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Our File: 9506

January 14, 2014

R.J. Burnside and Associates Limited
292 Speedvale Avenue West, Unit 20
Guelph, Ontario, N1H 1C4

Attention: Mr. David Hopkins, P.Geo.
Hydrogeologist

Dear Mr. Hopkins:

Re: Response to Burnside Review of Hydrogeological Summary Report Hidden Quarry Site for Township of Guelph/Eramosa Burnside File No.: 300032475.0000

We are pleased to respond to the November 12, 2013 comments provided by R.J. Burnside and Associates Limited (attached Appendix A). It appears that we were able to address several issues and that there are some outstanding. It is our intention to provide sufficient technical analysis in this letter to satisfy the outstanding concerns raised by Burnside and Associates.

1.0 Karst

We agree that cavernous karst features do not exist at this site.

2.0 Water Quality

We agree that throughout the forty-one metres of aquifer encountered in monitoring well M15, groundwater mainly enters the well from two discrete zones and one diffuse zone. There is little inflow to the well from the 19 to 26 metre depth but some 20% of inflow occurs between 26 and 36 metres depth below ground surface.

We agree that nitrate in groundwater originating from upgradient sources likely occurs mainly in fractures within the upper ten metres of the bedrock.

We agree that if the quarry does not extend to the full depth of 41 metres below ground surface and the deeper 33% of inflow is not encountered, there will be less inflow to the quarry and less water for dilution. We have recalculated the nitrogen mass balance (presented in accompanying letter) under these conditions as discussed below.

Nitrate Balance without Full Through Flow

Assuming that a third of the groundwater through flow from lower fractures is not available for dilution the overall nitrogen balance of the site will not change significantly. The net concentration of nitrogen in groundwater entering and leaving the site will increase somewhat owing to the decrease in available dilution. In this analysis we assume that the lower third of the active aquifer does not contribute to dilution. Dilution is only derived from flow through for the remaining two thirds of overall flow. Of this, half is assumed to be derived from the shallow source and half is derived from the intermediate depth fractures.

The volume of groundwater input to this site is calculated as inflow occurring a) under existing gradients and b) flow induced by the lower hydraulic head in the quarry pond.

The volume of flow under natural gradients is estimated using the average hydraulic gradient upgradient of the site and is estimated to be 2 m over 175 m or 0.011 m/m. The width of the flow field is 700 m and the transmissivity is estimated to be 50 m^2/day (this value is a third lower than the value of 75m^2/day estimated by Burnside).

Using

Q = T x i x W

Where
T – transmissivity (m^2/day)
i – gradient (m/m)
W – width of flow field (m)

the estimated flow through the site under a natural gradient is 385.3 m^3/day or 140,646 m^3/year. Of this, 70,323 m^3 is assumed to flow through the shallow fracture set and 70,323 m^3 in the intermediate fracture set observed in monitoring well M15.

The observed concentrations of nitrogen compounds in the groundwater entering the northern boundary of the site average 4.38 mg/L. Assuming that this value applies to the upper 50% of flow, the mass of nitrogen compounds entering the site from natural flow is

308 kg. It is estimated that the lower flow system has a nitrogen concentration of 0.2 mg/L resulting in an additional 14 kg of nitrogen annually.

Table 1: Nitrogen Balance

Zone	**Nitrogen Concentration (mg/L)**	**Groundwater Flow Volume (m^3)**	**Mass of Nitrogen (kg)**	**Total Nitrogen (kg)**
Upper	4.38	70,323	308	
Middle	0.2	70,323	14	
Induced Flow				
Upper	4.38	128,250	562	
Middle	0.2	128,250	26	
Total from Groundwater			910	
Total from Explosives			894	1,804
Total Dilution		397,146		
Final Nitrogen Concentration	4.54			

The active quarrying will result in 256,500 m^3 of additional groundwater inflow annually assuming that there is no year over year deficit in water balance. This is our experience with below-water-table extraction in similar and less permeable conditions. Assuming that the upper 50% of flow already has a concentration of 4.38 mg/L from upgradient sources, the mass of nitrogen brought into the site by shallow groundwater flow induced by extraction processes is 562 kg and by flow in the middle portion of the aquifer another 26 kg of nitrogen.

The total nitrogen input to the site is estimated to be 910 kg from upgradient groundwater and 894 kg[1] from explosives residue for a total of 1,804 kg.

The water input from upgradient is 140,646 m^3 + 256,500 m^3 = 397,146 m^3.

As shown in Table 1, the expected downgradient nitrogen value is therefore expected to be 4.54 mg/L at the downgradient property line in the absence of any denitrification.

Using the relative absence of nitrogen compounds in water obtained from the Rental House well (W1) as an example, the aquifer has the capability of naturally reducing

[1] For detailed assumptions used to calculate the nitrogen residue from explosives please refer to accompanying response to “Summary of Drilling and Testing of New Well M15 at Hidden Quarry Site”

nitrogen concentrations. In addition, nitrogen will be sequestered in any organic mat created in the pond.

It is our conclusion that the total nitrogen concentration in the groundwater leaving the site will have a lower concentration of total nitrogen than shallow groundwater entering the site and will be well below the Ontario Drinking Water Quality standards.

Deeper Water Sources

We agree that quarry activities will result in the mixing of groundwater from various depths. The testing results from monitoring well M15 indicate that confining conditions occur at depth. This generally suggests that the water sources at depth are somewhat isolated from shallower groundwater sources and less exposed to anthropogenic contamination. The vast majority of wells, however, obtain water from the upper and middle portions of the aquifer exposing most wells to contamination from anthropogenic activities and possibly surface water already. This is particularly true for wells located downgradient of the quarry in the Blues Springs Creek valley where overburden is thin or absent. The bedrock aquifer is already susceptible to contaminants from the ground surface as recognized in several reports including Halton Rural Drinking Water Study, Phase 1 and City of Guelph Final Groundwater and Surface Water Vulnerability Report (Aqua Resources, March 2010). The water quality survey by Halton Region found that the water from 31% of drilled wells in their survey was unsafe for drinking. The Beak International (1999) study states that in the Blue Springs Creek watershed, the rapid movement of surface water into the bedrock leads to high susceptibility of contamination. Therefore, the quarry is being developed in an area already susceptible to contamination from the ground surface.

Groundwater on the quarry property does not flow northward. The exception to this is when the production well at the Mushroom Farm (W3) is operating, there may be sufficient drawdown in the well to draw water from the quarry property. If this is the case, the production well will benefit from the body of water developed on the quarry property.

We agree that the mixing of water in the quarry will occur. We note that this mixing already occurs in each bedrock well drilled in this area, including the deep well servicing the Mushroom Farm. The aquifer is also exposed to surface contaminants in the Eramosa River valley and the Blue Springs Creek valley.

GUDI Condition in proposed Well No. 4

We disagree that the quarry may result in the classification of the future Well No. 4 as Groundwater Under the Direct Influence of Surface Water (GUDI).

We have reviewed the definition of GUDI wells as presented in Ontario Regulation 170/03. We understand that Rockwood Wells No. 1 and 2 were deemed GUDI by Burnside and Associates Limited based on the proximity of the exposed bedrock aquifer nearby (GRCA Approved Assessment Report, 2012). We understand that Well No. 3 is not GUDI and obtains water from deep fractures (45 to 48 metres below ground surface).

The following are excerpts from Ontario Regulation 170/03 (italics) and our interpretation relative to future Well No. 4.

> **2.** (1) *A drinking water system that obtains water from a raw water supply that is ground water under the direct influence of surface water is deemed, for the purposes of this Regulation, to be a drinking water system that obtains water from a raw water supply that is surface water. O. Reg. 170/03, s. 2 (1).*

> (2) *The following drinking water systems are deemed, for the purposes of this Regulation, to be drinking water systems that obtain water from a raw water supply that is ground water under the direct influence of surface water:*
>
> *1. A drinking water system that obtains water from a well that is not a drilled well or from a well that does not have a watertight casing that extends to a depth of six metres below ground level.*

This rule does not apply.

> *2. A drinking water system that obtains water from an infiltration gallery.*

This rule does not apply.

> *3. A drinking water system that is not capable of supplying water at a rate greater than 0.58 litres per second and that obtains water from a well, any part of which is within 15 metres of surface water.*

This rule does not apply.

> *4. A drinking water system that is capable of supplying water at a rate greater than 0.58 litres per second and that obtains water from an overburden well, any part of which is within 100 metres of surface water.*

This rule does not apply.

5. A drinking water system that is capable of supplying water at a rate greater than 0.58 litres per second and that obtains water from a bedrock well, any part of which is within 500 metres of surface water.

This rule already applies given that Tributary A and associated wetlands are within 500 metres of Well No. 4 (Figure 1). Tributary A is a perennial stream that loses water between Eramosa Line 6 and Hwy 7 part of which falls within 500 metres of Well No. 4. This will flag the well as potentially GUDI and appropriate chemical and physical testing will be required to determine if the well is indeed GUDI or not.

6. A drinking water system that exhibits evidence of contamination by surface water.

This will only be known after extensive testing of Well No. 4. There are numerous sources of surface water contamination including the Eramosa River, Tributary A and poorly constructed/abandoned water wells.

7. A drinking water system in respect of which a written report has been prepared by a licensed engineering practitioner or professional hydrogeologist that concludes that the system's raw water supply is ground water under the direct influence of surface water and that includes a statement of his or her reasons for reaching that conclusion. O. Reg. 170/03, s. 2 (2); O. Reg. 418/09, s. 1 (5).

Source water protection analysis has been undertaken by Golder and Associates, Gartner Lee Limited and AquaResources. The approach taken by each of the consultants is to use an equivalent porous media model rather than a discrete fracture model. This approach is justified by the assumption that over a macro scale there is sufficient vertical interconnection between fractures over a large area and thus the aquifer behaves as a continuum. Figure 2 identifies the "water found at" (i.e. fracture) elevations from the water well records. Figure 1 shows the wells used in this analysis. Figure 2 shows that fractures are found at various depths throughout the aquifer and are common enough to allow for the equivalent porous media concept to apply. Figure 3 shows a frequency of occurrence of 'water found at' elevations. It is recognized that individual fractures control groundwater flow on a local scale as observed at the Hidden Quarry site (M15 to M2) and between Rockwood Well No. 3 and observation well OW3D, however, for single fractures to persist in a confined manner between proposed Well No. 4 and the Hidden Quarry is unlikely. For example, although the Rockwood Well No. 3 is sealed to a depth of 36.5 metres, there was a significant response to pumping in observation well OW5D which is only 15.6 metres deep.

It is our conclusion that the proposed Well No. 4 will be flagged as potentially GUDI even in the absence of the proposed quarry, there are other potential sources of surface water contamination closer than the proposed quarry and it is unlikely that fractures are isolated to the extent that interconnections to the bedrock surface will not occur between proposed Well No. 4 and the proposed quarry.

Pathogen Movement

Figure 4 shows the wells that are downgradient of the quarry. These are the only wells that have any risk of water quality impacts. It is our opinion that the detailed monitoring program will identify chemical and bacteriological movement from the quarry and contingency measures are in place in the event that a local well is impacted. Recent testing of the Guelph Limestone quarry during blasting found that the water met all Ontario Drinking Water Quality Standards for comprehensive suite of parameters.

Quarry Depth Limitation

The flow profiling at M15 indicates that there are significant fractures at elevations of 318 m and 324 m AMSL (42 and 36 metres below ground surface respectively). The proposed quarry will extend to an elevation of 320 m AMSL. It is our opinion that limiting the depth of the quarry to an elevation greater than 324 m AMSL will not guarantee the protection of the lower fracture set. The pumping test in Rockwood Well No. 3 shows that at that location there is a hydraulic connection between fractures located more than forty metres below the ground surface and fractures found less than fifteen metres below the ground surface. Therefore, limiting the quarry depth may reduce the volume of water moving through the lower fracture set but will not necessarily eliminate it. Therefore, monitoring and contingency plans are required in any event. The treatment of well water for biological agents is simple, effective and in-expensive. Therefore, we recommend mitigating water quality issues at the few downgradient wells, if they arise, using proven, effective methods designed specifically to address such problems.

3.0 Private Wells with Shallow Fracture Sources of Water

We agree that the bulk transmissivity of the aquifer is approximately 75 m^2/day and that a storativity of 0.00004 is suggested by the limited pumping test in M15 with response in M2.

We agree that flow profiling identified fractures at 36 metres below ground surface and 41 metres below ground surface that accounted for two thirds of the flow entering Well M15.

We agree that testing of local wells by Burnside (and others) suggest that the bulk transmissivity of the full aquifer thickness is typically in the range of 50 to 100 m^2/day and lower fractures account for 25 to 50 m^2/day of that transmissivity.

We agree that fracture flow through a single fracture is much faster than predicted by an equivalent porous media model.

We disagree that groundwater with elevated nitrate may move rapidly away from the quarry before dilution with deeper aquifer water can occur. Our reasons for this disagreement are;

1) Nitrogen compounds that are already in groundwater flowing beneath the quarry property from upgradient sources will likely continue. This water captured in the active quarry will be mixed via extractive processes (i.e. plunging of drag line, blasting) with deep water in the quarry pond. These processes will dilute the concentration of nitrogen compounds by mixing with rainwater and intermediate depth groundwater.

2) Nitrogen loading from the blasting process will occur under turbulent conditions, resulting in significant mixing within the pond and without a significant increase in total nitrogen concentration.

We agree that upon leaving the pond, nitrate can move with greater velocity within discrete fractures than in a porous media situation.

We agree to install individual monitors in M15 and assess hydraulic properties of individual fractures.

We agree that the short term testing in M15 was insufficient for water levels to stabilize, however, the immediate response in M2 suggests that significant local confining conditions exist and the response in M2 is a true response with minimal lag. The minimal lagtime in the response means that the drawdown observed in M2 even for short periods is a good indication of the expected long term response. The level of response observed in M2 is similar to that anticipated in the groundwater model.

We agree that the extrapolation of testing results to 12 hours would result in an approximate drawdown of 1.9 metres in M2, and corresponds to an approximate drawdown in M15 of 3.4 metres which is greater than the proposed maximum allowable water level change in the quarry. A drawdown of 2.5 metres in M15 would occur after 75 minutes resulting in a drawdown at M2 of approximately 1.1 metres. The maximum drawdown predicted to occur in the quarry is 2.54 metres resulting in a 1.6 metre drawdown in the nearest private well. The pumping test in M15 corroborates the model simulations thereby validating the model results.

We agree that shallow wells have the greatest potential to be impacted. We have identified the shallow wells on Figure 5 and none of the shallow wells are located upgradient of the quarry. These wells are located downgradient where water levels will rise. In regards to wells that are upgradient of the quarry, it is our opinion that the magnitude of change will not affect the functioning of the domestic wells. This opinion will be verified upon completion of a detailed pre-bedrock extraction water well survey. If an upgradient well is found, during a flow test, to have a drawdown near to the location of the pump, then the pump will be set to a deeper depth.

We disagree that pro-actively modifying all nearby wells is a necessary step. The predicted maximum impact of 1.6 metres will not affect the yield of any well upgradient of the quarry. James Dick Construction Ltd. has committed to resolving all water well issues related to the quarry activities.

4.0 Groundwater Model Parameter – Hydraulic Conductivity

We agree that a reconstructed M15 will provide improved characterization of individual fracture sets. It is our opinion that this knowledge will not materially affect the predictions of drawdown in neighbouring wells.

We agree that when M15 is reconstructed as a multi-level well additional testing will assist in refining the hydraulic conductivity of individual fracture sets.

Verification of Model Results Using Analytical Approach

In order to corroborate the model results using traditional well hydraulic methods, we have simulated the extraction process by using a series of dewatering wells. Figure 6 shows the location of the dewatering wells used in the simulation. The theory of superposition is that the impact of each dewatering well is additive. Therefore, as depicted in Figure 7, the anticipated drawdown at private well W3 is determined as follows;

$$s_{W3} = s_{DW1} + s_{DW2} + s_{DW3} + s_{DW4} + s_{DW5} + s_{DW6}$$

where s_{W3} is used to signify the total drawdown at private well W3 and s_{DWi} (i = 1 to 6) are the drawdown values from each dewatering well.

We have designed the dewatering wells to drawdown the aquifer by approximately 2.5 metres, thereby mimicking the maximum allowable water level change in the quarry.

The aquifer characteristics calculated by Burnside and Associates based on the short term pumping in M15 are as follows;

Transmissivity = 75 m^2/day

Storativity = 0.00004

These results are similar to the aquifer characteristics found by Burnside in Well No. 3 being T = 37 m^2/day (113 m^2/day at OW3D) and a storativity of 0.000024.

In order to estimate the magnitude of impact at the nearest five private wells shown on Figure 6, we have calculated the cumulative drawdown from each of the six dewatering wells (DW1-DW6) at each private well. The drawdown is estimated using the modified equilibrium equation (Cooper and Jacob, 1946);

Equation (1)

$$s = \frac{0.183Q}{T} \log \frac{2.25Tt}{r^2 S}$$

Where

s = drawdown

Q = pumping rate in dewatering well (m3/day)

T = transmissivity (m2/day)

t = time (days)

r = distance to pumping well (m)

S – storativity (dimensionless)

This equation provides a reasonable estimate of drawdown for an equivalent porous media for the following conditions;

1) the water bearing formation is uniform in nature and hydraulic conductivity is the same in all directions,

2) the formation is uniform and infinite in areal extent,

3) the pumped well penetrates and receives water from the full thickness of the water bearing formation,

4) the water removed from storage is discharged instantaneously when the head is lowered,

5) the pumping well is 100% efficient,

6) all water removed from the well comes from aquifer storage,

7) laminar flow exists throughout the well and aquifer,

8) the water table or potentiometric surface has no slope, and

9) the formation receives no recharge from any source.

It is recognized that all of these conditions are not met for this application, however, it is widely accepted that the non equilibrium equation is a reasonable approach to evaluating drawdown. Burnside and Associates used the same method to estimate drawdown around Well No. 3.

Two scenarios were simulated in this analysis.

Scenario 1

The quarry penetrates all of the major water bearing fractures and the transmissivity of 75 m^2/day is applied.

Scenario 2

The quarry penetrates the upper two thirds of the water bearing zone and a transmissivity of 50 m^2/day is applied.

Table 2 summarizes the cumulative impact from the dewatering wells on the nearest five wells and compares the results to the 3-D Modflow model presented in the Harden 2012 report.

Table 2: Estimated Drawdown Using Dewatering Wells to Simulate Quarry Drawdown

	Scenario 1	Scenario 2	Model
	T = 75 Q = 47	T = 50 Q =33	
Private Well	Drawdown (m)	Drawdown (m)	Drawdown (m)
W3	1.50	1.45	1.37
W4	1.42	1.37	1.22
W5	1.44	1.39	1.12
W8	1.30	1.24	1.02
W9	1.23	1.17	0.972

The results are very comparable and confirm less than a 1.5 metre water level change expected in the worst case scenario at the nearest private water well. The dewatering well analysis suggests slightly higher drawdown than the model due to the analytical method not accounting for recharge.

The analysis of Scenario 2 results in less impact to local wells. This results because drawdown cones developed in lower transmissivity aquifers are steeper and have less area of influence than wells in higher transmissivity aquifers (Freeze and Cherry, 1979, Figure 8.6).

This analytical analysis confirms that;

a) the results obtained from the model are reasonable,

b) if the lower fracture set does not contribute water to the quarry, the quarry will fill slower but the impact on local wells is similar to the full depth scenario, and

c) the maximum drawdown in the nearest wells is always less than will occur in the quarry.

This analysis allows us to restate that local wells will not be significantly impacted by the proposed quarry and that a shallower quarry will not result in significantly less impact.

5.0 Brydson Spring and Blue Springs Creek

We agree that there should be no long term impacts to Brydson Spring.

We disagree that there will be short term impacts to Brydson Spring. The quarry will be developed in the northern portion of the site with a maximum water level change of 2.5 meters. This is insufficient to change the water level along the southern property boundary being approximately five metres lower than along the northern property boundary. As the quarry proceeds southward, water levels along the southern property boundary will rise.

There will not be any decrease in flow to Brydson Spring. Blue Springs Creek located 1200 metres from the site will not be impacted in any way.

6.0 Rock Extraction Water Level Change

In order to confirm the model results regarding potential impacts to local wells during the initial rock excavation from the sinking cut, we used four pumping wells to simulate maximum drawdown scenario in the sinking cut. Figure 6 shows the proposed location of the sinking cut and the location of the four simulation wells (DW7-DW10).

The maximum drawdown in the sinking cut is approximately 2.5 metres, therefore the maximum drawdown in the four dewatering wells is adjusted to 2.5 metres by modifying extraction rates from each well. The potential impact occurring in private wells can be estimated by summing the drawdown from each dewatering well at the residential well. The drawdown at the residential wells is estimated using equation (1) introduced previously in section 4.0.

The drawdown in the nearest private wells during the sinking cut extraction is summarized in Table 3. The maximum drawdown in the nearest well is estimated to be 0.87 m.

Table 3: Estimated Drawdown Using Dewatering Wells to Simulate Drawdown in Sinking Cut

	T = 50 Q =33	T = 520 Q = 286
Private Well	Drawdown (m)	Drawdown (m)
W3	0.87	1.13
W4	0.84	1.11
W5	0.75	1.03
W8	0.73	1.02
W9	0.74	1.03

This analysis confirms that the potential water level change at the nearest private wells is not significant relative to their available drawdown. This analysis also shows that under the unlikely scenario of full daily recovery of water levels in the quarry pond, there will not be a significant impact to any local well.

Combined Impact from Rockwood Well No. 4 and Hidden Quarry

We agree that there is a potential for a combined impact of the proposed municipal well and the quarry on wells located between them. It is our opinion that the combined impact will be small relative to the available drawdown in the private wells. We base this opinion on two factors;

a) In their hydrogeological analysis of Rockwood Well No. 3, Burnside suggests that wells between 500 and 3000 metres of Well No. 3 may have a drawdown of up to three metres and conclude that domestic wells will not experience adverse effects and

b) When I visited the mushroom farm in 2012, the owner explained that he was pumping 89 gallons per minute from his 60 m deep well and we could hear the pump cavitating. I understood that the pump was located at a depth of 45 metres. It is also our understanding that none of the neighbours wells were being impacted by this taking and there does not appear to be any impact on bedrock water levels at the Hidden Quarry site. Therefore, it is our opinion that the impacts from the proposed pumping Well No. 4 at a distance of more than one kilometre will not be significant.

We agree that at the maximum rate of extraction and if the quarry water level stabilized on a daily basis, the flow of water into the excavation would be 13.3 L/s. James Dick Construction Ltd. is committing to a maximum water level change of 2.54 m resulting in a maximum water level change of 1.6 m in the nearest domestic water well. We disagree that the flow of 13.3 L/s may be sustainable upon quarrying to the maximum depth. This rate of inflow when the maximum drawdown is 2.54 metres would require a very high transmissivity that has not been measured at the site or anywhere nearby.

However, it is possible to simulate the impact to local wells if this hydrogeological condition occurred. Assuming that the aquifer is capable of refilling the quarry on a daily basis at the maximum rate of rock extraction (1145 m^3 /day), the aquifer transmissivity would have to be approximately 520 m^2/day. Under these conditions, the maximum impact to the local wells is summarized in the third column in Table 3. The maximum drawdown is estimated to be 1.13 metres in the nearest well.

For clarification, the mining process is that the maximum depth of the quarry is achieved in the first blast of the sinking cut, therefore all fractures to the bottom of the quarry will be exposed in the quarry.

It is our conclusion that local wells will not be impacted by this level of water level change.

Burnside Recommendations

1.0 We disagree that the maximum allowable drawdown in the initial sinking cut needs to be restricted to 0.9 m. There are no shallow wells upgradient of the quarry that can be affected by a water level change of 2.54 m in the sinking cut. Figure 6 shows the approximate location of the sinking cut. The cut will be 349 m from the nearest well (W3). Figure 8 is a scaled cross section showing the magnitude of the maximum allowable water level change in the sinking cut relative to the depth of the nearest up-gradient wells. It is our opinion that the magnitude of water level change will not affect the yield of any nearby private water well. As the quarry increases in size, the influence of the extraction will decrease. When the quarry has reached the extent shown on Figure 9, the daily drawdown during maximum extraction is approximately eight centimetres.

2.0 A decrease in water levels can only occur upgradient of the proposed quarry. Modifying the pump setting on every well is unnecessary, particularly where water levels are predicted to increase. The maximum predicted water level change of 2.54 metres and as the response in M2 to pumping in M15 confirms, the maximum drawdown decreases with distance from the quarry.

3.0 According to information available from our water well survey and the MOE database, none of the downgradient wells obtain water exclusively from the lower fracture set. It is possible that if any of the downgradient wells are found to be affected by biological agents (e.g. Cryptosporidium, giardia) that the wells can be deepened or liners installed to access water from deeper fractures where the likelihood of encountering these agents is diminished. The more effective method of managing this issue, should it arise, is by providing simple, effective treatment at the well head.

The introduction of these biological agents to the quarry pond is not a foregone conclusion and these agents may not survive in the aquifer or may undergo natural filtration. Thus, it is our recommendation that this issue be addressed through on-site water quality monitoring with the contingency for off-site water quality monitoring, well modifications and water treatment.

7.0 Aquitard

We agree that there is no natural aquitard overlying the site.

9.0 Monitoring Plans, Trigger Levels and Contingency Plan

A revised monitoring program (January 2014) is provided in Appendix B.

1.0 On-site Monitoring Program

We agree to modify the monitoring program to include monthly year round water levels and daily water levels in wells with data loggers.

We agree to hourly measurements with data loggers in monitoring wells M2, M3, TP1, M13S/D, M15 and M16. We cannot commit to including M14S/D until construction of acoustic and hydraulic berm is complete.

We agree to add SW5 and SW7 to the surface water level list.

We have already agreed with the Grand River Conservation Authority to monitor flow at SW4 and SW7 including a data logger installation. Therefore the inclusion of flow measurements at SW5 and SW7 is not necessary.

We agree to include W1 in the water quality program.

We agree to increase surface water quality monitoring to spring and fall samples corresponding to groundwater sampling. We agree to include the Northwest Wetland and Tributary B (at SW4 and SW3) in the sampling program and to add cryptosporidium and giardia to the list of parameters.

2.0 Trigger Levels

2.1 Trigger Levels for the Bedrock Aquifer

We agree to establish trigger levels for M15 and M16 after monitoring begins. The trigger levels correspond to the maximum water level change expected to occur at the site. We predict the maximum water level change will occur near the end of the quarry life, as the southern portion of the quarry is extracted.

2.2 Trigger Level for Northwest Wetland

We concur with the Burnside recommendation of daily water levels in the Northwest Wetland. We have agreed with the GRCA to install a data logger at SW6 to obtain daily water levels.

3.0 Contingency Measures

3.1 Groundwater Levels and Northwest Wetland

1) We agree to install an onsite weather station when the scale house is established.

2) We agree to limit the time for evaluation of data to 7 days.

3) We agree to changing the contingency measures such that either decreasing the rate of extraction or cessation of extraction is the initial response to a trigger threshold being breached.

4) We agree to increase monitoring to weekly until the source of the trigger level exceedence is identified.

3.2 Groundwater Quality

We agree to commence the groundwater quality program at least one year prior to bedrock extraction.

We agree to initiate contingency measures when any quarry related water quality result is above the ODWQS or above the 95^{th} percentile.

We agree to include the following surface water pathogens to the list of quality parameters; cryptosporidium, giardia, e-coli.

4.0 Pre-Bedrock Extraction Water Well Survey

Contingent upon accessibility, we agree to include a number of domestic wells in the water level monitoring program.

10.0 Well Complaint

We agree to advise the Township of Guelph Eramosa and the Ministry of the Environment upon the receipt of a complaint and the findings of the investigation.

11.0 Next Steps

We agree to construct M15 as a multi-level installation as per the zones identified by Burnside and Associates.

We agree to completing a pre-quarrying water well survey in order to identify needed modifications to residential wells.

The potential impacts from surface water pathogens have been discussed herein. Mitigation measures include on-site and off-site groundwater monitoring, well modifications and water quality treatment.

The final depth of the quarry remains at 320 m AMSL.

The comments provided by Burnside and Associates have been addressed herein.

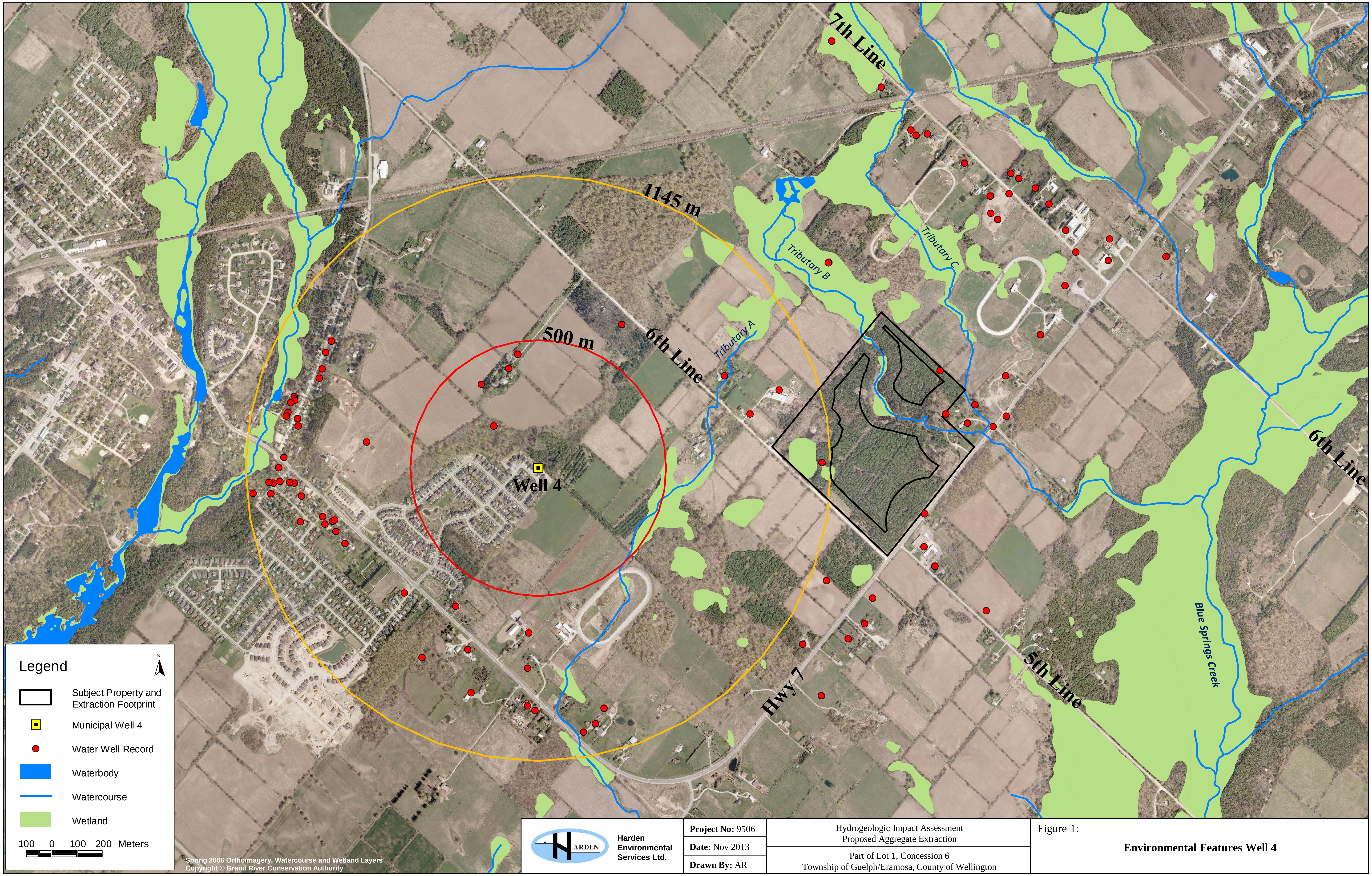
Respectully submitted,
Harden Environmental Services Ltd.

Stan Denhoed

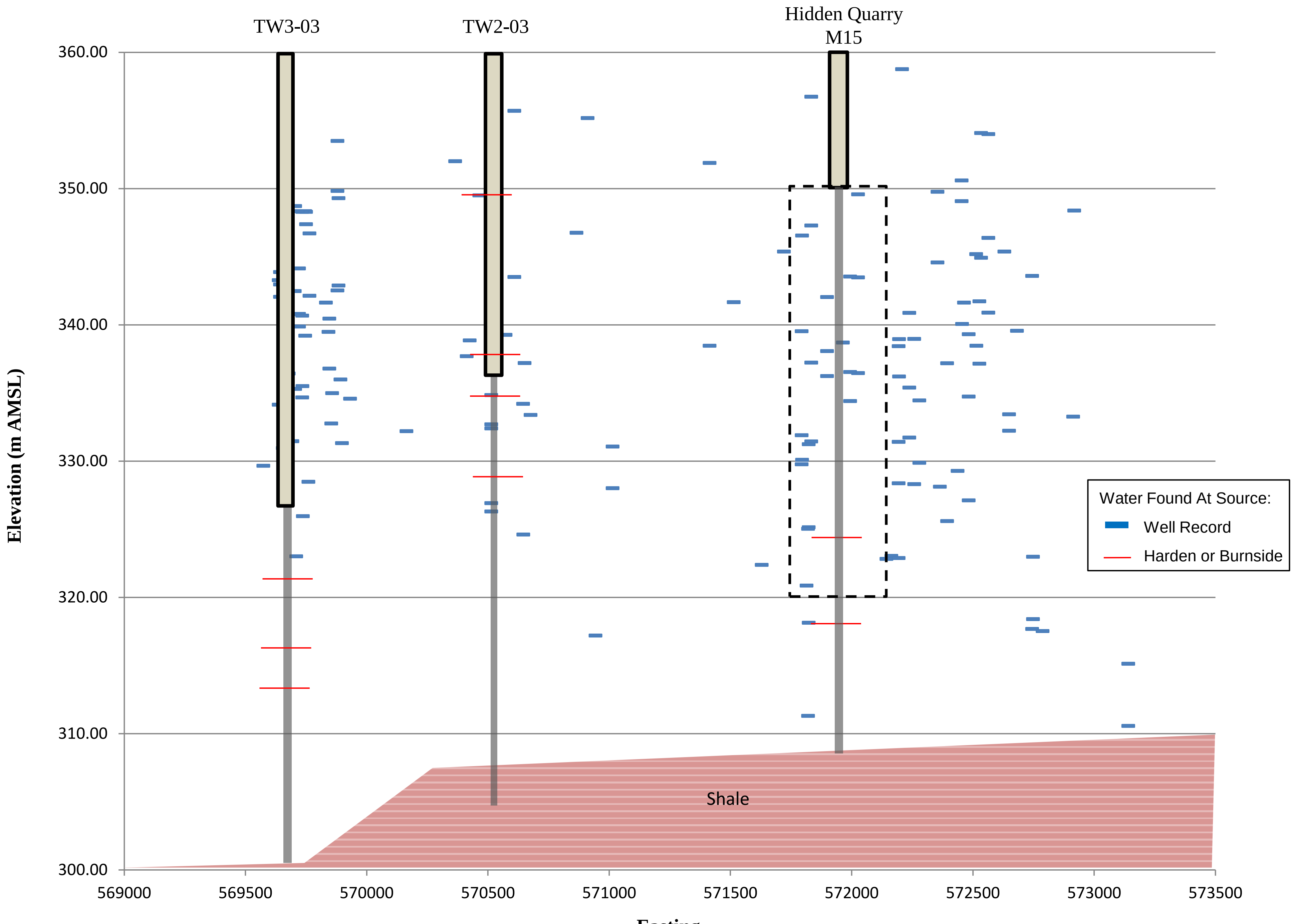
LICENSED PROFESSIONAL ENGINEER
S. E. DENHOED
Jan 14/14
PROVINCE OF ONTARIO

Stan Denhoed, M.Sc., P. Eng.
Senior Hydrogeologist

cc: Greg Sweetnam, James Dick Construction Limited

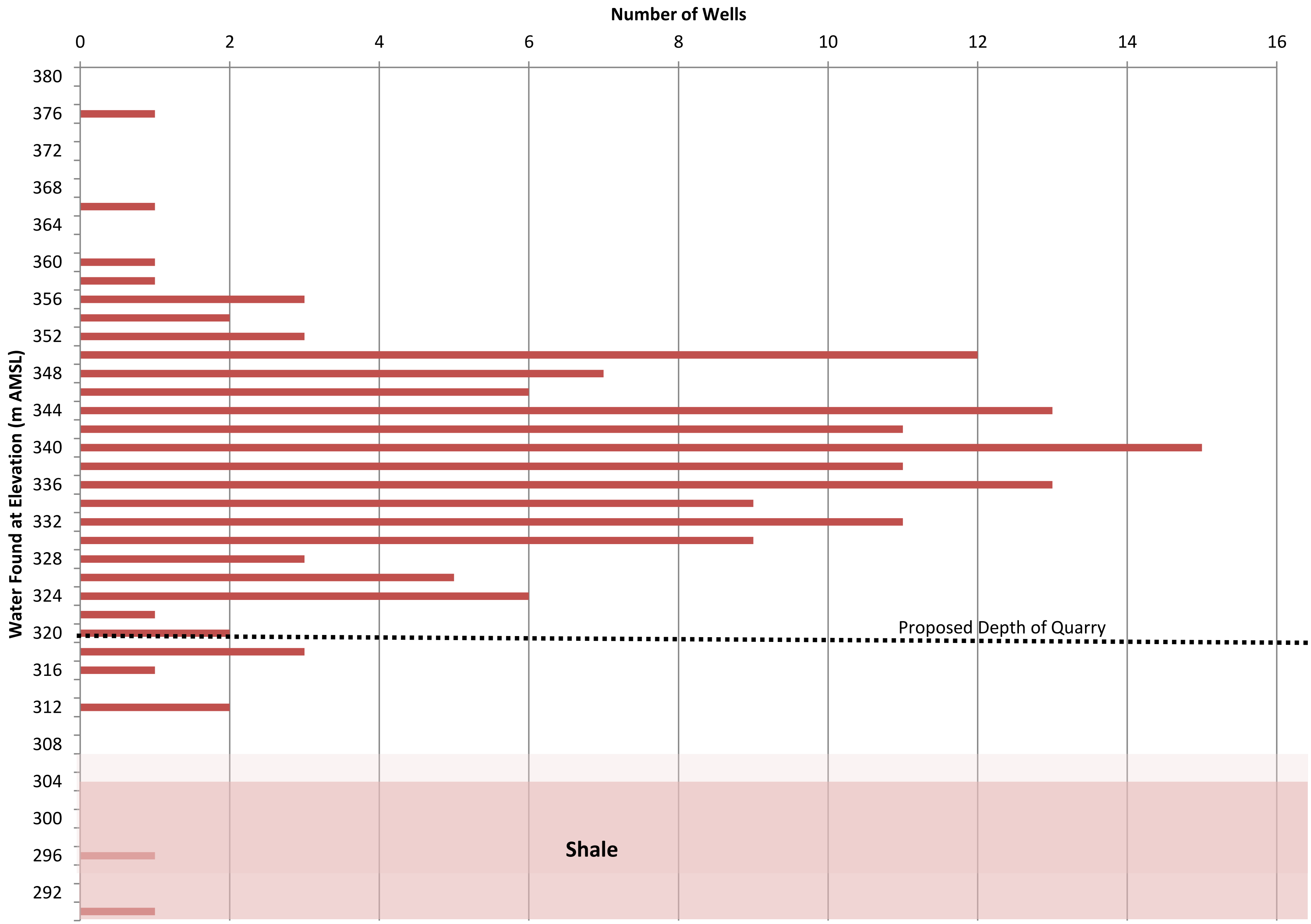


Harden Environmental Services Ltd.	**Project No:** 9506	Hydrogeologic Impact Assessment Proposed Aggregate Extraction	Figure 1:
	Date: Nov 2013	Part of Lot 1, Concession 6 Township of Guelph/Eramosa, County of Wellington	**Environmental Features Well 4**
	Drawn By: AR		



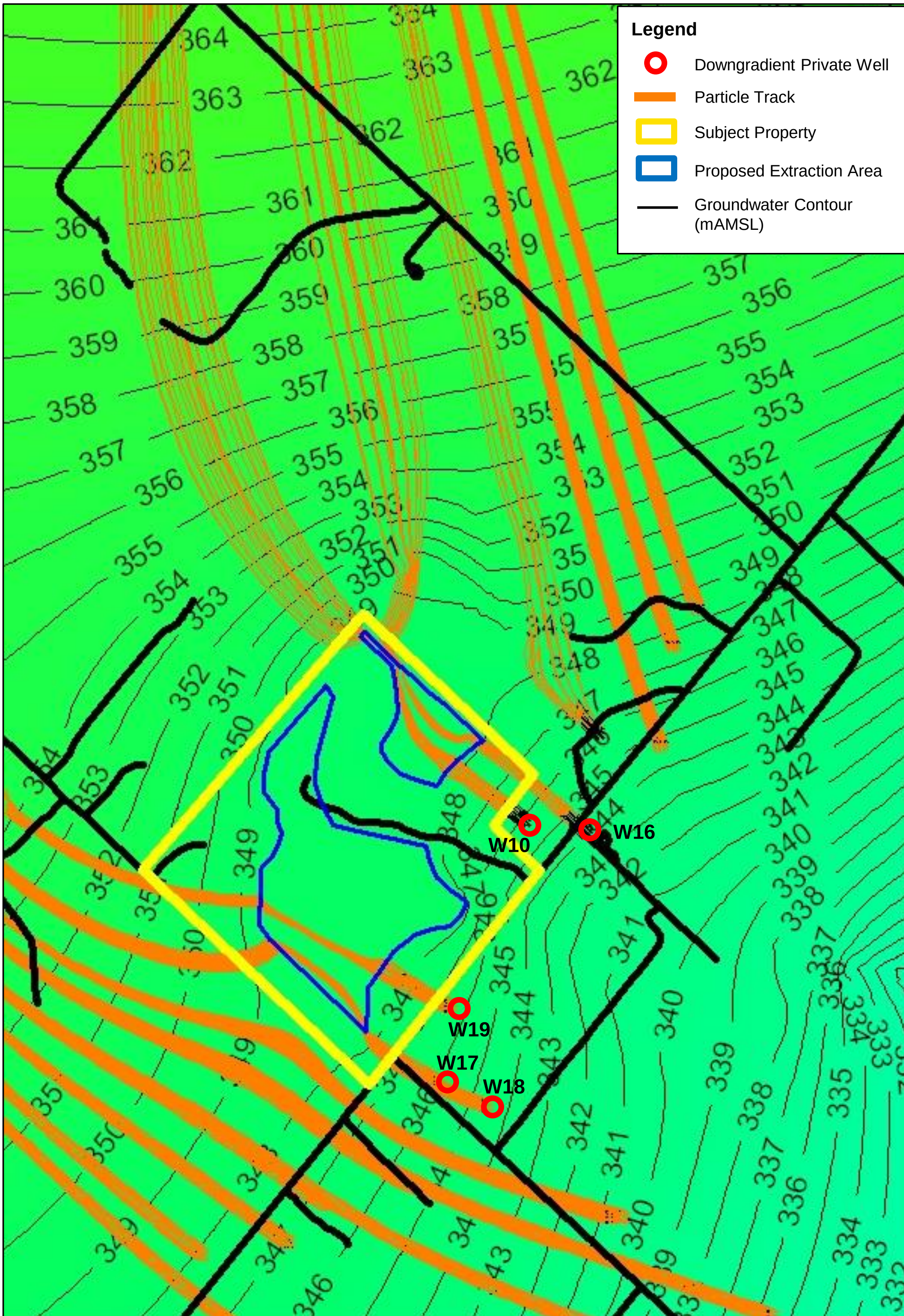
Well Record Source: Ministry of the Environment Water Well Database (2012)

Harden Environmental Services Ltd.	**Project No:** 9506	Hydrogeologic Impact Assessment Proposed Aggregate Extraction	**Figure 2: Water Found At Fracture Elevations**
	Date: Nov 2013		
	Drawn By: AR	Part of Lot 1, Concession 6 Township of Guelph/Eramosa, County of Wellington	

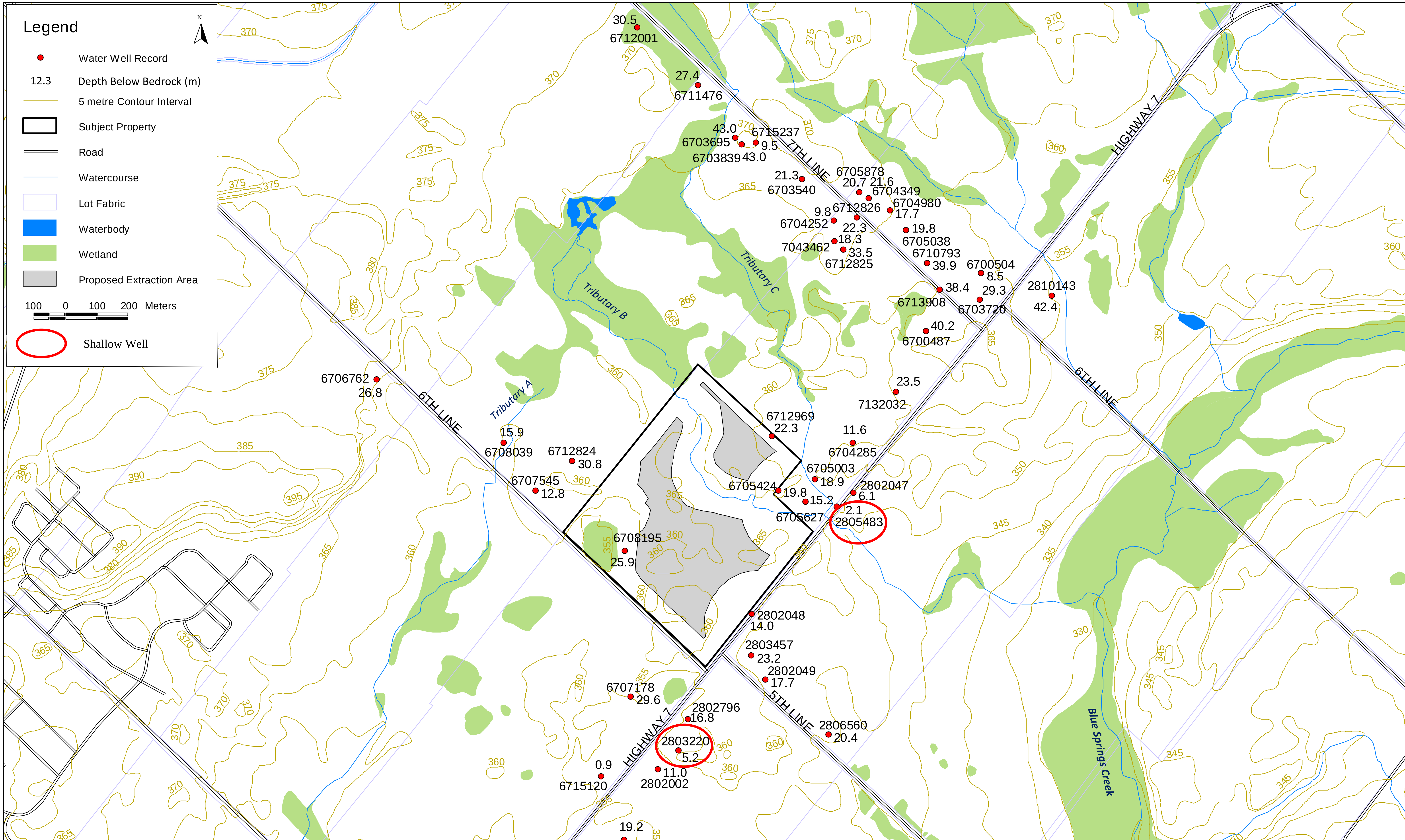


Source: Ministry of the Environment Water Well Database (2012)

Harden Environmental Services Ltd.	**Project No:** 9506	Hydrogeologic Impact Assessment Proposed Aggregate Extraction	**Figure 3: Water Found At Frequency of Occurrence**
	Date: Dec 2013		
	Drawn By: AR	Part of Lot 1, Concession 6 Township of Guelph/Eramosa, County of Wellington	



Harden Environmental Services Ltd.	**Project No:** 9506	Hydrogeologic Impact Assessment Proposed Aggregate Extraction	**Figure 4:**
	Date: Dec 2013	Part of Lot 1, Concession 6 Township of Guelph/Eramosa, County of Wellington	**Downgradient Private Wells**
	Drawn By: SD		



Harden Environmental Services Ltd.

Project No: 9506
Date: Aug 2013
Drawn By: AR

Hydrogeologic Impact Assessment
Proposed Aggregate Extraction

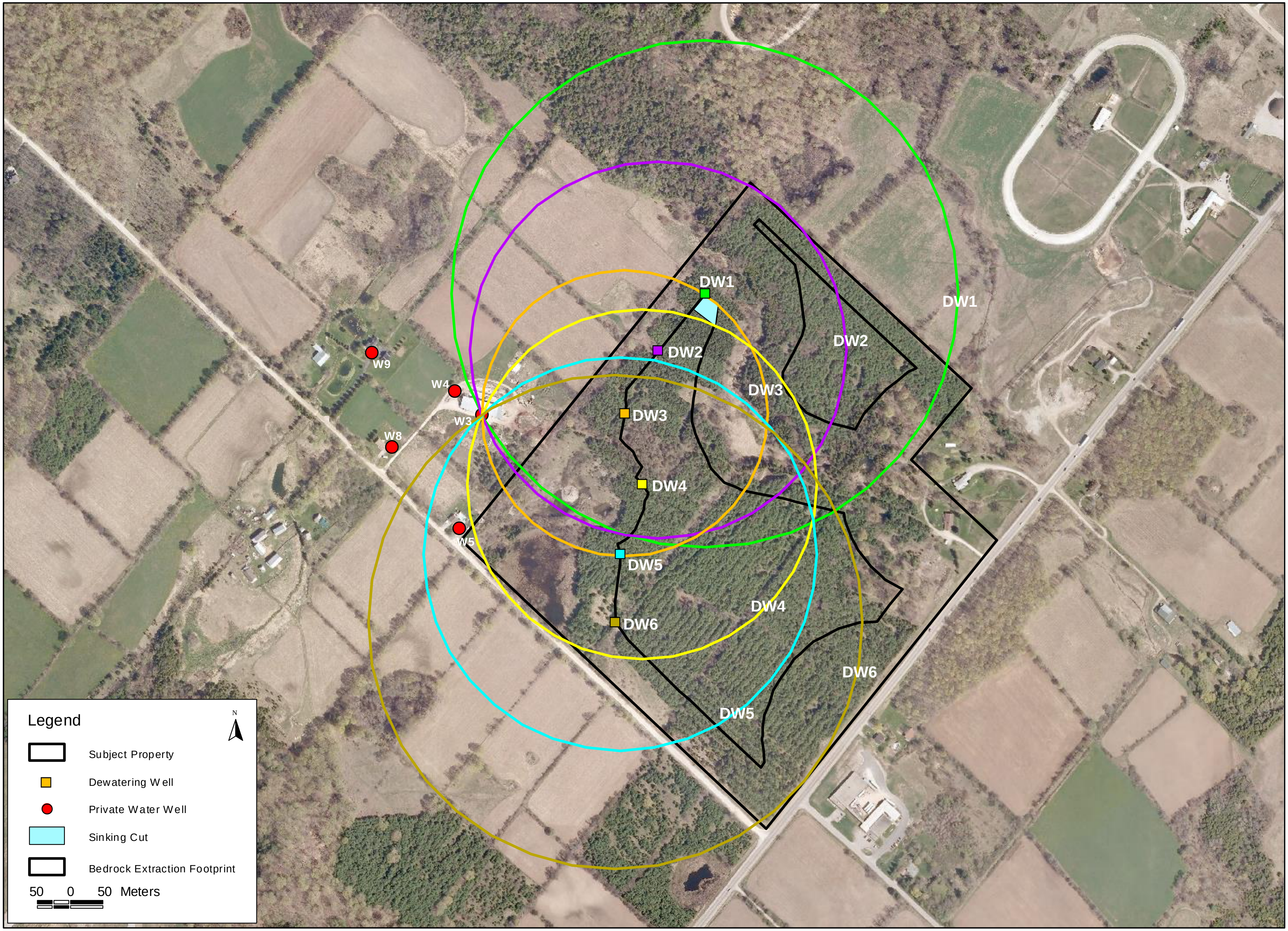
Part of Lot 1, Concession 6
Township of Guelph/Eramosa, County of Wellington

Figure 5:

Depth of Private Wells Below Bedrock (m)

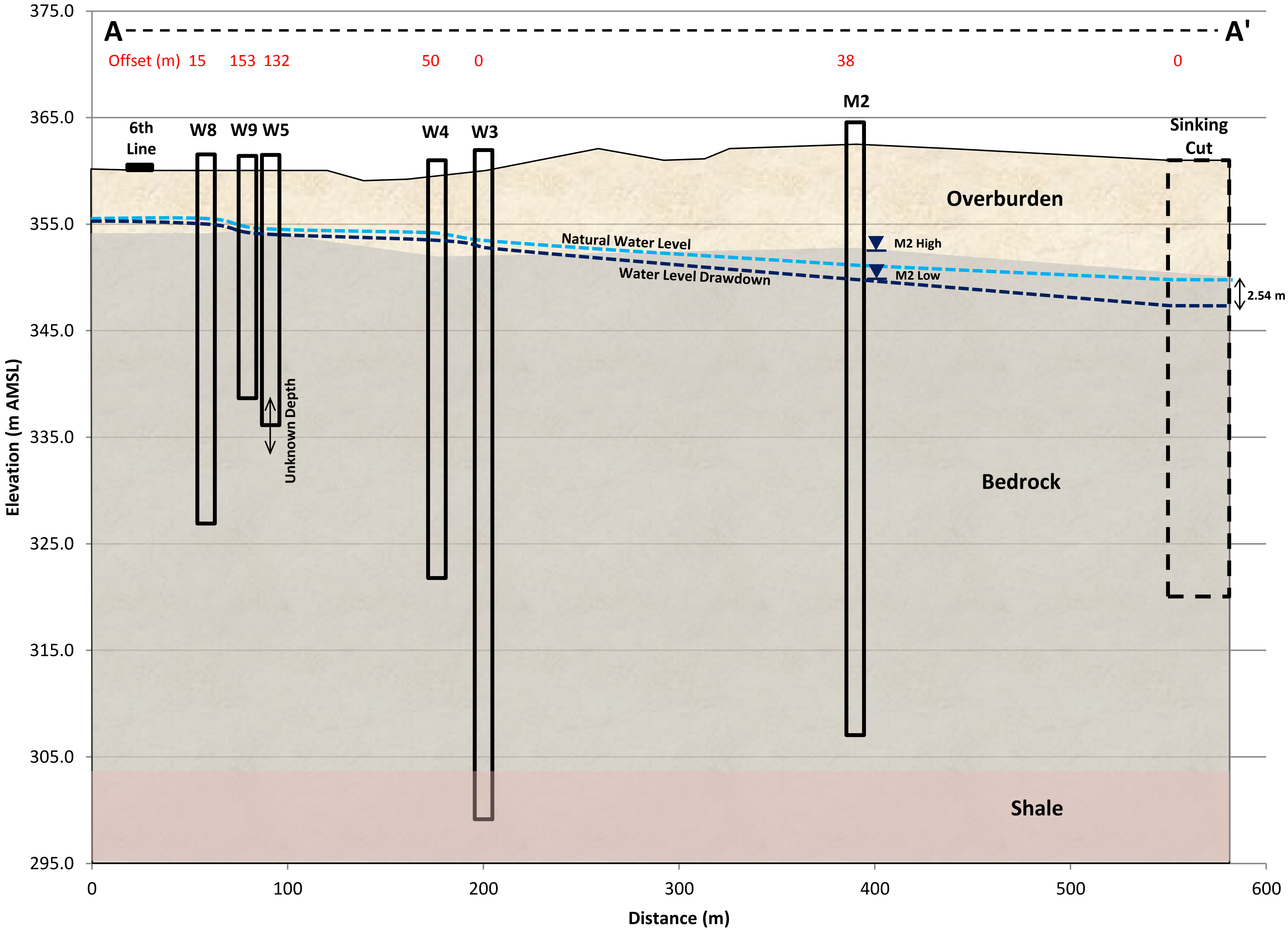
Harden Environmental Services Ltd.

Project No: 9506	Hydrogeologic Impact Assessment Proposed Aggregate Extraction	**Figure 6: Cross Section A-A' Key Map**
Date: Dec 2013	Part of Lot 1, Concession 6 Township of Guelph/Eramosa, County of Wellington	
Drawn By: AR		

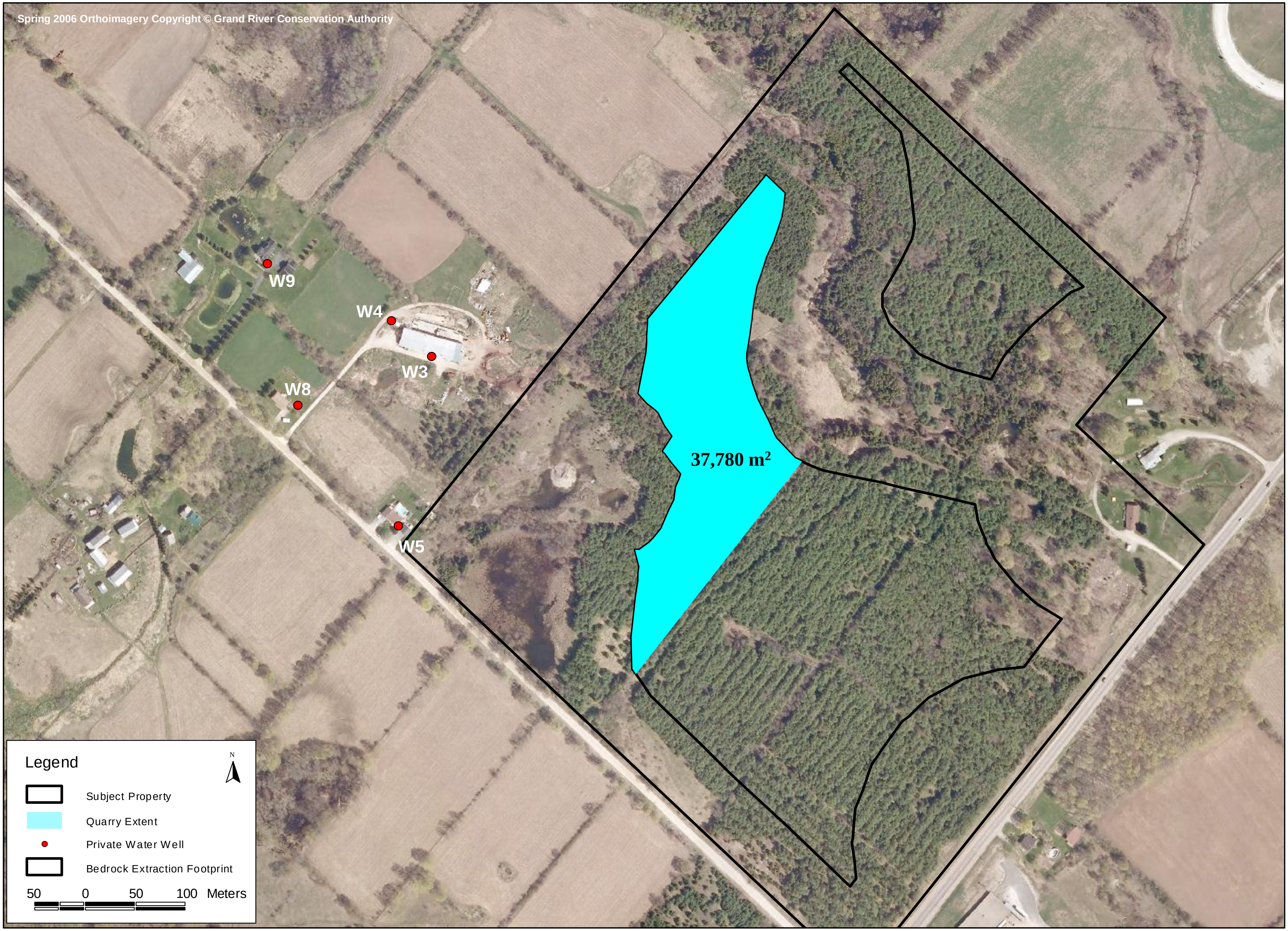


Harden Environmental Services Ltd.

Project No: 9506	Hydrogeologic Impact Assessment Proposed Aggregate Extraction	**Figure 7: Cumulative Drawdown from Dewatering Wells for W3**
Date: Dec 2013	Part of Lot 1, Concession 6 Township of Guelph/Eramosa, County of Wellington	
Drawn By: AR		



Harden Environmental Services Ltd.	**Project No:** 9506	Hydrogeologic Impact Assessment Proposed Aggregate Extraction	**Figure 8: Cross Section A-A'**
	Date: Dec 2013	Part of Lot 1, Concession 6 Township of Guelph/Eramosa, County of Wellington	
	Drawn By: AR		



Harden Environmental Services Ltd.

Project No: 9506

Date: Dec 2013

Drawn By: AR

Hydrogeologic Impact Assessment
Proposed Aggregate Extraction

Part of Lot 1, Concession 6
Township of Guelph/Eramosa, County of Wellington

Figure 9: Quarry Extent Daily Drawdown 8cm

Appendix A

Burnside & Associates Comments

November 12, 2013

R.J. Burnside & Associates Limited 292 Speedvale Avenue West Unit 20 Guelph ON N1H 1C4 Canada
telephone (519) 823-4995 **fax** (519) 836-5477 **web** www.rjburnside.com

BURNSIDE
[THE DIFFERENCE IS OUR PEOPLE]

November 12, 2013

Via: Email/Mail

Mr. Stan Denhoed, M.Sc., P.Eng.
Harden Environmental Services Ltd.
4622 Nassagaweya-Puslinch Townline Road
RR #1
Moffatt, ON L0P 1J0

Dear Mr. Denhoed:

Re: Hydrogeological Summary Report for Township of Guelph/Eramosa
File No.: 300032475.0000

Thank you for providing R.J. Burnside & Associates Limited (Burnside) with a copy of the Harden Environmental Services Ltd. (Harden) September 5, 2013 letter to review. The Burnside comments are provided below under the same headings used in the letter.

1.0 Karst

Harden indicates that a karst environment is not present in the area proposed to be mined by Hidden Quarry.

Burnside Comment

Burnside reviewed GIS mapping generated by the OGS as part of "Brunton, F.R. and Dodge, J.E.-P, 2008. Karst of Southern Ontario and Mantoulin Island, Ontario Geological Survey, Groundwater Resources, Study 5."

The mapping indicates the presense of karst features along the Eramosa River in Rockwood and near Blue Springs Creek to the south of the proposed quarry. There is no evidence to suggest that the site is in an area of karst terrain. Some scientists now refer to the water producing fractures in the bedrock as micro-karst but this is much different that the large cavernous conditions typically associated with karst.

2.0 Water Quality

Harden indicates that the proposed Hidden Quarry will result in the mixing of groundwater from various discrete fracture sources with an overall decrease in nitrate concentrations already found in the shallow groundwater. The proposed subaqueous mining method will not result in the chemical degradation of groundwater quality.

Burnside Comment

Flow profiling indicated water in the upper 35 m of bedrock comes from three discrete zones with little flow between 19 and 36 mbgs. It appears that most of the nitrate is contributed from fractures in the upper 10 m of the bedrock. If the quarry does not encounter the deepest zone at 41 mbgs then about 30% of the water may not contribute to dilution. Although the depths and water production from fractures in the rock is heterogeneous, the water quality impacts should be calculated using the available information. Once M15 is equipped as a multi-level well, it should be purged and water quality samples collected to see if there are variations with depth. The nitrate contributed by the blasting materials should be quantified and included in the mass balance.

We concur with harden that water wells drilled in the bedrock access multiple fractures, however it is important to note that the Ontario Water Resources Act through the well Regulation 903 (Last amendment: O.Reg. 468/10) states in Section 14 that:

> "any annular space, other than annular space surrounding a well screen, is sealed to prevent any movement of water, natural gas, contaminants or other material between subsurface formations or between a subsurface formation and the ground surface"

The purpose of this section of the well regulation is to protect the good quality groundwater in the subsurface for use as potable sources. The fractures found at 36 and 41 m are currently secure sources of groundwater that are recharged over time by water moving into those formations. These deeper fractures are also the future water source for Rockwood Well 4 that will be constructed this year.

The excavation of the quarry into these fractures will cause the water in the deep fracture system to be under the influence of surface water and the associated bacteria and viruses such as Cryptospiridium and Giardia. Quarrying activities will result in constant mixing of the water in the quarry. The existing secure water quality in deep bedrock aquifer will therefore be changed to a surface water source for an unknown distance surrounding the quarry. This could result in the classification of Rockwood Well 4 as a GUDI water source.

Once the quarry is finished, there will be a large surface body directly in contact with the bedrock fracture system which may allow rapid movement of pathogens towards bedrock wells downgradient of the site.

As a result, there may be some benefit to restricting the extraction to the bedrock above 36 m in order to protect the lower fractures system.

3.0 Private Wells with Shallow Fracture Source of Water

Harden predicts a 1.6 m decline in the closest domestic well due to the quarry and indicates that testing of M15 suggests that the lack of water level response in M1, M3 and M13 is due to poor lateral shallow connectivity and poor connectivity to fractures at depth.

Burnside Comment

Analysis of the response observed at M2 indicates a total Transmissivity of 75 m^2/day. Further analysis of the data indicates a Storativity of only 0.00004. This relatively low Storativity results in the rapid (5 minutes) response at a relatively distant (125 m) location. Depressurization of the deep formation at M15 will result in rapid response over a large area. This Storativity is indicative of a confined aquifer system and is likely caused by response in the deeper fractures at 34 and 41 m.

Testing completed by Burnside on existing wells in Rockwood indicates that a well that penetrates the entire carbonate formation typically exhibits a Transmissivity in the range of 50 to 100 m^2/day. Wells that only access the fracture systems below 35 m exhibit Transmissivity of 25 to 50 m^2/day. M15 is consistent with these historical tests. It is important to note that the Transmissivity of an individual fracture or group of fractures cannot directly be converted into a hydraulic conductivity based on the entire bedrock thickness. The groundwater flow is much faster and can reach much further distances within an individual fracture than in a bulk porous media as predicted by a model. As a result, groundwater with elevated nitrate may move rapidly away from the quarry before dilution with deeper water can occur.

Currently, the total transmissivity of the fractures encountered by M15 has been estimated. Once individual monitors are installed opposite the fractures testing should be completed to assess the hydraulic properties of the individual fractures. Monitoring of water levels in this monitor well and the quarry itself can be used to predict off site impacts.

The pumping test did not continue for a period long enough for water levels to stabilize. Nearby wells (Rockwood Well 3) typically stabilize after approximately 12 hours of pumping in the deep bedrock fractures. Extrapolation of existing data to at least 12 hours allows an estimate of the actual response that will occur during quarrying activities. For example, extrapolation of the test of M15 to 12 hours would result in approximately 1.9 m of drawdown in M2. This data indicates that water levels in domestic well close to the site will be measurably impacted by onsite activities. As a result, wells with pumps set at shallow depths may experience water quantity issues. The six wells indicated on Figure 2 to be completed from 0 to 5 m below bedrock have the greatest potential to be impacted. The proposed domestic well survey plan should be combined with proactive well upgrades to ensure that no domestic water supplies are adversely impacted by the quarrying activities. Upgrades of nearby wells to include pitless adaptors and water level conduits should be included as part of the program to ease the monitoring process.

4.0 Groundwater Model Parameter – Hydraulic Conductivity

Harden indicates that the bulk hydraulic conductivity of the bedrock aquifer used by the groundwater model is 2.0×10^{-5} m/s.

Testing of M15 resulted in estimated hydraulic values ranging from 1.4×10^{-5} to 1.98×10^{-5} m/s.

Burnside Comment

Although a bulk value for hydraulic conductivity is useful in predicting the long term behaviour of water in the quarry, video flow profiling suggests that there are many metres of rock that are competent and contribute little in the way of groundwater flow. As a result, groundwater flow into the quarry may be highly variable with depth.

In-situ hydraulic conductivity of M15 when it is re-constructed as a multi-level well will help to refine the hydraulic conductivity estimates.

5.0 Brydson Spring and Blue Springs Creek

Harden indicates that there will be neither a significant quantity nor quality impact to waters discharging from the Brydson Spring and no change to groundwater quantity or groundwater quality discharging to Blue Springs Creek.

Burnside Comment

In the long term, there should be no impacts to Byrdson Spring. There may be some short term reductions in flow as the quarry fills with water following rock extraction.

6.0 Rock Extraction Water Level Change

Harden indicates that removal of rock from below the water table will simulate a pumping effect on the surrounding aquifer. Groundwater will flow into the quarry to fill the space previously occupied by rock.

The initial rock extraction will occur in a sinking cut with the dimensions of 25 x 50 m (1,250 m^2). Harden indicates the removal of this material from below the water table will cause the water levels in the quarry to decrease by 0.91 m/day. James Dick has committed to a maximum drawdown of 2.54 m in the sinking cut to be monitored daily with the rate of rock extraction moderated in the event that drawdown approaches 2.54 m.

Burnside Comment

There is significant potential for impacts from the proposed quarry activities on the groundwater resources in the surrounding area. There are several existing domestic water wells with unconfirmed pump installation depths and a municipal well that will be pumping 10 to 16 L/s when it is constructed. The combined impact of the quarry and the municipal well on the existing wells between the sites is difficult to assess in a heterogeneous carbonate aquifer.

Testing completed on M15 in 2013 showed that a pumping rate of 4.2 L/s resulted in drawdown of just under 1 m at a distance of 125 m in less than 100 minutes. This water level response was used to calculate a Transmissivity of 75 m^2/day. It was also determined that only 30% or only 1.3 L/s was derived from the bedrock above 35 m.

The description of how rock will be quarried indicates that a 25 m by 50 m strip will be mined vertically at a rate of 0.9 m/day. The daily volume of rock removed will be 1,145 m^3. If the area mined is below the water table, then removal of 1.145 m^3 of rock will require 1,145 m^3 of water to flow into the strip on a daily basis. This will necessitate a continuous flow of 13.3 L/s from the shallow bedrock fracture system 24 hours/day in order to maintain the pre-extraction water level. This will cause a measureable impact to existing domestic wells in the surrounding area during the initial days of the quarrying activities when all of the "make up" water is derived from the shallow fractures which may not be able to sustain the rate of flow into the excavation to keep if full of water. Once the first strip is quarried to the maximum depth and all of the water producing intervals are encountered, then the flow of 13.3 L/s may be sustainable. This will depend on the size and extent of the fracture system encountered.

Burnside recommends that in order to ensure that offsite impacts are minimized that:

1. The initial stages of excavation are completed at a rate that allows the water level to be maintained within 0.9 m of static conditions as predicted in the report. This would mean that at the beginning of the day removal of rock could only occur if water levels had returned to static levels. This would prevent a cumulative dewatering of the bedrock adjacent to the site.
2. All domestic wells within 500 m of the quarry site be inspected and tested to evaluate how susceptible they are to water level variations. Submersible pumps should then be set as deep as possible in the wells to ensure that they are not impacted by the quarry activities. The proposed monitoring program (Appendix A of your letter) for onsite wells and surface water stations is comprehensive, but should be expanded to include representative domestic wells.
3. Flow profiling at M15 indicated that a deeper fracture system provided about 66% of the flow. These fractures are separated from a shallow fracture system by several metres of rock which produces minimal water. If the deeper fracture set is providing water to a number of nearby domestic wells, James Dick may wish to maintain the base of the quarry above this level to ensure that an alternate water supply is available in the event that the shallow zone has water quality/quantity impacts due to quarry activities.

7.0 Aquitard

Harden indicates that the Eramosa Formation (a natural aquitard protecting the Goat Island and Gasport formation) is not present at the Hidden Quarry site.

Burnside Comment

Burnside concurs with Harden that the Eramosa Formation is not present at the Hidden Quarry site.

9.0 Monitoring Plans, Trigger Levels and Contingency Plan

Appendix A contains a revised monitoring program that was submitted to the MOE by Harden. The Burnside comments will follow the same headings as contained in the monitoring plan.

Burnside Comment

1.0 Onsite Monitoring Program

Groundwater Levels – These should be measured monthly year round (with exception of well listed below) in wells with manual levels and daily year round in wells with dataloggers.

Groundwater Levels – M2, M3, TP1, M13S10, M14SID, M15, M16. As a minimum, these should be measured hourly with the data logger during the first three months of extraction in order to ensure the maximum daily drawdown of 0.91 m is not exceeded and that any exceedance of the trigger levels can be quickly mitigated.

Surface Water Levels – SW5 and SW7 should be added to the list.

Surface Water Flow – SW5 and SW7 should be added to see if the extraction has any effect on when flow ceases in Tributary B.

Groundwater Quality – W1 should be added along with the most vulnerable wells identified in the pre-bedrock extraction water well survey (Section 4.0).

Surface Water Quality – Increase to semi-annual (spring and fall) at some time as groundwater sampling. Add northwest wetland and Tributary B (at SW4 and SW3) to confirm east and west ponds are not impacting surface water/groundwater. Add cryptosporidium and giardia to the list of parameters

2.0 Trigger Levels

The trigger levels proposed by Harden are designed to verify that water levels in the bedrock aquifer do not exceed predicted values and that the hydro-period of the northwest wetland does not change.

2.1 Trigger Levels for the Bedrock Aquifer

Harden uses the historical low levels in M1D, M2, M13D and M14D and the predicted water level change to establish conservative trigger levels.

Burnside Comment

Trigger levels should be established for M15 and M16 after monitoring begins. It is not clear how the trigger levels relate to the drawdown trigger of 2.54 m in the sinking cut. It is also not clear if the predicted change is following completion of extraction or is the maximum expected change.

2.2 Trigger Level for Northwest Wetland

The historical low value of 344.20 m AMSL at SW6 is the recommended trigger value with a warning level of 354.35 m AMSL. Harden recommends an increase in manual water level measurements to bi-weekly if the warning level is exceeded.

Burnside Comment

Burnside recommends daily water level monitoring begin 3 weeks prior to the initial overburden/bedrock extraction so pre-extraction trends can be established. Daily water level measurements should continue as long as weather conditions permit.

3.0 Contingency Measures

3.1 Groundwater Levels and Northwest Wetland

If a trigger level is breached Harden recommends the following measures be undertaken:

1. Confirmation of water levels with 24 hours.
2. Evaluation of precipitation, groundwater monitoring data and quarry activities to determine if quarry activities are responsible for the low water level observed.
3. If quarry activities are found to be responsible, the following actions will be considered and a response presented to the GRCA and the Township of Guelph/Eramosa:

- increase the length and/or width of barrier;
- decreased rate (or stopping) subaqueous extraction;
- change in configuration of mining or decrease in mining extent; and
- after timing of extraction to coincide with high seasonal groundwater levels.

Burnside Comment

Burnside recommends the following:

1. An onsite weather station be established as it can take significant time to obtain data from GRCA/Environment Canada.
2. A timeline be provided for the evaluation of data.
3. A decreased rate (or stopping) of subaqueous extraction be the initial response.
4. Increased monitoring be undertaken at other locations until the source of the trigger level exceedance is identified.

3.2 Groundwater Quality

Harden recommends semi-annual (summer) sampling for a variety of parameters. An increasing trend in the concentration of one or more elements will result in a study to determine the source of the water quality change. If the quarry is found to be responsible or there is a potential for impact to downgradient wells, James Dick Construction Ltd. will commence with the following actions:

1. Semi-annual testing of the water quality of private wells that could potentially be impacted by the quarry.
2. In the event that a water quality issue related to the quarry occurs, James Dick Construction Ltd. will remedy the issue by either providing the appropriate treatment in the home or drilling a new well and isolating the water supply to the deeper aquifer.

Burnside Comment

Burnside concurs with the proposed water quality monitoring program. It is recommended that the program begin at least a year prior to extraction so that existing conditions can be established. When a sufficient data set is available, Burnside recommends that any result above the ODWQS or above the 95th percentile result in actions 1 and 2 above. Surface water pathogens should be included in the list of quality parameters.

4.0 Pre-Bedrock Extraction Water Well Survey

Harden recommends that a detailed water well survey be completed prior to the extraction of bedrock resources.

Burnside Comment

The Harden plan is comprehensive and will provide valuable baseline information. Burnside recommends the results of the survey be used to select a number of domestic wells for inclusion in the water level monitoring program.

10.0 Well Complaint

Harden provided a proposed protocol for dealing with complaints about water well issues.

Burnside Comment

Burnside concurs with the proposed protocol. The Township of Guelph/Eramosa and the Ministry of the Environment should be advised when a complaint has been received and should be provided with the results of the independent investigation.

11.0 Next Steps (Next included in the Harden Report)

The following are the outstanding issues that need to be addressed:

- M15 should be constructed as a multilevel monitor with appropriate hydraulic conductivity and water quality testing completed. The groundwater model should be modified as necessary to incorporate the test results.
- Burnside will provide information on the construction and testing of Rockwood Well 4 to James Dick once it is available.
- The detailed domestic well survey should be completed so that pre quarrying improvements can be established.
- The potential for impacts from surface water pathogens should be quantified along with mitigation methods.
- The final depth of the quarry should be confirmed.
- Burnside comments should be addressed.

Should you have any question regarding the above, please contact the undersigned.

Yours truly,

R.J. Burnside & Associates Limited

Dave Hopkins, P.Geo.
Hydrogeologist
DH:sd

cc: Ms. J. Sheppard, Township of Guleph/Eramosa (Hand Delivery)
Mr. D. McNalty, R.J. Burnside & Associates Limited (Email)
Cuesta Planning Consultants Inc. (Mail)
Mr. Greg Sweetnam, James Dick Construction Ltd. (Mail)

Appendix B

Revised Monitoring Program and Contingency Measures

Harden Environmental Services Ltd.
4622 Nassagaweya-Puslinch Townline Road
R.R. 1, Moffat, Ontario, L0P 1J0
Phone: (519) 826-0099 Fax: (519) 826-9099

HIDDEN QUARRY

REVISED MONITORING PROGRAM AND CONTINGENCY MEASURES (JANUARY 2014)

1.0 ON-SITE MONITORING PROGRAM

Monitoring has been taking place at this site since 1995. An extensive database of background groundwater and surface water elevations and flow measurements has been developed. A detailed monitoring program will continue to ensure that sensitive features and surface water flows are maintained. The monitoring program is designed to identify trends towards unacceptable impacts early on to allow for time to implement contingence measures.

The monitoring program for this proposed pit/quarry involves the following activities:

- measuring groundwater levels,
- obtaining water quality samples,
- monitoring water levels in the on-site wetland and stream, and
- stream flow measurements.

We recommend the following monitoring program.

Parameter	Monitoring Locations	Frequency
Groundwater Levels	M1S/D, M2, M3, M4, M6, M13S/D, M14S/D, MPN1, MPN2, MPS1, MPS2, MPE1, MPE2, MPW1, MPW2, TP1, TP8, TP9 MP1, MP2, MP3, MP4, M15, M16	Manually Monthly Automatic Daily Measurement in M1D, M2, M3, M4, M15, M16 for year prior to and year following bedrock extraction with re-evaluation of monitoring frequency after 1st year of

Parameter	Monitoring Locations	Frequency
		bedrock extraction.
Groundwater Levels	M2, M3, TP1, M13S/D, M14S/D, M15, M16	Hourly during first 3 months of extraction
Surface Water Level	Sinking Cut	Daily
Surface Water Level	SW14, SW5, SW7	Manually Monthly Coincident with groundwater monitoring
Surface Water Levels	SW6, SW4, SW8	Automated Water Level Readings (4 hour interval)
Surface Water Flow	SW4, SW8, SW3	Semi-Monthly April to November *coincident with groundwater monitoring
Groundwater Quality	W1,M2, M4, M15, M16	Semi-Annually
Surface Water Quality	West Pond, East Pond, Northwest Wetland, Tributary B (SW4, SW3)	Semi –Annually (Spring and Fall)
Climate	On-Site Weather Station at Scale House to include precipitation and temperature	Daily

Monitoring locations are shown on Figure C1.

2.0 TRIGGER LEVELS

Groundwater and surface water monitoring will be used at this site to a) verify that predictions of water level change in the bedrock aquifer do not exceed those predicted and b) verify that the hydro-period of the northwest wetland does not change. The water level measurements obtained as part of the monitoring program will be used to trigger contingency measures that may be necessary for the mitigation of a low water level in the northwest wetland, a lower than expected water level in the bedrock aquifer or an anomalous low flow level in Tributary B.

2.1 Trigger Levels for the Bedrock Aquifer

The greatest water level change in the bedrock aquifer is expected to occur to the north and northwest of the site. Water levels obtained from bedrock monitors M1D, M13D, M14D and M2 will be used to verify that actual water level changes do not exceed the predicted water level change. A warning level of 75% of the predicted change will be used to initiate bi-weekly manual measurements from the groundwater monitors.

Table 1: Trigger Levels for the Bedrock Aquifer

Monitor	Historical Low	Predicted Change	Warning Level	Trigger Level
M1D	350.58	0.8	349.98	349.78
M2	349.81	2.0	348.31	348.08
M13D	352.68	1.4	351.63	351.28
M14D	353.48	1.5	352.36	351.98
M15	TBD			
M16	TBD			

TBD – to be determined

The historical water levels, warning level and trigger level are presented in Figures C2, C3, C4 and C5.

2.2 Trigger Level for Northwest Wetland and Allen Wetland

Water levels from Station SW6 will be used to trigger contingency measures for the northwest wetland. Historical monitoring has shown that the water level in the wetland is somewhat independent from adjacent groundwater levels and therefore any potential change in the hydro-period is best determined by the surface water level in the wetland.

Trigger levels and warning levels have been determined for three periods as follows:

Winter Trigger Level - lowest water level observed between December 1 and March 1

Spring Trigger Level - lowest water level observed between March 2 and June 15

Summer/Fall Trigger Level - lowest water level observed between June 16 and November 30.

A warning level is established 0.15 metres higher than the trigger level. The warning and trigger levels relative to historical water levels are shown on Figure C6.

Table 2: Trigger Levels for the Surface Water Features

Station	Winter		Spring		Fall	
	Warning	Trigger	Warning	Trigger	Warning	Trigger
Northwest Wetland (SW6)	354.35	354.20	354.48	354.33	354.38	354.23
Allen Wetland (SW4)	The warning level will be a flow rate of less than 25 L/s occurring in May and the trigger level will be cessation of flow prior to June 22.					

Manual water level measurements will increase to bi-weekly if the warning level is exceeded.

3.0 CONTINGENCY MEASURES

3.1 Groundwater Levels and Northwest Wetland

If any trigger level is breached, the following measures will be taken;

1) Confirmation of water level within 24 hours. Increase monitoring to weekly until source of the trigger level exceedence is identified.

2) Within seven days conduct an evaluation of precipitation, groundwater monitoring data and quarry activities to determine if quarry activities are responsible for the low water level observed.

3) If quarry activities are found to be responsible, the following actions will be considered and a response presented to the GRCA and the Township of Guelph-Eramosa.

- decreased rate (or stopping) subaqueous extraction
- increase the length and/or width of barrier
- change in configuration of mining or decrease in mining extent
- alter timing of extraction to coincide with high seasonal groundwater levels.

3.2 Water Quality

The water quality program will commence at least one year prior to bedrock extraction.

Groundwater Monitors and the East and West Pond

The parameters that will be included in the semi-annual monitoring (summer) will be general chemistry, cryptosporidium, giardia, e-coli, TKN, ammonia, DOC, pH, temperature, anions and metals.

In the event that there is an increasing trend in the concentration of one or more elements or compound or if any quarry related contaminant is found above the Ontario Drinking Water Quality Standard or above the 95% percentile of results obtained, a study will be conducted to determine the source of the water quality change. If the quarry is found to be responsible and if there is a potential for impact to downgradient wells, James Dick Construction Ltd. will commence with the following actions;

1) Semi-annual testing of the water quality of private wells that could potentially be impacted by the quarry.

2) In the event that a water quality issue related to the quarry occurs, James Dick Construction Ltd. will remedy the issue by either providing the appropriate treatment in the home or drilling a new well and isolating the water supply to the deeper aquifer.

Northwest Wetland

The northwest wetland water will be analyzed for nitrate, dissolved oxygen, temperature, conductivity and pH for a period of three years or upon completion of construction activities in the surface water catchment area of the northwest wetland whichever is longer.

4.0 PRE-BEDROCK EXTRACTION WATER WELL SURVEY

We recommend that a detailed water well survey be completed prior to the commencement of the extraction of bedrock resources. This survey will as a minimum include all wells in the shaded area shown on Figure C7. The well survey will include the following;

- construction details of the well (drilled, bored, sand point etc..)
- depth of well and depth of pump
- location of well relative to septic system
- static water level

- history of water quantity or quality issues
- comprehensive water sample including bacteriological analysis, general chemistry, anions and metals
- one hour flow test

The purpose of the survey is to have a baseline evaluation of both water quality and water quantity in nearby water wells. Should an issue arise with a local water well, the baseline data can be used as a reference against future measurements.

If there are domestic wells suitable for water level monitoring identified in the survey, they will be included in the water level monitoring program and monitored on a semi-annual basis.

If the survey indicates that modification(s) to the well are necessary either for continued monitoring or to minimize the potential for impact, the modifications will be made to the well at the expense of James Dick Construction Ltd.

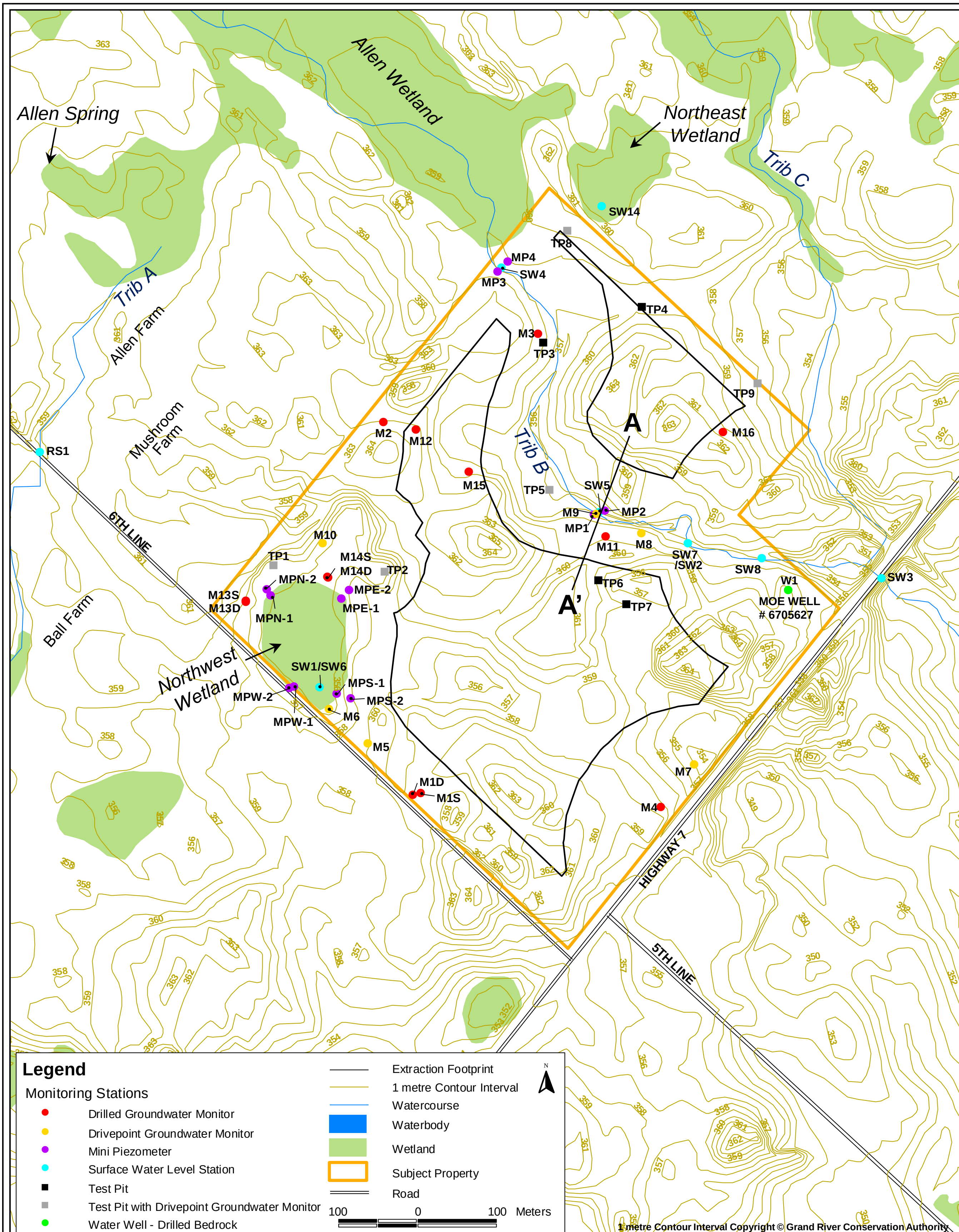
5.0 ANNUAL MONITORING REPORT AND INTERPRETATION

An annual report will be prepared and submitted to the Ministry of the Environment and the Ministry of Natural Resources on or before March 31st of the following calendar year. The report will be prepared by a qualified professional, either a professional engineer or a professional geoscientist.

The monitoring report will include all historical monitoring data and an interpretation of the results with respect to potential impact to the quality and quantity of bedrock groundwater, hydro-period of the northwest wetland and streamflow loss from Tributary B.

6.0 Water Well Complaints

James Dick Construction Ltd. agrees to inform the Township of Guelph Eramosa and the Ministry of the Environment upon the receipt of a water well complaint and the results of any related investigation.



Harden Environmental Services Ltd.

Project No: 9506

Date: Jul 2013

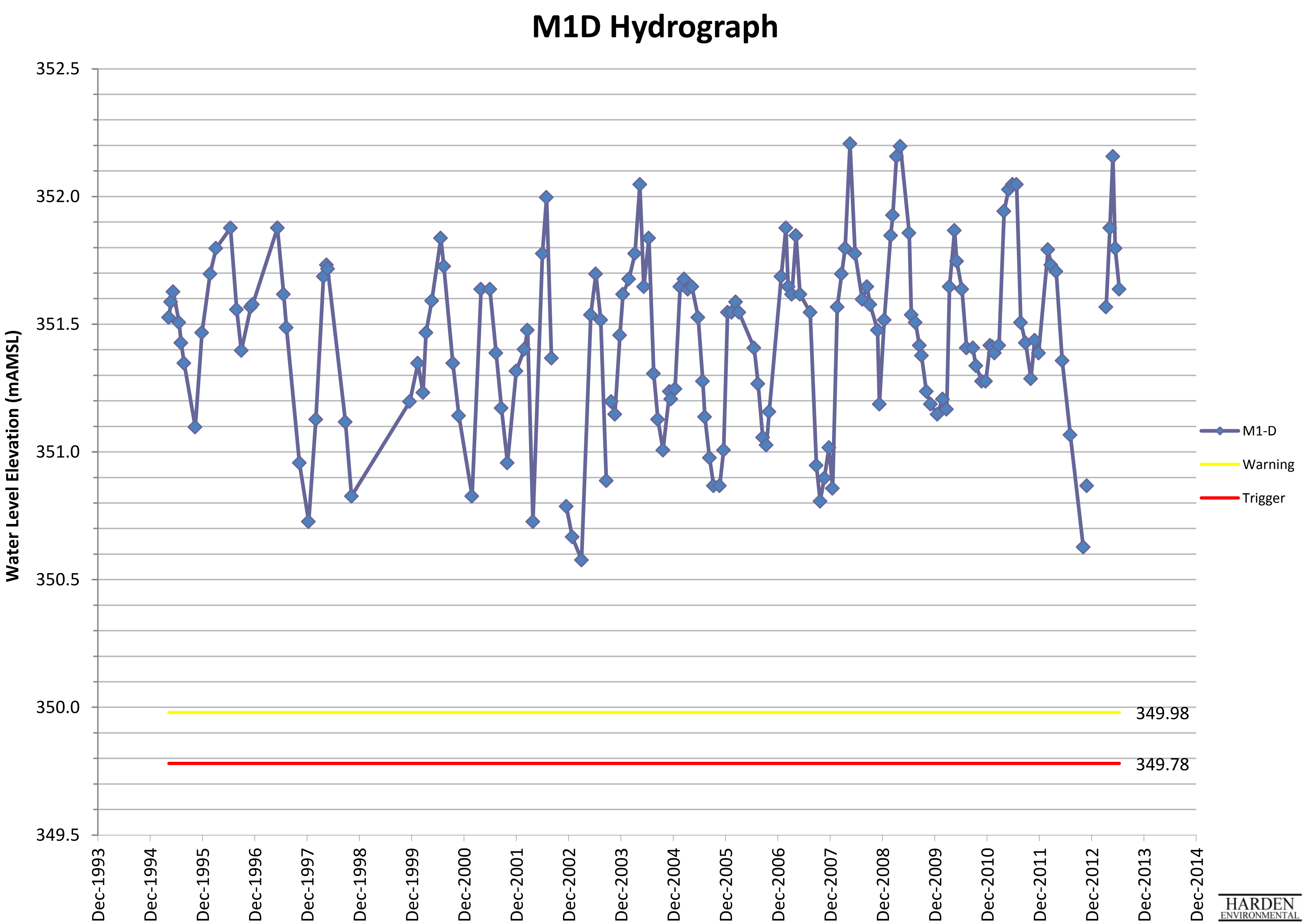
Drawn By: AR

Hydrogeologic Impact Assessment
Proposed Aggregate Extraction

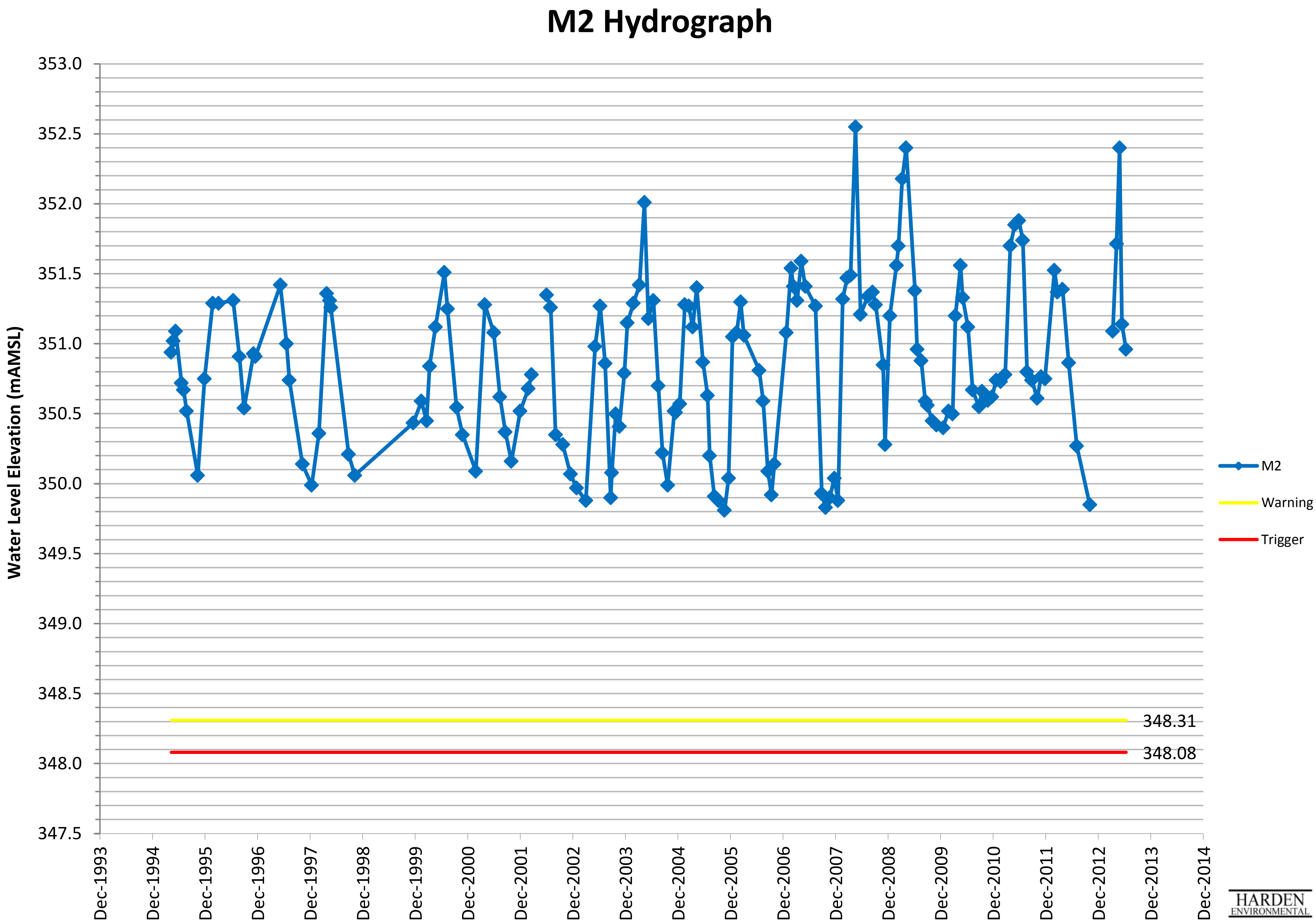
Part of Lot 1, Concession 6
Township of Guelph/Eramosa, County of Wellington

Figure C1:

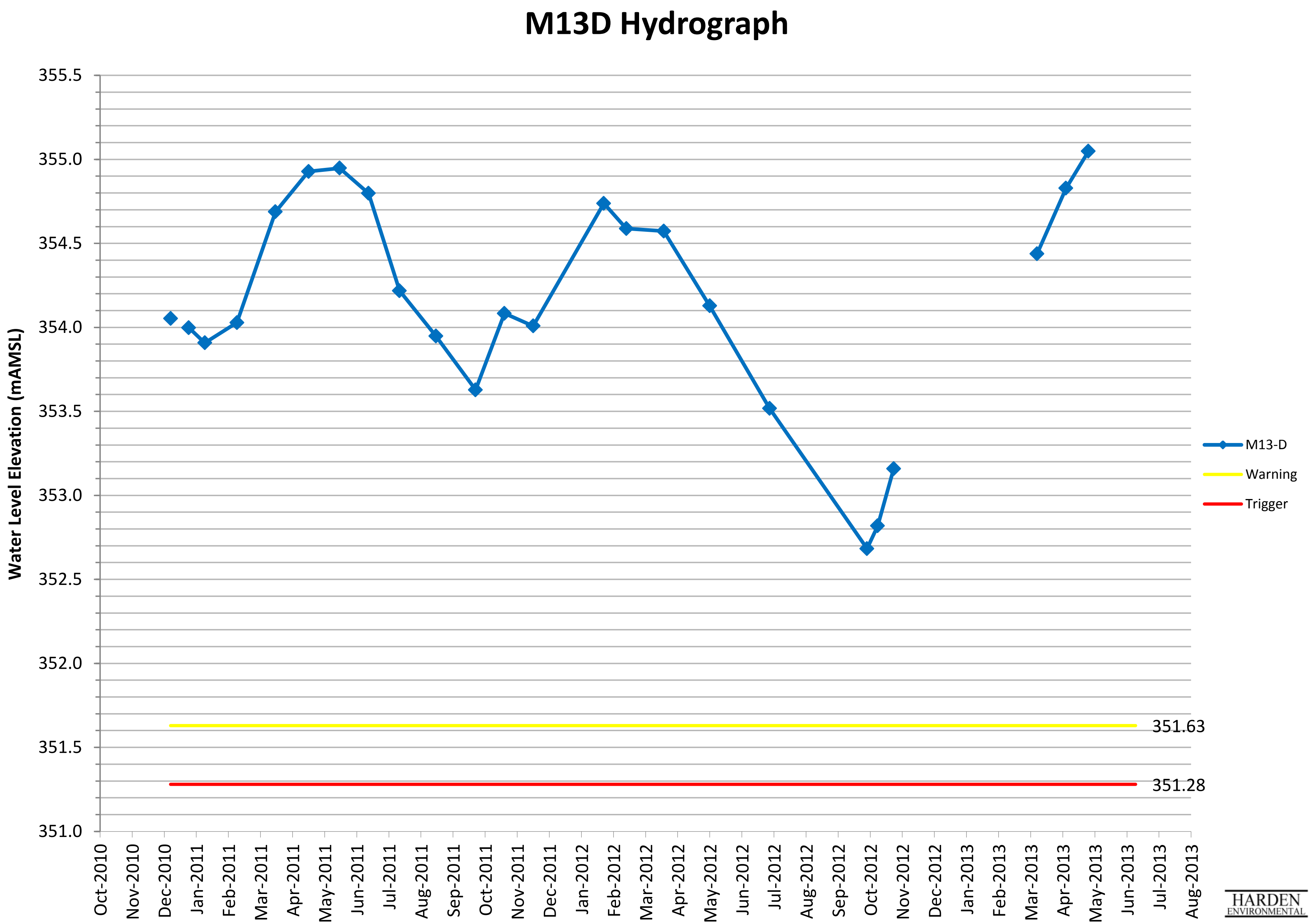
Monitoring Locations



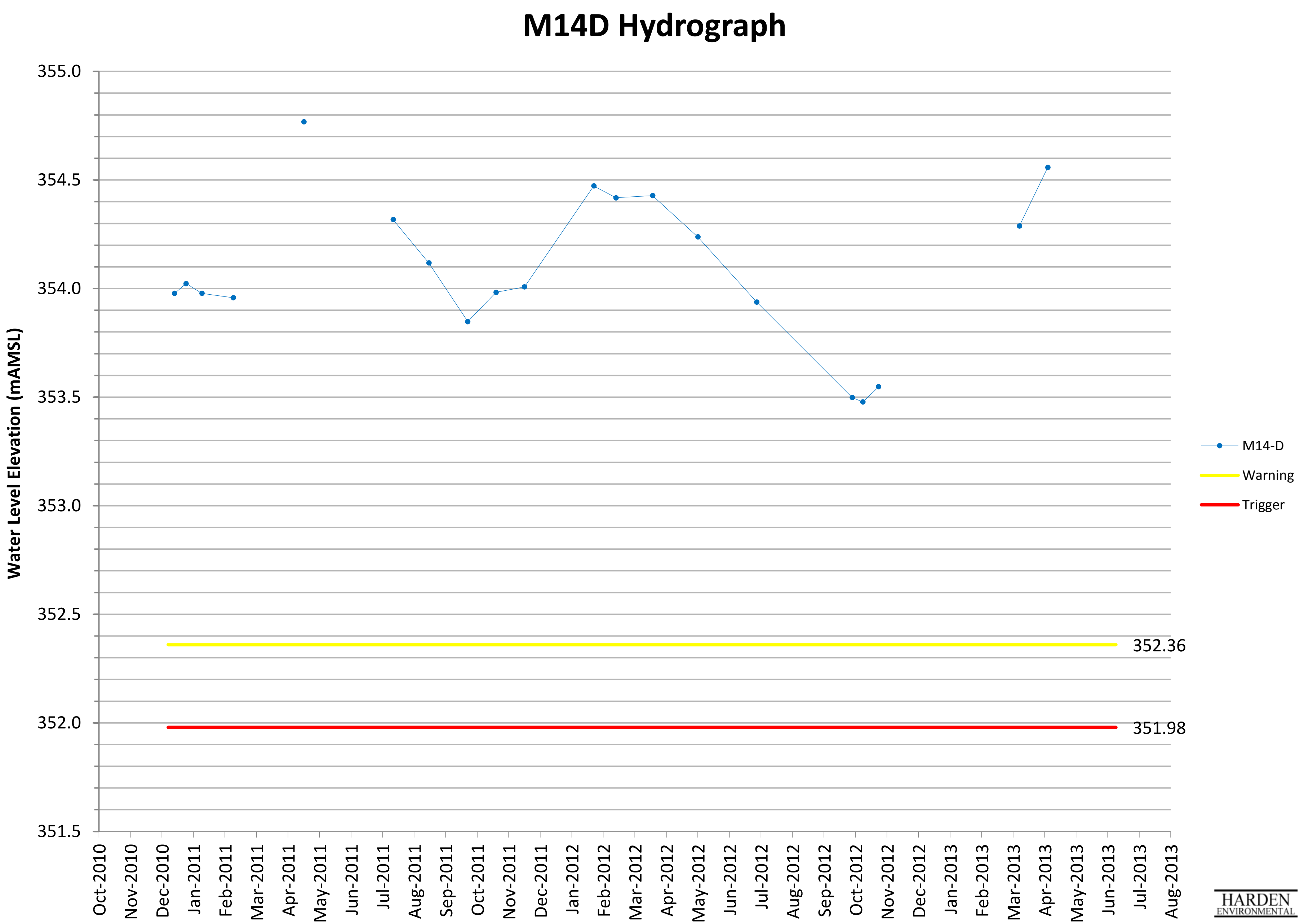
Harden Environmental Services Ltd.	**Project No:** 9506	Hydrogeologic Impact Assessment Proposed Aggregate Extraction	**Figure C2: M1D Trigger Level**
	Date: Jul 2013	Part of Lot 1, Concession 6 Township of Guelph/Eramosa, County of Wellington	
	Drawn By: AR		



Harden Environmental Services Ltd.	**Project No:** 9506	Hydrogeologic Impact Assessment Proposed Aggregate Extraction	**Figure C3: M2 Trigger Level**
	Date: Jul 2013		
	Drawn By: AR	Part of Lot 1, Concession 6 Township of Guelph/Eramosa, County of Wellington	



Harden Environmental Services Ltd.	**Project No:** 9506	Hydrogeologic Impact Assessment Proposed Aggregate Extraction	**Figure C4: M13D Trigger Level**
	Date: Jul 2013	Part of Lot 1, Concession 6 Township of Guelph/Eramosa, County of Wellington	
	Drawn By: AR		



Harden Environmental Services Ltd.	**Project No:** 9506	Hydrogeologic Impact Assessment Proposed Aggregate Extraction	**Figure C5: M14D Trigger Level**
	Date: Jul 2013	Part of Lot 1, Concession 6 Township of Guelph/Eramosa, County of Wellington	
	Drawn By: AR		

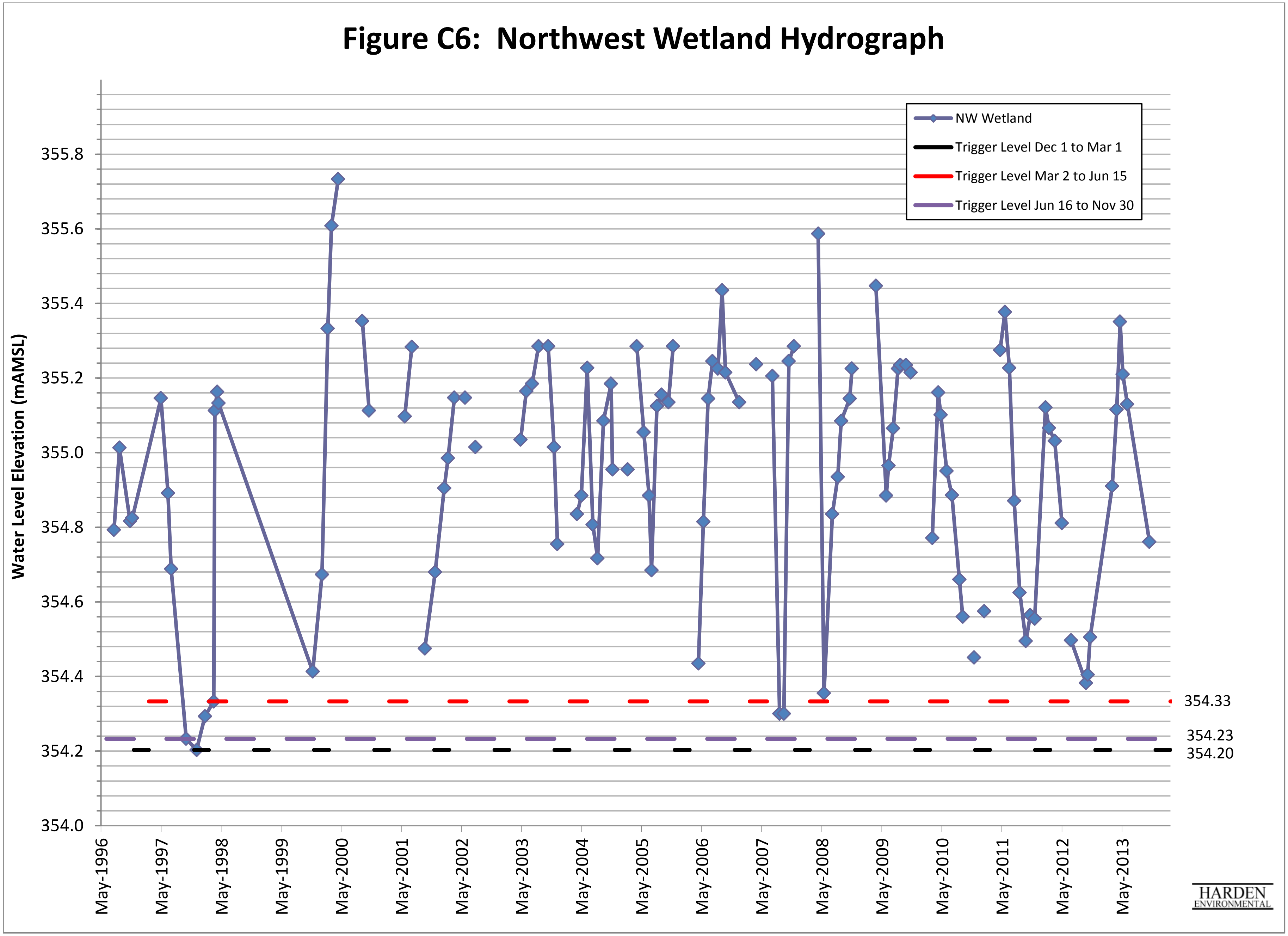
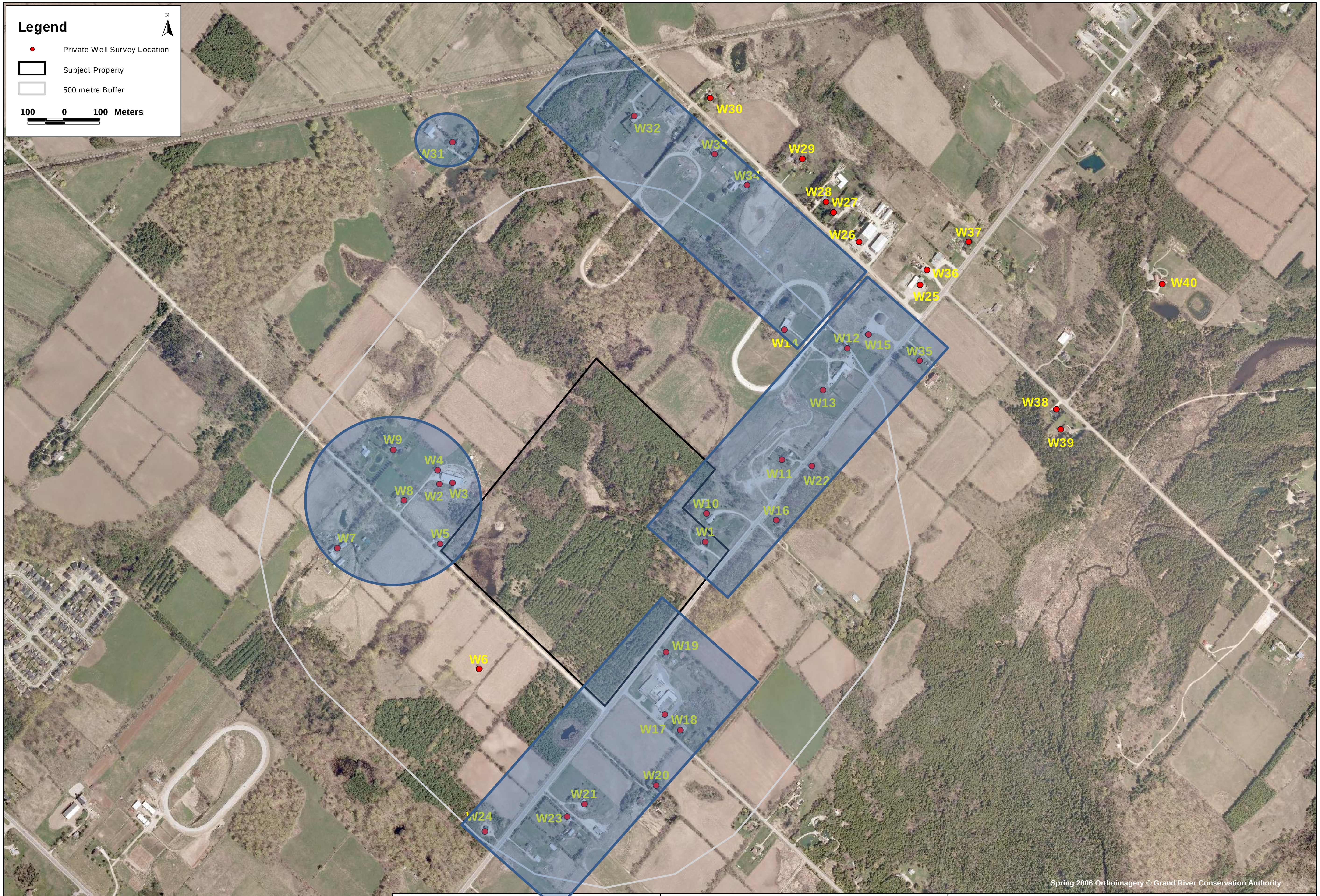


Figure C6: Northwest Wetland Hydrograph
Water Level Elevation (mAMSL)
NW Wetland
Trigger Level Dec 1 to Mar 1
Trigger Level Mar 2 to Jun 15
Trigger Level Jun 16 to Nov 30
355.8
355.6
355.4
355.2
355.0
354.8
354.6
354.4
354.2
354.0
354.33
354.23
354.20
May-1996
May-1997
May-1998
May-1999
May-2000
May-2001
May-2002
May-2003
May-2004
May-2005
May-2006
May-2007
May-2008
May-2009
May-2010
May-2011
May-2012
May-2013
HARDEN ENVIRONMENTAL



HARDEN Harden Environmental Services Ltd.	**Project No:** 9506	Hydrogeologic Impact Assessment Proposed Aggregate Extraction	Figure C7:
	Date: Jul 2012	Part of Lot 1, Concession 6 Township of Guelph/Eramosa, County of Wellington	**Proposed Pre Quarry Well Survey Locations**
	Drawn By: SD		