as defined in the Ecological Land Classification for Southern Ontario Guide (ELC, Lee et al. 1998).

Fish sampling was conducted on August 25, 2009. On that day at 915hrs, the conductivity of the water was 682μs/cm, dissolved oxygen was 10.27ppm and 90.0% of saturation. Water temperature was 12°C and air temperature was 17°C.

Station EMS-002 has substrates that are dominated by cobble, gravel and pebbles, with some silt and sands present. Riffles marked the upstream and downstream extents of the station. Pools, runs, woody debris, overhanging banks and vegetation also contribute to habitat within the station. The surrounding land use is classified by ELC as Cultural Meadow, Dry – Moist Old Field Meadow Type (Lee et al. 1998).

Fish sampling was conducted on August 17, 2009. The conductivity of the water was 830µs/cm; dissolved oxygen was 8.67ppm and 92.0% of saturation. Water temperature was 18.4°C at 1315hrs while air temperature was 31°C.

Station EMS-003, located on Tributary A1, is surrounded by a swamp classified by the ELC as White Cedar – Hardwood Mixed Swamp (Lee et al. 1998). The tributary originates along the south side of Laird Rd and flows north through the cedar swamp. A tile drain from an agricultural field to the east of the cedar swamp also flows into this tributary and contributes a substantial portion of the flow. The station is roughly 30m upstream of the confluence with the main branch and is downstream of the tile drain location. There is very limited aquatic vegetation throughout this tributary and limited water hemlock and watercress are present in the reach sampled. Substrate consists of muck, silt, sand and detritus. Instream habitat consists of woody debris, undercut banks, and small pools.

Fish sampling was conducted on August 26, 2009. At approximately 1000hrs, the conductivity of the water was 957µs/cm. The water temperature was 13.2°C while air temperature was 17°C. Dissolved oxygen was recorded at the same time, and was 8.02ppm and 77.2% of saturation.

Station EMS-004 is a new station for 2009. It is located downstream of Road A crossing and where the pond is being removed. Substrates consist of cobble, gravel, pebbles, and sand within the riffle sections, and sand and detritus in pools. Habitats within the sampling station consist of riffle, pool, woody debris, undercut banks, and cobble. The surrounding land use is classified by ELC as White Cedar-Hardwood Mixed Swamp Type (Lee et al. 1998).

Fish sampling was conducted on August 26, 2009. At 1648hrs the conductivity was 831µs/cm, dissolved oxygen was 8.77ppm and 93.5% of saturation. Water temperature was 18.6°C and air temperature was 20°C.

Station EMS-005, located upstream of Laird Road, is surrounded by a forest classified by the ELC as a Fresh-moist Poplar deciduous forest type (Lee et al. 1998). Added in 2009, this site is located downstream of the proposed Storm Water Management pond 4 outflow. Substrates are highly varied and consist of gravel, pebble, cobble, as well as silt, muck, and detritus in the slower-flowing depositional areas. Instream habitat and cover consists of riffle, woody debris (branches), and vegetation (grasses).

Fish sampling was conducted on September 8, 2009. At approximately 1030hrs, the conductivity of the water was 656µs/cm. The water temperature was 13.3°C while air temperature was 20°C. Dissolved oxygen was recorded at the same time, and was 9.44ppm and 90.7% of saturation.

4.2.2 Fish Community Data

The water conditions during electrofishing, the settings on the electrofisher, and the duration of sampling time are important to document for comparing fish sampling results from year to year. This information is summarized in Table 9.

Table 9. Electrofishing Conditions, Settings, and Shocking Time

	Station EMS-001	Station EMS-002	Station EMS-003	Station EMS-004	Station EMS-005
Date	August 25, 2009	August 17, 2006	August 26, 2009	August 26, 2009	September 8, 2009
Sampling start time	0900hrs	1315hrs	1210hrs	1630hrs	0930hrs
Sampling end time	1330hrs	Appox. 1715hrs	1435hrs	Approx. 1930hrs	1430hrs
Air temperature (°C)	17	31	17	20	20
Water temperature (°C)	12	18.4	13.2	18.6	13.3
Time water temp. taken	0915hrs	1315hrs	0954hrs	1648hrs	1030hrs
Conductivity (µs/cm)	682	830	957	831	656
Dissolved Oxygen (ppm)	9.63	8.67	8.02	8.77	9.44
Electrofisher Type	Haltech Model 1 backpack unit	Haltech Model 1 backpack unit	Haltech Model 1 backpack unit	Haltech Model 1 backpack unit	Haltech Model 1 backpack unit
Number of Netters	1	1	1	1	1
Voltage (V)	300	300	300-400	300-400	400
Pulsating Frequency (Hz)	60	60	60	60	60
Shocking time (sec.) – Pass 1	589	504	521	626	509
Shocking time (sec.) – Pass 2	537	487	584	443	419
Shocking time (sec.) – Pass 3	411	505	440	440	339
Shocking time (sec.) – Pass 4	341	-	334	n/a	344
Shocking time (sec.) – Pass 5	n/a	n/a	n/a	n/a	338

Station EMS-001

Electrofishing in 2009 resulted in the capture of three fish species. They were blacknose dace *(Rhinichthys obtusus)*, brook stickleback *(Culaea inconstans)*, and central mudminnow *(Umbra limi)*. A combined total of 48 individual fish were captured through the four passes. These species have been captured at this station in the previous years of monitoring, but in 2008 creek chub (*Semotilus atromaculatus*) were also captured. The detailed results are provided in Table 10.

Station EMS-002

Electrofishing in 2009 resulted in the capture of three fish species. They were blacknose dace, brook stickleback, and central mudminnow. A combined total of 33 individual fish were captured in the four passes. Creek Chub has been captured at this station before but not since 2008. The detailed results are provided in Table 11.

Station EMS-003

Electrofishing in 2009 resulted in the capture of one fish species, brook stickleback. A combined total of 28 individual fish were captured in the four passes. Blacknose dace was captured at this station in 2008, but was not captured in 2009. Creek chub was captured at this station in 2006, but was not captured at this station in 2007, 2008 or 2009. The detailed results are provided in Table 12.

Station EMS-004

Electrofishing took place on this site for the first time in 2009 and resulted in two species being caught. They were blacknose dace and brook stickleback. A combined total of 27 individual fish were captured in three passes. The detailed results are provided in Table 13.

Station EMS-005

Electrofishing took place on this site for the first time in 2009 and resulted in three species being captured. They were blacknose dace, brook stickleback, and central mudminnow. A combined total of 61 individual fish were caught in five passes. The detailed results are provided in Table 14.

Table 10. Fish Sampling Results for EMS-001

Fish Name		Number Captured						Length (mm)	
Common	Scientific	Pass 1	Pass 2	Pass 3	Pass 4	Pass 5	Total	Smallest	Largest
Blacknose Dace	*Rhinichthys obtusus*	6	3	0	1	n/a	10	41	70
Brook Stickleback	*Culaea inconstans*	15	14	4	1	n/a	34	26	57
Central Mudminnow	*Umbra limi*	1	3	0	0	n/a	4	35	89
COMBINED TOTAL (n/a = not applicable)		22	20	4	2	n/a	48	n/a	n/a

Table 11. Fish Sampling Results for EMS-002

Fish Name		Number Captured						Length (mm)	
Common	Scientific	Pass 1	Pass 2	Pass 3	Pass 4	Pass 5	Total	Smallest	Largest
Blacknose Dace	*Rhinichthys obtusus*	3	6	4	1	n/a	14	42	90
Brook Stickleback	*Culaea inconstans*	4	5	4	3	n/a	16	26	52
Central Mudminnow	*Umbra limi*	1	1	1	0	n/a	3	89	93
COMBINED TOTAL (n/a = not applicable)		8	12	9	4	n/a	33	n/a	n/a

Table 12. Fish Sampling Results for EMS-003

Fish Name		Number Captured						Length (mm)	
Common	Scientific	Pass 1	Pass 2	Pass 3	Pass 4	Pass 5	Total	Smallest	Largest
Brook Stickleback	*Culaea inconstans*	8	10	7	3	n/a	28	30	58
COMBINED TOTAL (n/a = not applicable)		8	10	7	3	n/a	28	n/a	n/a

Table 13. Fish Sampling Results for EMS-004

Fish Name		Number Captured						Length (mm)	
Common	**Scientific**	**Pass 1**	**Pass 2**	**Pass 3**	**Pass 4**	**Pass 5**	**Total**	**Smallest**	**Largest**
Blacknose Dace	*Rhinichthys obtusus*	15	7	1	n/a	n/a	23	29	97
Brook Stickleback	*Culaea inconstans*	2	2	0	n/a	n/a	4	37	51
COMBINED TOTAL (n/a = not applicable)		17	9	1	n/a	n/a	27	n/a	n/a

Table 14. Fish Sampling Results for EMS-005

Fish Name		Number Captured						Length (mm)	
Common	**Scientific**	**Pass 1**	**Pass 2**	**Pass 3**	**Pass 4**	**Pass 5**	**Total**	**Smallest**	**Largest**
Blacknose Dace	*Rhinichthys obtusus*	3	0	1	0	0	4	48	56
Brook Stickleback	*Culaea inconstans*	17	10	5	5	3	40	29	57
Central Mudminnow	*Umbra limi*	8	2	2	2	3	17	35	80
COMBINED TOTAL (n/a = not applicable)		28	12	8	7	6	61	n/a	n/a

Habitat Preferences of Fish Captured

Brook Stickleback prefer “vegetated lake margins, ponds, and clear, quiet to flowing pools and backwaters of creeks and small rivers...” (Eakins 2007).

Blacknose Dace prefer “riffles and runs of cool, small- to medium-sized streams with moderate to steep gradient and gravel substrate... “(Eakins 2007).

The Central Mudminnow prefers “heavily vegetated ponds, wetlands or pools of small creeks and quiet, shallow (0.5 m) areas of lakes with mud and organic substrates” (Eakins 2007).

All of the species captured prefer a cool-water thermal regime (Eakins 2007). The presence of fish with such a thermal preference is consistent with the cool to cold water temperatures known from these watercourses. No trout species were captured in the quantitative sampling stations, which is consistent with the previous years of pre-construction monitoring.

Population Estimates

In the previous years of pre-construction monitoring, some of the data did not produce estimates that could be considered reliable. The lack of reliability occurs because a statistical model cannot be developed to fit the data with sufficient accuracy. As a check, the software compares the actual data with the model within the range of known data. If the fit is considered good (P-Value greater than 0.2), the model can be extrapolated to the theoretical point where no fish (or biomass of fish) remain in the reach. It is this extrapolation that facilitates the estimate. If the fit is not good enough (P-Value less than 0.2), the model is considered unreliable and should be rejected.

As a result of this statistical unreliability, comparability from year to year is limited when it involves one of the estimates that is deemed unreliable. The reliable results show substantial variation from year to year, which is attributable to natural variation. We provide the results of the population estimates from all years of pre-construction monitoring for information purposes and to facilitate a brief commentary on the data to the extent that it can be relied upon. The results are summarized in Table 15.

Table 15. Fish Population Estimates by Station

Station	2006	2007	2008	2009
EMS-001	9.07	> 87*	80	48.5
EMS-002	55.56	173.07	>53*	40.2
EMS-003	> 31*	13.89	31	32.7
EMS-004				29.4**
EMS-005				82.3

* These results are approximate because the population estimate was not statistically valid.
** Estimate obtained using the least squares regression method.

In 2009, the estimated number of fish at station EMS-001 decreased from 2008. Considerable variability in the population has been observed over the years at EMS-001..

In 2009, the population estimate at EMS-002 is lower than all other years of monitoring. The estimate for 2007 stands out as a high year, and the other 3 years may be considered more typical.

At EMS-003 the population estimate for 2009 is very similar to 2008. Although the estimate for 2007 is lower, there is no obvious trend in the population at this station.

At EMS-004 the statistical model using the maximum likelihood, constant probability method was rejected. This is surprising since the numbers for each pass get progressively lower at a very consistent rate from one pass to another. Using the least squares regression method, the predicted population is 29.4. The coefficient of determination (r^2) for the regression is 0.969, which demonstrates a very good fit to the data. Comparison with previous years of monitoring data is not possible as this site was established in 2009.

At EMS-005 the population estimate was 82.3. Comparison with previous years of monitoring data is not possible as this site was established in 2009.

<u>Brook Trout Spawning Survey</u>

No brook trout redds or fish were observed during the spawning survey. The survey included selected sections of Tributary A on the HCBP lands and downstream of Teal Drive, and the entire length of Tributary A1 (Figure 1).

The water temperatures taken during the October 14, 2009 spawning survey are summarized in Table 16.

Table 16. Water Temperatures in Tributary A on October 14, 2009

Location	Water Temperature (°C)	Air Temperature (°C)	Time of Day
Approx. 50 to 100m downstream of Teal Drive	3.4 to 3.6	5	1045hrs
Approx. 50 to 100m upstream of Teal Drive	4.1 to 4.2	7	1130hrs
Swamp downstream of Road A crossing	6.6	4	1200hrs
Between Road A and confluence with Tributary A1	6.3	8	1215hrs
Tributary A immediately upstream of the confluence with Tributary A1	4.5	7	1225hrs
Tributary A1	9.0	8	1240hrs

From these temperatures, we can see that groundwater was providing the most stable water temperatures in Tributary A1, because the water temperature is warmer than the air temperature. This is consistent with the 2009 continuous temperature monitoring (AECOM 2009), which shows that Station 3 on Tributary A1 is the most temperature-stable of the 7 monitoring locations.

Tributary A in the vicinity of Teal Drive was observed on October 14, 2009. The substrates in this section of Tributary A are predominantly fine material, which is generally not suitable for brook trout spawning. The water temperatures measured during the October 14 investigation of this area ranged from 3.4 to 4.2°C with air temperatures of 5 to 7°C.

Tributary A from the swamp downstream of the Road A crossing to the confluence with Tributary A1 was observed during both site visits. Some of the substrate materials near the confluence are more suitable for spawning than most other areas on the HCBP lands. The occurrence of fine substrates presents a limitation for spawning throughout much of the Tributary A system on the HCBP lands. The water temperature in this section of Tributary A was 10°C on October 21, 2009. Air temperature was 13°C, and time of day was 10:35am. This was a warmer temperature than was measured on the first survey date (6.3°C, Table 16).

Tributary A1 is the most likely location for spawning to occur, based on the influence of groundwater. For this reason, its entire length was investigated during both site visits. On October 21, 2009, the water temperature at the tile drain outlet, which provides most of the flow to this tributary, was 11°C. The air temperature was 12°C, and the time of day was 9:30am. Near the confluence with Tributary A, the water temperature was 10°C and the air temperature was 12°C at 10:05am. This further demonstrates the temperature stability in Tributary A1.

The investigation in the vicinity of Laird Road was conducted on October 21, 2009. While there is some variation in substrate immediately upstream of Laird Road, fine materials predominate. The water temperature on this date was 10°C while the air temperature was 12°C at 11:45am.

5.0 Conclusions and Recommendations

The 2009 pre-construction monitoring program was successful in providing informative aquatic monitoring data for the baseline pre-construction condition. Natural variation was observed from 2006 to 2009, which is important to capture in the pre-development monitoring because it provides a better representation of pre-construction conditions.

We recommend that the aquatic biological monitoring should continue in 2010 as per the Standard Operating Procedures provided in the HCBP Consolidated Monitoring Program (NRSI 2010). This includes fish and benthic invertebrate monitoring at the 5 sites sampled in 2009, and a brook trout spawning survey.

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APPENDIX I
Benthic Invertebrate Raw Data

GROUP	FAMILY	TAXON	BTH001 rep1 18-Sep	BTH001 rep2 18-Sep	BTH001 rep3 18-Sep	BTH002 rep1 17-Sep	BTH002 rep2 17-Sep	BTH002 rep3 17-Sep	BTH003 rep1 17-Sep	BTH003 rep2 17-Sep	BTH003 rep3 17-Sep	BTH004 rep1 17-Sep	BTH004 rep2 17-Sep	BTH004 rep3 17-Sep	BTH005 rep1 18-Sep	BTH005 rep2 18-Sep	BTH005 rep3 18-Sep
HIRUDINEA	Erpobdellidae	Erpobdella dubia											1				
	Glossiphoniidae	Glossiphonia complanata											1				3
OLIGOCHAETA	Tubificidae	Immatures with hair chaetae		22							6	15	5	13	2	93	3
		Immatures without hair chaetae		3						1							
ACARI	Hygrobatidae	Hygrobates sp								1							
	Lebertiidae	Lebertia sp	1								1						
Oribatida	Hydrozetidae	Hydrozetes sp													1		
AMPHIPODA	Crangoncytidae	Crangonyx sp juv									1		1			1	
ISOPODA	Asellidae	Caecidotea sp juvs	19	17	17	17	40	25	17	15	22	31	42	89	45	56	36
COLEOPTERA	Dytiscidae	Agabus sp			1										1		
	Elmidae	Dubiraphia sp larvae	1									2	1				
		Optioservus sp larvae	10		11	15	2	2						1			
		Optioservus fastiditus												1			
	Hydrophilidae	Cymbiodyta vindicata		2	1										4		
		Paracymus sp													2		
		Tropisternus sp larvae		1											1		
	Scirtidae	Prionocyphon sp											1				
COLLEMBOLA	Isotomidae	Isotomidae	1												1		
DIPTERA	Ceratopogonidae	Ceratopogonidae type III								1							1
		Ceratopogonidae type IV	1	4	2					2					1		
	Chironomidae	Damaged pupae				2											
	Chironominae	Cryptochironomus sp									1	2					
		Microtendipes sp											1				
		Polypedilum sp									1	6	1	3			
		Tribelos sp		1			1						1				
		Cladotanytarsus sp													1		10
		Micropsectra sp	18	10	17	19	19	11	44	68	77	27	25	10	13	5	17
		Tanytarsus sp															16
	Prodiamesinae	Prodiamesa sp									5		1				5
	Orthocladiinae	Orthocladiinae early instars	5						4	8		4				2	16
		Brillia sp		4								1			2	1	
		Chaetocladius sp	1														
		Corynoneura sp	1	1								1				1	
		Heterotrissocladius marcidus gp	7	8	3	2	11		11	9	13	13	4	1	2		9
		Orthocladius sp		1							8						
		Parametriocnemus sp	11	16	18	8	2	2		7	4	41	1	47	2		2
		Thienemanniella sp		3					1			1					1
		Tvetenia sp	17	33	19	21	3	3	2		1	4			1		
	Tanypodinae	Tanypodinae early instars	5	9	27	10	23	16	8	7	1	15	5	3	38	8	24

GROUP	FAMILY	TAXON	BTH001 rep1 18-Sep	BTH001 rep2 18-Sep	BTH001 rep3 18-Sep	BTH002 rep1 17-Sep	BTH002 rep2 17-Sep	BTH002 rep3 17-Sep	BTH003 rep1 17-Sep	BTH003 rep2 17-Sep	BTH003 rep3 17-Sep	BTH004 rep1 17-Sep	BTH004 rep2 17-Sep	BTH004 rep3 17-Sep	BTH005 rep1 18-Sep	BTH005 rep2 18-Sep	BTH005 rep3 18-Sep
		Brundiniella sp	6	2			4	2	9	20	12	6	6	1	5	13	21
		Conchapelopia sp		2	1		1	3	1	1	1				10		
		Natarsia sp		4			1		1			1	1		1	1	
		Procladius sp				1	6						7				1
	Empididae	Hemerodromia sp													1		
	Psychodidae	Pericoma sp									2						
	Ptychopteridae	Ptychoptera sp													1		
	Simulidae	Simulium sp			1	2		11	1		1	1		1			
	Stratiomyidae	Stratiomyidae v incomplete															1
	Tabanidae	Chrysops sp	4				1	1			1	1		1			7
	Tipulidae	Dicranota sp		1	2	3	2	1									
		Pilaria sp														5	9
		Tipulidae early instars							6	6	6	3		6	1		2
EPHEMEROPTERA	Baetidae	Baetis brunneicolor	2	3		8								1	1	1	
	Leptophlebiidae	Paraleptophlebia sp	6	35	28	1	3	6				1	3	1	44	9	7
HEMIPTERA	Gerridae	Gerris sp nymphs	3	1													
	Veliidae	Microvelia sp												1	2		
MEGALOPTERA	Sialidae	Sialis sp	4	12	8	3	17	8	12	14	19	16	6		4	2	
ODONATA	Calopterygidae	Calopteryx sp juv					1										
PLECOPTERA	Leuctridae	Leuctra sp				8	29	30	59	36	16						
	Nemouridae	Nemouridae early instars	7		7		3		1		1						
		Amphinemura sp juv		1													
TRICHOPTERA	Dipseudopsidae	Phylocentropus sp							2	1	2	2	4				
	Glossosomatidae	Glossosoma sp				3	1										
	Hydropsychidae	Cheumatopsyche sp				26	13	82	4			2	1	11			
		Diplectrona modesta	60	12	59	39	7	9	1		1				6		
		Hydropsyche sp					1										
		Parapsyche apicalis				2											
	Lepidostomatidae	Lepidostoma sp		2	1												
	Limnephilidae	Limnephilidae early instars	1			1	6	1	2	2	3	1	2	3	1	1	1
		Nemotaulius hostilis		1													
	Molannidae	Molanna sp	6				3		2	1	2	3	22	4	1	2	6
	Philopotamidae	Chimarra sp				22	1	1						3			

GROUP	FAMILY	TAXON	BTH001 rep1 18-Sep	BTH001 rep2 18-Sep	BTH001 rep3 18-Sep	BTH002 rep1 17-Sep	BTH002 rep2 17-Sep	BTH002 rep3 17-Sep	BTH003 rep1 17-Sep	BTH003 rep2 17-Sep	BTH003 rep3 17-Sep	BTH004 rep1 17-Sep	BTH004 rep2 17-Sep	BTH004 rep3 17-Sep	BTH005 rep1 18-Sep	BTH005 rep2 18-Sep	BTH005 rep3 18-Sep
	Phryganeidae	Oligostomis sp	5	2				2		1		2	1	1	5	2	2
		Ptilostomis sp															1
	Psychomyiidae	Lype diversa						2				1		1			
GASTROPODA	Lymnaeidae	Pseudosuccinea columella		1											2		
	Physidae	Physella gyrina									1						
BIVALVIA	Sphaeriidae	Pisidium sp	1			1			13	3	2	1	3	5	2		1
TURBELLARIA	Planariidae	Planariidae				1		1									
		TOTALS	203	214	223	215	201	219	201	204	211	204	147	208	204	203	202
		Number of Taxa	26	29	17	22	25	20	21	19	27	26	25	21	31	17	24
		Percentage picked	45	18	50	33	43	29	64	46	44	27	100	57	17	19	78
		Sample number 2009/***	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274

APPENDIX II
Fish Population Biomass Estimate Data

Fish Population Estimates Using Maximum Likelihood Constant P – 2006

Results	EMS-001	EMS-002	EMS-003
Estimated Population	9.07	55.56	34.81
Chi-squared	0.52	1.44	2.57
Standard error	0.3	3.05	3.82
Degrees of freedom	1	1	1
Number observed	9	52	31
Lower 95% conf. interval	9.00	52.00	31.00
Upper 95% conf. interval	9.66	61.53	42.30
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.4724 (accept)	0.2305 (accept)	0.1089 (reject)

Fish Biomass Estimates Using Maximum Likelihood Constant P – 2006

Results	EMS-001	EMS-002	EMS-003
Estimated Biomass (g)	5.03	66.10	67.21
Chi-squared	0.23	0.03	14.37
Standard error	0.19	1.30	2.05
Degrees of freedom	1	1	1
Number observed	5	65	65
Lower 95% conf. interval	5.00	65.00	65.00
Upper 95% conf. interval	5.40	68.65	71.22
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.6319 (accept)	0.8638 (accept)	0.0002 (reject)

Fish Population Estimates Using Maximum Likelihood Constant P – 2007

Results	**EMS-001**	**EMS-002**	**EMS-003**
Estimated Population	88.76	173.07	13.89
Chi-squared	3.42	0.44	0.23
Standard error	1.68	3.84	1.53
Degrees of freedom	1	1	1
Number observed	87	166	13
Lower 95% conf. interval	87.00	166.00	13.00
Upper 95% conf. interval	92.05	180.59	16.88
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.0646 (reject)	0.5073 (accept)	0.6315 (accept)

Fish Biomass Estimates Using Maximum Likelihood Constant P – 2007

Results	**EMS-001**	**EMS-002**	**EMS-003**
Estimated Biomass (g)	52.51	158.46	18.45
Chi-squared	3.97	1.06	0.02
Standard error	1.65	5.28	0.88
Degrees of freedom	1	1	1
Number observed	51	148	18
Lower 95% conf. interval	51.00	148.11	18.00
Upper 95% conf. interval	55.75	168.81	20.17
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.0463 (reject)	0.3040 (accept)	0.8853 (accept)

Fish Population Estimates Using Maximum Likelihood Constant P – 2008

Results	EMS-001	EMS-002	EMS-003
Estimated Population	80.02	91.84	30.93
Chi-squared	1.08	3.39	0.58
Standard error	4.17	35.62	5.22
Degrees of freedom	1	1	1
Number observed	74	53	26
Lower 95% conf. interval	74.00	53.00	26.00
Upper 95% conf. interval	88.20	161.65	41.15
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.2922 (accept)	0.0655 (reject)	0.4444 (accept)

Fish Biomass Estimates Using Maximum Likelihood Constant P – 2008

Results	EMS-001	EMS-002	EMS-003
Estimated Biomass (g)	55.82	105.00	36.08
Chi-squared	1.13	9.30	5.39
Standard error	4.63	1.17	9.68
Degrees of freedom	1	1	1
Number observed	50	104	27
Lower 95% conf. interval	50.00	104.00	27.00
Upper 95% conf. interval	64.89	107.29	55.05
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.2870 (accept)	0.0023 (reject)	0.0202 (reject)

Fish Population Estimates Using Maximum Likelihood Variable P – 2009

Results	EMS-001	EMS-002	EMS-003	EMS-005
Estimated Population	48.51	40.19	32.73	82.31
Chi-squared	0.56	0.35	0.24	0.17
Standard error	0.90	7.84	5.71	23.13
Degrees of freedom	1	1	1	2
Number observed	48	33	28	61
Lower 95% conf. interval	48.00	33.00	28.00	61.00
Upper 95% conf. interval	50.28	55.56	43.93	127.64
Probability, or P-Value (if > 0.2, accept the model; if < 0.2, reject)	0.4550 (accept)	0.5516 (accept)	0.6234 (accept)	0.9179 (accept)

** Constant P method used for Population Estimate due to only 3 passes.

Fish Population Estimates Using Least Squares Regression – 2009

Results	EMS-004
Estimated Population	29.42
Slope	- 0.596
Y – Intercept	17.55
r^2 (Coefficient of Determination)	0.969
Residual Sum of Squares	3.916
Regression Sum of Squares	124.084
Degrees of Freedom	1
F	31.687

APPENDIX IV

TERRESTRIAL AND WETLAND MONITORING REPORT

DRAFT

Hanlon Creek Business Park
Pre-Construction
Terrestrial and Wetland Monitoring
2009

Prepared for:
City of Guelph
Economic Development & Tourism Services
City Hall, 59 Carden Street
Guelph, ON

Project No. 682G

Date: April 2010

NATURAL RESOURCE SOLUTIONS INC.
Aquatic, Terrestrial and Wetland Biologists

DRAFT

Hanlon Creek Business Park
Pre-Construction Terrestrial and Wetland Monitoring 2009

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1.0 Introduction

Terrestrial and wetland monitoring in the Hanlon Creek Business Park (HCBP) has been ongoing since 2006. Monitoring commenced because of recommendations made in the Hanlon Creek Business Park Consolidated Environmental Impact Study (NRSI 2004) and a condition set out in the Draft Plan Approval from the Ontario Municipal Board (OMB 2006). The monitoring program was laid out in the Terms of Reference for the HCBP Environmental Implementation Report (TOR 2007) and endorsed by the City of Guelph's Environmental Advisory Committee (EAC 2007). The terrestrial and wetland monitoring program is only a small subset of the monitoring taking place within the HCBP. The complete monitoring program, including responsibilities and timelines, is provided in the HCBP Consolidated Monitoring Program (NRSI 2010).

The objective of terrestrial and wetland monitoring is to identify and track any changes that may occur to the terrestrial and wetland ecology because of the planned industrial development of the HCBP. Baseline (pre-construction) monitoring took place in 2006, 2007, and 2008. This report (for the monitoring year 2009) documents another year of pre-construction monitoring. The exception is monitoring related to the Mast-Snyder Gravel Pit, which is tied to the timing of the pit's operation and restoration.

Over time, the terrestrial and wetland monitoring program has expanded to address concerns and recommendations made by reviewing groups and agencies. The following areas were monitored in 2009 and are documented in this report:

- Vegetation
- Soil
- Breeding Birds
- Amphibians

Several new surveys were conducted in 2009 based on EAC's review of the 2008 Environmental Implementation Report (EAC 2009). EAC requested further intensive monitoring for the Jefferson salamander (*Ambystoma jeffersonianum*) and western chorus frog (*Pseudacris triseriata*). It was also requested that wildlife (specifically amphibian) crossings and mitigation measures be determined for Laird Road. The City of Guelph requested NRSI conduct road mortality surveys to identify areas of concentrated wildlife movement across the road. Hence, salamander surveys, salamander larval surveys, and road mortality surveys along Laird Road were conducted in the HCBP for 2009. As well, an additional breeding bird plot was added in 2009 to provide a better representation of the area, and seven new amphibian call count stations were established based on EAC's concerns over the western chorus frog.

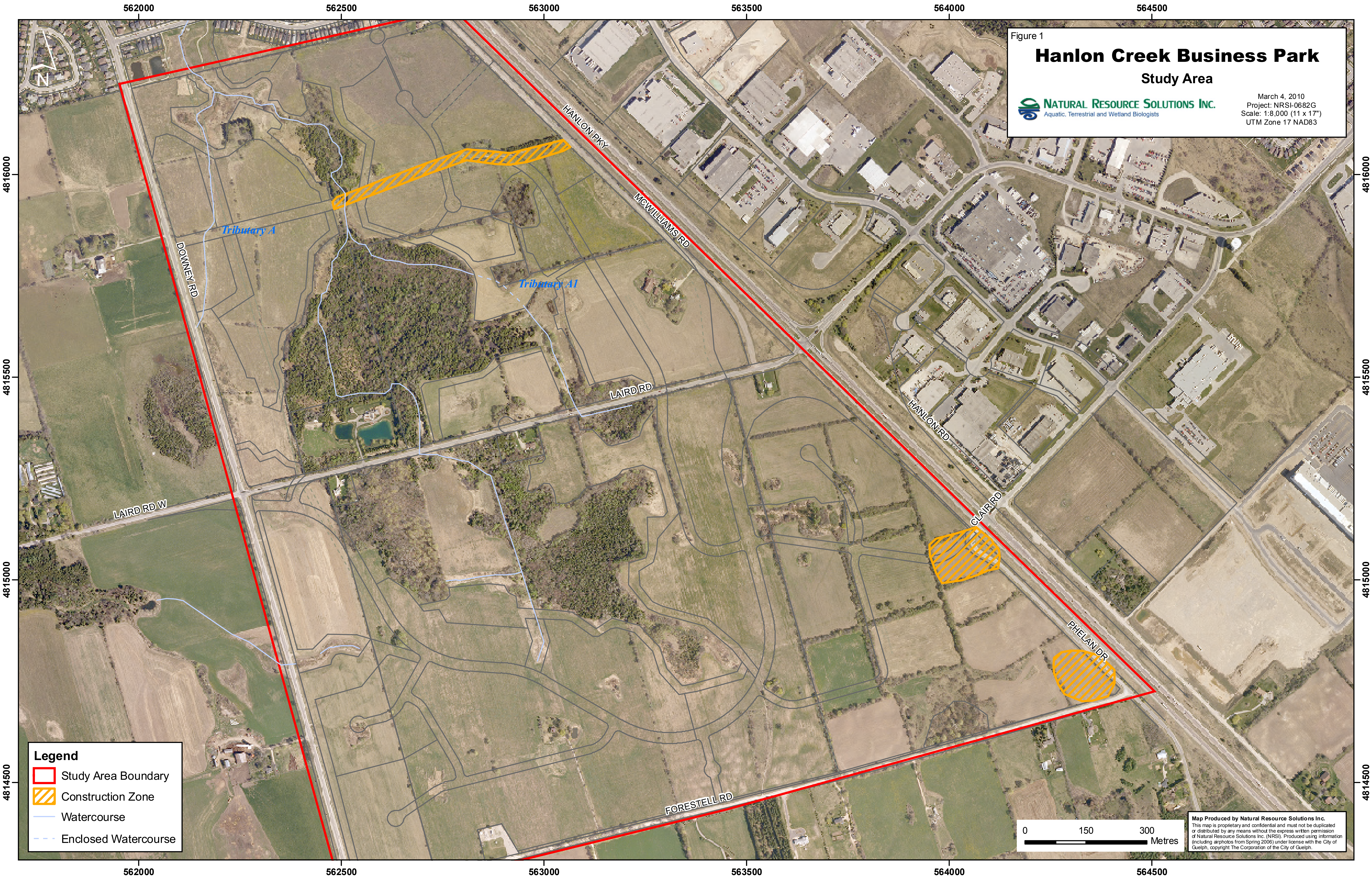
2.0 Study Area

Hanlon Creek Business Park is located in the south end of the City of Guelph. As seen in Figure 1, the study area is bounded to the east by the Hanlon Expressway, to the north by the Kortright IV subdivision, to the west by Downey Road, and to the south by Forestell Road. Laird Road runs parallel to Forestell Road, dividing the study area into north and south sections. The study area is comprised of agricultural fields, hedgerows, forested areas and wetland (swamp and marsh) pockets. The surrounding landscape to the south and west is dominated by much of the same. A residential subdivision is found north of the site and the Hanlon Expressway and industrial areas are located to the east.

The creek, wetlands and forested uplands in the study area are part of the much larger Hanlon Creek watershed. This watershed contains provincially significant wetlands (Hanlon Swamp, Hall's Pond Wetland), Environmentally Significant Areas (Speed River ESA, Hanlon Swamp ESA, Hall's Pond Wetland ESA), an Area of Natural and Scientific Interest (Paris-Galt-Moffat Moraine ANSI), and other unclassified natural areas. The central wetlands in the study area are part of the Hanlon Swamp Wetland Complex and are therefore considered provincially significant. In addition, a small wetland in the southern portion of the Business Park, adjacent to Downey Road, is part of the provincially significant Speed River Wetland Complex.

The study area encompasses a headwater tributary of Hanlon Creek. The tributary within the study areas was designated as Tributary A in the Hanlon Creek Watershed Study (NRSI 2004).

Construction commenced in 2009, though minimally. A culvert was to be installed at Tributary A in the northern section of the study area. A temporary access road was graded from McWilliams Road to the work zone. However, due to protests, the culvert was not installed and the temporary road and other bare soil areas were seeded with an erosion control mix. Preparatory works for installation of a watermain crossing at Phelan Drive and the Hanlon Expressway were done at Clair Road. In addition, some topsoil was moved in the far southeast corner of the study area. Construction zones are highlighted in Figure 1.



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3.0 Methodology

3.1 Vegetation Monitoring

A total of eight permanent plots were established and monitored in the 2006 pre-construction year. An additional plot was added in 2007 to gain baseline information on the provincially significant wetland (PSW) situated immediately east of Downey Road. Plots were selected by means of stratified random sampling. This sampling technique involved use of vegetation community mapping to guide sample selection. Ecological Land Classification (ELC) mapping was completed as part of the original EIS (NRSI 2004). A range of vegetation plot types and locations were chosen. Selected plots focused primarily on wetlands within the study area, as well as larger upland woodlots north and south of Laird Road.

Each randomly selected permanent plot is 10x10m in size. In 2006 and 2007, the southwest corner of each plot was marked with a wooden stake and the remaining three corners marked with metal flags. The wooden stakes were approximately 1.5m in length and the top of each was painted bright orange in order to increase visibility. As a result of time, weather and human interference, the monitoring plots were no longer clearly visible in 2008 and the wooden posts were replaced with 6m high metal t-posts.

At each of the nine vegetation plots, herbaceous plants, shrubs, and trees were recorded. Vegetation monitoring took place on June 11, 25, and 29, 2009.

The following information was recorded for each vegetation group:

3.1.1 Herbaceous Species

In 2006, five subplots were randomly chosen within each permanent plot. Randomly generated bearings and distances were used, and were taken from the southwest corner of each plot. The same bearings and distances were used in each of the nine plots, as well as every year. Comparison of year to year data is more meaningful since the same approximate subplot locations are used every year. The subplot locations are given in Table 1. Each herbaceous subplot was $1m^2$. All of the plant species observed within each subplot were recorded including their number and percent cover (the number of individuals of dense growing species like sedges, grasses and moss was not recorded). In addition, all herbaceous species observed within the 10x10m plots were recorded, along with their relative abundance within the plot (i.e. D – Dominant, A – Abundant, O – Occasional, R – Rare).

Table 1. Subplot Locations

Sub-plot	Length (m)	Degrees
1	6	20
2	9	50
3	7	60
4	8	80
5	4	30

3.1.2 Shrubs

All shrub species within each permanent plot were recorded, as well as their approximate percent cover.

3.1.3 Trees

Tree species within each plot were recorded. In 2006, all trees having a diameter at breast height (dbh) of ≥10cm were tagged using an aluminum tag nailed into the tree at breast height (approximately 1.37m above the ground). Tags are added to any trees that become ≥10cm dbh each year. The tag includes the plot number and the tree number. For each tree, the following information was recorded: species, physical condition, and dbh. Physical condition was recorded as actively growing, mature, or in decline. If the tree was dead (a snag), no other information was recorded. A densiometer was used to estimate canopy cover in each of the vegetation plots. Within each plot, canopy cover readings were taken while facing north, south, east and west from the plot's centre to provide an average estimate.

3.2 Soil Sampling

Soil sampling was undertaken on June 25 and 29, 2009. A central location within the vegetation plot was randomly selected and a dutch auger was used to obtain a soil column approximately 1.20m in length. In some instances soil columns were shorter as impenetrable areas were encountered (e.g. till). The following information was recorded for each soil sample according to the Field Manual for Describing Soils in Ontario (Ontario Centre for Soil Resource Evaluation 1993): depth and texture of both the organic and mineral soil horizons; the effective texture of the mineral layer; and the presence and depth of mottles, gley, bedrock, water table, and carbonates. The moisture regime was determined from the pore pattern and depth of the mineral soil material, the topographic position of the site and characteristics of the soil profile such as mottling or gley which indicate impeded drainage were noted.

3.3 Breeding Birds

Breeding bird point counts were performed according to the standard Ontario Breeding Bird Atlas protocol (OBBA 2001). According to protocol, each of the stations was visited between dawn and 10:00 a.m. on two occasions during the breeding bird season. Ten minute point counts were conducted at each of the stations. Bird species, breeding evidence, and the number of birds encountered were recorded. The first point count was taken on June 11, 2009, with a follow-up visit on June 29, 2009 at the 9 previously existing plots. These plots coincided with the vegetation plots. A tenth plot was added in 2009, which was surveyed on June 18 and 29, 2009. The additional breeding bird station was added to monitor the Heritage Maple Grove along Forestell Road. This area became a focal point for amphibian monitoring in 2009, and it was felt prudent by NRSI to add a bird station as well.

3.4 Amphibian Surveys

Call counts, salamander surveys, larval surveys, and road mortality surveys were all undertaken to assess the amphibian population in the area. Each monitoring protocol is described below.

3.4.1 Call Counts

Evening amphibian surveys were conducted on April 23, May 11, and June 2, 2009 at the seven wetland stations. These stations coincided with the vegetation plots. Vegetation Plots 3 and 5 were not surveyed for anurans, as they are located in upland forests. Monitoring focused on calling anurans during 3 minute call counts. Call intensity and an estimated number of amphibian individuals were recorded following the Marsh Monitoring Program protocol (Bird Studies Canada 2008). Immediately after the three-minute monitoring period, time, air and water temperature, pH, wind speed, and cloud cover were recorded for each station.

The 2008 Terrestrial and Wetland Monitoring Report (NRSI 2009) recommended that additional herpetofauna monitoring stations be established within the Business Park, with focus on the vernal pools within Heritage Maple Grove along Forestell Road and wetlands adjacent to Laird Road. Seven additional call count stations were added in 2009 based on this recommendation and concerns raised by EAC (2009) over the Great Lakes/St. Lawrence – Canadian Shield population of the western chorus frog (*Pseudacris triseriata* pop. 2), which is considered threatened in Canada and vulnerable in Ontario (NHIC 2010). This species was recorded from Plot 6 in 2007 by NRSI.

3.4.2 Salamander Trap Survey

A total of 21 un-baited minnow traps were set at seven stations between March 27 and April 9, 2009. Traps were set within vernal pools, ponds and wetlands dispersed in the study area. Each trap was checked the morning after it was set to document any salamanders captured. Detailed field notes were collected on any other amphibian species observed in the traps.

3.4.3 Salamander Larval Survey

On June 17, 2009, NRSI biologists and MNR staff assessed wetlands within the study area for potential breeding habitat and where appropriate, conducted larval surveys under the direction of MNR Species at Risk Biologist, Karine Bériault. Potential breeding habitats were identified as wetland features containing vernal pools/ponds or small remnants of standing water, with associated deciduous tree or shrub cover. Where conditions were adequate, dip netting surveys were conducted using aquatic nets or small colanders. As salamander larvae hide within the leaf litter among the wetland bottom, leaf litter/muck was brought to the surface with the dip nets and scoured for signs of salamander larvae.

Subsequent to the June 17 survey, NRSI received the necessary permitting to conduct further larval surveys. Dip net surveys were conducted daily from July 6 to July 10, 2009. The methodology for larval surveys was based on guidance provided by both Dr. Jim Bogart, from the University of Guelph, and MNR Species at Risk Biologist, Karine Bériault. The methods consisted of visual searches and dip-netting by 2 to 3 biologists throughout the ponds previously identified as potential breeding habitat. In a number of instances, wetlands identified as potential breeding habitat during the June 17 visit were completely dry at the time of larval surveys; therefore, dip net surveys could not be conducted within these areas. Larval surveys were conducted within three of the wetland areas identified as potential salamander breeding habitat.

Larval surveys were conducted during daylight hours on each day, except July 9, when surveys were conducted at night. A night-time survey was conducted as it was noted by Dr. Jim Bogart that salamander larvae are sometimes easier to observe and collect during the night in June and July when they are relatively large and are floating and feeding in the water column.

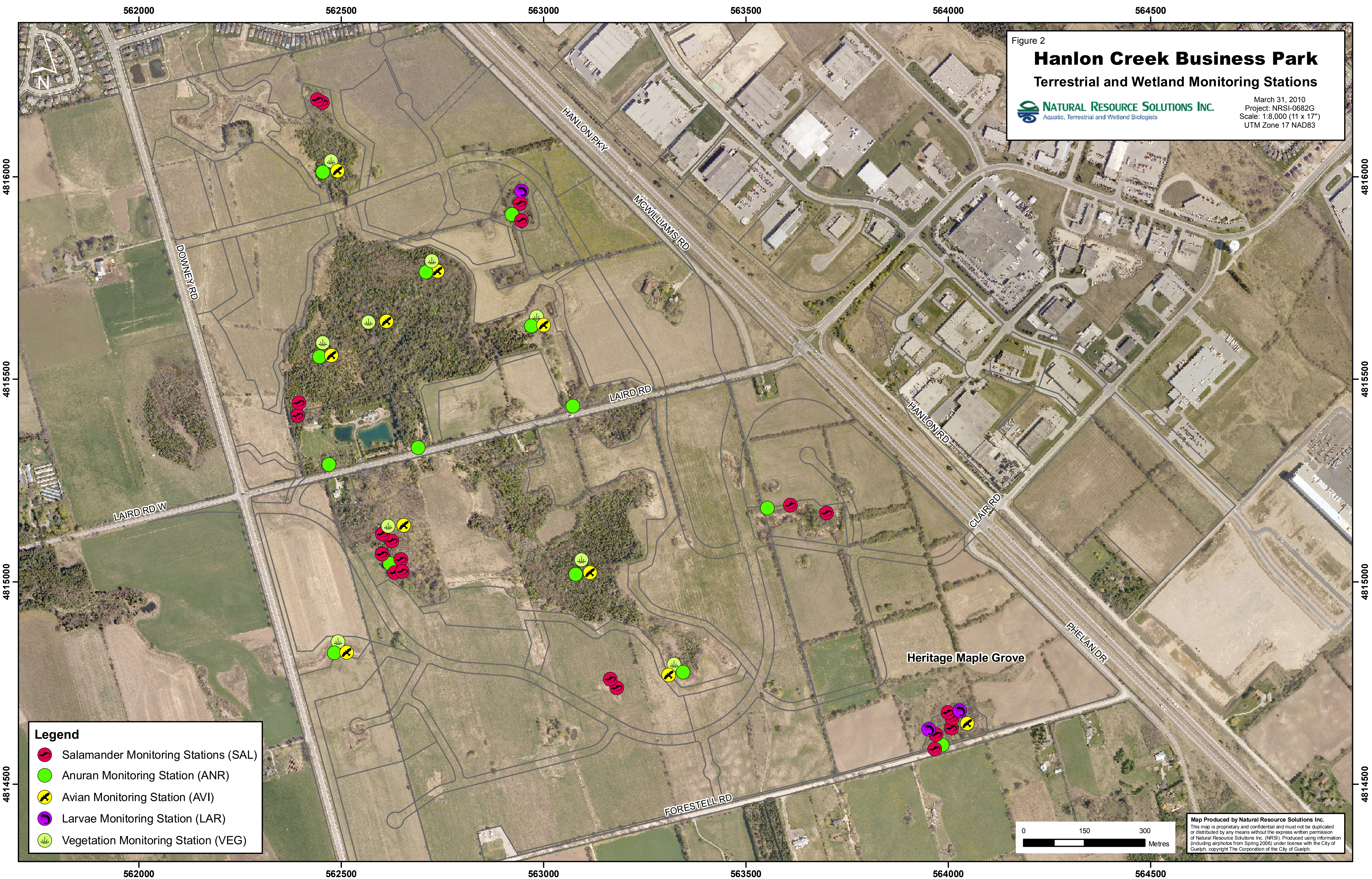
Locations of monitoring stations for all surveys are shown in Figure 2.

3.4.4 Laird Road Wildlife Movement Survey

From the review process for the Hanlon Creek Business Park Environmental Implementation Report (NRSI 2008), the public identified the need to evaluate the effectiveness of wildlife crossings (i.e. culverts) by monitoring the incidence of wildlife mortality along Laird Road. Based on this comment, a road mortality survey was established.

Nighttime surveys were conducted twice a week from April 20 to June 18, 2009. Surveys involved biologists walking along Laird Road from the Hanlon Expressway to

Downey Road, recording all wildlife species observed. Searches commenced one-half hour after sunset and ended before midnight. For each visit, detailed field notes were taken which included weather conditions, species observed on the road, individual status (i.e. dead, alive, or injured) and direction of movement. The location of each individual observed along the road was recorded using a GPS and mapped on an airphoto.



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4.0 Results

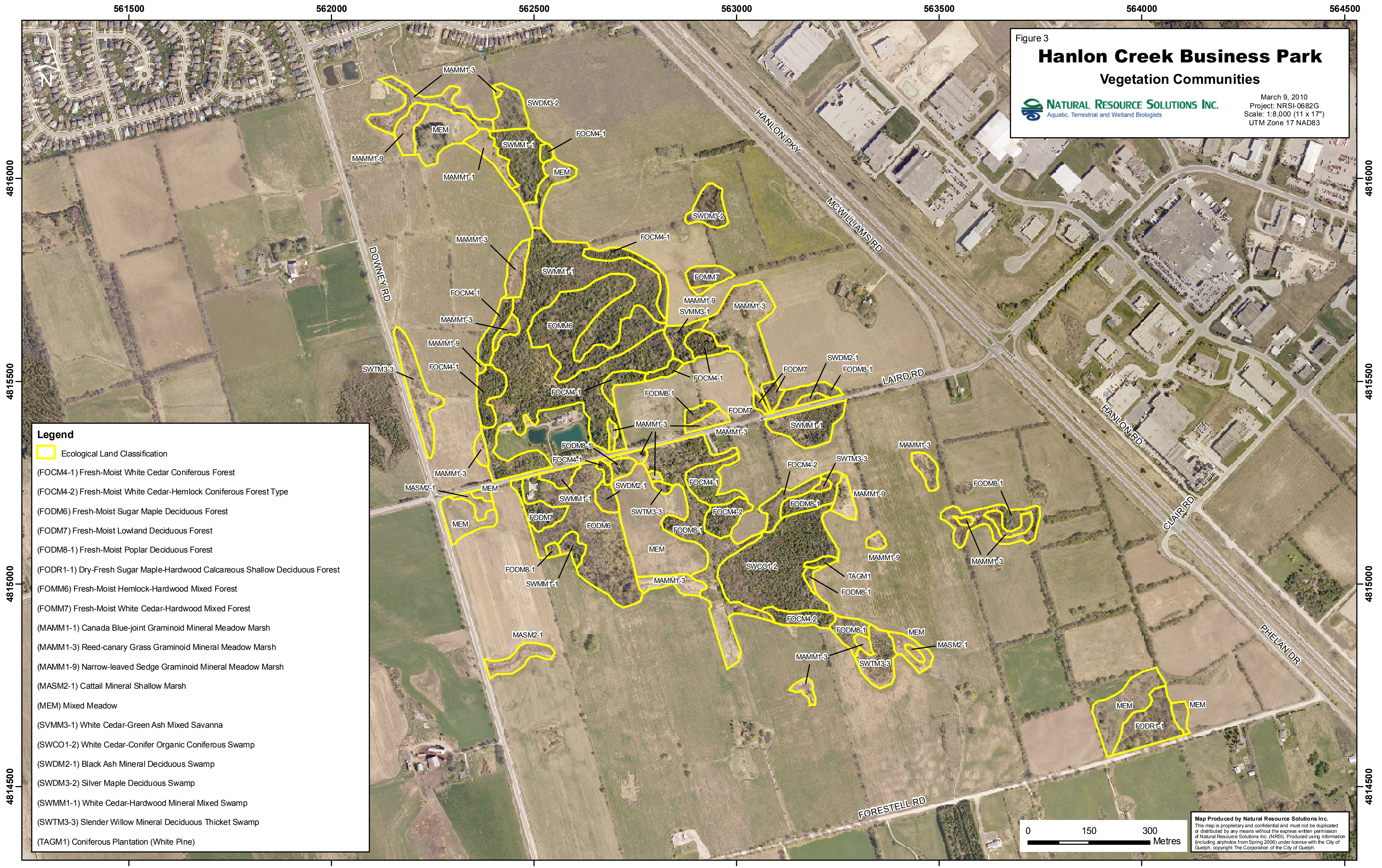
4.1 Vegetation Surveys

The ELC communities were unofficially revised by Harold Lee (2008). The new community descriptions have been used and are listed in Table 2 and mapped in Figure 3.

Table 2. Monitoring Plot ELC Communities

Plot	Previous ELC Code	New ELC Code	New Community Description Name
1	MAM2-2	MAMM1-3	Reed-canary Grass Graminoid Mineral Meadow Marsh
2	SWC3-2	SWCO1-2	White Cedar - Conifer Organic Coniferous Swamp
3	FOD6	FODM6	Fresh - Moist Sugar Maple Deciduous Forest
4	SWM1-1	SWMM1-1	White Cedar - Hardwood Mineral Mixed Swamp
5	FOM6	FOMM6	Fresh - Moist Hemlock-Hardwood Mixed Forest
6	MAM2-2	MAMM1-3	Reed-canary Grass Graminoid Mineral Meadow Marsh
7	SWM1-1	SWMM1-1	White Cedar - Hardwood Mineral Mixed Swamp
8	SWM1-1	SWMM1-1	White Cedar - Hardwood Mineral Mixed Swamp
9	MAS2-1	MASM1-1	Cattail Mineral Shallow Marsh

Refer to Appendix I for a comprehensive list of the vegetation species observed from 2006 to 2009. The data from past years was thoroughly reviewed for inclusion in this report, and only those species that were recorded from within the monitoring plots was included in the list. As seen in Appendix I, 95 species were recorded in 2006, 108 in 2007, 107 in 2008, and 116 in 2009. Overall, 171 species have been observed in the vegetation monitoring plots. None of these species are rare or regionally significant.



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4.1.1 Floristic Indices

A common method for evaluating and assessing natural areas is using floristic composition. This method is based on the character of a region's flora. Plant species display varying degrees of fidelity to specific habitats, which is expressed by species conservatism. Species conservatism is the degree of faithfulness a plant displays to a set of environmental conditions. The quality of a natural area is reflected in the number of conservative species found within a certain habitat (Wilhem and Ladd 1988 *In* Oldham et al. 1995). There are several floristic indices which can be used to describe the character of the vegetation in the plot. These include the Coefficient of Wetness, the Coefficient of Conservatism, and the Natural Area Index. All species (herbs, shrubs, and trees) from each plot are considered in these equations.

Coefficient of Wetness

The Coefficient of Wetness (CW) is based on wetland values given to each individual plant species. Values range from -5 to +5, where -5 indicates an obligate wetland species, and +5 indicates an obligate upland species. "0" is assigned to facultative species, those that are just as likely to be found in wetland or upland habitats. The Coefficient of Wetness values used are based on Oldham et al. (1995). Figure 4 shows the average wetness per plot, based on the wetness coefficients of all species found within a plot. Most plots are wetlands. Plots 3 and 5 are upland, designated as a sugar maple forest and hemlock-hardwood forest respectively. Plot 1 is the wettest, with an average coefficient of wetness score of -3.9 in 2009. This plot is located in a reed-canary grass marsh.

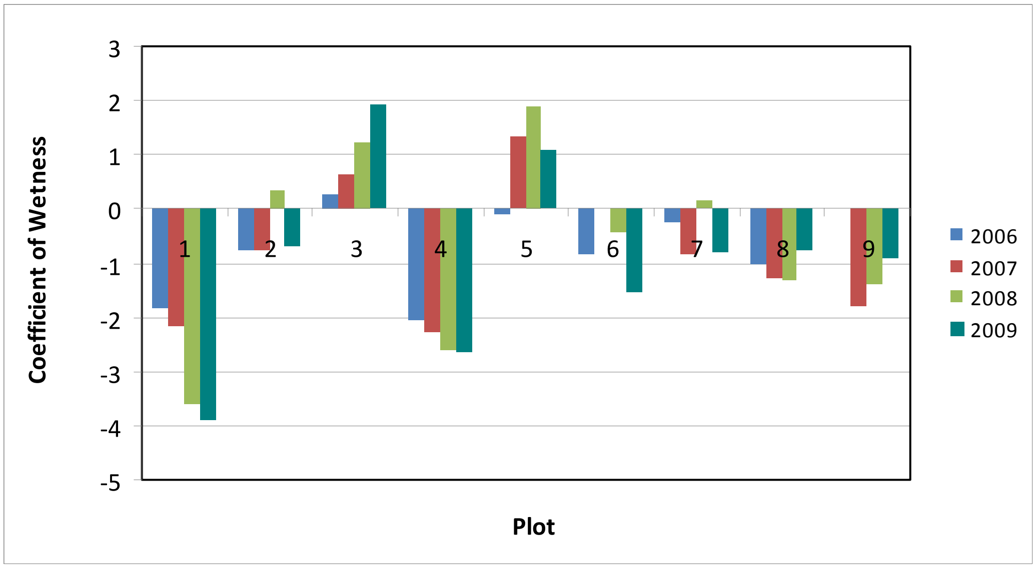

Figure 4. Coefficient of Wetness by Plot 2006-2009

Coefficient of Conservatism

The Coefficient of Conservatism (CC) is also based on Oldham et al. (1995). Each species is given a rank between 0 and 10, based on its degree of fidelity to a range of synecological parameters (Oldham et al. 1995). Synecology is the study of the structure, development, and distribution of ecological communities. Species ranked between 0 and 3 are found in a variety of plant communities, including disturbed sites. Species ranked between 4 and 6 are those associated with a specific plant community, but which can tolerate moderate disturbance. Species ranked from 7 to 8 are found in plant communities in an advanced stage of succession with minor disturbance. Plants with a ranking of 9 or 10 have high degrees of fidelity to a narrow range of synecological factors. The average Coefficient of Conservatism per plot is shown in Figure 5. The highest scores are found at Plots 1, 5, and 7. Plot 1 is the reed-canary grass marsh, Plot 5 is located in a hemlock-hardwood forest, and Plot 7 is found in a white-cedar – hardwood swamp. The lowest average Coefficient of Conservatism is found at Plot 9, a cattail marsh.

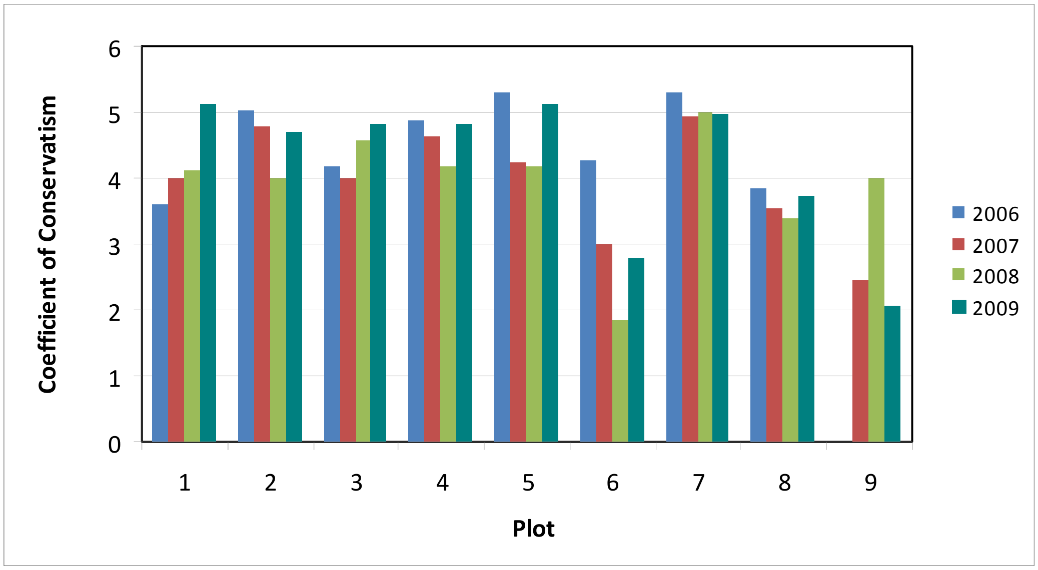

Figure 5. Coefficient of Conservatism by Plot 2006-2009

Natural Area Index

The Natural Area Index (NAI), or floristic quality index, allows the objective comparison of two or more natural areas or vegetation types (Oldham et al. 1995). The NAI is calculated by multiplying the average coefficient of conservatism by the square root of the total number of *native* species. Whereas the abundance and frequency of species can fluctuate greatly by season and year, the NAI is more stable and offers a more accurate picture. The NAI for each plot is shown in Figure 6.

The Ministry of Natural Resources reports that natural areas with NAI values of over 35 are considered significant at the provincial level (Wilhelm and Ladd 1988 *in* MNR 1994). For comparison, an old successional field may score as low as <5 (Andreas et al. 2002). None of the plots score a value of 35 or higher. The highest value is found at Plot 7, in the white-cedar – hardwood swamp. Its NAI is 32.3. The plot with the lowest NAI score is Plot 9, the cattail marsh, with a value of 8.0.

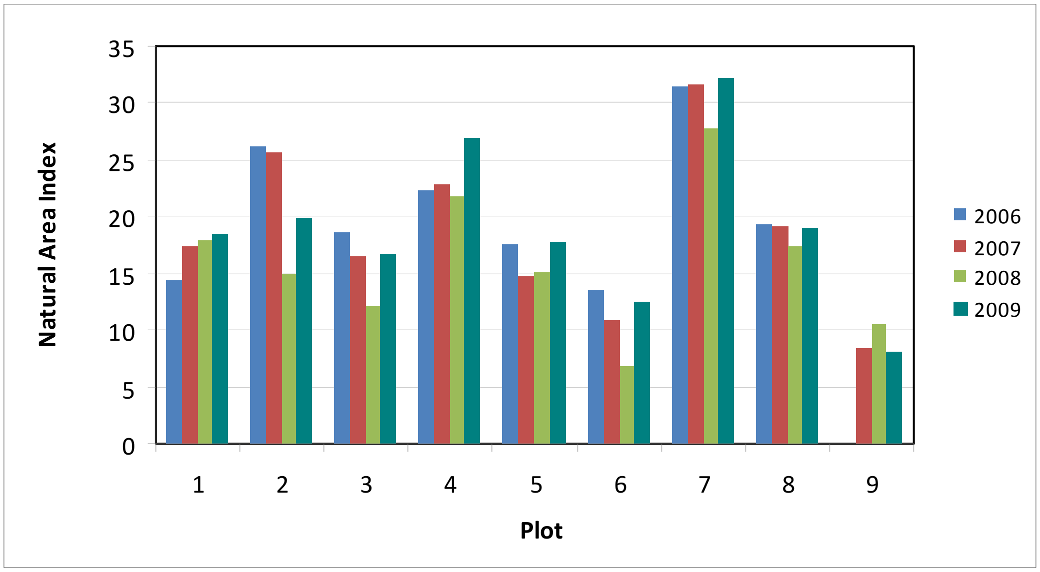

Figure 6. Natural Area Index by Plot 2006-2009

4.1.2 Non-Native Species

The number of non-native species found in each plot is compared in Figure 7. All plots have had non-native species recorded. The greatest number of non-native species (13) recorded was at Plot 8, located in the white-cedar – hardwood swamp.

Certain species are considered particularly invasive, and are given a score of '-3' on a weediness scale ranging from '-1' to '-3'. The invasive species found in the HCBP include three different types of shrubs: common buckthorn (*Rhamnus cathartica*), glossy buckthorn (*Rhamnus frangula*), and tartarian honeysuckle (*Lonicera tatarica*). Common buckthorn is the most widely dispersed, being found in five plots. Plot 8 is the most impacted, containing all three of these highly invasive species.

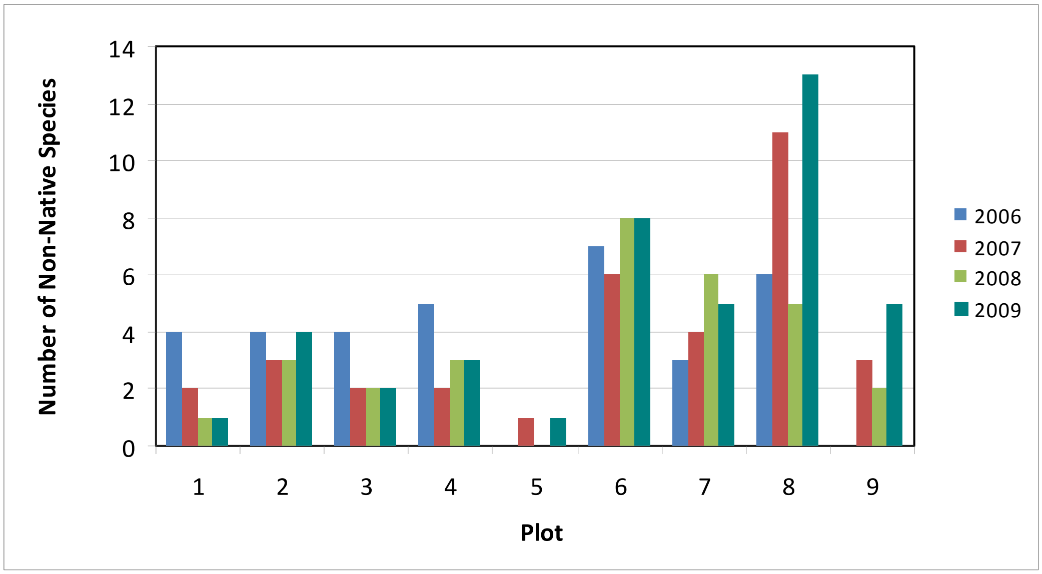

Figure 7. Non-Native Species by Plot 2006-2009

In previous years, two other invasive species were recorded: quack grass (*Elymus repens*) and moneywort (*Lysimachia nummularia*). Quack grass was recorded from Plot 6 in 2008, and moneywort was recorded from Plots 7 and 8 in 2007.

Of note is that garlic mustard (*Alliaria officinalis*) was never recorded in any of the vegetation monitoring plots. Garlic mustard is a very common, invasive species, and it is rare to find areas that do not contain this species.

4.1.3 Herbaceous Inventory

Appendix II displays species observed in 2009 within each vegetation plot. A total of 57 species of herbaceous plants were observed during the plot-based vegetation monitoring that was conducted in 2009.

Appendix III compares the herbaceous species recorded in each subplot between 2006 and 2009. Even though the same subplot is monitored each year, the results vary. It is very difficult to monitor the exact same location from year to year, despite using the same bearing and location as listed in Table 1.

4.1.4 Shrub Inventory

The number of shrub species found within each monitoring plot and their approximate percent cover was recorded. Fifteen shrub species were observed in 2009, in comparison to 16 in 2006, and 15 in 2007 and 2008. Refer to Appendix IV for shrub species recorded within each monitoring plot in 2009 and Appendix V for a comparison between all years. Composition of species recorded has varied from year to year, although all shrubs seen within the entire plot are recorded.

4.1.5 Tree Inventory

Results from 2009 are found in Appendix VI. Trees are absent from Plots 1, 6 and 9. The dominant tree species found within each plot did not change from the data obtained in previous years.

The tree data collected from 2006 to 2009 is compared in Appendix VII. The trees were re-numbered and re-tagged in 2008 to aid in field identification.

4.2 Soil Surveys

Refer to Appendix VIII for results obtained during the 2009 soil surveys, as well as previous data.

4.3 Breeding Bird Surveys

A total of 45 species of birds were observed during the breeding bird monitoring that was conducted in 2009 (Appendix IX). Birds observed in the study area while conducting other field surveys and transects between breeding bird stations were also recorded as incidentals and are included in Appendix X. Table 3 summarizes the number of birds observed under each breeding evidence code.

Table 3. Breeding Bird Evidence

Breeding Evidence	Number of Species			
	2006	2007	2008	2009
PO	30	12	20	21
PR	11	15	14	20
CO	0	11	2	4
X	0	8	4	0

LEGEND	
PO	Possible
PR	Probable
CO	Confirmed
X	Observed

The most abundant species observed during 2009 surveys was red-winged blackbird (*Agelaius phoeniceus*), making up 15.9% of the observations during breeding bird point counts. This was followed by European starling (*Sturnus vulgaris*) with 11.3%, and song sparrow (*Melospiza melodia*) with 8.0%. All other species made up less than 5%. Figure 8 represents the seven most abundant species observed in 2009. NRSI did not observe any rare or provincially significant bird species during the breeding bird surveys.

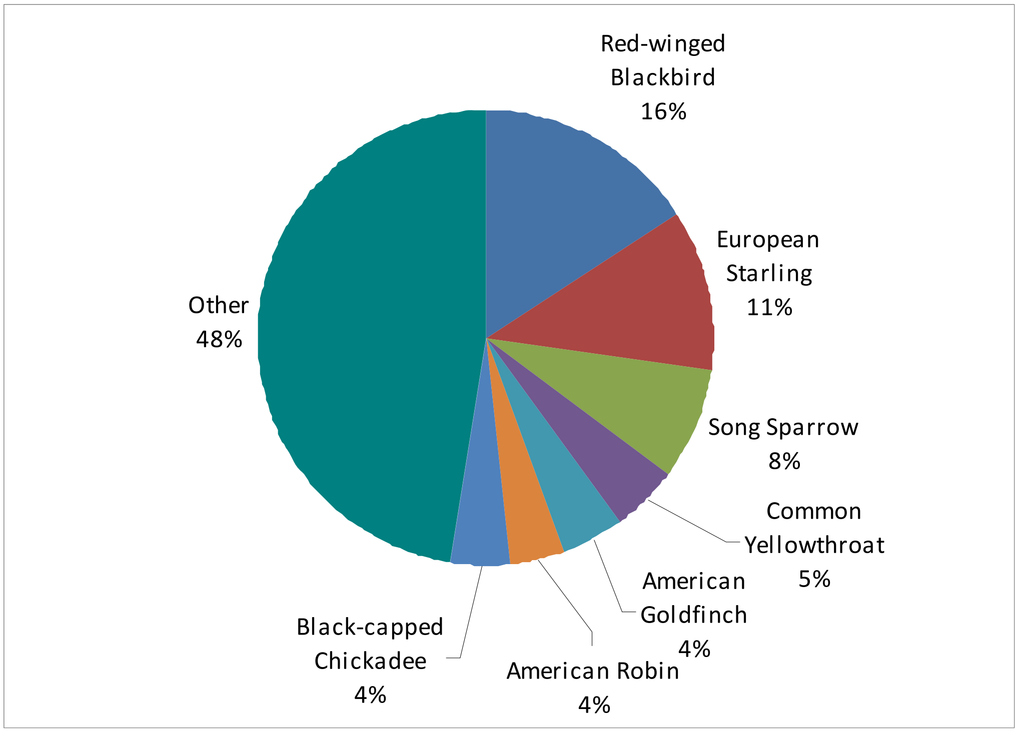

Figure 8. Most Abundant Bird Species Observed in 2009

Figures 9 and 10 represent a comparison of breeding bird species abundance and richness for each monitoring year within each habitat type found within the study area. Species abundance is the number of individuals of all species found at each plot. Species richness is the number of different species found at each plot. Table 4 lists each plot and the habitat type it falls into. A tenth plot was added in 2009 within a dry-fresh sugar maple – hardwood forest.

Table 4. Habitat Type Per Plot

Plot	ELC	Habitat Type
1	MAM2-2	Marsh
2	SWC3-2	Coniferous Swamp
3	FOD6	Fresh-Moist Forest
4	SWM1-1	Coniferous Swamp
5	FOM6	Fresh-Moist Forest
6	MAM2-2	Marsh
7	SWM1-1	Coniferous Swamp
8	SWM1-1	Coniferous Swamp
9	MAS2-1	Marsh
10	FODR1-1	Dry-Fresh Forest

During each pre-construction monitoring year, average species abundance was greatest in the meadow marsh communities and lowest in the fresh-moist forests (i.e. Fresh-Moist Sugar Maple Deciduous Forest and Fresh-Moist Hemlock Mixed Forest). This trend continued in 2009, with even more individuals recorded in the marsh and swamp communities. In the fresh-moist forest, one individual less was recorded over 2008. The newly added dry-fresh forest community had the second highest number of individuals, with an average of 33 per plot.

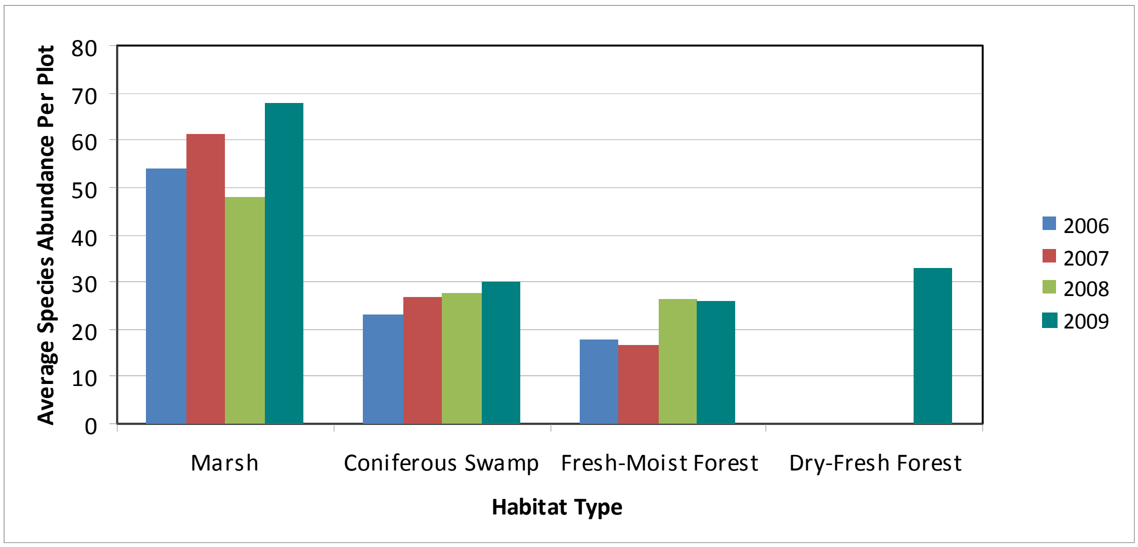

Figure 9. Breeding Bird Species Abundance by Habitat Type

It can be seen from Figure 10 that average species richness per plot is highest within the coniferous swamp communities, followed by the dry-fresh forest. The number of species seen in each habitat type has been increasing over the years. In 2009, a greater number of species was seen in all habitat areas, than in previous years. This may be a result of less agricultural disturbance. Each year more fields are being left fallow, providing more grassland habitat for birds to nest and forage in. The decrease in pesticides also has a positive benefit in providing more food (i.e. insects) for the birds.

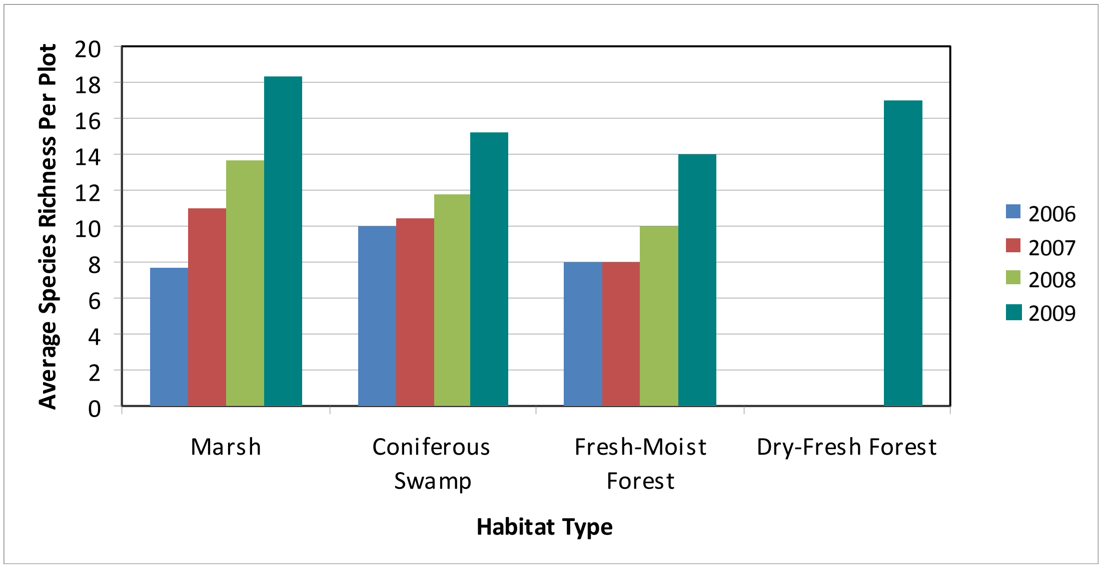

Figure 10. Breeding Bird Species Richness by Habitat Type

4.4 Amphibian Surveys

4.4.1 Call Count Surveys

Six amphibian species were recorded during evening herpetofauna surveys in 2009: American toad (*Bufo americanus*), northern spring peeper (*Pseudacris crucifer crucifer*), tetrapolid gray treefrog (*Hyla versicolor*), northern leopard frog (*Rana pipiens*), green frog (*Rana clamitans melanota*), and wood frogs (*Rana sylvatica*). Only one other anuran species is known from the area: western chorus frog (*Pseudacris triseriata* pop.2), which was recorded from Plot 6 in 2007, but has not been observed since. Appendix XI provides a comprehensive list of herpetofauna species observed by NRSI since 1998.

The number of species observed each year during call count surveys has increased over the years, as shown in Table 5. In 2009 the greatest number of species was recorded, as seven new stations were added to get a better representation of the study area, as well as to search for the western chorus frog.

Table 5. Number of Species Recorded From Call Counts

Year	# of Species
2006	0
2007	5
2008	4
2009	6

In order to compare species abundance over time and between stations, the maximum call code is used. The maximum call code is used to provide an estimate of abundance, as estimating numbers of individuals is not accurate. The three call codes are explained below as per the Marsh Monitoring protocol:

1. Calls can be counted; not simultaneous
2. Some simultaneous calls; yet distinguishable
3. Calls not distinguishable; overlapping (i.e. "full chorus")

By comparing the number of stations that a species has been observed at and the maximum call code over time (given in Table 6), increases or decreases in species abundance can be determined. The following is a brief discussion of trends observed by species:

- The most abundant species is spring peeper. Spring peeper was recorded with a call code 3 at Plots 6, 12, and 16; it was the only species in 2009 that was recorded with this call code. It is also the most widely distributed anuran, being observed at 10 plots.
- American toad has been recorded from a different station each year. In 2009 it was recorded from only one plot (Plot 14). In 2008, American toad was recorded with a call code 3 at one station, but otherwise, it is found in small numbers.
- Tetraploid gray treefrog was first recorded in 2008. It was observed in the same plots in 2009, with the addition of a new plot.
- Northern leopard frog was newly observed from the call count surveys in 2009. It was recorded in three of the newly established plots. Although it had previously not been observed during call count surveys, northern leopard frog has been known from the site previously through other types of field work and observations.
- Green frog was observed from two stations in 2009; three individuals were recorded. In previous years it was recorded in even small numbers.
- Wood frog is the second most widely distributed species, being recorded at 6 different plots in 2009. It is also one of the more abundant species.

- American toad, green frog, and spring peeper have been recorded consistently over the last 3 years.

With regards to the plots:

- Plot 9 has the greatest diversity of species, with 6 different anurans recorded from this site over the years. In 2009, 4 species were recorded here, also the greatest number for one year.
- Plots 2, 7, 8, 13, and 15 had no species recorded in 2009. The first three plots have had species recorded in previous years; the latter two were new stations for 2009.

Table 6. Maximum Call Code by Plot, Year, and Species

Plot	Year	American Toad	Northern Spring Peeper	Tetraploid Gray Treefrog	Western Chorus Frog	Northern Leopard Frog	Green Frog	Wood Frog
1	2006							
	2007		3					1
	2008		1					
	2009		1	1				1
2	2006							
	2007							
	2008		2					
	2009							
4	2006							
	2007							
	2008	1	3					
	2009		1					
6	2006							
	2007	1	3		1			
	2008		2	3			1	
	2009		3	1			1	
7	2006							
	2007							
	2008		2					
	2009							
8	2006							
	2007							
	2008		2					
	2009							
9	2006							
	2007		2				1	1
	2008	3	1	1				
	2009		1	1		1		1
10	2006							
	2007							
	2008							
	2009							1
11	2006							
	2007							
	2008							
	2009		1			1		1

Plot	Year	American Toad	Northern Spring Peeper	Tetraploid Gray Treefrog	Western Chorus Frog	Northern Leopard Frog	Green Frog	Wood Frog
12	2006							
	2007							
	2008							
	2009		3			1	1	1
13	2006							
	2007							
	2008							
	2009							
14	2006							
	2007							
	2008							
	2009	1						
15	2006							
	2007							
	2008							
	2009							
16	2006							
	2007							
	2008							
	2009		3					
17	2006							
	2007							
	2008							
	2009							1
Max. Call Code by Species:		**3**	**3**	**3**	**1**	**1**	**1**	**1**
Total number of point counts observed at:		**4**	**10**	**3**	**1**	**3**	**3**	**6**

Site Conditions

Amphibians breed in several types of wetland habitat. All require the presence of water for some duration of the spring. Some species, such as spring peeper, western chorus frog, and wood frog, take advantage of temporary, seasonal pools created by spring rains and melting snow. The temporary pools dry up mid to late summer, by which time the larvae have metamorphosed into adults and moved to upland habitats. Some species of anurans, such as the leopard frog, green frog and bullfrog, require semi-permanent to permanent water bodies in order for the larvae to develop into adults, which can take up to 2 years.

Weather on the first visit, April 23, was clear and cool, with 3°C. There was no precipitation on any of the evening call count visits. The second visit, May 11, was very similar to the first visit, with 5°C. The final visit, on June 2, was warmer with close to 14°C and a little more cloud cover.

Water temperatures ranged from 3.4 to 8.9°C on the first visit, 6.2 to 11.5°C on the second visit, and 8.5 to 16.7°C on the final visit.

pH values ranged from 7.8 to 9.9 throughout the spring. The average pH values have gone up from 7.8 in 2006, to 8.8 in 2009. Whereas a pH value of 9 or more was not reached at any of the plots previously, this value was reached or surpassed approximately half the time in 2009. In fact, all plots (where water was present) had a pH value of 9 or higher on the final visit in June.

Anurans are known to prefer habitats that are pH neutral (pH 7) (Audubon International, 2000). When pH values decrease, becoming acidic, or increase, becoming alkaline, it can impact their survival. Seburn (1998) states that the northern leopard frog breeds successfully at a pH range of 8.5-9.5 and that fertilization of eggs is reduced at a pH of less than 6.5.

Chemical processes such as photosynthesis and drying out that occur daily and throughout the breeding season result in fluctuations of water pH and other water chemistry values (Wetzel 1983). A study of 180 ponds across southwestern Ontario found that pH averaged 8.3 +/-0.05 with a range of 7.2-10.2 (Hecnar and M'Closkey 1996). According to this study, ponds in southwestern Ontario, are generally alkaline, hard, and well buffered with high pH values. Hecnar and M'Closkey (1996) did not find any correlation between amphibian species richness and water chemistry. Several studies have found that amphibian species richness is not related to water chemistry (pH, conductivity, and hardness) (Hecnar and M'Closkey 1996). The presence or absence of anuran species is more commonly related to hydroperiod and the presence of predatory fish.

The pH values found during the monitoring period are within the normal range for southern Ontario. The recorded pH levels have not been recognized as having harmful effects on the presence of amphibian species.

All ponds that the plots are located at had water in 2009, other than Plots 11 and 17 on the third visit.

4.4.2 Salamander Trap Survey

No salamander species were observed or trapped during salamander trap surveys. The memo addressing the salamander trap survey is appended (Appendix XII).

4.4.3 Salamander Larval Survey

No salamander larvae were found during the larval surveys. The full monitoring report is appended (Appendix XIII).

4.4.4 Laird Road Wildlife Movement Survey

A total of 101 wildlife observations were made along Laird Road during mortality surveys. These observations included herpetofauna (frogs, toads and snakes) and mammals. Of the 101 observations, 77% were found dead, 22% were alive and none were injured. Amphibian species comprised 95% of these observations. American toad (35), northern leopard frog (33), northern spring peeper (16), unidentified anuran species (7), green frog (3), and wood frog (2) were all observed. The anuran species not identified to species were unidentifiable after being run over by vehicles.
In addition to amphibians, a dead eastern milksnake (*Lampropeltis t. triangulum*), eastern chipmunk (*Tamias striatus*) and two mouse species were recorded. The eastern milksnake is ranked as vulnerable provincially and is also considered a species of special concern by COSSARO and COSEWIC.

One dead salamander species was observed and collected on April 20, 2009. DNA extraction and analysis was performed at the University of Guelph by Dr. Jim Bogart. Genetic analysis of the tail clipping identified the salamander to be *Ambystoma laterale-(2) jeffersonianum;* indicating a Jefferson salamander sperm donor within the area. Appendix XI lists all herpetofauna species known from the study area.

Observations of wildlife were generally quite dispersed along Laird Road; however, concentration areas were noted where natural features are present along both sides of the road, especially wetlands.

When feasible, direction of movement for each individual observed was recorded. Based on observations, 28% were moving north, 32% were moving south, while only 2% were noted to be moving east or west. In cases where carcasses were unidentifiable due to road mortality, direction of movement, unless quite obvious, was recorded as unknown (37%). As anticipated, amphibian movement was concentrated in a north/south direction, indicating movement from breeding ponds located adjacent to Laird Road.

The amphibian breeding season generally begins in mid to late March for a number of amphibian species (i.e. Jefferson salamander, wood frog, northern spring peeper and western chorus frog) and tapers off in June for species such as green frog and northern leopard frog. In cases where wetlands are adjacent to busy roadways, there is often a correlation between increased amphibian road mortalities and peak breeding seasons.

Observations of amphibians along Laird Road was considerably higher in April than in June, which correlates with the fact that many of the amphibian species known to occur within the vicinity of the study area breed primarily in early to mid spring.

The full monitoring report is appended (Appendix XIV).

5.0 Conclusions and Recommendations

The 2009 monitoring year was successful in providing another year of pre-construction data, contributing to a good baseline data set that can be compared to future years. No rare or significant plant and bird species have been recorded from the site. Two significant herpetofauna species were recorded, both through Laird Road mortality surveys: Eastern milk snake and a salamander of the Jefferson complex. It is recommended that all monitoring should continue in 2010 as in 2009, with an increased effort in salamander monitoring to confirm the presence and distribution of Jefferson's salamanders. The reduction in active agriculture within the study area has a positive effect on the wildlife.

6.0 References

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APPENDIX I
Vegetation Species Observed in the Study Area 2006-2009

Appendix I. Vegetation Species Observed in the Study Area

Scientific Name	Common Name	CC	CW	Weed	+	NRSI 2006	NRSI 2007	NRSI 2008	NRSI 2009
LYCOPIDIACEAE	**CLUBMOSS FAMILY**								
Moss spp	Moss					√	√	√	√
EQUISETACEAE	**HORSETAIL FAMILY**								
Equisetum arvense	Field Horsetail	0	0				√	√	√
Equisetum palustre	Marsh Horsetail	10	-3			√	√		
Equisetum pratense	Meadow Horsetail	8	-3			√		√	√
OSMUNDACEAE	**ROYAL FERN FAMILY**								
Osmunda cinnamomea	Cinnamon Fern	7	-3				√		√
DRYOPTERIDACEAE	**WOOD FERN FAMILY**								
Dryopteris carthusiana	Spinulose Wood Fern	5	-2			√	√	√	√
Dryopteris clintoniana	Clinton's Wood Fern	7	-4				√		
Dryopteris cristata	Crested Wood Fern	7	-5			√	√	√	√
Dryopteris marginalis	Marginal Wood Fern	5	3						√
Polystichum acrostichoides	Christmas Fern	5	5			√		√	√
ONOCLEACEAE	**SENSITIVE FERN FAMILY**								
Matteuccia struthiopteris	American Ostrich Fern	5	-3			√	√	√	√
Onoclea sensibilis	Sensitive Fern	4	-3			√	√	√	√
WOODSIACEAE	**WOODSIA FAMILY**								
Cysptopteris tenuis	Mackay's Fragile Fern	6	5					√	
Athyrium filix-femina	Northeastern Lady Fern	4	0						√
Cystopteris bulbifera	Bulblet Fern	5	-2			√	√		√
Gymnocarpium dryopteris	Oak Fern	7	0				√	√	√
THELYPTERIDACEAE	**BEECH FERN FAMILY**								
Thelypteris palustris	Marsh Fern	5	-4			√	√	√	√
PINACEAE	**PINE FAMILY**								
Pinus strobus	White Pine	4	3			√	√	√	√
Tsuga canadensis	Eastern Hemlock	7	3			√	√	√	√
CUPRESSACEAE	**CYPRESS FAMILY**								
Thuja occidentalis	White Cedar	4	-3			√	√	√	√
TYPHACEAE	**CATTAIL FAMILY**								
Typha latifolia	Common Cattail	3	-5			√	√	√	√
ALISMATACEAE	**WATER-PLANTAIN FAMILY**								
Alisma subcordatum	Water-Plantain	3	-5					√	
POACEAE	**GRASS FAMILY**								
Bromus inermis ssp. inermis	Smooth Brome Grass	*	5	-3	+		√		
Calamagrostis canadensis	Canada Blue-joint	4	-5			√	√	√	√
Echinochloa crusgalli	Barnyard Grass	*	3	-1	+				√
Elymus repens	Quack Grass	*	3	-3	+			√	
Glyceria striata	Fowl Manna Grass	3	-5				√		√
Leersia oryzoides	Cut Grass	3	-5			√			√
Phalaris arundinacea	Reed Canary Grass	0	-4				√	√	√
Phleum pratense	Timothy	*	3	-1	+			√	
	Grass spp.					√	√	√	√
Poa nemoralis	Woodland Spear Grass		0	-1					√
Poa pratensis	Kentucky Blue Grass	0	1				√	√	√
CYPERACEAE	**SEDGE FAMILY**								
Carex spp.	Sedge species					√	√	√	√
Carex aquatilis	Aquatic Sedge	7	-5						√
Carex arctata	Compressed Sedge	5	5						√
Carex gracillima	Graceful Sedge	4	3						√
Carex intumescens	Bladder Sedge	6	-4						√
Carex lacustris	Lake Sedge	5	-5			√		√	√
Carex laxiflora	Loose-flowered Sedge	5	0						√
Carex stipata	Awl-fruited Sedge	3	-5			√	√	√	√
Carex stricta	Stiff Sedge (Tussock)	4	-5					√	√
Carex utriculata	Beaked Sedge	7	-5				√		√
Carex vulpinoidea	Fox Sedge	3	-5					√	√
Schoenoplectus pungens	Common Threesquare	6	-5			√			
Scirpus atrovirens	Dark Green Bulrush	3	-5					√	√
ARACEAE	**ARUM FAMILY**								
Arisaema triphyllum	Jack-in-the-pulpit	5	-2			√	√	√	√
LEMNACEAE	**DUCKWEED FAMILY**								
	Duckweed species								√
Spirodela polyrhiza	Duckweed	4	-5				√		
JUNCACEAE	**RUSH FAMILY**								
Juncus spp	Juncus					√	√		
Juncus effusus	Soft Rush	4	-5						√

						NRSI			
Scientific Name	**Common Name**	**CC**	**CW**	**Weed**	**+**	**2006**	**2007**	**2008**	**2009**
Juncus tenuis	Path Rush	0	0			√		√	√
ALLIACEAE	**ONION FAMILY**								
Allium tricoccum	Wild Leek, Ramps	7	2				√		
RUSCACEAE	**LILY-OF-THE-VALLEY FAMILY**								
Maianthemum canadense	Wild Lily-of-the-valley	5	0			√	√	√	√
Maianthemum racemosum	False Solomon's-seal	4	3			√	√	√	
Maianthemum stellatum	Star Flowered False Solomon's-seal	6	1					√	√
Polygonatum pubescens	Hairy Solomon's-seal	5	5				√	√	
LILIACEAE	**LILY FAMILY**								
Clintonia borealis	Bluebead-lily	7	-1				√	√	√
IRIDACEAE	**IRIS FAMILY**								
Iris spp.	Iris						√		
ORCHIDACEAE	**ORCHID FAMILY**								
Epipactis helleborine	Helleborine	*	5	-2	+			√	√
Cypripedium calceolus var. parviflorum	Small Yellow Lady's Slipper	7	-1						√
SALICACEAE	**WILLOW FAMILY**								
Salix spp.	Willow species						√		
Salix bebbiana	Beaked Willow, Bebb's Willow	4	-4					√	
Salix exigua	Sandbar Willow	3	-5			√			
Salix petiolaris	Slender Willow	3	-4			√		√	√
BETULACEAE	**BIRCH FAMILY**								
Betula alleghaniensis	Yellow Birch	6	0			√	√	√	√
Ostrya virginiana	Ironwood	4	4			√		√	
FAGACEAE	**BEECH FAMILY**								
Fagus grandifolia	American Beech	6	3				√		
ULMACEAE	**ELM FAMILY**								
Ulmus americana	White Elm	3	-2			√	√	√	√
URTICACEAE	**NETTLE FAMILY**								
Pilea pumila	Clearweed	5	-3					√	
RANUNCULACEAE	**CROWFOOT FAMILY**								
Actaea species	Baneberry species						√		√
Caltha palustris	Marsh-marigold	5	-5			√	√	√	√
Coptis trifolia	Gold-thread	7	-3				√		
Ranunculus abortivus	Small-flowered Buttercup	2	-2			√	√		
Ranunculus acris	Tall Buttercup	*	-2	-2	+	√	√		√
Ranunculus flabellaris	Yellow Water-crowfoot	7	-5					√	
Ranunculus repens	Creeping Buttercup	8	-5				√		
Ranunculus hispidus var. caricetorum	Swamp Buttercup	5	-5			√			√
Ranunculus pensylvanicus	Bristly Buttercup	3	-5					√	
Ranunculus recurvatus	Hooked Buttercup	4	-3				√	√	
Ranunculus sceleratus	Cursed Crowfoot	2	-5				√		√

Scientific Name	Common Name	CC	CW	Weed	+	NRSI 2006	NRSI 2007	NRSI 2008	NRSI 2009
BRASSICACEAE	**MUSTARD FAMILY**								
Arabis glabra	Tower-mustard	4	5		+			√	
Cardamine pensylvanica	Bitter Cress	6	-3						√
Nasturtium officinale	Watercress		-5	-1					√
SAXIFRAGACEAE	**SAXIFRAGE FAMILY**								
Tiarella cordifolia	Foam Flower	6	1				√		
GROSSULARIACEAE	**GOOSEBERRY FAMILY**								
Ribes americanum	Wild Black Currant	4	-3			√	√	√	
Ribes hirtellum	Smooth Gooseberry	6	-3						√
Ribes lacustre	Bristly Black Currant						√		
Ribes rubrum	Red Currant	*	5	-2				√	
Ribes sp.	Currant species					√	√		
ROSACEAE	**ROSE FAMILY**								
Crataegus spp.	Hawthorn species					√	√		
Fragaria vesca	Woodland Strawberry	4	4			√	√	√	√
Fragaria virginiana	Common Strawberry	2	1				√	√	√
Geum spp.	Avens spp.					√			
Geum aleppicum	Yellow Avens	2	-1					√	√
Geum canadense	White Avens	3	0				√		
Geum laciniatum	Rough Avens	4	-3				√		
Prunus serotina	Wild Black Cherry	3	3			√	√	√	√
Prunus virginiana	Chokecherry	2	1					√	√
Rubus allegheniensis	Common Blackberry	2	2				√		
Rubus idaeus	Red Raspberry	0	-2			√	√	√	√
Rubus parviflorus	Thimbleberry	7	2						√
Rubus pubescens	Dwarf Raspberry	4	-4			√	√	√	√
Waldsteinia fragarioides	Barren Strawberry	5	5				√		
FABACEAE	**PEA FAMILY**								
Lotus corniculatus	Bird-foot Trefoil	*	1	-2	+	√	√	√	√
Trifolium hybridum	Alsike Clover	*	1	-1	+	√			
Trifolium pratense	Red Clover	*	2	-2	+			√	
GERANIACEAE	**GERANIUM FAMILY**								
Geranium robertianum	Herb Robert	*	5	-2	+	√	√	√	√
ANACARDIACEAE	**CASHEW FAMILY**								
Rhus radicans ssp. negundo	Poison-ivy	5	-1			√	√		√
ACERACEAE	**MAPLE FAMILY**								
Acer rubrum	Red Maple	4	0			√	√	√	√
Acer saccharum	Sugar Maple	4	3			√	√	√	√
Acer saccharinum	Silver Maple	5	-3			√	√	√	√
BALSAMINACEAE	**TOUCH-ME-NOT FAMILY**								
Impatiens capensis	Spotted Jewelweed	4	-3			√	√		√
Impatiens pallida	Pale Jewelweed	7	-3				√	√	
RHAMNACEAE	**BUCKTHORN FAMILY**								
Rhamnus cathartica	Common Buckthorn	*	3	-3	+	√	√	√	√
Rhamnus frangula	Glossy Buckthorn	*	-1	-3	+	√	√	√	√
VITACEAE	**GRAPE FAMILY**								
Parthenocissus inserta	Virginia Creeper	3	3			√	√	√	√
Vitis riparia	Riverbank Grape	0	-2			√	√	√	√
ONAGRACEAE	**EVENING-PRIMROSE FAMILY**								
Circaea alpina	Dwarf Enchanter's Nightshade	6	-3			√			√
Circaea quadrisulcata	Enchanter's Nightshade	3	3			√	√	√	√
Epilobium hirsutum	Great Hairy Willow-herb	*	-4	-2	+				√
ARALIACEAE	**GINSENG FAMILY**								
Aralia nudicaulis	Wild Sarsaparilla	4	3			√	√	√	√

						NRSI			
Scientific Name	**Common Name**	**CC**	**CW**	**Weed**	**+**	**2006**	**2007**	**2008**	**2009**
APIACEAE	**CARROT FAMILY**								
Cicuta maculata	Spotted Water-hemlock	6	-5			√	√	√	√
Cicuta bulbifera	Bulbous Water-hemlock	5	-5					√	√
Daucus carota	Wild Carrot, Queen Anne's Lace	*	5	-2	+		√		√
Hydrocotyle americana	Marsh Water-pennywort	7	-5			√			√
Sium suave	Water Parsnip	4	-5			√	√	√	
CORNACEAE	**DOGWOOD FAMILY**								
Cornus alternifolia	Alternate-leaved Dogwood	6	5			√	√	√	√
Cornus stolonifera	Red-osier Dogwood	2	-3			√	√	√	√
PRIMULACEAE	**PRIMROSE FAMILY**								
Lysimachia spp.	Loosestrife spp.							√	
Lysimachia ciliata	Fringed Loosestrife	4	-3				√	√	√
Lysimachia nummularia	Moneywort	*	-4	-3	+		√		
Lysimachia terrestris	Swamp Candles	6	-5				√		√
Lysimachia thrysiflora	Tufted Loosestrife	7	-5				√	√	√
Trientalis borealis	Star-flower	6	-1			√	√		√
OLEACEAE	**OLIVE FAMILY**								
Fraxinus americana	White Ash	4	3			√	√	√	√
Fraxinus nigra	Black Ash	7	-4			√	√	√	√
ASCLEPIADACEAE	**MILKWEED FAMILY**								
Asclepias incarnata	Swamp Milkweed	6	-5			√	√		
Asclepias syriaca	Common Milkweed	0	5			√			
HYDROPHYLLACEAE	**WATERLEAF FAMILY**								
Hydrophyllum virginianum	Virginia Waterleaf	6	-2					√	
LAMIACEAE	**MINT FAMILY**								
Lycopus uniflorus	Northern Water-horehound	5	-5			√	√	√	√
Mentha arvensis	Field or Common Mint	3	-3			√	√		√
Scutellaria galericulata	Hooded Skullcap	6	-5			√		√	√
Scutellaria lateriflora	Mad-dog Skullcap	5	-5			√	√		
Scutellaria var	Skullcap sp.					√			
SOLANACEAE	**NIGHTSHADE FAMILY**								
Solanum dulcamara	Bittersweet Nightshade	*	0	-2	+	√	√	√	√
SCROPHULARIACEAE	**FIGWORT FAMILY**								
Linaria vulgaris	Toadflax, Butter-and-eggs	*	5	-1	+			√	
Veronica spp.	Speedwell species						√	√	√
Veronica anagallis-aquatica	Water Speedwell	*	-5	-1	+	√			
Veronica officinalis	Common Speedwell	*	5	-2	+			√	√
Veronica scutellata	Marsh Speedwell		7	-5		√		√	
RUBIACEAE	**MADDER FAMILY**								
Galium asprellum	Rough Bedstraw	6	-5			√		√	√
Galium palustre	Marsh Bedstraw	5	-5			√	√	√	√
Galium triflorum	Sweet-scented Bedstraw	4	2			√		√	√
CAPRIFOLIACEAE	**HONEYSUCKLE FAMILY**								
Lonicera tatarica	Tartarian Honeysuckle	*	3	-3	+	√	√	√	√
Sambucus canadensis	Common Elder	5	-2			√			
Viburnum trilobum	Highbush-cranberry	5	-3			√			√
CUCURBITACEAE	**GOURD FAMILY**								
Echinocystis lobata	Wild Cucumber	3	-2				√	√	√
ASTERACEAE	**ASTER FAMILY**								
Arctium minus	Common Burdock	*	5	-2	+		√		
Aster spp.	Aster species								√
Bidens frondosa	Beggarticks	3	-3				√	√	
Cirsium arvense	Canada Thistle	*	3	-1	+	√	√	√	√
Erigeron philadelphicus	Common Fleabane	0	1				√		
Eupatorium maculatum	Spotted Joe-Pye-Weed	3	-5			√	√	√	√
Eupatorium perfoliatum	Boneset	2	-4				√	√	
Eurybia macrophylla	Large-leaved Aster	5	5			√			√
Euthamia graminifolia	Grass-leaved Goldenrod	2	-2					√	√
Hieracium var	Hawkweed sp							√	
Lactuca serriola	Prickly Lettuce	*	0	-1		√			√
Prenanthes alba	White Lettuce, Rattlesnake-root	6	3			√			
Solidago altissima	Tall Goldenrod	1	3			√			
Solidago canadensis	Canada Goldenrod	1	3			√	√	√	√
Solidago flexicaulis	Zig-zag Goldenrod	6	3			√			
Solidago nemoralis	Gray Goldenrod	2	5					√	
Solidago patula	Rough-leaved Goldenrod	8	-5				√	√	
Solidago spp.	Goldenrod species					√	√	√	√
Sonchus arvensis	Field Sow-thistle	*	1	-1	+			√	
Symphyotrichum novae-angliae	New England Aster	2	-3				√	√	
Symphyotrichum puniceum var. puniceum	Purple-stemmed Aster	6	-5			√	√		√
Taraxacum officinale	Dandelion	*	3	-2	+	√	√	√	√

						NRSI			
Scientific Name	**Common Name**	**CC**	**CW**	**Weed**	**+**	**2006**	**2007**	**2008**	**2009**
Tussilago farfara	Coltsfoot	*	3	-2	+	√	√	√	√
POLYGONACEAE	**BUCKWHEAT FAMILY**								
Rumex crispus	Curly Dock	*	-1	-2	+			√	
CARYOPHYLLACEAE	**PINK FAMILY**								
Silene vulgaris	Bladder Campion	*	5	-1	+	√			
Total					**28**	**95**	**108**	**107**	**116**

Legend
CC Coefficient of Conservatism
CW Coefficient of Wetness
Weed Weediness Index
+ non-native species

APPENDIX II
Herbaceous Species Observed by Plot 2009

Appendix II. Herbaceous Species Observed by Plot in 2009

Vegetation Plot 001	MAMM1-3						

Sub-Plot 1

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)*
Carex aquatilis	Aquatic Sedge	7	-5			30	60
Aster var	Aster species				3	5	40
Calamagrostis canadensis	Blue-joint Grass	4	-5		20	30	40
Veronica var	Speedwell species				1	6	20
Impatiens capensis	Spotted Jewelweed	4	-3		6	4	40
Total					**30.0**	**75.0**	
Average		**5.0**	**-4.3**				

Sub-Plot 2

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Carex aquatilis	Aquatic Sedge	7	-5			5	60
Lemna spp.	Duckweed species				50	35	20
Carex lacustris	Lake Sedge	5	-5			10	60
Total					**50.0**	**50.0**	
Average		**6.0**	**-5.0**				

Sub-Plot 3

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Aster var	Aster species				1	2	40
Solidago var	Goldenrod species				2	3	20
Carex lacustris	Lake Sedge	5	-5			30	60
Total					**3.0**	**35.0**	
Average		**5.0**	**-5.0**				

Sub-Plot 4

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Carex lacustris	Lake Sedge	5	-5			15	60
Total						**15.0**	
Average		**5.0**	**-5.0**				

Sub-Plot 5

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Carex aquatilis	Aquatic Sedge	7	-5			20	60
Carex stipata	Awl-fruited Sedge	3	-5			30	20
Calamagrostis canadensis	Blue-joint Grass	4	-5			15	40
Impatiens capensis	Spotted Jewelweed	4	-3		18	10	40
Total					**18.0**	**75.0**	
Average		**4.5**	**-4.5**				

Total Species	**9**
Average CC	**5.1**
Average CW	**-4.8**
Native Species	**9**
Non-Native Species	**0**
Square Rt	**3.00**
NAI	**15.30**

* Frequency is the percent chance the species is found in the five subplots. E.g. If the species was found in only one subplot, its frequency is 20%. If it was found in 4 subplots, its frequency is 80%.

Appendix II. Herbaceous Species Observed by Plot in 2009

Vegetation Plot 002	SWCO1-2

Sub-Plot 1

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Caltha palustris	Marsh Marigold	5	-5		6	80	60
Total					**6.0**	**80.0**	
Average		**5.0**	**-5.0**				

Sub-Plot 2

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Epipactis helleborine	Helleborine	*	5	-2	1	1	20
Moss	Moss species					10	20
Maianthemum canadense	Wild Lily-of-the-valley	5	0		4	2	20
Total					**5**	**13**	
Average		**5.0**	**2.5**				

Sub-Plot 3

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Caltha palustris	Marsh Marigold	5	-5		1	1	60
Total					**1**	**1**	
Average		**5.0**	**-5.0**				

Sub-Plot 4

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
No vegetation species observed, only bare ground within sub-plot							

Sub-Plot 5

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Caltha palustris	Marsh Marigold	5	-5		3	5	60
Total					**3**	**5**	
Average		**5.0**	**-5.0**				

Total Species	**4**
Average CC	**5.0**
Average CW	**-3.1**
Native Species	**4**
Non-Native Species	**0**
Square Rt	**2.00**
NAI	**10.00**

Appendix II. Herbaceous Species Observed by Plot in 2009

Vegetation Plot 003	**FODM6**						
Sub-Plot 1							
Scientific Name	**Common Name**	**CC**	**CW**	**Weed**	**Number/m^2**	**Cover (%)/m^2**	**Frequency (%)**
Matteuccia struthiopteris	American Ostrich Fern	5	-3		4	15	100
Arisaema triphyllum	Jack-in-the-pulpit	5	-2		11	10	80
Moss	Moss species					5	40
Total					**15.0**	**30.0**	
Average		**5.0**	**-2.5**				

Sub-Plot 2

Scientific Name	**Common Name**	**CC**	**CW**	**Weed**	**Number/m^2**	**Cover (%)/m^2**	**Frequency (%)**
Matteuccia struthiopteris	American Ostrich Fern	5	-3		5	40	100
Total					**5.0**	**40.0**	
Average		**5.0**	**-3.0**				

Sub-Plot 3

Scientific Name	**Common Name**	**CC**	**CW**	**Weed**	**Number/m^2**	**Cover (%)/m^2**	**Frequency (%)**
Matteuccia struthiopteris	American Ostrich Fern	5	-3		6	40	100
Arisaema triphyllum	Jack-in-the-pulpit	5	-2		7	5	80
Dryopteris marginalis	Marginal Wood Fern	5	3		1	1	40
Total					**14.0**	**46.0**	
Average		**5.0**	**3.0**				

Sub-Plot 4

Scientific Name	**Common Name**	**CC**	**CW**	**Weed**	**Number/m^2**	**Cover (%)/m^2**	**Frequency (%)**
Matteuccia struthiopteris	American Ostrich Fern	5	-3		3	15	100
Arisaema triphyllum	Jack-in-the-pulpit	5	-2		1	1	80
Dryopteris marginalis	Marginal Wood Fern	5	3		3	10	40
Total					**7.0**	**26.0**	
Average		**5.0**	**3.0**				

Sub-Plot 5

Scientific Name	**Common Name**	**CC**	**CW**	**Weed**	**Number/m^2**	**Cover (%)/m^2**	**Frequency (%)**
Matteuccia struthiopteris	American Ostrich Fern	5	-3		5	20	100
Arisaema triphyllum	Jack-in-the-pulpit	5	-2		2	2	80
Moss	Moss species					3	40
Total					**7.0**	**25.0**	
Average		**5.0**	**-2.5**				

Total Species	**4**
Average CC	**5.0**
Average CW	**-0.4**
Native Species	**4**
Non-Native Species	**0**
Square Rt	**2.00**
NAI	**10.00**

Appendix II. Herbaceous Species Observed by Plot in 2009

Vegetation Plot 004	SWMM1-1						

Sub-Plot 1

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Moss	Moss species					2	80
Total						**2.0**	
Average							

Sub-Plot 2

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Moss	Moss species					10	80
Total						**10.0**	
Average							

Sub-Plot 3

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Dryopteris cristata	Crested Wood Fern	7	-5		3	1	20
Taraxacum officinale	Dandelion	*	3	-2	1	0.1	20
Grass	Grass species					0.5	20
Thelypteris palustris	Marsh Fern	5	-4		3	3	60
Equisetum pratense	Meadow Horsetail	8	-3		2	1	40
Onoclea sensibilis	Sensitive Fern	4	-3		2	1	60
Maianthemum canadense	Wild Lily-of-the-valley	5	0		2	0.2	20
Total					**13.0**	**6.8**	
Average		**5.8**	**-2.0**				

Sub-Plot 4

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Carex aquatilis	Aquatic Sedge	7	-5			20	20
Scutellaria galericulata	Common Skullcap	6	-5		21	4	20
Carex lacustris	Lake Sedge	5	-5			10	20
Galium palustre	Marsh Bedstraw	5	-5		20	4	20
Thelypteris palustris	Marsh Fern	5	-4		4	4	60
Equisetum pratense	Meadow Horsetail	8	-3		4	5	40
Moss	Moss species					5	80
Lycopus uniflorus	Northern Bugleweed	5	-5		1	1	20
Onoclea sensibilis	Sensitive Fern	4	-3		5	15	60
Impatiens capensis	Spotted Jewelweed	4	-3		2	0.1	20
Total					**57.0**	**68.1**	
Average		**5.4**	**-4.2**				

Sub-Plot 5

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Thelypteris palustris	Marsh Fern	5	-4		1	0.5	60
Moss	Moss species					5	80
Onoclea sensibilis	Sensitive Fern	4	-3		5	2	60
Total					**6.0**	**7.5**	
Average		**4.5**	**-3.5**				

Total Species	**14**
Average CC	**5.2**
Average CW	**-3.5**
Native Species	**13**
Non-Native Species	**1**
Square Rt	**3.61**
NAI	**18.92**

Appendix II. Herbaceous Species Observed by Plot in 2009

Vegetation Plot 005	FOMM6						

Sub-Plot 1

Scientific Name	Common Name	CC	CW	Weed	Number/m²	Cover (%)/m²	Frequency (%)
	Fern species				1	0.1	20
Moss	Moss species					3	80
Total					**1.0**	**3.1**	
Average							

Sub-Plot 2

Scientific Name	Common Name	CC	CW	Weed	Number/m²	Cover (%)/m²	Frequency (%)
Moss	Moss species					5	80
Total						**5.0**	
Average							

Sub-Plot 3

Scientific Name	Common Name	CC	CW	Weed	Number/m²	Cover (%)/m²	Frequency (%)
Moss	Moss species					50	80
Total						**50.0**	
Average							

Sub-Plot 4

Scientific Name	Common Name	CC	CW	Weed	Number/m²	Cover (%)/m²	Frequency (%)
Grass	Grass species					0.1	20
Equisetum pratense	Meadow Horsetail	8	-3		7	3	20
Maianthemum canadense	Wild Lily-of-the-valley	5	0		1	0.1	20
Total					**8.0**	**3.2**	
Average		**6.5**	**-1.5**				

Sub-Plot 5

Scientific Name	Common Name	CC	CW	Weed	Number/m²	Cover (%)/m²	Frequency (%)
Moss	Moss species					1	80
Total						**1.0**	
Average							

Total Species	**5**
Average CC	**6.5**
Average CW	**-1.5**
Native Species	**5**
Non-Native Species	**0**
Square Rt	**2.24**
NAI	**14.53**

Appendix II. Herbaceous Species Observed by Plot in 2009

Vegetation Plot 006 **MAMM1-3**

Sub-Plot 1

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Echinochloa crusgalli	Barnyard Grass	*	3	-1		3	80
Birdsfoot Trefoil	Birdsfoot Trefoil	*	1	-2	2	0.2	40
Solidago canadensis	Canada Goldenrod	1	3		10	5	20
Tussilago farfara	Coltsfoot	*	3	-2	20	20	100
Equisetum arvense	Field Horsetail	0	0		6	2	60
Carex vulpinoidea	Fox Sedge	3	-5			50	60
Euthamia graminifolia	Grass-leaved Goldenrod	2	-2		22	3	100
Total					**60.0**	**83.2**	
Average		**1.5**	**0.4**				

Sub-Plot 2

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Echinochloa crusgalli	Barnyard Grass	*	3	-1			80
Cirsium arvense	Canada Thistle	*	3	-1	1	0.5	20
Tussilago farfara	Coltsfoot	*	3	-2	5	4	100
Taraxacum officinale	Dandelion	*	3	-2	1	0.5	40
Carex vulpinoidea	Fox Sedge	3	-5			6	60
Euthamia graminifolia	Grass-leaved Goldenrod	2	-2		20	15	100
Galium palustre	Marsh Bedstraw	5	-5		1	0.5	20
Juncus tenuis	Path Rush	0	0			8	60
Phalaris arundinacea	Reed Canary Grass	0	-4			50	80
Total					**28.0**	**84.5**	
Average		**2.0**	**-0.4**				

Sub-Plot 3

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Echinochloa crusgalli	Barnyard Grass	*	3	-1		8	80
Tussilago farfara	Coltsfoot	*	3	-2	4	5	100
Taraxacum officinale	Dandelion	*	3	-2	1	0.2	40
Equisetum arvense	Field Horsetail	0	0		2	0.5	60
Euthamia graminifolia	Grass-leaved Goldenrod	2	-2		40	25	100
Epilobium hirsutum	Hairy Willow Herb	*	-4	-2	3	1	40
Moss	Moss species					3	40
Juncus tenuis	Path Rush	0	0			3	60
Phalaris arundinacea	Reed Canary Grass	0	-4			45	80
Total					**50.0**	**90.7**	
Average		**0.5**	**-0.1**				

Sub-Plot 4

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Tussilago farfara	Coltsfoot	*	3	-2	3	0.2	100
Typha latifolia	Common Cattail	3	-5		30	50	20
Euthamia graminifolia	Grass-leaved Goldenrod	2	-2		35	20	100
Epilobium hirsutum	Hairy Willow Herb	*	-4	-2	2	0.2	40
Juncus tenuis	Path Rush	0	0			0.1	60
Phalaris arundinacea	Reed Canary Grass	0	-4			30	80
Total					**70.0**	**100.5**	
Average		**1.3**	**-2.0**				

Sub-Plot 5

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Echinochloa crusgalli	Barnyard Grass	*	3	-1		3	80
Lotus corniculatus	Birdsfoot Trefoil	0	0		2	0.1	40
Tussilago farfara	Coltsfoot	*	3	-2	6	8	100
Equisetum arvense	Field Horsetail	0	0		15	10	60
Carex vulpinoidea	Fox Sedge	3	-5			40	60
Euthamia graminifolia	Grass-leaved Goldenrod	2	-2		45	20	100
Moss	Moss species					5	40
Phalaris arundinacea	Reed Canary Grass	0	-4			5	80
Carex stricta	Stiff Sedge	4	-5			5	20
Total					**68.0**	**96.1**	
Average		**1.5**	**-1.3**				

Total Species	**16**
Average CC	**1.4**
Average CW	**-0.7**
Native Species	**11**
Non-Native Species	**5**
Square Rt	**3.32**
NAI	**4.48**

Appendix II. Herbaceous Species Observed by Plot in 2009

Vegetation Plot 007	**SWMM1-1**						
Sub-Plot 1							
Scientific Name	**Common Name**	**CC**	**CW**	**Weed**	**Number/m^2**	**Cover (%)/m^2**	**Frequency (%)**
Cystopteris bulbifera	Bulblet Fern	5	-2		2	0.2	60
Circaea quadrisulcata	Enchanter's Nightshade	3	3		10	1	20
Arisaema triphyllum	Jack-in-the-pulpit	5	-2		1	0.1	40
Aralia nudicaulis	Wild Sarsaparilla	4	3		5	6	100
Total					**18.0**	**7.3**	
Average		**4.3**	**0.5**				

Sub-Plot 2

Scientific Name	**Common Name**	**CC**	**CW**	**Weed**	**Number/m^2**	**Cover (%)/m^2**	**Frequency (%)**
Cystopteris bulbifera	Bulblet Fern	5	-2		3	2	60
Circaea alpina	Dwarf Enchanter's Nightshade	6	-3		5	1	20
Moss	Moss species					10	60
Lyopus virginicus	Northern Bugleweed	5	-5		7	3	20
Impatiens capensis	Spotted Jewelweed	4	-3		6	10	20
Cicuta maculata	Spotted Water Hemlock	6	-5		1	1	20
Hydrocotyle americana	Water-pennywort	7	-5		33	3	20
Aralia nudicaulis	Wild Sarsasparilla	4	3		1	3	100
Total					**56.0**	**33.0**	
Average		**5.3**	**-2.9**				

Sub-Plot 3

Scientific Name	**Common Name**	**CC**	**CW**	**Weed**	**Number/m^2**	**Cover (%)/m^2**	**Frequency (%)**
Arisaema triphyllum	Jack-in-the-pulpit	5	-2		1	1	40
Carex laxiflora	Loose-flowered Sedge	5	0			1	20
Dryopteris marginalis	Marginal Wood Fern	5	3		2	1	20
Moss	Moss species					6	60
Aralia nudicaulis	Wild Sarsasparilla	4	3		5	3	100
Total					**8.0**	**12.0**	
Average		**4.8**	**1.0**				

Sub-Plot 4

Scientific Name	**Common Name**	**CC**	**CW**	**Weed**	**Number/m^2**	**Cover (%)/m^2**	**Frequency (%)**
Grass	Grass species					2	20
Epipactis helleborine	Helleborine	*	5	-2	1	0.1	40
Gymnocarpium dryopteris	Oak Fern	7	0		8	1.5	20
Maianthemum canadense	Wild Lily-of-the-valley	5	0		1	0.1	40
Aralia nudicaulis	Wild Sarsaparilla	4	3		13	25	100
Total					**23.0**	**28.7**	
Average		**5.3**	**2.0**				

Sub-Plot 5

Scientific Name	**Common Name**	**CC**	**CW**	**Weed**	**Number/m^2**	**Cover (%)/m^2**	**Frequency (%)**
Cystopteris bulbifera	Bulblet Fern	5	-2		1	1	60
Epipactis helleborine	Helleborine	*	5	-2	1	0.5	40
Moss	Moss species					30	60
Maianthemum stellatum	Star Flowered False Solomon's-seal	6	1		17	5	20
Maianthemum canadense	Wild Lily-of-the-valley	5	0		9	1	40
Aralia nudicaulis	Wild Sarsaparilla	4	3		11	20	100
Total					**39.0**	**57.5**	
Average		**5.0**	**1.4**				

Total Species	**17**
Average CC	**4.9**
Average CW	**0.4**
Native Species	**16**
Non-Native Species	**1**
Square Rt	**4.00**
NAI	**19.70**

Appendix II. Herbaceous Species Observed by Plot in 2009

Vegetation Plot 008 **SWMM1-1**

Sub-Plot 1

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Carex stipata	Awl-fruited Sedge	3	-5			3	20
Echinochloa crusgalli	Barnyard Grass	*	3	-1		5	20
Galium palustre	Marsh Bedstraw	5	-5		2	1	20
Symphyotrichum puniceum var. puniceum	Purple-Stemmed Aster				10	25	40
Impatiens capensis	Spotted Jewelweed	4	-3		2	1	20
Eupatorium maculatum	Spotted Joe-Pye Weed	3	-5		16	30	20
Ranunculus acris	Tall Buttercup	*	-2	-2	1	1	40
Mentha arvensis	Wild Mint	3	-3		2	1	40
Poa nemoralis	Wood Bluegrass	0	0	-1		33	40
Total					**33.0**	**100.0**	
Average		**3.0**	**-2.5**				

Sub-Plot 2

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Taraxacum officinale	Dandelion	*	3	-2	1	5	40
Moss	Moss species					35	60
Total					**1.0**	**40.0**	
Average			**3.0**				

Sub-Plot 3

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Cystopteris bulbifera	Bulblet Fern	5	-2		2	2	20
Tussilago farfara	Coltsfoot	*	3	-2	3	5	20
Taraxacum officinale	Dandelion	*	3	-2	2	2	40
Moss	Moss species					2	60
Lactuca serriola	Prickly Lettuce	*	0	-1	3	5	20
Total					**10.0**	**16.0**	
Average		**5.0**	**1.0**				

Sub-Plot 4

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Moss	Moss species					1	60
Total						**1.0**	
Average							

Sub-Plot 5

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Carex aquatilis	Aquatic Sedge	7	-5			15	20
Galium palustre	Marsh Bedstraw	5	-5		1	1	20
Symphyotrichum puniceum var. puniceum	Purple-Stemmed Aster				1	5	40
Leersia oryzoides	Rice Cutgrass	3	-5			20	20
Ranunculus acris	Tall Buttercup	*	-2	-2	5	5	40
unknown species	unknown species				3	5	20
Mentha arvensis	Wild Mint	3	-3		10	5	40
Poa nemoralis	Wood Bluegrass	*	0	-1		20	40
Total					**20.0**	**76.0**	
Average		**4.5**	**-3.3**				

Total Species	**18**
Average CC	**4.2**
Average CW	**-0.5**
Native Species	**12**
Non-Native Species	**6**
Square Rt	**3.46**
NAI	**14.43**

Appendix II. Herbaceous Species Observed by Plot in 2009

Vegetation Plot 009	MASM1-1						

Sub-Plot 1

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Phalaris arundinacea	Reed Canary Grass	0	-4			80	100
Total						**80.0**	
Average		**0.0**	**-4.0**				

Sub-Plot 2

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Carex stipata	Awl-fruited Sedge	3	-5			30	60
Typha latifolia	Common Cattail	3	-5		3	3	60
Phalaris arundinacea	Reed Canary Grass	0	-4			67	100
Total					**3.0**	**100.0**	
Average		**2.0**	**-4.7**				

Sub-Plot 3

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Carex stipata	Awl-fruited Sedge	3	-5			20	60
Solidago canadensis	Canada Goldenrod	1	3		20	6	20
Tussilago farfara	Coltsfoot	*	3	-2	1	0.5	20
Taraxacum officinale	Dandelion	*	3	-2	3	0.5	20
Phalaris arundinacea	Reed Canary Grass	0	-4			70	100
Mentha arvensis	Wild Mint	3	-3		8	1.5	40
Total					**32.0**	**98.5**	
Average		**1.8**	**-0.5**				

Sub-Plot 4

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Carex stipata	Awl-fruited Sedge	3	-5			25	60
Typha latifolia	Common Cattail	3	-5		6	25	60
Lysimachia ciliata	Fringed Loosestrife	4	-3		22	5	20
Phalaris arundinacea	Reed Canary Grass	0	-4			44.5	100
Mentha arvensis	Wild Mint	3	-3		3	0.5	40
Total					**31.0**	**100.0**	
Average		**2.6**	**-4.0**				

Sub-Plot 5

Scientific Name	Common Name	CC	CW	Weed	Number/m^2	Cover (%)/m^2	Frequency (%)
Typha latifolia	Common Cattail	3	-5	0	2	5	60
Phalaris arundinacea	Reed Canary Grass	0	-4	0		85	100
Total					**2.0**	**90.0**	
Average		**1.5**	**-4.5**				

Total Species	**8**
Average CC	**1.6**
Average CW	**-3.5**
Native Species	**6**
Non-Native Species	**2**
Square Rt	**2.45**
NAI	**3.85**

APPENDIX III
Herbaceous Species Observed by Subplot 2006-2009

Appendix III. Herbaceous Species Observed by Sub-Plot 2006-2009

		NRSI			
		2006	2007	2008	2009
Vegetation Plot 001	**MAMM1-3**				
Sub-Plot 1					
Aster var	Aster species		√	√	√
Calamagrostis canadensis	Canada Blue-joint		√	√	√
Carex aquatilis	Aquatic Sedge				√
Carex lacustris	Lake Sedge	√			
Carex stipata	Awl-fruited Sedge			√	
Cirsium arvense	Canada Thistle	√			
Equisetum arvense	Field Horsetail		√	√	
Equisetum pratense	Meadow Horsetail	√			
Impatiens capensis	Spotted Jewelweed		√	√	√
Moss spp.	Moss		√		
Solidago canadensis	Canada Goldenrod	√			
Solidago spp.	Goldenrod species			√	
Veronica var	Speedwell species				√
Poa spp.	Grass species	√			
Sub-Plot 2					
Calamagrostis canadensis	Canada Blue-joint	√	√		
Carex aquatilis	Aquatic Sedge				√
Carex lacustris	Lake Sedge			√	√
Carex rostrata	Beaked Sedge		√		
Carex stipata	Awl-fruited Sedge	√	√		
Equisetum arvense	Field Horsetail		√		
Equisetum pratense	Meadow Horsetail	√			
Galium palustre	Marsh Bedstraw			√	
Grass	Grass species	√			
Impatiens capensis	Spotted Jewelweed	√	√	√	
Juncus species	Rush species	√			
Lemna spp.	Duckweed species				√
Lycopus uniflorus	Northern Water-horehound			√	
Solanum dulcamara	Bittersweet Nightshade	√			
Solidago canadensis	Canada Goldenrod	√			

Sub-Plot 3					
Aster var	Aster species				√
Calamagrostis canadensis	Canada Blue-joint	√	√		
Carex lacustris	Lake Sedge	√		√	√
Carex rostrata	Beaked Sedge		√		
Carex stipata	Awl-fruited Sedge	√			
Equisetum pratense	Meadow Horsetail	√			
Grass	Grass species	√			
Impatiens capensis	Spotted Jewelweed	√	√	√	
Lycopus uniflorus	Northern Water-horehound		√		
Lysimachia thrysiflora	Tufted Loosestrife		√		
Sium suave	Water Parsnip		√		
Solidago canadensis	Canada Goldenrod	√			
Solidago var	Goldenrod species				√
Sub-Plot 4					
Asclepias incarnata	Swamp Milkweed		√		
Calamagrostis canadensis	Canada Blue-joint	√	√		
Carex lacustris	Lake Sedge			√	√
Carex stipata	Awl-fruited Sedge	√	√		
Impatiens capensis	Spotted Jewelweed	√	√		
Leersia oryzoides	Cut grass	√			
Lycopus uniflorus	Northern Water-horehound		√		
Lysimachia spp.	Loosestrife species			√	
Sium suave	Water Parsnip	√			
Sub-Plot 5					
Aster spp.	Aster species		√		
Calamagrostis canadensis	Canada Blue-joint	√	√	√	√
Carex aquatilis	Aquatic Sedge				√
Carex lacustris	Lake Sedge		√		
Carex stipata	Awl-fruited Sedge	√	√	√	√
Carex stricta	Stiff Sedge (Tussock)		√		
Cirsium arvense	Canada Thistle	√			
Equisetum arvense	Field Horsetail		√	√	
Impatiens capensis	Spotted Jewelweed		√	√	√
Solidago canadensis	Canada Goldenrod	√			
Solidago spp.	Goldenrod species		√		

Vegetation Plot 002	**SWCO1-2**				
Sub-Plot 1					
Aster spp.	Aster species		√		
Caltha palustris	Marsh Marigold	√		√	√
Equisetum palustre	Marsh Horsetail		√		
Moss	Moss species	√		√	
Sub-Plot 2					
Caltha palustris	Marsh-marigold	√			
Cysptopteris tenuis	Mackay's Fragile Fern		√		
Epipactis helleborine	Helleborine				√
Equisetum pratense	Meadow Horsetail	√			
Fragaria vesca	Woodland Strawberry	√			
Grass	Grass species		√		
Lycopus uniflorus	Northern Water-horehound	√			
Maianthemum canadense	Wild Lily-of-the-valley	√	√	√	√
Moss	Moss species	√	√		√
Solidago spp.	Goldenrod species		√		
Taraxacum officinale	Dandelion		√	√	
Sub-Plot 3					
Caltha palustris	Marsh Marigold	√	√		√
Equisetum pratense	Meadow Horsetail	√			
Lycopus uniflorus	Northern Water-horehound	√			
Moss	Moss species	√	√		
Sub-Plot 4					
Caltha palustris	Marsh Marigold		√	√	
Moss	Moss species		√		
Sub-Plot 5					
Caltha palustris	Marsh Marigold	√	√	√	√
Dryopteris carthusiana	Spinulose Wood Fern		√		
Lycopus uniflorus	Northern Water-horehound		√		
Maianthemum canadense	Wild Lily-of-the-valley	√		√	
Moss	Moss species	√	√	√	
Taraxacum officinale	Dandelion		√		

Vegetation Plot 003	**FODM6**				
Sub-Plot 1					
Arisaema triphyllum	Jack-in-the-pulpit				√
Matteuccia struthiopteris	American Ostrich Fern	√	√	√	√
Moss	Moss species	√			√
Solanum dulcamara	Bittersweet Nightshade	√			
Thelypteris palustris	Marsh Fern			√	
Sub-Plot 2					
Matteuccia struthiopteris	American Ostrich Fern	√	√	√	√
Moss	Moss species	√			
Sub-Plot 3					
Arisaema triphyllum	Jack-in-the-pulpit				√
Dryopteris marginalis	Marginal Wood Fern				√
Matteuccia struthiopteris	American Ostrich Fern	√	√	√	√
Sub-Plot 4					
Arisaema triphyllum	Jack-in-the-pulpit				√
Dryopteris clintoniana	Clinton's Wood Fern		√		
Dryopteris marginalis	Marginal Wood Fern				√
Matteuccia struthiopteris	American Ostrich Fern	√	√	√	√
Sub-Plot 5					
Arisaema triphyllum	Jack-in-the-pulpit				√
Dryopteris clintoniana	Clinton's Wood Fern		√		
Matteuccia struthiopteris	American Ostrich Fern	√	√	√	√
Moss	Moss species				√

Vegetation Plot 004	**SWMM1-1**				
Sub-Plot 1					
Dryopteris clintoniana	Clinton's Wood Fern		√		
Moss	Moss species				√
Parthenocissus inserta	Virginia Creeper	√			
Sub-Plot 2					
Cicuta maculata	Spotted Water-hemlock		√		
Circaea quadrisulcata	Enchanter's Nightshade		√		
Cystopteris bulbifera	Bulblet Fern		√		
Dryopteris carthusiana	Spinulose Wood Fern			√	
Equisetum arvense	Field Horsetail		√		
Equisetum pratense	Meadow Horsetail	√			
Galium palustre	Marsh Bedstraw		√		
Maianthemum canadense	Wild Lily-of-the-valley			√	
Moss	Moss species		√	√	√
Onoclea sensibilis	Sensitive Fern	√	√	√	
Pilea pumila	Clearweed			√	
Scirpus americanus	Three Square		√		
Scutellaria lateriflora	Mad-dog Skullcap	√			
Sub-Plot 3					
Cystopteris bulbifera	Bulblet Fern		√		
Dryopteris carthusiana	Spinulose Wood Fern	√			
Dryopteris cristata	Crested Wood Fern			√	√
Equisetum arvense	Field Horsetail		√		
Equisetum pratense	Meadow Horsetail	√			√
Galium palustre	Marsh Bedstraw		√		
Grass	Grass species	√		√	√
Impatiens capensis	Spotted Jewelweed		√		
Maianthemum canadense	Canada Mayflower				√
Onoclea sensibilis	Sensitive Fern	√	√	√	√
Scirpus americanus	Three Square		√		
Scirpus pungens	Common Three Square	√			
Taraxacum officinale	Dandelion				√
Thelypteris palustris	Marsh Fern	√		√	√
Tiarella cordifolia	Foam Flower		√		
	Moss species	√	√	√	

Sub-Plot 4					
Carex aquatilis	Aquatic Sedge				√
Carex lacustris	Lake Sedge			√	√
Cicuta maculata	Spotted Water-hemlock		√		
Dryopteris clintoniana	Clinton's Wood Fern		√		
Dryopteris cristata	Crested Wood Fern			√	
Equisetum arvense	Field Horsetail		√	√	
Equisetum pratense	Meadow Horsetail	√			√
Eupatorium maculatum	Spotted Joe-Pye-Weed	√			
Galium palustre	Marsh Bedstraw	√	√	√	√
Grass	Grass species			√	
Impatiens capensis	Spotted Jewelweed		√		√
Lycopus uniflorus	Northern Bugleweed	√		√	√
Moss	Moss species	√	√	√	√
Onoclea sensibilis	Sensitive Fern	√	√	√	√
Parthenocissus inserta	Virginia Creeper	√		√	
Scirpus americanus	Three Square		√	√	
Scirpus pungens	Common Three Square	√			
Scutellaria galericulata	Hooded Skullcap			√	√
Solanum dulcamara	Bittersweet Nightshade			√	
Thelypteris palustris	Marsh Fern	√		√	√
Sub-Plot 5					
Dryopteris carthusiana	Spinulose Wood Fern	√			
Grass	Grass species		√	√	
Lysimachia terrestris	Swamp Candles		√		
Moss	Moss species	√	√	√	√
Onoclea sensibilis	Sensitive Fern	√	√	√	√
Taraxacum officinale	Dandelion	√			
Thelypteris noveboracensis	New York Fern		√		
Thelypteris palustris	Marsh Fern	√		√	√
Veronica scutellata	Marsh Speedwell	√			

Vegetation Plot 005	FOMM6				
Sub-Plot 1					
Arisaema triphyllum	Jack-in-the-pulpit		√		
Athyrium filix-femina	Northeastern Lady Fern		√		
Moss	Moss species	√	√		√
	Fern species				√
Sub-Plot 2					
Equisetum arvense	Field Horsetail		√	√	
Maianthemum canadense	Wild Lily-of-the-valley		√	√	
Moss	Moss species	√	√	√	√
Sub-Plot 3					
Equisetum arvense	Field Horsetail		√		
Equisetum pratense	Meadow Horsetail	√			
Moss	Moss species	√	√	√	√
Sub-Plot 4					
Equisetum arvense	Field Horsetail		√	√	
Equisetum pratense	Meadow Horsetail	√			√
Grass	Grass species				√
Maianthemum canadense	Canada Mayflower				√
Moss	Moss species	√			
Sub-Plot 5					
Moss	Moss species	√	√		√

Vegetation Plot 006	**MAMM1-3**				
Sub-Plot 1					
Birdsfoot Trefoil	Birdsfoot Trefoil		√		√
Carex vulpinoidea	Fox Sedge		√		√
Cirsium arvense	Canada Thistle	√	√		
Echinochloa crusgalli	Barnyard Grass				√
Equisetum arvense	Field Horsetail		√	√	√
Euthamia graminifolia	Grass-leaved Goldenrod				√
Grass	Grass species	√	√		
Juncus tenuis	Path Rush	√			
Poa pratensis	Kentucky Blue Grass			√	
Solidago altissima	Tall Goldenrod	√			
Solidago canadensis	Canada Goldenrod	√	√	√	√
Symphyotrichum lanceolatum	Panicled Aster			√	
Symphyotrichum novae-angliae	New England Aster		√		
Symphyotrichum puniceum var. puniceum	Purple-Stemmed Aster		√		
Tussilago farfara	Coltsfoot	√	√	√	√

Sub-Plot 2					
Aster novae-angliae	New England Aster			√	
Carex Stipata	Awl-fruited Sedge	√			
Carex trisperma var. trisperma	Three-seeded Sedge		√		
Carex vulpinoidea	Fox Sedge				√
Cirsium arvense	Canada Thistle	√	√	√	√
Echinochloa crusgalli	Barnyard Grass				√
Equisetum arvense	Field Horsetail		√	√	
Euthamia graminifolia	Grass-leaved Goldenrod				√
Galium palustre	Marsh Bedstraw				√
Grass	Grass species	√			
Hieracium pratense	King Devil Hawkweed			√	
Juncus tenuis	Path Rush				√
Lactuca serriola	Prickly Lettuce	√			
Lotus corniculatus	Bird-foot Trefoil			√	
Mentha arvensis	Field or Common Mint			√	
Moss spp.	Moss species		√		
Phalaris arundinacea	Reed Canary Grass				√
Poa pratensis	Kentucky Blue Grass		√	√	
Solidago altissima	Tall Goldenrod	√			
Solidago canadensis	Canada Goldenrod			√	
Symphyotrichum lanceolatum	Panicled Aster			√	
Symphyotrichum puniceum var. puniceum	Purple-Stemmed Aster		√		
Taraxacum officinale	Dandelion	√	√		√
Tussilago farfara	Coltsfoot	√	√	√	√
Waldsteinia fragarioides	Barren Strawberry		√		

Sub-Plot 3					
Carex stipata	Awl-fruited Sedge	√			
Carex stricta	Stiff Sedge (Tussock)			√	
Carex vulpinoidea	Fox Sedge			√	
Cirsium arvense	Canada Thistle	√	√		
Echinochloa crusgalli	Barnyard Grass				√
Epilobium hirsutum	Hairy Willow Herb				√
Equisetum arvense	Field Horsetail		√	√	√
Equisetum pratense	Meadow Horsetail	√			
Euthamia graminifolia	Grass-leaved Goldenrod			√	√
Grass	Grass species	√	√		
Juncus tenuis	Path Rush				√
Lotus corniculatus	Bird-foot Trefoil	√	√	√	
Moss	Moss species		√		√
Phalaris arundinacea	Reed Canary Grass				√
Scirpus atrovirens	Dark Green Bulrush			√	
Solidago altissima	Tall Goldenrod	√			
Symphyotrichum lanceolatum	Panicled Aster			√	
Symphyotrichum puniceum var. puniceum	Purple-Stemmed Aster		√		
Taraxacum officinale	Dandelion		√		√
Tussilago farfara	Coltsfoot	√	√	√	√
Waldsteinia fragarioides	Barren Strawberry		√		

Sub-Plot 4					
Carex vulpinoidea	Fox Sedge				
Cirsium arvense	Canada Thistle	√	√		
Eleocharis smallii	Small's Spike-Rush		√		
Epilobium hirsutum	Hairy Willow Herb				√
Equisetum arvense	Field Horsetail		√		
Equisetum pratense	Meadow Horsetail	√			
Euthamia graminifolia	Grass-leaved Goldenrod			√	√
Grass	Grass species	√	√	√	
Juncus tenuis	Path Rush				√
Lactuca serriola	Prickly Lettuce	√			
Lotus corniculatus	Bird-foot Trefoil	√	√	√	
Phalaris arundinacea	Reed Canary Grass				√
Solidago altissima	Tall Goldenrod	√			
Solidago canadensis	Canada Goldenrod	√	√		
Symphyotrichum lanceolatum	Panicled Aster				
Symphyotrichum puniceum var. puniceum	Purple-Stemmed Aster		√		
Trifolium hybridum	Alsike Clover	√			
Tussilago farfara	Coltsfoot	√	√	√	√
Typha latifolia	Common Cattail				√

Sub-Plot 5					
Carex stricta	Stiff Sedge				√
Carex trisperma var. trisperma	Three-seeded Sedge		√		
Carex vulpinoidea	Fox Sedge				√
Cirsium arvense	Canada Thistle	√		√	
Echinochloa crusgalli	Barnyard Grass				√
Equisetum arvense	Field Horsetail		√	√	√
Erigeron philadelphicus	Philadelphia Fleabane		√		
Euthamia graminifolia	Grass-leaved Goldenrod				√
Grass	Grass species	√	√		
Juncus tenuis	Path Rush			√	
Lotus corniculatus	Birdsfoot Trefoil		√		√
Moss	Moss species				√
Phalaris arundinacea	Reed Canary Grass				√
Phleum pratense	Timothy			√	
Poa pratensis	Kentucky Blue Grass			√	
Solidago altissima	Tall Goldenrod	√			
Solidago canadensis	Canada Goldenrod	√	√	√	
Symphyotrichum lanceolatum	Panicled Aster			√	
Symphyotrichum novae-angliae	New England Aster		√		
Symphyotrichum puniceum var. puniceum	Purple-Stemmed Aster		√		
Tussilago farfara	Coltsfoot	√	√	√	√

Vegetation Plot 007	**SWMM1-1**				
Sub-Plot 1					
Aralia nudicaulis	Wild Sarsaparilla			√	√
Arisaema triphyllum	Jack-in-the-pulpit				√
Cicuta maculata	Spotted Water-hemlock	√	√		
Circaea quadrisulcata	Enchanter's Nightshade		√		√
Cystopteris bulbifera	Bulblet Fern				√
Dryopteris carthusiana	Spinulose Wood Fern		√		
Impatiens capensis	Spotted Jewelweed		√		
Lycopus americanus	American Water-horehound	√			
Ranunculus hispidus var. caricetorum	Swamp Buttercup	√			
Scutellaria lateriflora	Mad-dog Skullcap	√			
Taraxacum officinale	Dandelion		√		
Thelypteris palustris	Marsh Fern	√			
Sub-Plot 2					
Alisma subcordatum	Water-Plantain			√	
Aralia nudicaulis	Wild Sarsasparilla				√
Caltha palustris	Marsh-marigold	√			
Cicuta maculata	Spotted Water Hemlock	√	√		√
Circaea alpina	Dwarf Enchanter's Nightshade				√
Circaea alpina	Enchanter's Nightshade	√	√		
Cystopteris bulbifera	Bulblet Fern				√
Dryopteris carthusiana	Spinulose Wood Fern	√			
Grass	Grass species		√		
Hydrocotyle americana	Water-pennywort	√			√
Hydrophyllum virginianum	Virginia Waterleaf			√	
Impatiens capensis	Spotted Jewelweed	√	√	√	√
Lycopus uniflorus	Northern Water-horehound			√	
Lyopus virginicus	Northern Bugleweed				√
Lysimachia spp.	Loosestrife spp.			√	
Maianthemum canadense	Wild Lily-of-the-valley	√			
Moss	Moss species	√	√		√
Parthenocissus inserta	Virginia Creeper	√			
Polystichum acrostichoides	Christmas Fern	√			
Thelypteris palustris	Marsh Fern	√			
Trientalis borealis	Star-flower	√			
Veronica officinalis	Common Speedwell			√	

Sub-Plot 3					
Aralia nudicaulis	Wild Sarsaparilla		√	√	√
Arisaema triphyllum	Jack-in-the-pulpit			√	√
Carex laxiflora	Loose-flowered Sedge				√
Clintonia borealis	Bluebead-lily		√		
Cystopteris bulbifera	Bulblet Fern		√		
Dryopteris marginalis	Marginal Wood Fern				√
Grass	Grass		√		
Impatiens capensis	Spotted Jewelweed	√			
Maianthemum canadense	Wild Lily-of-the-valley		√		
Moss	Moss species	√	√		√
Sub-Plot 4					
Aralia nudicaulis	Wild Sarsaparilla	√	√	√	√
Arisaema triphyllum	Jack-in-the-pulpit	√		√	
Dryopteris carthusiana	Spinulose Wood Fern	√	√		
Epipactis helleborine	Helleborine				√
Grass	Grass species		√		√
Gymnocarpium dryopteris	Oak Fern				√
Maianthemum canadense	Wild Lily-of-the-valley		√		√
Maianthemum stellatum	Star Flowered False Solomon's-seal			√	
Moss	Moss species	√	√		
Thelypteris palustris	Marsh Fern	√			
Sub-Plot 5					
Aralia nudicaulis	Wild Sarsaparilla	√	√	√	√
Arisaema triphyllum	Jack-in-the-pulpit		√		
Carex spp.	Sedge species		√	√	
Circaea alpina	Enchanter's Nightshade	√	√		
Cystopteris bulbifera	Bulblet Fern				√
Dryopteris carthusiana	Spinulose Wood Fern		√		
Dryopteris clintoniana	Clinton's Wood Fern		√		
Epipactis helleborine	Helleborine				√
Maianthemum canadense	Wild Lily-of-the-valley	√	√	√	√
Maianthemum racemosum	False Solomon's-seal		√	√	
Maianthemum stellatum	Star Flowered False Solomon's-seal			√	√
Moss	Moss species	√	√	√	√
Taraxacum officinale	Dandelion	√			
Thelypteris palustris	Marsh Fern	√			
Trientalis borealis	Star-flower		√		

Vegetation Plot 008	**SWMM1-1**				
Sub-Plot 1					
Carex stipata	Awl-fruited Sedge				√
Echinochloa crusgalli	Barnyard Grass				√
Eupatorium maculatum	Spotted Joe-Pye Weed				√
Galium palustre	Marsh Bedstraw				√
Geranium robertianum	Herb Robert	√			
Grass	Grass species		√		
Impatiens capensis	Spotted Jewelweed	√			√
Lysimachia nummularia	Moneywort		√		
Lysimachia thrysiflora	Tufted Loosestrife		√		
Mentha arvensis	Wild Mint				√
Moss	Moss species		√		
Poa nemoralis	Wood Bluegrass				√
Ranunculus acris	Tall Buttercup				√
Symphyotrichum puniceum var. puniceum	Purple-Stemmed Aster				√
Sub-Plot 2					
Dryopteris carthusiana	Spinulose Wood Fern			√	
Geranium robertianum	Herb Robert		√	√	
Moss	Moss species	√	√	√	√
Taraxacum officinale	Dandelion				√
Sub-Plot 3					
Cystopteris bulbifera	Bulblet Fern				√
Fragaria vesca	Woodland Strawberry			√	
Lactuca serriola	Prickly Lettuce				√
Moss	Moss species	√	√		√
Taraxacum officinale	Dandelion				√
Tussilago farfara	Coltsfoot				√
Sub-Plot 4					
Grass	Grass species		√		
Moss	Moss species	√	√	√	√
Scirpus pungens	Common Three Square	√			
Taraxacum officinale	Dandelion	√	√		

Sub-Plot 5					
Aster lanceolatus	Tall White Aster	√			
Caltha palustris	Marsh-marigold	√		√	
Carex aquatilis	Aquatic Sedge				√
Carex lacustris	Lake Sedge			√	
Galium palustre	Marsh Bedstraw				√
Grass	Grass species		√		
Impatiens capensis	Spotted Jewelweed	√	√		
Leersia oryzoides	Rice Cutgrass				√
Lycopus uniflorus	Northern Water-horehound			√	
Mentha arvensis	Common Mint	√	√		√
Poa nemoralis	Wood Bluegrass				√
Ranunculus acris	Tall Buttercup				√
Ranunculus flabellaris	Yellow Water-crowfoot			√	
Symphyotrichum puniceum var. puniceum	Purple-Stemmed Aster				√
Taraxacum officinale	Dandelion	√			
Tussilago farfara	Coltsfoot		√		
Veronica officinalis	Common Speedwell			√	
Waldsteinia fragarioides	Barren Strawberry		√		
unknown species	unknown species				√
Vegetation Plot 009	**MASM1-1**				
Sub-Plot 1		Not monitored in 2006			
Circaea quadrisulcata	Enchanter's Nightshade		√		
Equisetum palustre	Marsh Horsetail		√		
Lysimachia ciliata	Fringed Loosestrife			√	
Mentha arvensis	Field or Common Mint		√		
Phalaris arundinacea	Reed Canary Grass		√	√	√
Symphyotrichum novae-angliae	New England Aster		√		
Sub-Plot 2					
Carex spp.	Sedge species			√	
Carex stipata	Awl-fruited Sedge				√
Circaea quadrisulcata	Enchanter's Nightshade		√		
Phalaris arundinacea	Reed Canary Grass		√	√	√
Typha latifolia	Common Cattail		√		√

Sub-Plot 3					
Carex stipata	Awl-fruited Sedge				√
Equisetum palustre	Marsh Horsetail		√		
Lysimachia ciliata	Fringed Loosestrife			√	
Mentha arvensis	Wild Mint				√
Phalaris arundinacea	Reed Canary Grass		√	√	√
Solidago canadensis	Canada Goldenrod				√
Sonchus arvensis	Field Sow-thistle			√	
Taraxacum officinale	Dandelion				√
Tussilago farfara	Coltsfoot				√
Typha latifolia	Common Cattail		√		
Sub-Plot 4					
Arabis glabra	Tower-mustard			√	
Carex spp.	Sedge species			√	
Carex stipata	Awl-fruited Sedge		√		√
Circaea quadrisulcata	Enchanter's Nightshade		√		
Euthamia graminifolia	Grass-leaved Goldenrod			√	
Lysimachia ciliata	Fringed Loosestrife			√	√
Mentha arvensis	Wild Mint				√
Phalaris arundinacea	Reed Canary Grass		√	√	√
Symphyotrichum puniceum var. puniceum	Purple-Stemmed Aster		√		
Typha latifolia	Common Cattail		√		√
Sub-Plot 5					
Equisetum arvense	Field Horsetail			√	
Phalaris arundinacea	Reed Canary Grass		√	√	√
Typha latifolia	Common Cattail				√

APPENDIX IV
Shrub Species Observed by Plot 2009

Appendix IV. Shrub Species Observed by Plot

Vegetation Plot 001

Scientific Name	Common Name	CC	CW	Weed	Number	Cover (%)
Solanum dulcamara	Bittersweet Nightshade	*	0	-2	10	25
Salix petiolaris	Slender Willow	3	-4		5	5
Total					**15**	**30**
Average					**7.5**	**15**

Vegetation Plot 002

Scientific Name	Common Name	CC	CW	Weed	Number	Cover (%)
Solanum dulcamara	Bittersweet Nightshade	*	0	-2	6	10
Rhamnus cathartica	Common Buckthorn	*	3	-3	30	10
Rubus pubescens	Dwarf Raspberry	4	-4		1	2
Echinocystis lobata	Wild Cucumber	3	-2		1	2
Total					**2**	**4**
Average					**1**	**2**

Vegetation Plot 003

Scientific Name	Common Name	CC	CW	Weed	Number	Cover (%)
Cornus alternifolia	Alternate-leaved Dogwood	6	5		7	15
Rhamnus cathartica	Common Buckthorn	*	3	-3	10	5
Parthenocissus inserta	Virginia Creeper	3	3		1	1
Total					**18**	**21**
Average					**6**	**7.0**

Vegetation Plot 004

Scientific Name	Common Name	CC	CW	Weed	Number	Cover (%)
Solanum dulcamara	Bittersweet Nightshade	*	0	-2	100	2
Rubus pubescens	Dwarf Raspberry	4	-4		50	1
Rhamnus frangula	Glossy Buckthorn	*	-1	-3	8	10
Cornus stolonifera	Red-osier Dogwood	2	-3		10	5
Parthenocissus inserta	Virginia Creeper	3	3		15	2
Total					**183**	**20**
Average					**36.6**	**4.0**

Vegetation Plot 005

Scientific Name	Common Name	CC	CW	Weed	Number	Cover (%)
Rhamnus cathartica	Common Buckthorn	*	3	-3	2	0.2
Total					**2**	**0.2**
Average					**2**	**0.2**

Vegetation Plot 006

Scientific Name	Common Name	CC	CW	Weed	Number	Cover (%)
Cornus stolonifera	Red-osier Dogwood	2	-3		4	1
Total					**4**	**1**
Average					**4**	**1**

Vegetation Plot 007

Scientific Name	Common Name	CC	CW	Weed	Number	Cover (%)
Solanum dulcamara	Bittersweet Nightshade	*	0	-2	10	0.3
Rhamnus cathartica	Common Buckthorn	*	3	-3	5	2
Viburnum trilobum	High Bush Cranberry	5	-3		3	0.1
Total					**18**	**2.4**
Average					**6**	**0.8**

Vegetation Plot 008

Scientific Name	Common Name	CC	CW	Weed	Number	Cover (%)
Cornus alternifolia	Alternate-leaved Dogwood	6	5		15	10.0
Solanum dulcamara	Bittersweet Nightshade	*	0	-2	50	1.0
Prunus virginiana	Chokecherry	2	1		15	2.0
Rhamnus cathartica	Common Buckthorn	*	3	-3	75	5.0
Rhamnus frangula	Glossy Buckthorn	*	-1	-3	5	1.0
Viburnum trilobum	High Bush Cranberry	5	-3		2	0.1
Vitis riparia	Riverbank Grape	0	-2		15	0.5
Rubus parviflorus	Sparse-flowered Thimbleberry	7	2		25	0.5
Lonicera tatarica	Tartarian Honeysuckle	*	3	-3	10	2.0
Total					**212**	**22.1**
Average					**23.6**	**2.5**

Vegetation Plot 009

Scientific Name	Common Name	CC	CW	Weed	Number	Cover (%)
Solanum dulcamara	Bittersweet Nightshade	*	0	-2	10	3
Rubus idaeus	Red Raspberry	0	-2		3	0.5
Cornus stolonifera	Red-osier Dogwood	2	-3		5	2
Total					**18**	**5.5**
Average					**6**	**1.8**

APPENDIX V
Shrub Species Observed by Plot 2006-2009

Appendix V. Shrub Species Observed by Plot 2006-2009

		NRSI			
		2006	2007	2008	2009
Vegetation Plot 001	**MAMM1-3**				
Solanum dulcamara	Bittersweet Nightshade	√	√	√	√
Sambucus canadensis	Common Elder	√			
Rubus idaeus	Red Raspberry	√	√		
Salix petiolaris	Slender Willow	√		√	√
Parthenocissus inserta	Virginia Creeper	√	√		
Vegetation Plot 002	**SWCO1-2**				
Cornus alternifolia	Alternate-leaved Dogwood	√	√		
Solanum dulcamara	Bittersweet Nightshade	√	√	√	√
Rubus allegheniensis	Common Blackberry		√		
Rhamnus cathartica	Common Buckthorn	√	√	√	√
Rubus pubescens	Dwarf Raspberry	√	√		√
Rhamnus frangula	Glossy Buckthorn	√			
Rubus idaeus	Red Raspberry	√			
Parthenocissus inserta	Virginia Creeper	√	√		
Ribes americanum	Wild Black Currant	√	√		
Echinocystis lobata	Wild Cucumber				√
Vegetation Plot 003	**FODM6**				
Cornus alternifolia	Alternate-leaved Dogwood	√	√	√	√
Rhamnus cathartica	Common Buckthorn	√	√	√	√
Rhamnus frangula	Glossy Buckthorn	√			
Viburnum trilobum	Highbush-cranberry	√			
Vitis riparia	Riverbank Grape	√	√		
Parthenocissus inserta	Virginia Creeper	√	√	√	√
Vegetation Plot 004	**SWMM1-1**				
Solanum dulcamara	Bittersweet Nightshade	√	√	√	√
Rhamnus cathartica	Common Buckthorn	√		√	
Ribes sp.	Currant species		√		
Rubus pubescens	Dwarf Raspberry	√	√		√
Rhamnus frangula	Glossy Buckthorn	√			√
Cornus stolonifera	Red-osier Dogwood	√	√	√	√
Parthenocissus inserta	Virginia Creeper	√	√		√
Vegetation Plot 005	**FOMM6**				
Rhamnus cathartica	Common Buckthorn		√		√
Cornus alternifolia	Alternate-leaved Dogwood		√		
Vegetation Plot 006	**MAM2-2**				
Cornus stolonifera	Red-osier Dogwood	√	√	√	√
Salix bebbiana	Beaked Willow, Bebb's Willow			√	
Salix spp.	Willow species		√		
Vegetation Plot 007	**SWMM1-1**				
Cornus alternifolia	Alternate-leaved Dogwood	√	√	√	
Corylus americana	American Hazel			√	

Solanum dulcamara	Bittersweet Nightshade	√	√		√
Rhamnus cathartica	Common Buckthorn				√
Rubus pubescens	Dwarf Raspberry	√	√		
Rhamnus frangula	Glossy Buckthorn	√			
Viburnum trilobum	High Bush Cranberry				√
Parthenocissus inserta	Virginia Creeper	√	√	√	
Ribes americanum	Wild Black Currant			√	
Vegetation Plot 008	**SWMM1-1**				
Cornus alternifolia	Alternate-leaved Dogwood	√			√
Solanum dulcamara	Bittersweet Nightshade	√	√	√	√
Prunus virginiana	Chokecherry			√	√
Rhamnus cathartica	Common Buckthorn	√	√		√
Rubus pubescens	Dwarf Raspberry	√			
Rhamnus frangula	Glossy Buckthorn	√	√		√
Crataegus spp.	Hawthorn species	√			
Viburnum trilobum	High Bush Cranberry				√
Rubus idaeus	Red Raspberry	√	√	√	
Cornus stolonifera	Red-osier Dogwood	√	√	√	
Vitis riparia	Riverbank Grape	√	√	√	√
Rubus parviflorus	Sparse-flowered Thimbleberry				√
Ribes lacustre	Swamp Black Currant	√			
Lonicera tatarica	Tartarian Honeysuckle	√	√	√	√
Ribes americanum	Wild Black Currant		√		
Echinocystis lobata	Wild Cucumber		√	√	
Vegetation Plot 009	**MASM1-1**				
Solanum dulcamara	Bittersweet Nightshade				√
Rhamnus frangula	Glossy Buckthorn			√	
Rubus idaeus	Red Raspberry				√
Cornus stolonifera	Red-osier Dogwood		√	√	√

APPENDIX VI
Tree Species Observed by Plot 2009

Appendix VI. Tree Species Observed by Plot

Vegetation Plot 001						**MAMM1-3**
Species	Condition			#/plot	Composition (%)	Avg. dbh (cm)
	Ag	Ma	De			
No trees >10cm dbh found in plot						

Vegetation Plot 002	**SWCO1-2**
Canopy Closure (%):	94.5
# Dead/Snagged Trees:	2
Moisture Regime:	5
Dominant Species:	White Cedar
Trees Missing:	0

Species	Condition			#/plot	Composition (%)	Avg. dbh (cm)
	Ag	Ma	De			
Yellow Birch	3	0	0	3	21.43	17.77
White Cedar	3	0	3	6	42.86	17.82
White Elm	0	0	1	1	7.14	23.80
Black Ash	4	0	0	4	28.57	11.88
Total	**10**	**0**	**4**	**14**	**100**	**71.26**

Vegetation Plot 003	**FODM6**
Canopy Closure (%):	94.5
# Dead/Snagged Trees:	7
Moisture Regime:	2
Dominant Species:	Sugar Maple
Trees Missing:	0

Species	Condition			#/plot	Composition (%)	Avg. dbh (cm)
	Ag	Ma	De			
Sugar Maple	3	1	0	4	100	24.75
Total	**3**	**1**	**0**	**4**	**100**	**24.75**

Vegetation Plot 004	**SWMM1-1**
Canopy Closure (%):	95.8
# Dead/Snagged Trees:	12
Moisture Regime:	4/5
Dominant Species:	White Cedar
Trees Missing:	1 (#9)

Species	Condition			#/plot	Composition (%)	Avg. dbh (cm)
	Ag	Ma	De			
White Cedar	16	0	0	16	88.89	13.63
Black Ash	1	0	0	1	5.56	11.10
Silver Maple	0	1	0	1	5.56	36.10
Total	**17**	**1**	**0**	**18**	**100.00**	**60.83**

Vegetation Plot 005						FOMM6

Canopy Closure (%): 90.1
Dead/Snagged Trees: 2
Moisture Regime: 1
Dominant Species: White Cedar
Trees Missing: 0

Species	Condition			#/plot	Composition (%)	Avg. dbh (cm)
	Ag	Ma	De			
Black Cherry	1	0	0	1	6.25	11.50
Eastern Hemlock	2	1	0	3	18.75	17.40
White Cedar	10	0	1	11	68.75	13.09
White Pine	1	0	0	1	6.25	20.00
Total	**14**	**1**	**1**	**16**	**100**	**61.99**

Vegetation Plot 006						MAMM1-3
Species	Condition			#/plot	Composition (%)	Avg. dbh (cm)
	Ag	Ma	De			
No trees >10cm dbh found in plot						

Vegetation Plot 007						SWMM1-1

Canopy Closure (%): 89.1
Dead/Snagged Trees: 2
Moisture Regime: 4
Dominant Species: White Cedar
Trees Missing: 0

Species	Condition			#/plot	Composition (%)	Avg. dbh (cm)
	Ag	Ma	De			
White Cedar	5	4	1	10	62.5	25.6
Red Maple	0	0	1	1	6.3	24.3
White Birch	0	1	0	1	6.3	26.7
Black Ash	0	0	1	1	6.3	27.0
Eastern Hemlock	2	0	1	3	18.8	11.7
Total	**7**	**5**	**4**	**16**	**100**	**23.1**

Vegetation Plot 008						SWMM1-1

Canopy Closure (%): 94.8
Dead/Snagged Trees: 12
Moisture Regime: 4
Dominant Species: White Cedar
Trees Missing: 0

Species	Condition			#/plot	Composition (%)	Avg. dbh (cm)
	Ag	Ma	De			
White Cedar	0	3	1	4	80	28.73
White Elm	1	0	0	1	20	12.00
Total	**1**	**3**	**1**	**5**	**100**	**40.73**

Vegetation Plot 009						MASM1-1
Species	Condition			#/plot	Composition (%)	Avg. dbh (cm)
	Ag	Ma	De			
No trees >10cm dbh found in plot						

APPENDIX VII
Tree Species Observed by Plot 2006-2009

Appendix VII. Overstorey Tree Comparison 2006-2009

			2006		2007		2008		2009	
Plot #	Tag #	Species	DBH	Condition	DBH	Condition	DBH	Condition	DBH	Condition
001	No Trees >10cm dbh									
002	2-1	White Cedar	28	Ma	27.5	De	28.3	Ag	28.0	Ag
	2-2	White Cedar	10.5	De	10.6	Sn	10.1	De	9.6	De
	2-3	White Cedar	17.2	De	17.0	De	16.4	De	16.4	Ag
	2-4	Yellow Birch	20.5	Ag	21.2	De	21.4	Ag	21.1	Ag
	2-5	White Cedar	13.8	Ag	15.0	De	14.9	De	14.4	De
	2-6	White Spruce		Sn		Sn		Sn		Sn
	2-7	Black Ash	14	Ag	14.1	Ag	13.9	Ag	14.0	Ag
	2-8	White Cedar	16	De	16.0	De	17.7	De	17.4	Ag
	2-9	Black Ash	n/a	Sn		Sn	24.6	Sn	23.8	De
	2-10	Yellow Birch	10.7	Ag	10.6	Ag	12.1	Ag	12.8	Ag
	2-11	Black Ash	14	Ag	12.1	Ag	12.4	Ag	12.2	Ag
	2-12	Black Ash	10	Ag	10.1	Ag	10	Ag	10.1	Ag
	2-13	White Elm	45.2	Ma	45.6	Ma	48.1	Ma		Sn
	2-14	Black Ash	10.7	Ag	11.0	Ag	11.2	Ag	11.2	Ag
	2-15	White Cedar	20	De	20.4	De	21.1	De	21.1	De
	2-16	Yellow Birch	19	Ag	19.0	Ag	20.4	Ag	19.4	Ag
003	3-1	Sugar Maple	16	Ag	15.8	Ag	16.3	Ag	16.7	Ag
	3-2	Sugar Maple	17	Ag	16.8	Ag	17.8	Ag	17.8	Ag
	3-3	White Ash	32	Ma	32.3	Ma	31.2	Ag	21.1	Ag
	3-4	Sugar Maple	40	Ag	39.7	Ma	42.9	Ag	43.4	Ma
004	4-1	White Cedar	14	Ma	13.7	Ag	14.5	Ag	14.1	Ag
	4-2	White Cedar	10	Ma	10.4	Ma	10.5	Ag	10.2	Ag
	4-3	White Cedar	12.8	Ma	12.8	Ag	14.2	Ag	14.8	Ag
	4-4	White Cedar	14	Ma	13.9	Ag	15.6	Ag	14.4	Ag
	4-5	White Cedar	11.4	De	11.0	Ag	11.2	De	11.3	Ag
	4-6	White Cedar	12.2	De	12.1	Ag	13.8	De	12.6	Ag
	4-7	White Cedar	10.3	De	9.5	Ag	10.2	De	10.3	Ag
	4-8	White Cedar	12.4	De	11.8	Ag	13.8	De	12.4	Ag
	4-9	White Cedar	20.2	De	20.4	De		Sn		Mi
	4-10	White Cedar	13.4	Ag	13.7	Ag	14	Ag	15.7	Ag
	4-11	White Cedar	14	Ma	14.5	Ag	19	Ag	18.6	Ag
	4-12	White Cedar	10.8	Ag	10.7	Ag	10.5	Ag	11.1	Ag
	4-13	White Cedar	12	Ag	10.7	Ag	11.5	Ag		
	4-13	Black Ash					10	Ag	11.1	Ag
	4-14	White Cedar	16	Ma	15.3	Ag	16	Ag	16.9	Ag
	4-15	White Cedar	17	Ma	16.4	Ma	16.5	Ag	17.2	Ag
	4-16	Silver Maple	38	De	35.6	De	35.2	De	36.1	Ma
	4-17	White Cedar	11.9	Ma	11.5	Ag	13.1	Ag	14.3	Ag
	4-18	White Cedar	12	Ma	12.1	Ag	13	Ag	13	Ag
	4-19	White Cedar	10	Ma	8.6	Ag	11.1	Ag	11.1	Ag
005	5-1	White Cedar					11.1	Ag	10.9	Ag
	5-2	White Cedar	12	De	13.0	Ag	13.1	Ag	13.8	Ag
	5-3	White Cedar	12.2	Ag	11.9	Ag	12.3	Ag	12.2	Ag
	5-4	Black Cherry	10	Ag	10.2	Ag	11.5	Ag	11.5	Ag
	5-5	White Cedar	10.4	De	10.9	Ag	11.2	Ag	11.2	Ag
	5-6	White Cedar	10.3	Ag	11.1	Ag	10.9	Ag	11.3	Ag
	5-7	White Cedar	11.2	Ag	11.4	Ag	12	Ag	12.4	Ag
	5-8	White Cedar	10	De	10.2	Ag	10.9	Ag	10.5	Ag
	5-9	White Cedar	12	De	11.8	Ag	11.8	Ag	12	Ag
	5-10	Eastern Hemlock	26.7	Ma	27.5	Ma	27.8	Ag	28.7	Ma
	5-11	White Cedar	25.1	Ma	16.6	Ma	15.8	Ag	24.3	De
	5-12	White Pine	18.2	Ma	18.5	Ma	19.2	Ag	20	Ag
	5-13	Eastern Hemlock	12.1	Ag	12.2	Ag	12.4	Ag	13	Ag
	5-14	Eastern Hemlock	10	Ag	9.7	Ag	10.2	Ag	10.5	Ag
	5-15	White Cedar	10.3	De	10.2	Ag	10.5	Ag	10.9	Ag
	5-16	White Cedar	13	De	13.2	Ag	14	Ag	14.5	Ag
		White Cedar	19.7	Ma		Mi		Mi		

		White Cedar	22	Ma		Mi		Mi		
		White Cedar	10	De		Mi		Mi		
006	No Trees >10cm dbh									
007	7-1	White Cedar	18.3	Ma	17.7	Ag	18.1	Ag	18.5	Ag
	7-2	White Cedar	10	De	9.2	Ag	10.1	Ag	10	Ag
	7-3	White Cedar	25.6	Ma	27.2	Ma	27	Ag	27.8	Ag
	7-4	White Cedar	18.1	Ag	18.6	Ma	19.1	Ag	19.1	Ag
	7-5	White Cedar	14.7	Ag	14.9	Ag	15.8	Ag	16	Ag
	7-6	White Cedar	12.5	Ag	22.3	Ma	23.7	Ag	23.5	Ma
	7-7	White Cedar	37	Ma	36.9	Ma	35.2	Ma	36	Ma
	7-8	Eastern Hemlock	11.5	Ag	11.5	Ag	11.5	Ag	12	Ag
	7-9	Eastern Hemlock	12	De	11.3	De	11.6	Sn	11.7	De
	7-10	Eastern Hemlock					12.4	Ag	11.5	Ag
	7-11	White Ash	26.3	Ma	25.3	Ma	26.1	Ag	27	De
	7-12	White Cedar	43.3	Ma	45.9	Ma	45.5	Ma	46.3	Ma
	7-13	Yellow Birch	25	Ma	24.9	Ma	25	Ag	26.7	Ma
	7-14	White Cedar					22	Ag	22.4	De
	7-15	White Cedar	36.1	Ma	35.2	Ma	35.6	Ma	36.5	Ma
	7-16	Red Maple	24.8	Ag	24.6	Ag	24	Ag	24.3	De
	Mi		28.3	Ma		Mi		Mi		
008	8-1	White Cedar	21.4	Ma	20.0	Ma	20.7	Ma	20.7	Ma
	8-2	White Cedar	29.4	De	29.7	Ma	32.7	Ma	35	Ma
	8-3	White Cedar	25.5	Ma	21.0	Ma	20	Ag	24.4	De
	8-4	White Elm	13.5	Ag	13.3	De		Sn		Sn
	8-5	White Elm	10.3	Ag	10.4	Ag	11.5	Ag	12	Ag
	8-6	White Cedar	35.1	Ma	35.5	Ma	32.8	Ag	34.8	Ma
009	No Trees >10cm dbh									

Physical Conditions:
Ag = Actively Growing
Ma = Mature
De = Declining
Sn = Snag
Mi = Missing

APPENDIX VIII
Soil Survey Results

Appendix VIII. Soil Surveys 2006-2009

	2006	2007	2008	2009
Vegetation Plot 001	**MAMM1-3**			
Position	5	5	6	5
Aspect	0	1.1-3	E	NE
%	0	2-5	4	0.02
Type	Simple	Simple	Simple	Simple
Class	A	C	C	A
Texture	Om	Of	Oh	L
Depth (m)	0.34	0.24	0.48	0.57
Munsell	Of	Om	N/A	N/A
Texture	0.42	0.57	vfSC	SiC
Depth (m)	L	SC	* 1.07	0.72
Munsell	0.65	0.90	N/A	N/A
Texture	SC	L		
Depth (m)	0.76	1.2		
Munsell				
Effective Texture		N/A	vfSC	
Surface Stoniness	n/a	0	0	0
Surface Rockiness	n/a	0	0	0
Depth (m) to:				
Mottles	0.76	0.55	0.49	
Gley	0.51	0.57	0.69	
Bedrock	1	1	N/A	N/A
Water Table	0	0.90-	0.02 +	0.08
Carbonates	n/a	N/A	0.87	N/A
Depth of Organics (m)	0.42	0.57	0.49	0.57
Moisture Regime	7	4	4	9
Vegetation Plot 002	**SWCO1-2**			
Position	5	6	4	5
Aspect	0	0	S	NW
%	0	0-0.5	2	0.1
Type	Simple	Simple	Simple	Simple
Class	A	A	B	A
Texture	Si	Of	Of	L
Depth (m)	0.44	0.64	0.80	0.38
Munsell	SiL	Oh	N/A	N/A
Texture	0.63	0.75	CL	SiCL

Depth (m)	SS	CL	* 1.1	0.62
Munsell	0.92	1.14	N/A	N/A
Texture	n/a	LS		
Depth (m)	n/a	1.2		
Munsell				
Effective Texture		N//A	Of	L
Surface Stoniness	n/a	0	0	0
Surface Rockiness	n/a	0	0	0
Depth (m) to:				
Mottles	n/a	0.8	N/A	0.20
Gley	0.65	0.75	N/A	0.42
Bedrock	0.92	n/a	N/A	N/A
Water Table	0.64	0.05-	0	0
Carbonates	0.14	N/A	0.9	N/A
Depth of Organics (m)	n/a	0.75	0.8	0.1
Moisture Regime	2-3	3	7	7
Vegetation Plot 003	**FODM6**			
Position	5	6	6	1
Aspect	0	0	S	N
%	0	0-0.5	3	0
Type	Simple	Simple	Simple	Simple
Class	A	A	C	A
Texture	CL	Si	SiCL	L
Depth (m)	0.3	0.35	0.24	0.26
Munsell	SC	SiCL	N/A	N/A
Texture	0.48	0.67	CL	SiCL
Depth (m)	SCL	LS	* 0.68	0.40
Munsell	0.63	1.2	N/A	N/A
Texture	n/a			SCL
Depth (m)	n/a			0.55
Munsell				N/A
Effective Texture		U	SiCL	
Surface Stoniness	n/a	0	0	0
Surface Rockiness	n/a	0	0	0
Depth (m) to:				
Mottles	0.3	0.35	0.27	0.28
Gley	n/a	0.35	0.36	N/A
Bedrock	0.63	0.76	N/A	N/A
Water Table	n/a	0.76	0.47	N/A

Carbonates	0	N/A	0.5	N/A
Depth of Organics (m)	n/a	N/A	N/A	
Moisture Regime	6	5	6	3
Vegetation Plot 004	**SWMM1-1**			
Position	5	4	6	6
Aspect	0	0.3-1.1	NE	W
%	0	0.5-2.0	3	0.1
Type	Simple	Simple	Simple	Simple
Class	A	B	C	A
Texture	Water	Of	Oh	L
Depth (m)	0.23	0.45	0.61	0.40
Munsell	Om	Om	N/A	N/A
Texture	1.2	1.20	SiCL	SiL
Depth (m)	n/a		1.00	0.68
Munsell	n/a		N/A	N/A
Texture	n/a			
Depth (m)	n/a			
Munsell				
Effective Texture		N/A	N/A	
Surface Stoniness	n/a	0	0	0
Surface Rockiness	n/a	0	0	0
Depth (m) to:				
Mottles	n/a	N/A	0.87	0.42
Gley	n/a	N/A	0.65	0.68
Bedrock	n/a	N/A	N/A	
Water Table	-0.23	0.05	0.015 +	0.02
Carbonates	n/a	N/A	N/A	0.72
Depth of Organics (m)	1.2	1.20+	0.61	0.02
Moisture Regime	9	7	7	4
Vegetation Plot 005	**FOMM6**			
Position	5	1	1	1
Aspect	0	0	N	E
%	0	0-0.5	5	0.1
Type	Simple	Simple	Simple	Simple
Class	A	A	D	A
Texture	SCL	SiCL	SiCL	L
Depth (m)	0.14	0.26	0.33	0.12

Munsell	SC	SiC	N/A	N/A
Texture	0.45	0.66	CL	SiCL
Depth (m)	n/a		0.41	0.42
Munsell	n/a		N/A	N/A
Texture	n/a		SiC	SC
Depth (m)	n/a		* 0.63	0.62
Munsell			N/A	N/A
Effective Texture		U	SiCL	
Surface Stoniness	n/a	0	0	0
Surface Rockiness	n/a	0	0	0
Depth (m) to:				
Mottles	0.43	0.3	0.38	0.15
Gley	0.18	N/A	N/A	0.20
Bedrock	0.45	N/A	N/A	N/A
Water Table	0.31	N/A	N/A	N/A
Carbonates	0	N/A	0.45	0.34
Depth of Organics (m)	n/a	N/A	N/A	0.12
Moisture Regime	5	2	5	2
Vegetation Plot 006	**MAMM1-3**			
Position	5	6	6	1
Aspect	0	0	SW	E
%	0	0-0.5	1	0
Type	Simple	Simple	Simple	Simple
Class	A	A	B	A
Texture	C	SiC	SiCL	SiCL
Depth (m)	0.28	0.32	0.32	0.31
Munsell	SC	C	N/A	N/A
Texture	1.2	0.75	CL	vfSCL
Depth (m)	n/a		* 0.58	0.38
Munsell	n/a		N/A	N/A
Texture	n/a			
Depth (m)	n/a			
Munsell				
Effective Texture		U	CL	
Surface Stoniness	n/a	0	0	0
Surface Rockiness	n/a	0	0	0
Depth (m) to:				
Mottles	0.28	0.32	0.24	N/A
Gley	n/a	0.32	0.25	0.35

Bedrock	0.52	N/A	N/A	N/A
Water Table	n/a	0.72	0.27	0.35
Carbonates	0.28	N/A	0.33	0.32
Depth of Organics (m)	n/a	N/A	N/A	0.2
Moisture Regime	6	5	6	5
Vegetation Plot 007	**SWMM1-1**			
Position	5	5	6	5
Aspect	0	0.3-1.1	W	E
%	0	0.5-2.0	4	0.5
Type	Simple	Simple	Simple	Simple
Class	A	B	C	A
Texture	Of	Of	Om	L
Depth (m)	0.42	0.34	0.4	0.95
Munsell	Of	Om	N/A	N/A
Texture	1.2	0.48	Oh	CL
Depth (m)	n/a	Oh	1.2	1.05
Munsell	n/a	1.2	N/A	N/A
Texture	n/a			
Depth (m)	n/a			
Munsell				
Effective Texture		N/A	N/A	L
Surface Stoniness	n/a	0	0	0
Surface Rockiness	n/a	0	0	0
Depth (m) to:				
Mottles	n/a	N/A	N/A	0.52
Gley	0.42	0.62	N/A	0.60
Bedrock	n/a	N/A	0.51	N/A
Water Table	0	0.62	0	0.18
Carbonates	0.42	N/A	N/A	0.50
Depth of Organics (m)	1.2	1.2	1.2 +	0
Moisture Regime	7	7	7	9
Vegetation Plot 008	**SWMM1-1**			
Position	5	4	4	4
Aspect	0	1.1-3	NW	W
%	0	2-5	2	0-2
Type	Simple	Simple	Complex	Simple
Class	A	C	c	A

Texture	SCL	CL	SiCL	L
Depth (m)	0.28	0.26	* 0.42	0.30
Munsell	n/a	SiCL	N/A	N/A
Texture	n/a	0.49		
Depth (m)	n/a			
Munsell	n/a			
Texture	n/a			
Depth (m)	n/a			
Munsell				
Effective Texture		L	SiCL	L
Surface Stoniness	n/a	0	0	0
Surface Rockiness	n/a	0	0	0
Depth (m) to:				
Mottles	n/a	N/A	N/A	0.30
Gley	0.2	N/A	N/A	N/A
Bedrock	0.28	N/A	N/A	N/A
Water Table	n/a	N/A	N/A	N/A
Carbonates	0.2	N/A	N/A	0.15
Depth of Organics (m)	n/a	N/A	N/A	
Moisture Regime	2	5	2	5
Vegetation Plot 009	**MASM1-1**			
Position		5	6	5
Aspect		0	SW	W
%		0-0.5	3	0.1
Type		Simple	Simple	Simple
Class		A	C	A
Texture		Oh	SiCL	CL
Depth (m)		0.83	0.36	0.20
Munsell		LS	N/A	N/A
Texture		1.2	fSCL	SiCL
Depth (m)			* 0.82	0.45
Munsell			N/A	N/A
Texture				SCL
Depth (m)				0.76
Munsell				N/A
Effective Texture		N/A	SiCL	
Surface Stoniness		0	0	0
Surface Rockiness		0	0	0
Depth (m) to:				

Mottles		0.66	0.41	0.25
Gley		N/A	0.44	N/A
Bedrock		N/A	N/A	N/A
Water Table		0	0.2	0.47
Carbonates		N/A	0.69	N/A
Depth of Organics (m)		0.83	N/A	0.02
Moisture Regime		3	5	5

APPENDIX IX
Bird Species Observed by Plot 2009

Appendix IX. Bird Species Observed by Plot 2006-2009

Breeding Bird Plot 001	**MAMM1-3**												
		NRSI Observations								**Breeding Evidence**			
		2006		**2007**		**2008**		**2009**					
Common Name	**Scientific Name**	20-Jun	30-Jun	7-Jun	19-Jun	20-Jun	4-Jul	11-Jun	29-Jun	**2006**	**2007**	**2008**	**2009**
American Crow	*Corvus brachyrhynchos*												
American Goldfinch	*Carduelis tristis*	3	2	2			2		3	PR	X	PO	PO
American Robin	*Turdus migratorius*					1	1	2				PR	PR
Baltimore Oriole	*Icterus galbula*			1	1						PR		
Barn Swallow	*Hirundo rustica*	1		2						PO	PR		
Black-capped Chickadee	*Poecile atricapillus*		2					2		PO			PO
Bobolink	*Dolichonyx oryzivorus*				3			4			PO		PO
Brown-headed Cowbird	*Molothrus ater*						3					PR	
Cedar Waxwing	*Bombycilla cedrorum*		1		1			2	3	PO	PO		PR
Chipping Sparrow	*Spizella passerina*					1	1					PR	
Common Yellowthroat	*Geothlypis trichas*			1		1	2	2	2		PO	PR	PR
Downy Woodpecker	*Picoides pubescens*								1				PO
Eastern Kingbird	*Tyrannus tyrannus*	1						2		PO			PR
Eastern Meadowlark	*Sturnella magna*				1		2				PO	PO	
Eastern Wood-pewee	*Contopus virens*					1						PO	
European Starling	*Sturnus vulgaris*							3					X
Flycatcher species	*Empidonax species*		1			1				PO		X	
Gray Catbird	*Dumetella carolinensis*							1					PO
House Finch	*Carpodacus mexicanus*						1					CO	
Least Flycatcher	*Empidonax minimus*						1					PO	
Mourning Dove	*Zenaida macroura*						1					PO	
Northern Cardinal	*Cardinalis cardinalis*							1					PO
Northern Flicker	*Colaptes auratus*	1	1							PR			
Passerine species	*Unknown species*		2							PO			
Red-eyed Vireo	*Vireo olivaceus*							2					X
Red-winged Blackbird	*Agelaius phoeniceus*	26	3	4	5	6	5	7	5	PR	CO	PR	PR
Rose-breasted Grosbeak	*Pheucticus ludovicianus*							1					PO
Savannah Sparrow	*Passerculus sandwichensis*				2			1			PR		PO
Scarlet Tanager	*Piranga olivacea*		1							PO			
Song Sparrow	*Melospiza melodia*	6	2	1	1	1	3	2	2	PR	PR	PR	PR
Swamp Sparrow	*Melospiza georgiana*		1						1	PO	PO		PO
Tennessee Warbler	*Vermivora peregrina*		1							PO			
Tree Swallow	*Tachycineta bicolor*					1	3		2			PO	PO
Warbling Vireo	*Vireo gilvus*								1				PO
Willow Flycatcher	*Empidonax traillii*							1	1				PR
Yellow Warbler	*Dendroica petechia*			1			1	2	1		X	PO	PR
Yellow-billed Cuckoo	*Coccyzus americanus*	1								PO			
Total	**37**	**39**	**17**	**12**	**14**	**13**	**26**	**35**	**22**				

Appendix IX. Bird Species Observed by Plot 2006-2009

Breeding Bird Plot 002	**SWCO1-2**												
		NRSI Observations								**Breeding Evidence**			
		2006		**2007**		**2008**		**2009**					
Common Name	**Scientific Name**	20-Jun	30-Jun	7-Jun	19-Jun	20-Jun	4-Jul	11-Jun	29-Jun	**2006**	**2007**	**2008**	**2009**
American Crow	*Corvus brachyrhynchos*			2		1					PO	PO	
American Robin	*Turdus migratorius*				1	3	3	2	1		PR	PR	PR
Baltimore Oriole	*Icterus galbula*				1			1			PR		PO
Black-capped Chickadee	*Poecile atricapillus*			3	1	3	2		3		PO	PR	PO
Blue Jay	*Cyanocitta cristata*		1					1	1	PO			PR
Cedar Waxwing	*Bombycilla cedrorum*		1							PO			
Chestnut-sided Warbler	*Dendroica pensylvanica*		2							PO			
Common Grackle	*Quiscalus quiscula*					1						PO	
Common Yellowthroat	*Geothlypis trichas*					2	1	2				PR	PO
Downy Woodpecker	*Picoides pubescens*		1				2			PO		PO	
Eastern Wood-pewee	*Contopus virens*		1		1			1		PO	PO		PO
Great Crested Flycatcher	*Myiarchus crinitus*				1			1			PO		PO
House Wren	*Troglodytes aedon*			1	1		3	4			PO	PO	PO
Indigo Bunting	*Passerina cyanea*	2					2			PO		PO	
Killdeer	*Charadrius vociferus*								1				PR
Northern Cardinal	*Cardinalis cardinalis*			1				1	2		PO		PO
Northern Flicker	*Colaptes auratus*							1					PO
Passerine species	*Unknown species*		2							PO			
Red-winged Blackbird	*Agelaius phoeniceus*	1						1		PO			PO
Song Sparrow	*Melospiza melodia*	3	1	3	2	7	2	3	2	PR	PR	PR	PR
Wabler species	*Unknown species*		1							PO			
Total	**21**	**6**	**10**	**10**	**8**	**17**	**15**	**18**	**10**				
									28				

Breeding Bird Plot 003	**FODM6**												
		NRSI Observations								**Breeding Evidence**			
		2006		**2007**		**2008**		**2009**					
Common Name	**Scientific Name**	20-Jun	30-Jun	7-Jun	19-Jun	20-Jun	4-Jul	11-Jun	29-Jun	**2006**	**2007**	**2008**	**2009**
American Crow	*Corvus brachyrhynchos*	2	1	2				4		PR	PO		PR
American Robin	*Turdus migratorius*			2	2	4	3		1		PR	PR	PO
Baltimore Oriole	*Icterus galbula*				1						PO		
Black-billed Cuckoo	*Coccyzus erythropthalmus*								1				PO
Black-capped Chickadee	*Poecile atricapillus*	2	1				4			PR		PO	
Blue Jay	*Cyanocitta cristata*					1	1	2				PR	PO
Common Grackle	*Quiscalus quiscula*					1						PO	
Common Yellowthroat	*Geothlypis trichas*							1					PO
Eastern Wood-pewee	*Contopus virens*		1	1		1	1	1	1	PO	PO	PR	PR
European Starling	*Sturnus vulgaris*					1						PO	
Gray Catbird	*Dumetella carolinensis*					1						PO	
Great Crested Flycatcher	*Myiarchus crinitus*		1					1		PO			PO
House Wren	*Troglodytes aedon*					3	3	4	3			PR	PR
Northern Cardinal	*Cardinalis cardinalis*		1					1	2	PO			PR
Red-eyed Vireo	*Vireo olivaceus*	1	2		1				1	PR	PO		PO
Red-tailed Hawk	*Buteo jamaicensis*			2	1			1			PR		PO
Red-winged Blackbird	*Agelaius phoeniceus*					2		3	2			PO	PR
Rose-breasted Grosbeak	*Pheucticus ludovicianus*							1					PO
Song Sparrow	*Melospiza melodia*	1	2	1	2	2	3	2		PR	PO	PR	PO
Wood Thrush	*Hylocichla mustelina*			2	1						PR		
Yellow Warbler	*Dendroica petechia*						1					PO	
Total	**21**	**6**	**9**	**10**	**8**	**16**	**16**	**21**	**11**				
									32				

Appendix IX. Bird Species Observed by Plot 2006-2009

Breeding Bird Plot 004	**SWMM1-1**												
		NRSI Observations								**Breeding Evidence**			
		2006		**2007**		**2008**		**2009**					
Common Name	**Scientific Name**	20-Jun	30-Jun	7-Jun	19-Jun	20-Jun	4-Jul	11-Jun	29-Jun	**2006**	**2007**	**2008**	**2009**
American Crow	*Corvus brachyrhynchos*		2	2	2	1		5		PO	PR	PO	PO
American Goldfinch	*Carduelis tristis*			1	2	1		1			PO	X	PO
American Robin	*Turdus migratorius*		1	1	1	1		2		PO	PO	PO	PO
Black-capped Chickadee	*Poecile atricapillus*	1		6		3	4		4	PO	PO	PR	CO
Blue-gray Gnatcatcher	*Polioptila caerulea*								1				PO
Blue Jay	*Cyanocitta cristata*	1	2	1	2			2		PR	PR		PO
Brown-headed Cowbird	*Molothrus ater*								2				PO
Cedar Waxwing	*Bombycilla cedrorum*						1					PO	
Chipping Sparrow	*Spizella passerina*			1			1				PO	PO	
Common Grackle	*Quiscalus quiscula*		2			1			3	PO		X	CO
Common Yellowthroat	*Geothlypis trichas*	3	3	1	1	2	1	1	3	CO	PO	PR	PR
Downy Woodpecker	*Picoides pubescens*						1					PO	
Gray Catbird	*Dumetella carolinensis*							1					PO
Hairy Woodpecker	*Picoides villosus*		1							PO			
Mallard	*Anas platyrhynchos*			1							X		
Northern Cardinal	*Cardinalis cardinalis*		1				1	1	1	PO		PO	PR
Northern Waterthrush	*Seiurus noveboracensis*								1				PO
Red-tailed Hawk	*Buteo jamaicensis*				1						PO		
Red-winged Blackbird	*Agelaius phoeniceus*	3	6	1	2	2		1		PR	PR	PO	PO
Savannah Sparrow	*Passerculus sandwichensis*						1					PO	
Song Sparrow	*Melospiza melodia*		3	1	2	3	2	1		PO	PO	PR	PO
Swamp Sparrow	*Melospiza georgiana*	1							1	PO			PO
Wood Thrush	*Hylocichla mustelina*						1					PO	
Yellow Warbler	*Dendroica petechia*						1					PO	
Total	**24**	**9**	**21**	**16**	**13**	**14**	**14**	**15**	**16**				
									31				

Breeding Bird Plot 005	**FOMM6**												
		NRSI Observations								**Breeding Evidence**			
		2006		**2007**		**2008**		**2009**					
Common Name	**Scientific Name**	20-Jun	30-Jun	7-Jun	19-Jun	20-Jun	4-Jul	11-Jun	29-Jun	**2006**	**2007**	**2008**	**2009**
American Crow	*Corvus brachyrhynchos*		1				3	1		PO		PO	PO
American Goldfinch	*Carduelis tristis*	2			1					PO	PO		
American Robin	*Turdus migratorius*		1			4	1		1	PO		PR	PO
Black-capped Chickadee	*Poecile atricapillus*	4	6	4	2		3		2	PR	PR	PO	PO
Blue Jay	*Cyanocitta cristata*	2	1	2			2	1		PR	PO	PO	PO
Cedar Waxwing	*Bombycilla cedrorum*						2					PO	
Chipping Sparrow	*Spizella passerina*							1	1				PR
Common Grackle	*Quiscalus quiscula*								3				CO
Common Yellowthroat	*Geothlypis trichas*				1				1		PO		PO
Downy Woodpecker	*Picoides pubescens*						1					PO	
Great Crested Flycatcher	*Myiarchus crinitus*	1		1	1	1		1		PO	PR	PO	PO
House Wren	*Troglodytes aedon*		1							PO			
Killdeer	*Charadrius vociferus*	1								PO			
Mourning Dove	*Zenaida macroura*			1							PO		
Northern Cardinal	*Cardinalis cardinalis*		1	1				1		PO	PO		PO
Pine Warbler	*Dendroica pinus*					2	1					PR	
Red-breasted Nuthatch	*Sitta canadensis*								2				PO
Red-eyed Vireo	*Vireo olivaceus*							1	1				PR
Red-winged Blackbird	*Agelaius phoeniceus*								1				PO
Song Sparrow	*Melospiza melodia*						1					PO	
Swamp Sparrow	*Melospiza georgiana*								1				PO
White-breasted Nuthatch	*Sitta carolinensis*			1				1			PO		PO
Total	**22**	**10**	**11**	**10**	**5**	**7**	**14**	**7**	**13**				
									20				

Appendix IX. Bird Species Observed by Plot 2006-2009

Breeding Bird Plot 006	**MAMM1-3**												
		NRSI Observations								**Breeding Evidence**			
		2006		**2007**		**2008**		**2009**					
Common Name	**Scientific Name**	20-Jun	30-Jun	7-Jun	19-Jun	20-Jun	4-Jul	11-Jun	29-Jun	**2006**	**2007**	**2008**	**2009**
American Goldfinch	*Carduelis tristis*	2			2					PR	PR		
American Goldfinch	*Carduelis tristis*		1	5		3	2		1	PR	PR	PR	PO
American Robin	*Turdus migratorius*	1	1	2	2		2	1	2	PR	PO	PO	PR
Baltimore Oriole	*Icterus galbula*					1						PO	
Barn Swallow	*Hirundo rustica*		1	3	3	3	3			PO	PR	PR	
Black-capped Chickadee	*Poecile atricapillus*					1			1			PO	PO
Blue Jay	*Cyanocitta cristata*	1		1	1					PO	PO		
Brown-headed Cowbird	*Molothrus ater*								2				X
Cedar Waxwing	*Bombycilla cedrorum*								1				X
Common Grackle	*Quiscalus quiscula*					1	4		1			PO	X
Common Yellowthroat	*Geothlypis trichas*				1	1	1		6		PO	PR	PO
Eastern Wood-pewee	*Contopus virens*					1						PO	
European Starling	*Sturnus vulgaris*					15		10	13			X	PO
Field Sparrow	*Spizella pusilla*				1						PO		
Gray Catbird	*Dumetella carolinensis*						1					PO	
Great Crested Flycatcher	*Myiarchus crinitus*			1							PO		
Indigo Bunting	*Passerina cyanea*								1				PO
Mallard	*Anas platyrhynchos*	2		2						PO	PR		
Northern Cardinal	*Cardinalis cardinalis*		2	1	1				1	PO	PR		PO
Northern Flicker	*Colaptes auratus*				1						CO		
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*								2				PR
Red-winged Blackbird	*Agelaius phoeniceus*	80	10	8	7	18	10	11	14	PR	CO	CO	CO
Ring-billed Gull	*Larus delawarensis*				1						X		
Savannah Sparrow	*Passerculus sandwichensis*							1					PO
Song Sparrow	*Melospiza melodia*	3	2	3	1	1	2	4	2	PR	PR	PR	PR
Tree Swallow	*Tachycineta bicolor*						1					PO	
Vesper Sparrow	*Pooecetes gramineus*							1					PO
Yellow Warbler	*Dendroica petechia*							2	2				PR
Total	**28**	**89**	**17**	**26**	**21**	**45**	**26**	**27**	**47**				
									74				

Breeding Bird Plot 007	**SWMM1-1**												
		NRSI Observations								**Breeding Evidence**			
		2006		**2007**		**2008**		**2009**					
Common Name	**Scientific Name**	20-Jun	30-Jun	7-Jun	19-Jun	20-Jun	4-Jul	11-Jun	29-Jun	**2006**	**2007**	**2008**	**2009**
American Crow	*Corvus brachyrhynchos*	2	1		1					PR	PO		
American Goldfinch	*Carduelis tristis*		3	3		3	2		2	PO	PO	PR	PO
American Robin	*Turdus migratorius*	1	2			1			1	PR		PO	PO
Baltimore Oriole	*Icterus galbula*								2				CO
Black-capped Chickadee	*Poecile atricapillus*			1	2		3	1	2		PR	PO	PR
Blue Jay	*Cyanocitta cristata*	3	3	1				3	2	PR	PO		PR
Canada Goose	*Branta canadensis*			10							X		
Cedar Waxwing	*Bombycilla cedrorum*						1					PO	
Chipping Sparrow	*Spizella passerina*						1	1				PO	PO
Common Grackle	*Quiscalus quiscula*								2				X
Downy Woodpecker	*Picoides pubescens*			1			1				X	PO	
Eastern Kingbird	*Tyrannus tyrannus*			1							PO		
Eastern Meadowlark	*Sturnella magna*					1						PO	
Eastern Wood-pewee	*Contopus virens*								1				PO
Field Sparrow	*Spizella pusilla*						1		1			PO	PO
Gray Catbird	*Dumetella carolinensis*							1					PO
Great Crested Flycatcher	*Myiarchus crinitus*			1	1			1			PR		PO
Hairy Woodpecker	*Picoides villosus*		2							PO			
Indigo Bunting	*Passerina cyanea*		1						1	PO			PO
Northern Cardinal	*Cardinalis cardinalis*			1			1	1			PO	PO	PO
Passerine Species	*Unknown species*	1				1				PO		PO	
Red-eyed Vireo	*Vireo olivaceus*								1				PO
Song Sparrow	*Melospiza melodia*	1	2	1		3	2	2	2	PR	PO	PR	PR
White-breasted Nuthatch	*Sitta carolinensis*			1				1	2		PO		PR
Total	**24**	**8**	**14**	**21**	**4**	**9**	**12**	**11**	**19**				
									30				

Appendix IX. Bird Species Observed by Plot 2006-2009

Breeding Bird Plot 008	**SWMM1-1**												
		NRSI Observations								**Breeding Evidence**			
		2006		**2007**		**2008**		**2009**					
Common Name	**Scientific Name**	20-Jun	30-Jun	7-Jun	19-Jun	20-Jun	4-Jul	11-Jun	29-Jun	**2006**	**2007**	**2008**	**2009**
American Crow	*Corvus brachyrhynchos*			3	2			1			PR		PO
American Goldfinch	*Carduelis tristis*	2	3	2		2	3	2		PR	PO	PR	PR
American Robin	*Turdus migratorius*	2		1		1	2		1	PO	PO	PR	PO
Black-billed Cuckoo	*Coccyzus erythropthalmus*								1				PO
Black-capped Chickadee	*Poecile atricapillus*			4	3	1	3	1	1		PR	PR	PR
Blue Jay	*Cyanocitta cristata*		1		2			1	1	PO	PO		PR
Brown-headed Cowbird	*Molothrus ater*			1	2				2		PO		PO
Cedar Waxwing	*Bombycilla cedrorum*	2						2		PO			PO
Chipping Sparrow	*Spizella passerina*		3							PO			
Common Grackle	*Quiscalus quiscula*				1	1			2		PR	X	X
Common Yellowthroat	*Geothlypis trichas*		1			1			1	PO		PO	PO
Eastern Meadowlark	*Sturnella magna*					2	2	1				PR	PO
Gray Catbird	*Dumetella carolinensis*	2		1				1	2	CO	PR		PR
Hairy Woodpecker	*Picoides villosus*		1				1			PO		PO	
Mallard	*Anas platyrhynchos*			1							X		
Northern Cardinal	*Cardinalis cardinalis*	2					1	1	1	PO		PO	PR
Red-winged Blackbird	*Agelaius phoeniceus*		2	7		1	1	2		PO	PR	PR	PO
Savannah Sparrow	*Passerculus sandwichensis*						1		2			PO	PO
Song Sparrow	*Melospiza melodia*	2	2	3	3	1	3	3	2	PR	PR	PR	PR
Yellow Warbler	*Dendroica petechia*					2	1	1				PR	PO
Total	**20**	**12**	**13**	**23**	**13**	**12**	**18**	**16**	**16**				
									32				

Breeding Bird Plot 009	**MASM1-1**												
		NRSI Observations								**Breeding Evidence**			
		2006		**2007**		**2008**		**2009**					
Common Name	**Scientific Name**	20-Jun	30-Jun	7-Jun	19-Jun	20-Jun	4-Jul	11-Jun	29-Jun	**2006**	**2007**	**2008**	**2009**
American Crow	*Corvus brachyrhynchos*	Plot 009 not monitored in 2006					1	4				PO	PO
American Goldfinch	*Carduelis tristis*								5				PR
American Robin	*Turdus migratorius*					2		1	1			PO	PR
Barn Swallow	*Hirundo rustica*					2	3		3			PR	PO
Black-capped Chickadee	*Poecile atricapillus*						1					PO	
Bobolink	*Dolichonyx oryzivorus*							3					PO
Canada Goose	*Branta canadensis*			92	4						CO		
Common Grackle	*Quiscalus quiscula*							2					X
Common Yellowthroat	*Geothlypis trichas*				2		1	1			PR	PO	PO
Eastern Kingbird	*Tyrannus tyrannus*							1					PR
Eastern Meadowlark	*Sturnella magna*							1	2				PR
Eastern Wood-pewee	*Contopus virens*							1					PO
European Starling	*Sturnus vulgaris*							1	20				PO
Killdeer	*Charadrius vociferus*			2					2		PR		PR
Mallard	*Anas platyrhynchos*				2						X		
Northern Cardinal	*Cardinalis cardinalis*					1						PO	
Red-tailed Hawk	*Buteo jamaicensis*						1	1				PO	PO
Red-winged Blackbird	*Agelaius phoeniceus*			4		7	4	7	9		CO	CO	CO
Ring-billed Gull	*Larus delawarensis*				2	1					X	X	
Savannah Sparrow	*Passerculus sandwichensis*				2		3	2			PR	PO	PO
Song Sparrow	*Melospiza melodia*					4		1	2			PO	PR
Tree Swallow	*Tachycineta bicolor*				1		2				CO	PO	
Willow Flycatcher	*Empidonax traillii*							1					PO
Yellow Warbler	*Dendroica petechia*					1		1				PO	PO
Total	**24**	**0**	**0**	**98**	**13**	**18**	**16**	**28**	**44**				
									72				

Appendix IX. Bird Species Observed by Plot 2006-2009

Breeding Bird Plot 010	FOD5												
		NRSI Observations								Breeding Evidence			
		2006		2007		2008		2009					
Common Name	**Scientific Name**	20-Jun	30-Jun	7-Jun	19-Jun	20-Jun	4-Jul	18-Jun	29-Jun	**2006**	**2007**	**2008**	**2009**
American Crow	*Corvus brachyrhynchos*	Plot 010 not monitored in 2006		Plot 010 not monitored in 2007		Plot 010 not monitored in 2008			1				PO
American Goldfinch	*Carduelis tristis*								4				X
American Redstart	*Setophaga ruticilla*								1				PO
American Robin	*Turdus migratorius*								1				PO
Blue Jay	*Cyanocitta cristata*							1					PO
Common Grackle	*Quiscalus quiscula*							3					X
Eastern Meadowlark	*Sturnella magna*							2					PO
Eastern Wood-pewee	*Contopus virens*							1					PO
Gray Catbird	*Dumetella carolinensis*							1	3				PO
House Wren	*Troglodytes aedon*							3	1				PR
Killdeer	*Charadrius vociferus*							1					PO
Northern Cardinal	*Cardinalis cardinalis*							2					PO
Northern Flicker	*Colaptes auratus*								1				PO
Red-winged Blackbird	*Agelaius phoeniceus*							3					PO
Rose-breasted Grosbeak	*Pheucticus ludovicianus*							1					PO
Song Sparrow	*Melospiza melodia*							2	1				PR
Warbling Vireo	Vireo gilvis							2					PO
Total	**17**	**0**	**0**	**0**	**0**	**0**	**0**	**20**	**13**				
									33				

Incidentals													
		NRSI Observations								Breeding Evidence			
		2006		2007		2008		2009					
Common Name	**Scientific Name**	20-Jun	30-Jun	7-Jun	19-Jun	20-Jun	04-Jul	11-Jun	29-Jun	**2006**	**2007**	**2008**	**2009**
American Crow	*Corvus brachyrhynchos*	2				1		4	5	PO		PO	PO
American Goldfinch	*Carduelis tristis*	2		2		1		2		PR	X	PO	PO
American Robin	*Turdus migratorius*	1				1	1	2	1	PO		PO	PO
Baltimore Oriole	*Icterus galbula*		1		1			1		PR	PR		PO
Barn Swallow	*Hirundo rustica*					1	1					X	
Black-capped Chickadee	*Poecile atricapillus*					1		1				PO	PO
Blue Jay	*Cyanocitta cristata*	1							5	PO			PO
Bobolink	*Dolichonyx oryzivorus*		1			1				PO		PO	
Brown-headed Cowbird	*Molothrus ater*	1			1	1		1		PO	PO	PO	PO
Canada Goose	*Branta canadensis*			92							PR		
Cedar Waxwing	*Bombycilla cedrorum*				3	5					PR	PO	
Chipping Sparrow	*Spizella passerina*							1					PO
Common Grackle	*Quiscalus quiscula*				1	1					X	PO	
Common Yellowthroat	*Geothlypis trichas*				2	6	1				PO	PO	
Downy Woodpecker	*Picoides pubescens*					1						PO	
Eastern Kingbird	*Tyrannus tyrannus*	1		1	1					PO	PO		
Eastern Meadowlark	*Sturnella magna*				1	1	1	3	2		PO	PO	PO
Eastern Wood-pewee	*Contopus virens*				1			2	1		PO		PO
European Starling	*Sturnus vulgaris*	5				?			4	PO		PO	PO
Field Sparrow	*Spizella pusilla*				1	1					PO	PO	
Gray Catbird	*Dumetella carolinensis*				1	1			1		PO	PO	PO
Great Blue Heron	*Ardea herodias*					1						X	
Great Crested Flycatcher	*Myiarchus crinitus*					1						PO	
House Wren	*Troglodytes aedon*								2				PO
Indigo Bunting	*Passerina cyanea*	1			3	1	3			PO	PR	PR	
Mallard	*Anas platyrhynchos*			2				2	1		X		PR
Mourning Dove	*Zenaida macroura*					1		2				PO	PO
Northern Cardinal	*Cardinalis cardinalis*	1				3		3	2	PO		PO	PO
Northern Flicker	*Colaptes auratus*								1				PO
Pine Warbler	*Dendroica pinus*					1						PO	
Red-tailed Hawk	*Buteo jamaicensis*	1				1			1	PR		PO	PO
Red-winged Blackbird	*Agelaius phoeniceus*	4				1		2	2	PO		PO	CO
Savannah Sparrow	*Passerculus sandwichensis*				1		1	2			PO	PO	PO
Song Sparrow	*Melospiza melodia*	2			2	1		2	1	PO	PO	PO	PO
Tree Swallow	*Tachycineta bicolor*		1						1	PR			CO
Turkey Vulture	*Cathartes aura*					1						X	
Vesper Sparrow	*Pooecetes gramineus*							1					PO
White-breasted Nuthatch	*Sitta carolinensis*		1							PO			
Wood Thrush	*Hylocichla mustelina*						1					PO	
Yellow Warbler	*Dendroica petechia*					1		1				PO	PO
Total	**40**	**22**	**4**	**97**	**19**	**36**	**9**	**32**	**30**				

APPENDIX X
Bird Species Known From the Study Area 2006-2009

Appendix X. Bird Species Observed in the Study Area

Common Name	Scientific Name	GRANK	SRANK	COSEWIC	OMNR	NRSI			
						2006	2007	2008	2009
HERONS & BITTERNS									
Great Blue Heron	*Ardea herodias*	G5	S5B,SZN					X	
GEESE									
Canada Goose	*Branta canadensis*	G5	S5B,SZN				PR		
DUCKS									
Wood Duck	*Aix sponsa*	G5	S5B						X
Mallard	*Anas platyrhynchos*	G5	S5B,SZN			PO	PR		X
VULTURES									
Turkey Vulture	*Cathartes aura*	G5	S4B,SZN			PO	X	X	X
HAWKS, KITES & EAGLES									
Northern Harrier	*Circus cyaneus*	G5	S4B,SZN	NAR	NAR				
Sharp-shinned Hawk	*Accipiter striatus*	G5	S5B,SZN	NAR	NAR				
Cooper's Hawk	*Accipiter cooperii*	G5	S4B,SZN	NAR	NAR				
Red-tailed Hawk	*Buteo jamaicensis*	G5	S5B,SZN	NAR	NAR	PO	CO	PO	CO
CARACARAS & FALCONS									
American Kestrel	*Falco sparverius*	G5	S5B,SZN						X
PARTRIDGES, GROUSE & TURKEY									
Ruffed Grouse	*Bonasa umbellus*	G5	S5						
Wild Turkey	*Meleagris gallopavo*	G5	S4						
RAILS, GALLINULES & COOTS									
Virgiania Rail	*Rallus limicola*	G5	S4B,SZN						
Sora	*Porzana carolina*	G5	S4B,SZN						
Common Moorhen	*Gallinula chloropus*	G5	S4B,SZN						
American Coot	*Fulica americana*	G5	S4B,SZN	NAR	NAR				
PLOVERS									
Killdeer	*Charadrius vociferus*	G5	S5B,SZN			PO	CO		PO
SANDPIPERS & PHALAROPES									
Spotted Sandpiper	*Actitis macularia*	G5	S5B,SZN						
Wilson's Snipe	*Gallingo delicata*	G5	S5B,SZN						
American Woodcock	*Scolopax minor*	G5	S5B,SZN				PO	PO	PR
GULLS									
Ring-billed Gull	*Larus delawarensis*	G5	S5B,SZN				X	X	
DOVES									
Rock Pigeon	*Columba livia*	G5	SE				X		
Mourning Dove	*Zenaida macroura*	G5	S5B,SZN				PO	PO	PO
CUCKOOS									
Black-billed Cuckoo	*Coccyzus erythropthalmus*	G5	S4B,SZN						
Yellow-billed Cuckoo	*Coccyzus americanus*	G5	S4B,SZN			PO			
OWLS									
Eastern Screech Owl	*Otus asio*	G5	S5	NAR	NAR				
Great Horned Owl	*Bubo virgianus*	G5	S5						

Appendix X. Bird Species Observed in the Study Area

Common Name	Scientific Name	GRANK	SRANK	COSEWIC	OMNR	NRSI			
						2006	2007	2008	2009
HUMMINGBIRDS									
Ruby-throated Hummingbird	*Archilochus colubris*	G5	S5B,SZN						
KINGFISHERS									
Belted Kingfisher	*Ceryle alcyon*	G5	S5B,SZN						
WOODPECKERS									
Red-headed Woodpecker	*Melanerpes erythrocephalus*	G5	S3B,SZN	SC	SC				
Red-bellied Woodpecker	*Melanerpes carolinus*	G5	S4						
Yellow-bellied Sapsucker	*Sphyrapicus varius*	G5	S5B,SZN						
Downy Woodpecker	*Picoides pubescens*	G5	S5			PO	X	PO	
Hairy Woodpecker	*Picoides villosus*	G5	S5			PO	X	PO	PO
Northern Flicker	*Colaptes auratus*	G5	S5B,SZN			PR	CO		PO
Pileated Woodpecker	*Dryocopus pileatus*	G5	S4S5						
FLYCATCHERS									
Flycatcher spp						PO		X	
Eastern Wood-pewee	*Contopus virens*	G5	S5B,SZN			PO	PO	PR	PO
Willow Flycatcher	*Empidonax traillii*	G5	S5B,SZN						PO
Least Flycatcher	*Empidonax minimus*	G5	S5B,SZN			PO		PO	
Eastern Phoebe	*Sayornis phoebe*	G5	S5B,SZN				PO		
Great Crested Flycatcher	*Myiarchus crinitus*	G5	S5B,SZN			PO	PR	PO	PO
Eastern Kingbird	*Tyrannus tyrannus*	G5	S5B,SZN			PO	PO		PR
LARKS									
Horned Lark	*Eremophila alpestris*	G5	S5B,SZN						
SWALLOWS									
Tree Swallow	*Tachycineta bicolor*	S5	S5B,SZN			PO	CO	PO	PO
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	G5	S5B,SZN						
Bank Swallow	*Riparia riparia*	G5	S5B,SZN						
Barn Swallow	*Hirundo rustica*	G5	S5B,SZN			PO	PR	PR	
CROWS & JAYS									
Blue Jay	*Cyanocitta cristata*	G5	S5			PR	CO	PR	PR
American Crow	*Corvus brachyrhynchos*	G5	S5B,SZN			PR	CO	PO	PR
CHICKADEES									
Black-capped Chickadee	*Poecile atricapillus*	G5	S5			PR	PR	PR	PO
NUTHATCHES									
Red-breasted Nuthatch	*Sitta canadensis*	G5	S5B,SZN						
White-breasted Nuthatch	*Sitta carolinensis*	G5	S5			PO	PO		PO
CREEPERS									
Brown Creeper	*Certhia americana*	G5	S5B,SZN						PO
WRENS									
House Wren	*Troglodytes aedon*	G5	S5B,SZN			PO	PR	PR	PO
Winter Wren	*Troglodytes troglodytes*	G5	S5B,SZN						
KINGLETS									
Golden-crowned Kinglet	*Regulus satrapa*	G5	S5B,SZN						
Ruby-crowned Kinglet	*Regulus calendula*	G5	S5B,SZN						

Appendix X. Bird Species Observed in the Study Area

Common Name	Scientific Name	GRANK	SRANK	COSEWIC	OMNR	NRSI			
						2006	2007	2008	2009
THRUSHES									
Eastern Bluebird	*Sialia sialis*	G5	S4S5B,SZN	NAR	NAR				
Veery	*Catharus fuscescens*	G5	S4B,SZN						
Hermit Thrush	*Catharus guttatus*	G5	S5B,SZN						
Wood Thrush	*Hylocichla mustelina*	G5	S5B,SZN				CO	PO	
American Robin	*Turdus migratorius*	G5	S5B,SZN			PR	CO	PR	PR
MIMIDS									
Gray Catbird	*Dumetella carolinensis*	G5	S5B,SZN			PR	PR	PO	PO
Northern Mockingbird	*Mimus polyglottos*	G5	S4B,SZN						
Brown Thrasher	*Toxostoma rufum*	G5	S5B,SZN						
WAXWINGS									
Cedar Waxwing	*Bombycilla cedrorum*	G5	S5B,SZN			PO	PR	PO	PO
SHRIKES									
Northern Shrike	*Lanius excubitor*	G5	S2S3B,SZN						
Loggerhead Shrike	*Lanius ludovicianus*	G4	S2B,SZN	END	END-R				
STARLINGS									
European Starling	*Sturnus vulgaris*	G5	SE			PO	X	PO	PO
VIREOS									
Blue-headed Vireo	*Vireo solitarius*	G5	S5B,SZN						
Warbling Vireo	*Vireo gilvis*	G5	S5B,SZN						
Red-eyed Vireo	*Vireo olivaceus*	G5	S5B,SZN			PR	PO	PO	PO
WOOD WARBLERS									
Warbler spp.						PO			
Tennessee Warbler	*Vermivora peregrina*	G5	S5B,SZN			PO			
Blue-winged Warbler	*Vermivora pinus*	G5	S4B,SZN						
Golden-winged Warbler	*Vermivora chrysoptera*	G4	S4B,SZN						
Nashville Warbler	*Vermivora ruficapilla*	G5	S5B,SZN						
Yellow Warbler	*Dendroica petechia*	G5	S5B,SZN				X	PR	PR
Chestnut-sided Warbler	*Dendroica pensylvanica*	G5	S5B,SZN			PO			
Magnolia Warbler	*Dendroica magnolia*	G5	S5B,SZN						
Black-throated Blue Warbler	*Dendroica caerulescens*	G5	S5B,SZN						
Yellow-rumped Warbler	*Dendroica coronata*	G5	S5B,SZN						
Black-throated Green Warbler	*Dendroica virens*	G5	S5B,SZN						
Blackburnian Warbler	*Dendroica fusca*	G5	S5B,SZN						
Pine Warbler	*Dendroica pinus*	G5	S5B,SZN					PR	
Prairie Warbler	*Dendroica discolor*	G5	S3S4B,SZN	NAR	NAR				
Black-and-white Warbler	*Mniotilta varia*	G5	S5B,SZN						
American Redstart	*Setophaga ruticilla*	G5	S5B,SZN						
Ovenbird	*Seiurus aurocapillus*	S5	S5B,SZN				PO		
Northern Waterthrush	*Seiurus noveboracensis*	G5	S5B,SZN						
Mourning Warbler	*Oporornis philadelphia*	G5	S5B,SZN						
Common Yellowthroat	*Geothlypis trichas*	G5	S5B,SZN			PR	PR	PR	PO
Canada Warbler	*Wilsonia canadensis*	G5	S5B,SZN						
Yellow-breasted Chat	*Icteria virens*	G5	S2S3B,SZN	SC	SC				
TANAGERS									
Scarlet Tanager	*Piranga olivacea*	G5	S5B,SZN			PO			

Appendix X. Bird Species Observed in the Study Area

Common Name	Scientific Name	GRANK	SRANK	COSEWIC	OMNR	NRSI			
						2006	2007	2008	2009
CARDINALS									
Northern Cardinal	*Cardinalis cardinalis*	G5	S5			PO	PR	PO	PO
SUMMER FINCHES									
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	G5	S5B,SZN						PO
Indigo Bunting	*Passerina cyanea*	G5	S5B,SZN			PO	PR	PR	
SPARROWS									
Eastern Towhee	*Pipilo erythrophthalmus*	G5	S4B,SZN						
American Tree Sparrow	*Spizella arborea*	G5	S5B,SZN						
Chipping Sparrow	*Spizella passerina*	G5	S5B,SZN			PO	PO	PR	PO
Clay-coloured Sparrow	*Spizella pallida*	G5	S4B,SZN						
Field Sparrow	*Spizella pusilla*	G5	S5B,SZN				PO	PO	
Vesper Sparrow	*Pooecetes gramineus*	G5	S4B,SZN						PO
Savannah Sparrow	*Passerculus sandwichensis*	G5	S5B,SZN				PR	PO	PO
Grasshopper Sparrow	*Ammodramus savannarum*	G5	S4B,SZN						
Henslow's Sparrow	*Ammodramus henslowii*	G4	S1B,SZN	END	END-R				
Song Sparrow	*Melospiza melodia*	G5	S5B,SZN			PR	CO	PR	PO
Swamp Sparrow	*Melospiza georgiana*	G5	S5B,SZN			PO			
White-throated Sparrow	*Zonotrichia albicollis*	G5	S5B,SZN						
Dark-eyed Junco	*Junco hyemalis*	G5	S5B,SZN				X		
Snow Bunting	*Plectrophenax nivalis*	G5	SZB?,SZN						
BLACKBIRDS									
Bobolink	*Dolichonyx oryzivorus*	G5	S4B,SZN			PO	PO	PO	PO
Red-winged Blackbird	*Agelaius phoeniceus*	G5	S5B,SZN			PR	CO	CO	CO
Eastern Meadowlark	*Sturnella magna*	G5	S5B,SZN				PO	PR	PO
Common Grackle	*Quiscalus quiscula*	G5	S5B,SZN			PO	PR	PO	X
Brown-headed Cowbird	*Molothrus ater*	G5	S5B,SZN			PO	PR	PR	PO
ORIOLES									
Orchard Oriole	*Icterus spurius*	G5	SZB,SZN						
Baltimore Oriole	*Icterus galbula*	G5	S5B,SZN			PO	PR	PO	PO
WINTER FINCHES									
Purple Finch	*Carpodacus purpureus*	G5	S5B,SZN						
House Finch	*Carpodacus mexicanus*	G5	SE					CO	
Pine Siskin	*Carduelis pinus*	G5	S5B,SZN						PO
American Goldfinch	*Carduelis tristis*	G5	S5B,SZN			PR	CO	PR	PR
OLD WORLD SPARROWS									
House Sparrow	*Passer domesticus*	G5	SE						
	Total Observed					**41**	**46**	**41**	**42**

Appendix X. Bird Species Observed in the Study Area

Common Name	Scientific Name	GRANK	SRANK	COSEWIC	OMNR	NRSI			
						2006	2007	2008	2009
Legend									
GRANK (Global Rank)									
G4 Common	G5 Very common								
SRANK									
S1 Critically Imperiled			B Breeding						
S2 Imperiled			SZ Not of practical conservation concern						
S3 Vulnerable			SE Exotic						
S4 Apparently Secure			SAN Non-breeding accidental						
S5 Secure			SZN Non-breeding migrants/vagrants						
? Rank Uncertain									
S#S# Range Rank —Numeric range rank (e.g., S2S3) used to indicate any range of uncertainty about the status of the species									
COSEWIC, OMNR Codes									
END-R Endangered. Regulated under Ontario's Endangered Species Act (ESA). OMNR only.									
END Endangered									
THR Threatened									
SC Special Concern									
NAR Not at Risk									
Breeding Evidence Codes									
X Observed									
PO Possible breeder									
PR Probable breeder									
CO Confirmed breeder									

APPENDIX XI
Herpetofauna Observed in the Study Area 2006-2009 and Previous

Appendix XI. Herpetofauna Species Observed in the Study Area

						NRSI				
SCIENTIFIC NAME	**COMMON NAME**	**GRANK**	**SRANK**	**COSEWIC**	**OMNR**	**1998-2004**	**2006**	**2007**	**2008**	**2009**
Turtles										
Chelydra serpentina serpentina	Common Snapping Turtle	G5T5	S5	SC		√				
Snakes										
Lampropeltis t. triangulum	Eastern Milksnake	G5T5	S3	SC	SC					√
Thamnophis sirtalis sirtalis	Eastern Gartersnake	G5T?	S5			√				
Salamanders										
Ambystoma jeffersonianum-laterale polyploids	Jefferson/Blue-spotted Salamander Polyploids	hybrid	S2							√
Plethodon cinereus	Eastern (Northern) Redback Salamander	G5	S5			√				
Toads and Frogs										
Bufo americanus	American Toad	G5	S5			√	√	√	√	√
Hyla versicolor	Tetraploid Gray Treefrog	G5	S5			√	√		√	√
Pseudacris triseriata pop.2	Western Chorus Frog*	GNR	S3	THR	NAR			√		
Pseudarcris crucifer crucifer	Northern Spring Peeper	G5	S5			√	√	√	√	√
Rana clamitans melanota	Green Frog	G5	S5			√	√	√	√	√
Rana pipiens	Northern Leopard Frog	G5	S5	NAR	NAR	√	√			√
Rana sylvatica	Wood Frog	G5	S5			√		√	√	√
	*Great Lakes / St. Lawrence - Canadian Shield Population				**Total**	**9**	**5**	**5**	**5**	**8**

Legend
GRANK (Global Rank)
G5 Very common
GNR Not ranked
SRANK
S2 Imperiled
S3 Vulnerable
S4 Apparently Secure
S5 Secure
COSEWIC, OMNR
NAR Not at Risk
NRSI
√ Observed

APPENDIX XII
Salamander Trap Survey Memo

Memo

Project No. 682-G

To: Dave Marriott

CC: Graham Buck

From: Tara Brenton

Date: June 4, 2009

Re: Hanlon Creek Business Park – Summary of 2009 Salamander Surveys

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To satisfy the Wildlife Animal Care Permit, the following report provides a summary of findings from the 2009 salamander surveys conducted at the Hanlon Creek Business Park (i.e. # of animals handled, injuries, fatalities or outline of any problems that arose).

Prior to conducting salamander surveys, NRSI applied for the following permits:

- OMNR Wildlife Animal Care Committee – Approval # 09-145
- Wildlife Scientific Collector's Authorization, permit # 1050876 under the Ontario Endangered Species Act (2007)

Salamander surveys were conducted within the Hanlon Creek Business Park from March 27, 2009 to April 9, 2009, to identify the presence of Jefferson salamander (*Ambystoma jeffersonianum*) within potential habitat features on-site. Road surveys began on April 20, 2009 and will conclude the week of June 12, 2009, to document movement of herpetofauna species across Laird Road. The methodologies for the field studies undertaken were based on agency consultation (A. Timmerman and K. Cornelisse, OMNR, Guelph District), consultation with experts (Dr. Jim Bogart, University of Guelph) and review of existing literature.

Methods

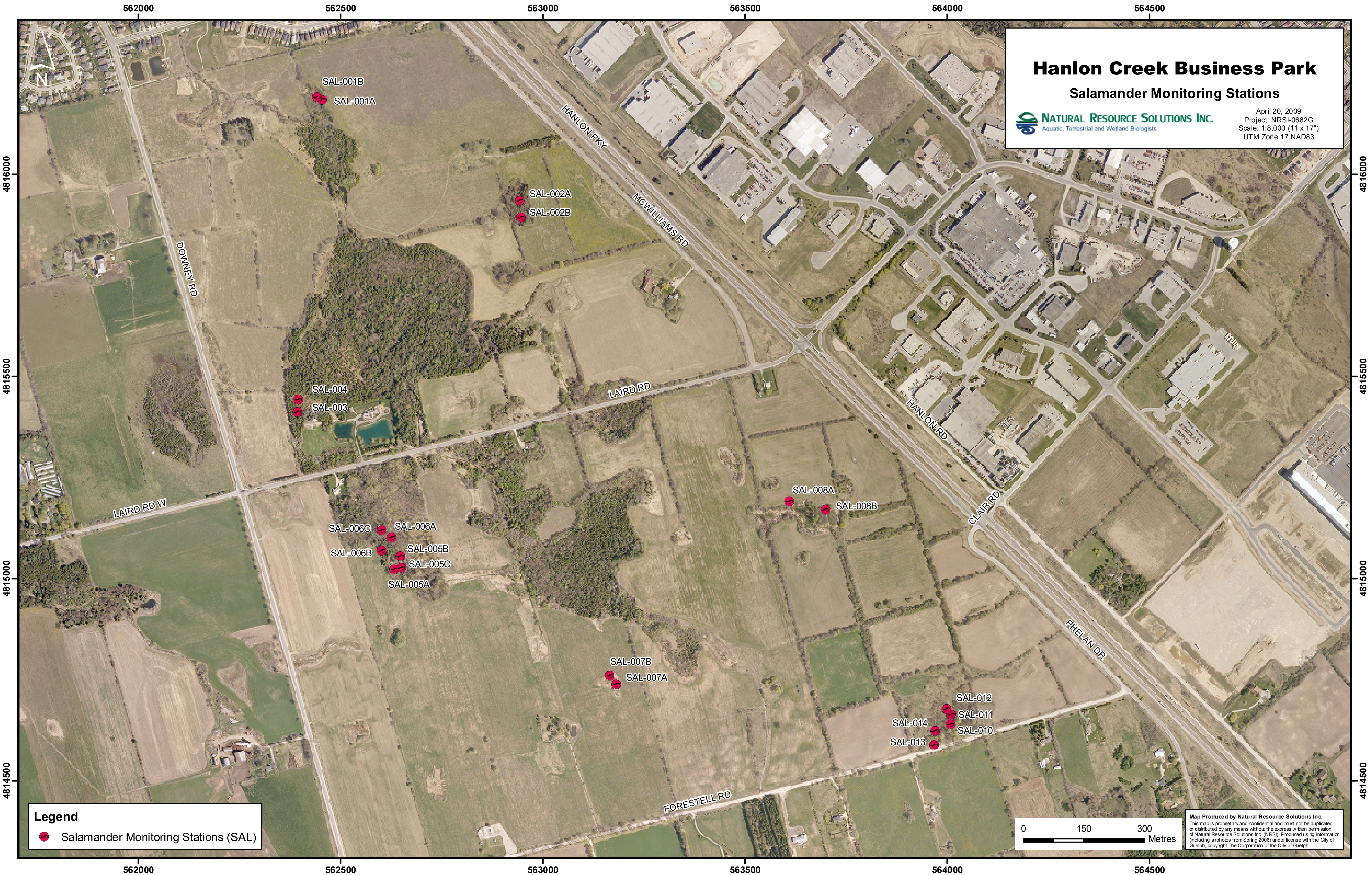
Initial habitat characterization was based on vegetation mapping completed by NRSI (2004) and first-hand knowledge of the study area. NRSI biologists located potential salamander habitat based on this available mapping, existing literature, and consultation with agency staff in the field.

<u>Salamander Surveys</u>

A total of 21 un-baited minnow traps were set at 7 stations between March 27 and April 9, 2009, resulting in 223 trap events. The dates that traps were set at each station are shown in Table 1. Traps were set within vernal pools, ponds and wetlands throughout the study area as shown on Figure 1. Staff from the OMNR (Ken Cornelisse and Graham Buck) assisted NRSI in the field with checking traps and recommending ideal locations for setting traps on April 2, 2009. Each trap was checked the morning after they were set to document any salamanders captured. Detailed field notes were collected on any other amphibian species observed in the traps.

Table 1. Salamander Survey Trap Events

Station #	27-Mar	28-Mar	30-Mar	31-Mar	1-Apr	2-Apr	3-Apr	4-Apr	5-Apr	6-Apr	7-Apr	8-Apr	9-Apr
SAL-001A	X	X	X	X	X	X	X	X	X	X	X	X	X
SAL-001B	X	X	X	X	X	X	X	X	X	X	X	X	X
SAL-002A	X	X	X	X	X	X	X	X	X	X	X	X	X
SAL-002B							X	X	X	X	X	X	X
SAL-003	X	X		X	X	X	X	X	X	X	X	X	X
SAL-004	X	X		X	X	X	X	X	X	X	X	X	X
SAL-005A	X	X	X	X	X	X	X	X	X	X	X	X	X
SAL-005B							X	X	X	X	X	X	X
SAL-005C							X	X	X	X	X	X	X
SAL-006A	X	X	X	X	X	X	X	X	X	X	X	X	X
SAL-006B							X	X	X	X	X	X	X
SAL-006C							X	X	X	X	X	X	X
SAL-007A	X	X	X	X	X	X	X	X	X	X	X	X	X
SAL-007B							X	X	X	X	X	X	X
SAL-008A	X	X	X	X	X	X	X	X	X	X	X	X	X
SAL-008B							X	X	X	X	X	X	X
SAL-010	X	X	X	X	X	X	X	X	X	X	X	X	X
SAL-011	X	X	X	X	X	X	X	X	X	X	X	X	X
SAL-012	X	X	X	X	X	X	X	X	X	X	X	X	X
SAL-013	X	X	X	X	X	X	X	X	X	X	X	X	X
SAL-014							X	X	X	X	X	X	X



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Road Mortality Surveys

Nighttime road mortality surveys were conducted to document movement of herpetofauna species across Laird Road. Surveys generally corresponded to weather conditions suitable for herpetofauna movement (i.e. warm, rainy nights). Nighttime searches consisted of biologists walking along Laird Road from the Hanlon Expressway to Downey Road, looking for herpetofauna species. Searches were conducted twice a week, beginning April 20, 2009, commencing one-half hour after sunset and ending before midnight. Surveys will conclude the week of June 12, 2009. To date, detailed field notes have included weather conditions, species observed on the road, species status (i.e. dead, alive or injured) and direction of movement. The location of each species observed along the road has been recorded using a GPS and mapped.

Due to the fact that Jefferson salamanders are extremely difficult to identify based on visual ID alone, a small tail clipping (approximately 5mm) was collected from the one salamander observed along Laird Road and preserved in 70% ethanol for subsequent DNA extraction and microsatellite examination. The location of the salamander was documented and mapped. DNA extraction and analysis was performed at the University of Guelph by Dr. Jim Bogart.

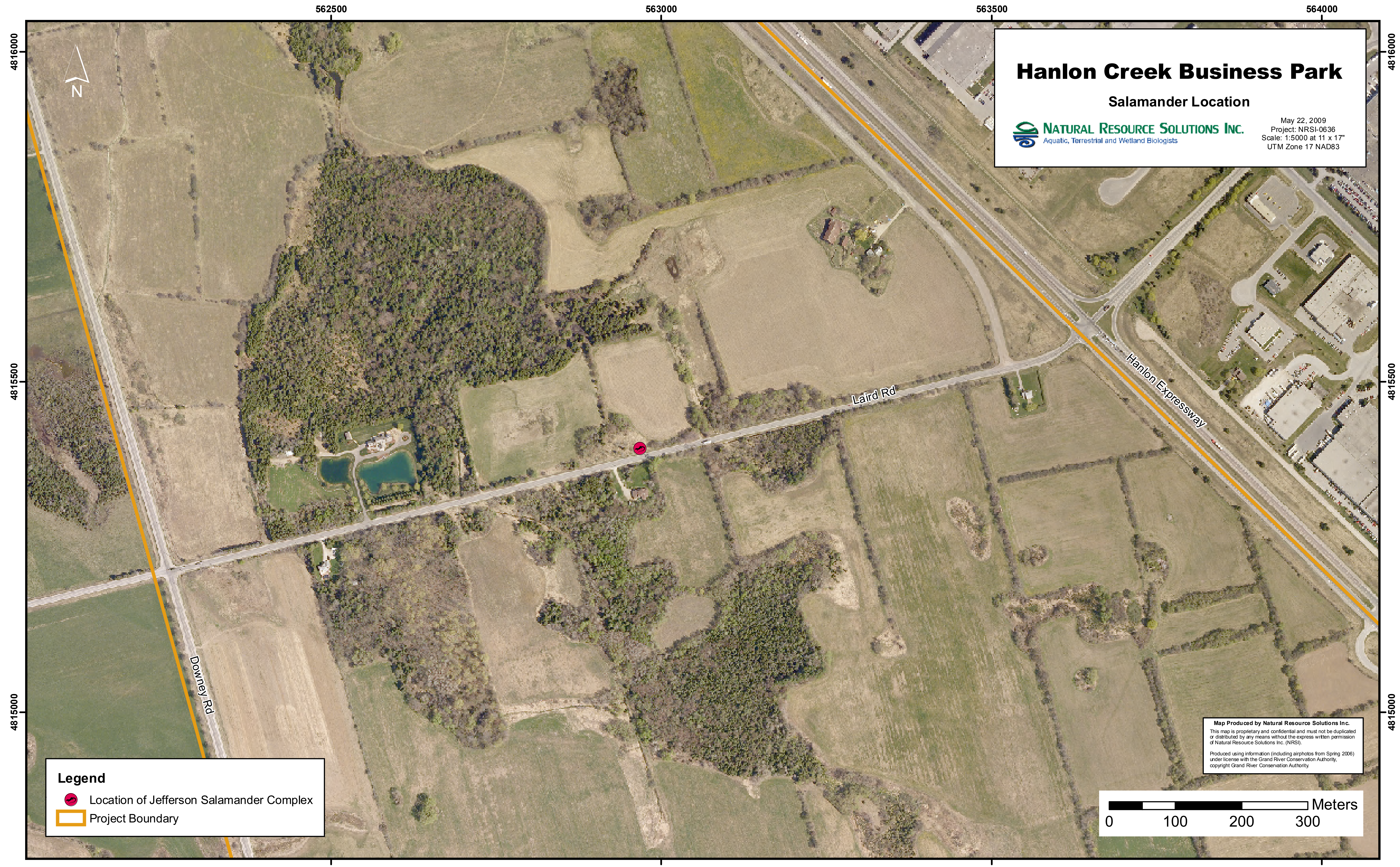
Findings

No salamander species were observed or trapped during salamander trap surveys. Refer toTable 2 for a list of other fauna species observed (i.e. wood frog (*Rana sylvatica*), crayfish (*Cherax spp.*)).

One dead salamander species was collected during road mortality surveys. Genetic analysis of the tail clipping identified the salamander to be *Ambystoma laterale-(2) jeffersonianum;* indicating a Jefferson salamander sperm donor within the area. Figure 2 indicates where the salamander was observed along Laird Road.

Table 2. Salamander Survey Trap Findings

Date	Trap #	Species	# of Individuals
Mar 28/09	SAL-005A	Diving Beetle (*Dytiscidae*)	1
Mar 28/09	SAL-011	Diving Beetle (*Dytiscidae*)	1
Apr 1/09	SAL-001A	Diving Beetle (*Dytiscidae*)	2
Apr 1/09	SAL-001B	Diving Beetle (*Dytiscidae*)	1
Apr 1/09	SAL-002A	Diving Beetle (*Dytiscidae*)	1
Apr 1/09	SAL-005A	Diving Beetle (*Dytiscidae*)	2
Apr 1/09	SAL-007A	Diving Beetle (*Dytiscidae*)	1
Apr 1/09	SAL-008A	Diving Beetle (*Dytiscidae*)	2
Apr 1/09	SAL-011	Diving Beetle (*Dytiscidae*)	5
Apr 1/09	SAL-012	Diving Beetle (*Dytiscidae*)	5
Apr 2/09	SAL-008A	Diving Beetle (*Dytiscidae)*	2
Apr 2/09	SAL-011	Diving Beetle (*Dytiscidae)*	1
Apr 2/09	SAL-012	Diving Beetle (*Dytiscidae)*	2
Apr 2/09	SAL-013	Diving Beetle (*Dytiscidae)*	1
Apr 3/09	SAL-007A	Crayfish	2
Apr 3/09	SAL-007A	Snail	2
Apr 3/09	SAL-004	Leopard Frog	1
Apr 5/09	SAL-007B	Crayfish	3
Apr 6/09	SAL-007A	Crayfish	1
Apr 7/09	SAL-001B	Diving Beetle (*Dytiscidae)*	2
Apr 7/09	SAL-008A	Diving Beetle (*Dytiscidae)*	1
Apr 7/09	SAL-010	Diving Beetle (*Dytiscidae)*	2
Apr 7/09	SAL-012	Diving Beetle (*Dytiscidae)*	4
Apr 8/09	SAL-002A	Diving Beetle (*Dytiscidae)*	2
Apr 8/09	SAL-002A	Crayfish	1
Apr 8/09	SAL-005A	Diving Beetle (*Dytiscidae)*	7
Apr 8/09	SAL-006A	Diving Beetle (*Dytiscidae)*	3
Apr 8/09	SAL-006B	Diving Beetle (*Dytiscidae)*	3
Apr 8/09	SAL-013	Diving Beetle (*Dytiscidae)*	2
Apr 8/09	SAL-014	Diving Beetle (*Dytiscidae)*	1
Apr 9/09	SAL-001A	Diving Beetle (*Dytiscidae)*	3
Apr 9/09	SAL-001B	Diving Beetle (*Dytiscidae)*	1
Apr 9/09	SAL-002A	Diving Beetle (*Dytiscidae)*	1
Apr 9/09	SAL-005A	Diving Beetle (*Dytiscidae)*	3
Apr 9/09	SAL-005B	Diving Beetle (*Dytiscidae)*	2
Apr 9/09	SAL-005C	Diving Beetle (*Dytiscidae)*	3
Apr 9/09	SAL-006A	Diving Beetle (*Dytiscidae)*	1
Apr 9/09	SAL-006B	Diving Beetle (*Dytiscidae)*	2
Apr 9/09	SAL-006C	Diving Beetle (*Dytiscidae)*	2
Apr 9/09	SAL-007A	Crayfish	2
Apr 9/09	SAL007A	Diving Beetle (*Dytiscidae)*	5
Apr 9/09	SAL-008A	Diving Beetle (*Dytiscidae)*	2
Apr 9/09	SAL-012	Wood Frog	1
Apr 9/09	SAL-012	Diving Beetle (*Dytiscidae)*	2



NRSI_0726_Hanlon_SalamanderLocation_5K_22May09_GCS

APPENDIX XIII
Salamander Larval Survey Report

DRAFT

Hanlon Creek Business Park
Salamander Larval Surveys
2009 Summary Report

Prepared for:

Peter Cartwright
City Hall, 1 Carden Street
Guelph, ON
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Project No. 682 J

Date: December 11, 2009

NATURAL RESOURCE SOLUTIONS INC.
Aquatic, Terrestrial and Wetland Biologists

DRAFT
Hanlon Creek Business Park Salamander Larval Surveys 2009 Summary Report

Project Team:

Staff	Role
David Stephenson	Senior Terrestrial Biologist/Certified Arborist – Project Advisor
Tara Brenton	Terrestrial/Wetland Biologist/Certified Arborist – Project Manager
Andrew Ryckman	Terrestrial/Wetland Biologist
Barry Moss	Terrestrial/Wetland Biologist
Caroline Walmsley	Terrestrial/Wetland Biologist
Christine Humphrey	Terrestrial/Wetland Biologist
Jessica Grealey	Terrestrial/Wetland Biologist
Jonathan Brubacher	Terrestrial/Wetland Biologist
Maggie Martin	Terrestrial/Wetland Biologist
Gerry Schaus	G.I.S Mapping
Shawn MacDonald	G.I.S Mapping

Report submitted on December 11, 2009

Tara Brenton, Project Manager

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1.0 Introduction

Under the new Endangered Species Act (ESA 2007), a Draft Recovery Strategy for the Jefferson salamander (*Ambystoma jeffersonianum*) was introduced in spring 2009, and will come into force February 18, 2010. Although the potential for Jefferson salamander within the Hanlon Creek Business Park (HCBP) had not been raised during extensive discussions with the Grand River Conservation Authority (GRCA), City of Guelph Environmental Advisory Committee (EAC), city staff or others, in response to the Jefferson Salamander Draft Recovery Strategy (Jefferson Salamander Recovery Team 2009) and recommendations from EAC, Natural Resource Solutions Inc. (NRSI) was retained by the City of Guelph to conduct salamander minnow traps surveys within the HCBP. Minnow trap surveys were conducted from March 27 to April 9, 2009.

Concerns about the intensity and length of the minnow trap surveys conducted in spring 2009 were raised by the MNR, Guelph District through letter correspondence (Hagman to Loewig, July 31 2009). In order to further assess potential salamander breeding habitat and determine the presence/absence of the species, the MNR recommended salamander larval surveys be conducted. In response to these recommendations, NRSI was retained by the City of Guelph to conduct larval surveys within potential breeding habitats.

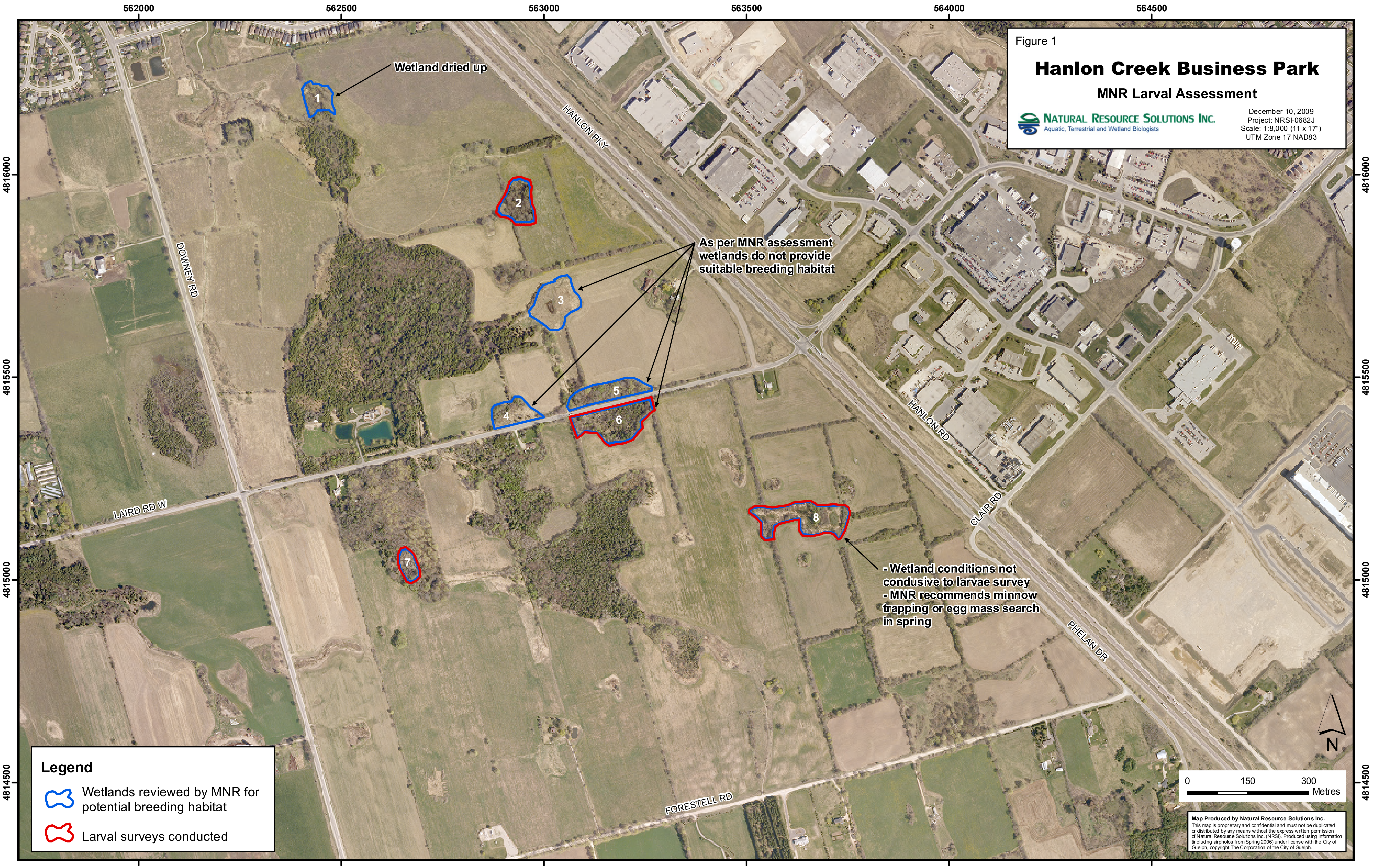
2.0 Survey Methods

On June 17, 2009, NRSI biologists and MNR staff (Art Timmerman, Graham Buck, Karolyne Pickett and Karine Bériault) assessed wetlands within the study area for potential breeding habitat and where appropriate, conducted larval surveys under the direction of MNR Species at Risk Biologist Karine Bériault. At the time of this survey, the OMNR Wildlife Animal Care Committee Approval and Wildlife Scientific Collector's Authorization that NRSI had conducted salamander minnow traps under had expired; therefore, NRSI conducted larval surveys under MNR supervision.

Based on NRSI's first-hand knowledge of the study area and Karine Bériault's expert opinion, potential breeding habitats were identified as wetland features containing vernal pools/ponds or small remnants of standing water, with associated deciduous tree or shrub cover. Where conditions were adequate, dip netting surveys were conducted using aquatic nets or small colanders. During the day, salamander larvae are known to hide within the leaf litter among the wetland bottom. Leaf litter/muck was brought to the surface with the dip nets and scoured for signs of salamander larvae. Figure 1 provides an overview of wetlands that were assessed by NRSI and MNR staff in the field.

Subsequent to surveys conducted on June 17, 2009, NRSI received the necessary permitting to conduct further larval surveys. Dip nets surveys were conducted daily from July 6 to July 10, 2009. The methodology for larval surveys was based on guidance provided by both Dr. Jim Bogart, from the University of Guelph, and MNR Species at Risk Biologist, Karine Bériault, which consisted of visual searches and dip-netting by 2 to 3 biologists throughout the ponds previously identified as potential breeding habitat. In a number of instances, wetlands identified as potential breeding habitat during the June 17 visit were completely dry at the time of larval surveys; therefore, dip net surveys were not conducted within these areas. Larval surveys were conducted within 3 of the wetland areas identified as potential salamander breeding habitat (see Figure 2).

Larval surveys were conducted during daylight hours on each day, except July 9 when surveys were conducted at night. A night-time survey was conducted as it was noted by Dr. Jim Bogart that salamander larvae are sometimes easier to observe and collect during the night in June and July when they are relatively large and are floating and feeding in the water column.



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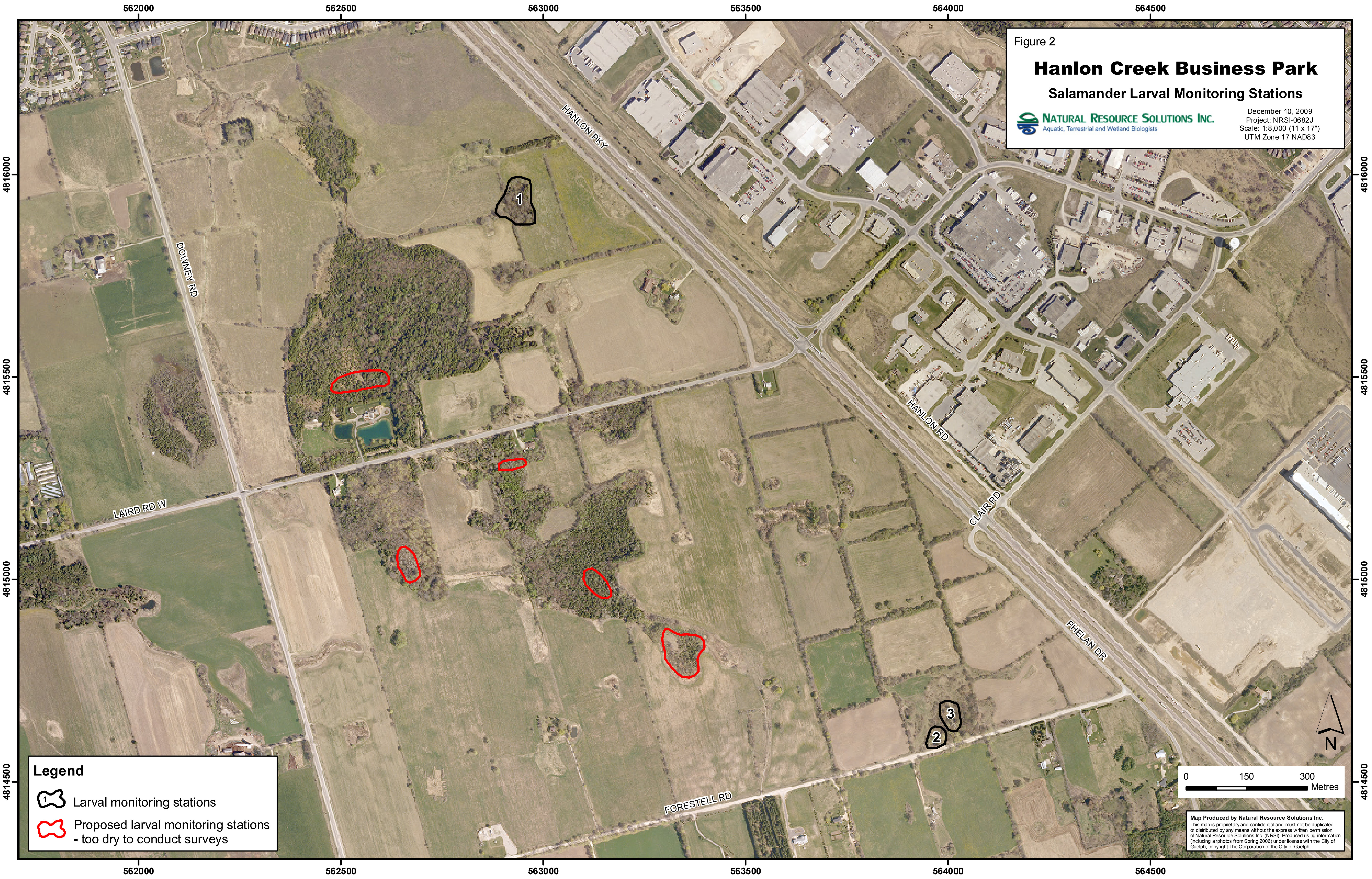

NRSI_0682J_Fig2_LarvaeMonitoring_8K_2009_12_10_SWM

3.0 Survey Findings

NRSI did not observe any salamander larvae during the larval surveys. During the June 17, 2009 surveys with the MNR, one dead specimen was collected by NRSI from Pond 7 (see Figure 1), which was suspected of being a salamander larvae. The specimen was sent to Dr. Jim Bogart for genetic analysis and was identified to be a frog tadpole.

During the larval surveys, NRSI observed both adult and tadpole wood frogs (*Rana sylvatica*) and an adult northern leopard frog (*Rana pipiens*).

4.0 Summary

In spring 2009, NRSI biologists conducted salamander minnow traps surveys within suitable breeding habitat throughout the HCBP. Concerns were raised by the MNR regarding minnow trap intensity and survey length. Therefore, under MNR direction, NRSI conducted salamander larval surveys within wetlands assessed by the MNR and NRSI to be suitable breeding habitat.

NRSI did not observe any adult or larvae salamander species during minnow trap or larval surveys in 2009.

The City of Guelph has retained NRSI to conduct a second season of salamander monitoring within the Business Park in spring 2010. A comprehensive monitoring plan has been developed by NRSI, with input from the MNR and City of Guelph. The monitoring plan has been designed to assess the presence of suitable breeding habitat for Jefferson salamander and determine presence of and direction of any salamander movements to and from natural areas with the use of un-baited minnow traps, as well as drift fencing and pitfall traps. Results obtained from the 2010 monitoring will be used to supplement findings from the 2009 surveys (minnow trap surveys, larval surveys and review of habitat characteristics).

5.0 References

Bogart, Jim. 2008. Protocol for *Ambystoma jeffersonianum*. University of Guelph. Unpublished Document. Pp.4

Jefferson Salamander Recovery Team. 2009. Draft Recovery Strategy for the Jefferson Salamander (*Ambystoma jeffersonianum*) in Ontario. Ontario Recovery Strategy Series. Prepared for the Ontario Ministry of Natural Resources, Peterborough, Ontario. Vi +27.

APPENDIX XIV
Laird Road Wildlife Movement Survey Report

DRAFT

Hanlon Creek Business Park
Laird Road Wildlife Movement Surveys
2009 Summary Report

Prepared for:

Peter Cartwright
City Hall, 1 Carden Street
Guelph, ON
N1H 3A1

Project No. 682 I

Date: December 11, 2009

NATURAL RESOURCE SOLUTIONS INC.
Aquatic, Terrestrial and Wetland Biologists

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Hanlon Creek Business Park
Laird Road Wildlife Movement Surveys
2009 Summary Report

Project Team:

Staff	Role
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Tara Brenton	Terrestrial/Wetland Biologist/Certified Arborist, Project Manager
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Jonathan Brubacher	Terrestrial/Wetland Biologist
Kevin Dance	Terrestrial/Wetland Biologist
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1.0 Introduction

In March 2009 the Guelph Natural Heritage Strategy (NHS) was finalized which summarized the results of amphibian monitoring that took place in the City of Guelph, including the lands to be developed as the Hanlon Creek Business Park. The NHS indicated that 3 amphibian road crossing locations were documented over 2004 and 2005, and additional crossings were identified by local naturalists during the stakeholder/public consultations over the fall of 2008. NHS mapping showed three Confirmed Amphibian Crossings along Laird Road between Downey Road and the Hanlon Expressway. Amphibian road mortality has been observed on Laird Road and may increase in the future as traffic volume increases, particularly during spring dispersal to breeding ponds.

The HCBP Environmental Implementation Report (NRSI 2009) was reviewed by the City of Guelph Environmental Advisory Committee (EAC) and approved on April 8, 2009, based on satisfaction of 17 conditions. The following conditions pertain to Laird Road:

- That as part of Phase 3, the road bed in the closed portion of the old Laird Road be removed and restored. If complete removal is not feasible, the road height and width should be reduced, road surfacing should be converted to a non-paved surface, road verges naturalized and wildlife/amphibian crossings be considered;
- That interim mitigation measures be employed to limit amphibian crossing until the closure of the old Laird Road.

In order to address the request for wildlife/amphibian crossings and mitigation measures, as well as determine areas of concentrated movement, Natural Resource Solutions Inc. (NRSI) was retained by the City of Guelph to conduct road mortality surveys along Laird Road during the remaining amphibian breeding/movement season. Once movement areas were identified, NRSI was to work with the City of Guelph and agency staff to develop appropriate mitigation measures.

2.0 Wildlife Movement Methodology

In order to collect site specific, primary data of amphibian movement across Laird Road, nighttime surveys were conducted twice a week from April 20 to June 18, 2009. Surveys involved biologists walking along Laird Road from the Hanlon Expressway to Downey Road, recording all wildlife species observed. Searches commenced one-half hour after sunset and ended before midnight. For each visit, detailed field notes were taken which included weather conditions, species observed on the road, individual status (i.e. dead, alive or injured) and direction of movement. The location of each individual observed along the road was recorded using a GPS and mapped on an airphoto.

The timing of these surveys was based on information that locals had documented considerable mortality of frogs and toads in previous years. NRSI initiated mortality surveys following approval of the EIR (NRSI 2009) and work plan approval.

3.0 Survey Findings

A total of 101 wildlife observations were made along the road surface during mortality surveys. These observations included herpetofauna (frogs, toads and snakes), and mammals. Of the 101 observations, 77% were found dead, 22% were alive and 0% were injured. Amphibian species comprised 95% of these observations, 7% of which were unidentified anuran species as shown on Figure 1. The anuran species not identified to species were generally unidentifiable after being run over by vehicles.

In addition to amphibians, NRSI also documented a dead eastern milksnake (*Lampropeltis t. triangulum*), eastern chipmunk (*Tamias striatus*) and two mouse species. The eastern milksnake is ranked as Vulnerable provincially and is also considered a species of Special Concern by the MNR and COSEWIC.

One dead salamander species was observed and collected on April 20, 2009. DNA extraction and analysis was performed at the University of Guelph by Dr. Jim Bogart. Genetic analysis of the tail clipping identified the salamander to be *Ambystoma laterale-(2) jeffersonianum;* indicating a Jefferson salamander sperm donor within the area.

Table 1 and Figure 1 outline the number and percentage of each species observed during mortality surveys. Refer to Appendix I for condition of each individual observed (i.e. dead or alive).

Table 1. Number of Wildlife Species Observed Along Laird Road

Common Name	Scientific Name	# Observed
Frogs and Toads		
American toad	*Bufo americanus*	35
Anuran species	*Anuran ssp.*	7
Green frog	*Rana clamitans melanota*	3
Northern leopard frog	*Rana pipiens*	33
Northern spring peeper	*Rana crucifer crucifer*	16
Wood frog	*Rana sylvatica*	2
Snakes		
Eastern milksnake	*Lampropeltis t. triangulum*	1
Salamanders		
Jefferson/blue spotted salamander complex	*Ambystoma laterale-(2) jeffersonianum*	1
Mammals		
Eastern chipmunk	*Tamias striatus*	1
Mouse ssp.	*Peromyscus ssp.*	2
Total:		**101**

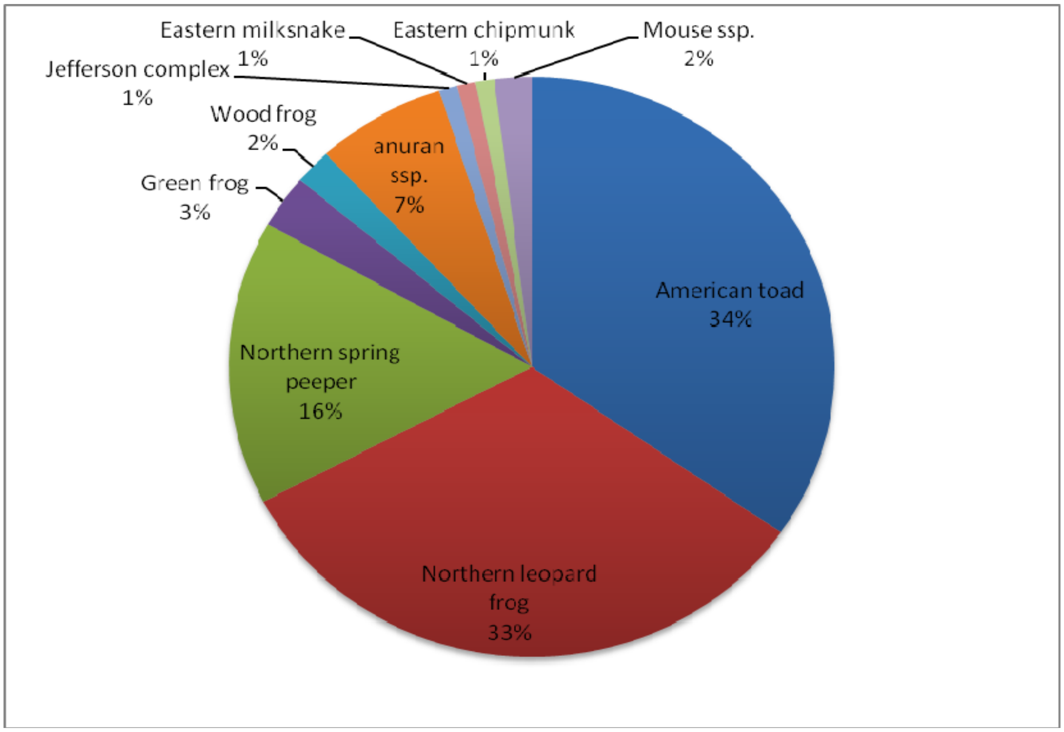
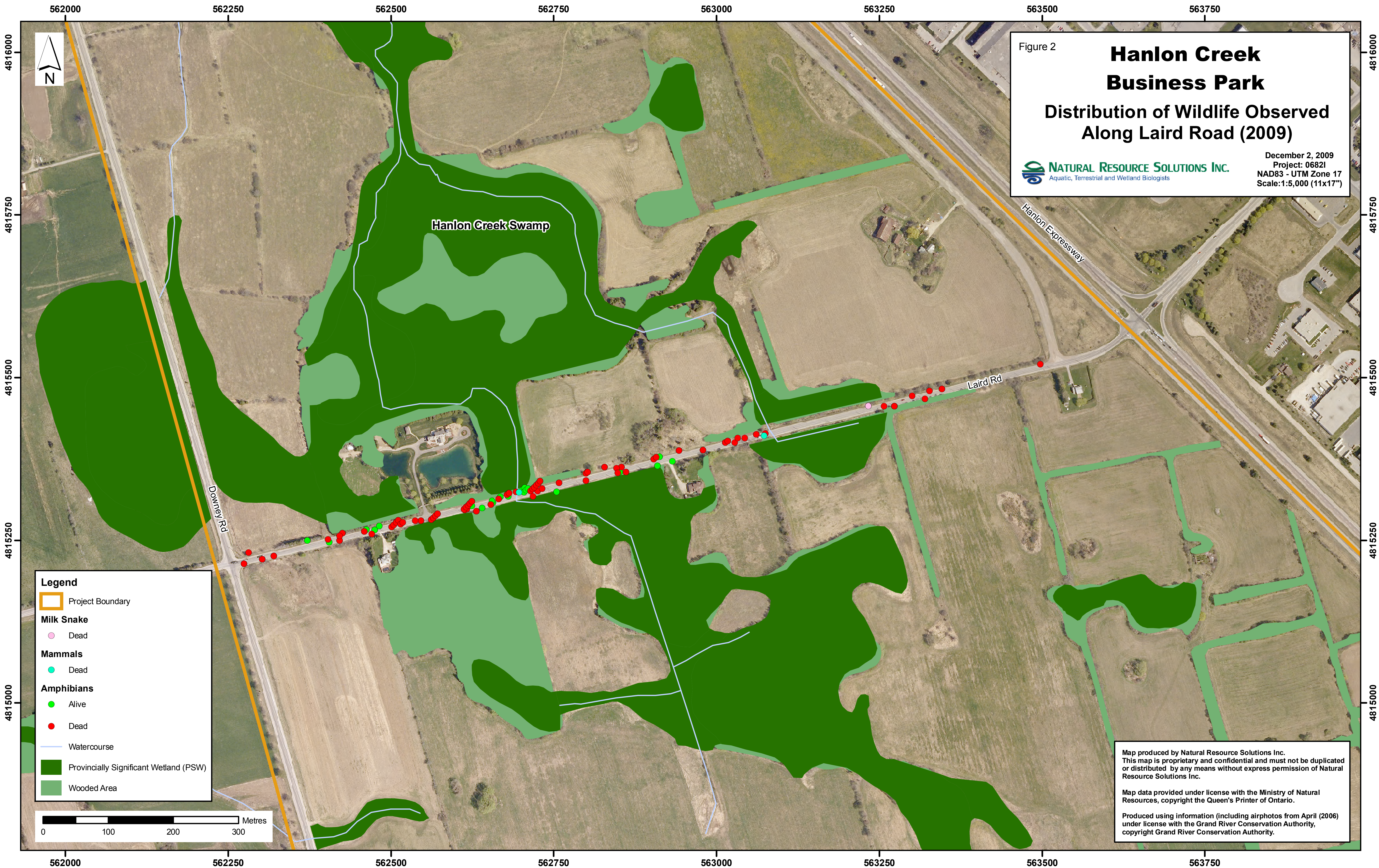


Figure 1. Wildlife Observed Along Laird Road in 2009

As mentioned previously, the location of each observation was recorded using a GPS and is shown on Figure 2. Observations of wildlife were generally quite dispersed along Laird Road; however, concentration areas are noticeable where natural features are present along both sides of the road, especially where wetlands.



NRSI_0682I_Fig2_LairdRdWildlifeObservations_5K_2009_12_02_SWM

When feasible, direction of movement for each individual observed was recorded. Based on observations, 28% were moving north, 32% were moving south, while only 2% were noted to be moving east and/or west. In cases where carcasses were unidentifiable due to road mortality, direction of movement, unless quite obvious, was recorded as unknown (37%). As anticipated, amphibian movement was concentrated in a north/south direction, indicating movement from breeding ponds located adjacent to Laird Road.

The amphibian breeding season generally begins in mid to late March for a number of amphibian species (i.e. Jefferson salamander, wood frog, northern spring peeper and western chorus frog) and tapers off in June for species such as green frog (*Rana clamitans melanota*) and northern leopard frog (*Rana pipiens*). In cases where wetlands are adjacent to busy roadways, there is often a correlation between increased amphibian road mortalities and peak breeding seasons.

As shown in Figure 3, observation of amphibians along Laird Road was considerably higher in April than in June, which correlates with the fact that many of the amphibian species known to occur within the vicinity of the study area breed primarily in early to mid spring.

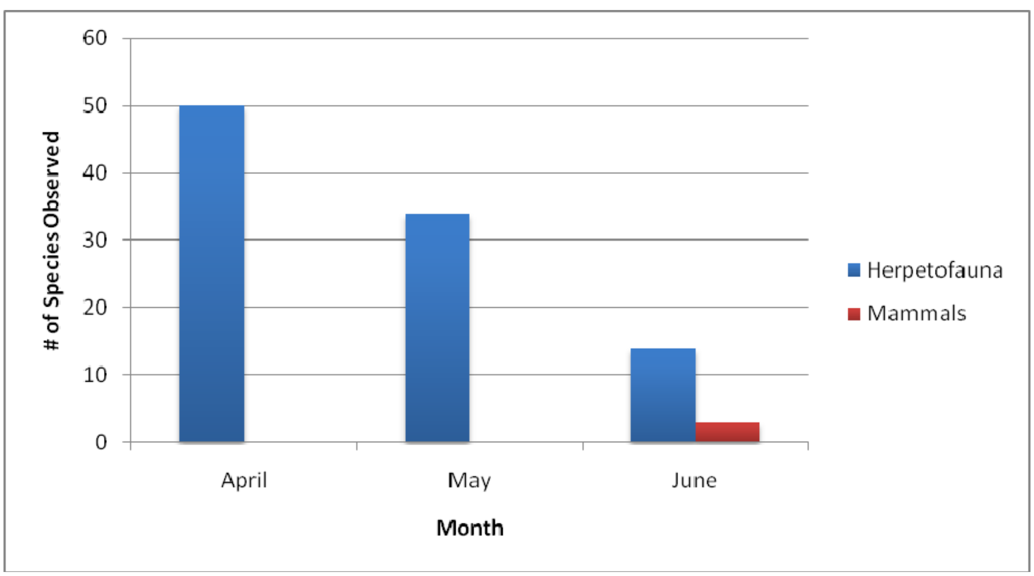


Figure 3. Wildlife Abundance by Month

4.0 Mitigation Measures and Recommendations

In fall 2009, it was noted by local residents that a high number of amphibian mortalities were occurring along Laird Road. Although concentrated amphibian movements are known to occur during the spring and decrease during the summer (June-August), there is recent evidence that a second period of movement occurs between late August and November, which likely corresponds to movement to hibernation grounds (Regosin et.al 2005). In response to this movement period, the City of Guelph temporarily closed Laird Road from September 22 to October 2, 2009 in an attempt to reduce the number of road mortalities.

The closure of Laird Road prior to development of Phase 3 of the Hanlon Creek Business Park is not feasible at this time as the road is utilized by many local residents, and is a major aggregate haul route for pits located to the west. Based on a preliminary analysis of road mortalities recorded by NRSI in 2009, a number of wildlife culverts were proposed in primary movement areas as a mitigation measure for road mortalities. Upon review of the proposed mitigation plan, the MNR, Guelph District provided the following comments:

- *"Given that salamanders can exhibit an aversion to culverts, we are worried that installing the culverts prior to the habitat use study may alter current natural movement patterns of salamanders across the road,*
- *MNR does not recommend installing these new culverts at this time. We note that this may be a mitigation measure that can be considered once both studies have ended"* [2010 salamander habitat use study]

NRSI has recommended installation of barrier fencing, in conjunction with pitfall traps along Laird Road as a mitigation measure for amphibian road mortality until results from the 2010 salamander habitat study are obtained. In comments from the MNR (November 2, 2009), it was stated that *"fencing along Laird Road will help prevent amphibian road crossing, hopefully reducing the number of animals killed by traffic. We also agree that installing pitfall traps along the fence is the best way to capture animals headed for the road.....MNR recommends there be no gaps between fence segments."* Following submission of the fencing plan along Laird Road, it was agreed that openings in the barrier fence would be permitted at residential and agricultural laneways.

The high concentrations of mortalities along Laird Road indicate the need for mitigation measures to be developed. From the road mortality surveys, it is evident that amphibians, particularly northern leopard frogs, American toads and northern spring peeper are experiencing high numbers of mortalities, and that incorporating safe passage for these species across the road is warranted until the eventual closure of the road. Pending results of the 2010 monitoring plan and further recommendations from the MNR, there are specific requirements for wildlife that need to be considered when designing wildlife culverts, including the following:

- diameter, length and number of culvert/tunnels,
- availability of light,
- substrate in the culvert/tunnel,
- moisture levels/standing water,
- noise levels, and
- use of drift fencing.

As Laird Road is not slated to be closed until the development of Phase 3 of the HCBP, the design of ecological and practical underpasses (i.e. culvert) for amphibians is recommended in the locations identified to have high concentrations of amphibians during their movement/breeding period. Incorporating additional culverts, as underpasses for wildlife, may be helpful in mitigating wildlife mortality along Laird Road. It is also recommended, as outlined in the HCBP EIR (NRSI 2009), that mechanisms such as speed limit and wildlife crossing signs be erected along Laird Road while it remains open. Wildlife and speed limit signs, although not barriers to wildlife movement, increase the public's awareness of the potential movement of wildlife along a stretch of road. It is anticipated, that when made aware, local motorists will reduce their speed limit to minimize impact to crossing wildlife.

5.0 References

Natural Resource Solutions Inc. 2009. Hanlon Creek Business Park Environmental Implementation Report. February 2009. Prepared for the City of Guelph.

Regosin, J.V., B.S. Windmiller, R.N. Homan and J.M. Reed. 2005. Variation in Terrestrial Habitat Use by Four Pool-Breeding Amphibian Species. Journal of Wildlife Management 69(4): 1481 – 1493; 2005.

APPENDIX I
Species Observed During Laird Road Wildlife Movement Surveys (2009)

Hanlon Creek Business Park - Laird Road Wildlife Movement Surveys (2009)

Common Name	Direction of Movement	Status	Date Observed
American toad	south	dead	April 20, 2009
unknown anuran	unknown	dead	
Northern leopard frog	unknown	dead	
Northern leopard frog	south	alive	
Northern leopard frog	south	alive	
Northern spring peeper	north	alive	
Northern spring peeper	unknown	dead	
Northern spring peeper	south	alive	
unknown anuran	unknown	dead	
unknown anuran	unknown	dead	
Northern spring peeper	unknown	dead	
American toad	north	dead	
Northern leopard frog	south	alive	
Northern leopard frog	unknown	dead	
Northern spring peeper	unknown	dead	
Northern spring peeper	unknown	dead	
American toad	north	alive	
Northern leopard frog	south	alive	
Northern leopard frog	south	alive	
Northern leopard frog	south	alive	
Jefferson complex	unknown	dead	
American toad	north	dead	
American toad	unknown	dead	
Northern leopard frog	unknown	dead	
American toad	unknown	dead	April 30, 2009
Wood frog	west	dead	
Northern leopard frog	south	alive	
Northern leopard frog	unknown	dead	
Northern leopard frog	unknown	dead	
Green frog	south	alive	
American toad	south	dead	
American toad	south	alive	
unknown anuran	unknown	dead	
Northern leopard frog	north	alive	
American toad	south	alive	
American toad	unknown	dead	
American toad	north	dead	
American toad	north	dead	
American toad	north	dead	
Northern leopard frog	unknown	dead	
unknown anuran	north	alive	
Northern leopard frog	unknown	dead	
Northern leopard frog	unknown	dead	
Northern leopard frog	south	alive	
Northern leopard frog	south	alive	
American toad	north	dead	
American toad	north	dead	
American toad	north	dead	
Northern spring peeper	south	dead	
Northern spring peeper	south	dead	

Hanlon Creek Business Park - Laird Road Wildlife Movement Surveys (2009)

Common Name	Direction of Movement	Status	Date Observed
Green frog	unknown	dead	May 5, 2009
Northern leopard frog	north	dead	
Northern leopard frog	north	dead	May 6, 2009
Northern leopard frog	north	dead	
Northern spring peeper	north	dead	
Northern spring peeper	north	dead	
Northern leopard frog	south	alive	
Northern leopard frog	south	alive	
Northern leopard frog	south	alive	
Northern spring peeper	south	dead	
Northern spring peeper	south	dead	
Northern spring peeper	south	dead	
Northern spring peeper	south	dead	
American toad	south	dead	
American toad	south	dead	
American toad	south	dead	
American toad	south	dead	
American toad	south	dead	
American toad	north	dead	
American toad	north	dead	
American toad	north	dead	
American toad	north	dead	
American toad	north	dead	
American toad	north	dead	
Northern spring peeper	south	dead	May 28, 2009
Northern leopard frog	south	alive	
Northern leopard frog	east	dead	
Northern leopard frog	north	dead	
Northern leopard frog	north	dead	
American toad	north	alive	
Northern leopard frog	unknown	dead	
American toad	unknown	dead	
Northern spring peeper	unknown	dead	
Northern leopard frog	unknown	dead	
Eastern chipmunk	unknown	dead	June 4, 2009
Mouse ssp.	unknown	dead	
American toad	north	dead	June 8, 2009
American toad	west	dead	
American toad	unknown	dead	
Northern leopard frog	east	dead	
American toad	unknown	dead	
American toad	unknown	dead	
unknown anuran	unknown	dead	June 11, 2009
Eastern milksnake	unknown	dead	
Green frog	unknown	dead	
unknown anuran	unknown	dead	
Wood frog	unknown	dead	
Northern leopard frog	unknown	dead	
American toad	south	dead	
Northern leopard frog	north	dead	
Mouse ssp.	unknown	dead	June 15, 2009

Hanlon Creek Business Park - Laird Road Wildlife Movement Surveys (2009)

Common Name	Direction of Movement	Status	Date Observed
	Total Herpetofauna	98	
	Dead	76	
	Alive	22	
	Total Mammals	2	
	Dead	3	
	Alive	0	
	Direction of Movement		
	North	28	
	East	2	
	South	32	
	West	2	
	unknown	37	

APPENDIX V

CONSTRUCTION INSPECTION REPORTS

NATURAL RESOURCE SOLUTIONS INC.
Aquatic, Terrestrial and Wetland Biologists

Memo

Project No. 726

To: Colin Baker

CC: Bill Luffman

From: Tara Brenton

Date: May 22, 2009

Re: Hanlon Creek Business Park Fill Borrow Location

The following memo is in response to comments received from Colin Baker from the City of Guelph prior to issuing a site alteration permit for lands within Phase II of the Hanlon Creek Business Park. The following requirements have been requested:

1. Response to EAC Comment No. 6 regarding the presence/absence of the Jefferson Salamander on the HCBP site.
2. Confirmation that the tree protection fencing and signage around the Heritage Maple Grove will be installed prior to site alteration.

The Hanlon Creek Business Park is situated between Downey Road and the Hanlon Expressway, between Forestell Road and the south end of the Kortright IV subdivision along Teal Drive. Lands under ownership of Cooper Construction are located south of Laird Road and north of Forestell Road within Phase II of the proposed development. An Environmental Implementation Report (EIR) was prepared for the proposed business park by Natural Resource Solutions Inc. and approved by the City of Guelph Environmental Advisory Committee with 17 conditions.

<u>Proposed Undertaking</u>
The proposed location of the fill borrow area is as shown on the '200 Acres in South Guelph' plan prepared by Cooper Construction (see attached Figure). The topography associated with Phase II is fairly flat to gently undulating, with some steeper slopes present, resulting in an excess of fill material. Additional fill material is required for Cooper Construction development lands located along the east side of the Hanlon Expressway. To accommodate the need for additional fill material on lands east of the expressway, the excavation of approximately 35,000m^3 of fill from Phase II lands is proposed. This process would begin immediately upon approval of the site alteration permit.

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Sault Ste. Marie: 111 Elgin Street, Unit 201, Sault Ste. Marie, Ontario, P6A 6L6 **Tel:** (705) 253-0620 **Fax:** (705) 253-0670 | **Email:** info@nrsi.on.ca

Location of the Proposed Fill Borrow Area
The location selected for the proposed fill borrow area will be situated on lands designated Industrial in the Guelph Official Plan and abut lands which will be developed for industrial uses which are next to the Hanlon Expressway.
The fill borrow area will be in the southeast portion of Phase II, at the corner of Forestell Road and Phelan Drive within an active agricultural field. Two hedgerows are located along the north and west perimeter of the borrow area; however, removal of trees and shrubs within these hedgerows is not anticipated. Lands associated with the fill borrow area were included in the HCBP EIR (NRSI 2009) as future development lands and associated hedgerows were proposed for removal.

Salamanders
Natural Resource Solutions Inc. biologists conducted salamander surveys within the business park from March 27 to April 9, 2009. Staff from the MNR was consulted during the establishment of survey stations to ensure maximum coverage of potential salamander habitat. In particular, five salamander stations were established in the two wetlands within the Heritage Maple Grove, which is approximately 220m from the proposed topsoil borrow site.

No salamander species were observed within the Heritage Maple Grove during surveys. As the proposed topsoil borrow area is comprised of active agricultural lands that are surrounded by roadways, no salamander species are anticipated to utilize this area.

Tree Retention/Removal
Hedgerows that border the north and west edges of the proposed fill borrow area will be retained as part of this permit application. As these hedgerows are proposed for removal within the HCBP EIR (NRSI 2009), it is not necessary to provide protective fencing along the hedgerow areas.

The EIR specifies that protective fencing be placed around the Heritage Maple Grove prior to commencement of any construction activities (NRSI 2009). Although no impacts to the grove are anticipated as a result of the topsoil borrow area, the landowner is committed to installing a paige-wire fence on posts around the entire block, providing a fence gate for access/maintenance and providing signage to identify ownership and significance of the trees, prior to clearing activities. Once the paige-wire fence is erected, location will be confirmed in the field. Refer to attached Figure (Figure 12. Property Demarcation Plan) from the EIR, for proposed fencing location.

Conclusion
The location of the proposed fill borrow area has been selected as it is within active agricultural lands, is beyond 120m from all wetlands and is approximately 220m from the Heritage Maple Grove. The lands are designated Industrial in the Guelph Official Plan and abut lands which will be developed for industrial uses which are next to the Hanlon Expressway. No direct impacts to any natural features, specifically, the Heritage Maple Grove and Jefferson salamander (*Ambystoma jeffersonianum*) are anticipated. The proposed borrow area is bordered by two hedgerows that are not identified for removal at this time.

Based on our review of the location of the proposed fill borrow area, it is our opinion that there will be no negative impacts on the natural features in the area.

Memo

Project No. 942

To: **Colin Baker**

CC: **Bill Luffman**

From: **Tara Brenton**

Date: **June 19, 2009**

Re: **HCBP - Analysis of trees adjacent to Tree Protection Fencing along Forestell Road**

The following memo provides an analysis of trees associated with installation of the tree protection fencing around the Heritage Maple Grove along Forestell Road (i.e. health, mechanical damage).

Prior to issuing a site alteration permit for lands within Phase II of the Hanlon Creek Business Park, Colin Baker from the City of Guelph requested that tree protection fencing be installed around the Heritage Maple Grove as outlined in the HCBP EIR (NRSI 2009).

Following installation of the tree protection fencing, the landowner contacted NRSI staff to inform them that the fencing had been placed along Forestell Road, which was not recommended within the EIR. It was noted by the landowner and City of Guelph that adjacent trees may have been impacted during installation. It was requested that a Certified Arborist examine any impacts associated with the fencing and provide recommendations.

A Certified Arborist from NRSI assessed the Heritage Maple Grove tree protection fencing along Forestell Road and adjacent trees on June 16, 2009. The following items were noted:
- A linear swath of land approximately 3m in width has been cleared of surface vegetation for installation of fencing
- Fencing is situated in a manner that excludes trees that were identified within the EIR (NRSI 2009) for retention with the Heritage Maple Grove
- Fencing does not correspond to recommended fencing area as noted in EIR (NRSI 1009)
- Fencing is beneath dripline of ironwood (*Ostrya virginiana*)
- Approximately 12 trees that may have been impacted by installation of fence (refer to Table 1)

Table 1. Forestell Road Tree Assessment

Species		Health/Hazard Assessment from EIR			Assessment Comments	Recommendations
		Hazard	Overall Condition	Retain/Remove		
Basswood	*Tilia americana*	N/A	N/A	Retain	- Mechanical damage to root flare and main trunk	- Monitor condition
Sugar maple	*Acer saccharum*	Low	Good	Retain	- No visible damage to main trunk - May have minimal root damage as cleared area extends up to base of tree	- Monitor condition
American beech	*Fagus grandifolia*	Medium	Excellent	Retain	- Tree is healthy and undamaged - Root wads and tree cuttings are placed up against base of trunk	- Remove root wads and tree cuttings from base of tree to avoid any potential impact to root crown - Monitor condition
Black cherry	*Prunus serotina*	Low	Poor	Retain	- Mechanical damage to two areas along trunk - Appears to have one root severed for placement of fence post - Tree being invaded by riverbank grape (*Vitis riparia*) and canopy showing signs of decline that aren't a result of fence installation	- If fence location is maintained and condition of tree continues to decline, recommend removal of tree due to hazard potential - Retain tree if tree protection fencing is removed from its current location - Monitor condition
Sugar maple	*Acer saccharum*	N/A	N/A	N/A	- Tree <10cm dbh, 2.5m crown radius, one-sided crown - Extensive mechanical damage to trunk	- If fence location is maintained, recommend removal of tree due to hazard potential - Retain tree if tree protection fencing is removed from its current location - Monitor condition
Sugar maple	*Acer saccharum*	Medium	Good	Retain	- Mechanical damage to root flare and lower portion of trunk - Fence situated right over top of root flare - During fence installation, 3-4 lower lateral branches were pruned. Branches pruned properly.	- Monitor condition

Basswood	*Tilia americana*	Medium	Good	Retain	- Small amount of damage due to small adjacent sugar maple rubbing on stem as a result of machinery driving by - Machinery tracks immediately adjacent to base of tree, leaving 2 large roots exposed; 1 severed and 1 damaged	- Monitor condition
Black cherry	*Prunus serotina*	High	Good	Retain	- No obvious damage as cleared area is approx. 3m from main trunk - May have incurred minimal root damage as a result of vegetation clearing beneath dripline	- Monitor condition
Sugar maple	*Acer saccharum*	Medium	Excellent	Retain	- Fencing beneath dripline but approx. 1- 1.5m from main trunk - No visible impact	- Monitor condition
Sugar maple	*Acer saccharum*	High	Fair	Retain	- Fence located at end of root flare beneath canopy - No visible damage to tree	- Monitor condition
Ironwood	*Ostrya virginiana*	Medium	Poor	Retain	- Fencing approx. 2.5m from base of tree, beneath dripline - No direct impact to tree	- Two recommendations; 1) remove tree protection fencing along Forestell Road, or 2) move existing fence south a minimum of 1m beyond the dripline - Monitor condition
Sugar maple	*Acer saccharum*	High	Good	Retain	- Fencing located over large root flare with main wooden fence post immediately adjacent - Mechanical damage (bark removal) on large overhanging lateral branch	- Monitor large lateral branch for signs of compartmentalization - If fence location is maintained: if over time there is no sign of compartmentalization or branch is showing signs of decay or insect infestation, recommend proper pruning of lateral branch due to hazard potential to Forestell Road - Monitor condition

**for full Health/Hazard Assessment, refer to HCBP EIR, Appendix V (NRSI 2009)*

In order to satisfy OMB Condition 3 (2006), the ironwood must be preserved with a tree protection zone that will extend a minimum of one metre past the dripline of the tree. The landowner is aware that the tree protection fencing adjacent to the ironwood must be readjusted. It has been requested that NRSI identify the necessary tree protection fencing location.

As previously noted, the tree protection fencing was installed in an area that excludes trees identified for retention within the EIR (NRSI 2009). As the tree protection fencing has already been installed, in order to reduce further impact to the Heritage Maple Grove and satisfy OMB Condition 3, the following options are recommended:

- readjust existing tree protection fence immediately adjacent to ironwood so it is provided a protection zone of at least one metre beyond dripline,
- realign tree protection fence so it is immediately adjacent to Forestell Road and includes trees identified for retention within the EIR, or
- remove current tree protection fencing along Forestell Road

It is recommended that the above options be assessed in the field by NRSI and the City of Guelph to determine the option having the least amount of impact.

I trust that the above information is satisfactory. If you have any questions, please do not hesitate to contact the undersigned.

Sincerely,

Tara Brenton, B.Sc., ISA Certified Arborist
Natural Resource Solutions Inc.

NATURAL RESOURCE SOLUTIONS INC.
Aquatic, Terrestrial and Wetland Biologists

Memo

Project No. 942

To: **Bill Luffman**

CC: **Suzanne Young**

From: **Tara Brenton**

Date: **July 1, 2009**

Re: **Cooper Construction – Tree Protection Fencing along Forestell Road**

The following memo provides an outline of action items that need to be addressed as per the tree inspection conducted by a Certified Arborist from NRSI on June 16, 2009 and the on-site meeting with Suzanne Young from the City of Guelph, Bill Luffman from Cooper Construction and Tara Brenton from NRSI (June 26, 2009).

As noted in NRSI's inspection report, dated June 19, 2009, tree protection fencing was installed in an area along Forestell Road that includes trees identified for retention within the EIR (NRSI 2009). In addition, the current fence location does not satisfy OMB Condition 3 (2006), "the single hop hornbeam (*Ostrya virginiana*) will be preserved with a tree protection zone that will extend one metre past the drip line of the tree". The tree protection fence is located beneath the canopy of the hop hornbeam (ironwood).

The City of Guelph and NRSI recommend the following steps be taken in order to satisfy OMB Condition 3 and recommendations with the EIR (NRSI 2009):

- remove existing tree protection fence that was installed along Forestell Road,
- ensure fence posts and fencing are removed in a manner that does not cause further damage to any of the adjacent tree species, including root systems,
- in the event that fence posts cannot be removed without causing further damage to trees and their roots, cut posts off at ground level,
- retain all other tree protection fencing that has been installed around perimeter of Heritage Maple Grove,
- excess woody debris resulting from clearing activities during previous fence installation that is resting against trees (i.e. American beech – Photo 1)) is to be cleared away by hand to avoid impact to trees and their roots,
- excess woody debris located at the base of west slope (close proximity to wetland) is to be cleared to ensure no unnecessary impact to wetland (Photo 2),

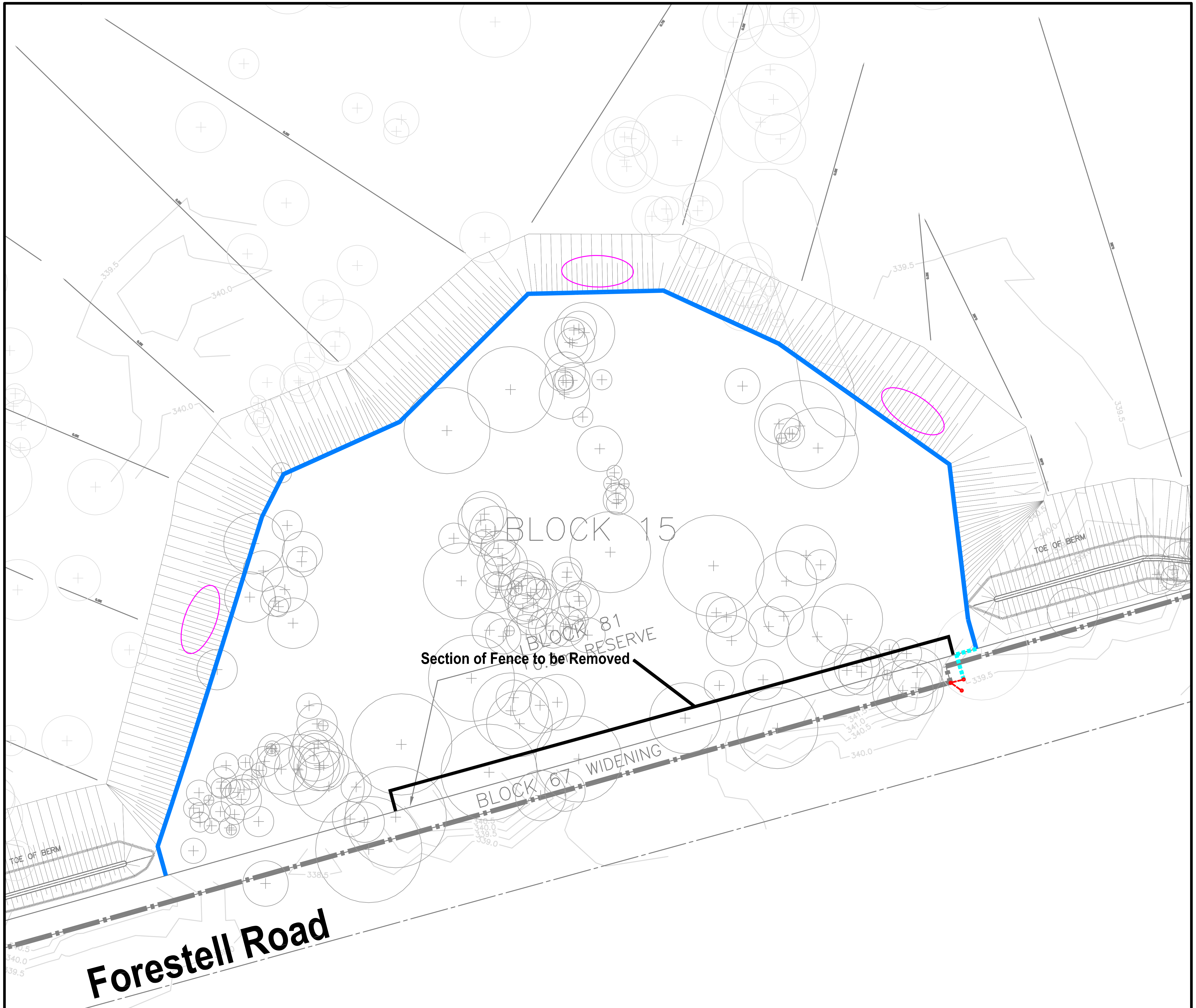
- remove gate that is situated on the east side of woodlot and re-locate closer to Forestell Road (see attached Figure),
- gate should direct any in-coming traffic along existing laneway (see Photo 3 for existing laneway position and appended Figure for overview of recommended fence and gate re-location), and
- install three Tree Protection signs around perimeter of Heritage Maple Grove to ensure highly visible to construction crews (see attached Figure)

Following removal of the existing fence along Forestell Road, it is recommended that the area be reassessed by a Certified Arborist to document conditions (i.e. further damage to trees, status of fence and fence posts). It is also recommended that a qualified biologist monitor the original fence area on an annual basis for two years to document status of adjacent trees (i.e. health and hazard rating), natural regeneration along cleared area and erosion issues and provide management recommendations to the City based on these observations. It should be noted that these recommendations are specific to the area associated with the tree protection fence installed by Cooper Construction and are in no way related to inspections associated with the Hanlon Creek Business Park.

I trust the above information is adequate. Should you have any further questions or comments, please contact the undersigned.

Sincerely,

Tara Brenton
Natural Resource Solutions Inc.



Hanlon Creek Business Park
City of Guelph

Heritage Maple Grove

June 2009
Project 0924
Universal Transverse Mercator - NAD83
Scale 1:750 @ (11x17")

Natural Resource Solutions Inc.
Aquatic, Terrestrial and Wetland Biologists

Legend

- Recommended tree protection sign location
- Tree protection fence location
- Revised tree protection fence location
- Revised gate location
- Tree Point (crown radius to scale) - Retain
- Tree Polygon (outline represents dripline) - Retain
- Tree Point (crown radius to scale) - Remove
- Tree Polygon (outline represents dripline) - Remove
- Existing Contours
- Proposed Contours

Base layers from AECOM received January 21, 2009 (X-prgrading, X-prlegal, X-prroad, X-excont) and from Cooper received June 11, 2008 (300-rg-grad-mod).

Tree Protection Fencing

Photo 1: Woody debris up against American beech (*Fagus grandifolia*)

Photo 2: Woody debris adjacent to wetland area (southwest edge of fence)

Photo 3: Existing gate and laneway

Environmental Inspection Report

Project Number:	942
Construction Project:	Hanlon Phase II – Fill Borrow Area
Date of Inspection:	June 16, 2009
Location:	HCBP – Small portion of Block 5, along Forestell Road
Works inspected:	- Silt fencing associated with fill borrow and topsoil pile locations - Any impacts to natural areas associated with fill borrow and topsoil pile locations
Activity:	Grading activities associated with removal of fill within small portion of Block 5 and relocation of fill to Cooper site east of the Hanlon Expressway
Weather Conditions at time of Inspection:	Approx. 27°C, 5% cloud cover, no precipitation (warm, sunny, slightly dry conditions)
Weather Conditions 24 hrs prior to Inspection:	Sunny, approx. 23°C, no precipitation

Description of Works:

- Erosion and sediment control (ESC) fencing has been installed around the perimeter of the fill borrow area.
- ESC fencing has been installed around the perimeter of the topsoil pile location.
- Topsoil has been removed from the fill borrow area and relocated to the topsoil pile location north of the fill borrow area.
- Earthwork trucks are in the process of removing fill from the fill borrow area

Comments:

In two locations, ESC fencing is not keyed in properly; 1) small area along NE corner of topsoil pile location, and 2) small panel along SE edge (beneath Cooper and LePage sign). The on-site contractor was notified of these areas and verified that they would be dealt with by the end of the day.

No ESC fencing along pathway between fill borrow area and topsoil pile location (hedgerow area).

Follow-up Requirements:

- Key in ESC fencing in areas noted above (Install ESC fencing between fill borrow area and topsoil pile location

Is Work in Compliance:	**Yes**	**No**
Is This the Final Inspection:	**Yes**	**No**

Inspection Report Distribution List

Title	Name	Date
Cooper Construction - Director of Development	Bill Luffman	June 19, 2009
Pitura Husson Ltd – Planning Engineer	Paul Husson	June 19, 2009
City of Guelph – Environmental Engineer	Colin Baker	June 19, 2009

Prepared By: Tara Brenton **Date: June 16, 2009**

Environmental Inspection Report

Project Number:	942
Construction Project:	Hanlon Phase II – Fill Borrow Area
Date of Inspection:	June 19, 2009
Location:	HCBP – Small portion of Block 5, along Forestell Road
Works inspected:	- Silt fencing associated with fill borrow and topsoil pile locations - Any impacts to natural areas associated with fill borrow and topsoil pile locations
Activity:	No construction activity taking place during the time of the site inspection
Weather Conditions at time of Inspection:	Approx. 20^{o}C, 20% cloud cover, no precipitation
Weather Conditions 24 hrs prior to Inspection:	Some minor precipitation June 18 in the morning

Description of Works:

- Erosion and sediment control fencing (heavy duty silt fence with page wire, T bars, and filter fabric) has been installed around the perimeter of the fill borrow area.
- Heavy duty silt fencing has been installed around the perimeter of the topsoil pile location.
- Topsoil has been removed from the fill borrow area and relocated to the topsoil stockpile location north of the fill borrow area.

Comments:

Heavy duty silt fencing has been keyed in and installed as per the design drawings. There was no slumping or tares observed along the entire length of the silt fence. Small earth berms between the silt fence and grading site have been created as a result of construction activities which act to further isolate the construction area and limit the amount of potential pooling water or stress to the silt fence. Access to the site is located at a high point of land which limits the potential of material from leaving the site via the access lane. There was a gap noted in the silt fencing through the hedge row access to the stockpile area which may become a flow path for material to leave the site.

The hedge row is located at a higher point of land limiting the potential for material to exit the site; however the silt fence should be joined to address this issue and eliminate the potential for material to leave the site. The site is well contained and isolated with no other deficiencies observed.

Follow-up Requirements:

- Join silt fence along hedgerow from top soil removal site to stockpile area.
- Regular inspections of silt fencing for any deficiencies
- NRSI to make additional site inspections

Is Work in Compliance:	**Yes**	**No**
Is This the Final Inspection:	**Yes**	**No**

Inspection Report Distribution List

Title	**Name**	**Date**
Cooper Construction - Director of Development	Bill Luffman	June 19, 2009
Pitura Husson Ltd – Planning Engineer	Paul Husson	June 19, 2009
City of Guelph – Environmental Engineer	Colin Baker	June 19, 2009

Prepared By: Phil Anderson **Date: June 19, 2009**


Photo 1: Heavy duty silt fencing keyed in and installed as per design


Photo 2: Small earth berm created along inside of silt fencing

Photo 3: West side of access in hedge row missing silt fence

Photo 4: East side of access to stockpile along hedgerow missing silt fencing

Environmental Inspection Report

Project Number:	942
Construction Project:	Hanlon Phase II – Fill Borrow Area
Date of Inspection:	June 23, 2009
Location:	HCBP – Small portion of Block 5, along Forestell Road
Works inspected:	- Silt fencing associated with fill borrow and topsoil pile locations - Any impacts to natural areas associated with fill borrow and topsoil pile locations
Activity:	Grading activities associated with removal of fill within small portion of Block 5 and relocation of fill to Cooper site east of the Hanlon Expressway
Weather Conditions at time of Inspection:	Approx. 25°C, 2% cloud cover, no precipitation
Weather Conditions 24 hrs prior to Inspection:	Sunny conditions, approx. 20 °C, no precipitation

Description of Works:

- Erosion and sediment control fencing (heavy duty silt fence with page wire, T bars, and filter fabric) has been installed around the perimeter of the fill borrow area.
- Heavy duty silt fencing has been installed around the perimeter of the topsoil pile location.
- Topsoil has been removed from the fill borrow area and relocated to the topsoil stockpile location north of the fill borrow area.
- Earthwork trucks in process of removing fill from the fill borrow area

Comments:

ESC fencing remains sufficiently keyed in around fill borrow area and stockpile location as per design drawings. No slumping or tares were observed along the entire length of silt fence.

The gap in ESC fencing through the hedgerow access to the stockpile area that was noted during environmental inspections conducted by NRSI on June 16 and June 19, 2009 is still present. Vince D'Agostino from Cooper Construction was on-site during the environmental inspection, and was notified of the hedgerow area lacking ESC fencing.

The site is well contained and isolated with no other deficiencies observed. External roads associated with the construction site remain clear of construction debris and dust levels are being adequately maintained within the site.

Follow-up Requirements:

- Join silt fence along hedgerow from top soil removal site to stockpile area.
- Regular inspections of silt fencing for any deficiencies
- NRSI to make additional site inspections

Is Work in Compliance:	**Yes**	**No**
Is This the Final Inspection:	**Yes**	**No**

Inspection Report Distribution List

Title	**Name**	**Date**
Cooper Construction - Director of Development	Bill Luffman	June 23, 2009
Pitura Husson Ltd – Planning Engineer	Paul Husson	June 23, 2009
City of Guelph – Environmental Engineer	Colin Baker	June 23, 2009

Prepared By: Tara Brenton **Date: June 23, 2009**

Photo 1: Current status of fill borrow area

Photo 2: Current status of stockpile area

Photo 3: West side of hedgerow area missing silt fence

Photo 4: East side of hedgerow missing silt fencing

Environmental Inspection Report

Project Number:	942
Construction Project:	Hanlon Phase II – Fill Borrow Area
Date of Inspection:	June 26, 2009
Location:	HCBP – Small portion of Block 5, along Forestell Road
Works inspected:	- Silt fencing associated with fill borrow and topsoil pile locations - Any impacts to natural areas associated with fill borrow and topsoil pile locations
Activity:	Grading activities associated with removal of fill within small portion of Block 5 and relocation of fill to Cooper site east of the Hanlon Expressway
Weather Conditions at time of Inspection:	Approx. 28°C, 2% cloud cover, no precipitation
Weather Conditions 24 hrs prior to Inspection:	Scattered showers and thunderstorms, approx. 29 °C

Description of Works:

- Erosion and sediment control fencing (heavy duty silt fence with page wire, T bars, and filter fabric) has been installed around the perimeter of the fill borrow area.
- Heavy duty silt fencing has been installed around the perimeter of the topsoil pile location.
- Topsoil has been removed from the fill borrow area and relocated to the topsoil stockpile location north of the fill borrow area.
- Earthwork trucks in process of removing fill from the fill borrow area

Comments:

The heavy duty silt fencing around the fill borrow area continues to be adequately keyed in and in good condition, with the exception of the following areas:

- small tear in silt fence along south edge, in close proximity to survey pole (Photo 1)
- fencing has become un-keyed in south edge tear location
- slumping of fence in southwest corner, which may become an issue if further slumping occurs (Photo 2)
- along west edge, small tear in fence and fencing un-keyed (Photo 3)
- slight slump in fence in northwest corner (Photo 4)

The gap in ESC fencing through the hedgerow access to the stockpile area is still present. At this time, there does not appear to be a significant amount of construction traffic between the stockpile area and fill borrow area; however, it is recommended that silt fencing be installed prior to works within the stockpile area.

Heavy duty silt fencing around stockpile area remains sufficiently keyed with no slumping or tears.

At time of inspection, water truck washing Phelan Drive clean of any on-site fill material.

Overall, the site continues to be well contained and isolated with no other deficiencies observed. External roads associated with the construction site remain clear of construction debris and dust levels are being adequately maintained within the site.

Follow-up Requirements:

- Key in areas of silt fence within the fill borrow area (south edge, southwest corner) prior to returning stockpile material to fill borrow area to ensure no erosion issues,
- Join silt fence along hedgerow from top soil removal site to stockpile area,
- Monitor slumping in fence to ensure no further failure
- Regular inspections of silt fencing for any deficiencies
- NRSI to make additional site inspections

Is Work in Compliance:	**Yes**	**No**
Is This the Final Inspection:	**Yes**	**No**

Inspection Report Distribution List

Title	Name	Date
Cooper Construction - Director of Development	Bill Luffman	June 26, 2009
Pitura Husson Ltd – Planning Engineer	Paul Husson	June 26, 2009
City of Guelph – Environmental Engineer	Colin Baker	June 26, 2009

Prepared By: Tara Brenton **Date: June 26, 2009**


Photo 1: Tear in silt fence along south edge of fill borrow area


Photo 2: Slumping in silt fence in southwest corner of fill borrow area


Photo 3: Tear in silt fence along west edge of fill borrow area


Photo 4: Slight slumping in silt fence in northwest corner of fill borrow area

Environmental Inspection Report

Project Number:	942
Construction Project:	Hanlon Phase II – Fill Borrow Area
Date of Inspection:	June 29, 2009 1:10pm
Location:	HCBP – Small portion of Block 5, along Forestell Road
Works inspected:	- Silt fencing associated with fill borrow and topsoil pile locations - Any impacts to natural areas associated with fill borrow and topsoil pile locations
Activity:	Soil removal activity taking place during the time of the site inspection
Weather Conditions at time of Inspection:	Approx. 16^{o}C, 100% cloud cover, Just started raining at 1:30 (Thunder storm)
Weather Conditions 24 hrs prior to Inspection:	No precipitation Thunderstorms in forecast for the rest of the day

Description of Works:

- Erosion and sediment control fencing (heavy duty silt fence with page wire, T bars, and filter fabric) has been installed around the perimeter of the fill borrow area.
- Heavy duty silt fencing has been installed around the perimeter of the topsoil pile location.
- Topsoil has been removed from the fill borrow area and relocated to the topsoil stockpile location north of the fill borrow area.

Comments:

Keyed in heavy duty silt fence has been installed as per the design drawings and appears to be in good condition. There was no major slumping observed along the entire length of the silt fence. Small earth berms between the silt fence and grading site have been created as a result of construction activities which act to further isolate the construction area and limit the amount of potential pooling water or stress to the silt fence. Access to the site is located at a high point of land which limits the potential of material from leaving the site via the access lane. the gap noted in the silt fencing through the hedge row access to the stockpile area which may become a flow path for material to leave the site is still present.

The hedge row is located at a higher point of land limiting the potential for material to exit the site; however the silt fence should be joined to address this issue and eliminate the potential for material to leave the site. The site is well contained and isolated with no other deficiencies observed.

Follow-up Requirements:

- Join silt fence along hedgerow from top soil removal site to stockpile area.
- Regular inspections of silt fencing for any deficiencies
- NRSI to make additional site inspections

Is Work in Compliance:	**Yes**	**No**
Is This the Final Inspection:	**Yes**	**No**

Inspection Report Distribution List

Title	Name	Date
Cooper Construction - Director of Development	Bill Luffman	June 29, 2009
Pitura Husson Ltd – Planning Engineer	Paul Husson	June 29, 2009
City of Guelph – Environmental Engineer	Colin Baker	June 29, 2009

Prepared By: Phil Anderson **Date: June 29, 2009**

Photo 1: Heavy duty silt fencing keyed in and installed as per design

Photo 2: Small earth berm created along inside of silt fencing

Photo 3: West side of access in hedge row missing silt fence

Photo 4: East side of access to stockpile along hedgerow missing silt fencing

Environmental Inspection Report

Project Number:	942
Construction Project:	Hanlon Phase II – Fill Borrow Area
Date of Inspection:	July 2, 2009 10:30am
Location:	HCBP – Small portion of Block 5, along Forestell Road
Works inspected:	- Silt fencing associated with fill borrow and topsoil pile locations - Any impacts to natural areas associated with fill borrow and topsoil pile locations
Activity:	No construction activity taking place during the time of the site inspection
Weather Conditions at time of Inspection:	Approx. 15°C, 80% cloud cover, no precipitation during site visit; however, had rained earlier in the day
Weather Conditions 24 hrs prior to Inspection:	Sporadic rain showers, heavy at times, throughout the entire day.

Description of Works:

- Erosion and sediment control fencing (heavy duty silt fence with page wire, T bars, and filter fabric) has been installed around the perimeter of the fill borrow area.
- Heavy duty silt fencing has been installed around the perimeter of the topsoil pile location.
- Topsoil has been removed from the fill borrow area and relocated to the topsoil stockpile location north of the fill borrow area.

Comments:

Keyed in heavy duty silt fence has been installed as per the design drawings and continues to be in good condition. There were no major tears or slumping observed along the entire length of the silt fence. Small earth berms between the silt fence and grading site have been created as a result of construction activities which act to further isolate the construction area and limit the amount of potential pooling water or stress to the silt fence. Access to the site is located at a high point of land which limits the potential of material from leaving the site via the access lane. The gap noted in the silt fencing through the hedge row access to the stockpile area which may become a flow path for material to leave the site is still present.

The hedge row is located at a higher point of land limiting the potential for material to exit the site; however the silt fence should be joined to address this issue and eliminate the potential for material to leave the site. The site is well contained and isolated with no other deficiencies observed.

Conditions within the work site are extremely wet, therefore, no construction activity was taking place during the inspection.

The stockpile area has been over-seeded and is beginning to sprout, which will help with dust control and reduce any potential run-off issues.

Head Office: 225 Labrador Drive, Waterloo, Ontario, N2K 4M8 **Tel:** (519) 725-2227 **Fax:** (519) 725-2575 **Web:** www.nrsi.on.ca
Sault Ste. Marie: 111 Elgin Street, Unit 201, Sault Ste. Marie, Ontario, P6A 6L6 **Tel:** (705) 253-0620 **Fax:** (705) 253-0670 **Email:** info@nrsi.on.ca

Follow-up Requirements:

- Join silt fence along hedgerow from fill borrow site to stockpile area.
- Regular inspections of silt fencing for any deficiencies
- NRSI to make additional site inspections

Is Work in Compliance:	**Yes**	**No**
Is This the Final Inspection:	**Yes**	**No**

Inspection Report Distribution List

Title	**Name**	**Date**
Cooper Construction - Director of Development	Bill Luffman	July 2, 2009
Pitura Husson Ltd – Planning Engineer	Paul Husson	July 2, 2009
City of Guelph – Environmental Engineer	Colin Baker	July 2, 2009

Prepared By: Tara Brenton **Date: July 2, 2009**


Photo 1: Moist conditions within fill borrow area


Photo 2: Stockpile area beginning to sprout

Environmental Inspection Report

Project Number:	942
Construction Project:	Hanlon Phase II – Fill Borrow Area
Date of Inspection:	July 6, 2009
Location:	HCBP – Small portion of Block 5, along Forestell Road
Works inspected:	- Silt fencing associated with fill borrow and topsoil pile locations - Any impacts to natural areas associated with fill borrow and topsoil pile locations
Activity:	Grading activities associated with removal of fill within small portion of Block 5 and relocation of fill to Cooper site east of the Hanlon Expressway
Weather Conditions at time of Inspection:	Approx. 24^{o}C, sunny, no precipitation
Weather Conditions 24 hrs prior to Inspection:	Approx. 25 ^{o}C, sunny, no precipitation; however, thundershowers in late evening on July 5, 2009

Description of Works:

- Erosion and sediment control fencing (heavy duty silt fence with page wire, T bars, and filter fabric) has been installed around the perimeter of the fill borrow area.
- Heavy duty silt fencing has been installed around the perimeter of the topsoil pile location.
- Topsoil has been removed from the fill borrow area and relocated to the topsoil stockpile location north of the fill borrow area.
- Earthwork trucks in process of removing fill from the fill borrow area

Comments:

The heavy duty silt fencing around the fill borrow area continues to be adequately keyed in and in good condition, with the exception of the following areas:

- small tear in silt fence at top of bank along western edge (Photo 1)
- second small tear at bottom of silt fence along western edge (Photo 2)
- small separation between two sections of silt fence along northern edge (Photo 3)

The gap in ESC fencing through the hedgerow access to the stockpile area is still present. Still does not appear to be any significant construction traffic between the stockpile area and fill borrow area; however, it is recommended that silt fencing be installed prior to works within the stockpile area.

Small earth berms between the silt fence and grading site have been created as a result of construction activities which act to further isolate the construction area and limit the amount of potential pooling water or stress to the silt fence. Access to the site is located at a high point of land which limits the potential of material from leaving the site via the access lane.

Conditions within the fill borrow area were noted to be quite dry during the inspection, although there were still small areas of standing water from previous rain events. It is recommended that more frequent dust suppression measures be implemented if dry conditions persist.

Heavy duty silt fencing around stockpile area remains sufficiently keyed with no slumping or tears. Seed within the stockpile area is becoming slightly more established, thus, reducing potential for run-off and dust issues.

Overall, the site continues to be well contained and isolated with no other deficiencies observed. External roads associated with the construction site remain clear of construction debris and dust levels are being adequately maintained within the site.

Follow-up Requirements:

- Repair tears in silt fence along west side of fill borrow area
- Repair gap in silt fence along north edge of fill borrow area
- Join silt fence along hedgerow from fill borrow area to stockpile area
- Regular inspections of silt fencing for any deficiencies
- NRSI to make additional site inspections

Is Work in Compliance:	**Yes**	**No**
Is This the Final Inspection:	**Yes**	**No**

Inspection Report Distribution List

Title	**Name**	**Date**
Cooper Construction - Director of Development	Bill Luffman	July 6, 2009
Pitura Husson Ltd – Planning Engineer	Paul Husson	July 6, 2009
City of Guelph – Environmental Engineer	Colin Baker	July 6, 2009

Prepared By: Tara Brenton **Date: July 6, 2009**


Photo 1: Tear in silt fence along west edge of fill borrow area


Photo 2: Second tear in silt fence along west edge of fill borrow area

Photo 3: Separation in silt fence along north edge of fill borrow area

Photo 4: East side of access to stockpile along hedgerow missing silt fencing


Photo 5: West side of access in hedge row missing silt fence


Photo 6: Current conditions of fill borrow area


Photo 7: Seed establishment within stockpile area

Environmental Inspection Report

Project Number:	942
Construction Project:	Hanlon Phase II – Fill Borrow Area
Date of Inspection:	July 9, 2009 5:35 pm
Location:	HCBP – Small portion of Block 5, along Forestell Road
Works inspected:	- Silt fencing associated with fill borrow and topsoil pile locations - Any impacts to natural areas associated with fill borrow and topsoil pile locations
Activity:	Last dump truck left site during inspection and a bulldozer was at work grading the main pit. Wash truck was spraying down Phelan Dr at the access point.
Weather Conditions at time of Inspection:	Approx. 26^{o}C, 0% cloud cover, no precipitation
Weather Conditions 24 hrs prior to Inspection:	Mix of sun and cloud, 27^{o}C, no precipitation

Description of Works:

- Erosion and sediment control fencing (heavy duty silt fence with page wire, T bars, and filter fabric) has been installed around the perimeter of the fill borrow area.
- Heavy duty silt fencing has been installed around the perimeter of the topsoil pile location.
- Topsoil has been removed from the fill borrow area and relocated to the topsoil stockpile location north of the fill borrow area.

Comments:

Keyed in heavy duty silt fence has been installed as per the design drawings and continues to be in good condition. There was no major slumping observed along the entire length of the silt fence, however, there were two small tears in the fence along the western edge (Photo 1 and 2), and one in the front right corner (northeast corner – Photo 3). Small earth berms between the silt fence and grading site have been created as a result of construction activities which act to further isolate the construction area and limit the amount of potential pooling water or stress to the silt fence. Access to the site is located at a high point of land which limits the potential of material from leaving the site via the access lane. The gap noted in the silt fencing through the hedge row access to the stockpile area which may become a flow path for material to leave the site is still present (Photo 4 and 5).

The hedge row is located at a higher point of land limiting the potential for material to exit the site; however the silt fence should be joined to address this issue and eliminate the potential for material to leave the site. The site is well contained and isolated with no other deficiencies observed.

Conditions within the work site were quite dry; however, it appeared as though the work site and Phelan Drive had been sprayed to reduce dust.

The stockpile area has been over-seeded and is beginning to sprout, which will help with dust control and reduce any potential run-off issues.

Follow-up Requirements:

- Repair tears in silt fence along west and northeast edge of fill borrow area
- Join silt fence along hedgerow from fill borrow site to stockpile area.
- Regular inspections of silt fencing for any deficiencies
- NRSI to make additional site inspections

Is Work in Compliance:	**Yes**	**No**
Is This the Final Inspection:	**Yes**	**No**

Inspection Report Distribution List

Title	**Name**	**Date**
Cooper Construction - Director of Development	Bill Luffman	July 9, 2009
Pitura Husson Ltd – Planning Engineer	Paul Husson	July 9, 2009
City of Guelph – Environmental Engineer	Colin Baker	July 9, 2009

Prepared By: Jonathan Brubacher **Date: July 9, 2009**

Photo 1: Small tear in ESC fence along west edge of fill borrow area

Photo 2: Tear in ESC fence along west edge of fill borrow area

Photo 3: Tear in ESC fence in northeast corner of fill borrow area

Photo 4: West side of access in hedge row missing silt fence

Photo 5: East side of access to stockpile along hedgerow missing silt fencing

Environmental Inspection Report

Project Number:	942
Construction Project:	Hanlon Phase II – Fill Borrow Area
Date of Inspection:	July 13, 2009 3:00 pm
Location:	HCBP – Small portion of Block 5, along Forestell Road
Works inspected:	- Silt fencing associated with fill borrow and topsoil pile locations - Any impacts to natural areas associated with fill borrow and topsoil pile locations
Activity:	Fill removal activities taking place on-site during site visit.
Weather Conditions at time of Inspection:	Approx. 24^{o}C, sunny, no precipitation
Weather Conditions 24 hrs prior to Inspection:	Approx. 24^{o}C, sunny, no precipitation

Description of Works:
- Erosion and sediment control fencing (heavy duty silt fence with page wire, T bars, and filter fabric) has been installed around the perimeter of the fill borrow area.
- Heavy duty silt fencing has been installed around the perimeter of the topsoil pile location.
- Topsoil has been removed from the fill borrow area and relocated to the topsoil stockpile location north of the fill borrow area.

Comments:
The heavy duty silt fence around the fill borrow area continues to be adequately keyed in and in good condition, with the exception of the following areas:
- small tear at base of silt fence at top of bank along east side of fill borrow area (Photo 1)
- two separate tears in silt fence at top of bank along western edge of fill borrow area (Photo 2 and 3)

The gap noted in the silt fencing through the hedgerow access to the stockpile area which may become a flow path for material to leave the site is still present. The hedge row is located at a higher point of land limiting the potential for material to exit the site; however the silt fence should be joined to address this issue and eliminate the potential for material to leave the site.

Heavy duty silt fence around stockpile area remains sufficiently keyed in with no tears. Accumulation of topsoil against approximately 10-15m of silt fence is occurring along the southern edge of the stockpile area, causing slumping (Photo 4). It is recommended that excess topsoil be removed from this area of fence to reduce pressure on fence and avoid further slumping.

Small earth berms between the silt fence and grading site have been created as a result of construction activities which act to further isolate the construction area and limit the amount of potential pooling water or stress to the silt fence. Access to the site is located at a high point of land which limits the potential of material from leaving the site via the access lane. The site is well contained and isolated with no other deficiencies observed.

Follow-up Requirements:

- Repair tears in silt fence along west and east edge of fill borrow area
- Join silt fence along hedgerow from fill borrow site to stockpile area
- Remove excess topsoil from fence along south edge of stockpile area to avoid further slumping
- Regular inspections of silt fencing for any deficiencies
- NRSI to make additional site inspections

Is Work in Compliance:	**Yes**	**No**
Is This the Final Inspection:	**Yes**	**No**

Inspection Report Distribution List

Title	**Name**	**Date**
Cooper Construction - Director of Development	Bill Luffman	July 13, 2009
Pitura Husson Ltd – Planning Engineer	Paul Husson	July 13, 2009
City of Guelph – Environmental Engineer	Colin Baker	July 13, 2009

Prepared By: Tara Brenton **Date: July 13, 2009**


Photo 1: Small tear in ESC fence along east edge of fill borrow area


Photo 2: Small tear in ESC fence along west edge of fill borrow area

Photo 3: Second tear in ESC fence along west edge of fill borrow area

Photo 4: Accumulation of topsoil against southern edge of silt fence in stockpile area

Environmental Inspection Report

Project Number:	942
Construction Project:	Hanlon Phase II – Fill Borrow Area
Date of Inspection:	July 16, 2009 9:00 am
Location:	HCBP – Small portion of Block 5, along Forestell Road
Works inspected:	- Silt fencing associated with fill borrow and topsoil pile locations - Any impacts to natural areas associated with fill borrow and topsoil pile locations
Activity:	No fill removal activity taking place. Fill removal activities complete.
Weather Conditions at time of Inspection:	Approx. 18^{o}C, sunny, no precipitation
Weather Conditions 24 hrs prior to Inspection:	Approx. 20^{o}C, slightly overcast, no precipitation. Light rain on evening of July 15th.

Description of Works:

- Erosion and sediment control fencing (heavy duty silt fence with page wire, T bars, and filter fabric) has been installed around the perimeter of the fill borrow area.
- Heavy duty silt fencing has been installed around the perimeter of the topsoil pile location.
- Topsoil has been removed from the fill borrow area and relocated to the topsoil stockpile location north of the fill borrow area.

Comments:

On-site fill removal activities appear to be complete.

The heavy duty silt fence around the fill borrow area continues to be adequately keyed in and in good condition, with the exception of two small tears in the silt fence along the western edge (same tears as documented on July 13, 2009). It is not anticipated that there will be any significant erosion issues as a result of these tears as they are situated along the top of the slope.

The gap noted in the silt fencing through the hedgerow access to the stockpile area which may become a flow path for material to leave the site is still present. The hedge row is located at a higher point of land limiting the potential for material to exit the site; however the silt fence should be joined to address this issue and eliminate the potential for material to leave the site (Photo 1 and 2).

Heavy duty silt fence around stockpile area remains sufficiently keyed in with no tears. Accumulation of topsoil against approximately 10-15m of silt fence is occurring along the southern edge of the stockpile area, causing slumping (Photo 3). It is recommended that excess topsoil be removed from this area of fence to reduce pressure on fence and avoid further slumping.

Small earth berms between the silt fence and grading site have been created as a result of construction activities which act to further isolate the construction area and limit the amount of potential pooling water or stress to the silt fence. Access to the site is located at a high point of land which limits the potential of material from leaving the site via the access lane. The site is well contained and isolated with no other deficiencies observed.

Follow-up Requirements:

- Join silt fence along hedgerow from fill borrow site to stockpile area
- Remove excess topsoil from fence along south edge of stockpile area to avoid further slumping
- Weekly inspection of silt fencing for any deficiencies (specifically slumping within stockpile area as a result of topsoil build-up)
- NRSI to make additional site inspections until seed mix in fill borrow area (to be planted within 30 days) begins to establish

Is Work in Compliance:	**Yes**	**No**
Is This the Final Inspection:	**Yes**	**No**

Inspection Report Distribution List

Title	**Name**	**Date**
Cooper Construction - Director of Development	Bill Luffman	July 16, 2009
Pitura Husson Ltd – Planning Engineer	Paul Husson	July 16, 2009
City of Guelph – Environmental Engineer	Colin Baker	July 16, 2009

Prepared By: Tara Brenton **Date: July 16, 2009**

Photo 1: East side of access to stockpile along hedgerow missing silt fencing

Photo 2: West side of access in hedgerow missing silt fence

Photo 3: Accumulation of topsoil against southern edge of silt fence in stockpile area

Photo 4: Current conditions of fill borrow area

Environmental Inspection Report

Project Number:	942
Construction Project:	Hanlon Phase II – Fill Borrow Area
Date of Inspection:	July 22, 2009 4:00 pm
Location:	HCBP – Small portion of Block 5, along Forestell Road
Works inspected:	- Silt fencing associated with fill borrow and topsoil pile locations - Any impacts to natural areas associated with fill borrow and topsoil pile locations
Activity:	No fill removal activity taking place. Fill removal activities complete.
Weather Conditions at time of Inspection:	Approx. 22°C, overcast, no precipitation
Weather Conditions 24 hrs prior to Inspection:	Approx. 20°C, overcast, roughly 2.5mm of precipitation

Description of Works:

- Erosion and sediment control fencing (heavy duty silt fence with page wire, T bars, and filter fabric) has been installed around the perimeter of the fill borrow area.
- Heavy duty silt fencing has been installed around the perimeter of the topsoil pile location.
- Topsoil has been removed from the fill borrow area and relocated to the topsoil stockpile location north of the fill borrow area.

Comments:

On-site fill removal activities appear to be complete.

The heavy duty silt fence around the fill borrow area continues to be adequately keyed in and in good condition, with the exception of two tears in the silt fence (see Photo 1) along the western edge (same tears as documented on July 13, 2009). It is not anticipated that there will be any significant erosion issues as a result of these tears as they are situated along the top of the slope.

The gap noted in the silt fencing through the hedgerow access to the stockpile area which may become a flow path for material to leave the site is still present. The hedge row is located at a higher point of land limiting the potential for material to exit the site; however the silt fence should be joined to address this issue and eliminate the potential for material to leave the site (Photo 2).

Heavy duty silt fence around stockpile area remains sufficiently keyed in with no tears. Accumulation of topsoil against approximately 10-15m of silt fence is occurring along the southern edge of the stockpile area, causing slumping (Photo 3). It is recommended that excess topsoil be removed from this area of fence to reduce pressure on fence and avoid further slumping.

Small earth berms between the silt fence and grading site have been created as a result of construction activities which act to further isolate the construction area and limit the amount of potential pooling water or stress to the silt fence. Access to the site is located at a high point of land which limits the potential of material from leaving the site via the access lane. The site is well contained and isolated with no other deficiencies observed.

The topsoil pile is showing good establishment of the cover crop as is evidenced in Photo 4.

Follow-up Requirements:

- Join silt fence along hedgerow from fill borrow site to stockpile area
- Remove excess topsoil from fence along south edge of stockpile area to avoid further slumping
- Weekly inspection of silt fencing for any deficiencies (specifically slumping within stockpile area as a result of topsoil build-up)
- NRSI to make additional site inspections until seed mix in fill borrow area (to be planted within 30 days) begins to establish

Is Work in Compliance:	**Yes**	**No**
Is This the Final Inspection:	**Yes**	**No**

Inspection Report Distribution List

Title	**Name**	**Date**
Cooper Construction - Director of Development	Bill Luffman	July 22, 2009
Pitura Husson Ltd – Planning Engineer	Paul Husson	July 22, 2009
City of Guelph – Environmental Engineer	Colin Baker	July 22, 2009

Prepared By: Brett Woodman **Date: July 22, 2009**


Photo 1. 1 of 2 tears in silt-fencing along western edge of borrow pit


Photo 2. Access lane between borrow pit and topsoil missing silt fence


Photo 3. Accumulation of topsoil against southern edge of silt fence in stockpile area

Photo 4. Good germination of the cover crop on the topsoil pile

Photo 5.: Current conditions of fill borrow area

Environmental Inspection Report

Project Number:	942
Construction Project:	Hanlon Phase II – Fill Borrow Area
Date of Inspection:	July 29, 2009 9:00 am
Location:	HCBP – Small portion of Block 5, along Forestell Road
Works inspected:	- Silt fencing associated with fill borrow and topsoil pile locations - Any impacts to natural areas associated with fill borrow and topsoil pile locations
Activity:	No fill removal activity taking place. Phelan Drive being cleaned by water truck.
Weather Conditions at time of Inspection:	Approx. 20^{o}C, overcast, scattered showers
Weather Conditions 24 hrs prior to Inspection:	Approx. 26^{o}C, slightly overcast, scattered showers with periods of heavy rain.

Description of Works:

- Erosion and sediment control fencing (heavy duty silt fence with page wire, T bars, and filter fabric) has been installed around the perimeter of the fill borrow area.
- Heavy duty silt fencing has been installed around the perimeter of the topsoil pile location.
- Topsoil has been removed from the fill borrow area and relocated to the topsoil stockpile location north of the fill borrow area.

Comments:

On-site fill removal activities complete. Inspections continuing on a weekly basis to ensure no erosion issues arise prior to fill borrow area being seeded.

Conditions within the fill borrow area are quite wet as a result of heavy rains within the area over the last two weeks; however, the heavy duty silt fence continues to be adequately keyed in and in good condition, with the exception of two small tears in the silt fence along the western edge (same tears as documented on July 13, 16 and 20, 2009). It is not anticipated that there will be any significant erosion issues as a result of these tears as they are situated along the top of the slope.

The gap noted in the silt fencing through the hedgerow access to the stockpile area which may become a flow path for material to leave the site is still present. Seed along the hedgerow area is establishing well; however, if the pathway between the stockpile area and fill borrow site are left un-seeded and heavy rain events continue, may experience erosion issues within the un-fenced area. The silt fence should be joined to address this issue and eliminate the potential for material to leave the site (Photo 1 and 2).

Heavy duty silt fence around stockpile area remains sufficiently keyed in, with the exception of one large gap in silt fence within the southwest corner. The silt fence is beginning to slump in this area as well (Photo 3).

As previously documented, there is an accumulation of topsoil against approximately 10-15m of silt fence occurring along the southern edge of the stockpile area, causing slumping (Photo 4). It was noted during the inspection that efforts have been made to remove some of the excess topsoil against the fence and reduce the grade in an attempt to lessen the pressure on the silt fence. As the fence is still slumping slightly, it is recommended that this area be inspected regularly to ensure no further build up of topsoil occurs.

Small earth berms between the silt fence and grading site have been created as a result of construction activities which act to further isolate the construction area and limit the amount of potential pooling water or stress to the silt fence. Access to the site is located at a high point of land which limits the potential of material from leaving the site via the access lane. The site is well contained and isolated with no other deficiencies observed.

Follow-up Requirements:
- Join silt fence along hedgerow from fill borrow site to stockpile area
- Continue to inspect fence within area of excess topsoil to ensure no further slumping
- Repair large gap in silt fence in southwest corner of stockpile area
- Weekly inspection of silt fencing for any deficiencies (specifically slumping within stockpile area as a result of topsoil build-up)
- NRSI to make additional site inspections until seed mix in fill borrow area (to be planted within 30 days) begins to establish

Is Work in Compliance:	**Yes**	**No**
Is This the Final Inspection:	**Yes**	**No**

Inspection Report Distribution List

Title	**Name**	**Date**
Cooper Construction - Director of Development	Bill Luffman	July 29, 2009
Pitura Husson Ltd – Planning Engineer	Paul Husson	July 29, 2009
City of Guelph – Environmental Engineer	Colin Baker	July 29, 2009

Prepared By: Tara Brenton **Date: July 29, 2009**


Photo 1: East side of access to stockpile along hedgerow missing silt fencing


Photo 2: West side of access in hedgerow missing silt fence


Photo 3: Gap and slumping in silt fence in southwest corner of stockpile area


Photo 4: Accumulation of topsoil against southern edge of silt fence in stockpile area and grading change to alleviate pressure on silt fence

Photo 5: Current conditions within fill borrow area

Environmental Inspection Report

Project Number:	942
Construction Project:	Hanlon Phase II – Fill Borrow Area
Date of Inspection:	August 4, 2009 8:30 am
Location:	HCBP – Small portion of Block 5, along Forestell Road
Works inspected:	- Silt fencing associated with fill borrow and topsoil pile locations - Any impacts to natural areas associated with fill borrow and topsoil pile locations
Activity:	No activity taking place.
Weather Conditions at time of Inspection:	Approx. 22^{o}C, slightly overcast, no precipitation
Weather Conditions 24 hrs prior to Inspection:	Approx. 25^{o}C, sunny, no precipitation

Description of Works:

- Erosion and sediment control fencing (heavy duty silt fence with page wire, T bars, and filter fabric) has been installed around the perimeter of the fill borrow area.
- Heavy duty silt fencing has been installed around the perimeter of the stockpile area.
- Topsoil has been removed from the fill borrow area and relocated to the stockpile area north of the fill borrow area.

Comments:

On-site fill removal activities complete. Inspections continuing on a weekly basis to ensure no erosion issues arise prior to fill borrow area being seeded.

Erosion and sediment control fencing has been installed at the entrance of the fill borrow area, the northeast corner of the fill borrow area and southeast corner of the stockpile area between the hedgerows. The heavy duty silt fence has been installed at the site entrance, while Terrafix fencing has been installed in the other two locations. As the fencing is not keyed in, the bottom is beginning to fray and blow around when wind conditions are moderate to high.

As observed during previous inspection, conditions within the northwest corner of the fill borrow area remain quite wet as a result of heavy rains, which may pose a problem for the establishment of the recommended seed mix to be applied in the area. The heavy duty silt fence continues to be adequately keyed in and in good condition within the fill borrow area, with the exception of two small tears in the silt fence along the western edge (same tears as documented on July 13, 16, 20 and 29, 2009). It is not anticipated that there will be any significant erosion issues as a result of these tears as they are situated along the top of the slope.

The gap noted in the silt fencing through the hedgerow access to the stockpile area which may become a flow path for material to leave the site is still present. Seed along the hedgerow area is establishing well; however, if the pathway between the stockpile area and fill borrow site are left un-seeded and heavy rain events continue, may experience erosion issues within the un-fenced area.

Heavy duty silt fence around stockpile area remains sufficiently keyed in, with the exception of one large gap in silt fence within the southwest corner. The silt fence is beginning to slump in this area as well. No erosion issues are anticipated as a result of this gap as the cultural meadow is significantly higher in grade than the stockpile area.

It appears as though no additional topsoil has accumulated against the southern edge of the stockpile area (area referenced in previous inspection report). Silt fence is continuing to hold up, although it is slumping slightly. As the silt fence is slumping slightly, it is recommended that the area be inspected regularly to ensure no further build up of topsoil occurs.

Small earth berms between the silt fence and grading site have been created as a result of construction activities which act to further isolate the construction area and limit the amount of potential pooling water or stress to the silt fence. Access to the site is located at a high point of land which limits the potential of material from leaving the site via the access lane. The site is well contained and isolated with no other deficiencies observed.

Follow-up Requirements:

- Seed pathway between fill borrow area and stockpile area to avoid any potential erosion issues
- Key in new sections of silt fence in northeast corner of fill borrow area and south east corner of stockpile area between hedgerows
- Continue to inspect fence within area of excess topsoil to ensure no further slumping
- Repair large gap in silt fence in southwest corner of stockpile area
- NRSI to make additional site inspections until seed mix in fill borrow area (to be planted within 30 days) begins to establish

Is Work in Compliance:	**Yes**	**No**
Is This the Final Inspection:	**Yes**	**No**

Inspection Report Distribution List

Title	**Name**	**Date**
Cooper Construction - Director of Development	Bill Luffman	August 4, 2009
Pitura Husson Ltd – Planning Engineer	Paul Husson	August 4, 2009
City of Guelph – Environmental Engineer	Colin Baker	August 4, 2009

Prepared By: Tara Brenton **Date: August 4, 2009**

Photo 1: New fencing in northeast corner of fill borrow area between hedgerows

Photo 2: New fencing in southeast corner of stockpile area between hedgerows


Photo 3: Gap and slumping in silt fence in southwest corner of stockpile area


Photo 4: Southern edge of stockpile area that experienced accumulation of topsoil

Photo 5: Slumping in fence along southern edge of stockpile area

Photo 6: Wet conditions within northwest corner of fill borrow area

Environmental Inspection Report

Project Number:	942
Construction Project:	Hanlon Phase II – Fill Borrow Area
Date of Inspection:	August 17, 2009 3:00 p.m.
Location:	HCBP – Small portion of Block 5, along Forestell Road
Works inspected:	- Silt fencing associated with fill borrow and stockpile locations - Any impacts to natural areas associated with fill borrow and stockpile locations
Activity:	No activity taking place.
Weather Conditions at time of Inspection:	Approx. 35^{o}C, slightly overcast, with scattered showers
Weather Conditions 24 hrs prior to Inspection:	Approx. 30^{o}C, sunny, hot and humid with no precipitation

Description of Works:

- Erosion and sediment control fencing (heavy duty silt fence with page wire, T bars, and filter fabric) has been installed around the perimeter of the fill borrow area.
- Heavy duty silt fencing has been installed around the perimeter of the stockpile area.
- Topsoil has been removed from the fill borrow area and relocated to the stockpile area north of the fill borrow area.

Comments:

On-site fill removal activities complete. Inspections will continue on a bi-weekly basis until fill borrow area and portion of stockpile area are seeded, unless weather conditions (i.e. frequent heavy rains) permit otherwise.

Conditions within the fill borrow area have become quite wet as a result of heavy rains. As mentioned in previous inspection report, water levels present may pose a problem for the establishment of the recommended seed mix to be applied to the fill borrow area. Seed mix has not been applied to the fill borrow area, therefore, bare side slope areas are showing fairly significant gullying from run-off into lowest section of fill borrow area. The southwest corner of the fill borrow area is showing the most significant signs of gullying.

A small section of fence along the east edge of the fill borrow area is no longer keyed in due to heavy run-off within this area. Un-keyed area of silt fence is approximately 8m in length.

The gap noted in the silt fencing through the hedgerow access to the stockpile area which may become a flow path for material to leave the site is still present. Seed along the hedgerow area is establishing well; however, as the pathway between the stockpile area and fill borrow area has been left un-seeded, heavy rain events have begun to cause run-off into fill borrow area and stockpile area beneath the new portions of un-keyed in silt fence.

The remaining heavy duty silt fence around the fill borrow area continues to be adequately keyed in and in good condition.

A section of silt fence along the south edge of the stockpile area has begun to fail as a result of high water levels and topsoil run-off. Water and topsoil have breached small portion of fence, thus flowing into hedgerow area. The south portion of the stockpile area has not been re-seeded, and as a result of heavy rains, is beginning to show signs of run-off, thus increasing pressure to silt fence.

The remaining heavy duty silt fence around the stockpile area remains sufficiently keyed in and in good condition.

The site is well contained and isolated with no other deficiencies observed.

Follow-up Requirements:

- Seed pathway between fill borrow area and stockpile area to avoid further erosion issues
- Re-seed cleared area within stockpile area
- Seed fill borrow area once water levels are reduced to ensure no further erosion issues
- Key-in new sections of silt fence in northeast corner of fill borrow area and south east corner of stockpile area between hedgerows
- Repair fencing along south edge of stockpile area and remove excess topsoil
- Key-in section of fence along east side of fill borrow area
- NRSI to make additional site inspections until seed mix in fill borrow area, stockpile area and laneway between hedgerows (to be planted within 30 days) begins to establish

Is Work in Compliance:	**Yes**	**No**
Is This the Final Inspection:	**Yes**	**No**

Inspection Report Distribution List

Title	**Name**	**Date**
Cooper Construction - Director of Development	Bill Luffman	August 18, 2009
Pitura Husson Ltd – Planning Engineer	Paul Husson	August 18, 2009
City of Guelph – Environmental Engineer	Colin Baker	August 18, 2009

Prepared By: Tara Brenton **Date: August 18, 2009**

Photo 1: Wet conditions within fill borrow area

Photo 2: Gullying in southwest corner of fill borrow area


Photo 3: Un-keyed silt fence along east side of fill borrow area


Photo 4: Fencing along south edge of stockpile area that has failed as a result of heavy rains and excess topsoil


Photo 5: Run-off within stockpile area

Environmental Inspection Report

Project Number:	942
Construction Project:	Hanlon Phase II – Fill Borrow Area
Date of Inspection:	August 28, 2009 9:30 a.m.
Location:	HCBP – Small portion of Block 5, along Forestell Road
Works inspected:	- Silt fencing associated with fill borrow and stockpile locations - Any impacts to natural areas associated with fill borrow and stockpile locations
Activity:	No activity taking place.
Weather Conditions at time of Inspection:	Approx. 15^{o}C, overcast, no precipitation
Weather Conditions 24 hrs prior to Inspection:	Approx. 16^{o}C, partly sunny, no precipitation

Description of Works:

- Erosion and sediment control fencing (heavy duty silt fence with page wire, T bars, and filter fabric) has been installed around the perimeter of the fill borrow area.
- Heavy duty silt fencing has been installed around the perimeter of the stockpile area.
- Topsoil has been removed from the fill borrow area and relocated to the stockpile area north of the fill borrow area.

Comments:

On-site fill removal activities complete. Inspections will continue on a bi-weekly basis until fill borrow area and portion of stockpile area are seeded, unless weather conditions (i.e. frequent heavy rains) permit otherwise.

Conditions within the fill borrow area remain quite wet. As mentioned in previous inspection report, water levels present may pose a problem for the establishment of the recommended seed mix to be applied to the fill borrow area. Seed mix has not been applied to the fill borrow area, therefore, bare side slope areas are showing signs of gullying from run-off into lowest section of fill borrow area.

Overall, the heavy duty silt fence around the fill borrow area continues to be in good condition and is adequately keyed in with no significant tears or slumping.

Fencing between the fill borrow area and stockpile area has been keyed in, reducing potential for run-off into respective areas. Vegetation is beginning to sprout within open area, further reducing potential for erosion issues.

The section of silt fence along the south edge of the stockpile area as noted in previous inspection reports is still showing signs of significant slumping as a result of excess topsoil. In the event of heavy rainfall, this section of fence will likely fail again, resulting in run-off into hedgerow area.

The remaining heavy duty silt fence around the stockpile area remains sufficiently keyed in and in good condition.

The site is well contained and isolated with no other deficiencies observed.

Follow-up Requirements:

- Seed cleared area within stockpile area
- Seed fill borrow area once water levels are reduced to ensure no further erosion issues
- Repair fencing along south edge of stockpile area and remove excess topsoil
- NRSI to make additional site inspections until seed mix in fill borrow area and stockpile area begins to establish

Is Work in Compliance:	**Yes**	**No**
Is This the Final Inspection:	**Yes**	**No**

Inspection Report Distribution List

Title	**Name**	**Date**
Cooper Construction - Director of Development	Bill Luffman	August 28, 2009
Pitura Husson Ltd – Planning Engineer	Paul Husson	August 28, 2009
City of Guelph – Environmental Engineer	Colin Baker	August 28, 2009

Prepared By: Tara Brenton **Date: August 28, 2009**

Photo 1: Wet conditions within fill borrow area

Photo 2: Seed beginning to establish in open area between hedgerows

Photo 3: Fencing along south edge of stockpile area failing as a result of excess topsoil

Photo 4: Run-off within stockpile area


Photo 5: Current conditions within stockpile area

Environmental Inspection Report

Project Number:	942
Construction Project:	Hanlon Phase II – Fill Borrow Area
Date of Inspection:	September 1, 2009 3:30 p.m.
Location:	HCBP – Small portion of Block 5, along Forestell Road
Works inspected:	- Silt fencing associated with fill borrow and stockpile locations - Any impacts to natural areas associated with fill borrow and stockpile locations
Activity:	No activity taking place.
Weather Conditions at time of Inspection:	Approx. 21^{o}C, overcast, no precipitation
Weather Conditions 24 hrs prior to Inspection:	Approx. 20^{o}C, partly sunny, no precipitation

Description of Works:

- Erosion and sediment control fencing (heavy duty silt fence with page wire, T bars, and filter fabric) has been installed around the perimeter of the fill borrow area.
- Heavy duty silt fencing has been installed around the perimeter of the stockpile area.
- Topsoil has been removed from the fill borrow area and relocated to the stockpile area north of the fill borrow area.

Comments:

On-site fill removal activities complete. Inspections will continue on a bi-weekly basis until fill borrow area and portion of stockpile area are seeded, unless weather conditions (i.e. frequent heavy rains) permit otherwise.

Conditions within the fill borrow area remain quite wet. As mentioned in previous inspection report, water levels present may pose a problem for the establishment of the recommended seed mix to be applied to the fill borrow area. Seed mix has not been applied to the fill borrow area, therefore, bare side slope areas are showing signs of gullying from run-off into lowest section of fill borrow area.

Overall, the heavy duty silt fence around the fill borrow area continues to be in good condition and is adequately keyed in with no significant tears or slumping. The entrance which had been blocked off with silt fencing has been knocked down to allow for the entry of (an) ATV(s) as evidenced by Photo 1. The tracks suggest that a limited amount of joy-riding occurred over the weekend.

Fencing between the fill borrow area and stockpile area has been keyed in, reducing potential for run-off into respective areas. Vegetation is beginning to sprout within open area, further reducing potential for erosion issues.

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Photos 1 & 2. Evidence of ATV activity on-site

The section of silt fence along the south edge of the stockpile area as noted in previous inspection reports is still showing signs of significant slumping as a result of excess topsoil. In the event of heavy rainfall, this section of fence will likely fail again, resulting in run-off into hedgerow area.

The remaining heavy duty silt fence around the stockpile area remains sufficiently keyed in and in good condition.

The site is well contained and isolated with no other deficiencies observed.

Follow-up Requirements:

- Seed cleared area within stockpile area
- Seed fill borrow area once water levels are reduced to ensure no further erosion issues
- Repair fencing along south edge of stockpile area and remove excess topsoil
- NRSI to make additional site inspections until seed mix in fill borrow area and stockpile area begins to establish

Is Work in Compliance:	**Yes**	**No**
Is This the Final Inspection:	**Yes**	**No**

Inspection Report Distribution List

Title	**Name**	**Date**
Cooper Construction - Director of Development	Bill Luffman	August 28, 2009
Pitura Husson Ltd – Planning Engineer	Paul Husson	August 28, 2009
City of Guelph – Environmental Engineer	Colin Baker	August 28, 2009

Prepared by: Brett Woodman **Date: September 1, 2009**

Photo 2: Wet conditions within fill borrow area

Photo 3: Fencing along south edge of stockpile area failing as a result of excess topsoil

Photo 4: Current conditions within stockpile area

Environmental Inspection Report

Project Number:	942
Construction Project:	Hanlon Phase II – Fill Borrow Area
Date of Inspection:	September 8, 2009 3:30 p.m.
Location:	HCBP – Small portion of Block 5, along Forestell Road
Works inspected:	- Silt fencing associated with fill borrow and stockpile locations - Any impacts to natural areas associated with fill borrow and stockpile locations
Activity:	No activity taking place.
Weather Conditions at time of Inspection:	Approx. 25^{o}C, sunny, no precipitation
Weather Conditions 24 hrs prior to Inspection:	Approx. 24^{o}C, partly sunny, no precipitation

Description of Works:

- Erosion and sediment control fencing (heavy duty silt fence with page wire, T bars, and filter fabric) has been installed around the perimeter of the fill borrow area.
- Heavy duty silt fencing has been installed around the perimeter of the stockpile area.
- Topsoil has been removed from the fill borrow area and relocated to the stockpile area north of the fill borrow area.

Comments:

On-site fill removal activities complete. Inspections will continue on a bi-weekly basis until fill borrow area and portion of stockpile area are seeded, unless weather conditions (i.e. frequent heavy rains) permit otherwise.

Conditions within the fill borrow area remain quite wet. As mentioned in previous inspection report, water levels present may pose a problem for the establishment of the recommended seed mix to be applied to the fill borrow area. It is apparent that the dry portions of the bottom of the borrow pit have been scarified for seeding. Wether the seed has been applied is not known. The side slope areas are showing signs of gullying from run-off into lowest section of fill borrow area.

Overall, the heavy duty silt fence around the fill borrow area continues to be in good condition and is adequately keyed in with no significant tears or slumping.

Fencing between the fill borrow area and stockpile area has been keyed in, reducing potential for run-off into respective areas. Vegetation is beginning to sprout within open area, further reducing potential for erosion issues.

The section of silt fence along the south edge of the stockpile area as noted in previous inspection reports is still showing signs of significant slumping as a result of excess topsoil. In the event of heavy rainfall, this section of fence will likely fail again, resulting in run-off into hedgerow area.

The remaining heavy duty silt fence around the stockpile area remains sufficiently keyed in and in good condition.

The site is well contained and isolated with no other deficiencies observed.

Follow-up Requirements:
- Seed cleared area within stockpile area
- Seed fill borrow area once water levels are reduced to ensure no further erosion issues
- Repair fencing along south edge of stockpile area and remove excess topsoil
- NRSI to make additional site inspections until seed mix in fill borrow area and stockpile area begins to establish

Is Work in Compliance:	**Yes**	**No**
Is This the Final Inspection:	**Yes**	**No**

Inspection Report Distribution List

Title	**Name**	**Date**
Cooper Construction - Director of Development	Bill Luffman	August 28, 2009
Pitura Husson Ltd – Planning Engineer	Paul Husson	August 28, 2009
City of Guelph – Environmental Engineer	Colin Baker	August 28, 2009

Prepared by: Brett Woodman **Date: September 8, 2009**


Photo 1: Wet conditions within fill borrow area

Photo 2: Current conditions within stockpile area

Photo 3: Recent scarification of soil in preparation for seeding.

Environmental Inspection Report

Project Number:	942
Construction Project:	Hanlon Phase II – Fill Borrow Area
Date of Inspection:	September 25, 2009 8:30 a.m.
Location:	HCBP – Small portion of Block 5, along Forestell Road
Works inspected:	- Silt fencing associated with fill borrow and stockpile locations - Any impacts to natural areas associated with fill borrow and stockpile locations
Activity:	No activity taking place.
Weather Conditions at time of Inspection:	Approx. 11^{o}C, overcast, no precipitation
Weather Conditions 24 hrs prior to Inspection:	Approx. 12^{o}C, partly sunny, no precipitation

Description of Works:

- Erosion and sediment control fencing (heavy duty silt fence with page wire, T bars, and filter fabric) has been installed around the perimeter of the fill borrow area.
- Heavy duty silt fencing has been installed around the perimeter of the stockpile area.
- Topsoil has been removed from the fill borrow area and relocated to the stockpile area north of the fill borrow area.

Comments:

The high water level within the fill borrow area has gone down substantially, leaving only moist conditions within the northwest corner. Seed mix has been applied to the southern portion of the fill borrow area (only limited, small sprouts beginning to emerge). Seed mix has not been applied to side slopes or the northern portion of the fill borrow area. In order to avoid further gullying along side slopes, the recommended **native seed mix** should be applied as soon as possible.

Overall, the heavy duty silt fence around the fill borrow area continues to be in good condition and is adequately keyed in with no significant tears or slumping.

The section of silt fence along the south edge of the stockpile area as noted in previous inspection reports has been replaced with a section of heavy duty silt fence. This area has also been reinforced with two new sections of heavy duty silt fence, the first immediately adjacent to the original section and the second approximately 1m from the original fence. As seed mix within the area is establishing well and the fencing has been reinforced, no further erosion issues are anticipated for this area.

The remaining heavy duty silt fence around the stockpile area remains sufficiently keyed in and in good condition.

The site is well contained and isolated with no other deficiencies observed.

Follow-up Requirements:

- Seed side slopes and northern portion of fill borrow area with **native seed mix** to ensure no further erosion issues
- NRSI to make additional site inspections until seed mix in fill borrow area begins to establish

Is Work in Compliance:	**Yes**	**No**	Seed mix was to be applied within 30days of construction.
Is This the Final Inspection:	**Yes**	**No**	

Inspection Report Distribution List

Title	**Name**	**Date**
Cooper Construction - Director of Development	Bill Luffman	September 28, 2009
Pitura Husson Ltd – Planning Engineer	Paul Husson	September 28, 2009
City of Guelph – Environmental Engineer	Colin Baker	September 28, 2009

Prepared By: Tara Brenton **Date: September 28, 2009**

Photo 1: Current conditions within fill borrow area

Photo 2: Moist conditions within northwest corner of fill borrow area

Photo 3: Reinforced fencing along south edge of stockpile area

Photo 4: Current conditions within stockpile area

Environmental Inspection Report

Project Number:	942
Construction Project:	Hanlon Phase II – Fill Borrow Area
Date of Inspection:	October 5, 2009 9:40 a.m.
Location:	HCBP – Small portion of Block 5, along Forestell Road
Works inspected:	- Silt fencing associated with fill borrow and stockpile locations - Any impacts to natural areas associated with fill borrow and stockpile locations
Activity:	No activity taking place.
Weather Conditions at time of Inspection:	Approx. 9^{o}C, overcast, no precipitation (precipitation half hour prior to site visit)
Weather Conditions 24 hrs prior to Inspection:	Approx. 11^{o}C, overcast, scattered showers

Description of Works:

- Erosion and sediment control fencing (heavy duty silt fence with page wire, T bars, and filter fabric) has been installed around the perimeter of the fill borrow area.
- Heavy duty silt fencing has been installed around the perimeter of the stockpile area.
- Topsoil has been removed from the fill borrow area and relocated to the stockpile area north of the fill borrow area.

Comments:

Standing water is once again present within northwest corner of fill borrow due to recent rain events. The bottom of the fill borrow area has been scarified and seeded, with the exception of the northern portion, where moist to wet conditions persist. Seed mix is established very slowly, with limited, small sprouts beginning to emerge. The side slopes within the fill borrow area, especially along the east side are showing signs of significant run-off with the presence of gullying. To avoid further gullying along side slopes, it is recommended that the **native seed mix** as outlined by NRSI be applied as soon as possible.

Overall, the heavy duty silt fence around the fill borrow area continues to be in good condition and is adequately keyed in with no significant tears or slumping.

Seed mix within the southern portion of the stockpile area that was previously cleared appears to no longer be establishing, thus, leaving large areas of exposed soil. Due to recent rain events, areas with bare ground are showing signs of run-off, especially toward the previously reinforced section of fencing along the southern edge. Erosion within the area is currently not significant; however, if bare ground left un-seeded, persistent rain events may lead to increased sedimentation along the southern silt fence. It is recommended that the **native seed mix** as outlined by NRSI be applied as soon as possible.

The remaining heavy duty silt fence around the stockpile area remains sufficiently keyed in and in good condition.

Similar to open areas within the stockpile area, the hedgerow area separating the fill borrow area and stockpile area is no longer establishing. Minimal run-off is occurring toward the stockpile area; however, it is recommended that this area, in addition to the stockpile area, be seeded with the native seed mix to ensure no further erosion issues arise.

The site is well contained and isolated with no other deficiencies observed.

Follow-up Requirements:

- Seed side slopes and northern portion of fill borrow area with **native seed mix** to ensure no further erosion issues
- Reapply native seed mix within southern portion of stockpile area and hedgerow area separating fill borrow and stockpile area
- NRSI to make additional site inspections until seed mix within areas mentioned above begins to establish

Is Work in Compliance:	**Yes**	**No**	Seed mix was to be applied within 30days of construction.
Is This the Final Inspection:	**Yes**	**No**	

Inspection Report Distribution List

Title	**Name**	**Date**
Cooper Construction - Director of Development	Bill Luffman	October 8, 2009
Pitura Husson Ltd – Planning Engineer	Paul Husson	October 8, 2009
City of Guelph – Environmental Engineer	Colin Baker	October 8, 2009

Prepared By: Tara Brenton **Date: October 8, 2009**

Photo 1: Current conditions within fill borrow area

Photo 2: Gullying along fill borrow side slopes


Photo 3: Signs of run-off due to lack of seed establishment within stockpile area


Photo 4: Current conditions within stockpile area

Photo 5: Hedgerow area – view east

Photo 6: Hedgerow area – view west

Environmental Inspection Report

Project Number:	942
Construction Project:	Hanlon Phase II – Fill Borrow Area
Date of Inspection:	November 10, 2009 9:00 a.m.
Location:	HCBP – Small portion of Block 5, along Forestell Road
Works inspected:	- Silt fencing associated with fill borrow and stockpile locations - Any impacts to natural areas associated with fill borrow and stockpile locations
Activity:	No activity taking place.
Weather Conditions at time of Inspection:	Approx. 5^{o}C, slightly overcast, no precipitation
Weather Conditions 24 hrs prior to Inspection:	Approx. 7^{o}C, slightly overcast, no precipitation

Description of Works:

- Erosion and sediment control fencing (heavy duty silt fence with page wire, T bars, and filter fabric) has been installed around the perimeter of the fill borrow area.
- Heavy duty silt fencing has been installed around the perimeter of the stockpile area.
- Topsoil has been removed from the fill borrow area and relocated to the stockpile area north of the fill borrow area.
- Fill borrow and stockpile areas have been seeded

Comments:

With the exception of the northwest corner of the fill borrow area where standing water is still present, the bottom of the fill borrow area has been scarified and seeded with the recommended seed mix. The seed in the bottom of the fill borrow area is just beginning to sprout. It appears as though a seed mix has been broadcast along the side slopes; however, seed has not begun to sprout.

Overall, the heavy duty silt fence around the fill borrow area continues to be in good condition and is adequately keyed in with no significant tears or slumping.

The southern portion of the stockpile area that was identified to have exposed areas of soil during the October inspection does not appear to have been seeded as recommended. As non-native herbaceous species continue to establish very slowly in this area, erosion issues are minimal. In the event that erosion issues increase over the winter season, it is recommended that the native seed mix be applied in spring 2010.

The remaining heavy duty silt fence around the stockpile area remains sufficiently keyed in and in good condition.

The site is well contained and isolated with no other deficiencies observed.

Follow-up Requirements:

- Once water levels are reduced, seed northwest portion of fill borrow area with native seed mix
- Apply native seed mix to southern portion of stockpile area in spring 2010 if erosion issues arise over the winter season [is likely too late in 2009 season for seed to establish before winter]
- NRSI to make additional site inspections until seed mix within areas mentioned above begins to establish

Is Work in Compliance:	**Yes**	**No**	Seed mix was to be applied within 30days of construction.
Is This the Final Inspection:	**Yes**	**No**	

Inspection Report Distribution List

Title	**Name**	**Date**
Cooper Construction - Director of Development	Bill Luffman	November 10, 2009
Pitura Husson Ltd – Planning Engineer	Paul Husson	November 10, 2009
City of Guelph – Environmental Engineer	Colin Baker	November 10, 2009

Prepared By: Tara Brenton **Date: November 10, 2009**


Photo 1: Current conditions within fill borrow area


Photo 2: Southwest corner of fill borrow area

Photo 3: Current conditions within stockpile area

Photo 4: Reinforced heavy-duty silt fence along south portion of stockpile area

Photo 5: Hedgerow area – view east

Photo 6: Hedgerow area – view west

Environmental Inspection Report

Project Number:	942
Construction Project:	Hanlon Phase II – Fill Borrow Area
Date of Inspection:	December 4, 2009 9:42 a.m.
Location:	HCBP – Small portion of Block 5, along Forestell Road
Works inspected:	- Silt fencing associated with fill borrow and stockpile locations - Any impacts to natural areas associated with fill borrow and stockpile locations
Activity:	No activity taking place.
Weather Conditions at time of Inspection:	Approx. -1°C, slightly overcast, no precipitation
Weather Conditions 24 hrs prior to Inspection:	Approx. -4°C, overcast, raining

Description of Works:

- Erosion and sediment control fencing (heavy duty silt fence with page wire, T bars, and filter fabric) has been installed around the perimeter of the fill borrow area.
- Heavy duty silt fencing has been installed around the perimeter of the stockpile area.
- Topsoil has been removed from the fill borrow area and relocated to the stockpile area north of the fill borrow area.
- Fill borrow and stockpile areas have been seeded

Comments:

Small sprouts of vegetation are present within the bottom of the fill borrow area; however, seed is still not establishing well due to on-set of cold weather. It is recommended that the native seed mix be reapplied to the fill borrow area in spring 2010.

Conditions within the northwest corner of the fill borrow area continue to be quite wet, with standing water present. There is evident drainage occurring from the culvert located west of Phelan Drive, causing slope beneath silt fence to erode (see Photo). Although slope is eroding, silt fence is still intact; however, it is no longer keyed in.

Overall, the heavy duty silt fence around the fill borrow area continues to be in good condition and is adequately keyed in with no significant tears or slumping.

It appears as though the bare areas identified within the southern portion of the stockpile area noted in previous inspection reports have not been seeded, as a result, there is evidence of some run-off toward the re-enforced heavy-duty silt fence. Although run-off is occurring, the heavy-duty silt fence is still keyed in and in good condition. To avoid further run-off, it is recommended that the native seed mix be applied to this area in spring 2010.

The remaining heavy duty silt fence around the stockpile area remains sufficiently keyed in and in good condition.

The site is well contained and isolated with no other deficiencies observed.

Follow-up Requirements:

- In spring 2010 apply native seed mix to fill borrow area and southern portion of stockpile area.
- NRSI to make additional site inspections in spring 2010 to assess site following winter season.

Is Work in Compliance:	**Yes**	**No**	Seed mix was to be applied within 30days of construction.
Is This the Final Inspection:	**Yes**	**No**	Further inspections anticipated for spring 2010

Inspection Report Distribution List

Title	Name	Date
Cooper Construction - Director of Development	Bill Luffman	December 4, 2009
Pitura Husson Ltd – Planning Engineer	Paul Husson	December 4, 2009
City of Guelph – Environmental Engineer	Colin Baker	December 4, 2009

Prepared By: Tara Brenton **Date: December 18, 2009**


Photo 1: Current conditions within fill borrow area


Photo 2: Culvert adjacent to Phelan Drive that is draining into fill borrow area


Photo 3: Erosion along slope due to Phelan Drive culvert


Photo 4: Flow from culvert under silt fence into northwest corner of fill borrow area

Photo 5: Current conditions in stockpile area

Photo 6: Hedgerow area – view east


Photo 7: Hedgerow area – view west

Environmental Inspection Report

Project Number:	948
Construction Project:	HCBP Tributary A/Road A Crossing
Date of Inspection:	September 16, 2009
Location:	Hanlon Creek Business Park – Tributary A/Road A Crossing
Works inspected:	Sediment and erosion control fencing around work zone
Activity:	No construction activities taking place on-site
Weather Conditions at time of Inspection:	10^{o}C, sunny, no precipitation
Weather Conditions 24 hrs prior to Inspection:	10^{o}C, sunny, no precipitation

Description of Works:

- Erosion and sediment control fencing (heavy duty silt fence with paige wire, T bars and filter fabric) has been installed along east and west side of tributary.
- Terrafix fencing has been installed around the perimeter of the proposed work-site associated with the Tributary A/Road A culvert installation.

Comments:

Heavy duty silt fencing has been keyed in and installed as per the design drawings, immediately adjacent to the proposed Tributary A/Road A crossing location. Terrafix fencing has been installed around the perimeter of the proposed work site.

In response to comments received from the MNR regarding protection of salamanders within the area and elimination of 'pit-fall' areas associated with fence installation, the downstream side of both the heavy duty silt fence and Terrafix fence has been graded.

Seed mix has not begun to establish within the cleared area east of Tributary A. It is recommended that a follow-up inspection be conducted to ensure that this area is beginning to establish, otherwise, the area should be re-seeded to ensure no sedimentation occurs within the Tributary. Much of the native vegetation cover on the west side of the Tributary has been left intact. Small exposed earth mounds are present along the inside of the heavy duty silt fence immediately adjacent to the tributary (east and west of Tributary). It is recommended that these areas be seeded and inspected to ensure no run-off into the Tributary.

Follow-up Requirements:

- Seed small earth mounds associated with heavy duty silt fencing that is adjacent to Tributary to ensure no erosion issues arise
- NRSI to make additional site inspection to ensure seed mix is beginning to establish within open area and inspect silt fencing for any deficiencies

Is Work in Compliance:	**Yes**	**No**	If "No" see follow-up requirements
Is This the Final Inspection:	**Yes**	**No**	

Inspection Report Distribution List

Title	**Name**	**Date**
City of Guelph – Environmental Engineer	Colin Baker	September 17, 2009

Prepared By: Tara Brenton **Date: September 17, 2009**

Photo 1: Heavy duty silt fence and Terrafix fencing

Photo 2: Cleared area east of Tributary A – looking east

Photo 3: Cleared area east of Tributary A – looking west

Photo 4: Vegetation cover on west side of Tributary A

Photo 5: Small earth berm exposed along east side of Tributary A (NE corner)

Photo 6: Small earth berm exposed along west side of Tributary (NW corner)

NATURAL RESOURCE SOLUTIONS INC.
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Environmental Inspection Report

Project Number:	948
Construction Project:	HCBP Tributary A/Road A Crossing
Date of Inspection:	October 5, 2009
Location:	Hanlon Creek Business Park – Tributary A/Road A Crossing
Works inspected:	Sediment and erosion control fencing around work zone
Activity:	No construction activities taking place on-site
Weather Conditions at time of Inspection:	9^{o}C, overcast, scattered showers
Weather Conditions 24 hrs prior to Inspection:	11^{o}C, overcast, scattered showers

Description of Works:

- Erosion and sediment control fencing (heavy duty silt fence with paige wire, T bars and filter fabric) has been installed along east and west side of tributary.
- Terrafix fencing has been installed around the perimeter of the proposed work-site associated with the Tributary A/Road A culvert installation.

Comments:

Heavy duty silt fencing has been keyed in and installed as per the design drawings, immediately adjacent to the proposed Tributary A/Road A crossing location. Terrafix fencing has been installed around the perimeter of the proposed work site. Overall, the heavy duty silt fence and Terrafix silt fence continue to be in good condition and are adequately keyed in with no significant tears or slumping.

Hydro-seed has recently been applied to the cleared areas east and west of Tributary A, and along the temporary access road to McWilliams Road. The hydro-seed is generally broadcast evenly throughout the site; however, due to recent rain events, certain areas (i.e. small depressions in soil) are showing concentrations of hydro-seed, while other areas are bare.

No erosion issues were documented during the first follow-up inspection. It is recommended that a second follow-up inspection be conducted to ensure that the hydro-seed is beginning to establish. In the event that the hydro-seed does not establish well, it may be recommended that a seed drill be used to ensure seed does not wash away or run into the Tributary during rain events.

Follow-up Requirements:

- NRSI to make additional site inspection to ensure seed mix is beginning to establish within open area and inspect silt fencing for any deficiencies

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Is Work in Compliance:	**Yes**	**No**	If “No” see follow-up requirements
Is This the Final Inspection:	**Yes**	**No**	

Inspection Report Distribution List

Title	**Name**	**Date**
City of Guelph – Environmental Engineer	Colin Baker	October 8, 2009

Prepared By: Tara Brenton **Date: October 8, 2009**

Photo 1: Edge conditions along Tributary A looking west

Photo 2: Accumulation of seed mix within area east of Tributary A


Photo 3: Temporary access road leading to McWilliams Road

Environmental Inspection Report

Project Number:	948
Construction Project:	HCBP Tributary A/Road A Crossing
Date of Inspection:	December 4, 2009
Location:	Hanlon Creek Business Park – Tributary A/Road A Crossing
Works inspected:	Sediment and erosion control fencing around work zone
Activity:	No construction activities taking place on-site
Weather Conditions at time of Inspection:	Approx. -1^{o}C, sunny, no precipitation
Weather Conditions 24 hrs prior to Inspection:	Approx. 4^{o}C, overcast, raining

Description of Works:

- Erosion and sediment control fencing (heavy duty silt fence with paige wire, T bars and filter fabric) has been installed along east and west side of tributary.
- Terrafix fencing has been installed around the perimeter of the proposed work-site associated with the Tributary A/Road A culvert installation.

Comments:

Heavy duty silt fencing has been keyed in and installed as per the design drawings, immediately adjacent to the proposed Tributary A/Road A crossing location. Terrafix fencing has been installed around the perimeter of the proposed work site. Overall, the heavy duty silt fence and Terrafix silt fence continue to be in good condition and are adequately keyed in with no significant tears or slumping.

The hydro-seed applied to the cleared areas adjacent to Tributary A has not established well, especially along east side of Tributary. The seed mix may not have established well due to rain events immediately following application, as well as on-set of the winter season. During previous site visit, it was noted that the hydro-seed was beginning to establish along the access road to McWilliams Road. Large vehicle tracks/ruts that have removed a significant amount of the establishing vegetation were documented along the southern access road berm. Although hydro-seed has not established well in cleared areas adjacent to Tributary A and has been disrupted along the access road, there were no erosion issues identified. It is recommended that the site be inspected in early spring 2010 to ensure no erosion issues have arisen over the winter season.

During inspection it was noted that it appears someone has planted a few small trees and shrubs, such as red-osier dogwood (*Cornus stolonifera*) and hawthorn spp. (*Crataegus spp.*) along the east side of the tributary. Mulch has been placed around base of each tree/shrub.

Follow-up Requirements:

- NRSI to make additional site inspections in early spring 2010 to ensure no erosion issues have arisen over the winter season and inspect silt fencing for any deficiencies

Is Work in Compliance:	**Yes**	**No**	If “No” see follow-up requirements
Is This the Final Inspection:	**Yes**	**No**	

Inspection Report Distribution List

Title	Name	Date
City of Guelph – Environmental Engineer	Colin Baker	December 21, 2009

Prepared By: Tara Brenton **Date: December 21, 2009**


Photo 1: Edge conditions along Tributary A - view west


Photos 2: Edge conditions along Tributary A - view east


Photo 3: Vehicle tracks along access road from McWilliams Road


Photo 4: Current condition of fencing along northeast section of Tributary A

Photo 5: Current condition of fencing along northwest section of Tributary A

Photo 6: Potentially planted red-osier dogwood on east side of Tributary A

Environmental Inspection Report

Project Number:	980 D
Construction Project:	HCBP – Watermain and Utility Crossing
Date of Inspection:	December 4, 2009
Location:	HCBP – Watermain and Utility Crossing, edge of Phelan Drive
Works inspected:	- Silt fencing associated with excavation works - Any impacts to natural areas associated with excavation works
Activity:	Excavation activities associated with preparation of utility crossing installation beneath Hanlon Expressway.
Weather Conditions at time of Inspection:	Approx. -1^{o}C, slightly overcast, no precipitation
Weather Conditions 24 hrs prior to Inspection:	Approx. -4 ^{o}C, overcast, raining

Description of Works:

- Erosion and sediment control fencing (heavy duty silt fence with page wire, T bars, and filter fabric) has been installed around the perimeter of the watermain and utility crossing installation area.
- Excavation activities associated with construction of watermain and utility casings beneath the Hanlon Expressway, at the intersection of the Hanlon Expressway and Clair Road.

Comments:

Heavy-duty silt fencing has been keyed in and installed as per the design drawings. There was no slumping or tears observed along the entire length of the silt fence; however, it was noted that one small section of fencing in the northwest corner is not keyed in properly. As per the design drawings, the work zone is also surrounded by 1.8m high security fencing. Access to the site is located at a high point of land which limits the potential of material from leaving the site via the access lane.

The site is well contained and isolated with no other deficiencies observed.

Follow-up Requirements:

- Key in silt fence in northwest corner of excavation area
- NRSI to make additional site inspections of silt fencing for any deficiencies

Is Work in Compliance:	**Yes**	**No**
Is This the Final Inspection:	**Yes**	**No**

Inspection Report Distribution List

Title	Name	Date
City of Guelph – Environmental Engineer	Colin Baker	December 21, 2009

Prepared By: Tara Brenton **Date: December 21, 2009**

Photo 1: Heavy-duty silt fencing along south edge of work area

Photo 2: Heavy-duty silt fencing along north edge of work area


Photo 3: Excavation work within northeast corner


Photo 4: Small section of heavy-duty silt fencing in northeast corner not keyed in