LOWER TRENT
CONSERVATION

APPENDIX A

TECHNICAL GUIDELINES

May 12, 2016

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A-1. Introduction

This appendix includes general Technical Guidelines that provide background information on defining the area of regulation that are under the Lower Trent Region Conservation Authority (LTC) jurisdiction under ***Ontario Regulation 163/06 - Lower Trent Region Conservation Authority: Regulation of Development, Interference with Wetlands and Alterations to Shorelines and Watercourses***.

A-2. Discussion of Shoreline Hazards

Shorelines are comprised of three components: 1) flooding hazards, 2) erosion hazards, and 3) dynamic beach hazards.

A-2.1 Processes and Functions Along Shorelines

In general, flooding is a phenomenon influenced by and sensitive to water level fluctuations. Inundation of low-lying Great Lakes –St. Lawrence River System shorelines in and of itself does not necessarily constitute a significant hazard. The hazard is dependent on the type, design, location and density of any development in or near the flood inundated shorelines. However, where flooded lands are coupled with storm events, the cumulative impact can and frequently does pose significant degrees of risk. Of importance in managing a potential flood susceptible shoreline is the need to understand the interrelationship between pre-storm flooding, storm setup, wave height, wave uprush and other water related hazards (i.e., wave spray, ice). If the area of inundation is a wetland or an undeveloped area, the resultant "damage" caused by a storm event may be minimal if measured in terms of human losses (i.e., property and life). Indeed, periodic flooding of wetland complexes have been found to be beneficial for the continued maintenance and enhanced diversity of wetland vegetation itself, by helping to eliminate the invasion of water sensitive upland vegetation into low-lying shorelines during periods of low water levels. In terms of human use and occupation of the low-lying Great Lakes – St. Lawrence River System shorelines, development decisions based on or during periods of low water levels can present the most serious problem. During lower water levels, the potential flood hazard to homes, cottages and other development often goes unrecognized. Consequently, when water levels return to long-term averages or high water levels, flood damages are sustained. These damages are frequently quite significant (MNR, 1996b).

Erosion within the Great Lakes – St. Lawrence River System is a concern, particularly within the lower Great Lakes. Erosion rates are dependent upon a number of lake and land processes as well as the composition and morphology of the shore. In general terms, identification of erosion susceptible shorelines is rather simple in that erosion of bedrock and cohesive shores involves a unidirectional process. In the absence of human intervention and/or the installation of remediation measures, once material is removed, dislodged or extracted from the shore face and near shore profile it cannot reconstitute with the original material and is essentially lost forever. Even with the installation of remedial measures (i.e., assumed to address the erosion hazard), the natural forces of erosion, storm action/attack and other naturally occurring water and erosion related forces may prove to be such that the remedial measures may only offer a limited measure of protection and may only reduce or address the erosion hazard over a temporary period of time.

Given the naturally complex and dynamic nature of the beach environment, determining hazard susceptibility of a given beach formation requires careful assessment of a wide range of parameters. Over the short term, beach environments, impacted by flood and erosion processes, may undergo alternating periods of erosion and accretion as they attempt to achieve a dynamic equilibrium with the forces acting upon them. Over the long term, beaches experiencing a positive sediment budget (i.e., more sand and gravel is incoming than outgoing) are generally in fact accreting shore forms while those experiencing a negative sediment budget are eroding. As such, the depiction and evaluation of the hazard susceptibility of dynamic beaches should be dependent on the level of information, knowledge and understanding of the beach sediment budget and the cross-profile width over which most of the dynamic profile changes are taking place.

A-2.2 Shoreline Flood Hazard

The variable nature of water elevations of the Great Lakes is apparent from historical records. Of the two key factors influencing long-term and short-term changes in lake levels, natural phenomena (i.e., rainfall, evaporation, wind, storms, etc.) by far, cause the greater magnitudes of changes, than does human intervention (i.e., diversions, water control structures, etc.).

The most familiar changes in lake levels are seasonal fluctuations as evidenced by average differences of about 0.6 to 1.1 metres in lake levels between the summer and winter months. Superimposed on these seasonal fluctuations are some extremely short periods of significantly larger magnitudes of lake level changes. The most temporary of these are caused by storm winds which blow over the lake surfaces pushing the water to the opposite side or end of the lake. These “wind setups”, or “storm surges” have frequently caused total differences of more than 4 metres and occasionally as high as 5 metres in lake levels at opposite ends of some of the Great Lakes.

The shoreline refers to the furthest landward limit bordering a large body of water. Factors to be addressed in the areas susceptible to flooding along the shoreline include: the 100 year flood level; and flood allowance for wave uprush and/or other water related hazards (Figure 1).

The 100 year flood level is the water level due to the combined occurrences of mean monthly lake levels and wind set up having a 1% chance of occurring during any year.

The 100 year wave uprush level is based on mean monthly lake levels, wind setup and wind generated waves.

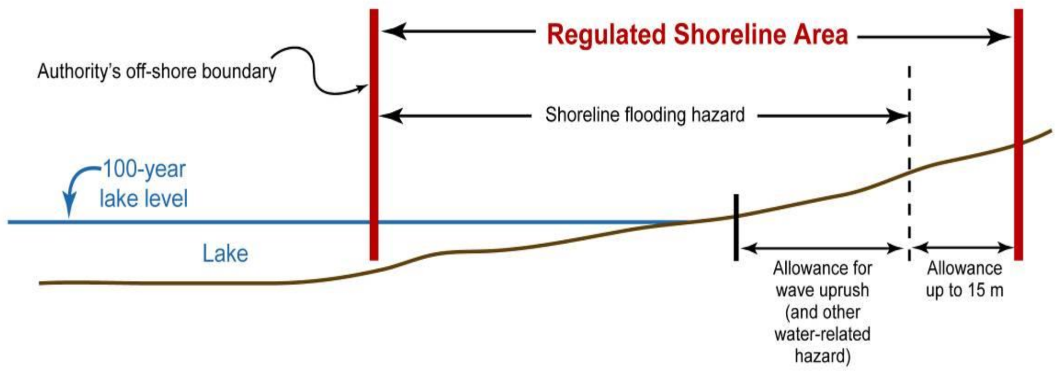

FIGURE 1: LAKE FLOODING

In areas susceptible to wave action, shoreline flood hazards extend landward beyond the 100 year flood level to the limit of wave action. All shorelines should be considered susceptible to wave action unless site specific studies using accepted engineering principles demonstrate that wave action is not significant.

Wave action includes wave uprush, wind setup, wave overtopping and/or wave spray. Wind setup is the mean increase in the water level caused by the onshore transport of water due to waves breaking at the shoreline, while wave uprush is the distance that the water will run-up on the shoreline. For straight, uniform shoreline reaches without protection works, the landward limit of wave action can be represented by the maximum sum of wave setup and wave uprush.

In areas where waves act on shore protection works and other structures, and in areas with irregular shorelines, the wave action may include wave overtopping and wave spray which are more difficult to determine and may require detailed study.

Shoreline flood hazards include, but are not limited to:

- wave overtopping;
- wave spray;
- ice piling;
- ice jamming; and
- ship generated waves

Wave overtopping essentially occurs when the height of the natural shoreline, or of the protection work, above the static water level is less than the limit of the wave uprush. As a result, wave overtopping the shoreline or protection work can cause flooding of the onshore area and can threaten the structural stability of protection works.

Wave spray has been observed passing over structures (houses) and well past them. The landward extent and quantity of wave spray depends on such factors as the type of shore, nearshore bathymetry, type of protection works, size of incident waves and wind conditions. Generally, during storms a significant amount of wave spray will occur behind structures that are near vertical and subjected to large breaking waves.

All shoreline areas and connecting channels form an ice cover. There are two types of ice which impact on shoreline features: drift ice (slush, frazil, pancake, floe and composite ice) and shorefast ice (anchor ice). The impact on the shoreline by drift ice is dependent on the physical orientation and composition of the shoreline, wave action, wind setup and duration of ice action as the ice is transported alongshore and thrown onshore and then drawn offshore by wave action. Anchor or shorefast ice action on a shoreline has a horizontal and vertical impact on shoreline features as the stationary ice grows or diminishes in response to the temperature fluctuations over the winter period.

Ice piling results from wind blowing over the ice, pushing the ice landward. This can produce ridging and a large build–up of ice at the shore. This shore ice can then scour sections of the beach and nearshore as well as destroy structures close to the shore. The moving ice can also remove boulders from the shallow areas, thereby reducing the level of shore protection provided by the boulders.

Ice jamming, the build-up of ice at the outlets of the lakes into the connecting channels, can cause extensive damage to shore structures and nearshore profiles. At the same time, ice jams frequently pose problems by impeding water flows outletting from the lakes and into the connecting channels causing varying magnitudes in lake level increases depending on the size and duration of the ice jam blockage.

Depending on the shoreline configuration and slope characteristics, ship generated waves can rush up the shoreline past the 100 year flood level. In addition to ship generated wave uprush, the subsequent ship generated wave drawdown can scour and damage a shoreline or protection work.

High points of land not subject to flooding but surrounded by the shoreline flood hazard or “flooded land” are considered to be within the flood hazard and part of the shoreline flood hazard.

A-2.3 Shoreline Erosion Hazard

Many geological, topographical and meteorological factors determine the erodibility of a shoreline. These include soil type, surface and groundwater, bluff height, vegetation cover, shoreline orientation, shoreline processes, wind and wave climate and lake level fluctuations.

Erosion over the long-term is a continuous process influenced by these lakeside (i.e. wave action, water levels) and landside factors (i.e., surface/subsurface drainage, loading/weight of buildings, removal of surface vegetation).

The rate of erosion may be heightened during severe storm events, resulting in large losses of land over a very short period of time. These large losses, which are more readily visible immediately following major storm events, at times can obscure the more continuing long-term processes.

The risk of erosion is managed by planning for the 100 year erosion rate (the average annual rate of recession extended over a one hundred year time span). The extent of the shoreline erosion hazard limit depends on the shoreline type: bluff or beach.

The shoreline erosion hazard limit includes the following (Figure 2):

- stable toe of slope (as may be shifted as a result of erosion over a 100 year period);
- predicted long term stable slope projected from the stable toe of slope; and
- an allowance inland of 15 metres on large inland lakes or 30 metres on the Great Lakes.

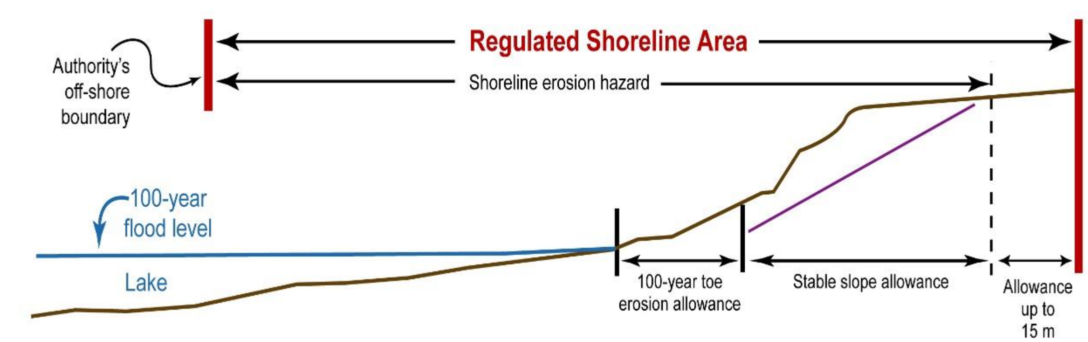

FIGURE 2: LAKE EROSION

For the purposes of delineating the regulated area, the Shoreline Erosion Hazard is determined by first applying the Stable Slope Allowance and then applying the 100-year erosion allowance.

To slow the erosion of shorelines, structures such as breakwaters, seawalls and revetments have been used. Technical Guidelines- Great Lakes –St. Lawrence River Shorelines- Part 7 – Addressing the Hazard (MNR, 1996b) provide guidance for considering how such structures may be considered to modify the Shoreline Erosion Hazard.

Specifically a Protection Works Standard- Erosion Hazard is provided to illustrate how shoreline erosion prevention structures should be evaluated.

However, even with the installation of remedial measures (i.e., assumed to address the erosion hazard), the natural forces of erosion, storm action/attack and other naturally occurring water and erosion related forces may prove to be such that the remedial measures may only offer a limited measure of protection and may only address the erosion hazard over a temporary period of time. Even if the shoreline is successfully armoured, the near shore lake bottom continues to erode or down cut eventually on all shorelines. This process is more active typically on cohesive shorelines. Eventually the lakebed down cutting will undermine the shoreline armouring causing the structure present to ultimately fail (Figure 3). The failure and ultimate property loss may extend back to the point at which the natural shoreline occurs. The natural shoreline position is typically not the present waterline or break wall interface, but actually some point inland from the armoured shoreline position.

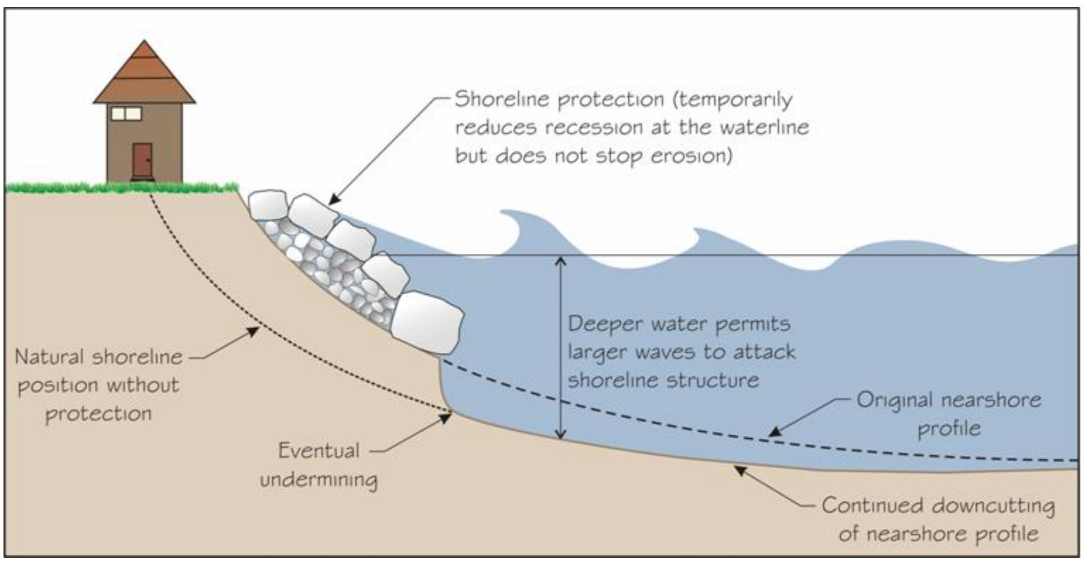

FIGURE 3: LAKE EROSION DOWN CUTTING. SEE ALSO TECHNICAL GUIDELINES - GREAT LAKES - ST. LAWRENCE RIVER (MNR, 1996B)

These problems usually occur on updrift and/or downdrift properties, aggravating existing off-site hazards, and/or posing unacceptable detrimental impacts on a wide array of environmental components of the shoreline ecosystem (e.g., fisheries, wetlands, water quality). The natural movement of the shoreline due to erosion can be aggravated by these human activities and the impact of the activity can be transferred some distance from the impact site.

Therefore, it is recommended as a general principle, that measures that harden the shoreline be avoided. Further, it is recommended that Shoreline Management Plans be undertaken to assist in development of shoreline specific policies and, specifically to evaluate whether the implementation of erosion protection structures (revetments, seawalls, etc.) are appropriate in the context of the overall shoreline processes (MNR, 1987).

A-2.4 Dynamic Beach Hazard

To define a dynamic beach, the flooding hazard limit must be known. The flooding hazard limit combines the 100 year flood elevation plus wave uprush. In dynamic beach areas, elevations can change quite dramatically from season to season and year to year due to build up and erosion of sand, cobbles and other beach deposits. A dynamic beach is considered an unstable accumulation of shoreline sediments generally along the Great Lakes – St. Lawrence River System and large inland lakes. In dynamic beach areas, topographic elevations can change quite rapidly due to the accumulation or loss of beach materials through the effects of wind and wave action. These changes can occur seasonally or yearly and, at times, quite rapidly and dramatically.

To determine the limit of a dynamic beach, the flooding hazard must be established. The flooding hazard is defined as the aggregate of the 100 year lake level plus a landward allowance to accommodate wave uprush and other water related hazards.

It is important that the 100 year lake level be established as a historic location rather than as an elevation.

If considered as an elevation, the location of the 100 year lake level will move with the accretion or loss of beach materials. For example, during a period of low lake levels, it is expected that the accretion of beach materials would occur. If established as an elevation, the 100 year lake level (and the subsequent flood hazard) would move lakeward. Under this approach the Regulation Limit could be construed as also moving lakeward. This area of accretion could rapidly be lost during a storm or when lake levels return to normal. Development permitted under this standard would be at risk.

Historic information about the location of the farthest landward extent of the 100 year lake level will be an important consideration for the long term management of dynamic beach hazards. The 1988 mapping created under the Flood Damage Reduction Program is an example that provides a historic location of the 100 year lake level for Lake Huron.

When topographic elevations change, so does the location of the flooding hazard limit. This is an especially important consideration, because in times of low lake levels, (as has recently been the case on the Great Lakes), the near shore areas that have been submerged under normal or high lake levels are now exposed, subjected to accretion and erosion processes. It may seem that the landward extent of the dynamic beach has changed, thereby introducing potential for development or expansion of existing development. Historic information about the farthest landward extent of flooding, will be an important consideration for good long-term management of dynamic beach hazards. The balance of various coastal processes, which allows for the state of dynamic equilibrium for these beach areas, only exists in the natural environment. Human intrusion within these areas can significantly and negatively impact on the form and function of the dynamic beach. Development should only be considered in limited defined areas outside of the dynamic beach hazard, following the appropriate level of scientific investigation and assessment

The dynamic beach hazard is applied to all shorelines of the Great Lakes – St. Lawrence River System where there is an accumulation of surficial sediment landward of the stillwater line (defined at the time of mapping under non-storm conditions), such that action by waves and other water and wind-related processes can lead to erosion of the sediments and a resultant landward translation of the shore profile.

The dynamic beach hazard is only applied where:

- beach or dune deposits exist landward of the water line (e.g., land/water interface);
- beach or dune deposits overlying bedrock or cohesive material are equal to or greater than 0.3 metres in thickness, 10 metres in width and 100 metres in length along the shoreline; and
- where the maximum fetch distance measured over an arc extending 60 degrees on either side of a line perpendicular to the shoreline is greater than 5 km (this normally does not occur where beach or dune deposits are located in embayment's, along connecting channels and in other areas of restricted wave action where wave related processes are too slight to alter the beach profile landward of the waterline.

The criteria used to define and classify a section of shoreline as a dynamic beach are intended to be applied over a stretch of shoreline on the order of 100 metres or more in length. Where shorter sections of sediments occur on a rocky or cohesive shoreline they are likely to be transitory. Beach width and thickness should be evaluated under calm conditions and at water levels between datum (IGDL) and the average annual low water level. When lake level conditions are higher, consideration should be given to the submerged portion of the beach. If possible, mapping should not take place during high lake level conditions. It is expected that the person carrying out the mapping will exercise judgment, based on knowledge of the local area and historical evidence, in those areas where the beach width is close to the suggested criteria for defining a dynamic beach.

Some Dynamic Beaches have been identified by MNRF and should be confirmed through a shoreline management plan (MNR, 1987).

The Dynamic Beach Hazard includes the following (Figure 4):

- 100 year flood level;
- an allowance for wave uprush, and if necessary, an allowance for other water related hazards, including ship generated waves, ice piling and ice jamming; and
- an allowance inland of 30 metres to accommodate for dynamic beach movement on the Great Lakes and, in the case of large inland lakes, this allowance is 15 metres.

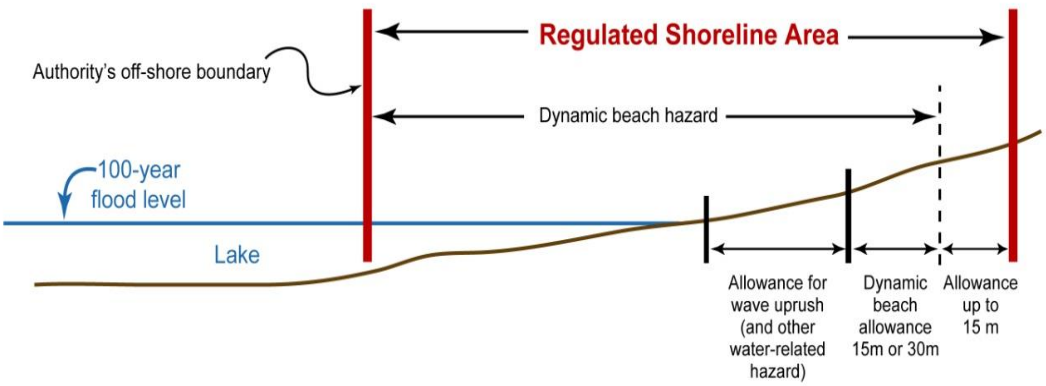

FIGURE 4: DYNAMIC BEACH

A-2.5 Regulation Allowances

The allowances adjacent to shoreline flood, erosion and dynamic beach hazards allow Lower Trent Conservation to regulate development in these areas in a manner that:

- Provides protection against unforeseen or predicted external conditions that could have an adverse effect on public safety, property damage and the natural conditions or processes of the shoreline;
- Protects access to and along the shoreline hazard areas. Access may be required for emergency purposes, regular maintenance to existing structures or to repair failed structures;
- Ensures that existing erosion, flooding and dynamic beach hazards are not aggravated and that new hazards are not created;
- Ensures that the control of pollution and the conservation of land will not be affected;
- Maintains and enhances the natural features and ecological functions of shorelines; and
- Addresses issues related to accuracy of the modeling and analysis tools utilized to establish the limits of the flooding, erosion and dynamic beach hazards.

A-3. Discussion of River or Stream Valleys

To define the Regulation Limits for river and stream valleys, it is important to understand the landforms through which they flow. While there are many different types of systems, the application of the Regulation Limit for rivers and stream systems is based on two simplified landforms, as explained in the Technical Guides for River and Stream Systems (MNR, 2002a; and

MNR, 2002b); Apparent1 (confined) river and stream valleys: see glossary for definition, and Not Apparent (unconfined) river and stream valleys: see glossary for definition.

To provide guidance in regulating river and stream valleys, it is necessary to highlight their hydrological and ecological functions.

A-3.1 Processes and Functions of River or Stream Valleys

River or stream valleys are shaped and re-shaped by the natural processes of erosion, slope stability and flooding. Erosion and slope stability are two natural processes that are quite different in nature yet often linked together. Erosion is essentially the continual loss of earth material (i.e. soil or sediment) over time as a result of the influence of water or wind. Slope stability, usually described in terms of the potential for slope failure, refers to a mass movement of earth material, or soil, sliding down a bank or slope face as a result of a single event in time.

The degree and frequency with which the physical change will occur in these systems depends on the interaction of a number of interrelated factors including hydraulic flow, channel configuration, sediment load in the system, storage and recharge functions, and the stability of banks, bed and adjacent slopes. The constant shaping and re-shaping of the river and stream systems by the physical processes results in hazardous conditions that pose a risk to life and cause property damages.

Erosion hazards pose a threat to life and property through the loss of land due to human or natural processes. The erosion hazard limit is determined using the 100 year erosion rate (the average annual rate of recession extended over a hundred year time span), and includes allowances for toe erosion, meander belt, and slope stability. The erosion hazard component of river and stream systems is intended to address both erosion potential of the actual river and stream bank, as well as erosion or potential slope stability issues related to valley walls.

Flooding of river or stream systems typically occurs following the spring freshet and may occur again as a result of extreme rainfall events. Rivers naturally accommodate flooding within their valleys. Historically, development occurred in floodplain areas because of the availability of water for power, transportation, energy, waste assimilation, and domestic and industrial consumption. However, floodplain development is susceptible to flooding which can result in property damage and/or loss of life.

In Ontario, either storm centred events, observed events, or a flood frequency based event may be used to determine the extent of the Regulatory floodplain.

[1] The LTC Regulation describes river or stream valleys as “apparent” and “not apparent”. Provincial Technical Guides utilize the terminology “confined” and “unconfined”, respectively.

River or stream systems may contain lands that are not subject to flooding or erosion. Examples of these non-hazardous lands include isolated flat plateau areas or areas of gentle slopes (see Figure 5). In these situations, LTC shall determine the applicability of the Regulation.

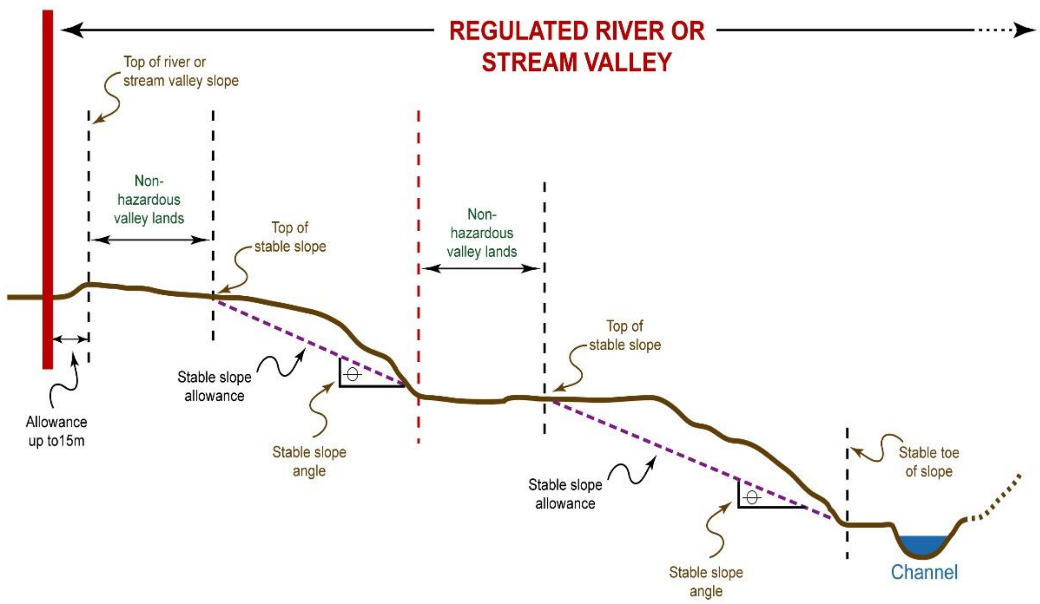

FIGURE 5: REGULATED RIVER OR STREAM VALLEY CONTAINING NON-HAZARDOUS VALLEY LANDS

River and stream systems also provide physical, biological and chemical support functions for sustaining ecosystems. These functions are directly associated with the physical processes of discharge, erosion, deposition and transport which are inherent in any river and stream system. The interplay between surface and ground water and the linkages, interactions and inter-dependence of aquatic environments with terrestrial environments supply hydrologic and ecological functions critical to sustaining watershed ecosystems. Given that ecological sustainability is based on the dynamic nature of these systems, it is essential that they be allowed to function in as natural a state as possible.

A-3.2 Defining River or Stream Valleys

The limit of the regulated river or stream valley is the furthest extent of the erosion hazard or flooding hazard plus an allowance. The following sections describe how the various components of a river or stream valley are determined.

A-3.3 Erosion Hazard

For the purpose of defining the regulated area, the extent of the erosion hazard is based on whether or not a valley is apparent (confined) or not apparent (unconfined) and whether or not the valley slopes are stable, unstable, and/or subject to toe erosion.

Apparent (Confined) River or Stream Valley where the valley slopes are stable:

See Figure 6. The Regulation Limit associated with the erosion hazard consists of:

- the river or stream valley extending to the stable top of slope; and
- an allowance not to exceed 15 metres from the stable top of slope.

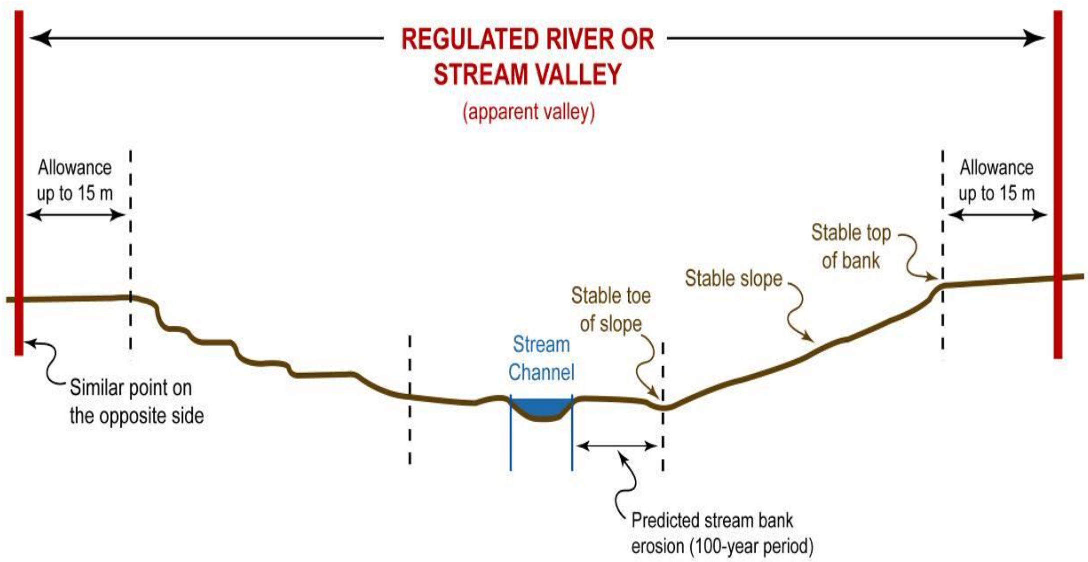

FIGURE 6: APPARENT RIVER OR STREAM VALLEY WHERE THE VALLEY SLOPES ARE STABLE

Apparent (Confined) River or Stream Valley associated with unstable slopes and stable toe:

See Figure 7. The Regulation Limit associated with the erosion hazard consists of:

- the river or stream valley including the predicted long term stable slope projected from the existing stable toe of slope; and
- an allowance not to exceed 15 metres from the stable top of slope.

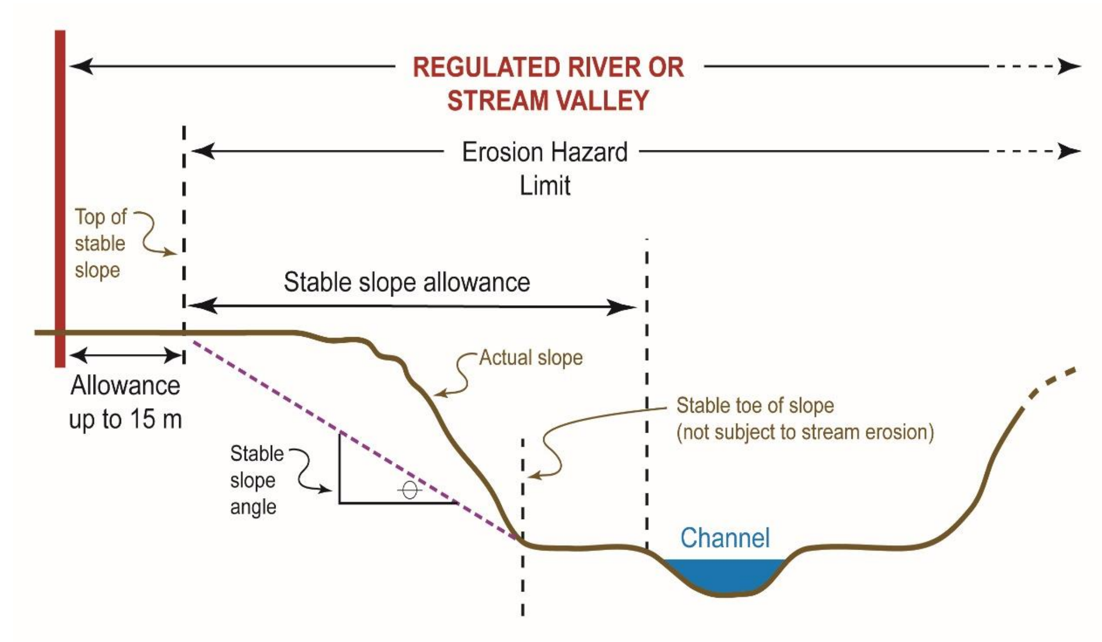

FIGURE 7: APPARENT RIVER OR STREAM VALLEY ASSOCIATED WITH UNSTABLE SLOPES AND STABLE TOE

Apparent (Confined) River or Stream Valley with unstable slopes and active toe erosion:

See Figure 8. The Regulation Limit associated with the erosion hazard consists of:

- the river or stream valley including the long term stable slope projected from the predicted stable toe of slope; and
- an allowance not to exceed 15 metres from the stable top of slope.

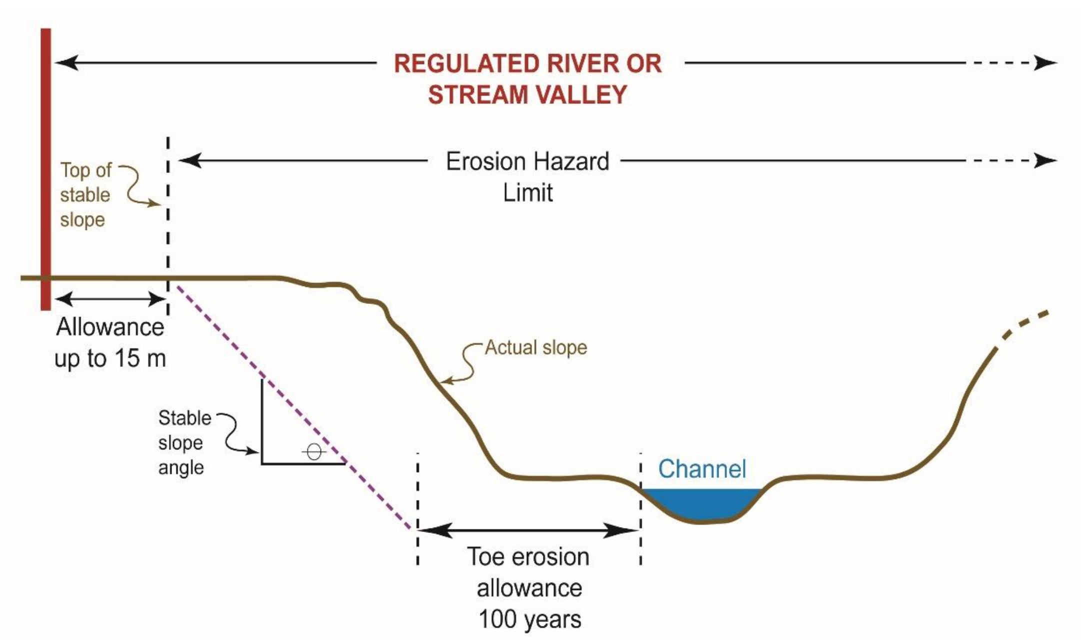

FIGURE 8: APPARENT RIVER OR STREAM VALLEY WITH UNSTABLE SLOPES AND ACTIVE TOE

Not Apparent (Unconfined) River or Stream Valley:

See Figure 9. The Regulation Limit associated with the erosion hazard consists of2:

- the maximum extent of the predicted meander belt of the river or stream; and
- an allowance not to exceed 15 metres from the edge of the predicted meander belt.

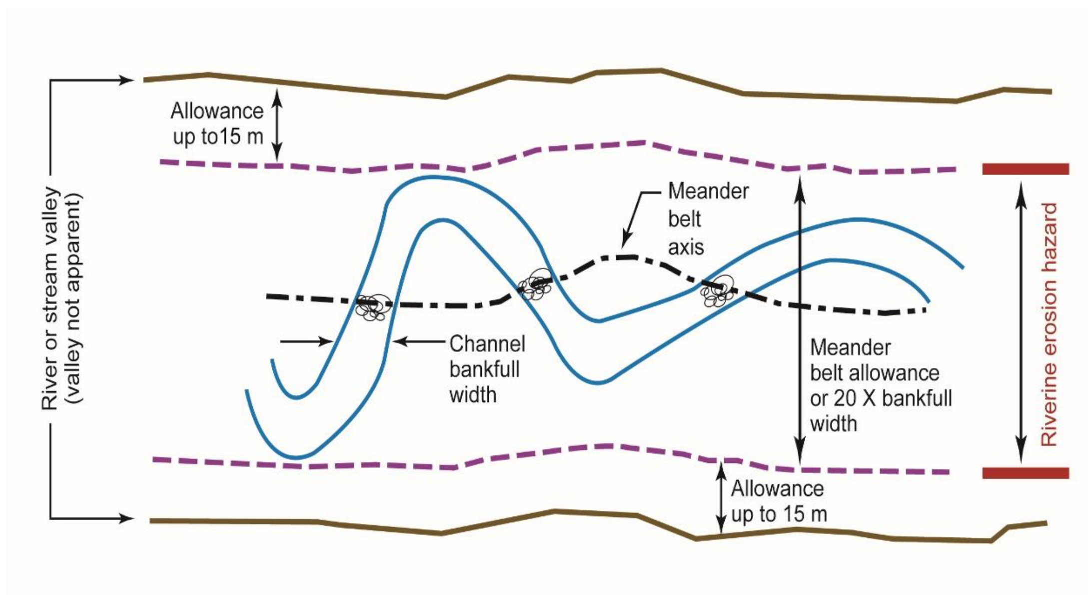

FIGURE 9: NOT APPARENT RIVER OR STREAM VALLEY (MEANDER BELT)

A-3.4 Technical Analysis for Erosion Hazards

Frequently technical analysis is required to determine the appropriate toe erosion, slope stability, and meander belt allowances. Technical studies should be carried out by a qualified professional, with recognized expertise in the appropriate discipline, and should be prepared using established procedures and recognized methodologies to the satisfaction of the CA. With respect to riverine erosion hazards, technical studies should be in keeping with the Technical Guide – River and Stream Systems: Erosion Hazard Limit, (MNR, 2002b) and must demonstrate that there is no increased risk to life or property.

The Technical Guide provides four methods of determining the toe erosion allowance. The technical guide also states that toe erosion rates are best determined through long-

[2] In river or stream valleys that are not apparent (unconfined), the regulated area is the greater of the maximum extent of the Regulatory floodplain or the maximum extent of the predicted meander belt plus an allowance not to exceed 15 metres.

term measurements and that a minimum of 25 years of data is recommended for erosion assessment rates. Sections 3.0, 3.1, 4.1, and 4.3 of the Technical Guide are particularly relevant in this regard. It is essential that qualified professionals properly characterize the watercourse in question to identify what processes are occurring. For channels where processes indicative of instability, such as downcutting, are identified, very detailed fluvial geomorphic analyses would likely be required to predict erosion rates. As well, watercourses in catchments experiencing rapid land use change where the sediment and hydrologic regimes are changing could be experiencing erosion rates that are shifting in response, and that rate of change may not be quantifiable without significant detailed analysis.

Sections 3.0, 3.2, 4.1, and 4.3 of the Technical Guide provide important direction with respect slope stability analysis. Slope stability analysis should also be undertaken in accordance with the Geotechnical Principles for Stable Slopes (Terraprobe Limited and Aqua Solutions, 1998). Recognized analytical methods should be utilized. An appropriate Factor of Safety should be incorporated into all designs/analysis based on the consequences or risks to land use or life in the event of a slope failure. Recommended minimum Factors of Safety are provided in the Technical Guide based on land use above or below the slope (Table 4.3, Page 60, Technical Guide – River and Stream Systems: Erosion Hazard Limit (MNR, 2002b)). These Factors of Safety should also be increased when necessary to account for the reliability of the information available for the technical analysis due to aspects such as natural soil variability in the subject area, limited site work due to constraints, etc.

The determination of the appropriate meander belt allowance usually involves a wide range of study areas such as geomorphology, engineering, ecology and biology. The existing and the ultimate configuration of the channel in the future must be considered. Due to the challenges in assessing meander belt widths, more than one method of determining the meander belt width may be required for any given application. Sections 3.0, 3.3 and 4.4 of the Technical Guide and the supporting documentation entitled “Belt Width Delineation Procedures” (Prent and Parish, 2001) provide further details.

Within not apparent valleys, there may be on occasion areas within the meander belt allowance that are not actually susceptible to erosion within a 100 year planning horizon. These areas may arise for a variety of reasons such as, but not limited to, soil type, hydraulic regime changes, implementation of publicly owned erosion protection works, etc. In these areas, some development, particularly development associated with existing uses, may be considered as the development would not be susceptible to actual stream erosion over the 100 year planning horizon.

When assessing an application for development within any type of valley system, consideration must be given to the ability for the public and emergency operations personnel to safely access through the valley system for emergency purposes, regular maintenance to existing structures or to repair failed structures.

As part of the review of an application, LTC may request an Environmental Impact Study (EIS) to address development within erosion hazards in order to assess pollution and/ or conservation of land. An EIS is a mechanism for assessing impacts to determine the suitability of a proposal. The submission of an EIS does not guarantee approval of the works. An EIS must be carried out by a qualified professional, with recognized expertise in the appropriate area of concern and shall be prepared using established procedures and recognized methodologies to the satisfaction of LTC. Appendix 6 provides additional details on what an EIS may contain.

A-3.5 Flooding Hazard

In Ontario, either storm-centred events, flood frequency based events, or an observed event may be used to determine the extent of the Regulatory floodplain3. These events are:

a) **A storm-centred event**, either Hurricane Hazel storm (1954) or Timmins storm (1961). This is the regulatory flood event for riverine systems except for the Trent River in the LTC watershed. A storm-centred event refers to a major storm of record that is used for land use planning purposes. The rainfall actually experienced during a major storm event can be transposed over another watershed and when combined with the local conditions, Regulatory floodplains can be determined. This centring concept is considered acceptable where the evidence suggests that the storm event could have potentially occurred over other watershed in the general area;
b) **100 year flood event** is a frequency based flood event that is determined through analysis of precipitation, snow melt, or a combination thereof, having a return period (or a probability of occurrence) of once every 100 years on average (or having a 1% chance of occurring or being exceeded in any given year). The 100-year flood event is the regulatory flood for the Trent River riverine system. The 100 year flood event is the minimum acceptable standard for defining the Regulatory floodplain; and
c) **An observed event**, which is a flood that is greater that the storm-centred events or greater that the 100 year flood and which was actually experienced in a particular watershed, or portion thereof, for example as a result of ice jams4, and which has been approved as the standard for that specific area by the Minister of Natural Resources.

[3] High points of land not subject to flooding but surrounded by floodplain or "flooded land" are considered to be within the flood hazard and part of the regulated floodplain.

[4] However, localized chronic conditions (e.g. ice or debris jams) related to flood prone areas may be used to extend the regulated area beyond the Regulatory Flood limit without the approval of the Minister of Natural Resources. It will be necessary to inform the property owner(s) as well as ensuring that the revised limits are reflected in the appropriate municipal documents at the first opportunity.

The Province has adopted standards for addressing floodplain management. Unless otherwise approved by the Minister of Natural Resources, the regulatory flood standard is the Hurricane Hazel (1954) standard for the south and central part of the province, the Timmins Storm (1961) for the central and northern part of the province and the 100 year flood for the eastern part of the province. The map titled “Flood Hazard Criteria in Ontario” (Figure 10) illustrates the province of Ontario and the three different flood hazard limit criteria zones. An observed event may take place in any part of the province, exceeding either the storm-centred events or the 100 year frequency based flood. These standards may be increased by the Minister of Natural Resources if a known flood (maximum observed) exceeds these criteria (Natural Hazards Technical Guidelines, 2002 (MNR) – Section 7.0, River and Stream Systems of Understanding Natural Hazards and River and Stream Systems Flooding Hazard Limit Technical Guide).

FIGURE 10: THE FLOOD HAZARD CRITERIA ZONES OF ONTARIO AND THE CONSERVATION AUTHORITIES WATERSHED BOUNDARIES

Thus, the Regulatory floodplain for river or stream valley systems is defined as the area adjacent to the watercourse which would be inundated by a flood event resulting from either Hurricane Hazel, the Timmins Storm, an observed event, or by the 100 year frequency based event.

The regulated area includes the floodplain and for not apparent valley systems, an allowance. The allowance is not to exceed 15 metres from the hazard (Figure 11).

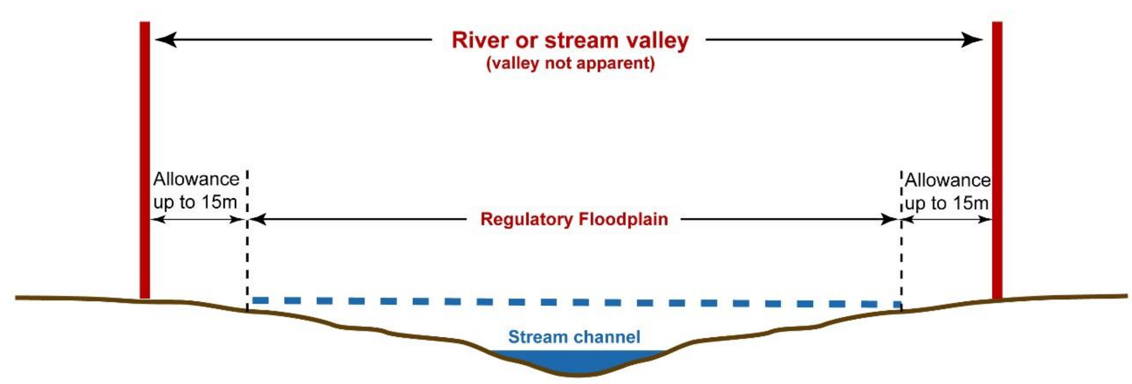

FIGURE 11: REGULATED AREA OF FLOODPLAIN FOR A NOT APPARENT VALLEY

A-3.6 Flooding Hazard Policy Concepts

Within Ontario, there are three policy concepts for floodplain management: One Zone (Figure 12), Two Zone (Figure 13), and Special Policy Area (SPA). In most river or stream valleys in Ontario, a One Zone concept is applied. This area encompasses the entire floodplain.

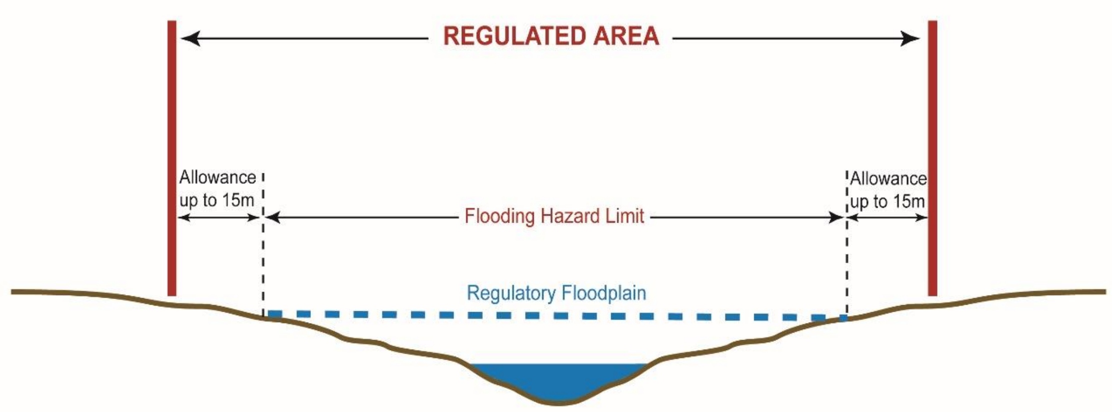

FIGURE 12: ONE-ZONE POLICY APPROACH

For areas adjacent to existing urban or built-up areas, where it can be demonstrated by the municipality that the One Zone approach is too restrictive, selective application of the Two Zone

(Figure 13) concept may be considered. The municipality and CA must agree to this approach and the MNRF Regional Engineer must be consulted. Development may be permitted within those portions of the floodplain where the depths and velocities of flooding are low (flood fringe) and provincial floodproofing and access standards can be met.

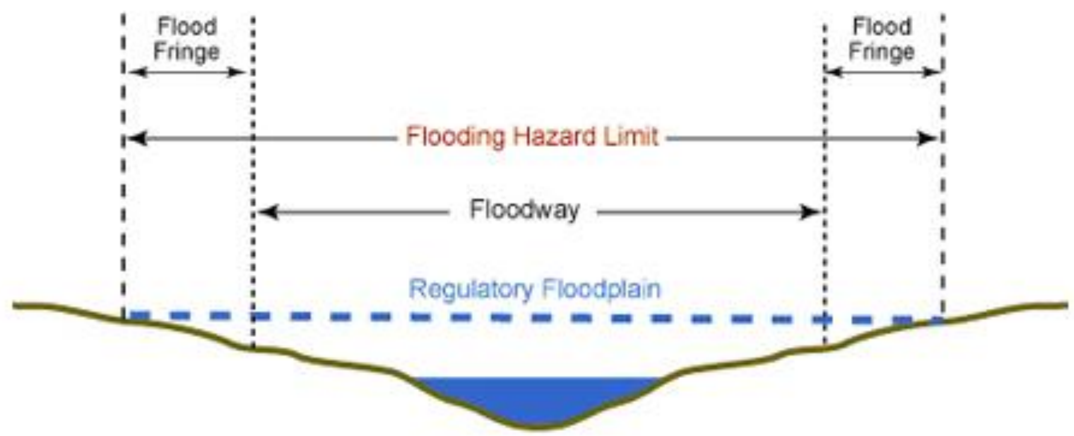

FIGURE 13: TWO-ZONE POLICY APPROACH

In the LTC watershed, the 2-zone approach is applicable to portions of: Butler Creek (Brighton, ON), Trout Creek (Campbellford, ON), Cold Creek (Frankford, ON), and Mayhew Creek (Trenton, ON).

Where the One Zone or Two Zone approaches have been demonstrated to be too stringent and would likely cause significant social and economic hardships to the community, SPAs may be considered. Where an SPA is applied, the municipality, CA, and the Province of Ontario (MNRF and MMAH) must agree to relax provincial floodproofing and technical standards and accept a higher level of risk. SPA application is generally limited to areas of historic development that qualify on the basis of community and technical criteria.

In the LTC watershed, an SPA exists within the downtown core of Stirling, ON, from the Highway 14 Bridge to the Mill Pond/James Street, including 1 E Front St., Stirling, ON.

A-3.7 Technical Standards for the Flooding Hazard

The ability for the public and emergency operations personnel (police, firefighters, ambulance etc.) to safely access the floodplain during regulatory flood events is a paramount consideration in any application for development within the riverine floodplain. Ingress and egress should be "safe" pursuant to Provincial floodproofing guidelines (MNR, 2002a). Depths and velocities should be such that pedestrian and vehicular emergency evacuations are possible. For minor additions and re-development on existing lots as a minimum, access should achieve the maximum level of flood protection determined to be feasible and practical based on existing infrastructure.

In the absence of a site-specific detailed analysis, it is recommended for any development that the flood depths for safe access not exceed 0.3 m and flood water velocities not exceed 1.7 m/s.

Safety risks are a function of the occupancy of structures as well as the flood susceptibility of the structures and the access routes to those structures. Risk should be controlled by limiting the size and type (and thereby limiting the occupancy) of additions or reconstruction projects in dangerous or inaccessible portions of the Regulatory floodplain. Floodproofing includes alteration to the design of specific buildings, raising of ingress and egress roadways and driveways, the construction of dykes, flood control channels, etc. The variety of floodproofing options and requirements are too detailed and extensive to include in a policy and procedures guideline. LTC has established criteria which are outlined in Appendix 5. Additional information is also available for referencing in the "Technical Guide – River and Stream Systems: Flooding Hazard limit" (MNR, 2002a). Where floodproofing standards or safe access cannot be obtained for development, the development should be prohibited.

To provide access and protection against unforeseen conditions, provincial guidelines recommend that development should be set back a minimum of 6 metres adjacent to erosion and flooding hazards (Sections 3.0 and 3.4, Erosion Access Allowance, Technical Guide – River and Stream Systems: Erosion Hazard Limit (MNR, 2002b)). MNRF recommends that this setback not only be applied to the erosion hazards discussed in the sections above, but also adjacent to the flooding hazard because of the potential for erosion throughout the flooding hazard as a result of the flow of water during significant runoff events. For those situations where additional study is warranted to determine the development setback required to provide the required public safety and access, a study should be undertaken using accepted scientific, geotechnical, and engineering principles.

Protection of public safety and access, however, may not be sufficient to provide for all of the above noted requirements or purposes for the allowances. Additional technical studies by qualified professionals may be required to establish the appropriate extent and location of development within the allowance. LTC may also determine that a reduced development setback is appropriate where the existing development already encroaches within the recommended 6 metre setback, and where further development will not aggravate the erosion or flooding hazard.

Consideration should also be given to allow for access between buildings and structures for emergency vehicles. This setback should be no less than 4 metres.

As part of the review of an application, LTC may request an EIS to address development within a flooding hazard in order to assess pollution and/ or conservation of land. An EIS is a mechanism for assessing impacts to determine the suitability of a proposal. The submission of an EIS does not guarantee approval of the works. An EIS must be carried out by a qualified professional, with recognized expertise in the appropriate area of concern and shall be prepared using established procedures and recognized methodologies to the satisfaction of LTC. Please see Appendix 6 as it provides additional details on what an EIS may contain.

A-3.8 Regulation Allowances

River or stream valley allowances allow LTC to regulate development adjacent to erosion and flooding hazards in a manner that provides protection against unforeseen or predicted external conditions that could have an adverse effect on the natural conditions or processes of the river or stream valley.

Allowances give LTC the opportunity to protect access to and along a valley and/or floodplain. This access may be required for emergency purposes, regular maintenance to existing structures or to repair failed structures.

Development within the allowance must be regulated to ensure that existing erosion and flooding hazards are not aggravated, that new hazards are not created, and to ensure that pollution and the conservation of land will not be affected. The allowance provides LTC with the opportunity to maintain and enhance the natural features and ecological functions of the river or stream valley.

Regulation of development in the allowance is also required to deal with issues related to accuracy of the modeling and analysis tools utilized to establish the limits of the erosion and flooding hazards.

A-4. Discussion of Hazardous Sites

Hazardous lands means land that could be unsafe for development because of naturally occurring processes associated with flooding, erosion, dynamic beaches or unstable soil or bedrock. If the activity is within hazardous sites with unstable soil and unstable bedrock hazardous lands, then this chapter applies, otherwise refer to the River or Stream Valleys and Great Lakes Shorelines chapters for other hazards such as flooding, erosion, and dynamic beaches.

Due to the specific nature of areas of unstable soil or unstable bedrock, it is difficult to identify these hazards. The potential for catastrophic failures in some areas of unstable soil and unstable bedrock warrant site specific studies to determine the extent of these hazardous lands, and therefore the appropriate limits of the hazard and Regulation Limits. The regulated area is based on the conclusions and recommendations of such studies.

Development within areas deemed as hazardous is considered through the “development” provision of the Regulation. Activities proposed within unstable soil and unstable bedrock hazardous lands must therefore meet the definition of “development” in the Conservation Authorities Act to be regulated.

A-4.1 Unstable Soil

Unstable soil includes but is not necessarily limited to areas identified as containing sensitive marine clays (e.g. leda clays) or organic soils (MNR & CO, 2005).

A-4.1.1 Sensitive Marine Clays (Leda Clay)

Sensitive marine clays, also known as leda clays, are clays that were deposited as sediment during the last glacial period in the Champlain Sea. Undisturbed, the clays can appear as solid and stable. But when disturbed by excessive vibration, shock or when they become saturated with water, the clays can turn to liquid (MNR, 2001). The resulting failures or earthflows can be sudden and catastrophic.

Sensitive marine clays are restricted to specific locations in the province, however, are not restricted to just along rivers and streams. Information is available from Geological Survey of Canada and the MNRF.

To determine Regulation Limits, it is recommended that site specific studies be undertaken to determine the full extent of the sensitive marine clays and their full potential for retrogressive failures. While useful standards for defining the limits of the hazardous lands are provided within the "Understanding Natural Hazards" (MNR, 2001) document and Hazardous Sites Technical Guide (MNR, 1996a), it is crucial to recognize that these standards only address a first occurrence of slope failure. As such, the Guidelines for Developing Schedules of Regulated Areas recommend the use of a site/area specific study in defining the appropriate hazard (and therefore the Regulation Limit) to account for the potential of subsequent failures.

Section 3.0 of the Hazardous Sites Technical Guide (MNR, 1996a) provides important guidance with respect to assessing marine sensitive clays and the potential for development within this type of hazardous lands.

A-4.1.2 Organic Soils

Organic soils are normally formed by the decomposition of vegetative and organic materials into humus, a process known as humification. A soil is organic when the percentage weight loss of the soil, when heated, is five to eighty per cent (MNR, 2001).

As a result, organic soils can cover a wide variety of soil types. Peat soils, however, are the most common type of organic soil in Ontario. Therefore, LTC's wetland inventory may provide guidance in the location of organic soils. In addition, maps by the Geological Survey of Canada, MNRF, Ministry of Northern Development & Mines, and the Ministry of Agriculture, Food and Rural Affairs may provide additional information on the location of organic soils.

Due to the high variability of organic soils the potential risks and hazards associated with development in this type of hazardous land are also highly variable. As such, assessment of development potential in areas of organic soils is site specific. Section 4.0 of the Hazardous Sites Technical Guide (MNR, 1996a) provides important guidance in this regard.

A-4.2 Unstable Bedrock

Unstable bedrock includes but is not necessarily limited to areas identified as karst formations. Karst formations may be present in limestone or dolomite bedrock, and are extremely variable in nature. Local, site-specific studies are required for identifying karst formations. Air photo interpretation of surface features such as sink holes may provide an indication of karst formations (MNR and CO, 2005).

As with unstable soils, the potential for development to be undertaken safely in an area of unstable bedrock is site specific. Section 5.0 of the Hazardous Sites Technical Guide (MNR, 1996a) provides important guidance in this regard.

A-5. Discussion of Wetlands and Other Areas

To provide guidance in the regulating of wetlands and the associated allowances, it is necessary to highlight the functions of wetlands.

A-5.1 Functions of Wetlands

Wetlands provide functions that have both ecosystem and human values. From an ecosystem perspective these include primary production, sustaining biodiversity, wildlife habitat, habitat for species at risk, maintenance of natural cycles (carbon, water) and food chains. From a human perspective, wetlands provide social and economic values such as flood attenuation, recreation opportunities, production of valuable products, improvement of water quality and educational benefits.

Wetlands retain waters during periods of high water levels or peak flows (i.e. spring freshet and storm events) allowing the water to be slowly released into the watercourse, infiltrate into the ground, and evaporate. As well, wetlands within the floodplain of a watercourse provide an area for the storage of floodwaters and reduce the energy associated with the floodwaters.

Wetlands retain and modify nutrients, chemicals and silt in surface and groundwater thereby improving water quality. This occurs temporarily in the plants of the wetland but long term in the organic soils.

In addition, wetlands provide a variety of hydrologic functions. Over 60 potential hydrological functions have been identified for wetlands when developing the Southern Ontario Wetland Evaluation System. However, confirmation of many of these functions requires hydrological experts and field studies by qualified hydrologists. Therefore, the Ontario Wetland Evaluation System utilizes easily identifiable features and measures as surrogate values for these hydrological features.

A-5.2 Development and Interference

There are three ways through which the Conservation Authorities Act and the LTC Regulation address wetlands and other areas (areas of interference or adjacent lands within which development may interfere with the hydrologic function of the wetland) (Figure 14):

- **Development within the wetland boundary** (Section 2.1 (d) of Regulations)
  To be regulated, the activity must meet the definition of Development. Applications for development must be assessed with respect to the five "tests" outlined in the Conservation Authorities Act (control of flooding, erosion, pollution, dynamic beaches and the conservation of land);
- **Development within the "other areas"** (Section 2.1 (e) of Regulations)
  To be regulated, the activity must meet the definition of Development. Applications for development must be assessed only with respect to the hydrologic function of the adjacent wetland; and
- **Interference with Wetlands** (Section 5 of Regulations)
  To be regulated, the activity must occur within the wetland boundary and must constitute an interference in any way with the wetland. Applications for interference must be assessed with respect to the natural features and hydrologic and ecological functions of the wetland.

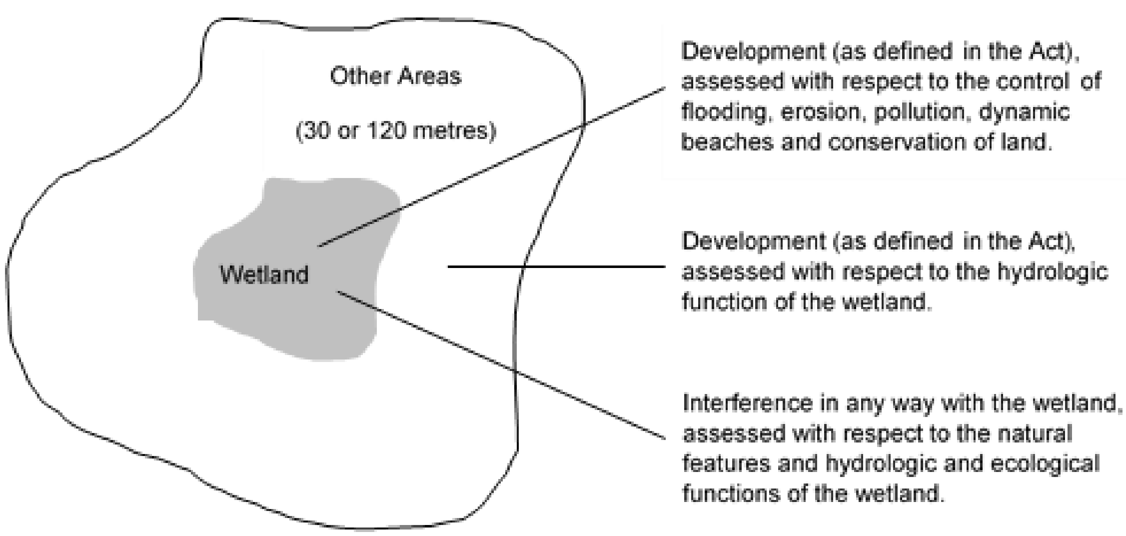

FIGURE 14: THREE WAYS THROUGH WHICH THE *CONSERVATION AUTHORITIES ACT* AND INDIVIDUAL CA REGULATIONS ADDRESS WETLANDS AND OTHER AREAS

Portions of wetlands may also be regulated due to presence of other hazards such as regulated floodplains or unstable soils. The applicable sections of this guideline document should be referenced with respect to these hazards.

Removal, filling, dredging, or changing the hydrologic regime of wetlands (e.g. ponds or drains) can result in reducing the capacity of wetlands to retain water. This can result in higher flows in watercourses with resulting increases in flooding and erosion. As well, with no ability to retain water, the ability to recharge the aquifer is reduced, and the hydrologic cycle is modified.

Development in wetlands has the potential to interfere with many of the natural features or ecological functions of wetlands. Development may remove or impact wildlife species and their habitat, degrade or remove natural vegetation communities and impair water quality and quantity in both surface and groundwater. As a result, development within wetlands can impact conservation of land.

Many wetlands develop on organic soils and, as a result, when reviewing **development** within a wetland, the soil composition should be reviewed. Where the soils are organic then the Hazardous Lands considerations should also be reviewed and the policies from this section should be incorporated in the decision making of LTC.

Pollution from development in the form of improperly installed or maintained septic systems or urban runoff has the potential to interfere with the wetland. Proposals to drain stormwater management facilities into wetlands do not benefit the wetland through constant flows for dilution and moving particulate matter. Nutrients, chemicals, and sediments could enter the wetland impeding the function of the wetland.

When reviewing an application with respect to **interference** or **development**, the evaluation done under the OWES may be used as an information resource because it identifies the features and functions of the wetland. It should be noted that when reviewing application with respect to **development** under the Regulation, the significance of the wetland as determined by the Ontario Wetland Evaluation System is not a reason to deny or approve the application. The application must be reviewed with respect to the control of flooding, erosion, pollution, dynamic beaches or the conservation of land.

Determining what represents an interference can be very challenging and is dependent on a variety of parameters such as the type and the scale of activity. The legal and practical implications associated with regulating interference will require ongoing discussions and court decisions over the upcoming years.

Many individual and cumulative hydrologic impacts to a wetland commonly occur within the catchment area of the wetland. It is important to consider the linkages between small wetlands and headwater areas, impacts of stormwater, and upstream constrictions to flow. Impacts to the hydrologic function of a wetland due to development within the “other areas” may also result from changes in imperviousness/infiltration due to a removal or change in vegetation, soil compaction during construction, disruption or alteration of groundwater flow paths due to underground construction, etc.

A-5.3 Technical Analysis - “Interfere in Any Way”

As part of the review of an application, LTC may request an Environmental Impact Study (EIS) to address Interference with a wetland. An EIS is a mechanism for assessing impacts to determine the suitability of a proposal. The submission of an EIS does not guarantee approval of the works. An EIS must be carried out by a qualified professional, with recognized expertise in the appropriate area of concern and shall be prepared using established procedures and recognized methodologies to the satisfaction of LTC.

A-6. Discussion of Watercourses

Watercourse means an identifiable depression in the ground in which a flow of water regularly or continuously occurs. These policies must be read in conjunction with the River or Stream Valleys section.

To provide guidance in the Regulation of watercourses, it is necessary to highlight the functions of watercourses.

A-6.1 Function of Watercourses

Watercourses transport both water and sediment from areas of high elevation to areas of low elevation. Watercourses also transfer energy (e.g. heating and cooling of stream waters) and organisms (e.g. movement of mammals, fish schooling and insect swarming) and provide habitat for fish and other species either in-stream or at the air-water interface. Moreover, watercourses provide a source of water supply for wildlife and livestock.

From a human perspective, watercourses provide social and economic values such as water supply, food resources, recreational opportunities (canoeing and fishing), hydro generation, land drainage, education experiences, and aesthetics.

Watercourses are dynamic, living systems with complex processes that are constantly undergoing change. The structure and function of watercourses are influenced by channel morphology, sediment characteristics (soil type, bedrock, and substrate characteristics) and the nature of the riparian vegetation both on the overbank and rooted in the bed of the watercourse. Any changes to one of these influences can have significant impacts upon other parts of the system. One of the key influences on the structure and function of a watercourse is related to the hydrology of the stream and its normal hydrograph. Changes in the volume, peaks and timing of flows can significantly impact the stream morphology, sediment transport and even riparian vegetation.

Changes to channel morphology reduce the ability of the watercourse to process sediment causing erosion and changing the amount or size of bed load being moved. Loss of riparian vegetation results in more pollutants and run-off being transferred from the land to the water, impacting water quality and flooding downstream reaches. These changes, in turn, degrade near shore and aquatic habitat and impair the watercourse for human use.