Master Drainage Plan

PURPOSE:

This document provides guidance for the preparation of a Master Drainage Plan which may be required for the submission of an application under the *Planning Act*. All Master Drainage Plans shall follow the requirements referenced in this document.

A Master Drainage Plan (MDP) is a technical plan/report that provides information regarding the current and future drainage needs of a given community in the context of sustainable development, and the natural and human environment. A Master Drainage Plan focuses on a broader context than a Sub-Watershed Plan, which addresses local issues for drainage areas within a Watershed Plan. The intent of this plan is to support land use planning and infrastructure planning, to allow and facilitate informed decision making, and to improve the efficiency and effectiveness of the municipal land use planning process.

The Master Drainage Plan shall be conducted in three stages:

- Stage 1: Subwatershed Characterization
- Stage 2: Subwatershed Management Strategies
- Stage 3: Implementation and Monitoring Plans

Each stage shall conclude with the preparation of a study report.

A Master Drainage Plan is required for a Planning Application in support of the following planning processes / development application types:

- Official Plan Amendment;
- Draft Plan of Subdivision/Condominium;
- Site Plan Control; and,
- Consent to Sever.

The objectives of the Master Drainage Plan are as follows:

The Master Drainage Plan is intended to present an approach to managing resources that will protect, enhance, and rehabilitate the environment within the study area limits and downstream. The Plan will provide the following:

- Identification of the location, extent, present status, significance, and sensitivity of the existing natural environment;
- Identification of sensitive areas and hazardous lands, and recommendation of buffers and appropriate management practices related thereto;
- Identification of lands where development may be considered;
- Determination of how existing and future land uses can be developed compatibly with natural features;
- Direction on best management practices (BMPs) (from a drainage perspective);
- An implementation strategy and requirements for environmental monitoring; and,
- Technical information to assist in the completion of a Class Environmental Assessment process.

PREPARED BY:

A Master Drainage Plan must be prepared by a qualified Civil Engineer (C.Eng.) with input of other engineers and scientists, which may include the following areas of expertise: Water Resources, Geotechnical, Hydrogeology, Environmental Science, Fluvial Geomorphology, or Planning.

The Master Drainage Plan must be sealed, dated, and signed by a Professional Engineer (P.Eng.).

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The applicant is encouraged to discuss the need, scope, concepts and design assumptions with City staff and the Conservation Authority(ies) having jurisdiction over the lands prior to preparing the report. Portions of the City of Hamilton are within the jurisdiction of Hamilton Conservation Authority, Conservation Halton, Grand River Conservation Authority and Niagara Peninsula Conservation Authority.

The Master Drainage Plan must provide sufficient engineering and Natural Heritage System information to allow for the necessary review and acceptance of the proposed drainage schemes in principle. The Plan shall be conducted in three stages, as outlined in the following sections.

1.1 Stage 1: Subwatershed Characterization

Characterization of the study area includes identification and assessment of features through desktop study, field reconnaissance and detailed fieldwork, as well as preliminary identification of issues and opportunities. Documents to be reviewed as part of this process include City planning documents, primary plans, and mapping as well as studies specific to the study area as may have been prepared by or for the City, landowners, Conservation Authorities, and other agencies. Through the Pre-Consultation process, City staff can assist with identification of available background information that must be considered.

Background data used shall be documented in an accepted bibliographic format. A brief summary of each background study referred to shall be provided in the Subwatershed Characterization report. Following review of background data, gaps in the data shall be assessed and a proposed program for collection of missing data shall be prepared.

It is strongly recommended that the proposed scope of study be reviewed and confirmed with the City of Hamilton and other relevant agencies prior to commencement of the specific study.

Studies required in support of the Subwatershed Characterization include:

1.1.1 Hydrology and Hydraulics

Background information on the study area is to be collected from all available sources, referring to Appendix A: Suggested Data Collection Requirement. Maps of the associated data collection locations shall be provided. In addition, the mapping of the watershed’s physical features (e.g., watershed boundary, major watercourses, drainage swales and wetland features) shall be verified, and subwatersheds shall be delineated,

and nodes at points of interest shall be established with development interests, environmental features, and / or watercourse system importance.

A detailed hydrologic model shall be developed and calibrated for the subwatersheds' existing condition for all events storms, ranging from 25 mm, 2, 5, 25, 100 years up to and including the Regional Storm. The model shall be a continuous, deterministic, hydrologic model, with a strong physical representation of surface runoff, baseflows, and surface and groundwater interaction. Modeling completed for previous studies may be available that can be updated or refined.

A water balance model shall be developed based on the output of the hydrologic model and hydrogeology of the area. The water budget shall include a monthly estimate of precipitation, evapotranspiration, runoff, and infiltration, including groundwater recharge / discharge estimations. The present low flow status shall be evaluated, and the constraints associated to water taking and land use changes shall be identified with reference to the specific locations of interest.

The successful proponent shall be responsible for the numeric modelling to establish the baseline hydrology and hydraulics of the subwatershed systems. The model will be calibrated based upon historical rainfall and flow monitoring data. The exercise should meet the accuracy and completeness to provide a comprehensive understanding of the existing condition of the study area, including an inventory of creeks, road crossings (culverts and bridges), stormwater facilities, etc. The current drainage systems and outlets shall be identified with drainage constraints and opportunities. The intent of modelling is to provide the details required for secondary planning, and identify additional criteria for water quality control, baseflow targets, infiltration targets, erosion, and flood control targets.

The flows at the subwatershed outlets in the calibrated model shall be compared to those determined in previous watershed studies for the given watercourses if such studies exist. The differences in the flow values shall be explained (e.g., more detailed information, change in watershed boundaries). The model input parameters shall be compared to previous studies and modified to represent the more detailed

subwatershed model. Hydrographs are to be established at the key nodes in the study area for all event storms, from 2-year to up to and including the Regional Storm. Model calibration will include the latest available data, incorporate the stream morphology observations.

For watercourses located in the study area, hydraulic analysis shall be conducted. Flood lines shall be established for the Regulatory Storm for existing conditions. For the creeks that have flood hazard delineation, as identified in previous studies, the flood lines shall be updated to reflect current conditions based on recent topographical data. The flood hazard delineation includes the hydraulic modelling, using the Hydrologic Engineering Centers River Analysis System (HEC-RAS) model from the U.S. Army Corps of Engineers, to generate the associated flood lines based on the hydrographs established with the hydrologic analysis conducted for this subwatersheds study. It should be noted that there are limitations with the use of HEC-RAS model, where topography is predominantly flat. The successful proponent shall undertake an assessment of the subwatersheds within the study area and identify through consultation with the Conservation Authority(ies) which features should be subject to flood plain evaluation. The Conservation Authorities' Flood Plain Mapping Standards should also be referred to, as to the approaches for survey, hydrology, hydraulics, and flood hazard maps.

The proposed detailed hydrology plan for this study is included in Appendix B: Proposed Hydrology Plan. The plan includes:

- Model platforms shall be confirmed with City and Conservation Authority(ies) staff;
- Modelling is to be established for discrete design event simulations, to produce runoff hydrographs at the nodes of interest in the study area and to size the required Stormwater Management (SWM) facilities; and,
- HEC-RAS should be used for determination and / or updating of the existing river hydraulics and flood elevations.

Justification of the applicability and sufficiency in utilizing any of the given numerical models shall be provided. The modelling exercises should ensure the hydrology and

hydraulics features are quantified for each watershed within the study area. Future City and Conservation Authority use of the model, and model results, must be considered. The model or model result shall be converted to the City's operational models, i.e., MIKE-SHE and MIKE-URBAN models. Further monitoring may be required, in addition to the existing rain gauges and flow monitoring stations that can be used for the study area.

1.1.2 Hydrogeology

The goal of this subwatersheds study with respect to hydrogeology is to establish a geological conceptual model for the study area, determining the key characteristics of the bedrock and overburden systems, in addition to their functions in terms of controlling groundwater movement, availability, and quality in these subwatersheds. An integral component is to assess the interactions between the groundwater system and the surface water system, and to determine the overall role or function of these interactions in an ecosystem context. It is also important to have an understanding of the effects of future development on the local groundwater resource to assist in the need for and implementation of low-impact development.

To accomplish the above goals, all of the data collected in Stage 1 shall be integrated to develop a detailed understanding of the hydrogeological processes operating within the subwatersheds. To that end, the following shall be completed:

- Conduct a detailed site reconnaissance to identify surface watercourses, areas of visible groundwater discharge and recharge, and areas of groundwater piezometer installations. Focus shall be placed on identification of sinkholes and their outlets typical of karst topography, if present within the study area;
- Carry out a karst geology study of the site to the satisfaction of a karst expert. The study shall identify any significant karst features, delineate any hazardous lands because of karst, and identify and characterize key subsurface flow paths within the karst. Groundwater tracing using fluorescent dyes may need to be carried out at selected locations to

understand subsurface hydrology and geology;

- Review and compile the following hydrogeological information from the relevant Source Protection Plan; Identify and address any data gaps:
  - General delineation of aquifers and karst topography;
  - Well locations as obtained from the MOE well record database;
  - Areas of ground or surface water takings as permitted by the MOE;
  - Areas of significant groundwater recharge or discharge;
  - Areas susceptible to contamination; and,
  - Areas suitable for stormwater infiltration;
- Install and monitor groundwater piezometers across the study area, when considered necessary, to determine water table levels, assess shallow groundwater flow directions, and determine the functional relationships between the shallow aquifers and watercourses/wetlands;
- Measure stream flow at appropriate locations along the watercourses, to identify areas of groundwater recharge/discharge and establish baseflow conditions. The stream flow monitoring program should first utilize existing monitoring data from sources of Conservation Authorities, municipalities, and other available studies. The monitoring could also be combined with the flow monitoring that is necessary to calibrate the hydrologic model;
- Identify potential impacts of construction and development on the features and functions of surface water and groundwater systems;
- Identify hazard lands in GIS mapping (particularly those relating to karst), in accordance with MNR Guidelines, regarding the Natural Hazards Policies of Section 3.1 of the Provincial Policy Statement.

The proposed detailed hydrogeology plan for this study is included in Appendix C: Proposed Hydrogeological Plan.

1.1.3 Stream Morphology

Some of the objectives concerning aquatic habitat are to protect the morphological and fluvial character of the streams, restore sinuosity (where appropriate and feasible), maintain physical habitat attributes (e.g., pools, riffles etc.) diversity and fluvial

processes (e.g., bed load transport, energy reduction through sinuosity, etc.), and to prevent increases in erosion and deposition through the maintenance of the hydrological regime.

The study shall include review of data collected from all sources and shall confirm and update the existing information. Where unavailable, the successful proponent shall characterize each reach of the watercourses using the Rosgen classification system, or other industry standardized methods. Baseline data requirements and standards for downstream monitoring shall be based on the assessment of a qualified fluvial geomorphologist. A baseline morphologic assessment, according to stream characterization and flood /erosion considerations, are expected including a detailed inventory of the stream morphology observations.

1.1.4 Channel Erosion

The study shall undertake an existing conditions erosion potential analysis, based on the erosion data collected to understand the erosion processes, and to identify areas which are highly prone to erosion, where erosions are occurring, or where structures may be at risk. The erosion potential analysis is also to determine the threshold flows for erosion at strategic points in the subwatersheds. Assessments will identify sites most sensitive to erosion, with reasonable details covering the entire study area.

Erosion potential assessment shall be carried out using continuous simulation of watercourse flows over several years and applying multiple exceedance methodologies such as duration of erosion threshold, cumulative effective work / shear stress, and cumulative effective discharge.

Regulated erosion hazards, setbacks and allowances shall be determined according to Conservation Authority guidelines and included in the mapping.

1.1.5 Aquatic Environment

There are a variety of Core Areas that have been identified as part of the Natural Heritage System within the Rural Hamilton Official Plan. These features include:

- Local natural area-Earth Science Area of Natural and Scientific Interest;

- Significant Woodlands;
- Wetlands;
- Lakes and littoral zones; and,
- Watercourses.

The study shall assess fisheries and benthic invertebrate communities in the subwatersheds. Stream classifications based on the priority of the habitat type as well as cold, cool, and warm water designations shall be identified. An assessment of stream barriers, on-line ponds and temperature survey data will also be undertaken to determine potential impacts of development on aquatic resources. Where applicable, the criteria and considerations contained in Table 1 (see below) will form the basis for evaluating watercourses. The data collected will be used to ensure that future development will have no negative impacts on fish habitat or the ecological functions for which the area has been identified.

It is noted that certain watersheds have more background information than the others. Where a subwatershed is lacking existing aquatic information, reconnaissance of the subwatershed is expected. A data gap analysis is required as part of the background data review to determine what inventories need to be undertaken. Detailed field assessments of the aquatic environments shall generally be provided to the areas of fish and riparian habitat, including areas immediately upstream and downstream of these habitat areas. When assessing species, status should include federal, provincial, and local rankings. In addition, maps that identify the results of the aquatic investigations shall be provided. The study area shall be screened for land uses, with a focus on the green belt areas, to identify the areas of interests.

A detailed protocol to conduct surveys for benthic invertebrates is included in Appendix E: Proposed Protocol to Sample Benthic Invertebrates. The criteria for evaluating the aquatic environment should include the following general requirement as indicated in Table 1, with the seasonally appropriate timelines identified for the work to be completed. Detailed inventory requirement shall be specified for the areas of interests. Fisheries and habitat assessments must be completed during a period when water is present in the watercourses to be assessed (generally in spring from April to June). The

Evaluation, Classification and Management of Headwater Drainage Features Guidelines (CVC & TRCA, January 2014) should be used for the assessment of watercourse features in the study area.

Table 1: Aquatic Environment Inventory Requirements

Biophysical Inventory	Inventory Requirements
Fisheries Assessment	Electrofishing may be required. Acceptable protocols (i.e., Ontario Stream Assessment Protocol (OSAP) should be followed.
Habitat Assessment	Assess watercourse habitat using acceptable protocols, i.e., the OSAP module.
Benthic Invertebrate Assessment	Assess benthic communities in watercourses using acceptable protocols (i.e., OSAP, Ontario Benthos Biomonitoring Network (OBBN), (Biological Monitoring and Assessment Program (BioMAP)). Minimum of family level identification is required for benthic invertebrate assessment.
Species at Risk Screening	Screening should include results from all available sources, i.e., Natural Heritage Information Centre, Ministry of Natural Resources (MNR), Municipal List and Conservation Authority database, and Fisheries and Oceans Canada (DFO) screening map.

1.1.6 Terrestrial Environment

An assessment of terrestrial resources in the subject subwatersheds shall be undertaken. The Natural Area Inventory works from Conservation Authorities should be consulted for any existing information. The data collected shall be used to ensure that future development has regard to Section 2.1 of the Provincial Policy Statement. The criteria for evaluating the terrestrial features should include the following requirements. Depending on the vegetation community Ecological Land Classification (ELC) results and habitats determined to be present in the study area, it may be appropriate to undertake targeted surveys for certain taxa or

species, rather than rely solely on incidental observation. Significant Wildlife Habitat Eco-Region 7E Criteria Schedule (MNR, Draft 2012) should be used in conjunction with the Significant Wildlife Habitat Technical Guide when assessing Significant Wildlife Habitat.

The landscape level analyses are required to identify terrestrial features connectivity, species movement, percent natural cover, etc.; while detailed field assessment of the terrestrial resources shall be provided to characterize the terrestrial environment and establish a baseline terrestrial environment for the study area, including the proximity to, and the degree of linkage with other habitats. When assessing species, status should include federal, provincial, and local rankings. In addition, maps that identify natural heritage features and the results of the terrestrial investigations shall be provided.

Table 2: Terrestrial Environment Inventory Requirements

Biophysical Inventory	Inventory Requirements
Vegetation Community Identification	Use Ecological Land Classification to classify vegetation communities.
Botanical Inventory	3 season survey (spring, summer, and fall) to identify species.
Evaluation of Unclassified Wetlands	Use MNR wetland evaluation system to classify unevaluated wetlands.
Breeding Bird Surveys	2 surveys at least 10 days apart; the first between May 24th and June 16th and the second between June 17th and July 10th using Ontario Breeding Bird Atlas protocol.

Biophysical Inventory	Inventory Requirements
Amphibian Breeding Surveys	3 surveys between April and July 5th corresponding to specific nighttime temperatures of >50C, >10 0C and >17 0C using the Marsh Monitoring Protocol Salamander surveys are required and should be completed in spring in appropriate ponds to determine the presence of salamander breeding areas
Reptile Surveys	Use active searching, cover boards or other commonly accepted protocols/methods (April- July and Sept.-Oct.)
Incidental Wildlife Observations	Incidental sightings of mammals, butterflies, dragonflies, damselflies, amphibians, and reptiles.
Species at Risk Screening	Screening should include results from all available sources, i.e., Natural Heritage Information Centre, MNR Municipal List and Conservation Authority database.
Assessment of Significant Wildlife Habitat	This assessment will utilize the MNR's Significant Wildlife Habitat Technical Guide 2000) and may include seasonal wildlife concentration areas, rare vegetation communities, specialized wildlife habitat, habitat for species at risk and animal movement corridors.

1.1.7 Surface Water Quality

Background information shall be used to define the baseline water quality in the subject study area, with a focus on sediment loadings in the surface water environment. Where available, existing datasets from Conservation Authorities or other sources shall be reviewed to understand the existing water quality status of the study area. Where background information is unavailable, a water quality sampling program shall be

conducted for each subwatershed as described in Appendix A: Suggested Data Collection Requirement to assess baseline water quality conditions. The existing water quality status shall be assessed to provide the baseline reference and identify any water quality concerns and constraints in the study area. Whenever possible, the water quality sampling should be conducted at the same location and time, when surface water and groundwater flow monitoring is conducted. The study will also identify any existing SWM pond and the respective catchment areas, as the baseline reference for stormwater management in terms of water quantity/ quality control.

1.1.8 Stage 1 Report – Subwatershed Characterization

At the completion of Stage 1, the general characteristics of the subwatersheds area will be identified and a clear understanding of the major issues and opportunities will have been developed. The Stage 1 report will provide the general characters of the study area, which will be the starting point from which the land use is developed from. The Stage 1 report shall considerate climate change in accordance with the Provincial Policy Statement.

The Stage 1 report shall include:

- Summary of background literature and data reviewed;
- Subwatersheds characterization based on the findings of the initial subwatersheds study;
- Summary of the subwatersheds major issues, concerns, and constraints; and
- Summary of the obvious opportunities for improvement or enhancement.

The following are considerations to determine the constraint analysis. The constraints shall be assessed with consideration of the core features and linkages and natural hazards, in accordance with the policy and definitions as indicated in the Official Plans.

- High Constraint: Native communities with highly significant habitat attributes present and / or with severe slope constraints and / or located directly adjacent to the permanent watercourse. High constraints should be protected.
- Medium Constraint: Native communities with moderately significant habitat

attributes present and / or with moderate slope constraints and / or associated with imperfect drainage and may include successional communities. Features protected and integrated into development where feasible; if not protected, opportunities to replace these features should be examined.

- Low Constraint: Cultural communities with limited significant habitat attributes present, no slope constraints and not associated with hydrological linkages. These features don't represent direct constraints to development and represent opportunities for habitat restoration.

1.2 Stage 2: Subwatershed Management Strategies

Based on data obtained in Stage 1 through the review of background information sources and supplementary fieldwork, Stage 2 involves assessing the impacts of future land use changes on the natural environment within the study area. The findings from the Stage 1 characterization work, completed for various disciplines, will be considered in an integrated manner in developing the subwatershed management strategies. The Stage 2 work will be completed concurrently to the land use plan, transportation plan and water / wastewater servicing plan. The intent of Stage 2 is to develop the management strategies that.

- protect the critical elements of the subwatershed;
- prevent environmental degradation;
- provide adequate flexibility for integration with adjacent development and redevelopment areas;
- assist in the establishment of open space linkages;
- identify opportunities and constraints to development;
- provide a strategy to manage existing land uses;
- detail location and area requirements for stormwater management facilities; and
- identify restoration and enhancement opportunities.

In Stage 2, a detailed analysis shall be completed to assess the impacts of future land use changes on the subject study area. Different options for mitigating these impacts shall be reviewed and management strategies shall be recommended. The proposed assessment of future land use changes shall include multiple future scenarios. This should include considerations of a scenario that allows for enhancement of environmental conditions by incorporating the use of a connected network of environmental features and functions, as well as low impact development practices for industrial, commercial, and institutional (ICI) lands to help sustain the local groundwater resource. In addition, constraint and opportunity mapping shall be provided.

1.2.1 Hydrologic Analysis

A hydrologic analysis shall be conducted for the future development conditions to determine post- development flows, hydrographs, and water balance.

The existing conditions model shall be modified to reflect post-development conditions for all events storms, ranging from 25 mm, 2, 5, 25, 100 years up to and including the Regional Storm. It shall be used to determine the potential impacts on surface water, groundwater, and water balance, with details of infiltration and runoff character changes. Surface water and groundwater interaction changes shall be addressed due to land use changes on the karst topography in the study area, if relevant. The hydrologic analysis will:

- Delineate a discretized drainage area plan based on potential development;
- Develop a model schematic diagram;
- Include a table of model input parameters;
- Calculate post-development flows with and without stormwater management controls, for all event storms at the predetermined locations, as per the discretized drainage area plan and model schematic diagram within the study area. The post-development flows shall be compared to existing flows for all storm events at the hydrologic nodes of interest;
- Conduct the water balance assessment at the nodes of interests. The water balance for the study area shall be completed in consultation with a

hydrogeologist, and shall include an estimate of precipitation, evapotranspiration, runoff, and infiltration, in addition to the groundwater recharge and discharge. Feature-based water balance for wetlands within the study area may also be required to ensure there will be no negative post-development impact to the hydrological function;

- Identify constraints related to imperviousness and intensity of development. Assess the requirement and/or performance of proposed stormwater management facilities; Consideration shall also be given to the timing, phasing, and types of stormwater management measures;
- Develop stormwater management strategies on the principles of at-source control, conveyance control, and end of pipe treatment;
- Investigate potential Low Impact Development (LID) designs for industrial, commercial, and institutional (ICI) lands, when groundwater recharge and discharge is critical; and,
- Assess the future infrastructure discharge impacts on the local watercourse and lake systems and identify appropriate mitigation measures.

Refer to Appendix B: Proposed Hydrology Plan in assessing future development conditions. The future development impact assessment should evaluate the impacts on both runoff volumes and peak flow rates.

1.2.2 Hydrogeology

The hydrogeology analysis shall examine the impact of future development and land use changes on groundwater systems. The report may need to investigate rural septic systems for potential interactions with sub-surface aquifer systems. It will make recommendations to adequately protect groundwater from both water quality and quantity perspectives. The hydrogeology plan also prevents disturbing the significant recharge/discharge areas identified in Stage 1. The hydrogeological component of the subwatersheds investigation shall:

- In accordance with the recharge / discharge areas delineated in Stage 1, ensure the groundwater sensitive areas are recognized and protected from

future urbanizing and disturbances;

- Within the water balance assessment, conduct an overall groundwater budget, at the pre- determined nodes of interest in the study area and the subwatersheds outlet, along with the surface water components for both existing and future scenarios; and,
- Make recommendations with respect to Low Impact Development (LID) measures to be implemented in order to mimic the pre-development groundwater conditions.

1.2.3 Hydraulics

The existing hydraulic condition shall be reviewed in the context of the proposed development, with the land use changes, runoff increases and/or channel modifications. The study shall assess the impacts of the proposed development on watercourse water levels, flow velocities and water surface profiles for all storm events. Any potential erosion and flood concern due to the proposed development shall be identified. Current flood line information shall be updated for post-development scenarios, using HEC-RAS models in accordance with standards set out in the City's Flood Damage Reduction Program and Conservation Authority guidelines. The model shall be modified with the updated topography, such as the changes in channel morphology, cross sections, bank lines, culverts, and bridges, etc. Backwater analysis is expected where flows are constrained due to flatness or downstream conveyance limitations.

The updated flood lines are to be presented on the maps, with Regulatory Storm flood line locations and cross sections identified with flood elevations. The overtopping depths, caused by the Regional Storm, shall be assessed, and documented on existing roads at all crossing structures. The flood hazard maps should confirm the post-development flood levels are in consistency with the current condition. Any changes in the flood inundation magnitude must be listed in inventory, with explanations of such changes. For any increases in flow, it must be demonstration that the change does not increase the flood risk or off-site development constraints. Any stormwater management (SWM) strategies, required to match the post-development flows to

existing conditions, shall be identified and to be addressed in detail in the following SWM section.

1.2.4 Stream Morphology and Erosion Analysis

The continuous erosion analysis for the existing condition shall be updated with the future development scenarios. Erosion potentials for the study area shall be estimated by applying the existing channel / bank conditions and the post-development flows to the same cross sections, as outlined in the proposed methodology in Appendix D: Tractive Force Analysis. Where flow increases are noted, it must be demonstrated that the change does not increase the flood risk or off-site development constraints. Appropriate mitigation measures shall be recommended for sections showing a significant increase in erosion potential. Stormwater management criteria shall be established for the proposed development to ensure there is no increase in downstream erosion.

The downstream work, to the next flow node at the specific subwatershed' s outlet, shall be linked to the erosion potential assessment from the proposed development. Development usually increases the volume and duration of flows to the watercourse. It is not likely that development will be able to maintain existing conditions, and this is not the expectation. Erosion analysis is to determine how to release the additional flow volume without negatively impacting the watercourse.

Natural channel design principles shall be applied in reaches where it has been previously altered or will be reconstructed through the development process, or where it has been determined that enhancements are required due to the morphological condition of the watercourse. Based on the results presented in Stage 1, the study shall identify which watercourses and drainage features in the proposed development area are stable and have sufficient conveyance capacity; and which need restoration or alteration through natural channel design approaches. Stream morphology shall be assessed in the downstream areas of future development areas, with a focus on the existing and potential erosion concerns. Existing and future development impacts shall

be evaluated with development strategy indicated to limit the negative impacts, while accommodating opportunities to restore and improve the existing channel status.

For areas of new development, the size of the channel block, necessary to allow natural channel design to occur, shall be determined. The natural channel design information, on which the preliminary assessments are made, shall be documented for use at the final design stage. The natural channel design strategy must clearly define that all channel blocks have the ability to convey flows associated with the Regulatory Storm event (Regional or 100-year, whichever is greater). Conceptual channel restoration / improvement, where required, shall indicate the overall stream morphology changes with these proposed section changes. The determination should be made based on stream morphology, in addition to the considerations of aquatic and terrestrial features and setbacks. The respective Conservation Authorities and Department of Fisheries Ontario must be consulted for approval of any channel works proposed.

1.2.5 Aquatic Environment

The study shall assess the potential impacts of future land use on the aquatic resources. Recommendations shall be identified for improvement of aquatic habitat, including in-stream, stream bank and flood plain habitat enhancement, removal of barriers and on-line ponds, and retrofitting existing altered habitats. The assessment shall relate physical characteristics and processes of the aquatic environment to biological communities. The assessment shall also identify and protect appropriate buffers/setbacks, and linkage of these habitats, which reflect the specific stream sensitivity and required buffer functions.

Detailed assessment shall be generally focused on the sensitive areas identified in Stage 1 and areas immediately downstream of new developments. Considerations should be given to cooling trenches for SWM facility, i.e., trenches, open channel drainage with shading areas, etc.

1.2.6 Terrestrial Environment

The study shall investigate potential land use impacts for areas adjacent to terrestrial resource features and identify buffer and management strategies. In addition, appropriate buffers/setbacks to disturbance, specific to the resource sensitivity and required buffer functions, shall be identified, and protected. In addition, potential linkages (natural areas that ecologically connect core areas) shall be identified and protected. Linkages are important in reducing the adverse impacts of habitat fragmentation on natural areas. The management strategies shall be documented, regarding the protection of these sensitive resources and functions. A graphic visualization of corridor and buffer alternatives, including successional habitats under a longer-term scenario (20-50 years), shall be presented in maps to:

- Identify habitat features that may be retained and incorporated into the Natural Heritage System due to their quality;
- Consider the potential impacts of development on wetlands, wildlife habitats, woodlands, valley lands, endangered and threatened species (if present) and their habitat; and
- Propose management strategies to protect these resources.

The assessment shall generally focus on the sensitive areas identified in Stage 1 and areas in the immediate vicinity of new developments. Where a continuous ELC-defined vegetation community extends beyond the subject areas, the assessment shall generally address the entire community, including portions beyond the study area boundaries.

1.2.7 Surface Water Quality

The study shall investigate potential land use impacts and develop strategies to maintain or enhance in-stream water quality. Actions to address existing point and non-point sources of pollution resulting in degraded water quality shall be developed. Best Management Practices (BMPs) for urban stormwater management shall be recommended for all new development to address stormwater quality. The proposed

BMPs shall be in accordance with the requirements of the Ministry of Environment and the City of Hamilton.

A detailed stormwater management strategy shall be determined for future development lands. BMPs shall be recommended for source controls and conveyance controls. Conceptual designs of the SWM facilities are required to ensure the discharging water will meet the MECP standards for total suspended solid removal. Water temperature indicators are to be evaluated, especially when receiving water are sensitive, i.e., cold water system for aquatic habitat. Based on the hydrogeological investigation and the recommendations of the hydrogeologist, the stormwater strategy should also identify Low Impact Development (LID) measures, which can be incorporated within industrial, commercial, and institutional developments to maintain the water balance and groundwater recharge in particular.

1.2.8 Development of Stormwater Management Strategy

Results of the hydrologic analysis for existing and developed conditions shall be used to develop a stormwater management strategy to control post-development peak flows because of urbanization. The fluvial geomorphological and erosion assessments, in conjunction with the hydrologic analysis shall be used to determine the control measures. In addition, storm runoff must be treated before it is discharged to receiving waters using source controls, conveyance controls, or end of pipe controls. All proposed SWM strategies shall confirm to acceptable standards as determined in the MOE Stormwater Management Practice Manual (2003), the City's drainage policy and stormwater management guidelines, in addition to the requirement of the respective Conservation Authorities.

The stormwater management strategy for the proposed development shall incorporate relevant SWM measures, alternate development proposal, including low impact development designs for ICI lands. Constraints and opportunities shall be evaluated for the specific strategy. Conceptual design shall be completed for facilities required to achieve the specific targets. For example, the drainage areas for proposed SWM features are to be delineated; The length of routes, size of conveyance conduits, and

open channel drainage vs. SWM ponds are to be evaluated; End of pipe treatments should include the required storage volumes, flow targets, land area requirements and locations; Details should include the stage – storage – discharge charts, SWM facility types and outlet control methods.

In general, with effective SWM source control measures at development stage, the post-development flow rates are to be controlled to pre-development levels as close as feasible. Additionally, the post-development controlled flows should not impact base flow in the watercourses receiving the runoff. Consequently, the future flood plains are expected to be consistent with the existing conditions. As part of the stormwater management strategy for future development, the successful proponent shall:

- Identify any drainage and stormwater management (SWM) works required for the study area, including stormwater management ponds, channel modifications and infiltration works;
- Assess the performance of existing drainage facilities (i.e., ditches, culverts);
- Based on MECP guidelines, establish stormwater management criteria related to water quality (Total Suspended Solid);
- Identify the SWM facility locations and the appropriate outlets to the receiving water bodies;
- Incorporate the proposed stormwater management facilities into the post-development model and select the sizes of the facilities to conform to the established criteria. The City and Conservation Authority(ies) should be consulted if regulatory storm controls are being considered to mitigate the impacts of development;
- Prepare a conceptual design of the proposed stormwater management facilities for water quantity and quality control; and,
- Consider general criteria for stormwater management as described in Appendix F: General Criteria for Stormwater Management.

1.2.9 Reporting – Stage 2 Subwatersheds Management Strategies

The study shall develop a detailed subwatershed management strategy for the proposed development, which will evaluate a range of subwatershed management options based on the subwatershed goals, objectives, and targets. The study shall identify additional studies to be completed in support of future development applications, as required to meet the objectives and targets of this subwatershed study. Each of the subwatershed management options shall be evaluated to determine preferred subwatershed strategies. The study shall recommend a comprehensive plan for the evaluation of the management options, which will form part of the subwatershed study proposal. Options such as alternative development forms/patterns, stormwater management and best management practices, rehabilitation and retrofitting of existing features shall also be considered in the subwatershed management options.

At the completion of Stage 2, a report shall be submitted to document the evaluation of the stormwater management options and recommended subwatershed management strategies as they relate to the proposed development. The computer modelling input and output files shall be appended to this report and a digital copy of all modelling files submitted. In addition, constraints and opportunities present in the study area, in terms of urban expansion, environment impacts and protection, shall be clearly documented with GIS maps for the associated locations. GIS shape files shall accompany the report.

1.3 Stage 3: Implementation and Monitoring Plans

Stage 3 shall set the framework for implementation and monitoring of the preferred subwatersheds management strategy. An implementation and monitoring plan shall be developed, which sets out the requirements for phasing, financing, operation of facilities, and monitoring to ensure the future developments are in compliance with the approved subwatershed study. The Stage 3 work will be completed at the end of the land use planning work, when a preferred land use plan has been determined. The findings of this study will provide a technical framework for future infrastructure works and support the future development proposals.

Where applicable, Stage 3 shall outline the agencies/organizations that are responsible for carrying out the various recommendations and specify when in the development process the various recommendations need to be initiated. Stage 3 shall include:

- Timing for the construction of any required facilities with respect to the future development;
- Funding formula for the construction of these facilities;
- Recommendations for future studies, if required;
- The operation and maintenance responsibilities for the recommended facilities;
- A monitoring program to ensure compliance with the subwatershed study, and a strategy for corrective actions which may be necessary based on results of the monitoring program;
- Time frame for the review/update of the subwatershed plans; and,
- The estimated cost of the monitoring program.

The implementation plan shall recommend the phasing of development. This will permit changes to recommend mitigation measures and management strategies for future phases of the development, in the case results of monitoring from the initial phases suggest that changes are warranted.

OTHER INFORMATION:

Comprehensive Development Guidelines and Financial Policies Manual (City of Hamilton, current edition).

https://www.hamilton.ca/build-invest-grow/planning-development/planning-policies-guidelines/comprehensive-development

Comprehensive Development Guidelines and Financial Policies - Stormwater Management Design Criteria – Figure G-1 Storm Sewer Sizing Criteria Decision Tree (City of Hamilton, current edition)

https://www.hamilton.ca/sites/default/files/2022-09/pedpolicies-developmentguidelines-financialpolices-manual.pdf

Stormwater Management Planning and Design Manual (Ministry of the Environment, Conservation and Parks, 2003).

Development, Interference & Alteration Regulations for all Conservation Authorities (Ontario Regulations 42/06 and 146/06 to 182/06). https://conservationontario.ca/fileadmin/pdf/conservation_authorities_section_planning__regulations/Development__Interference___Alteration_Regulations_for_all_Conservation_Authorities.pdf .

Policies and Procedures for Conservation Authority Plan Review and Permitting Activities (Conservation Ontario, 2010) https://conservationontario.ca/fileadmin/pdf/conservation_authorities_section_planning__regulations/Policies_and_Procedures_for_CA_Plan_Review_and_Permitting_Activities.pdf.

Conservation Halton Policies and Guidelines for the Administration of Part VI of the Conservation Authorities Act and Ontario Regulation 41/24 and Land Use Planning Policy Document (last amended June 21, 2024, or as may be further amended Policies and Guidelines - Conservation Halton

Municipal Class Environmental Assessment (Municipal Engineers Association, current version).

Drainage Act, R.S.O. 1990, and associated Regulations.

REVIEWED AND APPROVED BY:

Development Planning, Planning and Economic Development Department

Development Approvals, Planning and Economic Development Department

Source Water Protection, Public Works Department

The Conservation Authority with regulatory authority over the subject lands, namely:

- Hamilton Conservation Authority

- Conservation Halton
- Niagara Peninsula Conservation Authority
- Grand River Conservation Authority

Consultation with provincial agencies such as the Ministry of the Environment, Conservation and Parks, the Ministry of Natural Resources, and the Ministry of Transportation may be required.

Consultation with federal agencies such as Fisheries and Oceans Canada (DFO) may be required.

CONTACT:

Development Planning, Planning and Economic Development

pdgening@hamilton.ca

Development Approvals, Planning and Economic Development

deveng@hamilton.ca

Source Water Protection, Public Work

sourcewater@hamilton.ca

Hamilton Conservation Authority

nature@conservationhamilton.ca

Conservation Halton

envserv@hrca.on.ca

Niagara Peninsula Conservation Authority

planninginfo@npca.ca

Grand River Conservation Authority

grca@grandriver.ca

APPENDICES:

Appendix A: Suggested Data Collection Requirements

Appendix B: Proposed Hydrology Plan

Appendix C: Proposed Hydrogeological Plan

Appendix D: Tractive Force Analysis

Appendix E: Proposed Protocol to Sample Benthic Invertebrates

Appendix F: General Criteria for Stormwater Management

Master Drainage Plan – Summary Checklist

Master Drainage Plan – Standard Format for Table of Contents

Master Drainage Plan – Summary Checklist

The form is to be completed by the Professional that prepared the Master Drainage Plan.

Use of the form by the City of Hamilton is not to be construed as verification of engineering/scientific content.

Refer to the Terms of Reference for the Master Drainage Plan: Link to Terms of Reference

If Any Of The Requirements Listed Below Have Not Been Included In Master Drainage Plan, The Study Will Be Considered Incomplete.

Site Information	Notes
Site Address	
Property Owner	
Project Description	
Land Use	
Date Prepared:	
Prepared By:	

Summary of Key Information:

Master Drainage Plan Information	Notes	Page # & Section # of Report	Report Includes this Information City Staff (Check)
Date of Formal Consultation with City			
Date Master Drainage Plan was prepared			
Who Prepared the Master Drainage Plan (Consulting Firm)			
Name of Author of Master Drainage Plan			

STAGE 1: SUBWATERSHED CHARACTERIZATION REPORT

Does the study include the following sections and information?

Site Information	**Information is Included in the Study document?**	**Page # & Section # of Report**	**Report Includes this Information City Staff (Check)**
Description of location, site area, property owners, including relevant figures?	Yes/No		
Purpose of the study?	Yes/No		

Site Information	Information is Included in the Study document?	Page # & Section # of Report	Report Includes this Information City Staff (Check)
Type of application that triggered the study?	Yes/No		
Description of existing conditions?	Yes/No		
List of existing reports, studies, standards, guidelines, etc. relied upon?	Yes/No		
Summary of the following supporting studies:			
a) Hydrology and Hydraulics?	Yes/No		
b) Hydrogeology?	Yes/No		
c) Stream Morphology?	Yes/No		
d) Channel Erosion?	Yes/No		
e) Aquatic Environment?	Yes/No		
f) Terrestrial Environment?	Yes/No		
g) Surface Water Quality?	Yes/No		
Identification of gaps in the summarized data?	Yes/No		

Site Information	Information is Included in the Study document?	Page # & Section # of Report	Report Includes this Information City Staff (Check)
Description of the proposed program for collection of missing data?	Yes/No		
Subwatershed Characterization?	Yes/No		
Identification of Issues, Concerns and Constraints?	Yes/No		
Ranking of Constraints (High/Medium/Low)?	Yes/No/Not Applicable		
Identification of protection / integration into development / replacement of constraints?	Yes/No/Not Applicable		

STAGE 2: SUBWATERSHED MANAGEMENT STRATEGIES REPORT

Does the study include the following sections and information?

Site Information	Information is Included in the Study document?	Page # & Section # of Report	Report Includes this Information City Staff (Check)
Description of location, site area, property owners, including relevant figures?	Yes/No		
Purpose of the study?	Yes/No		
Type of application that triggered the study?	Yes/No		

Site Information	Information is Included in the Study document?	Page # & Section # of Report	Report Includes this Information City Staff (Check)
Description of existing conditions?	Yes/No		
List of existing reports, studies, standards, guidelines, etc. relied upon, including reference to the Stage 1 report?	Yes/No		
Assessment of Impacts, including the following:			
a) Hydrologic Analysis?	Yes/No		
b) Hydrogeology?	Yes/No		
c) Hydraulics?	Yes/No		
d) Stream Morphology and Erosion Analysis?	Yes/No		
e) Aquatic Environment?	Yes/No		
f) Terrestrial Environment?	Yes/No		
g) Surface Water Quality?	Yes/No		
Stormwater Strategy			
a) List of mitigation alternatives?	Yes/No		
b) Evaluation of alternatives?	Yes/No		
c) Recommended mitigation?	Yes/No		

Site Information	Information is Included in the Study document?	Page # & Section # of Report	Report Includes this Information City Staff (Check)
d) Comprehensive stormwater strategy?	Yes/No		
e) Summary of the stormwater strategy, including a listing of how each of the constraints identified in the Stage 1 report has been addressed?	Yes/No		

STAGE 3:IMPLEMETATION AND MONITORING PLANS REPORT

Does the study include the following sections and information?

Site Information	Information is Included in the Study document?	Page # & Section # of Report	Report Includes this Information City Staff (Check)
Description of location, site area, property owners, including relevant figures?	Yes/No		
Purpose of the study?	Yes/No		
Type of application that triggered the study?	Yes/No		
Description of existing conditions?	Yes/No		

Site Information	Information is Included in the Study document?	Page # & Section # of Report	Report Includes this Information City Staff (Check)
Reference to the Stage 1 and Stage 2 reports?	Yes/No		
Description of Project Timing?	Yes/No		
Definition of funding formula for construction of the facilities?	Yes/No		
Recommendations for future studies (if required)?	Yes/No		
Description of Operations and Maintenance requirements?	Yes/No		
Monitoring			
a) **Description of monitoring requirements?**	Yes/No		
b) **Description of the strategy for corrective actions?**	Yes/No		
c) **Estimate of costs of the monitoring program?**	Yes/No		
Time frame for review/update of the subwatershed plans?	Yes/No		

Qualified Professional who completed this report summary:

Name:_____

Email:_____

Phone:_____

Date:_____

Signature and Stamp:_____

Guideline for Applicants completing the Summary Checklist for Master Drainage Plan

Site Information:

Site Address: Provide municipal address, or lot and concession.

Owner: Provide company name if applicable and name of key contact person.

Project Description: Provide brief description – e.g. 20 Ha residential subdivision.

Land Use: e.g. Residential, industrial, commercial/ mixed use residential and commercial.

Prepared By: Provide name of consulting firm that completed the study.

Master Drainage Plan Information:

1. **Date of Formal Consultation with City:** List the date the Formal Consultation was held with the City.
2. **Date Master Drainage Plan was prepared:** List the publication date of the Master Servicing Plan.
3. **Who Prepared the Master Drainage Plan:** List the name of the consulting firm who prepared the Master Drainage Plan.

4. **Name of Author of Master Drainage Plan:** List the name of the professional who has signed and sealed the Master Drainage Plan.

STAGE 1:SUBWATERSHED CHARACTERIZATION REPORT

5. **Description of Location, site area, property owners, including relevant figures.**
   State all pertinent information and show on a plan. Provide sufficient information to define the geographic extent of the study area and all stakeholders.
6. **Purpose of the study.**
   State the purpose of the study.
7. **Type of application that triggered the study.**
   State the type of planning application that triggered the study (e.g., Application for Approval of Draft Plan of Subdivision).
8. **Description of existing conditions.**
   Describe the existing conditions within the study area, including general information with respect to land use, topography, buildings, natural hazards (including vegetative cover, watercourses, wetlands, slopes, karsts, etc.), Conservation Authority Regulation Limits, municipal and private services, etc.
9. **List of existing reports, studies, standards, guidelines, etc. relied upon.**
   Provide, in bibliographic format, a listing of the documents on which the study relies.
10. **Summary of supporting studies.**
    Provide a brief summary of relevant information included in each of the supporting studies on which the study relies.
11. **Identification of gaps in the summarized data.**
    Discuss the completeness of the information included in the supporting studies, and identify any gaps in the information which would impede the completion of the study.
12. **Description of the proposed program for collection of missing data.**
    Based on the gap analysis completed above, present a program through which the missing data will be collected. Include information with respect to timing, and how describe which aspects of the study may or may not continue prior to completion of the data collection.

13. **Subwatershed characterization.**

    Characterize the watershed in terms of all of the supporting studies.

14. **Identification of Issues, Concerns and Constraints.**

    Based on the watershed characterization, identify the issues, concerns and constraints which could impact the future landuse plan of the study area.

15. **Ranking of Constraints (High/Medium/Low).**

    Rank the issues, concerns and constraints.

16. **Identification of protection / integration into development / replacement of constraints.**

    Identify which constraints should be protected, which may be incorporated into the development, and which may be considered for replacement.

STAGE 2:SUBWATERSHED MANAGEMENT STRATEGIES REPORT

17. **Description of Location, site area, property owners, including relevant figures.**

    State all pertinent information and show on a plan. Provide sufficient information to define the geographic extent of the study area and all stakeholders.

18. **Purpose of the study.**

    State the purpose of the study. Describe the relationship between this study and the previous Stage 1 study.

19. **Type of application that triggered the study.**

    State the type of planning application that triggered the study (e.g., Application for Approval of Draft Plan of Subdivision).

Description of existing conditions.

Describe the existing conditions within the study area, including general information with respect to land use, topography, buildings, natural hazards (including vegetative cover, watercourses, wetlands, slopes, karsts, etc.), Conservation Authority Regulation Limits, municipal and private services, etc.

20. **List of existing reports, studies, standards, guidelines, etc. relied upon, including reference to the Stage 1 report.**

    Provide, in bibliographic format, a listing of the documents on which the study relies.

21. **Assessment of impacts.**

    Provide a brief summary of relevant information included in each of the supporting studies on which the study relies. Provide a detailed analysis of the impacts of future land use changes on the natural environment, in relation to each discipline of supporting study. Multiple future land use scenarios should be considered. The assessment of impacts should include investigation of different options for mitigation of impacts of the future land use change, as well as opportunities for restoration and enhancement.

22. **Stormwater Strategy.**

    Describe the stormwater management strategy for the future land use. Include qualitative and quantitative targets. Include the required location of stormwater management facilities, Low Impact Development measures, conveyance and end of pipe controls. Development of the strategy shall include assessment of alternate development scenarios. Evaluate constraints and opportunities for each. Provide conceptual design of all facilities required to achieve the specific targets. The strategy is to include assessment of the effectiveness of existing drainage facilities and measures to be implemented to provide necessary improvements. Include sufficient plans and details to illustrate the proposed strategy.

STAGE 3:IMPLEMENTATION AND MONITORING PLANS REPORT

23. **Description of Location, site area, property owners, including relevant figures.**
24. **State all pertinent information and show on a plan.**

    Provide sufficient information to define the geographic extent of the study area and all stakeholders.

25. **Purpose of the study.**

    State the purpose of the study. Describe the relationship between this study and the previous Stage 1 and Stage 2 studies.

26. **Type of application that triggered the study.**

    State the type of planning application that triggered the study (e.g., Application for Approval of Draft Plan of Subdivision).

27. **Description of existing conditions.**

Describe the existing conditions within the study area, including general information with respect to land use, topography, buildings, natural hazards (including vegetative cover, watercourses, wetlands, slopes, karsts, etc.), Conservation Authority Regulation Limits, municipal and private services, etc.

28. **List of existing reports, studies, standards, guidelines, etc. relied upon.**
    Provide, in bibliographic format, a listing of the documents on which the study relies.
29. **Reference to the Stage 1 and Stage 2 reports.**
    Reference the Stage 1 and Stage 2 reports and provide context of the relationship of the three reports.
30. **Description of Project Timing.**
    Provide a timeline for construction of the various aspects of the future development. Discuss the sequencing of the various aspects.
31. **Definition of Funding formula for construction of the facilities.**
    Provide a itemized breakdown on the source of funding for the various aspects. Where funding is expected from a party(ies) other than the proponent, describe the mechanisms by which cost shares would be recovered, and what role, if any, the City would play in cost sharing agreements. Describe the events and timing that would trigger the various aspects of cost sharing.
32. **Recommendations for future studies (if required).**
    Identify the scope, timing and triggers for any future studies that may be required. Identify the party responsible to undertake the future studies.
33. **Description of Operations and Maintenance requirements.**
    Describe the requirements for operation and maintenance of the facilities. Include the frequency and scope of inspections, routine maintenance, clean out, and ultimately replacement of the facilities. Include discussion of the triggers for maintenance. Estimate the costs associated with the operations and maintenance requirements and responsibility for the works and the costs.
34. **Monitoring:**
    a. **Description of monitoring requirements.**
       Prepare a monitoring program by which the effectiveness of the proposed measures will be assessed. Include a timeline for the frequency of monitoring.

Identify the party(ies) responsible for the monitoring. Describe the reporting and record keeping structure, including a list of what documents are to be provided to which agency(ies), and when.

b. **Description of the strategy for corrective actions.**
   Provide the strategy by which corrective actions will be undertaken, and by whom, in the event that monitoring demonstrates that the corrective actions are warranted. Provide a listing of potential deficiencies for which corrective actions may be required, as well as an analysis of the likelihood of occurrence and potential impact of each deficiency on the natural environment.

c. **Estimate of costs of the monitoring program.**
   Provide an itemized estimate the annual costs of the monitoring program, and indicate which party(ies) is to be responsible for the costs.

35. **Time frame for review/update of the subwatershed plans.**
    Discuss the triggers and anticipated timeline for review/update of the subwatershed plans. Indicate the party(ies) responsible to undertake the review/update.