ATTACHMENT 2

MEMO

TO: Saad Yousaf, P.Eng., City of Vaughan

FROM: Steven Van Haren, P.Eng., WSP

SUBJECT: Peer Review of "Dual-Use Stormwater Facilities Policy Paper, Dec. 2021"

DATE: May 20, 2022

Executive Summary: A policy paper has been advanced by a group of private companies ("Policy Paper: Dual-Use Stormwater Facilities Policy Paper, prepared for: The City of Vaughan, ON, MGP Ltd., SCS Consulting Group Ltd., and Schollen & Company Inc., Dec. 2021") promoting an alternative to traditional wet ponds as a preferred Stormwater Management approach. WSP has peer reviewed the policy papers and made recommendations and observations related to it. A summary of the most relevant points is as follows:

- Traditional wet ponds are a common approach to addressing stormwater management requirements for new development, but require significant amount of developable land, and have issues with increasing temperatures in pond discharge, as well as some issues with how water quality treatment is provided.
- The steadily increasing value of land is driving innovation in the application of publicly owned and operated Stormwater Management Facilities, traditionally configured as wet ponds.
- Underground Stormwater Management Facilities (UGSWMF's) are promoted as an equivalent approach with some noted benefits above the traditional approaches such as thermal issues. Traditional approaches retain some benefits such as passive recreation opportunities.
- UGSWMF's can be installed below park land or other appropriate publicly owned lands to allow the previously separated land dedications to be combined into a single dedication as a "Dual-Use Stormwater Management Facility (DUSWMF)". This will lead to conservation of land for additional programming.
- Operation and Maintenance issues are not similar between traditional SWMF's and UGSWMF's or DUSWMF's.
- There are specific issues to address with UGSWMF's including odor control and water quality treatment. UGSWMF's should be configured to drain fully between storm events and provide an appropriately designed treatment train based water quality treatment approach upstream of the UGSWMF's.

100 Commerce Valley Drive West
Thornhill, ON
Canada L3T 0A1

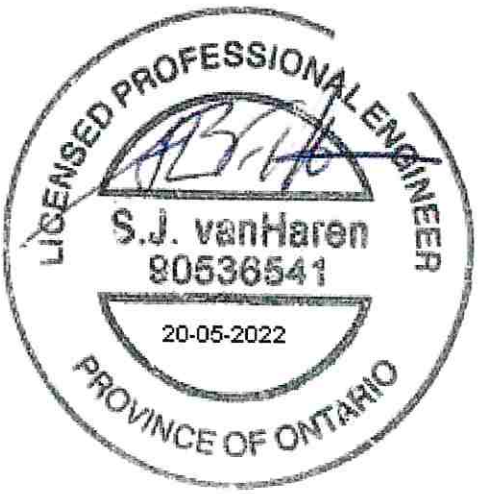
T: +1 905 882-1100
F: +1 905 882-0055
wsp.com

- UGSWMF's provide cooler runoff that would normally heat up in open water SWM ponds, particularly during the summer months. This will benefit receiving water systems, particularly those with endangered species often associated with cold water fisheries, such as red side dace systems.
- UGSWMF's should be configured with separate water quality treatment systems to avoid storing runoff underground between storm events. This will ensure that receiving water systems, such as creeks, are not impacted by water discharges with low dissolved oxygen concentrations.
- When configured appropriately, UGSWMF's and DUSWMF's may be considered an appropriate approach for addressing stormwater management issues associated with land development applications.

In summary, WSP recommends that the use of UGSWMF's and DUSWMF's may be considered as a valid Stormwater Management approach when considering land development applications. Any such strategy requires significant justification in the form of design documentation and review processes from an engineering and urban planning perspective,but do not require adjustments to the City's planning and development review processes. Significant issues remain to be addressed including specific risks associated with procurement, installation, operations and maintenance, but WSP has not identified any fundamental obstacles to consideration that place an undue burden on the City from consideration of such systems.

Yours sincerely,

Steven van Haren, P.Eng.
Manager, Land Development/Water Resources
Land Development and Muncipal Engineering



MEMO

TO: Saad Yousaf, P.Eng., City of Vaughan

FROM: Steven Van Haren, P.Eng., WSP

SUBJECT: **Peer Review of "Dual-Use Stormwater Facilities Policy Paper, Dec. 2021"**

DATE: **May 6, 2022**

Introduction & Objective: The City of Vaughan (the City) has retained WSP Canada Inc. (WSP) to provide peer review commentary on a policy paper ("Policy Paper: Dual-Use Stormwater Facilities Policy Paper, prepared for: The City of Vaughan, ON, MGP Ltd., SCS Consulting Group Ltd., and Schollen & Company Inc., Dec. 2021") submitted to the City detailing the perceived benefits of a new style of 'end of pipe' stormwater management facility (a "Dual-Use Stormwater Management Facility, DUSWMF"). These systems are conceived to combine the active storage performance of a traditional stormwater management approach for land development applications in an underground structural system specifically designed and constructed to contain the additional runoff created from the conversion of natural and pervious areas into relatively impermeable development areas. These Dual-Use facilities provide a compelling promise to remove impediments to conserving land by combining underground stormwater management functions with low loading surface uses (such as parks and recreational uses) and allow for more usable land that would otherwise be dedicated to one or both of those uses in a more 'traditional' approach. WSP notes that these systems cannot function identically to traditional stormwater management facilities such as wet ponds or constructed wetlands due to numerous considerations for how water quality treatment goals will be met and the hydraulic principles required in each system to provide the stormwater management functions. We also note that underground systems tend to improve on traditional stormwater management facilities in many ways, while they also face challenges in other areas, such as dissolved oxygen concentrations that are not associated with traditional facilities.

General Comments: In most areas, open water ponds (as part of a natural system, stormwater management facility, or otherwise) are not a common feature in the landscape. Areas of natural pond presence tend to be a result of glacial action, such as the numerous natural ponds and small lakes of the Oak Ridges Moraine (aka 'kettles'), or as a result of artesian groundwater pressure or streamflow collecting in shallow or deep surface depressions that have developed over a geologic time scale. It is actually more common to encounter open water areas that are a feature of a traditional stormwater

100 Commerce Valley Drive West
Thornhill, ON
Canada L3T 0A1

T: +1 905 882-1100
F: +1 905 882-0055
wsp.com

management facility or flood control facility in the urban areas of the Greater Toronto Area than a natural pond. Secondly, open water areas were not present in traditional urban areas before the late 1970's when policies that addressed the additional runoff from development began to be a requirement for development approvals. It is understandable that the most common form of stormwater management facility implemented is the 'wet pond' as it tends to provide the required stormwater management functions in the smallest footprint for the smallest overall investment, resulting in numerous private and public wet ponds throughout the Greater Toronto Area. The City of Vaughan currently owns and operates approximately 150 stormwater management facilities, of which the majority are wet pond style. It is WSP's opinion that the Dual-Use Stormwater Management Facilities Policy Paper has been prepared to illustrate the perceived benefits of an 'innovation' to the wet pond approach that combines park land and stormwater management facility footprints into a single block, allowing for more development or other land uses, as appropriate. This approach is becoming financially feasible as land values continue to increase in the GTA, and the stormwater management facility footprint area that would normally be a requirement for approval of a subdivision application (or other land development application) becomes a larger cost item on the development project's overall budget that can be mitigated with this approach.

WSP is concerned about the potential for UGSWMF's configured with permanent pools (which provide a close to zero flow energy area where sediment will fall out of suspension) will introduce conditions where low dissolved oxygen concentrations are present. This situation is likely to produce noxious odors (such as hydrogen sulfide due to reductive chemistry present in low dissolved oxygen conditions) as well as facility discharge that reduces overall dissolved oxygen concentrations in the local receiving water system, which would impact fish and aquatic ecological communities. We recommend that any UGSWMF be configured to temporarily store runoff volumes to the level required by the relevant policies, but that the systems should be configured to drain fully between precipitation events. In addition, water quality treatment should be provided by upstream treatment-train based approaches that remove sediment into more easily accessible areas for removal during maintenance activities. An exception to this would be integrated water quality filtration or gravity-based removals that do not require the presence of a sustained underground pool of water (such as isolator rows in plastic hemispherical chamber systems).

The following are specific comments by WSP on the contents of the policy paper and should be read in conjunction with it. The bolded, underlined text below refers to the relevant section of the policy paper.

Executive Summary: The statements made in the policy paper's executive summary are generally factually correct, however the conclusions reflect the judgement of the authors instead of an independent analysis. In effect, there is a bias present for promotion of the Dual-Use Underground Stormwater Management Facilities in place of traditional stormwater management facilities. In addition, the purpose statement does not discuss the need to compare Dual-Use Stormwater Management Facilities to traditional Stormwater Management Facilities, which would arguably be of increased utility to City staff.

Section 2.0 Application of Dual-Use Stormwater Facilities in the City of Vaughan, Greenfield Development: The statement that surface based wet pond style SWMF's have no above-ground usability is misleading. The aesthetic benefits to local residents and contribution to a pastoral setting often associated with open spaces is an undervalued benefit that is generally not considered by a municipality when the wet pond is only considered as a City infrastructure component. These facilities do contribute to passive recreation and an attractive feature along active transportation routes. The discussion on the use of Regional Storm Control facilities stating that quality treatment could be provided in the underground components is not recommended by WSP. The statement should be revised. **Intensification Development**: WSP's position is that UGSWMF systems related to intensification development will typically be located on private property and the statement that dual-use facilities provide the opportunity to create parks and other benefits is unsupported as the presence of an UGSWMF will not impact any site planning actions. **Vaughan Metropolitan Centre (VMC) Development**: The discussion here is focussed on increasing the use of UGSWMF's in context to the VMC master plan to preserve or increase the number of parks and open space in the face of intensified development pressures above the original master plans. WSP agrees that UGSWMF's have potential to allow for increased density while maintaining the original proportion of open space and park areas, but caution is required due the additional potential to introduce infrastructure conflicts and encumbrances on park lands due to these systems.

Section 3.0 Benefits of Dual-Use Stormwater Facilities: Summary of Benefits: WSP finds these bulleted items to be of a general nature, and while not factually inaccurate, do not provide much context for how these benefits are provided. Most of these items are required of any SWMF and therefore do not provide much information on how Dual-Use systems are superior in this regard. **Land Utilization**: WSP agrees that the vertical walls of UGSWMF's allow for a reduced footprint while providing similar volumes of active storage, a major benefit of these systems. The remaining discussion in this section discusses the use of the area above the UGSWMF and its various options for configuration. Most of these will be affected by various Municipal policies related to urban planning. The statement that additional parkland or community gathering space seems out of place, as the premise of the policy paper is that space for parkland and traditional SWMF are combined to conserve land, presumably for additional development as evidenced by the cost estimate in Section 6.0 that describes the additional tax & development charge revenue realized by these systems, which cannot be generated from additional parkland. We note that the provided table does not include major repairs or replacement costs. These costs are a vital concern for a municipality to consider to ensure long-term operations and maintenance considerations are addressed. These tables should be revised to include these costs, but we recognize that various practices will continue to evolve in the future and their related costs will be approximate for the time being. **Safety**: WSP agrees that UGSWMF's provide improved safety compared to open water based SWMF's due to reduced probability of exposure to drowning hazards, particularly for special needs and other residents for whom warning signs may not be an effective deterrent. Fencing and other barriers to address this hazard near wet ponds are often ineffective or neglected over time and may only be effective in reducing liability rather than improving safety. In terms of mosquito larvae, WSP does not

believe that open water based SWMF's or UGSWMF's provide any significant contribution to mosquito-based disease vectors due to predation and shallow wave action that disturb the development of mosquito larvae. Larger open water bodies do not provide sufficient suitable habitat for the development of mosquito larvae, and public perceptions of SWMF's as contributing to West Nile Virus or other issues are overblown, if not incorrect. Any discussion on the benefits of UGSWMF's compared to traditional SWMF's is unsupportable on this issue. **Aesthetics**: WSP agrees that UGSWMF's provide a preferred approach to traditional open water based SWMF's in the vicinity of airfields due to the reduction in propensity to attract waterfowl or other avian hazards near flight paths. WSP does not support the shallow burial of access locations due to the propensity to lose track of their location as documentation processes evolve. WSP does not agree with the statement that parkland amenities with fewer safety risks (implying that UGSWMF's are preferred to traditional SWMF's in this issue) are preferable from a mental health perspective as the statement is subjective and unsupported. It also reveals a bias by the authors to the use of UGSWMF's over traditional SWMF's. **Thermal Impacts:** The statements in this section are generally supportable. The various techniques to mitigate thermal impacts from open water based traditional SWMF's are known to be inefficient and considered as 'band-aid' style solutions that do not fundamentally address the issue of thermal aggradation associated with these systems. UGSWMF's provide a subsurface tank in thermal equilibrium with native soils and groundwater, which acts as a thermal heat sink. In essence, the propensity for thermal aggradation is removed, addressing that specific issue in a comprehensive manner. This is superior to open water based surface SWMF's for which the water must be cooled after the fact, by systems with varying levels of efficiency. **Maintenance and Installation:** The statements in this section are generally supportable. However, WSP cautions that UGSWMF's may suffer from an "out of sight, out of mind" issue and municipal staff replacement over time may contribute to neglected maintenance or consideration of these systems compared to surface based SWMF's that are easily noticed and contemplated on visual inspection by newer employees.

4.0 Policy Framework and Rationale: WSP has reviewed the policy references provided and confirmed that the content of the policy paper has summarized the issues and remained true to the context of the referenced policy documents. Most references are direct extracts of text from the referenced documents, and those that aren't are correctly interpreted. In general, the conclusions related to the content of the Provincial Policy Statement (PPS) are supportable. We note that the PPS is silent on the issue of traditional vs. UGSWMF's but the PPS does clearly support innovation in SWMF implementation as referenced in section 1.6.6.7 f) in the use of "best practices". In addition, the text of section 1.6.6.7 c) charges the various levels of government to consider the impacts of climate change in water balance, for which UGSWMF's have considerable advantage over traditional SWMF's. The statements related to the York Region Official Plan appear supportable and in context to the relevant text. Lastly, the policy paper appears to have correctly interpreted the intent of the TRCA letter included in its appendix based on WSP's review and a personal conversation with the author of it, Sameer Dhalla, P.Eng.

5.0 Engineering Overview of Dual Use Stormwater Facilities: Groundwater Interaction: WSP finds the statements in this section factually accurate, but the discussion on floatation potential would be of increased utility if it referenced an appropriate "factor of safety" related to buoyancy resistance by the facility. WSP does not agree with the statement on UGSWMF's outfitted with a permanent pool as that is not a preferred configuration for this system due to issues with dissolved oxygen concentration. **SWM Facility Design Considerations**: WSP agrees with the first paragraph in this section, but does not agree that a permanent pool should be integrated into an underground SWMF. The 'alternative' arrangement is preferred over an underground permanent pool due to issues with environmental performance, maintenance of water quality treatment systems and other issues, as outlined in various portions of this document. **Outlet Design Considerations**: This section should include a discussion about the relative elevations of outlet controls due to the loss of available head from the presence of UGSWMF's. A traditional, gravity-based SWMF would be preferred over an UGSWMF that relies on a pumped solution for discharge due to operational costs and the need for easements for electrical service alone. **Erosion and Sediment Control During Construction**: No specific comments.

6.0 Maintenance, Installation, Life Cycle, and Costs: Specific commentary on this section is provided in the detailed answer to Q3 below.

7.0 Above Ground Uses: WSP does not offer specific comments on this section, as the issues are better addressed by municipal staff affiliated with urban planning and parks development. We generally support the discussion and conclusions of this section, and note these additional points:

- Recreational uses above UGSWMF's should not use items that require structural foundations, supports or other infrastructure when insufficient cover is available.
- The SLZ area is an additional requirement of UGSWMF's to facilitate repairs or rehabilitation / replacement.

Questions Raised by City of Vaughan Staff & Responses to Specific Issues

Q1: Does the intent / purpose of the policy paper report ensure it is operationally and financially feasible for the City to adapt to dual SWMFs? The answer to this question should be supported by a decision matrix based on the comparison of a dual-use SWMF with a conventional SWMF in terms of cost, social, environmental, constructability, and operational criteria

A1. The policy paper does not provide a direct answer to this question, but it is presenting and supporting underground stormwater management facilities as a valid and innovative alternative to traditional stormwater management facilities. The paper does not provide discussion on the relative pros and cons of traditional stormwater management facilities versus dual-use underground stormwater management facilities. To address this question, the following decision matrix has been prepared.

Assumptions. Proponents are responsible for procurement, construction, commissioning, and warranty of underground stormwater management facilities similar to traditional stormwater management facilities and assume that a constructed DU/SWMF will be provided in an identified block of property in a manner similar to current practices. Some of the items in the decision matrix below may be affected if the above process is modified.

PARAMETER	TRAD. SWMF	DU-U/G SWMF	NOTES: DARKER CIRCLES IMPLY IMPROVED PERFORMANCE
Cost			
Land Value	○	●	High land values favor U/G SWMF.
Capital Cost	●	○	Trad: Capital Costs nominal (earthworks). U/G: Capital costs 2 – 3x higher.
Maintenance	◑	◑	Trad: untidy, long restoration periods. U/G: offers quicker, outsourced maintenance.
Social			
Safety	◑	●	Trad: accessible open water. U/G: no open water areas.
Aesthetics	◕	◑	Trad: Ponds with open water. U/G: turf areas
Nuisance	○	◑	Trad: perceived as illness vectors (West Nile, unclear water). U/G: non-preferred habitat for vector biology.
Recreation	◕	◔	Trad: passive options. U/G: park related options only.
Environmental			
Thermal	○	●	Trad: thermal aggradation issues. U/G: acts as heat sink to cool discharges.
Water Quality	◕	●	Trad: has integrated treatment via gravity settling. U/G: off-line treatment with addt'l options for filtration.
Footprint	◑	●	Trad: pond sloping required. U/G: Vertical walls.
Erosion	◕	◕	Both options dependent on design

PARAMETER	TRAD. SWMF	DU-U/G SWMF	NOTES: DARKER CIRCLES IMPLY IMPROVED PERFORMANCE
Infiltration	○	◑	Trad: generally, not feasible. U/G: Infiltration feasible.
Constructability			
Complexity	◕	◔	Trad: open excavation, earthen composition. U/G: confined space entry, need for air displacement, structural analysis, etc.
Materials	◕	◔	Trad: Native materials with less concrete. U/G: Increase in imported concrete
Operations			
Simplicity	◑	◕	Trad: Batch-flow and plug-flow system dynamics. U/G: Offline treatment followed by storage.
Recovery	○	◕	Trad: Vegetation recovery slow with disturbed soils. U/G: Same-day recovery after maintenance.
Advantage	✗	✓	

To summarize, in terms of the major performance metrics, dual-use underground stormwater management facilities appear to be superior in most areas, while traditional stormwater management facilities have several advantages. In essence, had dual-use underground stormwater management facilities been available and sufficiently developed in 2003, it is my professional opinion that they would have been included in the 2003 Stormwater Management Planning and Design Manual in Chapters 3 and 4, where valid end of pipe stormwater management facilities are outlined and summarized. At that time, they would likely have been considered cost prohibitive. However, the rapidly increasing value of land convincingly shifts the discussion on the use of dual-use systems as a valid alternative that does not impose an excessive burden on the assuming municipality based on the analysis presented in this decision matrix.

Q2: Has the dual-use SWMFs policy paper fulsomely referenced the relevant legislation and Official Plan policies related to parks and stormwater management?

A2. WSP reviewed the specific references in the paper's Provincial Policy Framework, correlating the text entries to the source documents and found the references to be faithfully interpreted as they apply to the subject of underground stormwater management facilities. In most cases, the referenced text is either a direct extract of wording from the referenced documents or has been correctly interpreted in the paper's context. The papers conclusions on the relevance of the Provincial Policy statement are supportable. WSP notes that the Provincial Policy Statement is silent on issues of traditional vs. underground stormwater management facilities but does directly support innovation in stormwater management facilities through the use of "best practices". WSP's opinion is that underground stormwater management facilities meet the description of a best practice when it is demonstrated that the alternative facility can convincingly and defensibly address the required stormwater management policies through the relevant design documents that satisfy the affected Conservation Authority's and municipality's development related policies.

Q3: Is the comparison of conventional SWMF versus Dual-Use SWMF (underground storage tank below City Park) reasonable, in terms of?

a. sediment cleaning frequency
b. structural inspection / rehabilitation frequency of the concrete tank
c. overall life cycle cost
d. maintenance costs
e. capital cost

A3.

i) Sediment Cleaning Frequency: There is no typical straightforward comparison applicable here between the two options, as UGSWMF's should not be configured with inherent underground treatment capacity (like a submerged permanent pool for gravity based settling of suspended solids) due to concerns with low dissolved oxygen concentrations. Upstream treatment-train based measures may require more frequent cleaning as they tend to be smaller scale than sediment forebays and main cells in wet ponds, but have more defined clean-out processes that may be implemented quicker, with less reestablishment time. Clean-out frequencies on UGSWMF's outfitted with a permanent pool (not recommended) will be at least twice as frequent and significantly more expensive due to additional manpower requirements and confined space entry procedures. Sediment cleaning on treatment separated tank arrangements is expected to be similar, if slightly less, than a traditional stormwater management facility pond. Sediment removal from upstream treatment-train systems may be more frequent but less costly depending on the amount of upstream loadings.

ii) Structural Inspection / Rehabilitation Frequency of the Concrete Tank: The policy paper provides a well-conceived and described approach to structural and rehabilitation issues related to underground stormwater management facilities. It is difficult to establish a standardized structural inspection or rehabilitation frequency in the absence of site-specific design issues (such as upstream drainage area characteristics) but the inspection and rehabilitation frequencies included in the policy paper, based on a typical application, seem reasonable on review and within the "Order of Magnitude" consistent with normal SWM practices. Structural inspection frequency may be minimized by using approved precast systems that benefit from improved quality control processes at the factory compared to cast-in-place systems, but certain components (such as joint waterproofing, where required) cannot be applied prior to installation and may affect the inspection frequency depending on the quality of the construction and installation processes utilized.

iii) Overall Life Cycle Cost: The lifecycle cost breakdown presented in Section 6.0 of the policy paper seems reasonable based on the assumptions attached to it. It is not possible to account for all variables, and the analysis does not account for the time value of money, so projection to any specific case or site is not possible. However, from a comparison perspective, the analysis seems reasonable and sufficiently comprehensive to show essentially equivalent annualized costs between the two options. The additional tax revenue items at the bottom of

the table imply that securing the property that would normally be dedicated to either a surface stormwater management facility or a park for other uses is offsetting any cost considerations for underground systems is highly subjective and should be removed from the table as it skews the conclusions in a biased manner. It should be noted that given the relative infancy and limited number of examples of UGSWMFs implemented in municipalities at the moment, the overall lifecyle comparative costs between SWMFs and UGSWMFs are still yet to be accurately determined and can be considered highly variable depending on a number of factors including but not limited to the location, the size of the drainage area, major repairs, replacement costs, regulatory impacts, etc. It is recommended a full detailed analysis of life cycle costs between traditional SWMF's and UGSWMF's be included in future policy development.

iv) Maintenance Costs: The detailed assessment of maintenance costs takes a "straight line" approach to distributing low frequency, but high cost items such as pond clean out, inlet / outlet structure reconstruction, concrete rehabilitation, LID system replacement, etc. to estimate an annualized cost. This may skew the conclusion as those costs must consider an inflation rate or other approach to provide a reasonable annualized cost for future expenditures. If the intent of the assessment is to compare traditional stormwater management facilities to underground stormwater management facilities, the effect is minimized, but it diminishes the reasonableness of the future cost estimates when projecting likely future costs for those items. It may be more appropriate to consider these comparisons using a "net present value" approach based on appropriate inflation rates.

Capital Cost: Section 6.0 of the policy paper provides a capital cost summary section but the cost tables it references list maintenance costs, not capital expenditures. The policy paper does not discuss initial or ongoing capital costs to procure, install and commission underground stormwater management facilities versus traditional stormwater management facilities. However, it is assumed that initial capital expenditures will remain the responsibility of the developer or other project proponent and be relevant to the assuming municipality. WSP anticipates that capital costs for underground stormwater management facilities to be much higher (possibly 2 to 3 times higher) than a typical traditional stormwater management facility when the cost of land is excluded from the consideration, due to the much higher amount of precast items and infrastructure required. This will be an issue for consideration of replacement costs should the systems fail over time should replacement costs be considered in the overall life cycle cost analysis. WSP anticipates the probability of a failure requiring full replacment to be exceedingly low, but the cost comparison should account for likely replacement costs based on varying amounts of system repair (i.e. 10%, 25%, 50%, 75%, 90%, 100% replacements). As mentioned in the General Comments, underground stormwater management facilities are a response to increasing land values when this important consideration is accounted for. Traditional municipal approval approaches involving the dedication of separate surface-based stormwater management facilities and park blocks by the proponent will be under significant cost pressure for revision as land values increase

exponentially in urban or urban adjacent settings as the land values are expected to offset the higher capital costs of the underground stormwater management facility, resulting in less overall cost to the proponents when considering all cost related factors.

Q4: Is the anticipated service life of precast concrete / concrete and plastic underground storage storm system and any similar underground tank products realistic and reasonable?

A4. WSP finds that the statements made by the University of Toronto Civil Engineering professor on the service life of underground precast stormwater storage tanks to be reasonable and defensible. The argument is supported by fundamental analyses, the parameters used in the modelling results appear appropriate and the modelling software that was utilized is a well-known software package specifically created to address this issue. WSP notes that the concrete mixture utilized in the construction of the pre-cast units has an outsized impact on the anticipated service life, and that the "Modified 336" mixture delayed the onset of rebar corrosion by double the duration of a more common "158" mixture. WSP recommends that the anticipated concrete mixture be detailed in any proposal for the use of an underground stormwater management facility to ensure the service life estimate is consistent with the project subsurface conditions.

Q5: Have the potential development opportunities and limitations on top of the underground concrete tank been fully explored?

A5: It is not possible to state that potential development opportunities and limitations for land uses above the underground facilities have been exhaustively explored. The paper has outlined various potential uses as examples of appropriate applications above the underground systems in an attempt to showcase how parkland can be combined with stormwater management functions in a single facility footprint. All of the proposed uses above the tanks correlate with uses that do not require extensive foundation elements or servicing infrastructure that would presumably conflict with the relatively shallow depth of cover over them. As cover depth above the tank is rarely expected to exceed 1.2 m, it is reasonable to assume that cover materials will freeze solid in the wintertime due to advancing frost depth, so foundations or infrastructure in such a position would be at risk. While most underground storage systems have criteria to support AASTHO HS-20 or HS-25 loading criteria (meaning they could support standard live loads for highway bridge designs), the authors of the policy paper suggest that land use above the underground facilities be limited to recreational and park uses to ensure that actual loadings never approach the limits of them.

Q6: Has the structural review of the underground concrete tank including foundation requirements to minimize settling been properly assessed?

A6. The Dual-Use Stormwater Management Facility paper does not attempt to provide a comprehensive structural review or foundation requirements to minimize settling, as that would be a function of the specific soil properties in the individual site locations. The paper has demonstrated that structural concerns related to underground concrete installations are appropriate for typical settings within the acceptable range of native structural soils present in

locations with generally acceptable soil properties. However, modifications may be required in areas of poor or structurally inappropriate locations, which may increase the cost of such systems. Whether that will make the system prohibitively expensive compared to a traditional stormwater management facility will be dependent on the project site setting.

Q7: Has the Policy Paper provided sufficient empirical evidence from other public agencies for the effective use and implementation of underground SWMF systems?

A7. The question of sufficient empirical evidence is subjective to the reader of this peer review memorandum. However, the paper has documented the use, approval, and satisfactory performance of various types of underground stormwater management facilities in a multitude of local applications, both on private and public property. The ratio of underground SWMF's to traditional SWMF's is small but growing and additional empirical evidence will emerge over time. At this point, it is WSP's professional opinion that the amount of empirical evidence available supports the use of UGSWMF's as a valid alternative to a traditional SWMF's when configured properly and defensibly by the proponent. Each approach has its advantages in certain areas, but the weight of evidence suggests that both approaches will produce adequate performance in the areas of flow control, quality treatment and erosion control when appropriately designed and constructed. Water balance is a more complicated issue to address as that issue applies to the facility and its upstream catchment area, as well as the specific site setting, so a comment on that issue in context is not applicable.

Q8: Has the Policy Paper sufficiently explored the socio-economic impacts of conventional SWMF versus Dual-Use SWMF?

A8. The answer to this question is also subjective to the reader, however, a comprehensive socio-economic analysis has been provided that details numerous benefits from the combination of SWM and park blocks into a Dual-Use SWMF block. WSP finds the statements to be generally supportable and the reported benefits attractive from a stormwater management design perspective. Issues of open water liability to the municipality from residents' use of or exposure to open water systems have been discussed and highlighted, with the benefit clearly in favor of underground systems from a safety and liability perspective. However, under an assumption that the Dual-use facility would host the same recreational block as a traditional SWMF approach, the paper doesn't address the loss of aesthetic and passive recreation typically associated with open water based SWMF's. While most municipalities typically treat wet ponds and other surface based SWMF's as an infrastructure component, traditional facilities do provide pastoral settings and facultative wildlife benefits that are considered a 'bonus' to area residents that live in proximity to them, despite not being included in the municipality's natural heritage resources. As a result, it is difficult to account for the loss of those bonus features, or the municipality will be at risk of trying to "have it both ways."

Q9: The Consultant shall provide conclusions and recommendations to the City for next steps.

A9. The policy paper is focused on the example of the I-Storm system by DeCast for large scale underground storage systems intended to function similarly to the active storage component of traditional wet ponds. The City should request a discussion with the authors of the policy paper on the issue of dissolved oxygen concentrations in dual-use systems to ensure that downstream receiving waters do not experience negative impacts from the use of them. In addition, City policy should specify that UGSWMF's be limited to providing integrated flow attenuation, storage, and water balance functions (including groundwater recharge and infiltration) rather than providing integrated water quality treatment to avoid the use of permanent pools of water below ground, which WSP discourages. These permanent pool systems are likely to result in stagnant water that produces low dissolved oxygen discharge with the potential for hydrogen sulfide or other noxious odour issues. WSP recommends that the City develop policies that UGSWMF's should be designed to fully empty between storm events, save for small depths of water intended to infiltrate fully after an appropriate design interval to avoid the slow release of dissolved oxygen and development of stagnant water in difficult to access locations.

Q10: UGSWMFs will require frequent access due to maintenance activities such as inspections, sediment clean-out, repairs, and rehabilitation. Will this access be disruptive to the surface of the above ground amenity area?

A10. While it is possible that UGSWMF's experience this kind of maintenance activity, much of this can be performed with little to no disturbance of the above ground amenity areas if access points are sited correctly during detailed design stages. Much of the works described involve inspections which are likely minimally invasive, while cleaning, corrective maintenance, emergency spill response and other activities likely to involve major equipment and disturbance will be relatively rare events that, in most cases, can be planned to minimize disturbance and access impediments to the above ground amenities. Amenities above the UGSWMF may or may not be able to sustain truck and vehicle loading in a manner similar to amenities not associated with an UGSWMF. Inspection and maintenance would typically be performed through appropriately designed access hatches with facility specific Operations and Maintenance requirements. Therefore, there is no fundamental reason to associate amenity areas with repeated surface rehabilitation after a maintenance or inspection activity.

Q11: Open bottom UGSWMFs can provide opportunity for groundwater recharge, enhanced water quality, and runoff reduction. Are there any specific maintenance considerations for these systems?

A11. The maintenance of open bottom UGSWMF's with infiltration layers would follow similar procedures to the maintenance of permeable unit pavers or other LID systems that rely on the open permeability of surface layers in contact with runoff, assuming appropriately sized equipment can be mobilized inside the system. UGSWMF's with off-line water quality treatment (through upstream treatment-train based processes) can be assumed to have virtually sediment free runoff stored within them, which limits the rate that infiltration beds will become 'clogged'. Like

permeable paved surfaces, these surfaces do not tend to become clogged uniformly or quickly, but rather have a gradual reduction in permeability that can be restored with typical maintenance when designed with infiltration in mind. Each UGSWMF design should include specific O&M requirements to maintain their associated infiltration beds.

Q12: UGSWMFs do not generally have quality control functions comparable to stormwater management ponds so UGSWMFs often rely on upstream treatment-trains to provide suitable quality control. The Policy Paper speaks to the use of filter type pre-treatment units however, the City does not currently permit filter type pre-treatment units within the public right of way due maintenance considerations. Should the City reconsider this approach?

A12. WSP agrees that UGSWMF systems should not incorporate a permanent pool or other integrated water quality treatment system inside it, as any approach will accumulate sediment in an inconvenient (and expensive) location to remove. Water quality treatment should be provided upstream with a treatment-train based approach that removes sediment in a manner that is easier to access and maintain. WSP also agrees that pre-treatment filter units within the public ROW can be problematic, but still believes that filter units can be part of a treatment-train based approach if provided with appropriate pre-treatment approaches to remove gross particulates prior to filtration, such as provided by upstream gravity-based or hydrodynamic separation-based OGS units. Bioretention and other LID systems as pre-treatment systems upstream of a filter-based oil / grit separator unit may also be an applicable approach. Filtration is inherently superior to gravity-based settling in the area of fine particulate removal, which will be crucial to ensuring that UGSWMF's are not configured with integrated underground quality treatment functions or be susceptible to clogging of infiltration based functions.

Q14: Are UGSWMFs recognized under the Ministry of the Environment, Conservation and Parks' (MECP) Consolidated Linear Infrastructure Environmental Compliance Approval (CLI ECA) as typical sewage infrastructure?

A14. WSP does not believe that the CLI ECA has considered Dual-Use UGSWMF's in its current form. The objective of the CLI ECA is to streamline processes for low-risk projects. Therefore, it is likely that initial installations of Dual-Use UGSWMF's will not qualify for the CLI ECA process but may require an Individual ECA process until the requirements for them meet the low-risk criteria. However, WSP anticipates that the risk associated with UGSWMF's does not exceed the risk associated with a traditional SWMF, so approval for UGSWMF's under the CLI ECA process should not be unduly postponed or onerous. That process will be specific to the conditions of the municipality's individual CLI ECA.

Q15: Do UGSWMFs contribute to odour or mosquito development and, if so, what are the recommended prevention and/or mitigation measures?

A15. The policy paper does not discuss these issues, but from a peer review perspective, it is anticipated that UGSWMF's should be configured to drain fully between storm events to avoid odour issues, thus obviating the need for odour control. The specific duration for emptying is not

relevant so long as water is not retained in the structure. As for mosquito development, the life cycle of mosquitos is dependent on an aquatic larval stage where the larvae's mouth parts form a floatation mechanism for air transfer in an undisturbed area that the adult mosquitos can access to deposit eggs. Thus, they prefer small, but sheltered standing pools of undisturbed water (such as tire swings, shaded puddles or similarly sheltered, but easily accessible locations by flying insects). UGSWMF's, when configured to empty fully between storm events, will not provide suitable habitat for the larvae development and thus are not anticipated to contribute to mosquito development in any significant manner.

Q16: Is burying access locations to UGSWMFs beneath shallow soil and vegetation cover, as suggested in the Policy Paper, recommended?

A16. WSP would recommend against burying access hatches beneath shallow soil and vegetation but does recommend associating hatches with maintenance or public roadways to facilitate maintenance that does not require surface restoration activities, if possible.

Q17: Is root intrusion a concern with respect to UGSWMFs?

A17. Root intrusion is not anticipated to be a significant concern for larger installations, while smaller systems may be affected where tree presence is dense in close proximity to them. WSP anticipates that root barriers such as those described here: https://www.deeproot.com/products/root-barrier/ can be effective in addressing this issue but should not be completely relied upon to warranty a system against tree root intrusion.

Q18: Inspection of the interior condition of UGSWMFs for concrete cracking and/or deterioration was flagged as a required maintenance activity. Is specialized equipment and/or personnel needed to carry out such inspections and, if so, what is the estimated cost for this work?

A18. WSP would recommend that visual inspection of cracking or other concrete deterioration is performed whenever a confined space entry is performed or by use of remote sensing equipment. Visual inspections of the tank system (by remote sensing or in rare conditions by qualified personnel during a confined space entry) are assumed to be required on a bi-annual basis in the initial years after commissioning with decreasing frequency on documentation of stable conditions with no required maintenance on a recurring basis year after year. As described above, certifications in confined space entry would be required for any entry, along with qualifications related to assessing the structural integrity of concrete structures, such as those possessed by bridge inspectors. Those costs will be variable, and we do not believe they have been included in the current annual expenditure estimate.

Q19: The Policy Paper suggested the need for corrective maintenance. What would trigger corrective maintenance and what equipment and/or personnel would be required to perform such maintenance? Is this maintenance included in the UGSWMF cost estimate?

A19. Corrective maintenance is assumed to be similar to maintenance for similar issues on other concrete structures, such as patching of spalled concrete and remedial repairs or grouting of

cracked concrete. In extreme cases, systems like the I-Storm system may be able to expose individual structural elements and replace them without the need for replacement of the entire structure. WSP assumes that equipment choices, procedures and qualifications / expertise of the required personnel will be determined based on the severity of the maintenance requirements. It is difficult to estimate or project costs beyond a standard allowance which we do not believe is included in the estimate.

Q20: The Policy Paper speaks to emergency spills. What kind of situation or spill would trigger an inspection of the tank?

A20. The policy paper suggests that an uncontrolled discharge of hydrocarbons from an accident or other situation would trigger an inspection. WSP believes the probability of such an incident to be low and that the severity would be minimized with appropriate upstream quality control systems configured to intercept such a discharge (via Oil / Grit Separators or other systems). Emergency spill response procedures should be included in the design and review process of such dual-use underground systems so that operational protocols on how to respond to such an event are documented and mitigation measures for the concerns outlined above are considered prior to installation and commissioning. Risks of amenity service disruption are likely minimized with sufficient documentation and training on specific procedures. While the risk of catastrophic failure and response are never zero, good records and designs will reduce the risk to a level that can be comfortably accommodated by City staff.

Q21: The Policy Paper speaks to excessive accumulation of hydrocarbons. Can the excessive accumulation of hydrocarbons be quantified as a trigger to initiate maintenance activities?

A21. The policy paper describes excessive accumulation as any visible sheen on the water surface indicating hydrocarbon discharge. If there is standing water in the tank with a visible sheen, then a maintenance activity must be immediately initiated and the contaminated water volume must be pumped to controlled tanks for treatment and disposal, like any spill response process. UGSWMF's configured to fully empty between storm events are unlikely to retain any visible sheen, however, it is anticipated that the upstream water quality treatment systems would intercept those discharges. Upstream oil/grit separators are typically configured for this purpose with reservoirs where floating hydrocarbons are intercepted and stored for subsequent removal during inspection and maintenance.

Q22: The Policy Paper speaks to the potential to fit other underground infrastructure (sanitary sewer, water main, hydro, etc.) in proximity to UGSWMFs. Does this pose a risk?

A22. The addition of other underground infrastructure in proximity to the UGSWMF should be discouraged. However, it does seem possible to envision an unavoidable situation where buried infrastructure must be placed in such a situation. In those situations, it is likely a requirement that the smaller infrastructure be positioned above the larger tank (provided there is sufficient cover and separation between systems to meet the specifics of the affected systems). As the UGSWMF tanks are anticipated to be structurally sufficient to meet HS-20 loadings, infrastructure

maintenance and repair on those affected systems is not likely to be overly encumbered by the presence of the tank system below it. In addition, the smaller footprint of UGSWMF's compared to traditional SWMF's is likely to create relatively fewer impediments to infrastructure deployment around them. Some impact to standard maintenance practices (such as open cut access) can be expected adjacent to an UGSWMF, but operational impacts or increased frequency of repair is not anticipated.

Q23: Should the bottom of UGSWMFs be moderately sloped (2% slope) towards to a sump area to facilitate sediment flushing and vacuuming?

A23. WSP feels that a 2% slope is likely too steep to facilitate the movement of contained water toward a sump or other discharge location. A 0.5% slope is likely the minimum required for such performance, although 0.35% may be considered in exceptional circumstances. A sump area is an advantageous configuration to maintain consistent pumping rates for maintenance activities.

Q24: Should UGSWMF be designed as watertight structures? If so, are there recommended repair methods in case of water intrusion?

A24. UGSWMF's can be configured as watertight structural elements, but it is likely that these systems will instead be typically configured as water intrusion resistant systems through the use of integrated gaskets between structural elements with optional waterproofing applied to joints after initial installation, per design specifications. The need for those elements will be dependent on the project setting and the relative elevation of groundwater resources. Minimal water intrusion resistance is anticipated to be required to prevent the tendency of an UGSWMF to function as a groundwater dewatering system. Repair of leakages observed during tank inspection likely require the exposure of the waterproofing application on the outside of the tank system (hence the need for a setback dimension as shown in the policy paper in Section 7.0) via temporary dewatering systems to provide sufficiently dry conditions for the procedure.

Q25: What are the effects of a high or low groundwater table on UGSWMFs and are there recommended anchoring systems for these applications?

A25. Detailed anchoring methods would be site and soil specific designs associated with the individual project and seem out of scope of the policy paper. However, it is standard practice to consider buoyancy effects on submerged systems that provide any significant submerged open volume. High and low groundwater tables would impact these considerations, but the use of an appropriate factor of safety should be incorporated to ensure that all conditions are accounted for.

Q26: Should remote monitoring and warning systems be installed to notify the City in the event of unexpected high water levels?

A26. These can be incorporated as required. However, when configured to empty fully between events, the probability of such a situation is anticipated to be very low. Remote monitoring and notification systems may be applicable and the cost of such systems may be sufficiently low that

they can be incorporated into a project's plans. The City will be required to supply the appropriate staff contacts or protocols for implementing such a system.

Q27: Should a flow bypass system be included to facilitate inspection and maintenance activities?

A27. Such a system can likely be accommodated, but inspection is likely to be of sufficiently short duration that scheduling it during periods of low precipitation via a weather forecast is likely to address the issue. Maintenance, particularly repair of structural elements is likely a longer process and may require a bypass approach so that the underground system where the repairs are taking place is considered 'off-line'. Numerous approaches to this issue are available, and best practices should be incorporated for all maintenance processes. It appears reasonable that smaller scale facilities should include an external bypass as they may fill in a 'flash flood' manner while larger facilities may be able to provide multiple internal flow pathways with removable flow restrictions at the outlet point to allow for bypassing of work areas without risk of worker exposure to incoming flows.

Q28: Is there a minimum setback to consider between UGSWMFs and adjacent properties to minimize the impact of potential tank leakage?

A28. WSP assumes the answer to this question is dependent on the site setting and soil properties at the project site. Minimum setbacks should be consistent with similar requirements for underground structures (such as basements) on neighboring properties. Tank leakage is minimized when the tank is configured to empty fully between storm events and in such a configuration, settling or impacts to adjacent properties should be obviated.

Q29: Traditional stormwater management ponds are designed with emergency overflows that can convey flows exceeding the designed storm. What storm event should the UGSWMFs' emergency outlet be sized to and what will happen in event that a storm exceeds the emergency outlet design storm?

A29. UGSWMF tanks can be configured to pass uncontrolled flows through them via careful outlet structure design like traditional SWMF's. Essentially, the outlet would be configured to pass a flow equal to the sum of full flow rates for any upstream pipes and/or surface openings. This is a fairly standard approach for civil engineers to implement. In the event of a storm exceeding that flow rate, it is anticipated that the upstream infrastructure will surcharge, and localized flooding is possible.

Q30: What is the level of risk associated with a blocked inlet?

A30. While inlet blockages can and do occur, it is unlikely that multiple inlets will all become blocked at the same time, so inlets in close proximity to each other are likely to provide some redundancy in accommodating such a situation.

Q31: Has the link between infiltration containing high salt content and tank deterioration been studied/explored as there was a mall parking lot failure fairly recently as a result of concrete deterioration due to chloride exposure.

A31. The letter contained in Appendix B of the policy paper addresses this subject with an analytical examination of the effect of chloride exposure to various concrete mixtures. In any event, salt application for ice maintenance should be discouraged wherever possible due to salination impacts on receiving water systems. In the event of parking lots associated with amenity areas as outlined in the policy paper, it may be assumed that traffic movements relative to shopping mall parking lots will be lower and therefore require less salt. In addition, commercial shopping plazas typically overapply salt to reduce ice buildup due to fear of liability or to avoid any impacts to customer experience, a condition that often leaves residual salt piles that can affect downstream conditions long after winter conditions have abated. While salt application concerns are valid for park and amenity parking lots, the anticipated lower use of the parking lots in winter suggests that plowing is a much more viable winter maintenance approach in these conditions, with consequently lower rates of salt application. In addition, underground tanks configured to fully empty between storm events are unlikely to retain salt laden runoff for sufficient amounts of time that such runoff would exacerbate the onset of rebar corrosion.

Q32: Is a flow modeling recommended as part of the tank design and review process to simulate the impact of various storm events?

A32. Flow dynamic modelling may be available if supported by the manufacturer of the UGSWMF systems, however, such modelling is not a standard submission item required by current development review processes, unless required by a site-specific concern. Again, if water quality treatment is provided by upstream, treatment-train based processes, it is unlikely that sufficient sediment or other suspended particulates will be present to significantly affect concrete erosion rates, particularly if concrete mixtures can be provided that provide specific resistance to this scenario. In addition, the lower levels of UGSWMF columns are the areas exposed to flowing water most frequently, and water is generally spread evenly across the floor of the system after it leaves the incoming pipe. Therefore, the unit velocity and exposure to sand / debris (if present) would be low on any particular column. Lastly, the typical capacity of the incoming and outgoing pipes suggest that water does not flow quickly in any part of the tank system as a general function. In the case of sustained inflows and outflows controlled by gravity and the typical designs of hydraulic orifices and weirs, the main body of the tank will fill uniformly to the various design water levels. The only anticipated areas of significant flow velocity will be at the inlets and outlets. The main tank volume will generally flow vertically as the system fills up and empties.

Q33: Are there any specific warranty considerations with respect to UGSWMFs?

A33. WSP anticipates that UGSWMF warranties would be consistent with relevant standards for similar structures, such as pre-cast culverts, bridges and other hydraulic structures. Warranty clauses would need to be discussed with the project proponents on a site-specific basis and may

be related to the construction or development companies involved in its design and construction. Specific warranty considerations should include precast components for substandard concrete depth over rebar, out of tolerance structural dimensions, improper installation by manufacturer supervised contractors, etc. Vegetation installations above UGSWMF's should be warrantied similarly to 3rd party constructed municipal assets. Clauses on who is responsible for maintenance and inspection are likely site specific and related to the type and frequency of previous installations of similar products. Products and their suppliers that are being introduced to the municipality for the first time can be reasonably expected to be responsible for maintenance and inspection for a longer period of time.