SLR Consulting (Canada) Ltd.
200-300 Town Centre Boulevard
Markham, ON, L3R 5Z6

Tel: 905-415-7248

Memorandum – Privileged and Confidential

To:	**Justyna Boroch Hidalgo H.B.Sc., M.A., J.D.** Solicitor	**From:**	SLR Consulting (Canada) Ltd.
Company:	Legal and Risk Management Services, Corporate Services City of Hamilton		
cc:	**Mani Seradj, M.A.Sc., P.Eng.** Project Manager – Watershed Management	**Date:**	February 25, 2019
Subject:	**CONFIDENTIAL PEER REVIEW**		

1.0 INTRODUCTION

On behalf of the City of Hamilton, SLR Consulting (Canada) Ltd. (SLR) has conducted a third-party review of Wood Environmental & Infrastructure Solutions (Wood) report titled, *MECP Order # 1-J25YB Item 1b Chedoke Creek Natural Environment and Sediment Quality Assessment and Remediation Report, City of Hamilton*, dated January 24, 2019.

1.1 Review Objective

The purpose of the peer review was not to replicate the work that was completed by Wood, nor to prepare and provide revised recommendations. In conducting this peer review SLR:

- Conducted an independent review of the work completed by Wood to investigate the significance and scale of impacts to the creek system, including streambed sediment, water quality and natural environment related to the wastewater discharge event described below in Section 1.2 of this memo;
- Provided an opinion on the appropriateness and completeness of the scope of investigation and the investigation methods that were applied;
- Provided an opinion on the appropriateness and completeness of the conclusions and recommendations made in the report, including the ecological risks posed by the deposits identified in the Creek, proposed remedial alternatives, and the recommendation to physically remove the organic sediment within Chedoke Creek.

1.2 Background

SLR understands that potential water quality impairment in Chedoke Creek, along Desjardin Recreational Trail at Princes Point, has been brought to the City of Hamilton's (the City) attention suggesting a possible discharge from the City's sanitary collection system. Subsequent investigations on July 18, 2018 by the City identified dry weather discharges from the Main Street and King Street combined sewer overflow (CSO) facility to the creek system. Additionally, it was determined that this contamination has been entering the waterway since January 29, 2014, and that the discharge mechanism was further altered in January 2018 after a second flow control gate outside the CSO facility failed.

On August 2, 2018, the Ministry of Environment, Conservation and Parks (MECP) issued Provincial Officer's Order #1-J25YB (the Order) to the City in relation to the accidental discharge of untreated wastewater to the environment. The Order included requirements for the:

- Quantification of the volume and contaminant loadings associated with the sewage discharged from the Main-King CSO facility to Chedoke Creek between January 28, 2014 and July 18, 2018; and,
- Evaluation of the impacts to Chedoke Creek from the sewage discharge as outlined above.

To fulfil these Order requirements, the City retained Wood Environment and Infrastructure Solutions (Wood) (and their sub consultant Hatch) to quantify the spill volume and contaminant loadings associated with the wastewater discharge, and to complete an environmental site assessment, environmental impact assessment, and development of a remedial plan if needed (Wood, 2019). The following documents have been prepared:

- *Final Report for Wood Group/City of Hamilton - Quantification of Volume and Contaminant Loadings*, dated September 28, 2018 by Hatch.
- *Chedoke Creek Natural Environment and Sediment Quality Assessment and Remediation Report*, dated January 24, 2019 by Wood.

The City has asked SLR to provide peer review services related to the investigation and mitigation recommendations presented in the *MECP Order # 1-J25YB Item 1b Chedoke Creek Natural Environment and Sediment Quality Assessment and Remediation Report* (the Report). SLR has not reviewed MECP Order. SLR also understands that the *Final Report for Quantification of Volume and Contaminant Loadings* has been provided for context only, and that a peer review of this document is not included in the scope of this assignment.

SLR has completed the review of Wood report and has summarized comments based on the above scope.

SLR appreciates the complexity of the project and notes that the evaluation of each environmental media is generally thorough. The comments provided in this memorandum are based on our review which was completed over a limited timeframe and based on the information provided in Wood report only. The comments raised are provided for the City's consideration, and it is possible that additional information not reviewed by SLR would address some of the comments.

2.0 SLR REVIEW COMMENTS

2.1 Overall Approach and Study Design

The overall approach was relatively comprehensive in that it included five lines of evidence (LOE): sediment physical characteristics and chemistry, surface water chemistry, benthic invertebrate community, fish community and aquatic habitat observations. Each LOE was evaluated separately in the report prepared by Wood to determine if adverse effects were occurring. Very little integration of findings among LOE was provided.

Rather than provide a description of the study area for context and understanding, the report commenced with a stated purpose of the investigation and methods for characterization of sediment quality and natural environment. The report would benefit from a brief description of the study area and its surroundings including land use, terrestrial and aquatic features and a figure showing the Chedoke Creek watershed, perhaps with a detailed inset showing the study area and location of the Main-King CSO relative to Chedoke Creek.

SLR understands that the purpose of the assessment was to evaluate the current conditions in Chedoke Creek, assess the extent of impact associated with discharge from the CSO event into Chedoke Creek for the period January 2014 to July 2018 and ultimately to support remediation design alternatives, if appropriate. As such, it would be appropriate to include a section on what overall approach was used to evaluate the potential adverse effects resulting from exposure to the sediment contamination for the receptors of concern. Although, the methodology for sample collection and data analysis has been provided for each of the abiotic and biotic components, there does not appear to be a description of the overall approach to evaluate the current impacts of the event. In addition, no apparent criteria were provided to distinguish recent effects from those expected downstream from a normally operating CSO, nor to identify the parts of the study area that require management, nor to select the remedial options if required.

The following list briefly outlines the items which would provide a clear process for analyses and criteria for decision making if included as part of the overall approach and study design:

- Description of provincial and/or federal guidance documents relevant to the study.
- Selection of the receptors of potential concern (human and/or ecological) and a description of the protection goal for these receptors, as well as assessment endpoints.
- Selection of the lines of evidence and measurement endpoints. This would support the selection or exclusion of lines of evidence typically used to assess sediment contamination (e.g., toxicity test, benthic community structure assessment). This is warranted since the study seems to indicate that habitat characteristics (e.g., substrate) may affect benthic community independently of sediment contamination.
- Description of the approach used to assess the potential adverse effects for each of the LOE, including the extent and magnitude of effects. This is warranted because the overall study design does not seem to use reference site(s) in Chedoke Creek or in another urban creek with similar characteristics. Guidance on the assessment and management of contaminated sediment generally require comparisons to reference sites to support the evaluation of adverse effects. This is of importance for an urban system such as Chedoke Creek which is known to receive various point-source and non-point-source inputs.

- Description of the overall weight of evidence approach to evaluate the potential adverse effects. The report does not provide an integration of the different LOE to support an evaluation of potential risks to ecological receptors exposed to sediment contamination.
- Description of the approach to evaluate and select the remedial options (e.g., selection criteria, closure of data gaps).

2.2 Sediment Quality

2.2.1 Method of Investigation

The depth of the soft sediment has been measured based on sediment core refusal and used to provide an estimate of the soft sediment volume. The report recognizes uncertainty in the method used to estimate the volume of soft sediment as the coring locations were selected to provide sediment chemistry rather than sediment bathymetry information. While imagery for Chedoke Creek in 2013 and 2017 was provided it is unclear if this was used to inform the discussion on the Creek morphology and habitat. For example, Figure 5-3 shows the presence of depositional areas on the west side of the Creek in 2013 within the study area. In addition, although particle size information has been collected it is unclear if this information was used to inform the evaluation of sediment transport. Finally, the ongoing contribution of fines from other sources upstream of the study area (e.g., storm events, erosion, additional CSOs) does not seem to have been considered.

The sediment samples were submitted for analysis of parameters generally associated with CSO evaluation. SLR recognizes that it is not practical to include all contaminants of potential concern (COPC) that are known to be associated with municipal wastewater discharges (e.g., pharmaceuticals and personal care products; endocrine disrupting compounds). Additional sediment variables that could have been added to the list include total organic carbon (TOC), AVS and hydrogen sulphides. These would provide additional information for interpreting the sediment chemistry data (e.g., bioavailability of COPC) and the concentrations of organics in the sediment.

The evaluation of sediment quality was conducted according to recommended methods: comparison of analytical results to the Provincial Sediment Quality Guidelines (PSQGs), lowest effect level (LEL) and severe effect level (SEL), as presented in Table B1-2a to Table B1-2f. The evaluation of the analytical results for metals should also have included comparisons to background sediment concentrations for metals published by Ontario Ministry of Environment (OMOE, 2008). Comparisons to background would show that at some of the sampling locations, select metals exceeded the LEL but were below the natural background concentrations (e.g., cadmium, copper, nickel); thus, would not be considered metals of concern for the given sampling location(s).

As Wood correctly identified the existence of other sources of contamination (e.g., other CSOs and urban runoff), the study design should include sampling at appropriate reference location(s) to support the evaluation of impacts.

While it may not be feasible to isolate all sources of contaminants, this is not the fundamental issue requiring resolution. To determine whether and to what extent remedial actions are required it is more important to identify how conditions differ upstream and downstream from the CSO under investigation, or how conditions differ between a properly functioning, and permitted CSO, and the CSO under investigation, than to distinguish sources of all contaminants. Given the importance of this issue, the Wood report should state why differences in conditions upstream and downstream from the Main-King CSO, or for a reference CSO, were not, or cannot, be characterized.

2.2.2 Sediment Characterization and Evaluation of Adverse Effects

Sediment quality is discussed in detail in Section 3.2, Figures 3-2 to 3-5 and Tables B1-2a to B1-2f. The interpretation of sediment quality focuses on comparing the concentrations in the grab and/or core samples to the PSQGs and the evaluation of potential effects is limited. The discussion does not clearly identify parameters that are potential drivers of risk or discuss the magnitude of potential adverse effects. Potential adverse effects are discussed in general terms and do not relate to site-specific exposure of ecological receptors. As per one of OMOE (now MECP) guiding principles "*any remediation decisions will be based primarily on biology, not chemistry, since chemical PSQGs (or other criteria in the absence of a PSQG value) are not clean-up numbers by themselves and need to be used in a risk assessment framework*" (OMOE, 2008)

The process of organic waste degradation, its measurement through biochemical oxygen demand (BOD) and its effects on dissolved oxygen (DO) levels are clearly explained in Section 3.2. The section on BOD and DO (page 9) reads that: *"low dissolved oxygen concentration associated with the organic sediments in Chedoke Creek likely reduces the diversity of benthic invertebrates and favours a few tolerant species. This, in turn, limits the available food sources for fish*". The Canadian Council of Ministers of the Environment (CCME) has derived guidelines for DO. These guidelines should be used to support the above statement as well as describing the extent of the potential adverse effect. For example, the report reads that: "*the highest porewater BOD results were found at sample transect C-5/G-6 immediately upstream of the Princess Point bridge, as shown on Figure 3-2, with the next highest BOD value observed at the G-3 sample transect located upstream of the Kay Drage Park bridge. These results indicate organic compounds are present in higher amounts at these sample locations and therefore require more oxygen for microbial metabolism, which typically suggests impaired environmental quality***."** Chedoke Creek is described as a warm water system. The CCME DO guidelines for warm water system specify lowest acceptable DO concentrations of 6 mg/L for early life stages biota and 5.5. mg/L for other life stages. Based on an interpretation of Figure 3-2, location G6 appears to be below the guideline for early life stages but not for other life stages. Location G3 appears to have DO concentration above the minimum guidelines, this appears to contradict the above statement.

The evaluation of bacterial indicator species indicates that concentrations have been declining during periods when no sewage discharge is occurring but note that periodic discharge to Chedoke Creek present ongoing potential sources of bacteria. The presence of bacteria in sediment within the creek is identified, in the report, as a potential ongoing risk to human health via direct contact. While the term "risk" is used, a risk assessment including an evaluation of the potential human receptors and potential exposure pathways is not provided in the report.

The evaluation of the nutrients (TKN and TP) shows that concentrations exceed the LEL but are below the SEL. The report also indicates ongoing sources of nutrients in the watershed and suggested historical enrichment prior to the Main-King CSO event. The report notes that the "*sediments contain a level of contamination that can be tolerated by the majority of sediment-dwelling organisms, but not necessarily stress-intolerant taxa*." Additional considerations should be given to whether stress-intolerant taxa would be expected, notwithstanding the event, to inhabit the study area based on the historical ongoing sources of nutrients or potential limitations imposed by habitat characteristics.

Comparisons to the PSQG indicate that various metals at locations C1, C2, G1, G2, G3, G4 and G5 exceed the LEL but are below the SEL. According to Ontario MOE sediment management framework this indicates "*that material fails the guideline and it is anticipated that such material may have an adverse effect on some benthic biological resources."* At locations C3, C4, C5 and C6, one or more metals exceed the SEL. Exceedances of the SEL in the surface horizon (< 15cm) are limited to copper in one sample at location C3, C4 an C5. According to Ontario MOE sediment management framework this indicates "*that material is considered highly contaminated and will likely have a significant effect on benthic biological resources*." The report provides a generic description of impact for metals: "*unlike nutrients, metals pose a direct toxicity to living organism and removal of soft sediment material containing these metals would likely be beneficial to the ecological conditions within Chedoke Creek and downstream*". This generic statement should be supported by the biological assessment results (benthic invertebrates) and/or toxicity tests, as per OMOE guidance mentioned above.

The evaluation of PAHs indicates that most individual PAHs exceed the LEL at all sampling locations but are below the SEL. As with metals and nutrients, the report indicates that several sources of PAHs exist in the watershed.

Generally, the nutrients, metals and PAHs contamination has not been delineated vertically. The implications of the lack of vertical delineation should be discussed as part of the evaluation of remedial options.

2.2.2.1 *Sediment Section - Minor Points for Edit*

Section 2.1.1, page 2, second paragraph, the report reads that cores have been separated into individual containers for analysis to provide depth related assessment of parameters of interest. Text should be added to clarify if the replicates (for each depth horizon) were homogenized prior to being submitted for analytical chemistry.

Quality assurance/quality control criteria were not presented in the report (e.g., blind field duplicates).

Table notes for Tables B1-2a to 2f indicate that exceedances of the SEL were formatted as bold, underlined and shaded. It seems that this rule has not been applied consistently, for example copper exceedances above the SEL were not consistently underlined.

SEL have been provided for PAHs, those were not shown in Table B1-2a to 2f. All the PAHs in sediment are below the SEL (assumed at 1% TOC).

2.3 Benthic Invertebrate Community

2.3.1 Method of Investigation

Benthic invertebrate samples were collected following the Ontario Benthic Biomonitoring Network protocols. These are considered industry standards and appropriate for this study.

The date at which the sediment grab samples were collected does not seem to have been provided. The time of sampling has potential implications on the species observed (e.g., period of emergence of some taxa as adults). This timing will also be important for any comparative analyses with future monitoring events.

While the report indicates that no data were available to characterize the benthic invertebrate community structure prior to the event, the study design does not seem to include reference sites either on Chedoke Creek or on a creek with similar characteristics. The lack of appropriate reference sites precludes a comprehensive evaluation of adverse effects and their significance.

The report uses several metrics to inform data interpretation and indicate general aquatic ecosystem health (%EPT, Simpson's Diversity Index, Hissenhoff Biotic Index) which are common and appropriate for this study. However, once normalized for differences in physical habitat, there are no statistical analyses of these metrics among sampling locations.

While sediment grab samples were collected concurrently and submitted for analytical chemistry, particulate size and benthic invertebrate community structure analysis, the interpretation of results does not seem to integrate this information.

The study design for the benthic invertebrates does not specify the assessment endpoint (e.g., functionality of benthic invertebrate community as fish food). The sampling method and measurement endpoints (e.g., biotic indices) are clearly described; however, the evaluation framework to support the identification of the adverse effects is not provided as part of the methodology. Without pre-established decision criteria and rationale, interpretations may appear arbitrary.

2.3.2 Analysis and Evaluation of Adverse Effects

SLR agrees that chironomids and oligochaetes are generally considered tolerant to pollution. Although each group contains species with varying tolerance levels, certain taxa may be indicators of pollution. The analysis does not seem to discuss *genera* known to associate with elevated nutrient levels. Such analyses may be more diagnostic than general tolerance indicators and may demonstrate relationships between the CSO event and the benthic invertebrate biota.

The report presents information on sediment grain size associated with benthic invertebrate sample collections and notes that upstream sample locations contain coarser substrates than downstream sampling locations. Figure 4-1 shows a general upstream to downstream decline in Simpson's Diversity and Total Invertebrate Density. The report states, '*Differences in habitat complexity are known to influence community metrics, such as taxa richness*', but neither describes *how* habitat complexity influences community metrics, nor *whether* observed differences are within the expected range of variation. The benthic invertebrate results recognize presence of taxa tolerant to environmental stress but not whether presence and abundance is outside the range of expectations for locations within the study area.

The report links dominance of tubificids and chironomids as indications of degraded sediment quality and surface water quality and habitat. However, current water quality was not compared to Provincial Water Quality Objectives (PWQO) nor to CCME guidelines thus limiting the ability to make conclusions on potential effects of water quality on benthic invertebrates.

There is no integration of benthic invertebrate results to sediment chemistry, however grab samples were collected for both chemistry and benthic community analysis.

Lack of integration of benthic invertebrate results with water quality and sediment quality and lack of interpretation of benthic invertebrate sample variation limits the use of this line of evidence to determine whether and to what extent mitigation associated with the CSO event is required.

An alternate approach including reference sites to allow comparison and interpretation of effects such as an upstream location or a similar creek in the area may have revealed appropriate reference sites for comparison. Such an approach would facilitate interpretation of results and review of the report.

2.4 Fish Community

2.4.1 Method of Investigation

Assessment of fish communities was undertaken using data collected by the Royal Botanical Gardens (RBG) from 2001 continuing through 2018. These collections allowed for comparison of fish community characteristics prior to and during the CSO event into Chedoke Creek from January 2014 until July 2018. Before-after and upstream-downstream comparisons represent a powerful study design to assess effects of spill events such as the one reviewed here, however owing to an extended culvert upstream from the CSO, comparable upstream fish collection may not be possible and only before and during overflow fish data comparisons could occur.

The report developed several metrics to inform data interpretation and indicate general aquatic ecosystem health:

- Abundance: estimated as number of fish per 50 m transect
- Species richness
- Total catch
- Relative proportion of generalist, piscivore and specialist species
- Relative proportion of stress tolerant, intolerant and intermediate species

The report proposed these metrics as a '*general indicator of health, and to provide a baseline for comparison to the same metrics following remedial actions*' (page 5). While these indicator metrics may collectively allow an interpretation of ecosystem health, some of the metrics are undefined, thus limiting usefulness to identify effects associated with the CSO event. For example, the report identified tolerant species (carp, suckers, sunfish, bass) without characterizing tolerance (eg., to warm or cold water temperatures, general habitat degradation, general urbanization, high levels of metals, nutrients, PAHs, DO, BOD).

2.4.2 Analysis and Evaluation of Adverse Effects

Indicators such as abundance, species richness and total catch may be useful as general indicators of health, however the MECP Provincial Officer's Order specifically required '*evaluation of impacts to Chedoke Creek from sewage discharged from the Main-King CSO facility to Chedoke Creek'*. Specificity of this direction provided Wood the opportunity to explore, develop and evaluate diagnostic indicators to assess effects related to sewage releases. What steps, if any, were taken to develop specific indicators to link changes in fish community characteristics to specific impacts associated with sewage discharge?

The report also refers to generalist and specialist species but does not define whether these species represent specialization, or generalization, in terms of habitat use, spawning or young rearing requirements, feeding habits, or other factors.

The report refers to sunfishes and basses as '*tolerant species*' (page 19). Fausch et al. (1990), a reference cited in the report, identified bass (sunfish are in the same family as bass) as indicators of high quality stream reaches because they were the first fish species to disappear downstream from sewage outfalls, this in contradiction to how bass and sunfish are used in the report.

The report neither characterizes variation associated with fish collections from various locations over time, or in comparison to reference locations, nor specifies what amount of change in fish community characteristics would be considered significant. Figure 4-3 and Figure 4-4 show variation in fish community indicators for four locations from 2001 to 2018 but without characterization of variation and threshold criteria for change, meaningful interpretation of the data is difficult and may appear arbitrary.

The report states, '*The relative proportion of piscivore species at transects C1 and C2 within the creek has increased recently (2017 to 2018), possibly suggesting recent improvement of environmental quality, since the proportion of top-piscivores are indicative of healthy fish communities*' but also concludes, '*In general, the fish community survey data show changes typically indicative of environmental stresses during the discharge event time period*' (page 19). The report does not appear to resolve these seemingly contradictory statements.

Confidence in these conclusions should be considered carefully given the lack of criteria for determining significant change, vague definitions for identification of species tolerance, sensitivity and specialization, as well identification of species tolerance contrary to findings in the peer reviewed literature.

The report should explain why integrative analyses of fish and water quality data were not considered. For example, the report shows results for total suspended solids (TSS). Given that fish exhibit a stress response to TSS ranging from behavioural avoidance to altered feeding habitats and physiological changes that can result in death when exposed to high TSS for sufficient duration (Newcombe and Jensen 1996), findings from fish community analyses could have been compared with water quality results to confirm whether findings corroborate anticipated trends. Fish species also show a range of sensitivity to dissolved oxygen, turbidity and other parameters associated with sewage discharge, and have demonstrated differences in relative abundance in response to effects of sewage discharge and sewage treatment in Toronto area waters (Wichert 1994; Wichert 1995).

2.5 Aquatic Habitat

2.5.1 Method of Investigation

Field observations at each sample location included photographs facing upstream and downstream, as well as examples of instream cover, structures and riparian habitat. Habitat characteristics were not reported specifically for individual fish and benthic invertebrate sampling sites, nor were habitat field sheets included in the report or its appendices, thus limiting the usefulness of habitat information to qualify biological sampling results.

2.5.2 Analysis and Evaluation of Adverse Effects

Recorded observations show an upstream to downstream transition in channel morphology and flow. Upstream near the CSO the stream channel showed sloping banks, flat bottom, meandering thalweg and boulders throughout the channel. Further downstream the bank included an armour stone wall, riparian vegetation and in stream large woody debris. Overhanging trees provided cover and instream structure in the form of eroded tree roots occurred approximately 200m downstream from the CSO. Waterflow toward Cootes Paradise was no longer evident approximately 400 to 500m downstream from the CSO implying water elevation in Chedoke Creek equilibrated with water elevation in Cootes Paradise.

Change in water movement from upstream flowing conditions to downstream stillwater conditions may imply change from dynamic upstream sediment transport to downstream zone of sediment deposition. These changes in habitat may influence composition of fish and benthic communities independent of the CSO event, however the potential implications were not discussed.

2.6 Water Quality

2.6.1 Method of Investigation

The evaluation of water quality is based on available analytical data for samples collected by third-parties between 1999 and 2018. Section 2.3 of the report indicates that water quality is available for numerous parameters for one or more locations upstream and downstream of the Main-King CSO. The report does not describe the data manipulation and processing (e.g., QA/QC, censoring, differences in analytical methods).

The analysis of water quality focuses on statistical comparisons of the water quality at select locations before and after the Gate 1 opening. The comparisons are provided as time series plots for select parameters and locations. An overall depiction of the concentrations of each parameter along the full length of the Creek (upstream, at CP-11 and downstream) seems to be missing from the report. In addition, the available plots do not include comparisons against federal or provincial water quality guidelines (CCME or PWQO) for the protection of aquatic life (e.g., a line representing the PWQO could be added to the plot). This information would support the evaluation of effects on benthic invertebrates and fish.

While the plots seem to indicate that the analytical data are available for late 2018, after the gate's correction (September and/or October 2018), these data were not used to evaluate the current water quality against federal or provincial water quality guidelines for the protection of aquatic life. For this reason, an identification of the potential COPC under current conditions in surface water is not available from the report. As indicated above, this information would support the evaluation of effects for benthic invertebrates and fish.

2.6.2 Surface Water Characterization and Evaluation of Adverse Effects

While the surface water quality analysis demonstrated a change in water quality (increase or decrease in concentrations) at select locations, the analysis did not address water quality in the context of PWQOs for the protection of aquatic life. The surface water quality dataset has not been used to identify surface water COPC, evaluate the extent and magnitude of exceedances above applicable PWQOs and/or relates the findings to the receptors that can be exposed to the surface water COPC, such as fish.

The surface water quality analysis generally showed that TP and *E. coli* concentrations increased in Chedoke Creek downstream of the outlet during the event and returned to pre-event concentrations after the event in 2018. The analysis of surface water quality is inconclusive regarding the potential impacts of the discharge event on downstream locations within Cootes Paradise.

The water quality assessment notes that "*TSS concentrations appear fairly similar between 2009 and 2018 at stations CP-1, CP-2 and CP-20*" (downstream locations). Figure 4-23 seems to show that TSS concentrations at CP-20 were lower during the event. The water quality assessment also reads that "*in general, the medians at stations CP-11 for TP, E. coli and TSS were lowest prior to 2014, increased between 2014 and 2017, increased again in early 2018 and decreased in late 2018*". While this seems to be the case for TP and *E. coli*, Figure 4-17, shows the opposite for TSS: the median for TSS was higher prior to 2014 and decreased between 2014 and 2018. There seem to be uncertainties regarding the sources and variability of TSS in Chedoke Creek. This is an important point because the soft sediment in the study area has been attributed to TSS load discharged to Chedoke Creek between 2014 and 2018.

2.7 Report Conclusions and Recommendations

2.7.1 Report Conclusions

As indicated in the introduction, SLR was asked to provide an opinion of the appropriateness and completeness of the conclusions made in the report, including the ecological risks posed by the deposits identified in the Creek, proposed remedial alternatives, and the recommendation to physically remove the organic sediment within Chedoke Creek.

The report lacks a conclusion section between the interpretation of results and the recommendations. In addition, the approach to data interpretation did not follow the general risk assessment framework, which represents a valid basis for a decision as to whether and to what extent mitigation is required; thus, a determination on whether the sediment pose an unacceptable risk to ecological receptors is not made in the report. The report did not provide other standards or criteria on which to identify adverse effects to ecological receptors.

SLR reviewed the data interpretation sections to identify the conclusions that were made for each LOE. The following summarizes SLR understanding of the conclusions and the level of uncertainties associated with them:

<u>Section 3.1, Sediment Characterization:</u> Soft sediment thickness across the sample location transects showed greater accumulation of sediments along the west shoreline throughout the creek. In general, the upstream sample locations contained less soft sediment compared to the most downstream sample locations. There is a high level of uncertainty associated with the physical sediment characterization due to the limited number of samples and the fact that the sampling locations were selected to provide information on the sediment chemistry. In addition, there is no information on sediment transport.

<u>Section 3.2, Sediment Quality:</u> The assessment of sediment quality concluded, based on bacteria analysis, that: "*pathogenic contamination of the sediment within Chedoke Creek may present ongoing risk to human health*". While this statement may be correct, it is associated with a high level of uncertainty since the report does not identify potential human receptors, exposure pathways and does not characterize the risks.

The assessment of sediment quality concluded, based on nutrient concentrations, that: "*nearly all TKN concentrations in surface strata were above the PSQG LEL (550 µg/g), suggesting these sediments contain a level of contamination that can be tolerated by the majority of* *sediment-dwelling organisms, but not necessarily stress-intolerance taxa*". There is a high level of uncertainty associated with the sources of nutrients as the results suggest that TKN and TP enrichments have occurred downstream in Cootes Paradise prior to the event, but it remains unclear when, or how, the enrichments occurred.

The assessment of sediment quality concluded, based on metals concentrations, that: "*unlike nutrients, metals pose a direct toxicity to living organisms and removal of soft sediment material containing these metals would likely be beneficial to the ecological conditions within Chedoke Creek and downstream.*" This statement represents a generic conclusion with a high level of uncertainty as it is not supported by a risk assessment or toxicity tests. There is a high level of uncertainty associated with the sources of metals as per the following statement made in the report:" *The 2018 results suggest legacy metal enrichment has occurred (prior to the Main/King CSO event), and removal may be beneficial. However, it is important to note other potential sources of metal enrichment are ongoing and likely occurred prior to the discharge event. These include, but are not considered limited to, other operating CSOs (e.g. Royal Tank) located upstream, the storm water drainage from the adjacent highway infrastructure and runoff from upstream urban environs (i.e., extensive roadway network) discharging to the creek, as well as other upstream sources (e.g., industrial and landfill sources). As noted earlier, establishing a clear distinction between legacy and event-based contamination is not considered feasible with the available data.*"

The assessment of sediment quality based on concentrations of PAHs showed that individual PAHs were frequently above the LEL but below the SEL. There is also a high level of uncertainty regarding the source of PAHs: "*As noted, the PAH concentrations of soft sediments within the creek do not solely represent impacts attributable to the discharge event and include other confounding factors such as other sources of contaminants (e.g., other CSOs and urban runoff), however isolating these sources with the current data is not considered feasible*."

The assessment of sediment quality shows that the highest concentrations are often found in the deeper sediment. There is a high level of uncertainty associated with these observations as it indicates that the sediment contamination has not been vertically delineated. The vertical distribution of COPC should also have been used to support the effect assessment because most sediment-dwelling organisms live in the surficial sediment (< 10cm). This is consistent with OMOE guidelines (OMOE, 2008) indicating: "*Benthic community structure assessments will also not be possible for sediments deeper than about 10 cm because the vast majority of the sediment-dwelling organisms live in shallower depths than 10 cm although some organisms (e.g., some bivalves) can burrow much deeper*."

<u>Section 4.1, Benthic Invertebrate Community:</u> The assessment concluded that Chedoke Creek represents an environmental degraded system based on the selected metrics. There is a high level of uncertainty with this assessment because the lack of appropriate reference sites or data collected prior to the event preclude a comprehensive evaluation of adverse effects and their significance. In addition, benthic invertebrate findings were not integrated with water quality and sediment quality findings and not related to sediment grain size to corroborate variation in benthic community metrics with habitat characteristics.

<u>Section 4.2, Fish Community:</u> The report states, '*In general, the fish community survey data show changes typically indicative of environmental stresses during the discharge event time period*' but also states, '*The relative proportion of piscivore species at transects C1 and C2 within the creek has increased recently (2017 to 2018), possibly suggesting recent improvement of environmental quality, since the proportion of top-piscivores are indicative of healthy fish*

communities' but also concludes (page 19). The report acknowledges *'some recent (2018) data suggest improvement in some community metrics and future monitoring will be required to confirm these early trends*'. Confidence in these conclusions should be considered carefully given the lack of criteria for determining significant change, vague definitions for identification of species tolerance, sensitivity and specialization, as well as identification of species tolerance contrary to findings in the peer reviewed literature.

<u>Section 4.3, Aquatic Habitat</u>: Aquatic habitat field observations documented substrate characteristics, water flow patterns, channel morphology, presence and location of cover and woody debris and riparian habitat in order to support interpretation of sediment and water quality data and biotic data. This potential habitat influence was referred to in the benthic invertebrate results (Section 4.1 of the report), however the potential implications were not discussed. Fish community results were not discussed with respect to aquatic habitat features in the report.

<u>Section 4.4, Water Quality Assessment:</u> The surface water quality analysis demonstrated a change in water quality (increase or decrease in concentrations) at select locations before, during and/or after the event but have not been used to evaluate the effects of the discharges. The report refers to "*degraded conditions in the water column*" (p. 19). This statement is not supported by an analysis of surface water analytical results (e.g., comparison against WWQG and/or PWQO) representing current conditions in Chedoke Creek.

<u>Integrated conclusions</u>: The observations made for each environmental media are not assessed and incorporated into an integrated conclusion to determine if adverse effects are occurring: to identify the ecological receptors potentially at risk, to evaluate the nature, severity, and areal extent of such adverse effects; and to identify the risk drivers causing or substantially contributing to adverse effects.

The CSO event from 2014 to 2018 may have resulted in alterations to sediment quality and water quality causing negative effects to downstream biota in Chedoke Creek. However, these effects cannot be established with confidence given the approach, study design, decision criteria, and data interpretation presented in the Wood report.

2.7.2 Report Recommendations

The report identified and described remedial options including no-action (e.g., do nothing option), physical capping, chemical inactivation and direct removal (e.g., dredging). Based on the information reviewed, SLR agrees with the assessment concluding that physical capping and chemical inactivation are not the preferred remedial options, if required. The direct removal option was selected. It is SLR's opinion that the uncertainties associated with the current assessment do not fully support the direct removal option.

An apparent incongruity appears between Sections 1 to 4 of the report and Section 5 Remedial Action Plan. Sections 1 to 4 describe methods and results associated with assessment of sediment quality, water quality and natural environment (benthic invertebrate and fish communities). Findings related to sediment quality, water quality and natural environment show high levels of uncertainty, and some potential evidence of stress and some potential evidence of recovery, however these statements are provided with caution because robust approaches to provide more certainty in these conclusions were not applied. In any case, compelling evidence supporting remedial action was not provided in the report.

Incongruity appears in Section 5 because support for the Remedial Action Plan appears not to rest on the basis of findings from sediment, water and natural environment analyses focused on Chedoke Creek but rather from speculation on the fate and potential impact of potential loadings to Cootes Paradise that appear inconclusive: '*It is unclear whether the Cootes Paradise stations CP-1, CP-2, and CP-20, have been directly impacted by the Chedoke Creek discharge event* (Wood 2019).

Based on the information provided in the report, it is unclear if the COPC in the sediment are causing adverse effects to ecological receptors. In addition, because of ongoing sources, it is unclear if sediment dredging will ameliorate the current conditions or if the potential for recontamination has been evaluated. The report suggests that sediment removal will likely not restore Chedoke Creek. Section 5.2.1. of the report reads: "*As noted earlier, the source of the material is not certain and conditions prior to the spill event suggest that the ecological conditions of Chedoke Creek had already been significantly impacted, so removal is not likely to restore Chedoke Creek*". The report indicates that sediment removal would be beneficial to the downstream receiving environment: Cootes Paradise. A high level of uncertainty is associated with this statement because nutrient enrichment has occurred in Cootes Paradis prior to the event and because it appears that most of the TP mass load (about 90%) has already been solubilized or transported downstream. In addition, the report does not discuss whether sediments in Chedoke Creek are in a state of relative equilibrium in terms of sediment transport, which could also influence interpretations. Also, the report does not include a comprehensive characterization or discussion of biological effects for Cootes Paradise.

A discussion of the presence of higher concentrations of COPCs at depth and lack of vertical delineation is missing from the analysis of the removal option. Finally based on the information provided in the report it is unclear if all three management units will be remediated equally or if the remediation of selected areas, based on the severity of effects, has been considered. Other options such as partial or no sediment removal in association with a risk assessment do not seem to have been considered.

3.0 REFERENCES

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4.0 CLOSURE

SLR is pleased to carry out this review on behalf of the City of Hamilton. Should you have any questions, please do not hesitate to contact the SLR team members listed below:

Team Member	Role	Contact Information
Celine Totman, M.Sc., RP.Bio Senior Scientist	Sediment and Surface Water Lead	(604) 738-2500 ctotman@slrconsulting.com
Gord Wichert, Ph.D., RP.Bio. Senior Ecologist	Fisheries and Aquatic Habitat Lead	(905) 415-7248 gwichert@slrconsulting.com
Kimberley Tasker, M.Sc., RP.Bio. Senior Ecologist	Benthic Invertebrate Lead	(905) 415-7248 ktasker@slrconsulting.com