Review of

CAPITAL PAVING INC.
Shantz Station Pit (Maryhill, Ontario)
Level 1 and Level 2 Hydrogeological Investigation
Proposed Category 3
Class ‘A’ Pit Above-Water-Table

by MTE Consultants Inc.

(MTE File 43294-100, dated May 10, 2019)

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Executive Summary

This review is concerned with the potential impact of the Shantz Station Pit on the water that the residents in the area depend on. MTE has conducted a Level 1 and Level 2 Environmental Assessment, concluding that, due to the nature of the above water-table pit operation, the pit will not affect the shallow or deep overburden aquifers, and there is no measurable risk (involving either water quantity or quality or both) to existing water supply wells, surface water features or to any of the local natural features or functions. This review questions those conclusions.

Basic concerns are the limited extent of the study area, and the close proximity of the site to wellhead protection areas, which may change in response to future growth.

Of concern is also the adequacy of the site characterization. Climate datasets selected are for the period before 2010, thus missing the last decade, and detailed field data was collected only for one year (or possibly two) prior to 2019, which cannot give adequate insight into the potential for extreme events (droughts and floods) and effects due to climate change. All of the boreholes drilled by MTE extend only to the depth of the first till layer, giving no insight into that heterogeneities and geologic complexities that may exist in lower layers. There are no monitoring wells around the southern part of the site.

By arguing that eliminating evapotranspiration will improve water quality and quantity in Hopewell Creek, MTE oversimplifies the role of vegetation in protecting groundwater as well as surface water features. The protective role of the topsoil layer is neglected.

Although the proposed pit is nominally above the water table, some impact on the groundwater flow system cannot be excluded. But because of the limited extent of the study area, there is no way that such an impact can be predicted.

With the pit floor set at 1.5 m above the highest historical water table, a major concern is the possibility of pit flooding if the water table were to rise above the historic level due to extreme weather events. This concern extends also to post-closure, thereby raising doubts about the rehabilitation potential of the pit for perpetual agricultural use.

Other concerns include an incomplete accounting of on-site water use, a missing creek, anomalies in the influx to Hopewell Creek, as well as the quality of that influx.

The proposed contingency plan for managing spills and adverse impacts also raises significant concerns.

Our review concludes with 18 recommendations for addressing the above concerns.

Table of Contents

1. Introduction

Capital Paving proposes to set up an aggregate pit (the Shantz Station Pit) on their property near Maryhill in Woolwich Township, which is part of the Regional Municipality of Waterloo. MTE Incorporated has prepared a hydrogeological evaluation for above-water-table aggregate extraction (the MTE report) at this site. This review focuses on the MTE report with particular emphasis on the groundwater, thereby identifying a variety of concerns.

It is hereby noted that the MTE report was dated May 10, 2019, and that no updates or revisions to that report have been received nor evaluated.

2. Study area

The proposed aggregate pit will occupy an area of 67.9 hectares of prime agricultural farmland within the 93.5 hectare site. To conduct their Level 1 and Level 2 Environmental Assessment, MTE proposes a study area extending 500 m out from the site boundaries.

Given the critical importance of water to both agriculture and the community, is a 500 m buffer sufficient to properly assess the impact of the proposed pit on the groundwater? Water does not obey site boundaries, and there is no “magic wall” at the 500-metre mark. Also, the glacial spillways and till plains of this part of Southern Ontario are notably complex. Glaciofluvial and glaciolacustrine terrains are known for their geological and hydrogeological complexity, which makes predictive assessments highly risky (Chapman and Putman, 1951).

A safer alternative would be to **assess the impact of the proposed pit on a subwatershed scale.** The relevant subwatershed is the smallest watershed unit that encompasses the entire property.

3. Intrinsic Vulnerability and Wellhead Protection Areas

In the context of aquifers, intrinsic vulnerability (IV) hinges on the idea that the natural environment provides a certain amount of protection against groundwater contamination from the surface. The IV concept encompasses characteristics such as the thickness of the unsaturated zone, hydraulic conductivity of the aquifer, the depth to the water table or aquifer, how much recharge that aquifer receives in an average year, the topography, and the presence or absence of any preferential flow pathways such as fractures. The IV concept does not consider the properties of a given contaminant or spill event (Liggett et al, 2011).

MTE dismisses the important topic of Intrinsic Vulnerability in a one-line statement of reassurance, because "only 0.3%" of the site is designated as SGRA[1]", thus the site overall has a low vulnerability score. This blanket statement is insufficient, as the long-term water supply of many people is at stake here.

MTE also notes that the site is located beyond the limits of any nearby Wellhead Protection Areas[2] (WHPAs). These have been designated by the Lake Erie Region Source Protection Committee (2018). The City of Guelph WHPAs extend to about two kilometres to the east of the site.[3] The Maryhill municipal wells are situated less than a kilometre to the north, with their WHPAs extending northwards.

Are these WHPAs permanent? Mayhill is situated just west of the boundary between Waterloo Region and Wellington County, and this location places Maryhill within convenient driving distance of four sizeable cities (Waterloo, Kitchener, Cambridge, and Guelph). The same attributes that make this location convenient as an aggregate source also make it attractive for rural-residential purposes, in addition to food production. Moreover, all these uses translate into demands for water supply.

As is typical for rural residential housing, each house has its own private well and thus should be considered a vulnerable receptor. While the site is presently distant from existing WHPAs, this could change in the future if pumping increases due to greater water demand for more development and/or increased agricultural irrigation (see also below for potential impacts of climate change).

MTE has considered Waterloo Region's 2018 proposed changes to WHPAs. However, caution must still be applied, because future WHPA changes are possible, given that pumping rates may need to be increased in order to supply more water. **The same growth that drives the demand for aggregate will also drive future demand for more water.** Beyond residential growth, water demand could also increase due to climate change, most notably extreme droughts (see also discussion below). Thus future changes in the WHPAs should be considered.

4. Adequacy of field monitoring and background data

[1] Significant Groundwater Recharge Area

[2] Wellhead Protection Areas. In Ontario as well as in many other jurisdictions, wellhead protection areas (WHPAs) are defined in four categories: (1) 100-metre radius surrounding the wellhead; (2) the travel time to wellhead is 2 years or less; (3) the travel time to wellhead is between 2 and 5 years; (4) the travel time to wellhead is between 5 and 25 years.

[3] The complex appearance of the Guelph-area wellhead protection areas in MTE Figure 7 (PDF page 36/229) is an artifact of the presently accepted mapping methodology of superimposing the vulnerabilities on top of the WHPAs.

MTE has installed 5 monitoring wells around the periphery of the site, with boreholes reaching to depths from 4 to 9.1 metres. No monitoring wells are evident around the southern part of the proposed pit. Stratigraphic observations were done by a representative from Capital Paving (who should be an experienced geologist). MTE (section 4.2) has also dug test pits throughout the site to depths of 3.7 to 6.1 metres. The field installation are shown in the Site Map in MTE Figure 2 (page 31/229)[4], albeit for some reason MW5 is not shown.

MTE's background data also includes the climate datasets (including averages and maximum and minimum temperatures) from 1981 to 2010.

4-1. Inadequate characterization in time: Uncertainty due to climate change

Climate change, also known as anthropogenic global warming (AGW) or global heating (GH), is the result of the increase in greenhouse gases in the atmosphere due to human activities. Climate change is already bringing extreme weather and this trend will undoubtedly continue and accelerate in the near future. In the context of aggregate pits, this means more protracted droughts as well longer periods of wetter weather, also more storms. Pit design, facilities design, operations, and contingency measures should reflect the possibility of such events occurring.

MTE has collected one year of field data as a basis for planning the pit. They suggest that a second year can be added as an Addendum. However, in this age of accelerating climate change, two years is hardly sufficient to describe seasonal variations in the water cycle, much less year-to-year trends. A reasonable minimum as a predevelopment dataset would be five years.[5] The MTE report was produced in early 2019; if data-gathering activities been continued since then we would now be in the second year. In any case, one year of data would be wholly inadequate.

MTE recommends that manual water levels be collected on a seasonal basis, three times per year (once each in the spring, summer and fall) at all on-site monitoring wells and participating domestic wells. MTE also recommends that annual groundwater monitoring extend throughout the life of the pit operation. While this plan is helpful, it cannot provide adequate insight into the impact of potential future changes due to GH.

A better monitoring plan would be based on continuously operating, automated instrumentation and would also include weather data along with groundwater levels. Only such continuous,

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[4] All page references here in are in the electronic version of the MTE report (Adobe PDF format). This document consists of 229 pages in total. Please note that when the document is printed on hard copy, the page numbers appearing on the printed pages will be different.

[5] Ten years is considered bare-minimum to meet formal meteorological standards. Overall, and from a practical viewpoint, we recommend a data-gathering program as follows: starting a minimum of five years before extraction begins, as well as continuing during the entire extraction period, and additionally continuing for a decade post-closure.

automated instrumentation will illustrate year-to-year trends and capture the effects of rainstorms and droughts, as well as extended pumping. Manual spot measurements can be subtly misleading if they happen to be done at different times with respect to major droughts or wet periods. Dip-tape measurements are, however, useful as a calibration check for pressure-transducer-type in-situ dataloggers. **Equipping just a few of the wells with continuous dataloggers would bring a major benefit over relying solely on manual spot measurements.**

The manner in which water levels respond to precipitation inputs varies with hydrogeology: a deep confined aquifer will be slow to respond and might be minimally influenced by seasonal precipitation variations, while a shallow aquifer will respond quickly. This is precisely the reason why continuous datalogging is so much more valuable than manual spot measurements taken in isolation. Furthermore, continuous data can be valuable for future research purposes (e.g. for investigating the impacts of climate change on water tables), as well as for legal-liability purposes.

Furthermore, the climate normals dataset adopted by MTE, taken from 1981 to 2010, completely misses the last decade, which was marked by record-breaking extreme weather, pointing to a future of accelerating climate change. It is remarkable that **not even a single mention of climate change occurs in the entire report.**

Given climate change in particular, serious concerns arise with MTE's assurances that the water-table fluctuations will forever be below the proposed pit bottom—simply because their high water table is based on just one year of data (i.e. 2018). We will further discuss this issue below under Pit floor uncertainty.

4-2. Inadequate characterization in space: Uncertainty due to hydrogeologic heterogeneity

The stratigraphic complexity of glaciofluvial and glaciolacustrine geologies, at scales ranging from centimetres to kilometres, as been documented in numerous textbooks and papers. (For southern Ontario in particular, Chapman and Putnam is the classic reference.) A rigorous examination of any borehole core taken from a well in such a terrain can be expected to contain materials of a variety of hydraulic conductivities. In other words, what a well driller might simply describe as "medium sand" could easily cover several orders of magnitude of hydraulic conductivities. The variation would be even more marked in settings that include sand, gravel, and clay in close proximity to each other in the borehole column.

All of the five boreholes that were drilled by MTE extend only to a depth of the first till layer underlying the sought-after sand-and-gravel layer. This means that interbedding and interleaving of till, sand, and gravel below that level would go undetected. But such interleaving and other geologic complexity could play a major role in when, where, and how groundwater recharge occurs, both spatially and temporally...and this, in turn, could affect nearby drinking-water wells in the long term. **Thus the depth of the MTE boreholes is likely insufficient.**

As an example, PW4 appears to be situated in a confined aquifer from which no nearby withdrawals are being done, whereas MW3 and MW4 seem to be in a confined aquifer from which significant withdrawals continue right into the fall. Keeping in mind that recharge takes a long time to reach those aquifers, this again points to **hydrogeologic complexity and uncertainty that MTE seems to be missing altogether** (and that is not reflected in the cross-sections Figs 12a and 12b, which imply hydrostratigraphic continuity that is simply not reasonable given the inherent complexity of glaciofluvial-glaciolacustrine landscapes). Instead, MTE contends that “variations are interpreted to be reflective of natural climatic conditions”.

More monitoring wells beyond the existing five wells would be helpful. In view of the hydrogeologic complexity of the glaciofluvial-glaciolacustrine sediments, a sound monitoring program should entail placing wells all around the site. The resulting boreholes should provide good hydrostratigraphic insight as well as long-term data, if equipped with dataloggers for continuous readings over the long term.

Another concern arises with the paucity of cross-sections. The two that MTE provides are insufficient to give the reader a full picture of this intrinsically complex site. Fence diagrams would be helpful for displaying the stratigraphy in three dimensions.

MTE’s placement of mini-piezometers in the wetlands is appropriate, but the absence of a piezometer in Wetland #5 (abutting the western edge of the pit) remains a concern since the topographic setting may imply that this is a particularly sensitive wetland. While it is understood that the private landowner has refused access, one wonders whether the refusal is linked to an inherent ecological sensitivity of that particular wetland.

On the positive side, MTE has carried out monitoring not only of groundwater, but also surface water. Flow monitoring at Hopewell Creek was matched up to GRCA datasets as well as precipitation datasets, with a reasonable correlation. MTE acknowledges that one year of streamflow data is not representative given how weather varies from year to year, yet at the same time, MTE disregards the year-to-year variations in groundwater level—and in particular the high water table, which is of particular importance to above-the-water-table pits such as this one.

As a means improving the MTE field-monitoring program, one option would be to extension-drill three of the existing boreholes (i.e. which were extended to the first till layer only) down to the average depth of the deepest wells in the area examined—for example, 50 metres.

5. The role of soil and vegetation

5-1. The role of evapotranspiration

MTE contends that the pit will exert a beneficial effect on groundwater levels by eliminating the evapotranspiration of ground vegetation. According to MTE, this will improve water quality and quantity in Hopewell Creek. This narrow view oversimplifies the role of healthy topsoil and vegetation in protecting groundwater supplies.

Similarly, MTE's argument that eliminating evapotranspiration will improve water quality and quantity in Hopewell Creek also oversimplifies the role of vegetation in protecting surface water features.

The idea of Hopewell Creek's coldwater-stream status being improved as a result of the gravel pit eliminating vegetation-caused evapotranspiration is inappropriate, especially in view of the geologic complexity and hydrostratigraphic uncertainty of the site.

It is also doubtful that Hopewell Creek's coldwater-stream status will be improved after the pit closes. All that can be said is that the rehabilitation of the depleted pit is highly uncertain.

Thus the effect of evapotranspiration should be re-evaluated. In addition to any effect on water quantity, a potential decline in water quality should be considered.

5-2. Effect of removal of protective layer

Aquifers are the sources of the baseflow that maintains streams, and the overburden layers above the aquifers serve to filter the precipitation that percolates downwards. Thus an aggregate pit that is above the water table, by definition, entails removing the protective layers above the aquifer.

It is also important to note that the carbon-rich topsoil layers, with their natural soil micro-organisms, fulfill an important filtration role. For example, microbes can break down minor amounts of spilled hydrocarbons. This protective function is lost in the open pit floor, which explains the concerns about spills of fluids from machinery (see comments on contingencies for spills).

Furthermore, extraction activities at aggregate pits have sometimes been correlated with increased turbidity in surrounding domestic wells. This relationship can be seen in the water-analysis datasets in the appendices of certain aggregate-pit reports. Although such turbidity is easily dealt with via simple water filters, long-term water-quality monitoring is needed in order to discern trends.

Thus the potential impact of the proposed pit on water quality should be investigated. This can be done by means of scenario analysis using a model.

6. Pit floor uncertainty with respect to highest water table

MTE (Section 2.3, page 8/229) notes that the ground-surface elevation varies from 344 m at centre-north portion of the proposed pit, and the lowest elevation of 322-323 m at Hopewell Creek to the east. (As is typical for surface-water bodies, the creek can effectively be thought of as a surface manifestation of the groundwater table.)

The floor of the proposed pit would be established at a minimum of 1.5 m above the highest water table. On the basis of its one year of fieldwork, MTE estimates (page 13/229) that the high water table throughout the site is 322-323 metres. But because of the paucity of field data, this crucial estimate is subject to substantial uncertainties. An unusually wet season could result in flooding of the pit while in operation. Even extending the data for a second year will not help much in view of the long-terms uncertainties of future climate change. Thus the pit floor level remains highly uncertain and predictions of water levels at the site must be considered as unreliable.

Agricultural tile drains are present in some fields, mostly to the south of the property. This raises the question that the water table might have been higher if the tiles had not been present. In other words, the measured water levels could be affected by tile drains (in addition to pumping at wells). What will happen to the water table in the long term, if the tiles are removed (or if they eventually clog up due to siltation), after the proposed pit has been decommissioned?

7. Potential impact on private and municipal wells

MTE lists 29 well records within the study area. Major water users are the municipal wells for the Town of Maryhill (400 metres away), and Merry Hill Golf Course.

The ALS Lab reports appended to the MTE Report reveal that the numerous private landowners in the vicinity nearly all have bacteria in their private wells. This is a GUDI[6] situation that could potentially be aggravated by aggregate extraction. These private dug wells have *E. Coli* and total coliforms, the probable source being the septic systems of the houses themselves. Some wells also show nitrates. Arguably these wells are too shallow, but in the immediate context, one

[6] Groundwater Under Direct Influence of surface water

hopes that the homeowners have some kind of treatment arrangement in place. It is important to keep in mind that these wells are at greatest risk of interference.

Also, these shallow dug wells may be vulnerable to drying up during future droughts (even if they have not yet had such problems) and/or turbidity changes in general, and these may or may not be attributable to the proposed gravel pit. (In other words, the gravel pit may bring a "tipping point" in terms of water quality-versus-quantity issues.)

The MTE report does not make it clear that the presence of the nearby existing pit (2 kilometres to the northeast) may make it more difficult to sort out issues of water quantity versus quality that might arise at the properties that are located in the area between the existing and the proposed pits.

Regarding the house at 1195 Foerster Road, which will be surrounded by the gravel pit, there are potential long-term geotechnical concerns with the foundations of the buildings (i.e. the house with outbuildings around it), given the steep slopes (and erosion concerns) being introduced around the homestead on three sides.

8. Site water usage and management

Section 6.2 of the MTE Report describes the wash plant and Section 6.3 describes the proposed facilities for water diversion and storage (including the Source Pond). Also noted is the highly permeable pit floor and rapid infiltration of water into the local groundwater system. (This high permeability again underscores the concern of groundwater contamination by spills.) The proposed wash plant will use recycled water, with a settling basin for removing fines. This is an accepted practice that is standard for the industry.

An apparent conflict exists between the statement of "there will be no water storage at the site" and the prior discussion about the Source Pond (for wash water). Furthermore, if the proposed water collection arrangement ends up being insufficient for wash-water needs (keeping in mind evaporation), then supplementation via well water will be needed. And this will add to concerns of water demand in the area.

Also, there is no accounting for water for site-dust and/or road-dust suppression. During extended periods of hot, dry weather, much water will be lost due to evaporation, and irrigation (for surrounding farmlands[7]) demand will also be high. So will homeowner water usage for their landscaping, and also for the Merry Hill Golf Course. With road-dust-suppression water being

[7] It is important to keep in mind that lands that currently do not require irrigation might be in need of irrigation in the future, as a consequence of climate change. The synergistic impacts of drought and new irrigation demand as well as other potential increases in demand (e.g. domestic, or for road-dust suppression) cannot be ignored.

by definition evaporated and thus lost, it is apparent that the proposed pit could become a significant water user in the area.

Conversely, during periods of unusually high rainfall, and particularly in conjunction with heavy snowfall and snowmelt, a surfeit of water may be present. It would thus seem logical to store this water in a pond for use during dry months. This point should be mentioned in the report.

The effect of uncertainty on water management at the site should be investigated. This can again be done by means of model-based scenario analysis.

9. Existing wetland features near the pit site

Figure 1 (Key Map) of the MTE Report shows a large wetland forest complex to the northwest of the proposed pit. Subsequent maps do not show these wetlands, suggesting they are not important. As noted earlier, a subwatershed-based assessment really would be appropriate here. This would also show interactions with private wells and other users, in addition to watercourses.

Also, it would have been helpful if MTE had included a regional map of groundwater flow. Showing the site in isolation of its surroundings is not amenable to a good understanding of the impact of the site.

All the wetlands (#2, #3, #4, shown in green overlay in MTE Figure 3) are PSWs[8], and all are located near the edge of the property (and thus close to the edge of the proposed pit). Wetland #5, which abuts the western edge of the site, remains unstudied due to the refusal of the private landowner to grant access permission. This is a significant data gap that should be rectified. Also, in Figure 3, which compiles data from various sources (GRCA, MNRF, and Riverstone), that same wetland appears to have been relabelled as Wetland #7.

The GRCA surface-water mapping shows a small creek running along the northern edge of the proposed pit, but MTE did not see anything on their field visits, so they (MTE) merely omitted it. This, in turn, raises a serious question: **Was this "missing creek" potentially an ephemeral stream? Or maybe part of a vernal pool system that forms in the springtime and is home to amphibians?**

To answer these questions and confirm the presence/absence of the stream, MTE and Riverstone employees[9] would need to visit the site several times during wet periods in the spring.

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[8] Provincially Significant Wetlands

[9] On page 4 of the MTE report, Riverstone Environmental Solutions was also mentioned for its involvement in stream fieldwork.

10. Groundwater influx and quality to Hopewell Creek

Hopewell Creek abuts the eastern edge of the site, and this proximity calls for care in assessing any potential impact. But MTE contends that the pit will improve infiltration and groundwater recharge by eliminating evapotranspiration. As noted above, this writes off the importance of healthy soils and healthy vegetation for protecting the aquifers which provide the baseflow to Hopewell Creek.[10]

MTE's placement of mini-piezometers at Hopewell Creek is appropriate. But the finding that Hopewell Creek appears to be a gaining stream everywhere except in the vicinity of MP4 is notable. MTE does not mention that **this anomaly is again an indicator of significant hydrogeologic complexity in the area.** None of this is reflected the oversimplified cross-sections of Figures 12a and 12b.

Regarding the water quality in Hopewell Creek, the observed high phosphorus levels are not surprising, given that this is an agricultural area with high fertilizer usage. Livestock are also present in many of these areas (e.g. swine farms), and phosphorus can be introduced by biosolids applications (i.e. sewage sludge from municipal sewage treatment plants).

Thus the potential impact of the pit on Hopewell Creek is a complex issue and it requires re-assessment. One way to study this issue would be through a numerical model. Such modelling would need to be supported by a rigorous, detailed fieldwork program.

11. Water balance and site-activities-driven water needs

MTE assures us that "since the pit will not be going below the water table, no effect on the overall groundwater balance is expected", and then the report goes on to provide contingency measures.

The key calculations are done in a Technical Memorandum, which is buried in Appendix F at the end of the MTE report. A potential source of confusion is that this memo is entitled "macro drainage analysis" in some places and "micro drainage analysis" in others. The key tables are Table 1.1 (page 189/229) and 3-1 (page 191/229).

[10] In simplest terms, the fact that streams continue to flow during long periods of dry weather is due to groundwater influx into the bottom and sides of the stream.

Concerns arise in Table 3-1 (in tech memo): Existing pits in the East Side Watersheds cover 0.93%, and the proposed pit will effectively double this by adding another 0.91% to that. While these amounts might seem minor in the largest context, **if these pit areas were tabulated in terms of their immediate subwatersheds only, then the proportional loss would be greater.** (Also, Table 1-1 in that tech memo does not consider regional-scale groundwater flow, thereby again glossing over hydrogeologic uncertainty.)

The MTE water-balance tables (1.1 and 1.2, for Wetland 1 and Hopewell Creek respectively), bring their own set of concerns, since there is no accounting for the potential future need of groundwater for aggregate-washing and site/road-dust suppression activities during long periods of dry weather. Although we are told that all onsite water needs will be met by seepage collection and water recycling, it is not difficult to imagine future scenarios (given climate change) where a water shortage will arise. In such cases, groundwater withdrawal will likely be required. This potential scenario should be considered by MTE.

12. Groundwater flow system under operating conditions

Figure 11 (page 40/229) of the MTE report shows a groundwater divide running through the middle of the proposed pit. Even though the water table shown in this figure is based solely on data from 2018, the divide is in itself plausible given the existence of the topographic high running from northwest to southeast across the site (as shown in MTE Figure 4). However, the biggest concern is the possibility of higher water levels in the future, as a result of climate change.

Knowing whether Wetland #5 (Figure 3), presently unevaluated, is a GW recharge or discharge area would help to confirm the flow directionality that MTE has mapped out in Figure 11 showing high-water-table conditions. Confirming the presence of the small stream/creek running across the northern edge of the site and mapped by the GRCA would also be helpful.

In terms of wells, domestic well PW3 is located “upstream of a small topographic divide”. But when the pit is in place and excavations are underway, some changes in the flow regime are to be expected. For example, the “gentle hill” of the site will be gone, and this will affect the surrounding area—and even though the pit will be above the water table, the fact that geologic material has been removed means that changes to groundwater flow gradients are to be expected. This topic (along with its potential future implications) merits further analysis. None of this has been considered by MTE.

13. Concerns regarding future land use after extraction

As noted elsewhere in these comments, because the high water table throughout the site is not well known, the 1.5-metres-above-the-water-table pit floor may be called into question. If the pit floods in the future, then dewatering will be needed—and future farmability of the pit, after closure and backfilling, becomes very doubtful.

After the pit closes and has (presumably) been backfilled, even if the pit does not regularly flood or become swampy in the future, **it is highly doubtful that it will ever be prime farmland again—**because the natural soil structure with the subsurface layers (i.e. the aggregate materials) will be gone forever.

Capital promises to replace tile drains after aggregate extraction has been done, but they omit the reality that putting in new tile drains will result in those new drains being at a lower elevation. What will they be draining? Will this require a network of pumps, all run by a diesel generator that will have to run in perpetuity? The cost will be a major factor. This issue needs to be clarified and future land uses need to be re-assessed under realistic conditions.

14. Concerns regarding contingencies for well interference and spills

MTE (section 9) list BMPs[11] for fuel handling and equipment maintenance. These appear to have been taken from a standard template. The same applies to Appendix H (Spills Contingency Plan).

In MTE's Well Interference Contingency Plan, a potential conflict of interest arises as the QP[12] who investigates complaints is paid for by Capital, and thus could be seen as having the incentive to exonerate Capital in the event of a domestic well being affected.

Regarding on-site fuel storage, double-walled fuel tanks are mentioned, but these are already standard and thus this is nothing new. More notable is that apparently there will be a number of diesel-engine-driven machines sitting directly in the pit. All this fuel needs to be transported and stored as well.

Not mentioned is how much fuel storage will be in the pit area, but any leak is a concern—and with the aforementioned geologic uncertainty, plus all those private domestic wells (and

[11] BMP = Best or Beneficial Management Practices
[12] QP = Qualified Person

municipal wells not far away), plus wetlands and a creek adjacent to the site, the concerns are serious ones.

As noted earlier, the existence of numerous nearby wetlands and private wells suggests an inherently highly sensitive site. In view of this sensitivity, the adequacy of the provincial regulation requiring notification (for MOCP and ROW) only for spills over 100 litres (for oil) and 50 litres (for fuels etc) may be questioned.[13]

Furthermore, the utilization of the entire spills plan hinges solely on the operator's estimate of the amount spilled. How exactly is a heavy-equipment operator to know how much was spilled in the first place? The incentive to under-report spills is obvious, given the desire to avoid paperwork hassles, operational downtime, costs, and potential job loss.

With the pit floor consisting of sand-gravel, anything spilled onto the pit floor will seep in rapidly, and with the water table nominally only 1.5 metres below the pit floor (or maybe even closer, giving my aforementioned concerns regarding geologic complexity), and with no carbon-and-microorganism-rich topsoil layer to help attenuate a minor leak, concerns are magnified.

The responsibility associated with an in-pit spill is a major one for a heavy-equipment operator to carry. And in fact, the spills plan does not make it clear exactly who is responsible for spills. Furthermore, what happens if the spill is not immediately noticed? Spill kits are useless if not deployed in time.

Thirdly, because of the financial incentive to be profitable, the time lost in reporting and cleaning up a spill will be worth orders of magnitude more than the value of the lost fluid. Given also that this is private property, the result is an incentive to simply not report spills.

Given the rule-of-thumb that one litre of fuel can contaminate a million litres of water to above the drinking-water threshold, simple calculations can be done on the cost of spill clean-ups to drinking-water standards.

Other details on spill-prevention measures are also lacking, such as secondary containment trays around stationary machinery, and the use of impervious surfaces for filling of equipment (and spill-capture systems for such impervious surfaces).

Consideration should also be given to instituting automatic spill-detection technology, with real-time reporting (via cellphone network, which is ubiquitous here). Such monitoring technology is widely available and low in cost.

Also, to alleviate concerns of vandalism of machinery, good physical security, with remote monitoring, should be provided at all times.

[13] In some documents the spill-threshold numbers are 80L and 40L, but in any case the concerns are significant.

In the light of the above concerns, the contingency plan should be revisited.

15. Recommendations

1. Consider extending the study area to the boundaries of the subwatershed encompassing the site.

2. Consideration should be given to possible future changes in the WHPAs due to growth in water demand as a consequence of population growth and/or climate change.

3. Groundwater monitoring should be continued for a period of five years before extraction begins, as well as during the entire extraction period, and additionally for a decade post-closure. Monitoring wells should be equipped with dataloggers.

4. The report used climatic data from 1981 to 2010, which misses more recent years with more extreme weather. The analysis should be redone with the inclusion of recent climate datasets.

5. Consideration should be given to increasing the number of monitoring wells to account for hydrogeologic heterogeneity/uncertainty.

6. Wells should be drilled deeper than the first encounter of the sand-till interface in order to check for any deeper permeable layers.

7. Additional cross-sections in the form of fence diagrams should be provided to assist in the visualization of the subsurface in the pit area.

8. The net effect of evapotranspiration should be re-evaluated, both with respect to water quantity and quality.

9. Uncertainties in the elevation of the pit floor, due to uncertainties in future climate conditions as well as to uncertainties due to the unknown hydrogeologic heterogeneity, must be acknowledged.

10. Potential impacts on private and municipal wells, both in terms of water quantity and water quality, should be investigated.

11. The potential impact of the removal of the protective layer overlaying the aquifer should be investigated.

12. The effect of uncertainty on water management at the site should be investigated.

13. The presence/absence of the small stream running along the northern edge of the proposed pit should be confirmed.

14. The potential impact of the pit on Hopewell Creek should be recognized as a complex issue that requires re-assessment.

15. Situations where additional water is required for the operation of the pit and related activities, particularly under adverse climatic conditions, should be recognized and investigated.

16. Potential changes in the groundwater flow regime as a result of pit operations and their effect on users should be investigated.

17. The post-extraction use of the site should be investigated under realistic conditions.

18. The contingency plan should be revisited and analyzed under realistic conditions.

16. References

Chapman, D.F. and L.J. Putnam. The Physiography of Southern Ontario, University of Toronto Press, 1951.

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Liggett, J., Lapcevic, P, and K. Miller. A Guide to the Use of Intrinsic Aquifer Vulnerability Mapping. BC Ministry of Forests, Lands, and Natural Resource Operations, Nanaimo, 2011.

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