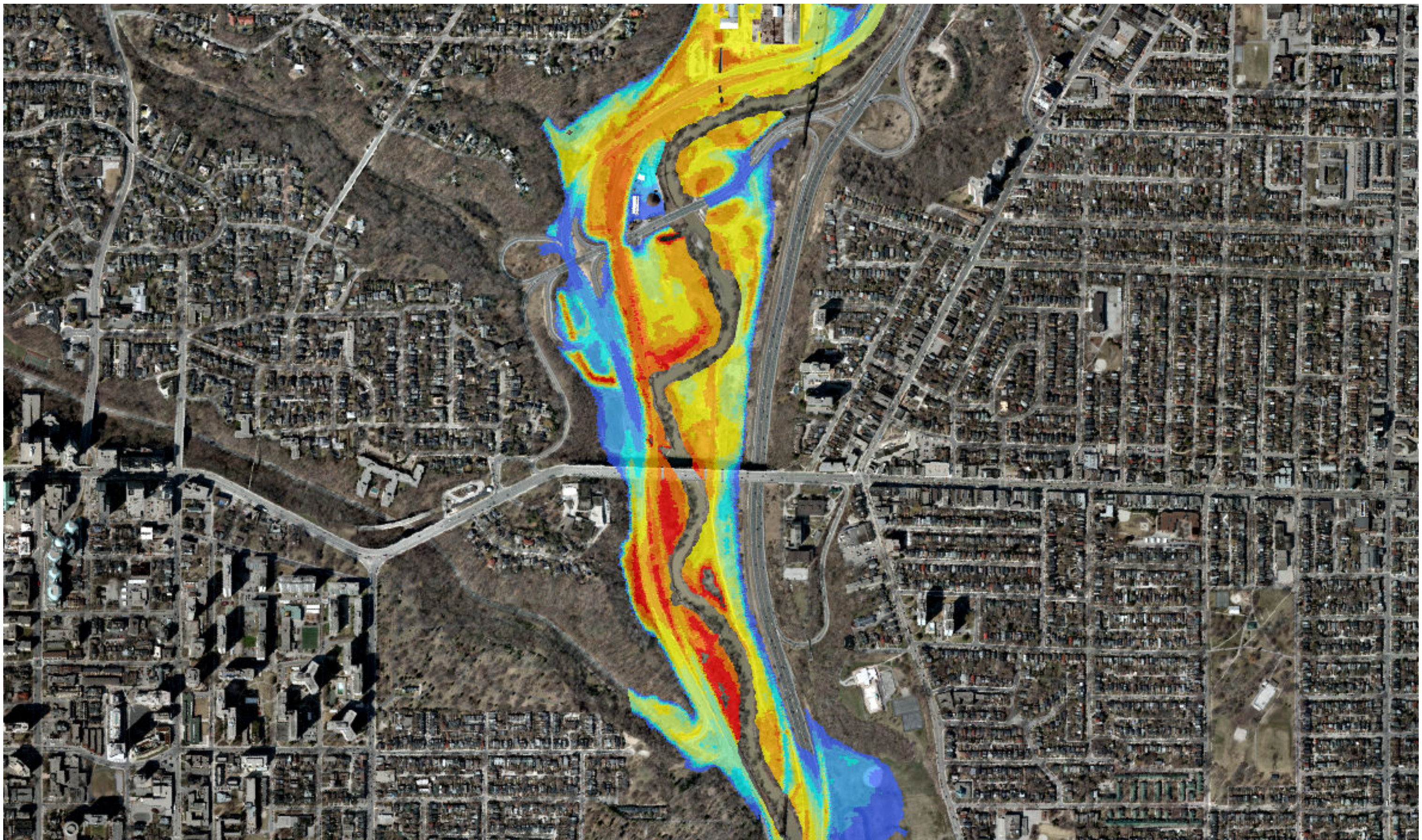

APPROACHES TO MANAGE REGULATORY EVENT FLOW INCREASES RESULTING FROM URBAN DEVELOPMENT

JUNE 2016

Toronto and Region Conservation Authority

In association with the Regional Storm Control Committee

Toronto and Region Conservation for The Living City

5 Shoreham Drive, Toronto, ON M3N 1S4

Contents

Figures

Tables

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REGIONAL STORM CONTROL COMMITTEE

The Regional Storm Control Committee is a working group under the Integrated Watershed Management Stormwater Management Technical Committee of Conservation Ontario, comprised of representatives of several Conservation Authorities who are facing, or will likely face the issue of Regulatory flood flow increases in the future as part of urbanizing watersheds. The Committee was tasked with investigating the issue, assessing the extent of this concern, and to provide a set of recommendations for managing increases to the Regulatory floodplain due to urbanization.

Committee Members:

Sameer Dhalla, *Toronto and Region Conservation Authority (chair)*

Robert Chan, *Toronto and Region Conservation Authority*

Perry Sisson, *Central Lake Ontario Conservation Authority*

Gus Rungis, *Grand River Conservation Authority*

Tim Mereu, *Credit Valley Conservation*

Amy Mayes, *Conservation Halton*

Bruce Reid, *Rideau Valley Conservation Authority*

Imtiaz Shah & Mark Shiflett, *Upper Thames River Conservation Authority*

USE OF THIS DOCUMENT

This document was created to provide guidance on approaches to address increases in Regulatory flood risk as a result of ongoing and proposed urban development. Historically the impact of urbanization on Regulatory flows were not considered since most analytical methods of the time indicated that the impact on Regulatory flows was negligible. However, current science and practice has found these assumptions to be no longer valid at a watershed and subwatershed scale resulting in the need to develop new and supportable approaches to address flood risk, both in practice and at a policy level. This document informs both development proponents and municipalities of the obligation to address potential future increases in Regulatory flows resulting from new development, as well as to present feasible alternatives to mitigate those increases in flood risk.

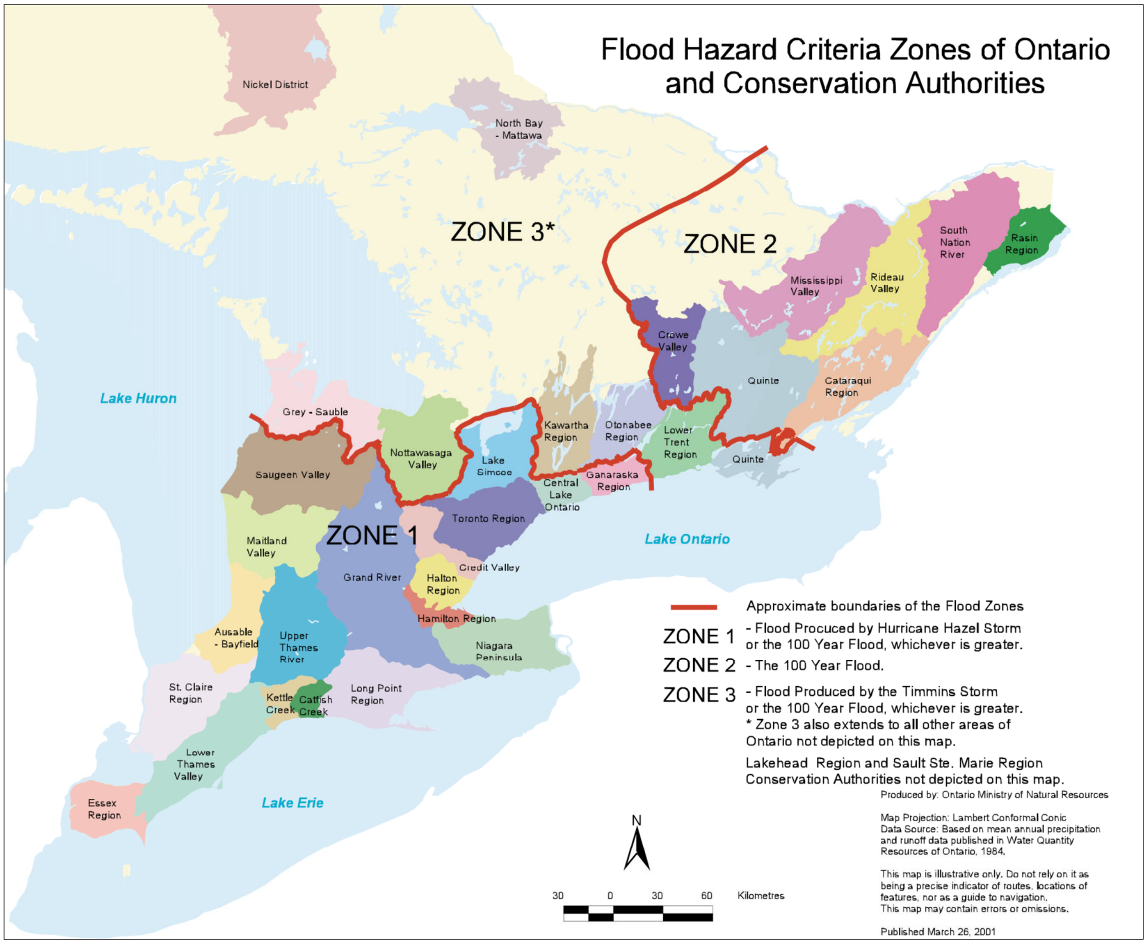
This document was created for Conservation Authorities (CAs) where large historic storms, such as Hurricane Hazel, is the Regulatory flood standard. Management plans to address Regulatory flow increases are most appropriately developed at a subwatershed or watershed scale, giving due consideration to the integrated watershed system, the socio-economic, and environmental impacts of the stormwater management strategy. The results of those studies should assess suitable management alternatives, which will then be analysed at the subwatershed/watershed scale with proponents/developers and municipalities through the appropriate planning process.

Each Conservation Authority (CA) and Municipality will need to consider how, or whether, to apply this document to their policies for local planning and regulation programs in the review of development applications. In doing so, each CA should consider the need to consult with subwatershed/watershed stakeholders before establishing Board approved policies to address the increases to flood risk arising from further development. The intent of this document is to provide a consistent approach across the Province to address the impacts of increasing Regulatory flows due to new urban development. However, it will be the responsibility of each individual CA and Municipality to ensure their policies (i.e. use of this document) are defensible for the delivery of their planning and regulations program.

1 THE REGULATORY FLOODPLAIN IN ONTARIO

For areas of Ontario served by CAs, Regulatory flood hazard limits for rivers and streams are based on the Regulatory event, which is the greater of either a 100-year return period storm or the observed rainfall from a major historic storm (Figure 1-1).

Figure 1-1 - Regulatory Flood Definition Zones in Ontario



Flood flows from the Regulatory event are calculated with hydrologic models using methodologies prescribed by the Ministry of Natural Resources and Forestry (MNRF). The resulting peak flows calculated through hydrologic simulations are then input into hydraulic models to delineate the Regulatory floodplain along a subject watercourse. CAs periodically update these hydrologic models for a number of reasons, including improved model calibration (using additional observed flow data), upgrades to state-of-the-art hydrologic modelling software, updated base mapping and land use data, and proposed future land use changes in the subject watersheds.

For most of southern Ontario, in an area that includes the jurisdiction of 19 of the province's 36 CAs (an area that has also undergone the most significant and rapid urban densification), the Regulatory Floodplain is governed by the peak discharge resulting from Hurricane Hazel. Hurricane Hazel was the 1954 storm that delivered 285 mm of rain to the southern part of the province over 48 hours, with the majority falling in the last 12 hours. Historically, it has been the general practice to assume soil conditions were saturated from the initial 73 mm of precipitation defined as part of the Hurricane Hazel rainfall distribution, thus it was assumed the resulting peak discharge would not be significantly altered by intensification and urban development, based on an assumption that impervious surfaces would have essentially the same runoff response as saturated soils on agricultural lands or natural areas.

1.1 The Experience with Urbanizing Watersheds

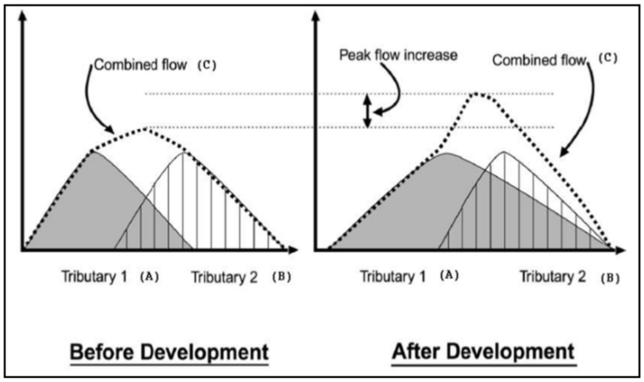
Ongoing urbanization of watersheds has resulted in progressive and incremental increases to Regulatory peak flows and runoff volumes as hydrologic models have been updated to account for constructed and planned development[1,2]. The hydrologic models used to generate Regulatory flows usually account for some future development, the degree of which is typically informed by the planning vision set in municipal Official Plans. As municipalities update their Official Plans to allow for further development the hydrologic models are periodically updated to follow suit. The updates to the hydrologic models usually generate greater Regulatory flows and runoff volumes as a result of watershed urbanization. This effect is especially problematic for watersheds where development moves from the downstream end towards headwater areas, since new development increases flood risk for existing downstream developments. This outcome contradicts the previously held assumption where runoff response between fully saturated pervious surfaces and impervious surfaces are assumed to be essentially the same. Other reasons for these increases in Regulatory flow and volume likely include:

- The extent of watershed urbanization is greater than previously assumed in the development of the hydrologic model.
- Changing development practices which have increased the intensity of impervious coverage compared to previous practices
- The ability of current hydrologic models to better simulate watershed runoff dynamics and related processes, primarily as a result of higher quality input data.

[1] Humber River Watershed Plan, TRCA, 2008;
[2] Rouge River Watershed Plan, TRCA, 2008

- Changes to runoff hydrograph timing for impervious land surface and saturated pervious surfaces can result in a cumulative increase to peak flow (Figure 1-2).

Figure 1-2 - Runoff Hydrographs Before and After Development



The net increase in peak flows and runoff volumes can increase flood risk within the Regulatory floodplain, with floodplains becoming generally wider and deeper or faster. Immediate implications are an increase in aggregate watershed flood risk, as areas that were in the floodplain may now be subjected to greater flood depths, and areas that were outside the floodplain may now reside inside the expanded flood hazard boundaries. Flood and erosion risk are also increased as a result of velocity increases. Not only is flood risk increased for areas that were previously in the floodplain, but "new" lands inside the expanded floodplain face immediate Regulatory encumbrances from existing floodplain management legislation and policies. Municipalities and floodplain regulators now face challenges in balancing development and flood risk management.

This document was created for CAs where large historic storms, such as Hurricane Hazel, is the Regulatory flood standard. However, this issue is considered to be independent of the flood standard used, and may therefore be an issue for other CA's in Ontario that either use the 100-year flood, the Timmins Storm, or other standard to delineate Regulatory flood hazard.

1.2 Challenges Imposed by Current Guidance On Mitigation and Control Strategies

Municipalities and/or Conservation Authorities maintain watershed hydrology models to provide flow rates used in the delineation of Regulatory floodplains. They are periodically updated to quantify hydrologic changes resulting from urban development and other land use changes. The output from hydrologic models (Regulatory peak flows) enable hydraulic models of watercourses to establish Regulatory flood hazard zones, and to identify where development needs to be restricted or prohibited. The hydrologic models are used to simulate runoff conditions related to various magnitudes of storm events. Model results from the 2 to 100-year storm scenarios are typically used for infrastructure design (e.g. roadway culverts), while the Regional Storm model scenario (which uses an extreme storm event, either statistical or historical in nature) generally determines the Regulatory flow. In cases where the 100-year event flow rate is greater than the Regional Storm flow it is the Regulatory flow.

According to the MNRF Technical Guide hydrologic models typically used for infrastructure design can inherently consider the function/influence of stormwater facilities and dams. Their ability to attenuate peak flows within receiving rivers and streams is recognized and thereby accounted for in these models

However, models used to establish the limits of the Regulatory floodplain are expected to follow the methodology prescribed by the MNRF Technical Guide: Rivers and Stream Systems Flood Hazard Limit. The most current iteration of the MNRF Technical Guide (2002) states that the Regulatory flood model cannot account for the influence of stormwater detention ponds or similarly constructed storage facilities:

- Stormwater management facilities may not be used to provide any reduction in flood flows *(River and Stream Systems: Flooding Hazard Limit, sections 4.6).*

The assumption is that these facilities may be full when needed or may fail and have the potential to increase downstream flood risk. Flow attenuation benefits from dams can be account for but is not preferred, since funds to maintain and replace the structure cannot be assured. Also, the dam may not operate as designed due to a loss of storage from ice, debris or sediment accumulation, operating problems, or from floods that vary from the event used to design the dam. The use of peak flows resulting from a dam failure is the most conservation option, and the recommended approach where public safety is the issue. The preferred approach is the use of unregulated flow to identify downstream flood hazard limits downstream of a dam.

This difference in methodology presents a particular challenge in the face of increasing Regulatory peak flows. The Regional Storm Control Committee is of the opinion that when supported by watershed planning and engineering design (refer to Section 4) the use of off-line Regional Storm flood control facilities to control Regulatory peak flows is appropriate and can be accounted for in Regulatory storm hydrologic models. The current MNRF Technical Guide recognizes that all eventualities and circumstances around stormwater management may not be addressed within the Technical Guide, and allows for the exercise of "good engineering and environmental judgment in adopting the most appropriate procedures" (ref. Preface, MNRF Technical Guide: River and Stream Systems, 2002). It is the CAs' interpretation that this clause allows CAs to recommend and give credit to Regional Storm flood control facilities, and defend this approach as the most appropriate practice in their engineering and environmental judgment.

The MNRF Technical Guide suggests that any measure with the ability to attenuate Regulatory peak flows requires a dam break analysis and a Lakes and Rivers Improvement Act (LRIA) permit in order to be formally approved and recognized in establishing Regulatory floodplains. However, the Province, as outlined in Section 1.3, has indicated that off-line flood control facilities, including those designed to provide Regional Storm controls, when not constructed in a lake or river would not require LRIA approval. Off-line flood control facilities are inherently situated away from the active flow area of a watercourse and would be constructed out of the Regulatory floodplain.

1.3 Conservation Authority Consultation with MNRF

CAs have recognized the policy and flood risk issues of Regulatory flow increases resulting from urban development and have consulted with the MNRF to seek further input and guidance. A summary of key past correspondence with MNRF from Conservation Ontario (CO) and other authorities is provided below.

<u>Re: Addressing Urbanization and the Regulatory Flood Hazard: Conservation Ontario letter to MNRF dated May 13, 2011</u>

This letter raised the issue where upstream urbanization has the potential to increase flood risk in downstream areas and refers to MNRF guidelines that prohibit the consideration of stormwater management facilities in the establishment of flood hazard limits. Conservation Ontario's position was that stormwater management facilities designed for the Regulatory event and used in conjunction with other measures established as part of a risk-based, watershed-scale approach, should be considered in the establishment of the Regulatory flood hazard. The correspondence stated that design standards and methodologies for facilities, whose function could be recognized in the delineation of flood hazard limits must be developed in partnership with the province and affected municipalities and incorporated into an update of the 2002 MNRF Technical Guide. Conservation Ontario requested that MNRF initiate the process to address this issue in a timely manner.

<u>Re: Urbanization and Regulatory Flood Hazard: MNRF letter to Conservation Ontario dated August 3, 2011</u>

In this letter MNRF indicated that it is exploring the complex issue of urban flooding, stormwater management, and flooding hazards in Ontario. MNRF staff were examining the issue with the Ontario Public Service to scope out the next steps for consideration. MNRF was undertaking a review of its Technical Guide to support Section 28 CA approvals and would consider CO input regarding Regulatory flood hazards into the review.

<u>Re: Urbanization and Regulatory Flood Hazard: Conservation Ontario Letter to MNRF dated August 24, 2011</u>

This letter stated that GTA Conservation Authorities were faced with extensive growth in new designated areas as per the growth plans. The timing of approvals for major land development projects were likely be required before the MNRF can complete a review of its technical guidelines. An interim approach, developed by the TRCA to deal with the issue, was offered:

1. "As part of the Master Environmental Servicing Plans prepared to support new major development, TRCA would require the impacts on the Regulatory flood hazard be assessed on a watershed basis.

2. If an increase in flood risk was apparent, TRCA would require that the increase be mitigated through the development process using acceptable stormwater management practices in consultation with the Municipality.
3. Proposed stormwater management practises/flood storage would be integrated into landscape plans and every effort will be made to ensure public safety and to reduce risk associated with failure.
4. TRCA would recognize the flood attenuation benefits of the facilities in mitigating any increase in regulatory flows until further guidance is available from the MNRF. Downstream flood hazard mapping would not be modified as these stormwater management practises would be designed to maintain existing Regulatory flows downstream."

Re: Halton Region – Stormwater Management – Regional Flood Control: Ministry of Municipal Affairs and Housing letter to Halton Region dated April 18, 2016

This letter from Ministry of Municipal Affairs and Housing (MMAH) on behalf of MNRF and MOECC provided guidance on the use of Regional Storm flood control facilities. The letter was prepared to provide direction for Regional Storm flood control facilities being planned for the Boyne and Derry Green Area of Milton and North Oakville. Provincial expectations were that municipalities and CAs were undertaking the appropriate risk management assessments and are not using stormwater management control in place of proper hazard management. The letter also states that MNRF approval under the Lakes and Rivers Improvement Act (LRIA) would not be required for the proposed Regional Storm flood control facilities because they are not located in a lake or river.

This letter confirms that through the Memorandum of Understanding between MMAH, MNRF, and Conservation Ontario, that Conservation Authorities have been delegated responsibility to "represent Provincial interest for the natural hazard policies of the Provincial Policy Statement 2014" and flags specific policies including stormwater management policy 1.6.6.7 which requires that stormwater management practices shall not increase risks to human health and safety and or result in property damage, and natural hazards policies 3.0 and 3.1 which no not support development that creates new or aggravates existing hazards.

2 LEGAL ASPECTS

CAs are governed by the Conservation Authorities Act, which provides legislative power to ensure development and other watershed activities do not introduce new risk or aggravate existing flooding or erosion risks. As outlined in the Memorandum of Understanding (MOU) between Conservation Ontario, Ministry of Natural Resources and Forestry, Ministry of Municipal Affairs and Housing on CA Delegated Responsibilities, CAs have been delegated the responsibility of representing the provincial interest on natural hazards encompassed by Section 3.1 of the 2014 Provincial Policy Statement (PPS, 2014).

The PPS, 2014 provides Provincial policies on land use planning matters. In their delegated role under the MOU, CAs review planning matters to ensure that local policies and approaches are consistent with Section 3.0 of the PPS. In their role as a public commenting agency under the Planning Act, a suite of PPS, 2014 policies related to Conservation Authority interests guide Conservation Authority review comments and advocacy during the land use planning process. Effective promotion of these policies is critical when considering any settlement area expansions, block and neighbourhood plans, secondary plans, Master Environmental Servicing Plans or other significant land use changes.

Watershed hydrology studies are periodically undertaken to inform CA and municipal policies that manage floodplain activities. These policies are developed to be consistent with the Provincial perspective as outlined in the PPS, 2014.

The laws governing water in Ontario involve consideration of both the common law as expounded in the case law and legislation that clarifies, modifies or provides exceptions to the common law. The main principles of the common law relating to water remain valid and are summarized below:

- An upper riparian owner has the right to natural drainage into the watercourse and a lower riparian owner is obliged to accept that drainage.
- Any alterations to the state of drainage must be “reasonable” and would not increase the volume of water by artificial means, if the water flows to a defined watercourse.
- Drainage works are a necessity for the common good, but while authorized under various pieces of legislation, do not by any means empower any authority or entity to create a nuisance.
- An entity may be liable in negligence when it knows of the direct and specific consequences that its system would have on another riparian owner when planning and constructing its system.

These principles have substantial implications for watershed managers and approval authorities.

2.1 OBLIGATIONS TO MANAGE FLOOD FLOW INCREASES

Applying the principles listed, and upheld by the Courts in various legal opinions[3], an entity given responsibility to manage the flow of water from the land into receiving streams and subsequent conveyance, is obligated to ensure downstream lands and uses, where the lands contain or border a defined watercourse and/or regulated floodplain, are not adversely affected as a result of deliberate changes to character and nature of upstream lands and drainage. Adverse impact has been defined on a case-by-case basis by the courts, but it follows that flood increases resulting in property damage, loss of use, or emergent impairment of ownership, and development rights in the private domain, would constitute an adverse impact. Within the public realm, an increase in flood levels may not increase flood risk as it relates to threat of economic damage or loss of life (e.g. if flood increases are confined to a public valley system designated as protected green space).

This implies both municipalities and CAs are required to prevent or mitigate adverse impacts upstream development may have on downstream lands. CAs and municipalities also have an obligation to provide comments and make planning decisions in a manner consistent with the PPS, 2014 (specifically Section 3, Subsections 5 and 6 – Natural Hazards).

These overarching obligations and responsibilities place CAs in a dilemma, as methods used to establish the Regulatory Flood Hazard limit, as prescribed by the MNRF in its 2002 Technical Guide, gives rise to a situation where development approved within their jurisdiction has imposed, or will impose adverse impacts on downstream lands and uses. The adverse impacts can come in the form of expanding and deepening Regulatory floodplains and increasing Regulatory flow velocities. The 2002 Technical Guide did not address this emerging aspect of floodplain management. The status quo is clearly not a legally sound strategy for the future, as there is now documented evidence (ref. *Rouge River Watershed Plan, Humber River Watershed Plan*) of likely Regulatory-scale impacts should floodplains continue to be managed as they have been in the past. Further expansion of urban areas, and future urban development cannot take place without a practical solution to address the issue of increased flood on downstream lands.

Note that Regulatory flows typically account for a degree of future urbanization. As such, flood hazard limits and flood risk management decisions based on these flows inherently considers the impact of planned development. It is development beyond these predicted amounts that can increase flood risk beyond what is currently managed.

The preferred solution is to have prescriptive guidance in the form of an update to the MNRF Technical Guidelines to establish approved practices for the design and implementation of Regulatory flood management systems, but it is anticipated such an undertaking will be a lengthy process due to the consultative process that would be central to that exercise. In the interim, CAs and municipalities are faced with the need to address

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[3] Scarborough Golf Club v Scarborough (City), Ontario Court of Appeal, 1988
Buysse v Town of Shelburne, 1984
Rylands v Fletcher, 1868

urban expansion driven by expanding populations and pressure on existing housing stock. This situation requires that CAs address the issue of Regulatory flood risk increases in their roles as: regulators, as representatives of the delegated provincial interest for hazards, public commenting bodies, resource management agencies, and service providers.

CAs' obligations in the context of flood risk management are:

- In an advisory capacity, to provide the best advice possible to municipalities under the Planning Act pertaining to land use planning processes and applications. This may involve CAs advising municipalities of future impacts and providing management or mitigation recommendations. This process of input shall satisfy CAs duty of care to member municipalities and by inference their inhabitants and future inhabitants. This may require new, or updates to outdated watershed studies and the development of recommendations to manage future impacts.

- To undertake flood mitigation and flood remediation works, independently or in conjunction with municipal partners located, within valleys and stream systems under the authority of the Conservation Authorities Act. These works cannot impose a nuisance to any lands and must not negatively impact flooding, erosion, pollution, or the conservation of land.

- To manage permits under the Authority's Regulations to ensure works will not knowingly increase flood risk without a means to mitigate any adverse impacts.

Further, it must be recognized that the limits of Regulatory floodlines are influenced by the land uses prescribed in municipal Official Plans. As urban areas are built out and amendments to land use designations occur, floodlines will change in the absence of long-term and acceptable management approaches. It is therefore imperative that Official Plan updates and changes be informed by floodplain mapping studies that will identify possible floodplain impacts and locations of high risk. These impacts and the remedial measures that may be required should also be identified as part of the Official Plan process.

3 Approaches to Manage Increased Future Regional Flood Risk

Future urbanization (beyond the extent assumed in current hydrologic models) has the potential to increase Regulatory flood flows and flood hazard limits should current stormwater management (SWM) practices (premised upon controlling up to the 100-year event) continue.

Municipalities are faced with a limited set of choices to address the issue of Regulatory flood flow increases. The alternatives and a brief discussion of each is provided in the sections below.

3.1 Regional Storm Flood Control Stormwater Management Facilities

Within the jurisdiction of several CAs, purpose-built Regional Storm flood control facilities have been constructed and their flood attenuating function accounted for in hydrologic modelling and floodplain mapping. The need for Regional Storm flood control facilities should be assessed as part of a risk-based, watershed-scale study to mitigate impacts of new development on the Regulatory flood hazard, which could include other measures, such as land acquisition and flood remedial works.

As noted in Section 1.2 of this document, the MNRF Technical Guide allows for the exercise of "good engineering and environmental judgment in adopting the most appropriate procedures". CAs' interpret this clause to allow CAs to recommend and give credit to Regional Storm flood control facilities, and defend this approach as the most appropriate practice in their engineering and environmental judgment.

Notwithstanding the above, there is the recognition that this approach can create liability to individual CAs since design guidelines have not been jointly developed between the province and affected municipalities. There is the risk that a Regional Storm flood control facility can deviate from the prescribed methodologies in the provincial technical guidelines for flood hazard management. As a result, there is a consensus among Ontario CAs that design standards and methodologies for stormwater management flood control facilities, whose function can be recognized in the delineation of downstream flood hazard limits, must be developed in partnership with the province and affected municipalities and incorporated into an update of the MNRF *Technical Guide*.

3.2 Comprehensive Flood Remediation/Mitigation

An alternate approach is to accept the increased flood risk resulting from new development and manage the manifestation of those risks through appropriate flood remediation and mitigation works. This alternative can include 'non-permanent' measures such as flood walls, dykes, and 'permanent' measures such as flood protection landforms, and improved channel conveyance.

It should be noted that 'non-permanent' flood mitigation works such as flood walls or dykes would not eliminate the Regulatory burden associated with floodplain expansion, as current MNRF guidelines do not grant credit for these works. Per Section 4.1.2 of the MNRF's 2002 Technical Guide "Dykes and flood walls are not regarded as permanent flood control structures and the land behind the dykes and flood walls should continue to require protection to the revised (increased) flood standard." While 'permanent' flood protection works, such as improving conveyance and larger scale landforming, might remove the Regulatory burden on existing landowners, this type of project can result in community disruption. However, addressing flood risk through implementation of a permanent solution is always the preferred approach.

This alternative can present significant challenges in resolving cross-jurisdictional issues should flood impacts manifest themselves in locations outside the parent jurisdiction (i.e. municipality) of new development areas. Even within the parent jurisdiction, there could be challenges to the implementation of flood remedial works from local communities.

3.3 No Regulatory Flood Control or Flood Mitigation

This approach would permit development to occur despite demonstrated or anticipated downstream impacts, with progressive expansion of the Regulatory floodplain, as hydrologic modelling is updated by CAs and/or municipalities to reflect land use changes. Municipalities and jurisdictions would continue to apply current stormwater management standards, whereby stormwater management facilities are designed to maintain pre-development flow rates for design events below the Regulatory standard. This alternative, while consistent with current MNRF technical guidelines, is based on watershed modelling assumptions that are no longer valid, and results in floodplains that continue to grow in extent. This is contrary to Provincial guidance as identified in the PSS, and may expose those municipalities and jurisdictions choosing this approach to legal risks, as obligations to manage impacts exist despite the lack of explicit direction in current guidelines. This alternative would also create an inequitable and difficult to manage situation whereby new restrictions are imposed on downstream landowners resulting from upstream development.

3.4 Policy Approaches

Another option is to manage increases to flood risk within the current Provincial policy framework. This can include measures such as restricting development, establishing new Two Zone floodplain management areas, or allowing limited exceptions associated with existing development in One Zone floodplain management areas.

While the Regional Storm Control Committee acknowledges the potential for policy approaches to manage flood risk, approaches that do not mitigate the increased flood risk may not be sufficient as independent solutions, and therefore the focus of this guidance document is on engineered approaches. It is noted that implementation of the engineered approaches will have to be in accordance with Provincial planning and flood hazard management standards.

Regardless of which management alternative/approach is chosen, there remains an obligation on the Public sector to address the issue of future Regulatory flood flow increases and resulting expansions of the Regulatory flood hazard limit.

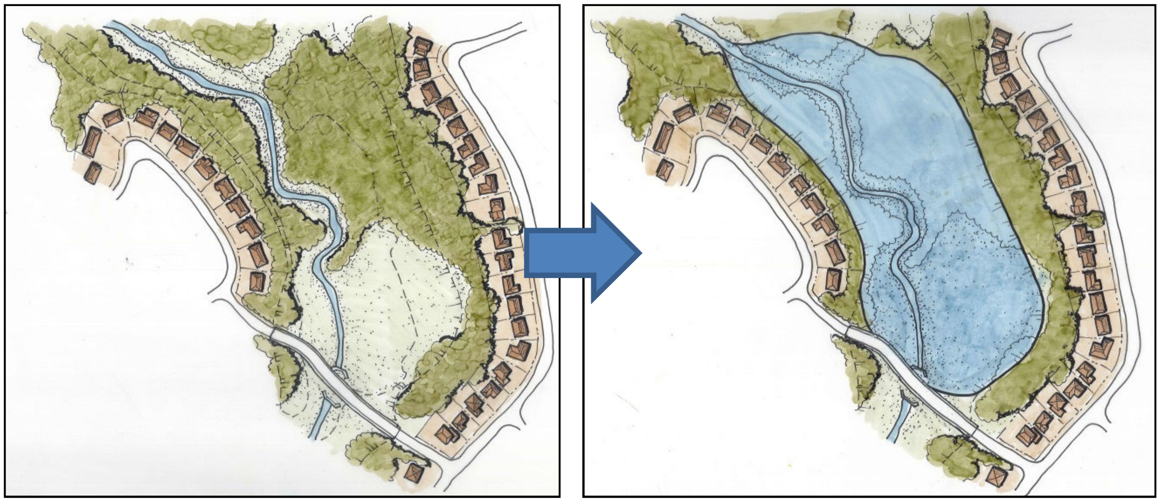
4 POTENTIAL ENGINEERED FLOOD RISK MANAGEMENT OPTIONS

The following sections provide additional detail on the potential engineered flood risk management options outlined in Section 3.

4.1 On-line Flood Control Facilities

Regulatory flows can be managed and their flood attenuation benefits accounted for by purpose-built flood control facilities situated on-line within rivers or streams with sufficient capacity and competence. Note that the on-line purpose-built flood control facilities discussed here are not on-line stormwater management ponds and are not intended to be multi-purpose reservoirs to provide low flow augmentation, water quality enhancements, aquatic habitat, recreation etc. in addition to flood storage. The on-line flood control facilities discussed are intended solely to regulate the Regulatory flow, and are not intended to regulate events below the Regulatory Event. Examples where flood reduction credit is given for such facilities, exist in the jurisdiction of the Grand River Conservation Authority, Hamilton Conservation Authority, Conservation Halton and others. On-line flood control facilities can be constructed within the valley system, or be designed to exploit the impoundment effect of roadway embankments across the valley system. They are constructed such that the watercourse is directed through the flood control facility with the capability to impound flows in excess of a controlled rate within the valley system. The impoundment can take the form of a purposely constructed structure, or may be implemented behind an appropriately modified roadway embankment (Figure 4-1). On-line flood control facilities that provide substantial impoundment of water will be classified as dams under the Lakes and Rivers Improvement Act, and will require the approval of the MNRF for its design and construction.

Figure 4-1 - On-line Control Facility Implementation



Given the potential for increased flood risk should an on-line structure fail, the MNRF Technical Guide does not generally credit these structures with downstream flow reductions. While Section 4.1.1 of the MNRF Technical Guide recognizes management of downstream floodplain on the basis of regulated flows as a potential option, “the preferred approach is the use of unregulated flow”, and it is further recommended that where public safety is at risk, flows downstream of the impoundment should be calculated with a dam break analysis, which could potentially increase downstream Regulatory flows.

On-line flood control shall only be considered where no other options exist, and where the geomorphic and ecologic impacts can be appropriately mitigated. From the perspective of various regulatory authorities, this is often considered the least preferred option due to the potential liabilities associated with failure of such structures, consequences of failure that may exceed flooding from the unregulated Regulatory flow, ecological impact, and the need to incorporate emergency planning and risk management. Further, CAs do not have the sole authority to approve on-line flood control facilities, and municipalities and the MNRF will need to be consulted. From the proponent’s perspective, this regulatory process for approval is often longer, more complex, and will require a greater level of analysis and design for potentially expensive structures. More importantly, there is no guarantee that the public agencies will approve the facility for construction or recognize its downstream management level.

4.1.1 Design of On-line Flood Control Facilities

Proposed on-line flood control facilities could work in conjunction with off-line stormwater management facilities to provide flood control below the Regulatory flood (i.e. off-line facilities would provide quantity control up to the 100-year storm). There are examples where on-line flood control facilities, designed and constructed in consultation with MNRF, have had their flow attenuation benefits accounted for in the delineation of floodplains.

The design of on-line flood control facilities intended to manage Regulatory flood flows would need to follow the procedures set out in the following:

- Consult relevant authorities including the Province and CA.
- Determine proposed discharge rates and volumes necessary to maintain downstream hydrograph peaks during the Regulatory event. This may require an iterative design process to adjust storage volumes and discharge rates until an optimal design is achieved. These assessments shall be undertaken using the approved watershed hydrology model. Assessment of hydrograph timing and magnitude effects shall be completed for all key downstream nodes, extending to the point downstream where the area controlled by the flood control facility becomes less than 10% of the total drainage area to that point.
- Determine limit of flooding behind proposed impoundment based on topography of selected site and estimated storage volumes required.
- Determine impacts to riparian owners due to upstream impoundment and identify mitigation options available. If there are no mitigation options, structural or consultative, then proposed site should be considered unsuitable.
- Prepare design of control structures for CA and MNRF review.
- Verify design maintains downstream peak rates and timing for the Regulatory event.
- Verify the design does not change flow conditions for storm events below the level of the Regulatory event (for example, ponding for more frequent events should be as small as possible i.e. the 25-year event).
- The embankment shall be designed in accordance with current dam design guidelines such as the LRIA Technical Bulletins (2011). This will ensure hydrodynamic stability of the embankment during the Regulatory event and will prevent water from piping around the outlet.
- A minimum freeboard from the crest of the embankment, or from the roadway shoulder, to the Regulatory storm flood level is to be provided as per Table 4-1.
- Install appropriate signage and barriers to inform public of the presence and function of the flood control facility. The signs will contain cautionary and safety information to educate on the dangers associated with these functions.
- Verify that the proposed control design will not negatively impact the watercourse’s environmental functions, including but not limited to fluvial stability and function, terrestrial and aquatic passage, and ecological function etc.
- Where embankments consist of modified roadway crossings, ownership of the roadway and associated rights-of-way, and ownership of the outlet structure and any other drainage infrastructure connected to it shall be clearly identified on plans of the site. Where ownership involves multiple local or regional municipalities, there shall be a requirement for a consolidated or consensus operations and maintenance program for the flood control facility to be developed.

- There shall be a requirement for a mechanism to be developed to ensure preservation of the valley storage upstream of the on-line flood control facility for as the long as the facility is required to be functional.
- There shall be a regular program of inspections to assess the state of the facility and its competence to provide its design levels of performance, and to recommend remediation measures to restore same if found deficient during inspections. Preparation and implementation of inspections, monitoring and maintenance programs will be a municipal responsibility.

Table 4-1: Minimum Freeboard (based on reservoir fetch length)

Fetch Length	Freeboard
Under 200 m	300 mm
Up to 400 m	450 mm
Up to 800 m	600 mm
Over 800 m	Consult Regulatory Authority

Adapted from Technical Bulletin, “Spillways and Flood Control Structures”, MNR, August 2011

4.2 Off-line Flood Control Facilities

Off-line flood control facilities are purpose-built flood control facilities situated outside of the Regulatory floodplain. They are constructed to store runoff and function up to the level of the Regulatory event. Off-line management may involve a mix of centralized facilities (such as a large storage area with controlled discharge), or centralized facilities paired with additional available storage located adjacent to, or distributed elsewhere within, the controlled area. Public amenity space can be incorporated into off-line flood control facilities to offer other uses besides runoff management. Off-line flood control facilities are typically much smaller than formal flood control reservoirs with a corresponding decrease in the consequences of failure. Off-line flood control facilities would not require an LRIA permit from the MNRF, and would instead fall under the purview of the MOECC and a permit (ECA) is required from them.

There are jurisdictions within Ontario where off-line flood control facilities are constructed to provide Regulatory control to protect downstream populations. In some cases the flow attenuation benefits of these purpose-built Regional flood control facilities are accounted for in determining downstream flood hazards, in other cases credit is not taken for the reduced flow rates. In either case, CAs consider the practice of crediting appropriately designed, constructed, and maintained Regional Storm off-line flood control systems as a practical, and equitable measure to balance increased flood risk. This would be consistent with the methodology used for eastern CA’s where the Regulatory storm is the 100-year event and constructed ponds designed for the 100-year event provide Regulatory control.

4.2.1 Design of Off-line Centralized Flood Control Facilities

This would take the form of a typical end of pipe facility designed to allow for storage and controlled release of Regulatory event runoff volumes. In some instances, it may be more advantageous from a planning and implementation perspective to provide Regulatory- level control by means of a typical end-of-pipe 100-year stormwater facility with additional dry storage connected in available adjacent areas. These adjacent areas may contain public amenity space such an open park to provide the facility with additional utility during non-flood conditions, subject to the approval from the Municipality.

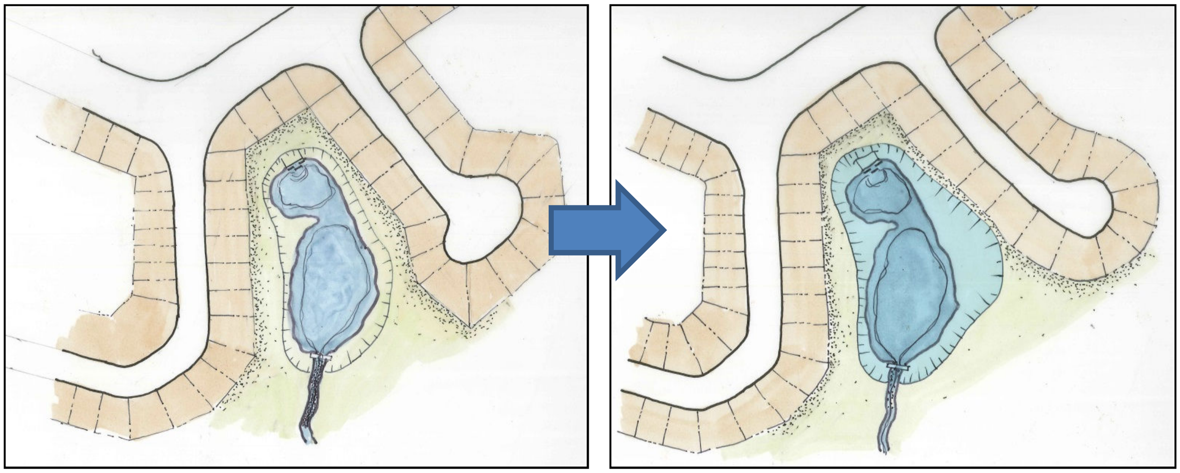
The design of off-line flood control facilities will be required to satisfy the following conditions:

- The facility should meet all relevant municipal and MOECC technical guidelines and standards. Appropriate setbacks, as determined in consultation with the CA and Municipality, shall be incorporated into the facility design.
- The facility should be constructed predominately as an excavation below existing ground. This ensures hydrostatic pressures on the “walls” of the facility are substantially and competently resisted by the pressure of surrounding earth bulk. Earth berms should be designed by geotechnical professionals to ensure they will remain competent during flooding conditions. Berm height of no more than 0.5 m is preferred, and where this is not possible berm heights should be kept to a minimum and supported by appropriate geotechnical engineering documentation.
- The facility should incorporate an emergency spillway capable of conveying the unregulated Regulatory peak flow safely away from the facility.
- A minimum freeboard is to be provided above the maximum Regulatory water level in the facility. Freeboard requirements will be determined in consultation with CA but typical freeboard dimensions are provided in Table 4-1. Note that since off-line flood control facilities are typically utilized for purposes other just Regional Storm control, (for example, water quality and erosion control) additional freeboard may be required to accommodate a reduction in available flood storage within the facility due to the stacking of storm events.
- The facility design volumes and discharge rates are to be set to ensure that the existing downstream peaks flows are maintained for the Regulatory event. This will require an iterative design process to appropriately adjust the storage volumes and discharge curves until an optimal design is arrived at. An assessment of hydrograph timing and magnitude effects shall be completed for all key downstream nodes, extending to the point downstream where the area controlled by the flood control facility becomes less than 10% of the total drainage area to that point.
- There is to be a continuous outlet path to the receiving watercourse that can convey the uncontrolled Regulatory flow (where feasible) and is entirely within public control.
- The facility must be located outside the Regulatory floodplain.
- The geometric design of the facility will also conform to Ministry of Environment and Climate Change’s Stormwater Management Planning and Design Manual and municipal design guidelines.
- Construction is to be supervised by a qualified Engineer(s), who must provide signed and sealed as-built drawings and written confirmation that the facility has

been constructed in accordance with the approved design and the Engineer's site specific directions. This includes sign-off from a geotechnical engineer.
- Long term operations and maintenance plans and enforcement of those plans will be required. Facility ownership and implementation of these plans will be a municipal responsibility.

Figure 4-2 illustrates the typical expansion of a conventional stormwater management facility to provide for Regional Storm control. Note the changes in road and lot layout to accommodate the expanded facility block.

Figure 4-2 - SWM Facility with Regional Storm Control Capabilities



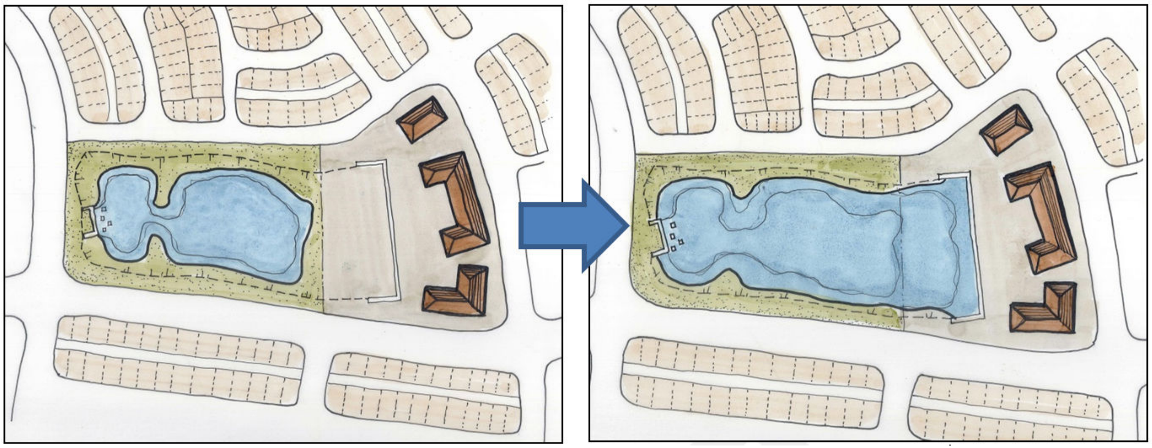
If the flood control facility is to incorporate additional dry storage from nearby amenity areas then the facility will need to meet the following additional requirements:

- The additional dry storage area for detention of Regulatory runoff should not be flooded to greater than 0.6 m during the Regulatory storm over recreational locations and 0.3 m over internal roadways local to the public amenity area. This is based on considerations of human stability in moving floodwaters, and the ability to get to safety by remaining mobile and upright (MNRF Technical Guide, Appendix 6, p. 26).
- Acceptance from the Municipal Parks department is required if the additional storage is provided on park land.
- The limits of flooding during the Regulatory event shall be clearly demarcated on grading plans of the adjacent dry storage area(s).
- Appropriate signage shall be posted to inform users of these spaces of their additional function and risks.
- A means shall be provided to restrict access to these spaces during a Regulatory event.
- A clear and unobstructed path of egress to allow for vehicles and people located within these spaces to exit shall be provided and maintained, and appropriate directional signage be posted. A clear and unrestricted flow path from the dry storage area(s) to the outlet structure of the wet pond is to be identified on design

plans. The path should be publically owned and a mechanism to maintain this path free and clear of obstructions is required.

Figure 4-3 illustrates an example of a flood control facility with designated additional dry storage available on adjacent lands.

Figure 4-3 - Off-line Flood Control Facility with Additional Storage



4.2.2 Design of Off-line Distributed Flood Control

Off-line flood control of Regulatory flows will sometimes be best achieved through a number of smaller storage facilities distributed throughout an area, but which work together to meet downstream flow targets and objectives. These smaller facilities could be single-purpose facilities, or facilities connected to adjacent dry storage areas, or stand-alone dry storage areas that are activated during the Regulatory event. These stand-alone dry storage areas may be located in community open spaces specifically graded to provide detention, or in dedicated land blocks that are strategically located throughout the area to be controlled. This option may also provide opportunities for integration with green infrastructure (GI) and Low Impact Development (LID), as the distributed nature and use of community open spaces is similar, but differ in scale and flow regime, since green infrastructure and LID operate in significantly smaller flow ranges than Regional Storm control facilities.

The design of a distributed system would be required to satisfy the conditions for centralized flood control with and without additional storage, as there will be elements of both present in such a system.

In addition, for stand-alone dry storage areas:

- An outlet for draining the dry storage area shall be identified on grading plans.
- A drawdown time less than 48 hours is preferred.
- A comprehensive maintenance and operations plan is to be prepared to ensure drainage outlets which are likely to see infrequent use are maintained in good order. This is because distributed systems have very complex interplay between the respective control structures and conveyance systems.

Figure 4-4 illustrates an example of a distributed Regulatory flood control. Note the multiple flood control facilities located within the area that collectively provides the required level of control. These facilities may be strategically placed to take advantage of adjacent open spaces for complementary storage during the Regulatory event.

Figure 4-4 - Plan View of a Distributed Flood Control System

4.3 Flood Risk Remediation and Mitigation

The preceding options for management of increases in Regulatory flows involve controlling peak flows in order to maintain existing flood risk levels in downstream areas. In contrast, this alternative would not manage Regulatory flows, but instead opts to protect at-risk areas in downstream reaches made vulnerable due to increased flow from upstream development. These risk reduction and mitigation works can be undertaken by private or public bodies, and examples are available in many jurisdictions.

The construction of dykes or flood walls, may provide some functional benefit, but would not reduce or eliminate Regulatory encumbrances, by Policy. Certain flood remediation works can be credited towards reducing or removing areas from the Regulatory floodplain. These works improve system conveyance and include measures such as channel widening and hydraulic crossing upgrades. Flood remediation measures that physically block flow, such as flood protection landforms, would require MNRF approval. The approval process would involve demonstrating the proposed flood remediation measure is permanent, passive, and adequately designed to address all modes of failure such as overtopping, saturation, and boils.

As there is potential for remediation and mitigation works to negatively impact environmental functions, such as fluvial stability and function, terrestrial and aquatic passage, habitat loss etc., a comprehensive cost-benefit analysis that duly weighs natural environmental impacts should be incorporated into any decision on the application of this flood risk management strategy.

There is an important distinction between measures undertaken to protect existing areas from current flood risk, and measures undertaken to address future increases in risk due to urban expansion. Measures undertaken to protect existing vulnerable areas may qualify as undertakings under the Conservation Ontario *Class Environmental Assessment for Remedial Flood and Erosion Control Projects*, which streamlines the approval and implementation of such works to protect life and property in previously developed areas. However, works in the second group are intended to address risk arising from new development, and as such will have to proceed as Individual Environmental Assessments or Municipal Class EAs since the definition of the *Class for Remedial Flood and Erosion Control Projects* specifically excludes "works which facilitate or anticipate development". An EA to support flood remediation measures to allow new development would presumably be harmonized with any approvals necessary under the *Planning Act* to implement the proposed development.

Flood risk remediation and mitigation will only be considered through a consultation process with the appropriate regulatory agencies. There are significant Regulatory, as well as cross-jurisdictional issues associated with this approach that will likely need discussion and consensus building before it can be advanced; among these issues are:

- Impacts may be manifested at a distant location from where new development is proposed. The location of impacts may even be in a different jurisdiction that lies downstream.
- Where works are necessary to be undertaken in another jurisdiction, a comprehensive funding plan for design and implementation of these works, as well as for their continued long term maintenance, will need to be developed.
- Projects may result in significant environmental impacts. An environmental impact assessment must be complete to ensure negative impacts are mitigatable.
- A comprehensive assessment of the long-term performance and impacts of mitigation measures will be required, such as influences on long-term planform, increases in downstream erosion as a result of right-sizing a previously undersized watercourse crossing, and ability to remain competent as the watercourse undergoes natural movement and evolution within the valley.
- Mitigation and remediation works will have to be undertaken through a consultative process with the affected downstream parties, both private and public through the appropriate EA, planning and CA permitting processes.

Clarification of ownership and maintenance of works located across jurisdictions will be required, and agreements put in place for same.

5 OPTIONS SUMMARY AND THEIR IMPLICATION FOR FLOODPLAIN MAPPING AND MANAGEMENT OF FLOODPLAINS

The implications of the suggested alternatives on floodplain mapping and flood hazard management are discussed in this section. The functional and Regulatory benefits of each alternative is discussed in terms of reducing flood risk in downstream areas within the framework deriving from the Provincial Policy Statement 2014, Planning Act, Conservation Authorities Act, the Lakes and Rivers Improvement Act, and the various Regulations that flow from these. The need for, and the suitability of these alternatives should be assessed at a subwatershed/watershed level to ensure comprehensive flood management for all affected stakeholders.

- Application of the No Regulatory Flood Control or Flood Mitigation approach is not recommended since it is not in accordance with the PPS 2014. Unmanaged new developments beyond that assumed in current hydrologic models can increase downstream flood risk which can expose regulatory authorities to legal liability.

- Purpose-built off-line flood control facilities properly designed for the Regulatory event are considered to provide flood attenuation that can be recognized in establishing the flood hazard (i.e. floodplain mapping). As noted in Section 1.2, current provincial guidelines do not allow floodplain limits to be established based on flood flows moderated by these types of facilities. However, these same guidelines are prefaced by the statement that the guidelines are:

  "not intended to be a list of mandatory instructions on technical methodologies to be rigidly applied in all circumstances, rather, it serves to assist technical staff experienced in water resources in the selection of the most appropriate computational method and flexible implementation measures, provided the decisions made are consistent with the latest Provincial Policy Statement."

  Other MNRF publications, some of which have been summarized in this document, provide design guidance to allow for these facilities to be perceived as robust and low-risk in the context of catastrophic failure, which in the opinion of the CAs may allow the use of these facilities to inform the hazard management decisions related to land use planning, floodplain management, and risk management. CAs and Municipalities may thereby determine due to the low risks associated with well-designed and maintained flood control facilities, to grant credit for them in order to ensure downstream landowners are not negatively impacted by larger floodplains and the inherent policy restrictions.

  This approach would meet the direction of the Provincial Policy Statement while allowing development to proceed as required by the Provincial Growth

Plan. It is important to note that flood reduction credit would only be given to facilities designed for the Regulatory event i.e. facilities designed below the Regulatory event standard would continue to not be included in the Regulatory event hydrologic models.

- On-line flood control facilities designed in conformance to this document and Provincial design criteria may have their flow control capabilities credited for, and reflected, in downstream floodplain mapping. It should be noted that design of such facilities will be required to satisfy Provincial requirements for approval. Due to the increased potential for failure and ecological impact associated with on-line controls, they should generally be viewed as a less-preferred option to off-line facilities. In addition, on-line food control facilities may not be preferred from a CA policy perspective.

- Flood remediation and mitigation works that improve system conveyance, such as larger crossings or larger conveyance channels, can provide flood risk reduction that can be reflected in floodplain mapping. These works are often preferred because they are inherently passive measures that do not rely on engineered (geotechnical or structural) solutions. It is recognized that flood remediation and mitigation works have the potential to significantly impact local ecological features and may not be a suitable approach for every case. Engineered flood remediation works that qualify as permanent and passive under MNRF guidelines, such as a flood protection landform, would need to meet strict engineering and size criteria in order to remove an area from the Regulatory floodplain. In either case, the remediation works need to be constructed on public lands (or on private lands subsequently placed into public stewardship and control), follow a formal consultative process that respects the rights of all downstream riparian owners, and managed by a public agency with sustainable funding for operations and maintenance before Regulatory flood reduction benefits can be realized. These works will result in floodplain mapping in downstream areas that will show Regulatory flood limits being maintained or reduced.

- Policy approaches to address increased flood risk are currently outside the scope of this document. From an engineering perspective approaches that eliminate or reduce flood risk are preferred. As such, policy changes to ease restrictions due to larger floodplains may not be preferred if it is the sole mechanism used to manage flood risk. However, a policy change approach may be appropriate if implemented in conjunction with functional flood protection works such as floodwalls or berms. This hybrid approach would provide for functional flood protection while satisfying strict provincial standards for flood hazard management without implementing large or impractical permanent flood protection measures.

Any new urban development that increases Regulatory flows can burden downstream areas with increased or new flood risk. Proponents and agencies are legally obligated to mitigate those risks based on legal principles regarding the development potential of affected downstream owners, as well as the rights of riparian landowners. The options to manage increases to Regulatory flows outlined in this document are intended only to help protect existing development already in the floodplain, and to prevent additional development from being put in an expanded floodplain. These options are not intended to facilitate new development. As previously noted, the preferred solution is to have prescriptive guidance in the form of an update to the MNRF Technical Guide to establish approved practices for the design and implementation of Regulatory flood management systems.

Each Conservation Authority (CA) and Municipality will need to consider how, or whether, to apply this document to their policies for local planning and regulation programs in the review of development applications. This may include individual CAs developing watershed specific approaches, and using this document as a template to create their own guidelines. Ultimately, It will be the responsibility of each individual CA and Municipality to ensure their policies are defensible for the delivery of their planning and regulations program.