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Item No. 15.1
Environment and Sustainability Committee
October 4, 2018

TO: Chair and Members of Environment and Sustainability Standing Committee

SUBMITTED BY: ***-Original Signed-***

Kelly Denty, Director, Planning & Development

-Original Signed-

Jacques Dubé, Chief Administrative Officer

DATE: September 10, 2018

SUBJECT: **National Disaster Mitigation Program – Flood Risk Assessment Study**

ORIGIN

- June 23, 2015 - Regional Council passed a motion directing staff to submit an application to the National Disaster Mitigation Program (NDMP) to carry out a risk assessment on flood prone areas in the municipality.

- July 25, 2016 - HRM received the fully executed funding agreement from the Province of Nova Scotia for the National Disaster Mitigation Program (NDMP) – Flood Risk Assessment study.

LEGISLATIVE AUTHORITY

Halifax Regional Municipality Charter, Subsection 74 (1) "The Municipality may agree with one or more municipalities, villages, service commissions, the Government of the Province or of Canada or a department or agency of either of them or a band council pursuant to the *Indian Act (Canada)* to provide or administer municipal or village services."

Halifax Regional Municipality Charter Part IV, Finance, Power to expend money, clauses 79 (1)(p)(al) **"**The Council may expend money required by the Municipality for….(p) preventing or decreasing flooding;…(al) wastewater facilities and stormwater systems;"

RECOMMENDATION

It is recommended that the Environment and Sustainability Standing Committee recommend that Regional Council:

1. Accept the methodology contained in the National Disaster Flood Risk Assessment study (Attachment E), as the basis for prioritizing mitigation projects in flood prone areas.

2. Direct the Chief Administrative Officer to:

    a. work with Halifax Water to develop a joint flood risk assessments implementation plan for the ten sites outlined in the Discussion section of this report, which will include a funding/cost-sharing strategy with options for consideration of Regional Council during the 2019/20 and 2020/21 business plan and budget deliberations; and

    b. submit an application to the National Disaster Mitigation Program to carry out follow up studies for the Sackville Rivers and Shubenacadie Lakes systems.

BACKGROUND

On February 26, 2013, Regional Council approved an interim Stormwater Infrastructure Funding Solution to help remedy private property flooding impacts that are not funded through either the tax rate or the utility rate. The interim funding solution, which expired in 2015, included projects that were evaluated on how well they met the following criteria:

- Residential/Utility/Municipal experience (flooding claims, roadway icing)
- Solution feasibility
- Diversion from wastewater system
- Opportunities for secondary funding from any sources (Provincial, Federal, Utility)
- Severity of impact on the community
- Project integration opportunity

While the evaluation criteria did include severity impacts on communities, it did not specifically address risk. In recognition of increasing disaster risks and costs, the Federal Government established the National Disaster Mitigation Program (NDMP) in 2014, as part of the Government's commitment to building safer and more resilient communities through investment in projects addressing rising flood risk and costs.

In broad terms, there are four categories of projects that are eligible for funding: risk assessments, flood mapping, mitigation planning, and small-scale mitigation projects. The NDMP is intended to address rising flood risks and costs, and to inform future mitigation investments that could reduce, or even negate, the effects of flood events.

Based on direction from Council, staff have been developing an inventory of areas in the Municipality that are at risk of flooding or that have flooded as a result of storm events. The overall list consists of almost 700 individual properties that are flood prone or have drainage issues. In addition, there are over 500 sites that are routinely visited by operations staff prior to a storm to clean inlets to prevent flooding.

From compiled historical service records and operational data, the Municipality and Halifax Water have identified thirty (30) key areas that are prone to frequent flooding concerns during heavy rainfall events. These key sites are shown in Attachment A.

DISCUSSION

The National Disaster Mitigation Program

The NDMP Study involved completion of a Risk Assessment Information Template (RAIT), issued by Public Safety Canada, which are included in Attachment B.

The current study falls under the first of four (4) available NDMP funding streams:

- **Stream 1: Risk Assessment (This Study) -** Identification of the potential hazards; impact(s) of the hazard to people, economy, structures and networks, the natural environment, etc.; the community's vulnerabilities; and assessment of the likelihood of occurrence. Involves determination of risk thresholds to serve as an informal decision-making support tool, and to inform the prioritization and selection of mitigation projects.
- **Stream 2: Flood Mapping -** Flood mapping to identify structures, people and assets most likely to be impacted.
- **Stream 3: Mitigation Planning -** Using information on identified flood risks to make informed planning decisions. Involves identifying broad mitigation goals, objectives/strategies, and key activities to meet the objectives.
- **Stream 4: Investments in Non-Structural and Small Scale Structural Mitigation -** Implementation of a specific mitigation project.

It is important to note that the NDMP funding guidelines recognize that additional work beyond Stream 1: Risk Assessment is needed to study and mitigate the flooding. The intent of the Stream 1 study is to identify and assess flooding as a hazard risk using the best information that is available, understanding that flood mapping and/or modelling (i.e., Stream 2 activities) may be required for the risk to be fully understood and addressed.

Types, Causes & Consequences of Flooding

The NDMP Guidelines define flooding as "The overflow of natural drainage channels, natural shorelines and/or human-made facsimiles leading to partial or complete inundation from the overflow of inland or tidal waters, and/or the accumulation or runoff of surface waters from any source".

Flooding can typically be described by the following terms:

- Riverine;
- Coastal;
- Urban;
- Failure of Water-Retaining Structures.

The primary causes of flooding in Canada are typically related to hydro-meteorological conditions such as:

- Extreme Rainfall;
- Snowmelt Runoff;
- Rainfall on Frozen Ground;
- Rain on Snow;
- Ice Jams;
- Natural Dams;
- Coastal Storm Surge.

Flooding can have a variety of impacts on a community at both a small and large scale, such as:

- **Infrastructure:** damage to transportation systems, water supply, wastewater system, communications.

- **Public Safety:** injury, fatalities, access to hospitals, limited emergency health response.
- **Society:** evacuation, relocations, access to schools, public perception.
- **Economic:** damage to businesses, loss of business, loss of economic assets, disruption to local economy, cost of damage recovery and re-build.
- **Environment:** damage to the natural environment such as vegetation, sedimentation, impacts on water quality.
- **Property and Building Damage:** structural damage, damage to building contents, sewer backups, basement flooding, water damage.

These were the primary criteria used in the NDMP Risk Assessment.

Study Framework

From a previous "Baseline Study", and in coordination with Halifax Water, staff consolidated a short-list of thirty (30) key sites (Attachment A) as candidates for assessment under the NDMP. The thirty sites were identified as ones where municipal and Halifax Water staff most frequently respond to during rain events.

The goal of this study was to investigate and document flood risks at these key flood-prone areas identified within the Municipality, focussing on the impacts at the community level. The results will assist Council in making decisions and to support future funding strategies for the implementation of flood mitigation measures within the Municipality.

The following framework was used for this study:

- **Background Review and Information Compilation:**
  - Review of available background material regarding the study, including the existing Baseline Study;
  - Compilation of background information on the 30-key flood-prone areas identified by HRM.

- **Preliminary Risk Assessments (30 Key Areas):**
  - Completion of preliminary site investigations for the 30 key areas identified by HRM;
  - Facilitation of Preliminary Risk Assessment Workshops to engage HRM and Halifax Water staff and to inform the preliminary risk assessments and site ranking;
  - Completion of Preliminary Risk Assessments for each of the 30 key areas, based on RAIT criteria and information collected in the consultation process.

- **Site Risk Ranking:**
  - Ranking of the Top-30 flood-prone sites, per the RAIT forms, with the goal of identifying the 10 highest flood risk sites to proceed to detailed assessment. Informed through review of background information, workshop feedback and preliminary site assessments.

- **Detailed Risk Assessments (10 Highest-Flood Risk Areas):**
  - Completion of detailed site investigations for the Top-10 highest risk areas;
  - Facilitation of Detailed Risk Assessment Workshops with HRM and Halifax Water staff to inform the detailed risk assessments and mitigation strategies;
  - Completion of Detailed Risk Assessments for each of the 10 highest risk areas including detailed RAIT forms.

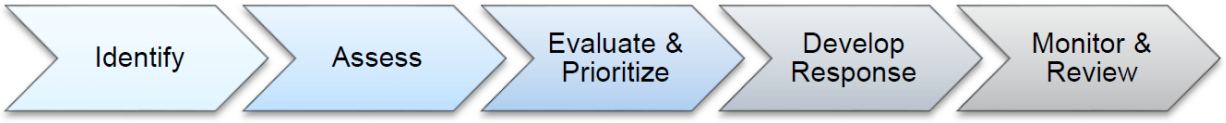
- **Preliminary Mitigation Strategy Recommendations:**
  - Development of Preliminary Mitigation Strategy Recommendations complete with order of magnitude cost estimates and NDMP funding streams for recommended remedial works.

Risk Assessment Methodology

This flood risk assessment considered the collected data on impacts, consequences, and frequency of occurrence for floods. Taking this data into account, certain mitigation recommendations for each site were formulated which may be eligible for funding under the NDMP or other similar programs.

For the purposes of this study, Flood Risk is defined as an uncertain event or condition that, if occurs, has potential negative impact on the community. Subsequently, Risk Management is the process of identifying risks, determining the likelihood of occurrence, severity of the consequences, and addressing those which are the most threatening to the community. The following outlines the Risk Assessment Methodology process used in this study:

- **Identify the Risk:** What type of flood? What area is at risk?
- **Assess the Risk:** What is the likelihood of the event occurring?
- **Evaluate and Prioritize Risks:** Is the flood risk low or high? What are the most critical risks?
- **Develop Response:** What mitigation strategies should be applied to manage the risk?
- **Monitor and Review:** Continue to monitor risks and implemented mitigation measures.



Top Ten Highest Priority Sites for Detailed Risk Assessment

Based on the study's evaluation framework, a list of the top ten highest priority sites for detailed risk assessment was developed, and a more detailed analysis was carried out for each of the sites. The prioritization matrix can be found in Attachment C. The top ten sites are as follows:

NDMP Ranking	Site Numbers (Attachment A)	Site Description
1	20, 21,25,26	Sackville Rivers
2	17,30	Shubenacadie Lakes
3	8	Karlson's Wharf (Upper Water Street)
4	9	Inglis Street at Barrington
5	16,17,23, 24	Highway 2
6	7	Pleasant Street (near Dartmouth General Hospital)
7	3, 5	Cole Harbour Road at Perron Drive
7	2	Shore Road – Eastern Passage
7	22	Hammonds Plains Road at Bluewater Road
7	A2	Bedford Highway at Mount St. Vincent

Flood Risk Site Categorization

When the "Baseline Study" was first commissioned, staff had a collection of several thousand service calls. These service calls ranged primarily from localized events occurring at individual properties to large flooding events impacting traffic and adjacent properties. The Baseline study identified 700 properties that have been impacted by stormwater drainage in some manner.

Out of the 700 properties, 30 key sites (Attachment A) were selected for further assessment under the NDMP. Sites being assessed vary from a neighbourhood or street location, to a broader community, depending on the operational issues and severity of the flooding impacts. The sites have been grouped as either Large Natural Watershed Systems, Localized Drainage Infrastructure, or Tidal Influenced Systems. Each group shares similar hydrologic and hydraulic causes, impacts and consequences, as well as mitigation strategies and are discussed below.

Large Natural Watershed Systems: Three of the ten highest priority sites may be categorized as Large Natural Watershed Systems, since they are located immediately adjacent and within the floodplain of one of the major natural drainage channel in the areas:

- Sackville River System
- Shubenacadie Lakes System,
- Cole Harbour / Bissett Lake Watershed System

Localized Drainage Infrastructure: Flooding at four of the ten highest priority sites may be characterized as the result of limited or inadequate capacity of the local stormwater drainage infrastructure systems:

- Highway 2, (Sites #16, #17, #23, and #24)
- Pleasant Street, near Dartmouth General Hospital - Dartmouth
- Hammonds Plains Road at Bluewater Road – Bedford
- Bedford Highway at Mount Saint Vincent

Of these sites, work is already underway on the Hammonds Plains Road at Bluewater Road site where a consultant has been engaged to develop preliminary design options and capital cost estimates.

Tidal Influence Systems: Three of the ten highest priority sites are understood to be influenced by the normal and extreme tidal range of the Atlantic Ocean coincident with peak stormwater runoff conditions:

- Karlson's Wharf at Upper Water Street - Halifax
- Inglis Street at Barrington Street – Halifax
- Shore Road - Eastern Passage

The Karlson's Wharf Site is within the boundaries of the Cogswell Interchange Redevelopment project. As a result, the Cogswell project consultant is preparing a design solution. The solution will be presented in a follow-up report to Council.

Costs of Possible Mitigation Actions

As part of this study, a recommended mitigation strategy along with an order of magnitude costing for the strategy was completed for the 10 highest priority areas. The strategies include interim, short term (1-2 years), medium (3-5 years) and long term (5+ years) solutions. Most of these time frames have been designated with a respective and associated costing.

Aggregating the information provided, the overall financial implications for mitigating these top ten sites is estimated to be in the range of $6.3 to $15 million. This order of magnitude is considered by staff to be the "known cost" to mitigate the issues at the top ten sites. Some costs are unknown and are not included in

this order of magnitude estimate, specifically, the long-term costs for the Sackville River and Shubenacadie Lakes Systems, as well as Shore Road and Inglis Street at Barrington.

Summary

Estimated costs provided by the consultant indicate that known cost of adaptation or mitigation of the top ten sites is at least $15 million. This amount will undoubtedly grow as studies are carried out on the Sackville River and Shubenacadie Lakes systems. It is important to note that the top ten sites that ranked high did so because of the impact of flooding on major corridors and streets. It is also important to note that the impacts are expected to become more severe in terms of both magnitude and frequency as the result of climate change.

Federal and provincial funding programs may provide a source of funding to help offset the cost of upgrading the stormwater system. The federally budgeted programs include the following:

- NDMP's final cycle in fiscal 2019/20 (Applications deadline is set for October 23, 2018);
- Disaster Mitigation and Adaption Fund as announced and in 2017 Federal Budget

To qualify for the NDMP federal funding program, applications need to be submitted by October 23, 2018. Staff are recommending that an application be submitted to have follow up studies carried out for the Sackville River ($150,000) and Shubenacadie Lakes systems ($300,000). Under the NDMP program, federal funding is provided up to 50% of the project costs. There is no Provincial cost-sharing component.

Additionally, on January 16, 2018, the Municipality and Halifax Water adopted an Integrated Stormwater Management Policy which recognized the various roles and responsibilities of stakeholders including Federal and Provincial Governments. This policy provides a fair and rational basis on which to apportion costs of upgrading a stormwater system, based on the benefit received from an upgrade. In this respect, the benefit received by the Municipality derives from protecting the road infrastructure and reducing flooding in the public right of way, the benefit received by Halifax Water derives from reduced inflow into the wastewater system, and the benefit received by private property owners derives from reducing flooding on private property.

A flood risk assessments implementation plan can be developed by applying these cost sharing principles to the findings of the NDMP Flood Risk Assessment Study. If the Municipality develops this plan, it would be prudent to include a component for research and development of green infrastructure, as a stewardship program to prevent future flooding.

Acceptance of the report recommendations would provide staff with a framework by which HRM’s flood related matters would be prioritized and actioned.

FINANCIAL IMPLICATIONS

Based on the cost estimates provided in the risk assessment report (Attachment D), staff anticipate that the Sackville Rivers study will require funding of $150,000 and the Shubenacadie Lakes study will require $300,000 for a total cost of $450,000. Through the NDMP program, this work is eligible to be cost shared to a maximum of 50% with Public Safety Canada, requiring $225,000 of municipal funding for the work. This funding is not included in the 2018/19 operating budget and would need to be incorporated as part of the on-going 2019/20 budget development process. Staff will return to Regional Council later in October with funding options for the two studies.

Within the next 12 months, staff will return to Regional Council for consideration of a flood risk assessment implementation plan and a long-term funding strategy.

RISK CONSIDERATION

There are no significant risks associated with the recommendations in this report. The risks considered rate low.

To reach this conclusion, consideration was given to the current operational level of service provided to the residents when tending to flood related complaints

COMMUNITY ENGAGEMENT

The study has been presented to the Regional Watershed Advisory Board (RWAB). The RWAB fully endorses that Council support the study's outcomes. RWAB has noted that the preventative and proactive approach to infrastructure inventory to manage emerging issues is a positive step forward for establishing integrated management opportunities with the solid focus areas of natural systems, local drainage infrastructure and tidal influences systems.

RWAB indicated that being reactive to climate change is not an option for a future of intense and frequent rainfall events which will put our municipal assets at risk. RWAB welcomes community engagement and educational opportunities at all stages of this process.

ENVIRONMENTAL IMPLICATIONS

If approved, the recommendations contained in this report will continue to move HRM towards a better understanding of flood risk and possible solutions to high priority risks.

ALTERNATIVES

1. The Environment and Sustainability Standing Committee could recommend that Regional Council not direct the CAO to develop an integrated funding strategy or flood risk assessments implementation plan with Halifax Water. This is not recommended for the reasons outlined in the report.

2. The Environment and Sustainability Standing Committee could recommend that Regional Council direct the CAO to develop a flood risk assessments implementation plan, and include other areas that have not been rated as high by the NDMP criteria, or have not been included in this study. This is not recommended for the reasons outlined in the report.

3. The Environment and Sustainability Standing Committee could recommend that Regional Council could decline to direct the CAO to submit applications to the "National Disaster Mitigation Program" for either or both of the Sackville Rivers and Shubenacadie Lakes system.

ATTACHMENTS

Attachment A: 30 Key Sites
Attachment B: Risk Assessment Information Templates
Attachment C: Site Prioritization Matrix
Attachment D: Summary of Recommended Strategies & Order of Magnitude Costing
Attachment E: National Disaster Mitigation (NDMP) Flood Risk Assessments Consultant Main Report
Attachment F: Financial Summary

A copy of this report can be obtained online at halifax.ca or by contacting the Office of the Municipal Clerk at 902.490.4210.

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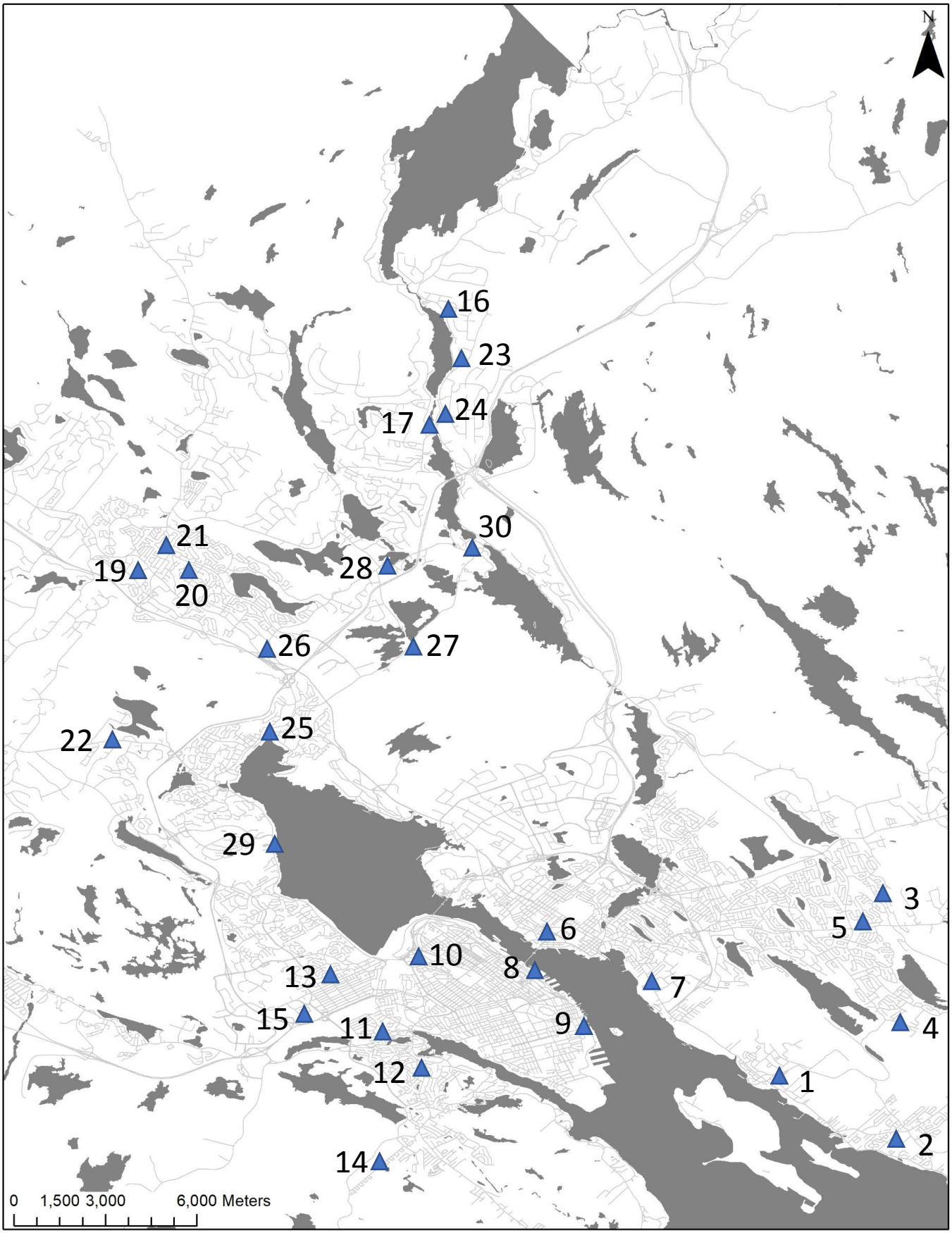
Report Approved by: Paul Burgess, Infrastructure Policy and Standards Program Manager

Attachment A

OVERVIEW OF 30 KEY SITES

Following completion of the HRM Stormwater Funding Strategy – Baseline Study (SDMM, 2015), HRM and Halifax Water developed a short-list of 30 flood prone areas within the municipality that are subject to frequent flooding. These 30 sites serve as a starting point for the current study, identified as candidates for preliminary risk assessment and potential funding under the Federal NDMP. An overview Figure of the 30 Key Sites is presented in the following page. The following table presents the list of 30 Key Sites provided in the Terms of Reference:

SITE NO.	LOCATION	REGION	DISTRICT
1	Autoport; Eastern Passage	East	3
2	Shore Road; Eastern Passage	East	3
3	John Stewart Drive; Dartmouth	East	4
4	Beaver Crescent; Cole Harbour	East	4
5	Cole Harbour Road @ Perron Drive; Cole Harbour	East	4
6	Nantucket Avenue @ Wyse Road; Dartmouth	East	5
7	Pleasant Street, near Dartmouth General Hospital; Dartmouth	East	5
8	Karlson's Wharf @ Upper Water Street; Halifax	West	7
9	Inglis Street @ Barrington Street; Halifax	West	7
10	Kempt Road @ Lady Hammond; Halifax	West	8
11	Keating Road @ Crown Drive; Halifax	West	9
12	Melville Avenue @ Winchester Avenue	West	9
13	Glenforest Weir; Halifax	West	10
14	Leiblin Drive @ Guildwood Crescent; Halifax	West	11
15	Bently Drive @ Ramsbrook Court; Halifax	West	12
16	Wellington Fire Station, Highway 2; Wellington	Central	1
17	Fletcher's Drive, near civic 57; Fall River	Central	1
18	Hammonds Plains Road, near Kynock Resources; Hammonds Plains	Central	13
19	Bambrick Road @ Orchard Drive; Middle Sackville	Central	14
20	Rankin Drive @ Glendale; Lower Sackville	Central	15
21	Sunnyvale Crescent @ Beaverbank Road; Lower Sackville	Central	15
22	Hammonds Plains Road @ Bluewater Road; Bedford	Central	16
23	Holland Road @ Highway 2; Fletcher's Lake	Central	1
24	Highway 2, from Holland Road to Miller Lake Road; Fall River	Central	1
25	Bedford Highway, from Union Street to Highway 102; Bedford	Central	16
26	Sackville Drive @ Cobequid Road; Lower Sackville	Central	15
27	Rocky Lake Drive, near quarry entrance; Bedford	Central	16
28	Cobequid Road @ Regwood Drive; Windsor Junction	Central	1
29	Bedford Highway @ Shaunslieve Drive; Bedford	Central	16
30	Ridge Avenue, from School Street to end; Waverley	Central	1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ATTACHMENT B

Public Safety Canada | Sécurité publique Canada

Ottawa, Canada
K1A 0P8

National Disaster Mitigation Program (NDMP)
Risk Assessment Information Template

Risk Event Details			
Start and End Date	Provide the start and end dates of the selected event, based on historical data.	Start Date:	End Date:
Severity of the Risk Event	Provide details about the risk, including: • Speed of onset and duration of event; • Level and type of damaged caused; • Insurable and non-insurable losses; and • Other details, as appropriate.		
Response During the Risk Event	Provide details on how the defined geographic area continued its essential operations while responding to the event.		
Recovery Method for the Risk Event	Provide details on how the defined geographic area recovered.		
Recovery Costs Related to the Risk Event	Provide details on the costs, in dollars, associated with implementing recovery strategies following the event.		
Recovery Time Related to the Risk Event	Provide details on the recovery time needed to return to normal operations following the event.		

National Disaster Mitigation Program
Risk Assessment Information Template

Risk Event Identification and Overview	
Provide a qualitative description of the defined geographic area, including: • Watershed/community/region name(s); • Province/Territory; • Area type (i.e., city, township, watershed, organization, etc.); • Population size; • Population variances (e.g., significant change in population between summer and winter months); • Main economic areas of interest; • Special consideration areas (e.g., historical, cultural and natural resource areas); and an • Estimate of the annual operating budget of the area.	
Methodolgies, processes and analyses	
Provide the year in which the following processes/analyses were last completed and state the methodology(ies) used: • Hazard identification; • Vulnerability analysis; • Likelihood assessment; • Impact assessment; • Risk assessment; • Resiliency assessment; and/or • Climate change impact and/or adaptation assessment. *Note:* It is recognized that many of the processes/analyses mentioned above may be included within one methodology.	

National Disaster Mitigation Program
Risk Assessment Information Template

Hazard Mapping	
To complete this section: • Obtain a map of the area that clearly indicates general land uses, neighbourhoods, landmarks, etc. For clarity throughout this exercise, it may be beneficial to omit any non-essential information from the map intended for use. Controlled photographs (e.g. aerial photography) can be used in place of or in addition to existing maps to avoid the cost of producing new maps. • Place a grid over the maps/photographs of the area and assign row and column identifiers. This will help identify the specific area(s) that may be impacted, as well as additional information on the characteristics within and affecting the area. • Identify where and how flood hazards may affect the defined geographic area. • Identify the mapped areas that are most likely to be impacted by the identified flood hazard. Map(s)/photograph(s) can also be used, where appropriate, to visually represent the information/prioritization being provided as part of this template.	
Hazard identification and prioritization	
List known or likely flood hazards to the defined geographic area in order of proposed priority. For example: (1) dyke breach overland flooding; (2) urban storm surge flooding ; and so on.	
Provide a rationale for each prioritization and the key information sources supporting this rationale.	
Risk Event Title	
Identify the name/title of the risk. An example of a risk event name or title is: "A one-in-one hundred year flood following an extreme rain event."	
Type of Flood Hazard	
Identify the type of flood hazard being described (e.g., riverine flooding, coastal inundation, urban run-off, etc.)	

Secondary hazards	
Describe any secondary effects resulting from the risk event (e.g., flooding that occurs following a hurricane).	
Primary and secondary organizations for response	
Identify the primary organization(s) with a mandate related to a key element of a natural disaster emergency, and any supporting organization(s) that provide general or specialized assistance in response to a natural disaster emergency.	

Risk Event Description	
Description of risk event, including risk statement and cause(s) of the event	
Provide a baseline description of the risk event, including: • Risk statement; • Context of the risk event; • Nature and scale of the risk event; • Lead-up to the risk event, including underlying cause and trigger/stimulus of the risk event; and • Any factors that could affect future events. *Note:* The description entered here must be plausible in that factual information would support such a risk event.	

Location	
Provide details regarding the area impacted by the risk event such as: • Province(s)/territory(ies); • Region(s) or watershed(s); • Municipality(ies); • Community(ies); and so on.	
Natural environment considerations	
Document relevant physical or environmental characteristics of the defined geographic area.	
Meteorological conditions	
Identify the relevant meteorological conditions that may influence the outcome of the risk event.	

Seasonal conditions	
Identify the relevant seasonal changes that may influence the outcome of the risk assessment of a particular risk event.	
Nature and vulnerability	
Document key elements related to the affected population, including: • Population density; • Vulnerable populations (identify these on the hazard map from step 7); • Degree of urbanization; • Key local infrastructure in the defined geographic area; • Economic and political considerations; and • Other elements, as deemed pertinent to the defined geographic area.	

Asset inventory	
Identify the asset inventory of the defined geographic area, including: • Critical assets; • Cultural or historical assets; • Commercial assets; and • Other area assets, as applicable to the defined geographic area. Key asset-related information should also be provided, including: • Location on the hazard map (from step 7); • Size; • Structure replacement cost; • Content value; • Displacement costs; • Importance rating and rationale; • Vulnerability rating and reason; and • Average daily cost to operate. A total estimated value of physical assets in the area should also be provided.	
Other assumptions, variability and/or relevant information	
Identify any assumptions made in describing the risk event; define details regarding any areas of uncertainty or unpredictability around the risk event; and supply any supplemental information, as applicable.	
Existing Risk Treatment Measures	
Identify existing risk treatment measures that are currently in place within the defined geographic area to mitigate the risk event, and describe the sufficiency of these risk treatment measures.	

Likelihood Assessment		
Return Period		
Identify the time period during which the risk event might occur. For example, the risk event described is expected to occur once every X number of years. Applicants are asked to provide the X value for the risk event.		
Period of interest		
Applicants are asked to determine and identify the likelihood rating (i.e. period of interest) for the risk event described by using the likelihood rating scale within the table below.		
Likelihood Rating	**Definition**	
5	The event is expected and may be triggered by conditions expected over a 30 year period.	
4	The event is expected and may be triggered by conditions expected over a 30 - 50 year period.	
3	The event is expected and may be triggered by conditions expected over a 50 - 500 year period.	
2	The event is expected and may be triggered by conditions expected over a 500 - 5000 year period.	
1	The event is possible and may be triggered by conditions exceeding a period of 5000 years.	
Provide any other relevant information, notes or comments relating to the likelihood assessment, as applicable.		

Impacts/Consequences Assessment			
There are 12 impacts categories within 5 impact classes rated on a scale of 1 (least impacts) to 5 (greatest impact). Conduct an assessment of the impacts associated with the risk event, and assign one risk rating for each category. Additional information may be provided for each of the categories in the supplemental fields provided.			
A) People and societal impacts			
	Risk Rating	**Definition**	**Assigned risk rating**
Fatalities	5	Could result in more than 50 fatalities	
	4	Could result in 10 - 49 fatalities	
	3	Could result in 5 - 9 fatalities	
	2	Could result in 1 - 4 fatalities	
	1	Not likely to result in fatalities	
Supplemental information (optional)			
Injuries	5	Injuries, illness and/or psychological disablements cannot be addressed by local, regional, or provincial/territorial healthcare resources; federal support or intervention is required	
	4	Injuries, illnesses and/or psychological disablements cannot be addressed by local or regional healthcare resources; provincial/territorial healthcare support or intervention is required.	
	3	Injuries, illnesses and/or psychological disablements cannot be addressed by local or regional healthcare resources additional healthcare support or intervention is required from other regions, and supplementary support could be required from the province/territory	
	2	Injuries, illnesses and/or psychological disablements cannot be addressed by local resources through local facilities; healthcare support is required from other areas such as an adjacent area(ies)/municipality(ies) within the region	
	1	Any injuries, illnesses, and/or psychological disablements can be addressed by local resources through local facilities; available resources can meet the demand for care	
Supplemental information (optional)			

National Disaster Mitigation Program
Risk Assessment Information Template

		Risk Rating	Definition	Assigned risk rating
Displacement	Percentage of displaced individuals	5	> 15% of total local population	
		4	10 - 14.9% of total local population	
		3	5 - 9.9% of total local population	
		2	2 - 4.9% of total local population	
		1	0 - 1.9% of total local population	
	Duration of displacement	5	> 26 weeks (6 months)	
		4	4 weeks - 26 weeks (6 months)	
		3	1 week - 4 weeks	
		2	72 hours - 168 hours (1 week)	
		1	Less than 72 hours	
Supplemental information (optional)				
B) Environmental impacts				
		5	> 75% of flora or fauna impacted or 1 or more ecosystems significantly impaired; Air quality has significantly deteriorated; Water quality is significantly lower than normal or water level is > 3 meters above highest natural level; Soil quality or quantity is significantly lower (i.e., significant soil loss, evidence of lethal soil contamination) than normal; > 15% of local area is affected	
		4	40 - 74.9% of flora or fauna impacted or 1 or more ecosystems considerably impaired; Air quality has considerably deteriorated; Water quality is considerably lower than normal or water level is 2 - 2.9 meters above highest natural level; Soil quality or quantity is moderately lower than normal; 10 - 14.9% of local area is affected	
		3	10 - 39.9% of flora or fauna impacted or 1 1 or more ecosystems moderately impaired; Air quality has moderately deteriorated; Water quality is moderately lower than normal or water level is 1 - 2 meters above highest natural level; Soil quality is moderately lower than normal; 6 - 9.9 % of area affected	

	2	< 10 % of flora or fauna impacted or little or no impact to any ecosystems; Little to no impact to air quality and/or soil quality or quantity; Water quality is slightly lower than normal, or water level is less than 0.9 meters above highest natural level and increased for less than 24 hours; 3 - 5.9 % of local area is affected	
	1	Little to no impact to flora or fauna, any ecosystems, air quality, water quality or quantity, or to soil quality or quantity; 0 - 2.9 % of local area is affected	
Supplemental information (optional)			

C) Local economic impacts

	Risk Rating	Definition	Assigned risk rating
	5	> 15 % of local economy impacted	
	4	10 - 14.9 % of local economy impacted	
	3	6 - 9.9 % of local economy impacted	
	2	3 - 5.9 % of local economy impacted	
	1	0 - 2.9 % of local economy impacted	
Supplemental information (optional)			

D) Local infrastructure impacts			
	Risk Rating	**Definition**	**Assigned risk rating**
Transportation	5	Local activity stopped for more than 72 hours; > 20% of local population affected; lost access to local area and/or delivery of crucial service or product; or having an international level impact	
	4	Local activity stopped for 48 - 71 hours; 10 - 19.9% of local population affected; significantly reduced access to local area and/or delivery of crucial service or product; or having a national level impact	
	3	Local activity stopped for 25 - 47 hours; 5 - 9.9% of local population affected; moderately reduced access to local area and/or delivery of crucial service or product; or having a provincial/territorial level impact	
	2	Local activity stopped for 13 - 24 hours; 2 - 4.9% of local population affected; minor reduction in access to local area and/or delivery of crucial service or product; or having a regional level impact	
	1	Local activity stopped for 0 - 12 hours; 0 - 1.9% of local population affected; little to no reduction in access to local area and/or delivery of crucial service or product	
Supplemental information (optional)			
Energy and Utilities	5	Duration of impacts > 72 hours; > 20% of local population without service or product; or having an international level impact	
	4	Duration of impact 48 - 71 hours; 10 - 19.9% of local population without service or product; or having a national impact	
	3	Duration of impact 25 - 47 hours; 5 - 9.9% of local population without service or product; or having a provincial/territorial level impact	
	2	Duration of impact 13 - 24 hours; 2 - 4.9% of local population without service or product; or having a regional level impact	
	1	Local activity stopped for 0 - 12 hours; 0 - 1.9% of local population affected; little to no reduction in access to local area and/or delivery of crucial service or product	

Supplemental information (optional)			
Information and Communications Technology	5	Service unavailable for > 72 hours; > 20 % of local population without service; or having an international level impact	
	4	Service unavailable for 48 - 71 hours; 10 - 19.9 % of local population without service; or having a national level impact	
	3	Service unavailable for 25 - 47 hours; 5 - 9.9 % of local population without service; or having a provincial/territorial level impact	
	2	Service unavailable for 13 - 24 hours; 2 - 4.9 % of local population without service; or having a regional level impact	
	1	Service unavailable for 0 - 12 hours; 0 - 1.9 % of local population without service	
Supplemental information (optional)			
Health, Food, and Water	5	Inability to access potable water, food, sanitation services, or healthcare services for > 72 hours; non-essential services cancelled; > 20 % of local population impacted; or having an international level impact	
	4	Inability to access potable water, food, sanitation services, or healthcare services for 48-72 hours; major delays for nonessential services; 10 - 19.9 % of local population impacted; or having a national level impact	
	3	Inability to access potable water, food, sanitation services, or healthcare services for 25-48 hours; moderate delays for nonessential services; 5 - 9.9 % of local population impacted; or having a provincial/territorial level impact	
	2	Inability to access potable water, food, sanitation services, or healthcare services for 13-24 hours; minor delays for nonessential; 2 - 4.9 % of local population impacted; or having a regional level impact	
	1	Inability to access potable water, food, sanitation services, or healthcare services for 0-12 hours; 0 - 1.9 % of local population impacted	

Supplemental information (optional)			
Safety and Security	5	> 20 % of local population impacted; loss of intelligence or defence assets or systems for > 72 hours; or having an international level impact	
	4	10 - 19.9 % of local population impacted; loss of intelligence or defence assets or systems for 48 – 71 hours; or having a national level impact	
	3	5 - 9.9 % of local population impacted; loss of intelligence or defence assets or systems for 25 – 47 hours; or having a provincial/territorial level impact	
	2	2 - 4.9 % of local population impacted; loss of intelligence or defence assets or systems for 13 – 24 hours; or having a regional level impact	
	1	0 - 1.9 % of local population impacted; loss of intelligence or defence assets or systems for 0 – 12 hours	
Supplemental information (optional)			

E) Public sensitivity impacts			
	Risk Rating	Definition	Assigned risk rating
	5	Sustained, long term loss in reputation/public perception of public institutions and/or sustained, long term loss of trust and confidence in public institutions; or having an international level impact	
	4	Significant loss in reputation/public perception of public institutions and/or significant loss of trust and confidence in public institutions; significant resistance; or having a national level impact	
	3	Some loss in reputation/public perception of public institutions and/or some loss of trust and confidence in public institutions; escalating resistance	
	2	Isolated/minor, recoverable set-back in reputation, public perception, trust, and/or confidence of public institutions	
	1	No impact on reputation, public perception, trust, and/or confidence of public institutions	
Supplemental information (optional)			

Confidence Assessment

Based on the table below, indicate the level of confidence regarding the information entered in the risk assessment information template in the "Confidence Level Assigned" column. Confidence levels are language-based and range from A to E (A=most confident to E=least confident).

Confidence Level	Definition	Confidence Level Assigned
A	Very high degree of confidence Risk assessment used to inform the risk assessment information template was evidence-based on a thorough knowledge of the natural hazard risk event; leveraged a significant quantity of high-quality data that was quantitative and qualitative in nature; leveraged a wide variety of data and information including from historical records, geospatial and other information sources; and the risk assessment and analysis processes were completed by a multidisciplinary team with subject matter experts (i.e., a wide array of experts and knowledgeable individuals on the specific natural hazard and its consequences) Assessment of impacts considered a significant number of existing/known mitigation measures	
B	High degree of confidence Risk assessment used to inform the risk assessment information template was evidence-based on a thorough knowledge of the natural hazard risk event; leveraged a significant quantity of data that was quantitative and qualitative in nature; leveraged a wide variety of data and information including from historical records, geospatial and other information sources; and the risk assessment and analysis processes were completed by a multidisciplinary team with some subject matter expertise (i.e., a wide array of experts and knowledgeable individuals on the specific natural hazard and its consequences) Assessment of impacts considered a significant number of potential mitigation measures	

C	Moderate confidence Risk assessment used to inform the risk assessment information template was moderately evidence-based from a considerable amount of knowledge of the natural hazard risk event; leveraged a considerable quantity of data that was quantitative and/or qualitative in nature; leveraged a considerable amount of data and information including from historical records, geospatial and other information sources; and the risk assessment and analysis processes were completed by a moderately sized multidisciplinary team, incorporating some subject matter experts (i.e., a wide array of experts and knowledgeable individuals on the specific natural hazard and its consequences) Assessment of impacts considered a large number of potential mitigation measures	
D	Low confidence Risk assessment used to inform the risk assessment information template was based on a relatively small amount of knowledge of the natural hazard risk event; leveraged a relatively small quantity of quantitative and/or qualitative data that was largely historical in nature; may have leveraged some geospatial information or information from other sources (i.e., databases, key risk and resilience methodologies); and the risk assessment and analysis processes were completed by a small team that may or may not have incorporated subject matter experts (i.e., did not include a wide array of experts and knowledgeable individuals on the specific natural hazard and its consequences). Assessment of impacts considered a relatively small number of potential mitigation measures	
E	Very low confidence Risk assessment used to inform the risk assessment information template was not evidence-based; leveraged a small quantity of information and/or data relating to the natural risk hazard and risk event; primary qualitative information used with little to no quantitative data or information; and the risk assessment and analysis processes were completed by an individual or small group of individuals little subject matter expertise (i.e., did not include a wide array of experts and knowledgeable individuals on the specific natural hazard and its consequences). Assessment of impacts did not consider existing or potential mitigation measures	

Rationale for level of confidence	
Provide the rationale for the selected confidence level, including any references or sources to support the level assigned.	

Key Information Sources	
Identify all supporting documentation and information sources for qualitative and quantitative data used to identify risk events, develop the risk event description, and assess impacts and likelihood. This ensures credibility and validity of risk information presented as well as enables referencing back to decision points at any point in time. Clearly identify unclassified and classified information.	
Description of the risk analysis team	
List and describe the type and level of experience of each individual who was involved with the completion of the risk assessment and risk analysis used to inform the information contained within this risk assessment information template.	

Attachment C

SITE PRIORITIZATION MATRIX

NDMP Flood Risk Assessments: Prioritization Matrix

Table E1: NDMP Impact Assessment

		RESULTS				NDMP RAIT CRITERIA[4]												ADDITIONAL CRITERIA[4]				
						A				B	C	D					E					
						People and Societal				Environmental	Local Economic	Local Infrastructure					Public Sensitivity	Residential Property Damage	Commercial Property Damage	Public Property Damage (Schools, Public Buildings, EMS Buildings)	Cultural/ Historical Assets	Operations & Maintenance Requirements
	CRITERIA WEIGHTING:					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Site #[1]	Site Name	GROUPED PRIORITY RANKING[2,3]	OVERALL WEIGHTED PRIORITIZATION SCORE	*HW Overall Rating (Workshop 1)*	*HRM Overall Rating (Workshop 2)*	*Fatalities*	*Injuries*	*Displacement (population)*	*Duration of Displacement*			*Transportation*	*Energy and Utilities*	*Information and Communications Technology*	*Health, Food, and Water*	*Safety and Security*						
25	Bedford Highway, from Union Street to Highway 102 - Bedford	1	38	3	3	2	2	2	3	2	3	3	2	2	3		3	3	3	2	2	1
A6	Shubenacadie Lakes	2	27	3	3	2	2	2	3	2	2	2		2	2		3			2	3	
8	Karlson's Wharf @ Upper Water Street - Halifax	3	25	3	3					2	3	2	3		3	2	3		2	2	2	1
9	Inglis Street @ Barrington Street - Halifax	4	21	3	2.5			1	1	2	1	1	2		3		3	2		1	1	3
24	Highway 2, from Holland Road to Miller Lake Road - Fall River	5	18	3	N/A	1	2				1	3	2	2	2		2	1				2
7	Pleasant Street, near Dartmouth General Hospital - Dartmouth	6	17	2	3					1	1	2	1	1	2		3			3	1	2
5	Cole Harbour Road @ Perron Drive - Cole Harbour	7	15	2	3					1	1	2	1		1		2	1	2	1	1	2
2	Shore Road - Eastern Passage	7	15	3	2			2	1			3	1		1		2	2			1	2
22	Hammonds Plains Road @ Bluewater Road - Bedford	7	15	3	3					2	2	2			1		3	1	1			3
A2	Mount Saint Vincent at Bedford Highway	7	15	3	3	1	1				2	2			2		3				1	3
19	Bambrick Road @ Orchard Drive - Middle Sackville	11	12	2	2			1	1	1		1	1		1		2	2			1	1
6	Nantucket Avenue @ Wyse Road - Dartmouth	11	12	2	3					1	2	2			1		3		1			2
1	Autoport - Eastern Passage	13	11	1	2					1	2	2			1		2		3			
27	Rocky Lake Drive, near quarry entrance - Bedford	14	10	1	2	1	1			3	2	1					2					
28	Cobequid Road @ Regwood Drive - Windsor Junction	15	9	1	1	1	1					1			1		1	1			2	1
12	Melville Avenue @ Winchester Avenue	15	9	1	1			2	2								1	1			1	2
11	Keating Road @ Crown Drive - Halifax	17	8	1	1			1	1	1							1	1			1	2
10	Kempt Road @ Lady Hammond - Halifax	17	8	3	1						1						1		1		2	3
21	Sunnyvale Crescent @ Beaverbank Road - Lower Sackville	19	7	1	2					1		1			1		1	1				2
18	Hammonds Plains Road, near Kynock Resources - Hammonds Plains	19	7	1	2					2	1	1					1		2			
13	Glenforest Weir - Halifax	19	7	2	1		2										1	1	1			2
14	Leiblin Drive @ Guildwood Crescent - Halifax	22	4	1	1												1	1				2
4	Beaver Crescent - Cole Harbour	22	4	1	1												1	1				2
15	Bently Drive @ Ramsbrook Court - Halifax	24	3	1	1													1				2
26	Sackville Drive @ Cobequid Road - Lower Sackville	N/A	25	2	0	1		1	2	2	1	2	2	2	2		2	2	1	2	2	1
30	Ridge Avenue, from School Street to end - Waverley	N/A	22	3	0			2	2	2		3	2	1	2		2	1		2	1	2
3	John Stewart Drive - Dartmouth	N/A	13	3	1			1	1	1							2	2		2	1	3
20	Rankin Drive @ Glendale - Lower Sackville	N/A	12	1	2			1	1	2		1	1				2	2				2
16	Wellington Fire Station, Highway 2 - Wellington	N/A	9	1	0							2			2		1			2		2
17	Fletcher's Drive, near civic 57 - Fall River	N/A	6	1	N/A												1	2			1	2
23	Holland Road @ Highway 2 - Fletcher's Lake	N/A	4	N/A	N/A												1	1				2
29	Bedford Highway @ Shaunslieve Drive	N/A	2	1	0						1										1	

Notes

[1]Sites A2 and A6 were not originally included on the list of 30 Sites, but were identified during the Preliminary Assessment Workshops as opportunities for a more community-based risk assessment.

[2]The Top 10 Priority Sites, based on the Preliminary Prioritization process, are highlighted in blue.

[3]A Priority Ranking of 'N/A' denotes the site was considered part of a grouping. The site in the grouping with the highest score was used in the Priority Ranking

[5]The Grouped Priority Ranking references the site with the highest score within the grouping.

The following should be considered in review of the Preliminary NDMP Impact Assessment Table above:

- The prioritization rating system is a tool to scope the relative priorities across the 30 sites in comparison to each other.
- Impact ratings should be considered to be subjective, but were informed through stakeholder workshops, consultation, and preliminary review. Workshops and consultation involved representatives from HRM, Halifax Water and the project team the fields of engineering, operations, planning emergency management, and climate change.
- The Overall Priority Score for each site was developed by combining its scores for each of the Prioritization Impact criteria. See Table E-2 for descriptions of how the Level of Impact scoring was applied. Each Impact Criteria was weighted equally.
- Preliminary Consultation identified the opportunity to group several key sites under common themes better suited for future analysis and/or funding under the NDMP for a more community-based assessment.

Table 3: Overview of Level of Impact Rating System for Site Prioritization

Level of Impact	Scoring Range	General Description
No impact	0	Impact of the Criteria is not applicable, or unknown at the site.
Low Impact	1	Low level of impact of the Criteria at the site.
Moderate Impact	2	Moderate level of impact of the Criteria at the site.
High Impact	3	High level of impact of the Criteria at the site.

Table 4: Level of Impact Rating System, by Category

Classification	Overall Priority Score Range	General Description
Low Priority	0-15	Lower level of impact. Least urgent in comparison to other sites. Consider further assessment or mitigation through other funding streams to reduce flood risks.
Moderate Priority	15-24	Moderate level of impact. Action or further analysis may be required. Consider proceeding to detailed risk assessment through the NDMP and consider mitigation measures to reduce flood risks.
High Priority	25-38	High level of impact. Action or further analysis required. Proceed to detailed risk assessment through the NDMP and consider mitigation measures to reduce flood risks.

Table E2: Level of Impact Rating System, by Category - Site Prioritization

	Category	Rating	Description
NDMP RAIT CRITERIA	Fatalities	0	No identified history of impact of this criteria at site location
		1	Mild risk of a fatality due to an event
		2	Moderate risk of fatality or multiple fatalities due to an event (ex. road hazards such as hydroplaning; high flows)
		3	Higher risk of fatalities due to event (ex. high risk road hazards such as adjacent bodies of water or high speed travel; extreme flows)
	Injuries	0	No identified history of impact of this criteria at site location
		1	Mild risk of an injury due to an event
		2	Moderate risk of an injury or multiple injuries due to an event (ex. road hazards such as hydroplaning; high flows)
		3	Higher risk of injuries due to an event (ex. high risk road hazards such as high speeds; extreme river flows)
	Displacement	0	No identified history of impact of this criteria at site location
		1	Possible displacement of a few constituents within the site location
		2	Possible displacement of a portion of constituents within or adjacent the site location
		3	Possible or certain displacement of a community of constituents within or adjacent the site location
	Duration of Displacement	0	No identified history of impact of this criteria at site location
		1	Displacement during the event, requires clean-up work
		2	Displacement for the duration of up to 1 week or requires some remedial work
		3	Displacement for more than 1 week or requires re-build
	Environmental	0	No identified history of impact of this criteria at site location
		1	Potential for minor environmental effect to a small portion of the site, or near an environmentally sensitive area.
		2	Recorded or potential for environmental damage, or near an area of environmental importance; combined sewer overflows.
		3	Recorded or potential for wide spread/severe environmental damage; storage of hazardous materials; likely release of contaminants.
	Local Economy	0	No identified history of impact of this criteria at site location
		1	Minor delays to delivery/shipping of goods and services, or impact on some nearby economic infrastructure
		2	Major delays to delivery/shipping of goods and services, or impact on nearby economic infrastructure
		3	Delivery/shipping of goods and services halted, or wide-spread impact on economic infrastructure
	Transportation	0	No identified history of impact of this criteria at site location
		1	Minor delays/impact to commuter/public transit/shipping routes
		2	Major delays/impact to commuter/public transit/shipping routes or Minor delays to emergency services routes
		3	Commuter/public transit routes re-routed or halted or Major delays/cut offs of emergency services routes
	Energy and Utilities	0	No identified history of impact of this criteria at site location
		1	Minor disruption to electricity, water/wastewater, or natural gas services
		2	Major disruption to electricity, water/wastewater, or natural gas services; or minor infrastructure damage
		3	Services cut off or major infrastructure damage
	Information and Communications Technology	0	No identified history of impact of this criteria at site location
		1	Minor disruption to Information/Communications services
		2	Major disruption to Information/Communications services, or minor infrastructure damage
		3	Services cut off or major infrastructure damage
	Health, Food and Water	0	No identified history of impact of this criteria at site location
		1	Minor health and water
		2	Major disruption to services or minor infrastructure damage
		3	Services cut off or major infrastructure damage
	Safety and Security	0	No identified history of impact of this criteria at site location
		1	Minor impacts to a single public safety/national defense asset
		2	Limited access to a single public safety/national defense asset or minor impacts to assets
		3	Multiple public safety/national defense asset assets impacted or no access to the asset(s)
	Public Sensitivity	0	No identified history of impact of this criteria at site location
		1	Known issue to some constituents within the site location or effects felt on an individual site level
		2	Known issue to the majority of constituents within the site location or effects felt throughout the local community
		3	Known issue to constituents outside of the site location/press news coverage or impact effects felt outside of the local community
ADDITIONAL CRITERIA	Residential Property Damage	0	No identified history of impact of this criteria at site location
		1	Recorded or potential for localized residental property damage
		2	Recorded or potential for property damage to a neighbourhood or high density area
		3	Recorded or potential for wide spread property damage at the community level
	Commercial Property Damage	0	No identified history of impact of this criteria at site location
		1	Recorded or potential for localized commercial property damage
		2	Recorded or potential for property damage to a commercial neighbourhood or high density area
		3	Recorded or potential for wide spread commercial property damage at the community level
	Public Property Damage (Schools, Public Buildings, EMS Buildings)	0	No impact of criteria at site location
		1	Recorded or potential minor impacts to public buildings.
		2	Recorded or potential impacts to educational and daycare facilities
		3	Recorded or potential to critical buildings such as police, fire, EMS and extended care
	Cultural/ Historical Assets	0	No identified history of impact of this criteria at site location
		1	Small pockets of elevated archaeological potential with the site location
		2	Site includes an area of elevated archaeological potential or contains an archaeological/culturally significant location or structure
		3	Presence of multiple archaeological/culturally significant locations or structures
	Operations & Maintenance Requirements	0	No identified history of impact of this criteria at site location
		1	Occasional site operational/maintenance issues reported, or minor nuissance issue
		2	Consistent site operational/maintenance issues reported, moderate demand for operational resources
		3	Reoccuring site operational/maintenance issues, high demand for operational resources

ATTACHMENT D

Priority	Site Name	Recommended Strategy
1	Sackville Rivers System	Engineering Feasibility Study Potential Flood Remediation Measures. Also, Update Planning & Development Policy within Floodplain
2	Shubenacadie Lakes	Watershed & Floodplain Mapping Study
3	Karlson's Wharf	Analysis & Preliminary Design of Future Local Storm System. Also, Construction of Local Storm Sewer System Infrastructure
4	Inglis Street at Barrington	Local Stormwater System Study & Concept Design
5	Highway 2	Highway 2 Stormwater Drainage Study
6	Pleasant Street	Hydrologic/Hydraulic Assessment & Conceptual Design of Flood Remediation Infrastructure
7	Cole Harbour Road at Peron Drive	Detailed Bisset Run Watershed Drainage Study & Mitigation Concept Development
7	Shore Road – Eastern Passage	Public Engagement & Emergency Preparedness
7	Hammonds Plains Road at Bluewater Road	Sandy Lake Watershed Drainage Study & Mitigation Concept Development. Also, Analysis & Design of Hammonds Plains Road Upgrades
7	Bedford Highway at Mt St. Vincent	Bedford Highway Sewer System Capacity Study for Future Development

Priority	Site Name	Order of Magnitude Costing		
		Short Term (0-2yrs)	**Medium Term (3-5 yrs)**	**Long Term (+5 yrs)**
1	Sackville Rivers System	$50-150K	$25-75K	TBD
2	Shubenacadie Lakes	$250-500K	$50-150K	TBD
3	Karlson's Wharf	$200-350K	$250-500K	Operations
4	Inglis Street at Barrington	$25-150K	TBD	TBD
5	Highway 2	$50-100K	$2-5M	$50-100K
6	Pleasant Street	$25-60K	$0.4-1M	TBD
7	Cole Harbour Road at Peron Drive	$50-90K	Operations	$0.5-$1M
7	Shore Road	$15-30K	$25-60K	TBD
7	Hammonds Plains Road at Bluewater Road	$50-200K	TBD	$2-5M
7	Bedford Highway at Mt. St Vincent	$50-100K	$75-150K	TBD
Totals		$0.8-$1.7M	$2.8-$6.9M	$2.6M-6.1M
		$6M - $15M		

ATTACHMENT E

HALIFAX REGIONAL MUNICIPALITY

NATIONAL DISASTER MITIGATION PROGRAM (NDMP)

FLOOD RISK ASSESSMENTS

FINAL REPORT - JANUARY 31, 2018

January 1956 - Chronicle Herald

NATIONAL DISASTER MITIGATION PROGRAM (NDMP)

FLOOD RISK ASSESSMENTS

HALIFAX REGIONAL MUNICIPALITY

FINAL REPORT

PROJECT NO.: 171-01778
DATE: JANUARY 2018

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January 31, 2018

Youssef Habboush, P.Eng., MBA
Program Engineer
Infrastructure Policy and Standards
Planning & Development
Halifax Regional Municipality
via email: [redacted]

Subject: HRM NDMP Flood Risk Assessments Final Report

Dear Sir:

We are pleased to provide to HRM for review, the Final Report for the HRM National Disaster Mitigation Program (NDMP) Flood Risk Assessments project. This submission includes the results of our Preliminary Risk Assessment process, Prioritization of the Top-Ten sites, Detailed Risk Assessments, and Recommended Mitigation Strategies.

Yours sincerely,

ORIGINAL SIGNED

Patrick Lewis, P. Eng.
Project Manager

Encl.
cc:
Suzanna Lewis, P.Eng, PMP (WSP)
Paul Burgess, P.Eng. (HRM)
Mark McGonnell, P.Eng (HW)
WSP ref.: 171-01778

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EXECUTIVE SUMMARY

PROJECT SCOPE

The National Disaster Mitigation Program (NDMP) was recently established by the Canadian Federal Government to focus on targeted investments to build safer and more resilient communities by addressing increased flood risks and the planning for the implementation of future mitigation measures. The NDMP fills a critical gap in the Halifax Regional Municipality's ability to effectively mitigate, prepare for, respond to, and recover from, flood-related events. As part of the program, the Halifax Regional Municipality (HRM) has retained WSP Canada Inc. (WSP) project team to carry out risk assessment and develop mitigation strategies for key areas of the Municipality.

Based on results of a recent 'baseline' study, and in coordination with Halifax Water, HRM developed a short-list of 30 key sites as candidates for assessment under the NDMP. The overall goal of this project is to investigate and document flood risks at these key flood-prone areas identified within the Municipality, focussing on the impacts at the community level. The results of the investigation will be used to inform future decisions of the HRM Council and to support future funding strategies for the implementation of flood mitigation measures within the Municipality. The current project involves the following activities:

→ **Background Review and Information Compilation** on key flood-prone areas identified by HRM.

→ **Preliminary Risk Assessments (30 Key Areas),** including site investigations, workshops and desktop assessments.

→ **Site Prioritization,** involving ranking of the 30 flood-prone sites with the goal of identifying the Top Ten (10) highest priority sites to proceed to detailed assessment.

→ **Detailed Risk Assessments (10 Highest-Priority Areas),** including detailed site investigations, workshops and completion of detailed RAIT forms, site maps and photos.

→ **Preliminary Mitigation Strategy Recommendations** for each of the Top Ten (10) Sites including order-of magnitude cost estimates for recommended remedial works.

NATIONAL DISASTER MITIGATION PROGRAM FUNDING

The NDMP has four (4) available funding streams**:** 1- Risk Assessment, 2-Flood Mapping, 3-Mitigation Planning 4-Investments in Non-Structural and Small Scale Structural Mitigation. The current study falls under **Stream 1: Risk Assessment**, which involves identification of the potential hazards; assessment of the likelihood of occurrence; impact(s) to people, economy, structures and networks, the natural environment, etc.; and the community's vulnerabilities. The NDMP recognizes that a comprehensive assessment of a flooding risk cannot be *completed* under Stream 1 alone. The intent of a Stream 1 project is to identify and assess flooding as a hazard risk using the best information that is available, understanding that flood mapping and/or modelling (ie. Stream 2 activities) are required for the risk to be fully understood and assessed.

GUIDING PRINCIPLES AND OUTCOMES OF THE PROJECT

The following guiding principles have served as a basis for all work performed as part of the current project:

→ **Multidisciplinary Team Approach:** The process was completed using a collaborative approach, involving an integrated team of consultants, subject matter experts, and HRM and HW departmental staff, including management, engineering, planning, emergency response, and operations personnel.

→ **Founded on NDMP Assessment Criteria, with a Focus on Local Context:** The project used a risk assessment and prioritization process based on the Federal NDMP program, while incorporating additional strategies to bring focus to the local context of the Halifax Regional Municipality.

- A project-specific preliminary assessment and prioritization method was applied to narrow the original 30 key sites to a list of the Top Ten Highest Priority Sites to proceed to detailed assessment. The Detailed Assessment process focussed on identifying site vulnerabilities, hazards and impacts, and involved completion of the NDMP Risk Assessment Information Template (RAIT).

→ **Inclusiveness:** Four (4) project workshops brought together key stakeholders within the HRM and HW organizations to hear varying opinions and perspectives as well as to gather background and historical information, in order to develop a collaborative understanding of the impacts of flooding at each site.

— Two workshops each were held with HRM and HW staff, at both the preliminary assessment stage and the detailed assessment/mitigation planning stage. The process was successful in gathering a unified consensus on the sites of highest priority within the municipality on which to focus the detailed assessment and development of mitigation measures.

→ **Consideration of Future Climate Changes:** The process examined future climate change factors, identifying the projected increase in the intensity and frequency of rainfall events, which could trigger flood events. This emphasizes the importance of planning for, developing, and implementing flood mitigation strategies in the near future to protect and plan for these future events.

— Projections of future trends in precipitation patterns involved development of extreme climate scenarios in the next 50-100 years using the Climate Change Hazards Information Portal (CHIP). The supplementary report, titled "Climate Observations and Projections in Support of Flood Risk Assessment for Halifax Regional Municipality" is included in Appendix C of this report.

→ **Evaluation of a Variety of Mitigation Options:** The four (4) available NDMP funding streams were reviewed and considered as potential next steps for recommended mitigation strategies for each of the Top Ten sites.

— Mitigation strategies for the Top Ten Highest Priority Sites were developed in consultation with the key HRM and HW project stakeholders. Recommended next steps were identified for each site, including reference to the applicable NDMP funding stream, and Rough Order of Magnitude Costing. Additional and subsequent strategies have been provided for each site for the Short, Medium and/or Long Term horizons.

→ **Municipality-Wide Flood Management Context:** While risk assessment and mitigation strategy development for each site was focussed on a particular area or community within the Municipality, the process considered flood management for the region as a whole.

— The project resulted in recommendation of a Municipality-Wide Comprehensive Flood Management Strategy, focussed on emergency preparedness, improving community resiliency, effective planning and development for community growth, and adaptive management.

MITIGATION STRATEGY RECOMMENDATIONS FOR THE TOP-10 HIGHEST PRIORITY SITES

Following the project-specific prioritization process, the Top Ten Sites of Highest Priority were identified for further detailed assessment. The results of the Risk Assessments for each of the ten (10) priority sites are presented in individual Site Reports, including an overview of site-specific background information, identified vulnerabilities and flood impacts, and mitigation strategy concepts. Each report also contains a completed NDMP RAIT Form. A snapshot of the risk assessment and mitigation strategies for each Site is presented in an Executive Summary Table found at the beginning of each Report. The following table summarizes the list of Top Ten Highest Priority sites, and their recommended next steps of the Federal National Disaster Mitigation Program:

Site Number	Site Name	Stream 1: Risk Assessment	Stream 2: Flood Mapping	Stream 3: Mitigation Planning	Stream 4: Infrastructure Investment
2	Shore Road	✓	⇨	●	●
5	Cole Harbour Road	✓	✓	●	●
7	Pleasant Street	✓	⇨	●	●
8	Karlson's Wharf	✓	⇨	⇨	●
9	Inglis at Barrington	✓	⇨	●	●
22	Bluewater Road	✓	●	●	●
24	Highway 2	✓	●	●	●
25	Sackville River	✓	✓	●	●
A2	Mt. St. Vincents	✓	●	●	●
A6	Shubenacadie Lakes	✓	●	●	●

✓	Completed
●	Next Step
●	Future Step
⇨	Proceed to Next Step

1 OVERVIEW

1.1 INTRODUCTION

The National Disaster Mitigation Program (NDMP) was recently established by the Canadian Federal Government to focus on targeted investments to build safer and more resilient communities by addressing increased flood risks and the planning for the implementation of future mitigation measures. The NDMP fills a critical gap in the Halifax Regional Municipality's ability to effectively mitigate, prepare for, respond to, and recover from flood-related events. As part of the NDMP, the Halifax Regional Municipality (HRM) has retained WSP Canada Inc. (WSP) project team to carry out risk assessment and develop mitigation strategies for key areas of the Municipality.

Through a review of historical service records and operational data, a recent 'baseline' study directed by HRM identified areas that are subject to flooding on a frequent basis. Based on the results of the study, and in coordination with Halifax Water, HRM developed a short-list of 30 key sites as candidates for further review and assessment under the NDMP.

The objectives of the current project are to investigate and document flood risks at these 30 key flood-prone areas identified within the Municipality; prioritize the 10 most critical flood locations; prepare a detailed risk assessment for these areas; and provide preliminary mitigation strategy recommendations to inform future decision making.

1.2 THE NATIONAL DISASTER MITIGATION PROGRAM (NDMP)

In 2014 the Federal Government implemented the National Disaster Mitigation Program (NDMP), aimed at establishing safer and more resilient communities through investment in projects addressing rising flood risk and costs. The 2014 Federal budget allocated $200M over five years to the NDMP, of which $183.8M is to be contributed to cost-shared projects with the provinces/territories, with remaining funding targeted to national-level initiatives. The primary objective is to reduce the impacts of natural disasters on Canadians by planning for future investments focussing on significant, recurring flood risks and costs; and advancing work to facilitate private residential insurance for overland flooding.

The NDMP Guidelines issued by Public Safety Canada are included in **Appendix A.** The current study falls under the first of four (4) available NDMP funding streams**:**

→ **Stream 1: Risk Assessment *(This Study)*** - Identification of the potential hazards; impact(s) of the hazard to people, economy, structures and networks, the natural environment, etc.; the community's vulnerabilities; and assessment of the likelihood of occurrence. Involves determination of risk thresholds to serve as an informal decision-making support tool, and to inform the prioritization and selection of mitigation projects.

→ **Stream 2: Flood Mapping** - Flood mapping to identify structures, people and assets most likely to be impacted.

→ **Stream 3: Mitigation Planning** - Using information on identified flood risk to make informed planning decisions. Involves identifying broad mitigation goals, objectives/strategies, and key activities to meet the objectives.

→ **Stream 4: Investments in Non-Structural and Small Scale Structural Mitigation** - Implementation of a specific mitigation project.

It is important to note that the NDMP Guidelines recognizes that a comprehensive assessment of a flooding risk cannot be *completed* under the current Stream 1: Risk Assessment. The intent of the Stream 1 project is to identify and assess flooding as a hazard risk using the best information that is available, understanding that flood mapping and/or modelling (ie. Stream 2 activities) are required for the risk to be fully understood and assessed.

1.3 GUIDING PRINCIPLES OF THE PROJECT

The following guiding principles have served as a basis for all work performed as part of the current project:

→ **Multidisciplinary Team Approach:** The process was completed using a collaborative approach, involving an integrated team of consultants, subject matter experts, and HRM and HW departmental staff, including management, engineering, planning, emergency response, and operations personnel.

- → **Founded on NDMP Assessment Criteria, with a Focus on Local Context:** The project used a risk assessment and prioritization process based on the Federal NDMP program, while incorporating additional strategies to bring focus to the local context of the Halifax Regional Municipality.
- → **Inclusiveness:** Four (4) project workshops brought together key stakeholders within the HRM and HW organizations to hear varying opinions and perspectives as well as to gather background and historical information, in order to develop a collaborative understanding of the impacts of flooding at each site.
- → **Consideration of Future Climate Changes:** The process examined future climate change factors, identifying the projected increase in the intensity and frequency of rainfall events, which could trigger flood events. This emphasizes the importance of planning for, developing, and implementing flood mitigation strategies in the near future to protect and plan for these future events.
- → **Evaluation of a Variety of Mitigation Options:** The four (4) available NDMP funding streams were reviewed and considered as potential next steps for recommended mitigation strategies for each of the Top Ten sites. Mitigation strategies for the Top Ten Highest Priority Sites were developed in consultation with the key HRM and HW project stakeholders.
- → **Municipality-Wide Flood Management Context:** While risk assessment and mitigation strategy development for each site was focussed on a particular area or community within the Municipality, the process considered flood management for the region as a whole.

1.4 SCOPE OF WORK

The overall goal of this project is to complete flood risk assessments for key areas of the Municipality that are susceptible to surface flooding, focussing on the impacts at the community level. The intent of the work is to investigate and define the localized and community-wide effects, impacts and risks associated with the flooding of these areas to inform future decisions of HRM Staff and HRM Council. The results of the investigation will be used to support future funding strategies for the design and construction of flood mitigation infrastructure and measures within the Municipality. The NDMP Flood Risk Assessments Project involves the following activities:

- → **Background Review and Information Compilation:**
  - — Review of available background material concerning the project, including the existing Baseline Study;
  - — Compilation of background information on the 30 key flood-prone areas identified by HRM.
- → **Preliminary Risk Assessments (30 Key Areas):**
  - — Completion of preliminary site investigations for the 30 key areas identified by HRM;
  - — Facilitation of Preliminary Risk Assessment Workshops to engage HRM and Halifax Water staff and to inform the preliminary risk assessments and site prioritization;
  - — Completion of Preliminary Risk Assessments for each of the 30 key areas, based on RAIT criteria and information collected in the consultation process.
- → **Site Prioritization:**
  - — Ranking of the Top-30 flood-prone sites with the goal of identifying the 10 highest priority sites to proceed to detailed assessment. Informed through review of background information, workshop feedback and preliminary site assessments.
- → **Detailed Risk Assessments (10 Highest-Priority Areas):**
  - — Completion of detailed site investigations for the Top-10 highest priority areas;
  - — Facilitation of Detailed Risk Assessment Workshops with HRM and Halifax Water staff to inform the detailed risk assessments and mitigation strategies;
  - — Completion of Detailed Risk Assessments for each of the 10 highest priority areas, including detailed RAIT forms, site maps and photos.
- → **Preliminary Mitigation Strategy Recommendations:**
  - — Development of Preliminary Mitigation Strategy Recommendations complete with order-of magnitude cost estimates and NDMP funding streams for recommended remedial works.

2 BACKGROUND

This section provides an overview of key flooding concepts, climate change considerations, the results of a literature review, and an overview of risk assessment methodology.

2.1 CONCEPTUAL BACKGROUND ON FLOODING

Flooding is defined in the NDMP Guidelines as "The overflow of natural drainage channels, natural shorelines and/or human-made facsimiles leading to partial or complete inundation from the overflow of inland or tidal waters, and/or the accumulation or runoff of surface waters from any source". Flooding can be described using the following concepts:

TYPES OF FLOODING

Flooding can typically be described by the following terms:

- **Riverine:** overflow of natural drainage channels such as brooks, streams, and rivers. Flooding causes can vary in nature from rainfall, snowmelt, ice jamming, etc. Characteristics such as size and shape, vegetation, and structures can affect the level of water in a waterway.
- **Coastal:** overflow of shorelines and coasts (lakes and oceans).
- **Urban:** overflow of human-made infrastructure such as swales, ditches, streets, sewers, foundation drains. Can also be contributed to by riverine flooding.
- **Failure of Water-Retaining Structures:** structural failure or breaching of water retaining infrastructure such as dams or dikes protecting against floods.

CAUSES OF FLOODING

The primary causes of flooding in Canada are typically related to hydro-meteorological conditions such as:

- **Extreme Rainfall:** Heavy rainfall, storms, and hurricanes of significant intensity and/or duration. When rain falls over land, some is captured by vegetation and infiltration into the soil, while the rest becomes runoff. The amount of rainfall runoff that reaches waterways and flood-prone areas depends on the characteristics of the tributary drainage area.
- **Snowmelt Runoff:** Melting snow and ice, often occurring in the spring.
- **Rainfall on Frozen Ground:** Frozen ground is impervious to infiltration resulting in 100% runoff.
- **Rain on Snow:** Heavy rain falling on melting snow, typically occurring in winter months. Frozen ground also contributes to reduced soil infiltration.
- **Ice Jams:** Obstruction of a riverine system by broken ice.
- **Natural Dams:** Blockage of a riverine system by landslide or buildup of debris.
- **Coastal:** Storm surge (rise of coastal water beyond the predicted astronomical tide driven by high winds and pressure during a storm), as well as large astronomical tides and rising sea levels can contribute coastal flooding.

CONSEQUENCES OF FLOODING

Extreme flooding can have a variety of impacts on the affected community at both a small and large scale, such as:

- **Infrastructure:** damage to transportation systems, water supply, wastewater system, communications.
- **Public Safety:** injury, fatalities, access to hospitals, limited emergency health response.
- **Society:** evacuation, relocations, access to schools, public perception.
- **Economic:** damage to businesses, loss of business, loss of economic assets, disruption to local economy, cost of damage recovery and re-build.
- **Environment:** damage to the natural environment such as vegetation, sedimentation, impacts on water quality.
- **Property and Building Damage:** structural damage, damage to building contents, sewer backups, basement flooding, water damage.

2.2 HALIFAX CLIMATE AND FLOODING

2.2.1 RAINFALL-RUNOFF

Halifax enjoys the benefits and challenges associated with the Maritime climate including receipt of average annual precipitation between 1200-1300 mm. While the normal or average total precipitation experienced in any given month may be only 100 mm – 130 mm, the peak volume of precipitation in a single day during the late summer hurricane period can exceed 200 mm in 24 hours. Two such extreme precipitation events have been recorded in the region: In Sept 1942, rainfall in excess of 230 mm fell and then in August 1971, associated with Hurricane Beth, HRM again experienced amounts in excess of 200 mm in 24 hours. More recently, many areas of the city experienced notable flooding events on March 31/April 1, 2003 (150 mm) and December 11/12, 2014 (107 mm).

In the urban areas of the municipality, stormwater infrastructure systems are typically designed based on the annual intensity-duration-frequency (IDF) curves for varying return periods. Current standard practice involves design of minor systems (catchbasins, storm sewers and driveway culverts) to convey the 1 in 5 or 1 in 10 year rainfall event, and design of major drainage route (streets, detention ponds and watercourse crossings) to handle the 1 in 100 year rainfall event.

Land-use within the municipality is diverse, ranging from highly urbanized in the downtown core, medium-density mixed-use and residential development in the suburban areas, to rural and natural landscapes in the outer areas of the city.

In highly urbanized areas, the time of concentration is typically short and the degree of imperviousness is high. Here, the influence of snow melt on system capacity is often minimal, however ice and snow build-up can block catchbasins and culverts, restricting their drainage capacity.

The municipality also encompasses several larger natural watersheds, including the Sackville Rivers System and the Shubenacadie Lakes System. In these larger watersheds, where the time of concentration is much longer, the definitive winter design storm may result in the greatest system impact. The winter storm typically includes a smaller total rainfall than the late summer storms but the degree of imperviousness increases significantly above the summer value due to frozen ground. In fact, one of the greatest flooding experienced recently along the lower reaches of the Sackville River in the past 30 years, occurred on April 1, 2003, when the flooding was the result of approximately 150 mm of rain falling on frozen ground combined with the significant snow melt from snow pack on the watershed. Similarly, increased urbanization of the tributary watersheds to these systems can increase the imperviousness and decreases runoff time, resulting in increased peak flows and volumes to both the natural and man-made drainage systems.

2.2.2 COASTAL CLIMATE & STORM SURGE

Situated on the Atlantic Coast of Nova Scotia, the Halifax Regional Municipality is subjected to a wide range of storms, including hurricanes, tropical storms and tropical cyclones. The wind, waves and low atmospheric pressure associated with such large-scale storms often produce storm surge: defined as the height difference between the water level due to astronomical tides and the total water level at the peak of a storm event. The intensity of such events, as well as rising sea levels, presents flooding and erosion risks to the coastal areas of HRM.

One of the most notable storms to hit the municipality was Hurricane Juan in September of 2003. The Category 2 hurricane imposed damage to property, infrastructure and the environment, with total losses of $130 million reported by the Insurance Bureau of Canada (2008). Then in February of 2004 a severe winter blizzard known as “White Juan” dumped nearly 90 cm of snow on the city, resulting in $5 million in snow removal and damage costs. (NRCAN, 2015)

While the scope of the current study was focussed primarily on pluvial (rainfall-induced) flooding, the potential risk of coastal flooding at many areas of the Municipality must be acknowledged. For the examined flood-prone areas which are situated near the coastline, efforts have been made to make note of potential hazards that could be caused or influenced by coastal flooding, storm surge and/or tidal levels. It is understood that separate work is being conducted by the Municipality and other Provincial initiatives to further identify and assess coastal flood-risk within the region.

2.3 BACKGROUND INFORMATION REVIEW

2.3.1 STORMWATER FUNDING STRATEGY – BASELINE STUDY

As part of the development of an Integrated Stormwater Management Policy in conjunction with Halifax Water, HRM commissioned the Stormwater Funding Strategy – Baseline Study, completed in 2015 by SDMM. The study involved compilation and review of historical flood service records and operational data, as well as consultation with HRM and Halifax Water staff on the nature of known/recorded incidents. The study identified over 900 flood-prone sites throughout the Municipality, from which HRM and Halifax Water developed a short-list of 30 key areas identified for further review and assessment. These 30 sites were historically subject to frequent flooding and were considered to pose the greatest flood risk to the community.

The Baseline Study outlined a map of recorded flood-related issues within the municipality, which was reviewed as part of the preliminary assessment process of the current project. As expected, many of the 30 identified sites were represented by large numbers of reported incidents/issues. It is important to note that while a number of other flood-prone locations identified in the Baseline Study did not make the Top-30 list, many of these sites may still be candidates for future mitigation or assessment by HRM/Halifax Water.

2.3.2 SITE-SPECIFIC STUDIES & ANALYSES

To gain a better understanding of flooding issues within the municipality, the following additional information was provided by HRM and reviewed as part of the current work:

- Sackville Rivers Floodplain Study – Phase II (CBCL, 2017)
- Sandy Lake Watershed Study (AECOM, 2014)
- Cole Harbour Floodplain Assessment Report (Dillon, 2015)

Additional online research and field investigations were conducted for each site as part of the current project, which is further detailed in the individual site reports in Appendix F.

2.3.3 HISTORICAL FLOODING: CANADIAN CONTEXT

In an effort to gain a relative understanding of the causes and impacts of severe flood events on communities and municipalities across the country, a Literature Review was undertaken of significant flooding events in other jurisdictions. Appendix B-1 provides an overview of the following flood events within Canada:

- **Calgary, Alberta – June 2013**
- **Hurricane Matthew, Sydney, Nova Scotia – October 9, 2016**
- **Toronto, Ontario – July 2005 & 2013**
- **Hurricane Hazel, Toronto, Ontario – October 15, 1954**
- **Saguenay, Quebec – July 19/20, 1996**
- **Red River, Manitoba – April/May 1997**

Sydney, NS - October 12, 2016 CBC/Island Aerial Media

2.4 CONSIDERATION OF CLIMATE CHANGE

There is now widespread scientific consensus that significant and unsustainable changes are being experienced within the climate of the Earth. Among the many changes anticipated, we expect to see an increase in the frequency, duration and volume of total precipitation in extreme events, which may have significant impact on municipal stormwater systems. While much of our stormwater infrastructure has been designed to handle the existing design storms, or based on

historical regulations (or lack thereof), it is recognized that this increase will stress much of our existing systems well beyond their design capacity. Many stormwater infrastructure systems in HRM built since Hurricane Beth (1971) have yet to be tested by an extreme event.

2.4.1 FUTURE TRENDS IN PRECIPITATION PATTERNS

In recognition of the importance of considering future climate change impacts on flooding, analysis of potential future precipitation events was performed as part of this project. This work involved projecting future trends in precipitation patterns to determine how often thresholds will be exceeded in the next 50-100 years and considering how this might impact future flooding events in HRM. These future extreme climate scenarios were developed using the Climate Change Hazards Information Portal (CHIP) to assess threats, risks and vulnerabilities, and develop adaptation strategies to help HRM achieve its sustainable development objectives.

Please refer to **Appendix C** for the full supplementary report, titled "Climate Observations and Projections in Support of Flood Risk Assessment for Halifax Regional Municipality".

2.5 RISK ASSESSMENT METHODOLOGY OVERVIEW

2.5.1 FUNDAMENTAL RISK ASSESSMENT PRINCIPLES

For the purposes of this study, Flood Risk is defined as an uncertain event or condition that, if occurs, has potential negative impact on the community. Risk Management is the process of identifying risks, determining the likelihood of occurrence, severity of the consequences, and addressing those which are the most threatening to the community. The following outlines the typical Risk Assessment Methodology process:

Figure 1: Risk Methodology

1. **Identify the Risk:** What type of flood? What area is at risk?
2. **Assess the Risk:** What is the likelihood of the event occurring?
3. **Evaluate and Prioritize Risks:** Is the flood risk low or high? What are the most critical risks?
4. **Develop Response:** What mitigation strategies should be applied to manage the risk?
5. **Monitor and Review:** Continue to monitor risks and implemented mitigation measures.

ONGOING MONITORING & REVIEW: ADAPTIVE MANAGEMENT

It is important to note that the Risk Management process does not conclude at the completion of the current project. The mitigation measures and next steps identifies the work that will need to be implemented and planned for. Following implementation of proposed strategies, it is critical that HRM and Halifax Water continue to monitor the identified risks. This should include a review of the effectiveness of implemented measures into the future, including an evaluation based on future risk management processes, to identify new risks as the municipality grows, the climate changes and as new regulations emerge.

2.5.2 NDMP RISK ASSESSMENT INFORMATION TEMPLATE (RAIT)

The NDMP Risk Assessment Information Template (RAIT) was developed by Public Safety Canada for the input of risk information based on a completed risk assessment process. The NDMP Guidelines including the RAIT form, can be found in **Appendix A.** The Stream 1 program requires that the template be completed and submitted to Public Safety Canada to proceed to the next stage(s) of funding. Completion of the RAIT generally involves the following activities:

COLLECTION OF INFORMATION FOR IDENTIFIED HAZARDS

Completion of the RAIT involves outlining and describing local risk. Information should include an estimate of the likelihood of occurrence and examination of the potential magnitude and type of consequences or impacts related to the identified risk. The NDMP Guidelines suggest that risk event descriptions include historical context, as well as consideration of future risk from climate change. Existing infrastructure, technologies and community capabilities shall be considered.

ASSESSMENT OF CONSEQUENCES AND IMPACTS

Generally, the evaluation criteria within the RAIT are organized under five (5) specific qualitative and quantitative impact categories, with the risks defined and ranked on a five-point scale. The five impact rating categories include:

- **People and Societal Impacts**, which may result in significant societal disruptions such as human and other evacuations and relocations as well as injuries, immediate fatalities, and deaths from unattended injuries or displacement.
- **Environmental Impacts**, which may include direct or indirect environmental damage resulting from a flooding event and involving cleanup and restoration costs in the short-term and far into the future.
- **Local Economic Impacts**, which may include the costs of damage and loss to local economically productive assets, as well as disruptions to the normal functioning of the local economic system of the community or the region for significant periods of time.
- **Local Infrastructure Impacts**, which may include damage, disruption or destruction of the wide range of municipal and regional infrastructure systems such as transportation, water supply, wastewater management, and communications systems, the proper functioning of which the community depends on for its quality of life and viability.
- **Public Sensitivity Impacts,** which include the operation and reputation of all levels of government, upon which the trust and welfare of the general public typically rests.

CONFIDENCE LEVELS

Completion of the RAIT also involves defining the level of confidence in the estimate and impact risk rating associated with the flood event. Confidence levels may vary depending on data availability, relevant expertise and information, and understanding of specific events. The levels are indicated by a rating raging from A to E where 'A' is the highest confidence level and 'E' is the lowest.

2.5.3 COMPARISON TO OTHER RISK ASSESSMENT PROGRAMS

Methodology of the following programs was reviewed based on their similarities to the NDMP.

- **PIEVC Protocol:** The Public Infrastructure Engineering Vulnerability Committee (PIEVC) was established by Engineers Canada to oversee the planning and execution of a national engineering assessment of the vulnerability of public infrastructure across Canada to anticipated climate change. The five-step process includes risk assessments, risk assessment workshops, identification of risk tolerance thresholds, risk ranking, and review of data sufficiency.
- **Municipal Climate Change Action Plans (MCCAP):** Under the 2010 - 2014 Municipal Funding Agreement, municipalities across Nova Scotia were asked to prepare Climate Change Action Plans, aiming to reduce greenhouse gas emissions and identify priorities for climate change adaptation. The six-step process involves: Build a Team (including local government staff, officials, and stakeholders); Identify Impacts and Hazards (past and future); Identify Affected Locations; Identify Affected Facilities, Infrastructure, and Service Delivery; Identify Social, Economic, and Environmental Considerations; and Identify Priorities for Adaptive Actions.

The Detailed Risk Assessment methodology employed during the current project follows a similar process to these other risk assessment programs, focused directly on flood risk and tailored specifically to the Federal NDMP Guidelines.

3 PRELIMINARY RISK ASSESSMENT & PRIORITIZATION

3.1 OVERVIEW OF 30 KEY SITES

Following completion of the HRM Stormwater Funding Strategy – Baseline Study (SDMM, 2015), HRM and Halifax Water developed a short-list of 30 flood prone areas within the municipality that are subject to frequent flooding. These 30 sites serve as a starting point for the current study, identified as candidates for preliminary risk assessment and potential funding under the Federal NDMP. An overview Figure of the 30 Key Sites is presented in the following page. The following table presents the list of 30 Key Sites provided in the Terms of Reference:

Table 1: List of 30 Key Sites

SITE NO.	LOCATION	REGION	DISTRICT
1	Autoport; Eastern Passage	East	3
2	Shore Road; Eastern Passage	East	3
3	John Stewart Drive; Dartmouth	East	4
4	Beaver Crescent; Cole Harbour	East	4
5	Cole Harbour Road @ Perron Drive; Cole Harbour	East	4
6	Nantucket Avenue @ Wyse Road; Dartmouth	East	5
7	Pleasant Street, near Dartmouth General Hospital; Dartmouth	East	5
8	Karlson's Wharf @ Upper Water Street; Halifax	West	7
9	Inglis Street @ Barrington Street; Halifax	West	7
10	Kempt Road @ Lady Hammond; Halifax	West	8
11	Keating Road @ Crown Drive; Halifax	West	9
12	Melville Avenue @ Winchester Avenue	West	9
13	Glenforest Weir; Halifax	West	10
14	Leiblin Drive @ Guildwood Crescent; Halifax	West	11
15	Bently Drive @ Ramsbrook Court; Halifax	West	12
16	Wellington Fire Station, Highway 2; Wellington	Central	1
17	Fletcher's Drive, near civic 57; Fall River	Central	1
18	Hammonds Plains Road, near Kynock Resources; Hammonds Plains	Central	13
19	Bambrick Road @ Orchard Drive; Middle Sackville	Central	14
20	Rankin Drive @ Glendale; Lower Sackville	Central	15
21	Sunnyvale Crescent @ Beaverbank Road; Lower Sackville	Central	15
22	Hammonds Plains Road @ Bluewater Road; Bedford	Central	16
23	Holland Road @ Highway 2; Fletcher's Lake	Central	1
24	Highway 2, from Holland Road to Miller Lake Road; Fall River	Central	1
25	Bedford Highway, from Union Street to Highway 102; Bedford	Central	16
26	Sackville Drive @ Cobequid Road; Lower Sackville	Central	15
27	Rocky Lake Drive, near quarry entrance; Bedford	Central	16
28	Cobequid Road @ Regwood Drive; Windsor Junction	Central	1
29	Bedford Highway @ Shaunslieve Drive; Bedford	Central	16
30	Ridge Avenue, from School Street to end; Waverley	Central	1

FIGURE 1: Overview of HRM NDMP Site Locations

3.2 PRELIMINARY INVESTIGATIONS

3.2.1 PRELIMINARY DESKTOP INVESTIGATIONS

In the early stages of the preliminary risk assessment process, desktop investigations were performed for each of the 30 sites. This included a historical review of:

- Previously recorded flooding issues,
- Topographic mapping,
- Previously completed background reports,
- Nearby public infrastructure systems,
- Publicly available site photos and aerial photos,
- Anecdotal information, and
- Previous media releases.

Information provided for the sites as part of the Baseline Study was also compiled. Road and property mapping data were used to describe the characteristics of the site and identify nearby areas and population groups that could potentially be impacted by surface flooding. The information collected as part of the desktop review was carried forward to inform the subsequent preliminary site investigations, workshops, and risk assessments.

3.2.2 PRELIMINARY SITE INVESTIGATIONS

On Sunday May 7, 2017, project team members visited each of the 30 key sites during a wet weather event. The intention of the visits was to familiarize the project team with each site area, obtain site photos, and review drainage issues. The visits were planned following a rainfall event on saturated ground in an effort to time the visits with wet-weather conditions.

3.3 PRELIMINARY RISK ASSESSMENT WORKSHOPS NO. 1 & 2

As part of the preliminary risk assessment process, two Preliminary Risk Assessment Workshops were facilitated with HRM and Halifax Water (HW) staff. The workshops were designed to liaise with representatives from various departments such as engineering, community and land use planning, operations, environmental control, and emergency services. The workshops were designed to bring awareness of the project to key municipal personnel, as well as to collect data on each of the 30 sites to ultimately inform the overall Preliminary Risk Assessment.

3.3.1 SITE QUESTIONNAIRE

In advance of the workshops, a Preliminary Site Questionnaire was circulated to attendees as an opportunity to collect background information on each site. A total of 44 questionnaires were returned with supplementary information. The Preliminary Site Questionnaire template is presented in **Appendix D**.

3.3.2 WORKSHOP SUMMARIES

WORKSHOP NO. 1 – HALIFAX WATER

Workshop No.1 was held with Halifax Water staff and included project engineers and on-the-ground operation managers for regions throughout the municipality's service boundary. This workshop provided the Project Team with information on each site from an operational stand point and included prevailing stormwater management issues, existing mitigation efforts, issue frequency, asset vulnerability, and level of impact on each site when events do occur.

WORKSHOP NO. 2 – HALIFAX REGIONAL MUNICIPALITY

Workshop No. 2 was held with HRM staff and included staff members from various departments including community and regional planning, environmental performance, transportation public works, planning and development, and municipal

emergency response services. This workshop provided the Project Team with information of each site from a regional land use perspective including community impacts, flood plain management efforts, evacuation and emergency response routes, environmental impacts and potential groundwater contamination risks, as well as impacts on vulnerable municipal and provincial infrastructure such as access to hospitals, NS Power plants, and bridge/road closures.

INFORMING PRELIMINARY RISK ASSESSMENTS

Each workshop began with a PowerPoint presentation providing background on the project and overview of the risk assessment process to the stakeholders. Background information was provided to the workshop attendees for reference, including location maps and summary of information compiled from the initial background review and questionnaires. An interactive review of each site was conducted, during which attendees offered feedback, discussion and anecdotal knowledge on past issues, impacts and vulnerabilities specific to each location.

Following an overview and discussion of the flooding concerns at each site, the group was then asked to collectively rate the risk level for each site from low to high (1 being low priority and 3 being high priority). Once each site was given a score, the groups were then asked to collectively identify the sites of highest priority. Results of each workshop's level of risk ranking and site prioritization have been presented in the following section.

ADDITIONAL RISK AREAS AND SITE GROUPINGS

In each of the two workshops, a heightened focus on potential future rainfall trends was discussed. By considering increased precipitation events, additional flood prone areas within the municipality beyond the original 30 sites were identified during each of the two workshops. Suggested site groupings were also provided by workshop attendees, as many of the original 30 sites were in close proximity to one another and would likely benefit by similar mitigation efforts. These workshop ratings, feedback and groupings were documented and considered in the Preliminary Risk Assessment Process.

3.4 PRELIMINARY ASSESSMENT CONSIDERATIONS

Following the Preliminary Workshops, a number of considerations were carried forward into to the Preliminary Risk Assessment and Prioritization process. Considerations included site specific characteristics at the preliminary-level evaluation, potential to group similar sites together, size and extent of particular watersheds, and consideration of sites beyond the preliminary 30 provided by HRM.

SITE-SPECIFIC CHARACTERISTICS AND RISK FACTORS

While the preliminary assessment process referenced the Federal NDMP Risk Assessment Information Template (RAIT) criteria, the collected information was summarized in a simplified table format, considered more suitable for this preliminary level of evaluation. Several key characteristics and risk factors of each site were considered, including:

- Site Geography
- Site Vulnerabilities (Social, Economic, Environmental and Infrastructure)
- Public Perception
- Emergency Services and Access Routes
- Affected Stakeholders

ADDITIONAL RISK AREAS AND SITE GROUPINGS

In an effort to broaden the scope of the current risk assessment to the community level, opportunities for site groupings were identified during the consultation process. This was based on an understanding that the effects of a flood event may extend beyond the specific points of interest covered by the Top-30 sites. These groupings may share infrastructure or may be impacted by the same drainage issues, or may have been flagged for consideration as a single cohesive group to be examined as a whole for future capital projects.

The site groupings carried forward for Preliminary Risk Assessment and Prioritization are as follows:

- Additional Site #A6: Shubenacadie Lakes System (including Sites #17 and #30)
- Site #25: Sackville River System (including Sites #20, #21, and #26)

— Site #5: Bissett Run (including Site #3)
— Site #24: Highway No.2 (including Sites #16, #17 and #23)
— Additional Site #A2: Bedford Highway at Mount St. Vincent (including Site #29)

These sites encompass large complex drainage areas, and could experience extensive impacts from flooding at multiple locations during an extreme rainfall event. Additionally, changes to any single part of such a system can have impacts felt throughout. The far-reaching extent of these major drainage networks gives rise to the need for assessment of flood risk at the watershed level.

The Sackville River system (Site 25), including the Little Sackville River, is currently being studied by HRM as part of the Sackville Rivers Floodplain study. The potential for a similar watershed study, including delineation of flood limits, was also identified for the Shubenacadie Lakes system (Site A6) during the workshop consultation process. Defining the current and future floodplain extents of these systems in response to rainfall events is beneficial in terms of emergency planning, protection of infrastructure assets and future development.

Though the Shubenacadie Lakes System and Highway No.2 are adjacent to each other, these two sites were considered separate based on differing flooding mechanisms. The Shubenacadie Lakes System considers the performance of the lakes, canals and rivers within the system and associated flooding. The Highway No.2 system considers the impacts of surface runoff on the roadway and adjacent drainage systems, beyond the flood levels of the Lakes system.

CONSIDERATION OF FLOOD RISK AREAS BEYOND 30 IDENTIFIED SITES

With a heightened focus on potential future rainfall trends, the preliminary investigative process also involved examination of the community and infrastructure beyond the initial geographic site extents. Several other flood prone areas within the municipality were identified by Preliminary Workshop attendees that were not originally listed in the Top-30:

— Kings Road near Grand Lake
— Mount Saint Vincent University at the Bedford Highway (Carried forward as Site A2 to replace original Site 29)
— Armdale Roundabout, Halifax
— Willow Tree Intersection, Halifax
— Quigley's Corner, Eastern Passage
— Kinsac Lake Area near the Fall River Road
— Sullivan's Pond, Dartmouth

While risk assessment of the above-noted sites is outside of the current scope of work focussing on the Top-30 pre-determined key sites, it is recommended that HRM and Halifax Water consider these areas for future review as part of subsequent work.

3.5 PRELIMINARY RISK ASSESSMENT & PRIORITIZATION

Using the information collected in the background information review, desktop investigation, site investigations, and stakeholder workshops, initial preliminary risk assessments were conducted for each of the Top-30 sites. The assessments were completed as part of a prioritization process aimed at identifying the Top-10 sites of highest priority to be addressed by HRM in the more immediate future, and to be carried forward to the Detailed Risk Assessment phase.

The preliminary assessment and prioritization strategy considers criteria from the NDMP Risk Assessment Information Template (RAIT) and implements a methodology developed specifically for this project, as outlined in the following sections.

3.5.1 INFORMING ASSESSMENTS & PRIORITIZATION THROUGH WORKSHOPS

During Preliminary Workshops held with HRM and HW staff, attendees were asked to collectively rate the risk level for each site as low-, medium-, and high-priority. The following Risk Rating scale was used:

Figure 2: Workshop Overall Site Risk Categorization Scale

Based on these ratings, the group was then asked to collectively identify the top priority sites. This Risk Categorizations and Prioritization feedback was documented and carried forward as a tool in the Preliminary Prioritization process.

3.5.2 PRELIMINARY RISK ASSESSMENT & PRIORITIZATION METHODOLOGY

CONSIDERATION OF NDMP RAIT CRITERIA

The Impacts/Consequences Assessment presented in the NDMP RAIT involves scoring each site from 1-5 under several criteria, falling under the following categories:

- People and Societal Impacts
- Environmental Impacts
- Local Economic Impacts
- Local Infrastructure Impacts
- Public Sensitivity Impacts

While the RAIT is a comprehensive tool at the national level, there were limitations to using the NDMP rating system alone during the Preliminary Prioritization process. The RAIT criteria and scoring scale was considered broad and did not give enough specificity for the project team to differentiate sites within the Top-30 from one another. Given that all of the sites are within the same geographic area (HRM), and have similar physical and environmental characteristics, minimal scoring variations were observed between the sites. Since many of the RAIT criteria require further analysis to quantify and assign a definitive impact rating, the level of uncertainty at this preliminary stage would have also resulted in similar scores for many of the sites.

In order for the project team to distill the list of Top-30 sites down to a list of Top-10 highest priority to be carried on to Detailed Risk Assessment, additional project- and HRM-specific criteria were required.

PROJECT-SPECIFIC PRIORITIZATION CRITERIA

The prioritization process implemented for this project considers the impacts and consequence categories identified in the RAIT, paired with additional evaluation criteria derived from the Preliminary Workshops, intended to incorporate HRM-specific issues and staff concerns.

The following 17 Criteria were considered as part of the Preliminary Risk Assessment and Prioritization process:

Table 2: Project-Specific Prioritization Criteria

NDMP RAIT Criteria	People and Societal	Fatalities	As part of the Preliminary Risk Assessment and Prioritization, each site was evaluated under these criteria as "Level of Impact" during a flood event on a scale of 0-3 (0= no impact 3= high impact).
		Injuries	
		Displacement (population)	
		Duration of Displacement	
	Environmental		
	Local Economic		
	Local Infrastructure	Transportation	
		Energy and Utilities	
		Information and Communications Technology	
		Health, Food, and Water	
		Safety and Security	
	Public Sensitivity		
Additional Criteria (HRM context-specific)	Residential Property Damage		
	Commercial Property Damage		
	Public Property Damage		
	Cultural/Historical Asset Damage		
	Operations & Maintenance Requirements		

RATING THE LEVEL OF IMPACT FROM FLOODING ON EACH CRITERIA

The prioritization process was primarily qualitative in nature, focussed on assigning a "Level of Impact" rating under each of the criteria noted in Table 2. The scale ranged from 0-3, with 0 being no impact (or not applicable), and 3 being a high level of impact. For example, at a particular site, Residential Property Damage may be given a score of 0 due to no residential homes existing in the area, while given a score of 3 under Environmental due to the potential for contamination of a nearby wetland. The ratings for each criteria, at each of the 30 sites, were assembled based on feedback from the Preliminary Workshops as well evaluation by the project team and subject matter experts.

This impact scoring method was project-specific for the purpose of prioritizing the Top-30 sites in relation to one another, and therefore does not correspond with the 1-5 rating scale in the NDMP RAIT template. Further information on the HRM context-specific criteria rating is outlined in Appendix E.

PRIORITIZATION RAKING

An **"Overall Priority Score"** for each site was developed by combining the scores for each Impact Criteria listed in Table 2. This Overall Priority Score was then used to rank the 30 sites from highest to lowest priority. It is important to note that the priority scoring was used only to rank the sites in relation to one another, and is not intended to replace a more detailed flood risk assessment. A general classification of the site priority level based on its Overall Score is provided in Table 3 below.

Table 3: Classification of Priority Sites

Relative Priority Classification	"Overall Priority Score" Range	General Description
Low Priority	0-12	Lower level of impact, in the context of this study. Least urgent in comparison to other sites. Consider further assessment or mitigation through other funding streams to reduce flood risks.
Moderate Priority	13-24	Moderate level of impact, in the context of this study. Action or further analysis may be required. Consider proceeding to detailed risk assessment through the NDMP and consider mitigation measures to reduce flood risks.
High Priority	25-38	High level of impact, in the context of this study. Action or further analysis required. Proceed to detailed risk assessment through the NDMP and consider mitigation measures to reduce flood risks.

3.5.3 PRIORITIZATION RESULTS

Table 4 summarizes the prioritization scores and ranking for the original Top-30 flood-prone sites in HRM. Appendix E provides details on criteria scoring and site prioritization during the Preliminary Risk Assessment and Prioritization Analysis.

Prior to preforming the Preliminary Risk Assessment and Prioritization Analysis, several of the Top-30 sites were combined under common groupings (as discussed in Section 3.4) to better suit future analysis and/or funding for streams under the NDMP. The sites that were repositioned under common grouping have been shown as "N/A" under Grouped Priority Ranking in Table 4.

The following key points should be considered regarding the prioritization process:

- **All 30 Flood-Prone Sites are priorities for the Municipality.** The Top-10 list is not intended to be definitive. Mitigation measures should eventually be implemented for all sites.
- **Prioritization is a Tool to Direct Focus.** By prioritizing ten sites of highest risk, focus can be dedicated to develop site-specific strategies. This focus helps to achieve action that is manageable in applying for and receiving funding.
- **Prioritization is Relative.** The process scores and ranks the 30 sites in relation to each other.

The site prioritization list was circulated and reviewed by the project advisory team, including HRM and Halifax Water, for comment and acceptance prior to proceeding with the Detailed Risk Assessment for the Top-10 Highest-Priority Areas.

Table 4: Summary of Preliminary Prioritization Matrix

Site#	Site Name	GROUPED PRIORITY RANKING[2,3]	OVERALL PRIORITIZATION SCORE	WORKSHOP RANKING COMPARISON	
				HW Overall Rating (Workshop 1)	HRM Overall Rating (Workshop 2)
25	Bedford Highway, from Union Street to Highway 102 - Bedford	1	**38**	High	High
A6	Shubenacadie Lakes	2	**27**	High	High
8	Karlson's Wharf @ Upper Water Street - Halifax	3	**25**	High	High
9	Inglis Street @ Barrington Street - Halifax	4	**21**	High	Medium
24	Highway 2, from Holland Road to Miller Lake Road - Fall River	5	**18**	High	-
7	Pleasant Street, near Dartmouth General Hospital - Dartmouth	6	**17**	Medium	High
5	Cole Harbour Road @ Perron Drive - Cole Harbour	7	**15**	Medium	High
2	Shore Road - Eastern Passage	7	**15**	High	Medium
22	Hammonds Plains Road @ Bluewater Road - Bedford	7	**15**	High	High
A2	Mount Saint Vincent at Bedford Highway	7	**15**	High	High
19	Bambrick Road @ Orchard Drive - Middle Sackville	11	**12**	Medium	Medium
6	Nantucket Avenue @ Wyse Road - Dartmouth	11	**12**	Medium	High
1	Autoport - Eastern Passage	13	**11**	Low	Medium
27	Rocky Lake Drive, near quarry entrance - Bedford	14	**10**	Low	Medium
28	Cobequid Road @ Regwood Drive - Windsor Junction	15	**9**	Low	Low
12	Melville Avenue @ Winchester Avenue	15	**9**	Low	Low
11	Keating Road @ Crown Drive - Halifax	17	**8**	Low	Low
10	Kempt Road @ Lady Hammond - Halifax	17	**8**	High	Low
21	Sunnyvale Crescent @ Beaverbank Road - Lower Sackville	19	**7**	Low	Medium
18	Hammonds Plains Road, near Kynock Resources - Hammonds Plains	19	**7**	Low	Medium
13	Glenforest Weir - Halifax	19	**7**	Medium	Low
14	Leiblin Drive @ Guildwood Crescent - Halifax	22	**4**	Low	Low
4	Beaver Crescent - Cole Harbour	22	**4**	Low	Low
15	Bently Drive @ Ramsbrook Court - Halifax	24	**3**	Low	Low
26	Sackville Drive @ Cobequid Road - Lower Sackville *(see Site 25)*	N/A	**25**	Medium	Low
30	Ridge Avenue, from School Street to end – Waverley *(see Site A6)*	N/A	**22**	High	Low
3	John Stewart Drive – Dartmouth *(see Site 5)*	N/A	**13**	High	Low
20	Rankin Drive @ Glendale - Lower Sackville *(see Site 25)*	N/A	**12**	Low	Medium
16	Wellington Fire Station, Highway 2 – Wellington *(see Site A6)*	N/A	**9**	Low	Low
17	Fletcher's Drive, near civic 57 - Fall River *(see Sites A6 & 24)*	N/A	**6**	Low	-
23	Holland Road @ Highway 2 - Fletcher's Lake *(see Site 24)*	N/A	**4**	Low	-
29	Bedford Highway @ Shaunslieve Drive *(see SiteA2)*	N/A	**2**	Low	Low

Notes:

[1]Sites A2 and A6 were not originally included on the list of 30 Sites, but were identified during the Preliminary Assessment Workshops as opportunities for a more community-based risk assessment.

[2]The Top-10 Priority Sites, based on the Preliminary Prioritization process, are highlighted in blue.

[3]A Priority Ranking of 'N/A' denotes the site was considered part of a grouping. The site in the grouping with the highest score was used in the Priority Ranking

[5]The Grouped Priority Ranking references the site with the highest score within the grouping.

The following should be considered in review of the Preliminary Prioritization Table:

- The prioritization rating system is a tool to scope the relative priorities across the 30 sites in comparison to each other.
- Impact ratings should be considered to be subjective, but were informed through stakeholder workshops, consultation, and preliminary review. Workshops and consultation involved representatives from HRM, Halifax Water and the project team the fields of engineering, operations, planning emergency management, and climate change.
- The Overall Priority Score for each site was developed by combining its scores for each of the Prioritization Impact criteria. See Table E-2 for descriptions of how the Level of Impact scoring was applied. Each Impact Criteria was weighted equally.
- Preliminary Consultation identified the opportunity to group several key sites under common themes better suited for future analysis and/or funding under the NDMP for a more community-based assessment.

4 DETAILED RISK ASSESSMENT OF 10 HIGHEST PRIORITY SITES

With the intent to better understand each of the site-specific risks and impacts associated with the Top-10 sites, a Detailed Risk Assessment was completed. This involved completion of detailed site visits and investigations, further desktop reviews, and additional HRM and HW staff workshops. The Detailed Risk Assessment also involved populating the NDMP Risk Assessment Information Template (RAIT) for possible submission for federal funding under subsequent NDMP Streams in flood risk assessment and mitigation measures.

4.1 OVERVIEW OF TOP-10 KEY SITES

The scope of the Detailed Risk Assessment process was limited to the **Top-10 highest-priority sites** that were identified in the Preliminary Risk Assessment and Prioritization Analysis, as shown in Table 5 below.

Table 5: Top Ten (10) Highest Priority Sites for Detailed Risk Assessment

Priority Ranking	Site #	Site Name
1	25	Bedford Highway, from Union Street to Highway 102 – Bedford *(including Sites #20, #21, and #26)*
2	A6	Shubenacadie Lakes *(including Sites #17 and #30)*
3	8	Karlson's Wharf at Upper Water Street - Halifax
4	9	Inglis Street at Barrington Street - Halifax
5	24	Highway 2, from Holland Road to Miller Lake Road - Fall River *(including Sites #16, #17 and #23)*
6	7	Pleasant Street, near Dartmouth General Hospital - Dartmouth
7	5	Cole Harbour Road at Perron Drive - Cole Harbour *(including Site #3)*
7	2	Shore Road - Eastern Passage
7	22	Hammonds Plains Road at Bluewater Road - Bedford
7	A2	Bedford Highway at Mount Saint Vincent

Building on the strategies implemented during the Preliminary Risk Assessment Phase, a Detailed Risk Assessment Methodology was developed for application on each of the Top-10 sites. The Detailed Risk Assessment Methodology is meant to fulfil the requirements of the NDMP's RAIT form, while also considering the usefulness and practicality of the results for HRM in further examining and responding to site specific risks.

The objective of the Detailed Risk Assessments are to identify the interactions between the sites-specific infrastructure, weather and climate, surrounding communities, natural and physical environments, as well as any other factors that could lead to vulnerability at the site.

4.2 DETAILED INVESTIGATIONS

4.2.1 DETAILED DESKTOP INVESTIGATIONS

Information previously collected for each of the Top-10 sites was compiled, including data collected from the background review, site questionnaires, Preliminary Workshops with staff, and information utilized during the Preliminary Risk Assessment and Prioritization process. Additional detailed site-specific information was also collected, including a more detailed inventory of existing site infrastructure, surrounding community populations, site and historical event documentation, and watershed and infrastructure site mapping.

4.2.2 DETAILED SITE INVESTIGATIONS

In November and December of 2017, project team members visited each of the 10 key sites during a wet weather event. The intention of the visits was to re-examine the site area based on information obtained during the preliminary assessment process, obtain additional site photos, and consider potential mitigation options. The visits were planned during wet weather in an effort to time the visits with wet weather conditions. The site visits were documented with notes and photos to supplement the results of the desktop investigation.

4.3 DETAILED RISK ASSESSMENTS & MITIGATION STRATEGIES WORKSHOPS NO. 3 & 4

Two separate follow up workshops were held with HRM and HW staff as part of the Detailed Risk Assessment process. The workshops were designed to validate and review initial assumptions and findings on impacts, risks, and mitigation measures for the Top-10 priority sites.

WORKSHOP NO. 3 – HALIFAX REGIONAL MUNICIPALITY

Workshop No. 3 was held with HRM staff, many of whom had taken part in the Preliminary Workshop held previously. Various departments including community and regional planning, environmental performance, transportation public works, planning and development, and municipal emergency response services were represented. HRM staff were able to validate and comment on the presented Detailed Risk Assessment and Mitigation Strategies for each of the Top-10 sites from the Municipality's perspective. These insights included:

- Conflicts with broad-based policies and land uses
- Impacts to existing and future communities
- Environmental control parameters
- Existing studies available for funding collaboration
- Real estate ownership and acquisition challenges
- Emergency response times and routing
- Operational response during flooding events

WORKSHOP NO. 4 – HALIFAX WATER

Workshop No. 4 was held with Halifax Water staff, many of whom had also taken part in the Preliminary Workshops held previously. Workshop attendees included project engineers, as well as on-the-ground operation managers for region throughout the service boundary. HW staff were able to validate and comment on the presented Detailed Risk Assessment and Mitigation Strategies for each of the Top-10 sites from an operational perspective. These insights included:

- Cause and impact of flooding events a each site
- Impacts to existing infrastructure during flooding events
- Ownership of infrastructure (e.g. HW or NSTIR)
- Existing and future studies/capital projects available for funding collaboration
- Capital projects accounted for in upcoming HW budgets
- Mitigation measures likely needed to reduce impacts on each site

4.4 DETAILED RISK ASSESSMENTS & NDMP RAIT FORMS

The Detailed Risk Assessments were completed according to the NDMP's Risk Assessment Information Template User's Guide, included in the NDMP Guidelines (Appendix A). Aspects of the assessment process and completion of RAIT forms are summarized below:

Documentation of Background Information: Risk Event Details (Historical); Previous Studies/Analysis; Hazard Identification and Mapping

Considerations and Vulnerabilities: Area Impacted; Natural environment, meteorological/seasonal conditions; Vulnerability of the affected population; Asset inventory Existing Risk Treatment Measures

Likelihood Assessment: The return period of an event at the site.

Impacts/Consequences Assessment: Assessment and scoring of the following Impacts at the site, according to the RAIT system:

A) People and Societal Impacts
- Fatalities
- Injuries
- Population Displaced
- Duration of Displacements

B) Environmental Impacts (ie. Flora/fauna; ecosystems; air quality; water quality; water levels; soil quality/quantity)

C) Local Economic Impacts (ie. Percentage of local economy impacted)

D) Local Infrastructure Impacts
- Transportation (Local activity stopped, reduced access, delivery of crucial services or products)
- Energy and Utilities
- Information and Communications Technology
- Health, Food, and Water (ie. Access to potable water, food, sanitation services, or healthcare services
- Safety and Security (ie. Loss of intelligence or defence assets or systems)

E) Public Sensitivity Impact (ie. loss of reputation, public perception, trust, and/or confidence of public institutions)

Confidence Level: Indication of the level of confidence regarding the information entered in the risk assessment information template, ranging from A to E, with A being a very high degree of confidence and E being a very low degree of confidence. Considers the degree to which the assessment was evidence-based, knowledge of the natural hazard risk event, the quantity/quality of data leveraged, the variety of data and information, composition of the Assessment Team, and the amount of mitigation measures considered.

4.4.1 COMPLETED DETAILED RISK ASSESSMENTS (10 SITES)

The results of the Risk Assessments for the Top-10 highest priority sites are presented in **Appendix F** as individual Site Reports. Each report provides an overview of site-specific background information, identified vulnerabilities and flood impacts, and mitigation strategy concepts. Each report also contains a completed NDMP RAIT form.

For a snapshot of the risk assessment and mitigation strategies for each Site, please refer to the **Executive Summary Table** that can found at the beginning of each Site Report.

4.5 DETAILED ASSESSMENT CONSIDERATIONS & DISCUSSION

4.5.1 FLOOD RISK CATEGORIZATION

Several of the Top-10 sites can be grouped under over-arching categories which share similar hydrologic and hydraulic causes, impacts and consequences, as well as mitigation strategies. To aid in the assessment and development of response/mitigation strategies for these sites (and potentially others) within the municipality, three site categories are discussed: Large Natural Watershed Systems, Localized Drainage Infrastructure, and Tidal Influenced Systems.

LARGE NATURAL WATERSHED SYSTEMS

A significant portion of urban development within HRM is located within the floodplain of large natural watershed systems. Three of the highest priority sites may be categorized as Large Natural Watershed Systems, since they are located immediately adjacent and within the floodplain of one of the major natural drainage channel in the areas:

- Site 25 - Sackville River System
- Site A6 - Shubenacadie Lakes System,
- Site 5 – Cole Harbour / Bissett Lake Watershed System

The overall degree and duration of flooding in the floodplain is typically influenced by the extent of the tributary watershed and the extended time of concentration for the peak of the runoff hydrograph to pass the location of the site. While most urban stormwater infrastructure systems can accommodate the peak runoff for a relatively short duration (less than 1 hour), the peak runoff from large natural watersheds can take much longer (>12 hours) to pass through their floodplain system. During the extended duration of the flood inundation, the cumulative costs and risks to the health and safety of the residents and the general public may be extensive and intolerable.

A challenge in addressing flooding within larger watersheds is the scale of work required to significantly alter the overall characteristics of the tributary watershed and stream channel system, or to store a portion of the peak runoff. Localized modifications to the layout and cross-section of a particular reach along a major drainage channel can, however, help to accommodate the 100-year peak flow and improve conveyance.

Often, the residential, commercial, and institutional development located within the floodplain are required to maintain adequate flood insurance to protect their investment. Where acceptable to the federal and provincial environmental authorities, the municipality may choose to make structural changes to increase the hydraulic capacity of the channel or to protect the inhabitants of the floodplain from damage. Recently, federal and provincial governments have expressed reluctance to intervene in the hydraulic behaviour of these large natural watershed and floodplain systems, opting instead to encourage residents to flood-proof their structures or to relocate outside the boundaries of the floodplain.

While several of these larger natural watershed systems have been studied under joint federal and provincial floodplain studies completed in past decades, the impacts of climate change and ongoing development within the tributary watershed will alter the characteristics of design storms and the resultant floodplain boundaries. In recognition of the potential for increased risk to the general public and damage to public and private assets, it is recommended that each of the large natural watershed systems within HRM be the subject of an up-to-date hydrologic and hydraulic floodplain study. These studies should be intended to identify the expanded floodplain boundaries, potential improvements to the hydraulics of the stream channel, and upstream changes in the tributary watershed.

LOCALIZED DRAINAGE INFRASTRUCTURE

Flooding at four of the highest priority sites may be characterized as the result of limited or inadequate capacity of the local stormwater drainage infrastructure systems:

- Site 7 – Pleasant Street, near Dartmouth General Hospital - Dartmouth
- Site 22 – Hammonds Plains Road @ Bluewater Road – Bedford
- Site 24 - Highway 2, from Holland Road to Miller Lake Road - Fall River (including Sites #16, #17 and #23)
- Site A2 – Bedford Highway at Mount Saint Vincent

While these sites have proven to be flood-prone under recent storm events, it is noted that many of the man-made, engineered stormwater collection, storage and transmission systems, constructed within HRM over the past 5 decades have never been tested by an event greater than their definitive design storm. As the intensity, duration, and frequency of rainfall and runoff events increase with climate change, the potential for failure of many of these stormwater systems will increase, potentially resulting in a higher risk of damage to public and private property.

Typically, flooding at these sites is due to the limited hydraulic capacity of the existing man-made stormwater systems to collect and convey peak flows from the tributary drainage area to a natural drainage receiving system. In many instances, the engineered drainage system may have been designed only to accommodate peak runoff from a 2-year or 5-year event, with excess flows being carried in the public roads or a local natural drainage channel.

In general, mitigation of these localized drainage infrastructure systems is achieved by completion of a proper hydrologic and hydraulic drainage study and the construction of capital improvements, such as upgrades to culverts and other local drainage conveyance systems.

TIDAL INFLUENCED SYSTEMS

Three of the highest priority sites are understood to be influenced by the normal and extreme tidal range of the Atlantic Ocean coincident with peak stormwater runoff conditions:

- Site 2 – Shore Road - Eastern Passage
- Site 8 - Karlson's Wharf @ Upper Water Street - Halifax
- Site 9 – Inglis Street @ Barrington Street - Halifax

Where the outlets of local drainage systems are located immediately adjacent to a marine water body such as the Bedford Basin, the Halifax Harbour, or the Atlantic Ocean, the hydraulic capacity of the sewer system may be impacted by normal and/or extreme tides and storm surge conditions.

Tidal conditions can also impact sanitary and combined sewer systems and sewage pumping stations. The occurrence of a peak combined sewage flow, combined with extensive inflow and infiltration (I/I) entering the sanitary collection system, can result in an extreme sewage discharge coincident with an extreme high tide, which can result in overflow of the local sanitary pumping stations and even backflow into private residences.

At Site 9, where Inglis Street meets the south end of Barrington Street, the Pier A Sewage Pumping Station is equipped with an overflow pipe that discharges through a rectangular box culvert to Halifax Harbour during extreme flow conditions. During normal rainfall and runoff conditions, when the pump station can handle the peak sewage flows, the station does not overflow. When the wet weather flows exceed the capacity of the pumps, then combined sanitary sewage overflows through the box culvert to the Harbour under most normal tidal conditions. When the extreme wet weather flows coincide with the highest high tides, however, the ocean causes a backwater effect on the wetwell resulting in system surcharge and even overflow of sewage to the public street.

Modification of these stormwater and sanitary sewer systems impacted by the tides can require extensive and expensive upgrades that may be challenging to achieve. The influence of tide waters on these system will continue to increase with future sea level rise associated with climate change.

4.5.2 DISCUSSION ON CONFIDENCE LEVELS

The NDMP Risk Assessment Information Template (RAIT) involves indication of the Level of Confidence regarding the information used to inform the risk assessment. The assigned Confidence Level considers the variety and quality of data leveraged, composition of the Assessment Team, and the amount of mitigation measures considered. The following common themes were taken into account in determination of Confidence Levels for the assessment of the Top ten sites.

DATA AVAILABILITY

- **Infrastructure Data:** Since the Risk Assessments were more qualitative in nature, the infrastructure data available for assessment use was sufficient, particularly where non-numerical, engineering judgement-based screening was applied. It is, however, recommended that more detailed numerical data be collected for future detailed assessment and mitigation planning at each site.

- **Rainfall Data:** A historical climate analysis was conducted using data from a variety of sources. As outlined in Appendix C, data from a nearby Environment Canada station was referenced based on proximity, the completeness of data over the period of record and the ability to relate it to the future data provided from the Future Climate Projections.

STRENGTHS OF THE PROJECT-SPECIFIC RISK ASSESSMENT PROCESS

The current project uses a risk assessment and prioritization process based on the Federal NDMP program, while incorporating additional strategies to bring focus to the local context of the Halifax Regional Municipality. The work performed to date has successfully met the expectations of HRM to examine vulnerabilities of the key flood-prone areas within the Municipality and identify high priority areas for further assessment and/or mitigation. Strengths and benefits of the process include:

- The process was completed using a collaborative approach, involving an integrated team of consultants, subject matter experts, departmental staff, management, engineering, planning, emergency response, and operations personnel.
- The project workshops brought together key stakeholders to hear varying opinions, information, and perspective to develop a collaborative understanding of each site, considering a variety of impacts.
- The process was successful in gathering a unified consensus on the sites of highest priority within the municipality to focus on more detailed assessment and development of mitigation measures.
- The process examined future climate change considerations, identifying the projected increase in the intensity and frequency of rainfall events, which could trigger flood events. This emphasizes the importance of planning for, developing, and implementing flood mitigation strategies in the near future to protect and plan for these future events.
- The process is flexible and reproducible, which can serve as a reference for additional sites for application under the NDMP, or in considering other risk events/geographic areas.
- The compilation of information for each site provides valuable information for use in future mitigation planning and engineering work.

ASSUMPTIONS & CONSIDERATIONS

Due to the limited amount data available at the first stage of the NDMP process (Stream 1), the Risk Assessment and Prioritization process does have limitations; however, we believe this does not compromise its ability to meet the expectations of HRM to identify high priority areas for further assessment and/or mitigation. Considerations, limitations and assumptions of the process include:

- The prioritization scoring provides a relative ranking of the 30 flood-prone sites previously identified by HRM. The scoring is a tool for comparison only, and not intended to replace a risk assessment or analysis.
- Prioritization ratings were assigned using project-specific criteria descriptions, assembled based on feedback obtained during the stakeholder workshop and professional judgement.
- Risks are primarily assessed based on available historical information, anecdotal information, feedback from engineering and operations staff, site questionnaires, site visits, workshop feedback and high-level desktop review of topography, infrastructure, and aerial photos. There are data gaps in terms of single-point values that are absent for certain sites (for example, lack of detailed information on existing stormwater infrastructure, lack of historical reports, limited anecdotal data, etc.).
- Approximations for municipal population growth projections and distribution of population projections affected by the area impacted directly by each flood area were not undertaken (with similar limitations related to the lack of detailed flood limits).
- The assessments were conducted at a community level as opposed to an individual component level, therefore recommendations on specific asset upgrades within each system are not within the scope of this assignment.
- In the absence of detailed flood mapping using analytical techniques for most sites, the impact of flooding is based on assumptions particular to each site, such as:
  - Extent of severe flooding if not previously recorded or reported.

- Extent of flooding due to future climate events.
- Impacts of a future event more severe than previously recorded.
- General assumptions related to emergency response and emergency preparedness.
- Potential environmental impacts or probability of contaminant release.
- Number of people affected by an event (dependant on event).
- Likelihood of the particular event causing damage to infrastructure with secondary impacts.

5 PRELIMINARY MITIGATION MEASURES RECOMMENDATIONS

Once flood risk and impacts were identified at the various key sites across the Municipality, the next step involved review and recommendation of strategies and measures to help mitigate the risk and impacts. Mitigation strategies were reviewed for the Top-10 sites, as well as on a municipal-wide level.

5.1 METHODOLOGY

To help inform the development of potential mitigation strategies to address flooding challenges across HRM, a literature review was conducted to examine mitigation techniques, adaptation strategies and best management practices (BMPs) from other municipalities and jurisdictions. Information collected from the Literature Review is presented in Appendix B-2.

Following the detailed risk assessment of the Top 10 sites, initial Mitigation Strategy ideas were developed by the project team. Initial concepts were presented and discussed as part of the second phase of Stakeholder Consultation (Workshops 3 & 4). During the workshops, attendees were asked to comment on the suitability of the potential mitigation strategies, suggest any additional strategy concepts, and comment on potential coordination of strategies with other planned or upcoming work. In recognition of common themes for addressing flooding many of the key sites, opportunities for implementation of municipality-wide mitigation strategies were also identified.

5.2 MITIGATION STRATEGY TIMELINES

Each mitigation strategy concept identified for the sites has been assigned a suggested time frame for implementation. The following timeline horizons have been considered:

- → **Interim:** Next steps to be implemented in the immediate future. Typically, these measures can be completed using existing capital funds or within operations budgets. The recommended step may be urgent in nature, or only require a small investment of time, budget, or resources.
- → **Short Term (1-2 Years):** These strategies are recommended for implementation within the next two years. The strategies may fall under previously identified capital or operations work. The suggested measures may be somewhat urgent in nature, and should be completed in a timely fashion. If a funding mechanism has been identified, the application process should begin immediately/in the near future.
- → **Medium Term (3-5 Years):** These strategies are recommended for implementation within the next three to five years. The strategies may first require completion of a study, planning or design process in the short-term. The strategies may fall under identified future capital work or should be worked into the organization's 5-year business plan.
- → **Long-Term (5+ Years):** These strategies are recommended for implementation beyond the 5-year planning horizon. The strategies may be less urgent in nature, or require prior completion of a study, planning or design process that would occur within the next 5 years. Opportunities to expedite prior work to allow for implementation of these strategies within the short or medium term horizon should still be considered, where feasible.

While efforts were made to identify reasonable timelines considering capital budgeting and funding application processes, the timelines identified for the implementation of mitigation strategies should not be considered definitive. HRM and Halifax Water are encouraged to consider opportunities to expedite further assessment and implementation of the suggested next steps wherever possible.

5.3 COSTING & FUNDING MECHANISMS

5.3.1 NDMP FUNDING STREAMS

Available subsequent funding streams under the National Disaster Mitigation Program are further defined in Section 2 of this report, summarized below:

→ **Stream 2: Flood Mapping** - Defining the geographical boundaries of a flooding event, used to help perform an updated risk assessment of flood impacts.

→ **Stream 3: Mitigation Planning –** Using risk information to make informed planning decisions. Involves identifying mitigation goals, strategies, objectives and key activities.

→ **Stream 4: Investments in Non-Structural and Small Scale Structural Mitigation –** Implementation of a specific mitigation project.

5.3.2 PROJECT COORDINATION

It is recommended that HRM and Halifax Water consider and investigate the potential application of the following funding programs to implement further assessment, analysis and/or implementation of the mitigation strategies:

→ **Coordination with Other Ongoing/Upcoming Projects:** Identify and act on potential opportunities to coordinate flood mitigation/infrastructure improvement work with upcoming planned capital projects in the vicinity of the site For example, planned road upgrades, new residential development, etc.

→ **Paired Study/Design/Implementation** – Grouping upcoming study, design and/or construction for a particular site under one project and funding application, such as Stream 4 – Investments.

5.3.3 ORDER OF MAGNITUDE COSTING

As part of the recommended next steps, Rough Order of Magnitude costs have been provided for each project. The intent of the costing is to give HRM and Halifax Water an idea of the potential level of effort required for the possible work. Estimates of this nature are extremely high-level and should be further reviewed against the detailed project scope of work (once defined) when allocating capital funds.

5.4 SITE-SPECIFIC MITIGATION STRATEGIES

Appendix F contains individual site reports for the Top-10 sites, presenting mitigation strategy options, with suggested implementation timelines, Rough Order of Magnitude Costs, and potential funding mechanisms. Each report also discusses operability, construction, and funding considerations related to each strategy.

In development of the site-specific strategies, common themes were identified for adaptation and mitigation that could be applied to many of the sites, as well as sites beyond the limits of the current study. This resulted in development of a proposed municipality-wide flood management strategy as discussed in the following section.

5.5 MUNICIPALITY-WIDE COMPREHENSIVE FLOOD MANAGEMENT STRATEGY

The following relevant flood mitigation techniques and adaptation strategies were reviewed for potential application in addressing flooding challenges across HRM.

1. EMERGENCY PREPAREDNESS AND RESPONSE PLANNING

- Evacuation route planning:
  - Incorporate identified flood-risk zones into evacuation route planning.
  - Conduct detailed traffic modelling of emergency routes.
- Maintain forecasting and early warning communication systems.
- Consider thresholds for evacuation of high-risk areas.
- Document flood management plans.

2. COORDINATION

- Coordination between coastal and pluvial flood mitigation/response strategies.
- Incorporate flood risk analysis and mitigation planning into upcoming capital work and studies.
- Coordinate recommended flood mitigation infrastructure or upgrades with ongoing and future capital projects.
- Enhanced information sharing between agencies.
- Dedication of a Flood Management Action Team to foster increased commitment, cooperation and communication between government and utilities.

3. DATA COLLECTION AND MONITORING

- Increase monitoring and collection of flood-related data to help improve understanding of flood risks within the municipality and inform future planning initiatives.
- Logging of historic and ongoing flooding in a digital database to allow for forensic analysis, including information such as:
  - Location of surface flooding;
  - Nature of the area (intersection of roads, Road dip);
  - Any obvious obstruction to drainage; and
  - Date and time of flooding.
- Coordinate with existing asset management programs. Incorporate data logging and reporting with the HRM and Halifax Water GIS systems.

4. LAND USE AND DEVELOPMENT POLICIES

- Review land use planning regulations to restrict development within defined floodplains, including:
  - No-build zones;
  - Defining types of development permitted within flood limits of varying return periods;
  - Mandatory incorporation of flood protection into new developments near/adjacent floodplains.
- Monitor and enforce policies to prevent development and expansion of property in high risk areas.
- Consider long term, strategic water-shed level stormwater management objectives through Stormwater Master Planning.

5. STORMWATER POLICIES

- Develop and/or enhance stormwater management policies, including management of stormwater quantity and quality.
- Enforce drainage standards (major/minor systems, design-storms).
- Monitor and enforce the regulations.
- Policy for implementation of stormwater management Best Management Practices (BMPs) in new developments.
  - Low Impact Development (LID) Measures can be used to mitigate peak flow rates from individual properties and, by extension, mitigate storm water quality and temperature impacts of overall development.
  - Possible LID measures include controlled flow roof drains, green roofs, rain gardens and underground storage.

6. REGIONAL FLOOD RISK MAPPING AND RISK ASSESSMENT

- Develop, or obtain from available sources, a high-level flood risk map for the municipality.
- Include vulnerability indicators, hazard mapping, and previously mapped flood extents.
- Use as a high-level planning and emergency management tool to help identify areas of high risk.
- Identify areas for further risk assessment and/or analysis.
- Include both pluvial (rainfall) and coastal flood risk mapping.

7. PUBLIC EDUCATION AND AWARENESS

- Conduct community outreach initiatives to educate the community on how to prepare for floods.
- Strengthen public awareness of flood risks and policies.

8. EMBRACING ADAPTIVE MANAGEMENT

- Ongoing data collection and monitoring of implemented mitigation strategies.
- Inter-departmental/utility coordination.

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ATTACHMENT F

Priority	Site Name	Recommended Strategy
1	Sackville Rivers System	Engineering Feasibility Study Potential Flood Remediation Measures. Also, Update Planning & Development Policy within Floodplain
2	Shubenacadie Lakes	Watershed & Floodplain Mapping Study
3	Karlson's Wharf	Analysis & Preliminary Design of Future Local Storm System. Also, Construction of Local Storm Sewer System Infrastructure
4	Inglis Street at Barrington	Local Stormwater System Study & Concept Design
5	Highway 2	Highway 2 Stormwater Drainage Study
6	Pleasant Street	Hydrologic/Hydraulic Assessment & Conceptual Design of Flood Remediation Infrastructure
7	Cole Harbour Road at Peron Drive	Detailed Bisset Run Watershed Drainage Study & Mitigation Concept Development
7	Shore Road – Eastern Passage	Public Engagement & Emergency Preparedness
7	Hammonds Plains Road at Bluewater Road	Sandy Lake Watershed Drainage Study & Mitigation Concept Development. Also, Analysis & Design of Hammonds Plains Road Upgrades
7	Bedford Highway at Mt St. Vincent	Bedford Highway Sewer System Capacity Study for Future Development

Priority	Site Name	Order of Magnitude Costing		
		Short Term (0-2yrs)	**Medium Term (3-5 yrs)**	**Long Term (+5 yrs)**
1	Sackville Rivers System	$50-150K	$25-75K	TBD
2	Shubenacadie Lakes	$250-500K	$50-150K	TBD
3	Karlson's Wharf	$200-350K	$250-500K	Operations
4	Inglis Street at Barrington	$25-150K	TBD	TBD
5	Highway 2	$50-100K	$2-5M	$50-100K
6	Pleasant Street	$25-60K	$0.4-1M	TBD
7	Cole Harbour Road at Peron Drive	$50-90K	Operations	$0.5-$1M
7	Shore Road	$15-30K	$25-60K	TBD
7	Hammonds Plains Road at Bluewater Road	$50-200K	TBD	$2-5M
7	Bedford Highway at Mt. St Vincent	$50-100K	$75-150K	TBD
Totals		$0.8-$1.7M	$2.8-$6.9M	$2.6M-6.1M
		$6M - $15M		