Item 9.2

Section III – Items for the Information of the Board

TO: Chair and Members of the Board of Directors
Meeting #8/20, Friday, November 20, 2020

FROM: Sameer Dhalla, Director, Development and Engineering Services

RE: **2020 FLOOD INFRASTRUCTURE STATE OF REPAIR REPORT**

KEY ISSUE

Report on the current state of repair of Toronto and Region Conservation Authority (TRCA) flood control infrastructure, including major deficiencies, and overview of dam safety regulatory guidelines, risk management approaches, and repair projects.

RECOMMENDATION

IT IS RECOMMENDED THAT the 2020 TRCA Flood Infrastructure State of Repair Report be received.

BACKGROUND

At Authority Meeting #4/13, held on May 24, 2013, Resolution #A87/13 was approved as follows:

> *THAT the Toronto and Region Conservation Authority (TRCA) Flood Management Service Flood Infrastructure State of Repair Report be updated and reported to the Authority bi-annually.*

The last TRCA Flood Infrastructure State of Repair Report was presented at the Authority Meeting #9/16. This report was delayed to 2020 due to changes in the ranking of structure conditions and risk. These changes were made to align flood infrastructure condition assessments with TRCA's asset management plan criteria. This report further aligns with TRCA's 2017 Asset Management Policy terminology for structure condition assessment and consequence ratings.

The purpose of the report is to document the current state of repair of TRCA-owned flood infrastructure and to outline the major capital improvement projects that have been implemented or that are required in the future. Information on the process of identifying projects, funding sources, and the regulatory framework for dam safety in Ontario is also included in this report.

Strategy 2 of TRCA's *Building the Living City Strategic Plan 5-Year Update* outlines TRCA's objectives to mitigate known flood risks, which includes the operation, maintenance, and surveillance of flood infrastructure. Additionally, Conservation Authorities are mandated, under Section 21 of the *Conservation Authorities Act*, to ensure conservation, restoration, and responsible management of Ontario's water resources. Specifically, Section 21 empowers Conservation Authorities to:

- *erect works and structures and create reservoirs by the construction of dams or otherwise;*
- *control the flow of surface waters in order to prevent floods or pollution or to reduce the adverse effect thereof;*

As part of this mandate, TRCA develops and maintain programs to prevent loss of life and property damage from flooding hazards. Where appropriate, this includes structural flood mitigation alternatives. TRCA has constructed various flood control structures to reduce flood risk in Flood Vulnerable Clusters (FVCs). The majority of TRCA's flood infrastructure was built between the late 1950's and the early 1980's as part of the flood mitigation response to the Hurricane Hazel flood of 1954. TRCA has also inherited infrastructure that controls or retains water through various land acquisition programs and transactions. For the purpose of this report, flood infrastructure refers to TRCA owned dams, channel and dykes. A general location map of all TRCA flood infrastructure is provided in ***Attachment 1***. ***Attachment 4*** contains photos of various structures and related projects for reference.

Dams
TRCA's dam inventory consists of 12 dams, of which 5 were specifically built to provide flood protection. The other dams are historical mill, recreational, and industrial dams acquired through various TRCA land acquisition programs. TRCA's dams range in age between 45-85 years old and most require major capital improvements in order to meet current dam safety guidelines. A list of TRCA-owned dams is included in ***Attachment 2***. Internationally, over the past several years, there have been numerous high-profile dam safety incidents that have resulted in loss of life, mass evacuation and population displacement, environmental damage and extensive property damage. The consequences of dam failures illustrated by these incidents underscores the importance of having a robust dam maintenance program at TRCA.

Flood Control Channels
Flood control channels are designed to increase the amount of flow that can be conveyed through a watercourse reach. Flood control channels are created by replacing the natural watercourse with an engineered channel. Flood conveyance is increased by lining the channel with concrete or stone to reduce resistance to the flow of water. Flood control channels often straighten the watercourse to increase flow conveyance. Flood control channels are extremely damaging to the natural processes of a river and are only used as a last option for reducing flood risk. Because they do not retain water, flood control channels are a less-risky flood control structure type, because a failure of a channel does not cause an uncontrolled release of water, unlike a dam or dyke.

TRCA's flood control channels were built in communities with historic flood risk. These communities were built prior to the existence of TRCA's regulations on limiting development in the floodplain. TRCA owns 9 flood control channels totaling approximately 11.5km. Of this, 8.5km is of concrete trapezoidal design and the remaining channel types are a mixture of rip rap and gabion basket design. A list of TRCA's flood control channels is provided in ***Attachment 2***.

Flood Control Dykes
Dykes, sometimes also called berms, are defined as an embankment built to control or hold back water. Dykes are typically built parallel to a river to prevent water from entering developed areas. Like dams, dykes hold back water during periods of high flows, however dykes are not considered dams under definitions provided by various dam safety and regulatory agencies. Dykes are primarily earthen embankment structures, although one structure owned by TRCA was constructed as a masonry wall**.** Dykes, like dams, carry more risk than channels because a dyke failure during a flood would create a situation where there would be an uncontrolled release of water into the area protected by the dyke. TRCA owns 6 dykes totaling approximately 3.6km. A list of TRCA's dykes is provided in ***Attachment 2***.

TRCA's portfolio of dams, dykes, and channels are aging, and many have experienced deterioration that could affect their performance, safety, and stability. Engineering specifications have also evolved to become more conservative, which renders older structures unable to meet new regulations, guidelines, and best practices. The regulatory framework for managing dams is constantly shifting as knowledge of hazards and risks advances. TRCA, through studies and inspections, continues to track and document deficiencies at dams, dykes and channels to prioritize capital works. Deficiencies associated with each structure are listed in ***Attachment 2***.

Over the last 15 years TRCA has made significant investments to remediate its inventory of flood protection structures in order to meet its objectives of protecting the public from flood impacts. TRCA is committed to continued improvements to the state of repair of all dams, and channel and dyke systems that it manages.

RATIONALE

Flood infrastructure is designed to protect life and property, but also carries risk. The failure of structures designed to create storage and divert flood water can cause an uncontrolled release of water into developed areas. As an owner of dams, channels, and dykes, TRCA must strive to ensure these structures are managed safely.

The following sections of this report outline:

a) the framework in which TRCA operates, maintains and inspects flood infrastructure
b) the current condition and associated risk of TRCA flood infrastructure
c) major studies and repairs from 2016 to 2020
d) future work to ensure long-term safety and stability of existing flood infrastructure
e) funding details and grant opportunities

Dam Safety in Ontario

Dam safety in Ontario is regulated by the Ministry of Natural Resources and Forestry (MNRF) under the Lakes and Rivers Improvement Act (LRIA). They are responsible for developing the criteria that dams must meet and regulating dam owners in the safe operation and maintenance of dams. The Canadian Dam Association (CDA) is an advisory body comprised of voluntary dam safety experts supported by dam owners in Canada, including TRCA. The CDA provides technical and management guidance for dam owners using internationally recognized best practices. TRCA uses a combination of both MNRF and CDA guidelines for managing structures. This is because there are cases where one set of guidelines do not cover specific topics. For example, LRIA guidelines do not address emergency management of dams and therefore TRCA uses the CDA Emergency Management for Dam Safety Technical Bulletin.

<u>Lakes and Rivers Improvement Act</u>

In 2011, the Ontario Ministry of Natural Resources and Forestry (MNRF) introduced the *Lakes and Rivers Improvement Act* Administrative Guide, Technical Bulletins and Best Management Practices Guide (LRIA). These documents are based on criteria developed by MNRF and the Canadian Dam Association (CDA), and provide guidelines for the safe design, construction, management, operation and repair of dams in Ontario. It is a resource for engineers, operators and owners to use when assessing the safety of a dam. The LRIA Guidelines are not legislated but define best management practices and therefore the minimum standard of safety for dam owners in Ontario.

A critical component of the LRIA is the Dam Safety Review (DSR). The DSR is an in-depth engineering study of a dam. Components of a DSR include geotechnical analysis of stability, a public safety review, hydro-technical analysis, structural inspection and other investigations.

Based on the results of the DSR, the dam receives a Hazard Potential Classification (HPC). The HPC determines the risk to the public if a dam were to fail. Dams with higher risks are required to meet more stringent and conservative engineering standards. For example, a dam failure that is estimated to cause a loss of life greater than 11 persons would have an HPC of Very High. Dams with an HPC of Very High would have to meet the strictest guidelines for dam safety including safely passing the largest theoretical flood that can occur in southern Ontario (which, for reference, is larger than Hurricane Hazel). Note that safely passing a flood flow does not equate to storing the volume of that flood in a reservoir. Safely passing a flood means that the resulting flows can pass through the dam and reservoir without causing a dam failure. ***Attachment 2*** in this report includes HPC's for each dam TRCA owns. The criteria from the LRIA Classification and Inflow Design Flood Technical Bulletin for assessing HPC is also included for reference in ***Attachment 2***, Table 4.

Canadian Dam Association Dam Safety Guidelines

The CDA is a volunteer body of dam safety experts who create dam safety guidance documents using the best industry standards developed by various international organizations. CDA also develops training and workshop programs that offer hands on experience for dam professionals. Particularly important recommendations from CDA include the development of emergency management guidelines. These provide a framework for responding to dam failures. TRCA assisted in the development of the emergency management guidelines and was an early adopter of CDA's recommendations for developing emergency management protocols. All TRCA high risk dams have emergency response plans in place. Additionally, TRCA is in the process of developing emergency response plans for dams with lower risks.

TRCA Flood Infrastructure Management Program - Dams

Dam Safety Management

TRCA's four largest dams are in urban areas. As such, a failure of one of these dams would have a significant impact on downstream communities. For example, the 2011 Dam Safety Review of G. Ross Lord Dam determined that a failure of the dam could place up to 3,000 persons at risk and cause up to approximately $1.3 billion in property damage. Proper management and maintenance of these dams is critical for public safety.

TRCA has adopted LRIA and CDA guidelines into its dam safety program and is in the process of upgrading each structure to meet the criteria required, where possible.

Inspection Program

Each dam in TRCA's inventory is inspected monthly and annually. TRCA's two largest dams (Claireville Dam and G. Ross Lord Dam) also undergo daily inspections to further reduce the risk of safety or stability issues. The total number of inspections on TRCA dams is approximately 550 each year.

- Daily inspections are visual inspections to note the condition of the earthen embankment, control structures and site security.
- Monthly inspections are more detailed. Emergency generators are exercised, gate motors are tested, back-up systems tested, communications equipment checked, dam instrumentation is calibrated, and embankments are inspected.
- Annual inspections are very detailed assessments of each dam. Each component is thoroughly checked for correct operation:
    - earthen embankments are thoroughly inspected
    - gates are fully opened and closed
    - concrete spillways are inspected

- gates are operated on emergency power
- tunnels and shafts are entered and inspected
- emergency generators serviced
- gates and motors are lubricated and serviced
- back-up gate operation systems tested

Operation, Maintenance and Surveillance Manuals

Each dam owned by TRCA has an Operation, Maintenance and Surveillance (OMS) manual. The OMS manual is a stand-alone document that describes all the activities necessary to manage the dam. Sections of an OMS include:

- roles and responsibilities with contact information
- how to operate the dam gates
- operation of emergency generators
- preventative maintenance procedures
- communications
- dam storage and discharge data
- emergency procedures
- inspection criteria

Each OMS is reviewed and updated each year to ensure the document is current.

Emergency Preparedness and Response Plans

TRCA uses CDA's Emergency Management for Dam Safety Technical Bulletin for guidance on drafting emergency response plans specific to each structure. There are two types of emergency management plans for dams. Emergency Preparedness Plans (EPP) are developed for external responding agencies that are responsible for public safety. In the event of a dam emergency, the responding agency can use the EPP to coordinate resources using the EPP's inundation maps. Inundation maps depict the expected flooded areas should a dam fail and can help first responders coordinate evacuations and road closures if required. Emergency Response Plans (ERP) are internal documents for TRCA use. Contact information for staff, roles and responsibilities, organizational flowcharts, equipment/aggregate supplier information, emergency dam repair documentation, and other critical information for managing dam emergencies are included in the ERP. TRCA maintains EPP's and ERP's for all High and Very High HPC dams.

Studies, Repairs and Preventive Maintenance

Due to the complexity of dam construction and risk, TRCA undertakes numerous engineering studies to investigate the condition of the structures. Dam Safety Reviews (DSR's) are the most common study but other investigations can be required as well. It may be necessary to design a repair or to further investigate a deficiency. For example, a DSR at Stouffville Dam found that the dam may be at risk of failure during an earthquake, warranting either further study on seismic risk, or alternatively a costly stabilization project. A specialized study was initiated using the latest seismic risk investigations to confirm whether a costly repair was warranted. The study found that the risk of failure due to an earthquake was minimal and modifications to the dam were not required.

When inspections or studies find that repairs are required, TRCA retains qualified consultants and contractors to undertake the repair. Most common repairs include electrical upgrades at dams, dredging of flood control channels, and minor concrete repairs. Major deficiencies require extensive design, complex approvals and significant capital funds. TRCA is investigating

opportunities to obtain adequate funding to undertake some of the major work required to make TRCA infrastructure fully compliant with current guidelines.

Preventative maintenance is a critical part of TRCA's management of dams. In 2019, TRCA assigned a field crew to specifically undertake preventative maintenance activities on flood infrastructure. Preventative maintenance on dams is primarily geared toward removing vegetation from embankments. Removing vegetation on a regular basis prevents large trees from establishing root systems that can damage the embankment. Trees on dams can also lead to seepage issues and impair an inspector's ability to see the condition of the embankment. Preventative maintenance activities on dams can also include minor concrete repairs, debris management at dam intakes, and painting of gate components.

Public Safety Around Dams

Dams in Ontario are required to follow the Public Safety Around Dams (PSAD) Technical Bulletin from the LRIA. Statistically, it is far more likely to have serious injury or death around a dam due to falls or drowning than from a dam failure. The PSAD evaluates all the hazards around a dam and prescribes mitigation measures to ensure that all areas of the dam are safe. Mitigation primarily includes barriers (fencing, guardrails and safety booms) and warning signage. PSAD documents are reviewed annually to ensure all hazards are properly mitigated.

Dam Decommissioning

There are technical difficulties in bringing older dams into compliance with modern design guidelines. Older flood control dams were constructed using the engineering principles of the period in which they were built and cannot meet newer requirements unless substantial modifications are made. Historic, legacy dams such as mill, and recreational dams were built without any proper engineering or construction techniques and may never be able to meet LRIA guidelines. In these cases, options are limited to decommissioning the dam or increased risk management and tolerance. TRCA has decommissioned several dams in the past. Most recently, Albion Hills Dam was decommissioned in 2017 because the structure was in poor condition and unrepairable. There are several other dams in TRCA's inventory that will need to be decommissioned or replaced because their poor condition puts them at risk of failing. These include:

- Secord Dam
- Osler Dam
- Glen Haffy Extension Upper Dam
- Glen Haffy Extension Lower Dam

Removing these structures reduces TRCA liability and long-term costs. Even small dam failures can cause large amounts of property and environmental damage. Additionally, removing dams restores the river's natural functions and improves habitat and water quality.

Major Dam Safety Projects 2016-2020

There were numerous projects undertaken at TRCA dams since 2016. Projects are a combination of repairs and studies and are outlined below along with proposed dam safety projects through 2024. Projects from 2016 to 2020 are listed in Table 1.

Table 1 *Major Dam Safety Projects 2016-2020*

Structure	Year	Project	Project Cost
Claireville Dam	2020	Control Building Roof Repair • Replace roof on control building.	$30,000
Claireville Dam	2020	HVAC Repair • Decommission boiler and install electric heaters throughout control building.	$35,000
Stouffville Dam	2020	Concrete Repair and Emergency Spillway Repair Design Study • Design for concrete and emergency spillway repairs.	$90,000
G. Ross Lord Dam	2019	Hydrogeological Study • Study to examine the dam's drainage and pressure relief systems.	$85,000
Stouffville Dam	2018	Liquefaction Study • Study to determine earthquake risk to dam.	$63,000
Palgrave Dam	2018	Dam Safety Review • Engineering review of the dam.	$59,000
Milne Dam	2018	Deficiency Study • Investigate overtopping mitigation options. • Investigate structural sliding deficiency. • Confirm uplift resistance of spillway.	$84,000
Black Creek Dam	2018	Dam Safety Review • Engineering review of the dam.	$61,000
Black Creek Dam	2018	Reservoir Dredging • Remove sediment and debris from dam spillway intake and restore capacity of reservoir.	$1,760,000
Albion Hills Dam Decommissioning	2017-2018	Dam Decommissioning • Remove existing dam and construct bridge over restored creek.	$1,820,000

TRCA's Flood Infrastructure Management Program – Flood Control Channels and Dykes

<u>Annual Inspections</u>

As part of TRCA's Flood Infrastructure Management Program, channels and dykes are inspected annually. TRCA staff walk the entire length of each structure each year. Flood control channel inspections ensure that the channels are free from sediment and large vegetation. Channel linings are inspected to ensure that they are not eroding. Concrete is checked to ensure that structures are not at risk of failing during large events. The dykes' earthen embankments are inspected to make sure the structures are not eroding, settling or failing. Culverts and flap gates are checked to make sure that flood water cannot surcharge to the dry side of the dykes. Information obtained during the inspection is used to direct preventative maintenance activities and, in the case of more serious deficiencies, design repairs for capital works projects. Dykes and channels are also inspected after flood events to confirm that they were not damaged.

Maintenance

TRCA's flood control channels and dykes require maintenance activities to ensure that the structures are functioning correctly. Channels require dredging of sediment and removal of vegetation to ensure the capacity is maximized for flood events. Dykes should remain free of trees and large brush to allow inspections of the earthen embankments. Large trees can also topple during large storms causing root systems to damage large sections of the dyke, possibly leading to failure. In the past, TRCA's flood control channels and dykes have received sporadic maintenance which has led to costly, large scale sediment and vegetation removal projects. In 2019, TRCA dedicated a full-time maintenance crew to conduct small-scale maintenance on the channels and dykes. By undertaking annual maintenance on these structures, the need for expensive large-scale projects is greatly reduced. Operations were suspended for several months in 2020 due to COVID-19, but the crew is now working full-time to continue maintaining these structures.

The following table outlines major channel and dyke projects undertaken since 2016 (Table 2).

Table 2 *Channel and Dyke Projects 2016-2020*

Structure	**Year**	**Project**	**Project Cost**
Yonge York Mills Channel	2020	Concrete Channel Repair • Concrete panel repair and underpinning.	$65,000
Bolton Berm (Dyke)	2019	Bolton Berm Ice Jam Study • Engineering assessment of the 2019 Bolton ice jam.	$55,000
Bolton Berm (Dyke)	2019	Bolton Berm Major Maintenance Design Project • Final Design drawings for Bolton Berm upgrades including erosion protection and raising of crest.	$160,000
Scarlett Channel	2019	Scarlett Channel Erosion Project • Repair erosion damage at outfall to Humber River.	$200,000
Bolton Berm (Dyke)	2018-2019	Bolton Berm Drainage Upgrades • Flap gate installation and maintenance	$20,000
Pickering Dyke/Ajax Dyke	2018-2020	Pickering/Ajax Dyke Rehabilitation • Conservation Class Environmental Assessment	$450,000
Pickering Dyke/Ajax Dyke	2016	Pickering/Ajax 2D Modeling and Dyke Assessment Project • Flood assessment and structural investigation of dyke.	$75,000
Malton Channel	2016	Channel Major Maintenance Dredging Project • Removal of sediment and vegetation from channel	$500.000
Bolton Berm (Dyke)	2016	Bolton Berm Hydraulic Assessment and Remediation Study • Flood assessment of berm and structural investigation of dyke.	$102,000

State of Repair - Dams

The CDA defines risk as “the consequence of an adverse event and the probability of such an event occurring”. Within a finite resource framework, it is not possible to completely eliminate the risks associated with dams. Using modern engineering analysis and techniques, however, it is possible to greatly reduce risk. When hazards are greater for a structure, the safety requirements are proportionately more rigorous to offset the increased risk. As the owners of flood protection infrastructure, TRCA has an obligation identify and undertake works to maintain these structures in a state of good repair. With limited funding available for flood infrastructure repairs, TRCA must rank the priority of capital works. This requires that TRCA understand how each structure is performing using engineering judgement alongside criteria provided by the CDA and the LRIA. Using inspection and engineering reports, each structure is ranked using a probability/consequence matrix. In order to understand the overall safety of a structure, performance during several scenarios must be considered. For example, a dam may be considered safe for smaller, more frequent flood events but may not be able to withstand an extreme flood. Therefore, several scenarios are considered when evaluating the state of repair. These include:

1. Normal Conditions. This scenario would include typical flood events that are frequent. Normal conditions would also consider typical loading or stressing of the structure, particularly embankment stability.
2. Extreme Flood Conditions. This scenario considers the ability of the dam to withstand extreme, less probable flood events. Dams that cannot safely pass extreme floods can overtop and fail.
3. Seismic Conditions. Seismic activity in Ontario is rare and is usually limited to small magnitude earthquakes. However, dam safety guidelines require high hazard dams to be able to withstand extreme earthquakes.

Evaluating dams using the criteria listed above helps prioritize capital works. Structures that do not meet guidelines for normal conditions would rank higher for repairs than a structure that is only at risk during extreme, low probability flood and seismic events. TRCA’s objective is to make dams, channels and dykes safe for all possible events, however this will require long-term and large capital investments to achieve.

Evaluating dams for normal, extreme flood, and extreme earthquake scenarios requires that a score be given to each condition. The score corresponds to the dam’s ability to withstand the normal and extreme events. For example, a dam may have a structure condition rated as very good for normal conditions. However, if the dam overtops during extreme floods, the structure condition for that scenario may rank as poor because the probability of failure is higher for this event. If the same dam meets the requirements for seismic events, the structure condition for that scenario would be rated as very good as the probability of failure would be low.

Normal Conditions Risk Ranking

Normal conditions risk ranking evaluates the risk of structures failing when conditions are within the expected range of events for a given year. Normal conditions would include periods with no precipitation and smaller, more probable flood scenarios.

For state of repair analysis for normal conditions, TRCA evaluates each structure and categorizes them in terms of "probability of failure" and “consequence rating”. The probability of failure is based on the structure condition assessment and estimates the likelihood of a deficiency causing the structure to fail. Structure condition considers the overall condition of the structure based on DSR studies and inspection results. Structures are scored from one (1) to

five (5). A structure with a score of one (1) is in very good condition with a low probability of failure. A structure with a score of five (5) has a very poor structure condition rating and therefore a very high likelihood of failure. Structure condition ratings are described in Table 1.

Table 3 - *Structure Condition Assessment/Probability of Failure Criteria*

Condition Rating Score	**Condition**	**Structure Condition Assessment Definition**	**Probability of Failure**
1	Very Good	Well maintained, good condition, new or recently rehabilitated.	Improbable
2	Good	Good condition, few elements exhibit deficiencies.	Not Likely
3	Fair	Some elements exhibit significant deficiencies. Asset requires attention.	Possible
4	Poor	A large portion of the structure exhibits significant deficiencies. Asset mostly below standard and approaching end of service life.	Likely
5	Very Poor	Widespread signs of deterioration. Service and safety are affected.	Very Probable

In addition to the condition rating score, TRCA also considers the consequence to public safety and property should the structure fail or perform below expectations. Known as the consequence score, the consequence score is determined by estimating property and risk to life during a failure. The score is estimated on a scale between one (1) and five (5). The higher the score, the higher amount of damage would be expected if the structure fails. See Table 2 for a description of consequence rating score criteria.

Table 4 - *Consequence Rating Score Criteria*

Consequence Rating Score	**Consequence Rating Definition**
1	Insignificant damage to property.
2	Minor/slight damage to property.
3	Limited damage to property.
4	Significant damage to property. Possible public safety risk.
5	Major risk to property and public safety.

The consequence rating score is multiplied by the condition rating score to determine an overall state of repair/risk ranking score. This score is then placed on a risk ranking matrix to determine the overall risk of the structure. Please see Table 3 for the risk ranking matrix. The results of the risk ranking matrix are included in ***Attachment 3*** for all TRCA flood infrastructure. Risk ranking is comprised of four (4) categories:

a) Low Risk (1-5, green shading)
b) Moderate Risk (6-10, yellow shading)
c) High Risk (11-15, orange shading)
d) Extreme Risk (16-25, red shading)

This assists TRCA in understanding where to focus limited capital funds for repairs. Structures with a risk ranking in the High and Very High Category require priority attention to repair the deficiency.

It should be noted that there are limitations to determining risk. The complexity of forces acting on a structure is difficult to quantify and therefore determining the probability of failure is difficult. Experience, training and engineering judgment are used to assess the stability and performance of flood infrastructure. Regardless, the process for evaluating structures is somewhat subjective. With the limitations of current inspection techniques, it is not possible to say with certainty that a structure will or will not fail. Inspections can identify potential failure modes, but the complexity of the loads and stresses placed upon structures cannot be precisely measured and so there is a degree of unpredictability in evaluating them.

Table 5 - *Risk Ranking Score Matrix*

	CONSEQUENCE RATING				
CONDITION RATING/RISK OF FAILURE	**Insignificant damage to property.** **1**	**Minor, slight damage to property.** **2**	**Limited damage to property.** **3**	**Significant damage to property. Possible public safety risk.** **4**	**Major damage to property. Major risk to public safety.** **5**
Very poor condition. Very probable risk of failure. 5	**5**	**10**	**15**	**20**	**25**
Poor condition. Failure likely. 4	**4**	**8**	**12**	**16**	**20**
Fair condition. Possible failure. 3	**3**	**6**	**9**	**12**	**15**
Good condition. Failure not likely. 2	**2**	**4**	**6**	**8**	**10**
Very good. Improbable. 1	**1**	**2**	**3**	**4**	**5**

Extreme Conditions - Dams

Additional analysis may be required to evaluate risks for rare conditions such as extreme floods or earthquakes. Extreme floods may overtop dams causing failures. Earthquake events could cause structural failures in dams. To understand how a risk is affected by extreme events, the structure condition assessment score is increased. For example, a dam that is considered safe under normal conditions but may fail during an earthquake, the structure condition assessment score is increased to account for the inability of the dam to withstand ground movement during a seismic event. This increases the risk score of the structure. The consequence score remains the same because the same area is affected by a dam failure. Risk rankings for extreme conditions at dams is included in ***Attachment 3***.

Dam safety guidelines consider extreme events in their criteria for determining safe structures; however, it is difficult for dam owners to meet all the guidelines because standards keep evolving. For example, a dam built in 1970 would meet the guidelines for that time period. As engineering knowledge progresses the standards change, and the dam built in 1970 would not meet standards in 2020. This creates difficulties for dam owners in that dams need to be constantly upgraded and modified to meet the most current safety guidelines. Often these repairs are very costly and difficult to implement. However, because the probability of these extreme events is so low, the priority to mitigate the risk is lower. Priority repairs are focused on deficiencies for normal conditions, however, TRCA is undertaking studies to implement repairs for extreme events as well. The risk ranking for TRCA dams for extreme/unlikely events is included in ***Attachment 3***.

State of Repair – Dykes and Flood Control Channels

TRCA undertakes annual inspections and engineering studies to determine the current state of repair for dykes and flood control channels. Dykes are assessed similarly to dams because during high flow events they impound water. Therefore, TRCA inspectors look for conditions that could cause the dyke to fail such as slumping, erosion, seepage, sinkholes, and other deficiencies. Flood control channels are inspected for blockages that reduce the capacity of the channel. Channel linings are also inspected for erosion that could lead to slope failure or damage to concrete panels. Channels and dykes are not assessed for performance during extreme events. For example, extreme floods can overtop channels, but the overall stability may not be affected. Additionally, seismic activity would have minimal impact to a channel's stability. Dykes typically are not assessed for seismic activity because the dyke is only under load during high flow events. The probability of a flood and a large earthquake occurring at the same time are very low.

Attachment 3 lists the structure condition assessment score and the probability of failure for TRCA dykes and flood control channels.

FINANCIAL DETAILS

Funding for the operation, maintenance, inspection and repair of TRCA flood infrastructure is from several sources, as outlined below.

MNRF Section 39

MNRF Section 39 grant funding is provided to Conservation Authorities for natural hazard management. TRCA receives approximately $165,000/year for operation and maintenance of flood infrastructure. This is matched by municipal levy.

Capital Levy

Municipal levy capital funding is provided for flood infrastructure maintenance repair works. Capital levy funding for 2020 was as follows:

Table 6 - *Municipal Capital Levy for Flood infrastructure*

Durham Region	$22,000
York Region	$71,000
Region of Peel	$309,000
City of Toronto	$267,000 (includes Floodworks Enhanced Capital)
Total	$669,000

Water and Erosion Control Infrastructure Funding

The Ministry of Natural Resources and Forestry supports conservation authorities to undertake maintenance activities throughout Ontario with the Water and Erosion Control Infrastructure Program (WECI). Under this program, repairs and studies undertaken on structures are eligible for 50% matching funds from the Province of Ontario. Projects are reviewed and prioritized by MNRF and only the highest ranked projects are awarded grants. TRCA applies for WECI funding every year for both repairs and studies. The WECI program has become a critical tool for funding capital improvement projects.

Table 7- *WECI Funding 2016-2021*

WECI Funding received by TRCA 2016-2020	
2016/2017	$230,425
2017/2018	$218,802
2018/2019	$128,023
2019/2020	$126,045
2020/2021	$280,000
Total	$983,295

National Disaster Mitigation Program (NDMP)

The NDMP is focused on flood risk studies, flood plain mapping, non-structural or small-scale structural risk reduction measures, and not toward maintenance and upgrade projects for existing flood infrastructure. However, TRCA was successful in obtaining funding to optimize gate operations at G. Ross Lord Dam and to examine flood risk at Claireville Dam and Stouffville Dam. Total contribution to these projects from NDMP was approximately $211,000. TRCA has been informed that there may be future intakes for infrastructure projects.

Disaster Mitigation and Adaptation Fund (DMAF)

DMAF was created to fund large-scale infrastructure projects to implement projects that increase resiliency and reduce risk to the public. It is specifically geared towards risks associated with flooding, wildfires and droughts. TRCA intends to pursue DMAF funding to address the major deficiencies with TRCA's flood infrastructure. Because the program has a minimum investment of $20,000,000, TRCA is bundling many flood infrastructure projects to meet this requirement. As a cost-sharing program, DMAF would still require matching funding contributions. Considering the significant capital costs of these projects, TRCA is initiating discussions for these future projects with funding partners.

Investing in Canada Infrastructure Plan (ICIP)
This is a federal program designed to assist municipalities and public sector agencies implement projects to create long-term economic growth while increasing climate change resiliency. Upgrading aging flood infrastructure would fall under this requirement. The provincial government has announced that a new intake will be opening in 2020. TRCA will be seeking funding when applications become available.

TRCA maintains a list of priority projects to take advantage of funding opportunities. TRCA's list of priority flood infrastructure projects is available in ***Attachment 5***. While TRCA is seeking funding from all levels of government and communicating the risk to the public posed by aging flood infrastructure, there is the possibility that only some (or none) of the projects will get the required funding. These projects present a significant liability for TRCA. To address the existing risks until deficiencies can be corrected, TRCA needs to continue improving surveillance, maintenance, risk prioritization and emergency management strategies to offset increasing deterioration of flood infrastructure. Early warning of dangerous or unstable conditions is an effective way of reducing risk to the public but should not replace the need to undertake improvements.

TRCA has made significant progress in upgrading the condition of its flood infrastructure over the past 15 years. Numerous projects have been undertaken to restore flood channels and increase dam safety, redundancy and reliability. Thorough Dam Safety Reviews and engineering studies have helped TRCA understand how the structures rank in terms of risk to the public and how to mitigate this risk. TRCA Flood Infrastructure staff will continue to receive regular training in dam surveillance and public safety, and to monitor for changes to dam safety guidelines and the evolution of best practices.

As outlined in the above report, TRCA's inventory of flood infrastructure is aging and, in some cases, has exceeded its expected functional life. There are many forces and natural stresses acting upon these structures that reduce their effectiveness in preventing flooding. TRCA is monitoring these structures and performing capital improvements as they become necessary. However, some mitigation projects are very large in scope and will require substantial funding. Many of these projects will take multiple years to complete because of the complex engineering, design and approval process required for flood infrastructure repairs. TRCA will pursue funding opportunities such as WECI and DMAF to offset costs for these large projects.

Flooding is a serious threat to the GTA. Weather is unpredictable and extreme events can happen at any time. Climate change science projects a future increase to extreme precipitation events in Canada. Extreme events combined with the dense urbanization of TRCA's watersheds increase the stresses placed upon TRCA's flood infrastructure. To respond to this threat, TRCA will continue ensure that flood infrastructure is performing at the highest level of protection possible. Rigorous monitoring, well designed repairs, and stable funding sources are all necessary to ensure that TRCA's dams, dykes and channels will continue to provide protection from future flood events.

Relationship to Building the Living City, the TRCA 2013-2022 Strategic Plan
This report supports the following strategy set forth in the TRCA 2013-2022 Strategic Plan:
Strategy 2 – Manage our regional water resources for current and future generations

Item 9.2

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Date: October 29, 2020
Attachments: 5

Attachment 1 – General Location Map for TRCA Flood Infrastructure
Attachment 2 – TRCA's Flood Infrastructure List with Deficiencies
Attachment 3 – TRCA's Flood Infrastructure State of Repair
Attachment 4 – Photographs of Various TRCA Flood Infrastructure and Projects
Attachment 5 - Priority Project List for Addressing TRCA's Flood Infrastructure Deficiencies