APPROACH FOR FLOOD PROTECTION IN RESPONSE TO CLIMATE CHANGE

EXECUTIVE SUMMARY

Submitted to:
City of Dieppe
Dieppe, New Brunswick

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BACKGROUND

The long-term shift in overall weather conditions over time is referred to as “climate change”. Anticipated climate change impacts include more frequent heat waves, droughts, storm surges and flooding. Climate change adaptation is a way to manage the risks by addressing the potential effects. Adaptation measures include developing effective policies and designing / upgrading municipal infrastructure to accommodate predicted impacts.

Climate change is a growing concern for many municipalities. The Tri-Community Area (City of Dieppe, City of Moncton, and Town of Riverview) is presently experiencing more frequent occurrences of flooding from the coast, inland watercourses and extreme precipitation events. The Tri-Community Climate Change Adaptation Measures project (AMEC, 2011) quantified the impact of projected climate change on regional precipitation and determined total water levels in the Petitcodiac River and Estuary for various planning horizons. Total water level comprises sea level rise, land subsidence, tide, storm surge and overland flow contribution. The study identified that predicted water levels would reach 10.25 m for a 1:100 year event in year 2100. For a worst case scenario, such as similar to the Saxby Gale, water levels reach 11.5 m in year 2100.

STUDY AREA

In order to delineate an area for further analysis, the water level elevations determined in the 2011 study were examined. A flood elevation level of 10.5 m, equivalent to a Saxby Gale event occurring under present conditions, was applied. In addition, it was decided to include an assessment of underground infrastructure at locations having surface elevations between 10.5 m and 13.5 m. In between these contour lines, there would be potential for backups in the piped sewerage and storm water drainage system and for flooding of basements, when a flood level reaches 10.5 m.

The Study Area is defined as the spatial area within the City of Dieppe limits, east of the Petitcodiac River that is at or below a geodetic elevation of 13.5 m. This area was divided into five “Sections” bounded by portions of existing and historical dike end points extended to the prescribed flooding elevation of 10.5 m and further to elevation 13.5 m. The end points of the dike sections were determined primarily by natural features (creeks, elevations, vegetation) or recognizable infrastructure such as trail bridges. The sections are named as follows:

- Section 1 (Paul Street).
- Section 2 (Chartersville Marsh).
- Section 3 (Amirault Street).
- Section 4 (Fox Creek).
- Section 5 (Dover Road).

Maps showing the contour lines for 10.5 m and 13.5 m are presented in Appendix A of the report.

SITUATION ANALYSIS

A planning and engineering analysis was completed for the five sections to determine: land uses, population densities (permanent and temporary), infrastructure (roads, water, sewer, and other utilities), and critical services (fire, police, hospitals, etc.). The sections were characterized as follows:

- Section 1 (Paul Street) – Very little residential population. 98% of the land use is designated as commercial. Paul Street and Champlain Street provide access to commercial establishments. There are varying lengths of sanitary sewer, storm water, and water supply pipelines, as well as underground natural gas, and telecommunications lines. The existing dikes are in good condition.
- Section 2 (Chartersville Marsh) – Dominated by the Flood Plain Zone (54% of the section area), where little development is permitted. Substantial residential area (35% of the section area, a number of small commercial areas (10%), and a small institutional zone (1%). 74% of the total Study Area population resides in this section. The main arterial routes are Acadie Avenue and Amirault Street. There are significant lengths of water line and sanitary sewer / storm water lines. The existing dikes are in good condition.
- Section 3 (Amirault Street) – 79% of the section area is low density Conservation Zone and 21% residential. There are varying lengths of sanitary sewer, storm water, and water supply pipelines, as well as underground natural gas, and some telecommunications lines.
- Section 4 (Fox Creek) – Land use is a mix of low population density land uses: Conservation, Park, Flood Plain (53%), medium density commercial and institutional uses (11%) and high density residential uses (36%). There are varying lengths of sanitary sewer, storm water, and water supply pipelines, as well as underground natural gas, and some telecommunications lines. The dikes are limited in length, are in good condition, and have a minimum crest elevation of approximately 8.5 m, geodetic. However, the land between the shoreline and the north abutment of the dike is topographically low, approximately 7 m.
- Section 5 (Dover Road) – Land use consists of three low density zones. The area is uninhabited. There are no utilities present.

DESIGN CRITERIA

Design criteria have been suggested to guide engineering and public works activities for the implementation of flood protection measures involving physical construction. These criteria include:

- Safety Plan
- Level of Protection - dike design determined in accordance with the Canadian Dam Association (CDA) Dam Safety Guidelines.
- Disturbance of Natural Resources and Vegetation – activities to minimize disturbance of natural resources.
- Existing Trail Network - disruption of the trail system will be minimized and existing vistas will be preserved.

- Legislative framework – Acts and Regulations that must be complied with.
- Communication Plan
- Dike design principles and specifications
- Financial Considerations
- Construction process
- Limitations

RISK ANALYSIS

Risk is a function of probability and consequences. To assess possible consequences, population, assessment values of properties, and critical infrastructure were considered. The combination of depth and velocity informs the hazard rating for the five Sections (and portions thereof). Hazard ratings are generally categorized into four degrees: low, moderate, significant and extreme.

The assessment of population, assessed value and critical infrastructure combined with the flood depth and assuming an average flow velocity of less than 1 m/s, partially informs the degree of flood hazard. The other important consideration is the Dam Safety Guidelines (Canadian Dam Association (CDA) 2007). These Guidelines are consequence-based, i.e., some of the criteria used in designing or assessing a dam, as well as inspecting and maintaining it, are based on the consequences / losses due to the failure of the structure, in consideration of four parameters:

- Population at Risk;
- Incremental Loss of Life;
- Incremental Loss of Environmental and Culture Values; and
- Incremental Loss of Infrastructure and Economics.

A detailed assessment of each of these parameters is presented in Appendix B of the main report. The results are summarized in Table E.1.

Table E.1 Summary of Provisional Dam Classifications

Section	Classification				
	Population at Risk	**Loss of Life**	**Environmental and Cultural Values**	**Economics and Infrastructure**	**Overall**
1	Significant	Significant	Low	High	High
2	High	Extreme	Significant to High	High	High
3	High	High	Low	Significant	Significant
4	High	Very High	Significant to High	High	High
5	Low	Low	Low	Low	Low

The degree of hazard for each section is as follows:

- Section 1: the degree of flood hazard is considered to be “high” as major land portions are inundated by 1-3 m of water, coupled with a significant daily temporary population (10,000), significant assessed value and substantial critical regional commercial and retail infrastructure.
- Section 2: the degree of flood hazard is considered to be “high” as major land portions are inundated by 1-3 m of water. However, most of this area is marsh and not zoned for development. There is a significant residential population), high assessed value and critical transportation infrastructure (particularly Acadie Ave.).
- Section 3: the degree of flood hazard is considered to be “significant” because a major land portion is inundated by 1-3 m of water, but this is largely existing marine marsh; the population and assessed value are low, and there is minimal infrastructure.
- Section 4: the degree of flood hazard is considered to be “high” because a major land portion is inundated by 1-3 m of water, but this area is for the most part an existing drainage corridor; the population and assessed value are medium in scale, and there is minimal infrastructure.
- Section 5: the degree of flood hazard is considered to be “low” because although a major land portion is inundated, this is primarily existing marine marsh and there are no people living in the affected area.

OPTIONS ANALYSIS

A number of flood protection options were examined. These options include non-structural mitigation (land-use zoning, subdivision control, and financial incentives / disincentives to encourage non-flood susceptible land use or the incorporation of flood-proofing during infrastructure construction); structural mitigation (raising structures/roads, installing barriers, dry and wet floodproofing techniques, installing exterior drainage systems, and relocation); and, engineered protection (dike construction). Potential options for each section are provided in Table E.2.

RECOMMENDATIONS

The preferred options for each section are ranked in Table E.3. The considerations include cost, benefits, risk and the potential for phasing the actions over time to provide incremental protection in step with the anticipated increase in sea level rise, high tides and storm frequency and intensity in the future.

In general the mitigation option selected has to be practical and cost effective. The capital and O&M costs of mitigation should be less than the assets protected. In some cases, a combination of non-structural measures and wet / dry floodproofing can be used to justify a lower dike crest elevation than required to comply with design guidelines.

Table E.2 Protection Options by Section

Section	Status Quo	Structural - Floodproofing	Structural – Diking[1]	Non-Structural Mitigation
1	High cost of repairs, possible injuries	Install temporary and/or permanent automated barriers, in conjunction with dikes.	Construct / raise dike with approximate crest elevation of 11.0 m around south and west perimeter. Some areas and roadways to be closed off during flooding events via temporary or permanent barriers.	Amend zoning by-law for minimum building elevations and prohibit basements in flood zone, for new developments or renovations/expansions. Buy-out of vacant commercial buildings below 10.5 m) and rezone.
2	High cost of repairs, possible injuries	Install drainage systems around structures below 10.5 m elevation. Install wet flood proofing for structures below 10.5 m elevation. Raise streets: Amirault St. and Virginia Avenue.	Construct continuous dike at approximate crest elevation 11.5 m.	Amend zoning by-law for minimum building elevations and prohibit basements in flood zone, for new developments or renovations/expansions. Buy-out of vacant commercial buildings below 10.5 m) and rezone. Rezone undeveloped areas under 10.5 m elevation to FP zone, including planned (yet unconstructed) subdivisions.
3	Some damage likely	Install drainage systems around structures below 10.5 m elevation. Install wet flood proofing for structures below 10.5 m elevation.	Not applicable	Amend zoning by-law for minimum building elevations and prohibit basements in flood zone, for new developments or renovations/expansions.
4	High cost of repairs, possible injuries	Install drainage systems around structures below 10.5 m elevation. Install wet flood proofing for structures below 10.5 m elevation. Raise Amirault St., Melanson Road (between Fox Creek Road. and Bourque Rd.), and southern portion of Chemin Fox Creek.	Construct continuous dike with approximate crest elevation 11.3 m, across western portion and raise the existing dike that crosses the Fox Creek aboiteaux.	Amend zoning by-law for minimum building elevations and prohibit basements in flood zone, for new developments or renovations/expansions. Rezone undeveloped areas under 10.5 m elevation to FP zone.
5	Low risk of injuries or damages	None required	None required	Rezone RA to FP

Note: 1. Required dike elevations for each section are determined utilizing CDA guidelines, as described in Section 5.3.1

Table E.3 Recommendations Ranked by Section

	Description	Benefits	Cost	Risk	Potential for Incremental Protection
Ranked Recommendation					
Section 1					
1	Dry flood proofing	Protection for individual structures	To be determined	Other infrastructure and amenities not protected	Establish priority for most threatened structures
2	Regional engagement to determine a comprehensive approach to protecting all assets within the jurisdiction of the City of Dieppe, City of Moncton and the Province of New Brunswick.	Protection for all structures and facilities	To be determined		Establish priority for most threatened structures and facilities.
3	Amend zoning by-law: minimum building elevations; prohibit basements for new developments or renovations/expansions in flood zone. Rezone undeveloped areas under 10.5 m to FP zone.	Regulates development to prevent future problems	Administrative time	No physical protection	Regulations can be modified gradually.
Section 2					
Ranked Recommendation					
1	Amend zoning by-law: minimum building elevations; prohibit basements for new developments or renovations/expansions in flood zone. Rezone undeveloped areas under 10.5 m to FP zone.	Regulates development to prevent future problems	Administrative time	No physical protection	Regulations can be modified gradually.
2	Construct continuous dike of 2.37 km length at approximate crest elevation 11.5 m.	Protection for all structures and facilities	$1.0 – 2.0 M	Wide range in costs dependent on transportation of material	Dike crest elevation can be raised a metre at a time, but this would result in higher total cost for construction tendering and mobilization.
3	Drainage systems and/or wet flood proofing for structures below 10.5 m	Protection for individual structures	$2.3- 2.5 M	Other infrastructure and amenities not protected	Establish priority for most threatened structures

Section 3					
Ranked Recommendation					
1	Amend zoning by-law: minimum building elevations; prohibit basements for new developments or renovations/expansions in flood zone.	Regulates development to prevent future problems	Administrative time	No physical protection	Regulations can be modified gradually.
2	Drainage systems and/or wet flood proofing for structures below 10.5 m	Protection for individual structures	$396,000 - $436,800	Other infrastructure and amenities not protected	Establish priority for most threatened structures
Section 4					
Ranked Recommendation					
1	Amend zoning by-law: minimum building elevations; prohibit basements for new developments or renovations/expansions in flood zone. Rezone undeveloped areas under 10.5 m to FP zone.	Regulates development to prevent future problems	Administrative time	No physical protection	Regulations can be modified gradually.
2	Drainage systems and/or wet flood proofing for structures below 10.5 m	Protection for individual structures	$842,000 - $930,000	Other infrastructure and amenities not protected	Establish priority for most threatened structures
3	Construct continuous dike of 1.58 km length at approximate crest elevation 11.3 m, across western portion of section and raise existing dike that crosses Fox Creek aboiteaux.	Protection for all structures and facilities	$600,000 – $1.6 M	Wide range in costs dependent on transportation of material	Dike crest elevation can be raised a metre at a time, but this would result in higher total cost for construction tendering and mobilization.
Section 5					
Ranked Recommendation					
1	Status Quo				
2	Rezone RA to FP	Regulates development to prevent future problems	Administrative time	No physical protection	Regulations can be modified gradually.

Note:
Engineering, land acquisition, legal fees, etc. are not included in the cost estimates.

CONCLUSION

The purpose of this study was to provide guidance to inform the development of design and intervention options to protect vulnerable populations and infrastructure as well as critical services in the City. The assignment identified that the five Sections in the Study Area have unique characteristics and require individualized adaptation measures which range widely in terms of capital cost and implementation effort, as well as the need to craft effective land use and development policies and design standards for municipal infrastructure.

Addressing climate change adaptation poses a difficult dilemma for municipalities as it often entails decisions about potential major expenditures within a context of financial constraint and some uncertainty with regard to when and how climate change impacts might occur.

This study is not a debate about climate change. Rather the underlying assumption is that the historical evidence related to climate dynamics is sufficient to warrant serious consideration of ways and means to protect vulnerable physical assets and people. The study has proposed ranked recommended adaptation measures for each Section on the basis of cost, benefits, and other factors.

In general the mitigation option selected should be practical and cost effective. The capital and operation and maintenance costs of mitigation should be less than the value of the assets protected. In some cases, a combination of non-structural measures and wet / dry floodproofing can be used to justify a lower dike crest elevation than required to comply with design guidelines. There may be other potential options to avoid, adapt and protect the community against flood - climate change related impacts.

These recommendations are still at the proposal stage and require further discussion and reflection by the City government, the citizens and the business community with respect what is affordable, logistically feasible and optimal in terms of protection against gradually increasing water levels and extreme climatic events in the future.