Torbay – Stormwater Management Plan

Town of Torbay, NL

PREPARED FOR:

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1.0 Introduction

Progressive Engineering & Consulting Incorporated (PEC) is an engineering and consulting company located in Paradise, Newfoundland and Labrador. Darryl Mills, P.Eng and Kelly Hickey, CET both founded the company in 2012. In May of 2018 Progressive Engineering and Consulting Inc. (PEC) was engaged to prepare a Stormwater Management Plan for the Town of Torbay. This Stormwater Management Plan will serve to quantify potential pre and post development flows, identify flood prone areas, examine the condition and capacity of existing stormwater infrastructure, prioritize infrastructure upgrades, propose probable solutions to mitigate flooding and identify potential areas for regional stormwater detention ponds. Given the increased population and development within the Town of Torbay, the amount of runoff has expectedly increased meaning that existing infrastructure could be compromised with regards to its capacity to appropriately convey stormwater. The amount of runoff has also increased in recent years due to the impacts caused by climate change.

The Town of Torbay consists of six major catchment areas that the Stormwater Management Plan will focus on. The six major stormwater catchment areas are as follows: Big River Catchment, Watts Pond Brook Catchment, Whiteway Pond Brook Catchment, Island Pond Brook Catchment, Kennedys Brook Catchment and Pond Brook Catchment. Pond Brook Catchment feeds into a protected wetland area known as “The Gully”, which was the subject of a previous study completed by PEC. A diagram of the catchment areas within the Town can be observed in Appendix C. At the request of the client the Island Pond Brook Catchment was set as a priority at the beginning of the project due to the increased development in the area as well as the presence of Skipper’s Landing, which has had a number of drainage issues in the past. During the course of this study a field program was conducted and detailed 1D/2D XPSWMM computer models were produced for all five major catchment areas mentioned previously. Existing conditions as well as updated conditions, including the use of regional detention ponds that will help mitigate the potential flooding and infrastructure damage that could occur in certain problem areas.

As a result of recent impacts of climate change, the City of St. John’s has recently updated its design storm database for rainfall events. The new design storms account for the increased intensity of storms that have been observed over the last several years. As a part of the Torbay Stormwater Management Plan, the new climate change storms were used to run simulations of the existing conditions as well as the updated conditions. The hyetographs for these storms can be seen in Appendix A. In keeping with best practices at the time, previous flood analysis projects which Progressive Engineering & Consulting Inc. have completed for the Town used the old design storms. This means the results presented in this report are relevant because they were analyzed as per the latest available data.

The following report outlines the process of developing both the existing conditions and upgraded conditions models for the entire town. Recommendations are provided regarding remedial actions that will help prevent flooding as well as outlining potential detention pond structures to assist in preventing flooding while accommodating future developments.

1.1 Existing Infrastructure

A crucial part of the development of the XPSWMM models and the determination of flood prone areas was the field program which was performed primarily in the summer of 2018. A total of 48 culverts and bridge structures were surveyed and inspected by PEC staff. A full spreadsheet can be found in Appendix D which lists the critical information pertaining to each piece of infrastructure. In this inspection spreadsheet, pertinent information such as structure size, inverts, elevations, photos and more importantly structural conditions are noted.

1.2 Anecdotal Data

Prior to running and analyzing models within the town, it is important to have a grasp on what areas have been prone to flooding in the past as well as the impact of any major storm events that have occurred. At the onset of the project, discussions took place between the staff of Progressive Engineering & Consulting Inc. and Town of Torbay representatives to discuss flood prone areas. Given the severity of recent storm events such as Hurricane Igor (2010) and Tropical Storm Chantal (2007), the rainfall hyetographs associated with these storms have been simulated and results from the model can be compared to what was observed at the time of those storms. These floodplains can be seen in Appendices E and F. Key findings of PEC's investigations are as follows

- In 2014 Progressive Engineering & Consulting Inc. completed a flood analysis of the area of Anstey's Cove Lane, which is contained within the Watt's Pond catchment area, and recommended that a berm be constructed to prevent flooding issues in the area. It was evident that there were overland flow issues and the existing infrastructure was very near capacity.
- While gathering topographical surveying in the area of Shea's Lane, it was brought to PEC's attention that there have been events in the past where flooding has occurred and widening of the channel in the area was required to prevent infrastructure damage.

- A property on Bridge Road has reported flooding or near flooding instances when heavy rainfall has resulted in stormwater from the adjacent channel spilling onto their property.
- Crowes Lane currently has three CSP culverts conveying runoff between two adjacent wetland areas. It was noted that in the past this portion of the road has previously washed out during a storm event and as a result these three CSP culverts were implemented and no flood events have been observed since these infrastructure upgrades.
- In 2017 Progressive Engineering & Consulting Inc. completed a flood plain analysis in the area of "The Gully" and determined that during heavy rainfall events, there is flooding occurring on Lynch's Lane and Mahon's Lane. The existing aluminum arch bottomless culvert does not appear to have the capacity to convey the amount of storm runoff that would occur during these storm events resulting in the existing infrastructure being under capacity as well as some overland flow occurring on a nearby property on Lynch's Lane.
- During the spring of 2018, a storm event took place which Progressive Engineering & Consulting Inc. analyzed and determined was between a 2 and 5 year 24 hour storm event in terms of its intensity and duration. During this storm, staff from Progressive Engineering & Consulting Inc. visited Torbay to view the flood prone areas that are described above. While no serious flooding or infrastructure damage was observed, several pieces of infrastructure were observed to be at or near capacity. This indicates that for more intense rainfall events, the infrastructure would be compromised and significant infrastructure damage could occur. In particular the aluminum arch bottomless culvert on Lynch's Lane was very near capacity and it was recommended in a previous flood analysis that this culvert be upsized.

1.3 Field Program & Relevant Data Gathering

A key part of developing an integrated 1D/2D model is the use of LIDAR data (Light Detection & Ranging). This data describes the topographical landscape of the town in 2D fashion. To help complement and complete the 1D/2D model, additional topographic surveying has to be completed to accurately model key pieces of storm sewer infrastructure such as CSP culverts, arch bottomless culverts and bridge structures. This survey information forms the basis of the model as it allows the storm infrastructure to be accurately modelled as well as being able to model accurate cross-sections of the river systems contained within the town. If storm runoff should spill over the banks of a river cross section during modelling, it will then pass onto the 3D landscape and be routed appropriately demonstrating where the flow would end up in the event of major storm event. To help with delineating areas of concern within the town, geo-referenced imagery of the town was provided which was imported into XPSWMM to assist in the flood plain mapping process. The geo-referenced images are of higher quality than typical imagery taken from applications such as Google Earth and thus provide clearer insight into the results given in the models.

The XPSWMM program runs a 2D model by using a 2D grid, containing cells. The 2D grid acts like a map for the 2D portion of the model. In each cell a single value for water depth, water elevation and velocity is calculated. Therefore, the smaller the cell size is, the more accurate the model is, simply based on the idea that the more cells contained within the model the more detailed the model becomes, which makes it easier to observe flow patterns on the topography. Reducing the 2D grid size to as small as possible is key in ensuring accurate results are obtained.

2D land uses were then created for all areas outside of the stream channel. This allows XPSWMM to accurately model how the stormwater will flow during flooding conditions. For example, water will flow around areas designated as buildings and will flow at a calculated rate when flowing over grassland or paved streets based on the Manning's roughness coefficients or retention capacity of these land uses. If these parameters were not specified the model would assume that the surface on which the runoff is passing over is totally impervious. This would be inaccurate given that some ponding should be expected in the wetland area.

Once all appropriate parameters were calculated and input into the model, various storm data files were used to simulate local storm events. Five different 100 year storms of durations equal to 1, 2, 6, 12 and 24 hours were run in simulation through the XPSWMM model to determine their impact on the existing system. These hyetographs can be seen in greater detail in Appendices A and B

1.4 Methodology

Once available field and LIDAR data was compiled, the next step in developing an accurate 1D/2D model of the town's stormwater system is to identify individual catchments and to perform computations on these catchments. These computations include calculations of area, slope, percent impervious and so on. These computations allow XPSWMM to model the catchments accurately to ensure that the correct amount of runoff leaves these catchment areas.

Next the major river systems are identified on base mapping and then exported into the XPSWMM model. This will allow for the set-up of a link-node system which XPSWMM uses to convey runoff from these catchment areas in the same way it does in a real world scenario. Since LIDAR data was provided, cross-sections of these river systems can be taken in XPSWMM to provide a cross-section of these rivers, such as the one shown in the figure below.

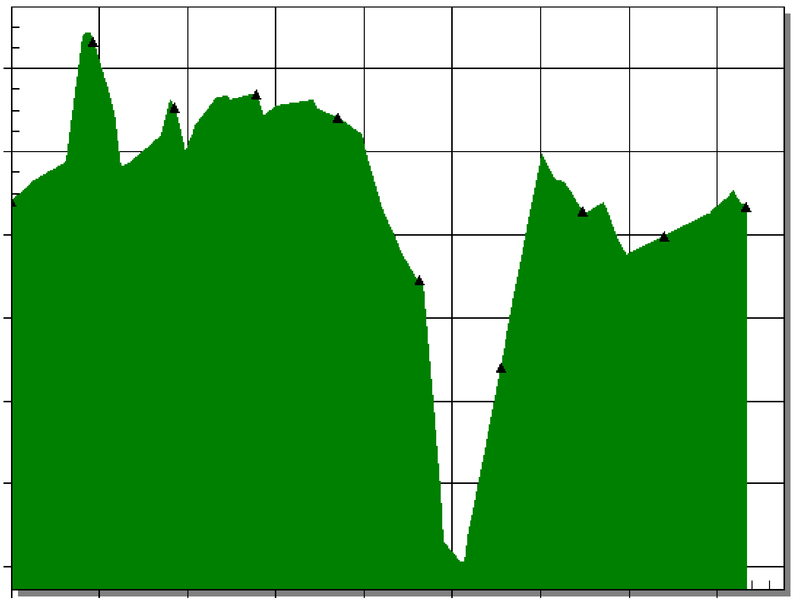

Figure 1: River Cross-Section Taken from LIDAR

Once the conveyance routes throughout the town have been clearly defined using the XPSWMM and LIDAR data, it is then important to import the topographic survey information obtained from the field program to accurately model the major pieces of storm sewer infrastructure within the Town. Similar to the cross-section noted above for a natural stream, the cross-section of a culvert imported from topographical survey can be observed in the Figure 2.

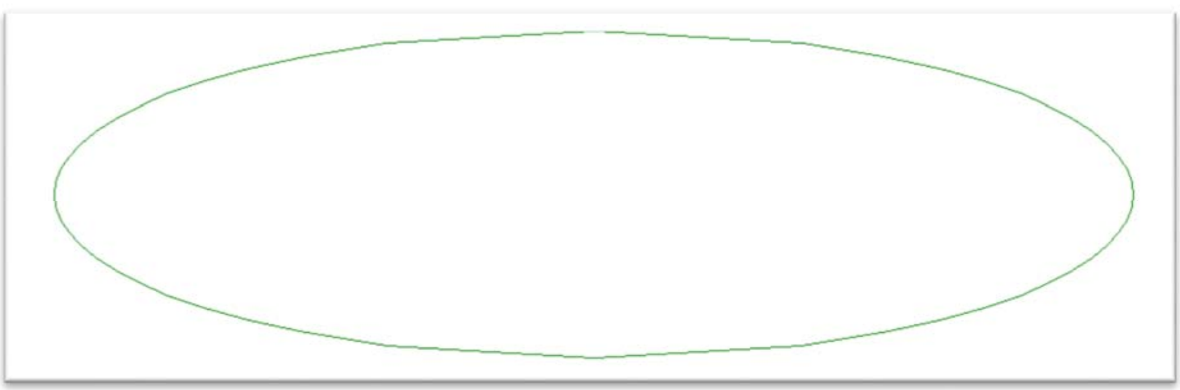

Figure 2: Culvert Cross-Section - XPSWMM

To calculate overland flows and flow rates within channels and culverts, rainfall data must be entered. The City of St. John's have recently updated their design storms to account for the impacts of climate change that have been observed during recent storm events within the province. These storms bring increased rainfall intensities when compared to the standard models which have been used in older modelling projects. It is standard practice now to use the updated data when designing and modelling storm sewer infrastructure.

2.0 Existing Conditions Models – No Future Development

For this study, three sets of models were developed. An existing conditions model that replicates storm water runoff under current buildout conditions was developed and essentially depicts the Town as it exists today. The second set of models are existing conditions models but have been updated to take into account future development within the town. Lastly, there are a set of remedial upgrades models which propose infrastructure upgrades that will address and help prevent issues shown in the first two sets of models. To accurately calibrate the models, Progressive Engineering & Consulting Inc. utilized rainfall data on file for previous storm events: Hurricane Igor which occurred in the fall of 2010, and Tropical Storm Chantal which occurred in the summer of 2007. These storm events brought significant wind and rainfall to the island portion of the province and caused wide spread infrastructure damage. Not only does this provide a basis for model calibration but also helps the Town visualize the severity of new climate change storms.

To further calibrate the model, staff from the Town of Torbay and Progressive Engineering & Consulting Inc. held a meeting on September 13, 2018 to present the existing conditions model and to discuss the accuracy of the results being displayed. The Town confirmed that most of the results displayed within the model accurately depicted real life scenarios. Discussion took place about potential locations for stormwater detention ponds, placement of earth berms and upsizing culverts within the town which set the basis for the development of upgraded conditions models.

The following sections break down results obtained from models of each of the individual catchments described previously.

2.1 Skipper's Landing Catchment

The Skipper's Landing Catchment area has been a major area of concern for the Town of Torbay for quite some time. It primarily consists of a residential area surrounded by a sparsely forested marsh area. The runoff entering this catchment takes in further residential area to the north, primarily from the Indian Meal Line, Victor Place, Nathaniel Drive and Flora Drive area. Most of this runoff is conveyed to a cutoff ditch located at the rear of the properties located on the west side of Skipper's Landing. Figure 3 is a photograph of this channel during heavy rainfall during a May 30th 2018 rainfall event.

Figure 3: Skipper's Landing Cutoff Drainage Ditch

Residents have expressed concern with this cutoff ditch, stating that the majority of overland flow issues are a result of the ditch becoming full and passing onto their properties, or potentially flooding their basements. From the cutoff ditch, the runoff is conveyed through a 600mm and a 700mm CSP culverts. These culverts are shown in Figure 4.

Figure 4: 600 & 700mm CSP Culverts - Skipper's Landing

Beyond these two culverts the runoff follows a natural stream through a marshy area at the rear of the homes located on the eastern portion of Skipper's Landing where it eventually passes through a 1200mm culvert on Western Island Pond Road, as shown on Figure 5.

Figure 5: Existing 1200 CSP Culvert Western Island Pond Drive

Progressive Engineering & Consulting Inc. have been involved in a number of projects in this area over the past several years and have proposed remedial actions to help mitigate flooding that the local residents have been experiencing. Previous recommendations included increasing the depth and widening the cutoff ditch at the rear of the properties on Skipper's Landing as well as correcting reverse graded road side ditches.

For the purposes of the modelling analysis this is considered to be the end of the Skipper's Landing catchment area, anything further east is taken into consideration in the Island Pond Brook Catchment analysis.

Running the 100 Year climate change storms for the Skipper's Landing area, it is confirmed that there are a number of drainage issues associated with this area. The Skipper's Landing model shows that the cutoff ditch located at the rear of the adjacent homes on Skipper's Landing lacks the capacity to sufficiently convey storm runoff, particularly near the end of the ditch where the slope becomes very flat resulting in significant ponding of water which then flows onto the adjacent property. Previous surveys indicate that the basement elevations of these homes are actually lower than the cutoff ditch itself. This would cause ground water surrounding these homes to rise above their basement elevations resulting in flooding. Flooding in this area has been ongoing and this existing conditions model further supports what has been witnessed.. Upon leaving the immediate area of Skipper's Landing, the storm water is conveyed through a wooded marshy area. It then encounters a property located on Civic #30 Western Island Pond Road that is located in a depression in the topography. As a result, there is a significant buildup of runoff at this property that could potentially result in significant private property and infrastructure damage. The culverts crossing Western Island Pond Drive also appear to be under capacity and as a result, flooding occurs on this property. There is also overland flow across this portion of the street as shown in Figure 6 below.

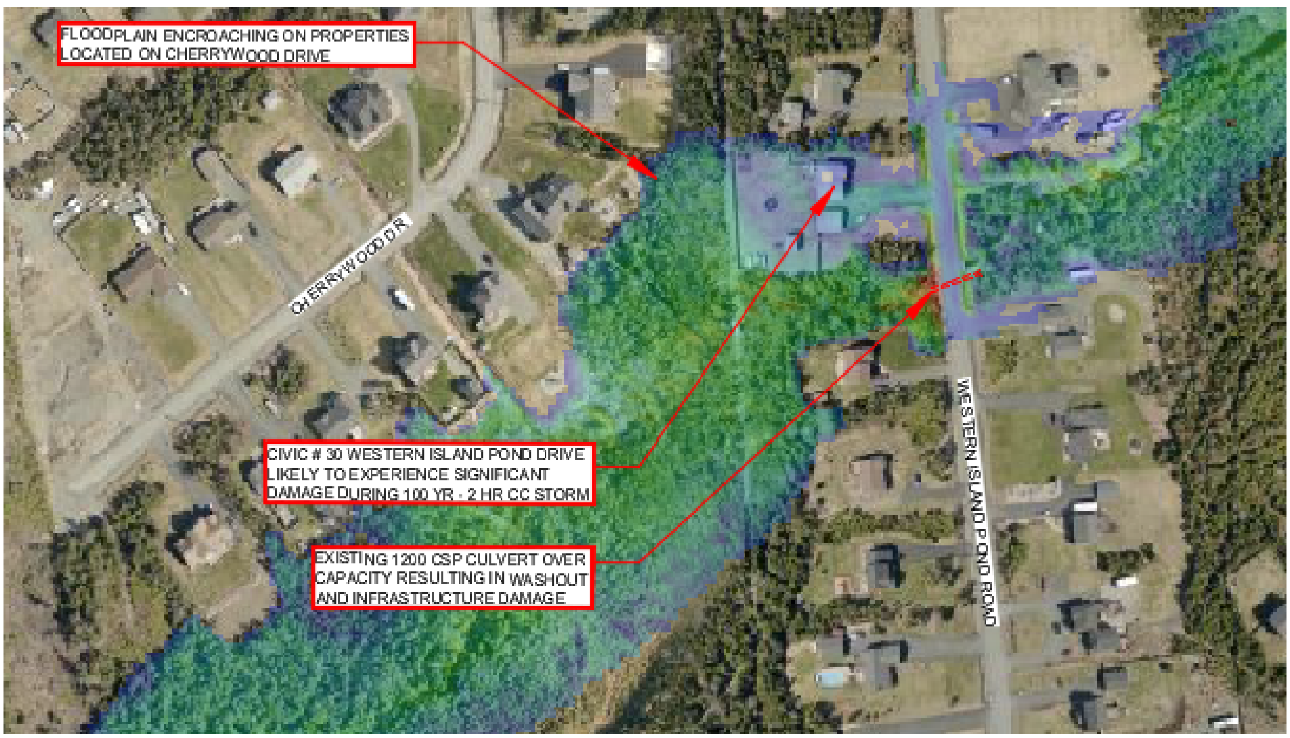

Figure 6: House Flooding on Civic #30 Western Island Pond Road Indicating Direction of Flow

It was also noted that several roadside ditches on Skipper's Landing are reverse graded, leading to ditches that are almost always partially full during rainfall events. During an extreme rainfall event, such as the climate change storms being modelled, some of these ditches become full and even convey runoff onto the adjacent asphalt. Several homes along this stretch of ditching have reported that they experience water in their basements during rainfall events. This could potentially be due to the depth of runoff in these ditches coupled with low basement elevations resulting in runoff being conveyed reversely through their weeping tiles and into their basements.

The high level of runoff saturating the surrounding soil which may raise the water table above their basements. Detailed topographic surveys of the finished floor elevations of these houses indicate that the basement elevations of certain homes are below the elevation of the road. The detailed surveys also suggests that the basement elevations of these homes are lower than the cutoff ditch behind them. Again, the water table could rise during a rainfall event and result in basement flooding for the adjacent homes

Analyzing the floodplains in Appendix E, it is evident that the 100 Yr – 12 Hr storm has the biggest impact on infrastructure. The twin culverts passing through Skipper's Landing and the larger culvert on Western Island Pond Drive are under capacity and flooding is observed on both of these streets. The cutoff ditch becomes full and significant overland flow and flooding can be observed on the properties on the western side of Skipper's Landing. The above issues can be observed in the figure below as well as Appendices E and F.

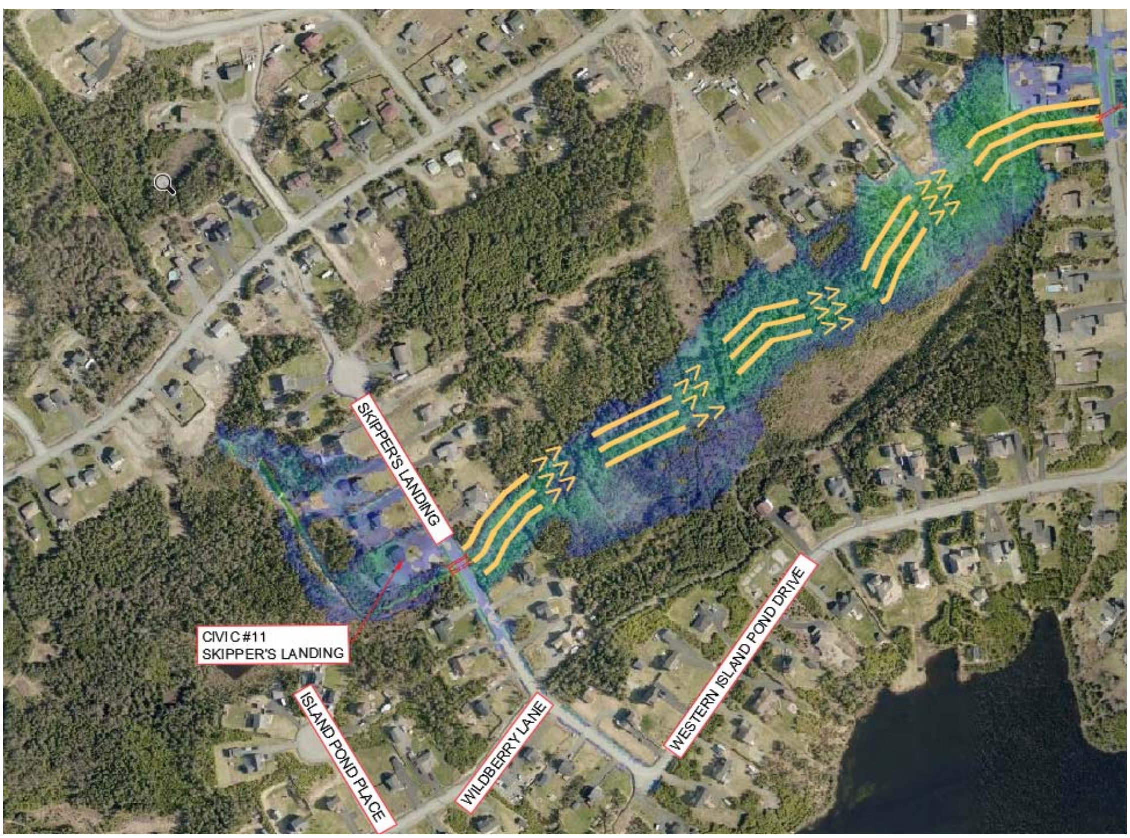

Figure 7: Skipper's Landing Floodplain 100 Yr - 12 Hr CC

These model results are not unlike what has been observed by residents and Town representatives. Specifically, Civic # 11 on Skipper's Landing has had severe drainage issues. The XPSWMM model under existing conditions shows that this residence is the first to experience overland flooding issues. Figure 8 is a photograph showing the amount of weeping tile and amount of runoff being carried away from the property during the May 30th 2018 rainstorm.

It is evident that this catchment area has a number of considerable drainage issues that are present under existing conditions.

Figure 8: Weeping Tile - Civic #11 Skippers Landing

2.2 Big River Catchment Area – Existing Conditions

The Big River catchment is one of the largest within the Town of Torbay. Consisting of several large bodies of water, such as Great Pond, Middle Three Island Pond, Axes Pond and so on. The catchment consists primarily of wooded and vegetative cover with very little hard surface/residential areas. Several natural rivers or streams convey runoff through the large catchment area. As a result there are number of pieces of key infrastructure located in this portion of the town, most notably is the concrete bridge structure located on Bauline Line as shown in Figure 9. Several smaller CSP culverts cross

Figure 9: Concrete Bridge Structure - Bauline Line

Bauline at low Points To convey runoff across the road. This structure has been upgraded in recent years and as a result is in good structural condition with little debris in the upstream and downstream inverts. Moving downstream of this bridge structure, the runoff passes through a 1400 and a 1000mm culvert which pass through Middle Three Island Pond Road, a gravel road with no residential or commercial areas nearby. There is also a large 2700mm diameter CSP culvert that conveys runoff from Great Pond and to the other side of Bauline Line. This structure can be observed in the Figure 10.

Figure 10: 2700 CSP - Bauline Line

Runoff from Great Pond passes adjacent to the newly developed “New Street” as listed in Appendices E and F

The majority of the runoff in this catchment is conveyed to a wooded/marshy area behind properties located on Bauline Line through several small culvert structures. That cross Bauline Line. From this marshy area, the runoff is conveyed through a massive structure, which measures approximately 6.7m x 4.6m on the Torbay Bypass Road and is then flows into the town of Flatrock

Figure 11: Large Culvert Structure - Torbay Bypass Road

Upon running the 100 year climate change storms for this catchment area it was evident that the majority of the infrastructure can handle the amount of runoff from these storms. The worst of these storms with regards to infrastructure damage is the 100 Year 6 hour storm. Shown in Appendix E is a map of the floodplain showing the extents of flooding under existing conditions. The culverts crossing the gravel Middle Three Island Pond Road are under capacity as well as the twin CSP culverts crossing Bauline Road near the soccer field and baseball field complex. One area of potential property damage that is observed in the floodplain of the 100 Year 6 hour storm is the newly constructed "New Street" For this particular storm event the storm runoff overtops the banks of the river located behind this property and passes onto some properties located on "New Street".

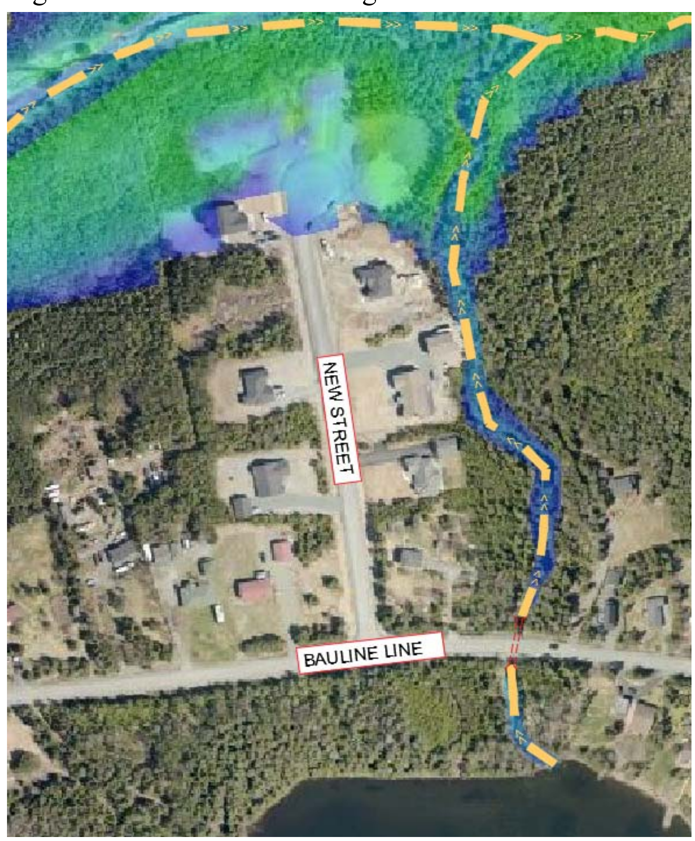

Figure 12: Flooding Observed on Middle Three Island Pond Road - 100 Yr - 24 Hr CC

On Middle Three Island Pond Road, there are two CSP culverts with diameters 1400mm and 1000mm CSP culverts that provide drainage between two marshy areas. These culverts are also under capacity during the 100 Yr – 24 Hr CC storm event. This would likely lead to a washout of this gravel road. The floodplain in this area can be seen in the Figure 13.

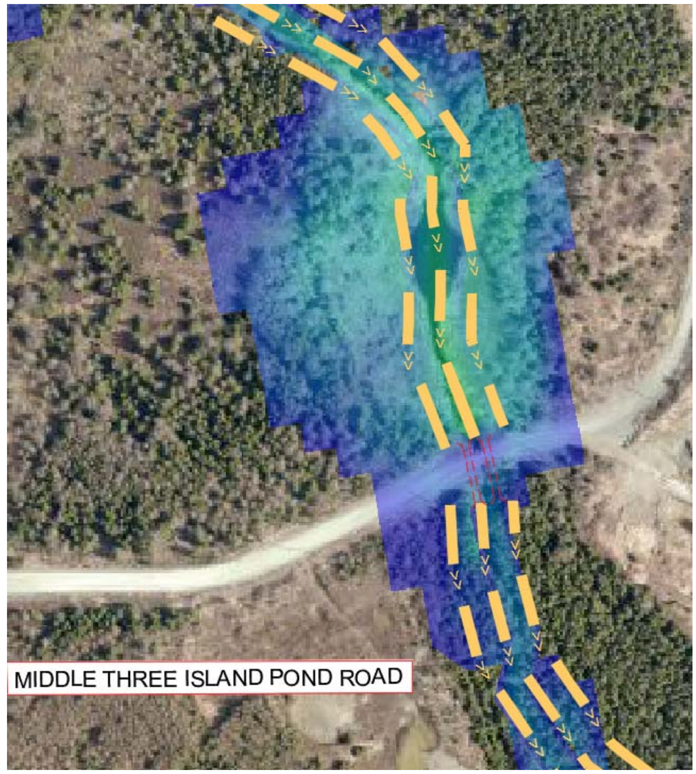

Figure 13: Flooding Occurring on 100 Yr – 6 Hr CC

Flooding also occurs at localized points along Bauline line where culverts crossing the street are under capacity. It is again important to recognize the severity of the storms being modelled.

The bridge structure on Bauline Line has lots of capacity during the 100 year 24 hour storm event.

This catchment area has several local problem areas but given that there is little residential development in this area that is heavily impacted by the observed floodplain, the consequences of failure are relatively minimal when compared to the rest of the catchments presented in this report. It is to be expected that under the new design storms, localized infrastructure will be under capacity as the intensity of these storms have not physically been observed to date in the Province.

2.3 Island Pond Brook Catchment - Existing Conditions

This catchment area was listed as an area of concern by Town representatives at the onset of the Torbay Stormwater Management Plan project. Not only does it technically include the Skipper's Landing area which has been discussed previously, it contains several other notable areas of concern. To accurately consider runoff from the Skipper's Landing catchment, runoff discharging through Western Island Pond road was taken into account in this model to simulate the influence Skipper's Landing has on the rest of the catchment area.

This is another large catchment area that encompasses a number of key pieces of infrastructure as well as several large bodies of water and contains the majority of the Town's residential area.

The catchment area extends to the Robins Pond area, which discharges through twin 900mm CSP culverts on Woodfine's lane and then through a 1600mm CSP culvert on Bauline Line, shown in the Figure 14.

Figure 14: Stream Approaching Capacity During Heavy Rainfall Event

Figure 15: Twin 900mm CSP Culverts – Woodfine's Lane

Further downstream, the runoff is conveyed through twin 1500mm CSP culverts crossing Rattling Brook Road and then through a large culvert structure passing through the Torbay Bypass Road

One notable area of concern is the home located on civic #20 Bridge Road. This property has had notable flooding issues in the past due to its proximity to the adjacent river system that conveys

Figure 16: Culvert Structures on Torbay Bypass Road and Rattling Brook Road

runoff from the rest of the catchment. The elevation of the home is very similar to the upstream elevation of the stream, meaning that if runoff should pass over the banks of the stream, a significant volume of runoff would likely pass onto the property and has in the past. Further downstream from this area, the runoff passes underneath a major bridge structure that crosses Torbay Road. This piece of infrastructure was observed to have a large amount of freeboard during the intense rainfall event in May of 2018

Figure 17: Bridge Structure - Torbay Road during May 30, 2018 Storm Event

Again, the 100 Year climate change storms were ran in the existing conditions model to examine worst case scenario flooding conditions. Several areas of concern were noted in the existing conditions models which correlated with some of the concerns the Town had previously expressed.

The most severe storm for this catchment area is the 100 year 2 hour storm. The floodplain for the large Island Pond Brook catchment can be observed in Appendix E One area of concern is in the area of Rattling Brook Road . Near the inlet of the twin 1500 CSP culverts on this street, the stream becomes very flat where the stream gives way to the roadside ditches on Rattling Brook Drive. As a result the runoff begins to pond near the culverts and is not being properly conveyed. Eventually the runoff begins to flow across the road. This is most significantly seen during the 100 year – 2 hour duration storm. This can be seen in the Figure 18.

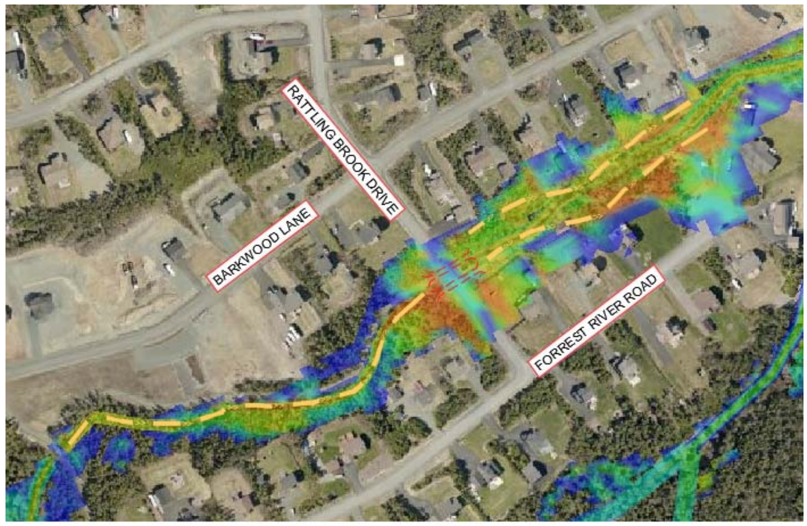

Figure 18: Flooding Occurring on Rattling Brook Road & Properties 100 Yr – 2 Hr CC

Further downstream, near the end of Forest River Road. There is a resident with a gazebo on their property and adjacent to their property is the river system which conveys runoff further downstream. There is a tremendous amount of overland flow occurring at this portion of the stream resulting in flooding occurring on many of the surrounding properties which

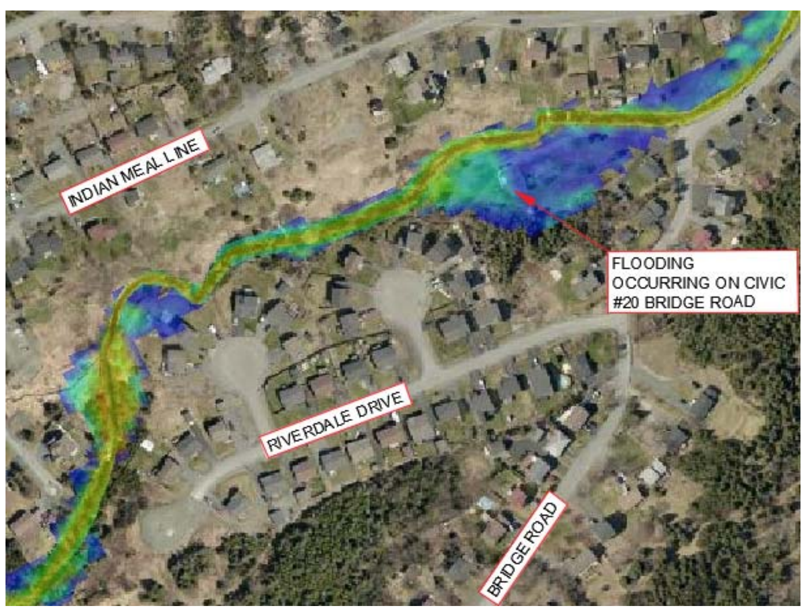

Figure 19: Flooding Occurring on Civic #20 Bridge Road 100 Yr – 2 Hr CC

can also be observed in Figure 19. At this point in the stream the slope and capacity of stream is too little and the flow begins to pass over its banks and make its way onto this property as well as some of the surrounding properties. The elevations taken from the LIDAR suggest that the homes near this stream are near the elevation of the stream.

There is also a property on Bridge Road that has had noted flood issues in the past. The 100 Year climate change storms suggests that this property will indeed experience significant flooding issues and potentially significant infrastructure damage. This can be observed in Figure 19. As described earlier in this section, the runoff passes the banks of the stream and due to little change of elevation, the runoff passes onto the property resulting in likely significant damage.

Not only does this property have numerous drainage issues that will likely result in significant damage, it is also the catchment that has a considerable area that is zoned for residential development, meaning the amount of runoff associated with this catchment will only increase in the years to come.

It was brought to PEC's attention that there is a local detention structure located in the area of Barkwood Lane. During a walkthrough under a separate project (PEC # 2018-010), the detention structure The inlet side of the storm detention system, has blasted rock placed in the ditch line and a headwall consisting of flat stones placed along the outlet side of the culvert.
These stones should be higher than the shouldering as the runoff from the asphalt is eroding the shouldering. Also, a solution of either extending the headwall or extending the riprap up the sides of the ditch should also be considered as the runoff from the street is eroding the shouldering is this area and depositing silt and sand in the inlet of the storm detention system.

Figure 20: Detention System - Barkwood Lane

2.4 Whiteway Pond Catchment – Existing Conditions

The Whiteway Pond Catchment captures runoff entering Whiteway Pond and the surrounding residential areas. There are two main stream systems. One that carries runoff away from Whiteway Pond and another that passes through a wooded area and discharges through a culvert near Hickey's Lane. The two streams eventually converge near an outfall into the Atlantic Ocean. There is a significant amount of residential development in this area as well.

The Torbay Bypass Road passes through the eastern portion of the Whiteway Pond and twin Culverts allow drainage between the two sides of the pond, if the level of the pond should reach a high elevation. There is a 2000mm CSP culvert and a 1000mm concrete culvert that allow drainage between both sides of the pond. From there, the runoff is conveyed through twin culverts crossing Country Drive.From Country Drive, twin culverts crossing Cannon Marsh Road convey runoff from the pond. From field inspection, it appears that a concrete barrier has compressed these culverts, reducing their capacity. This is difficult to model accurately, but it is assumed that the capacity of these culverts has been decreased. PEC recommends that the concrete barrier be removed from this area and that new culvert structures be implemented to allow for proper drainage, regardless of the results to be presented from the XPSWMM model.

Figure 21: Concrete Barrier Compressing Culverts - Cannon Marsh Road

Downstream from Cannon Marsh Road, the runoff is conveyed through twin culverts on Shea's Lane, which has had flooding issues in past storm events. The stream in this location has been widened and infrastructure crossing Shea's Lane has been replaced in the past. From here, the runoff spills over an embankment, and passes through twin 1200 CSP culverts on Moore's Valley Road, where the two streams previously mentioned converge.

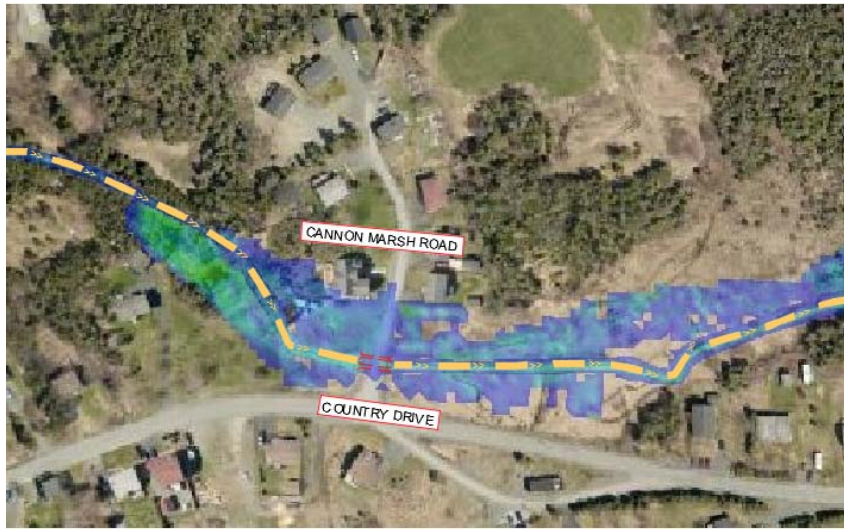

Figure 22: Resulting Flooding in the Cannon Marsh Road Area

The second stream mentioned previously passes through a 900mm CSP culvert which has been compressed at the intersection of Hickey's Lane and Country Drive.

In the Whiteway Pond catchment area there are several areas of concern upon running 100 year simulations. The worst observable storm that was modelled was the 100 year 24 hour storm. In particular, in the area of cannon marsh road, the natural stream becomes very flat and as a result the twin culverts crossing the road become overwhelmed and the model shows that there is currently flooding. This does not take into account that in the field, it was observed that a concrete barrier is compressing the outlet side of the culverts. This means that in a real world scenario, if the 100 year climate change storm were to occur, it most likely result in worse flooding than observed in the model. This is shown in Figure 22:

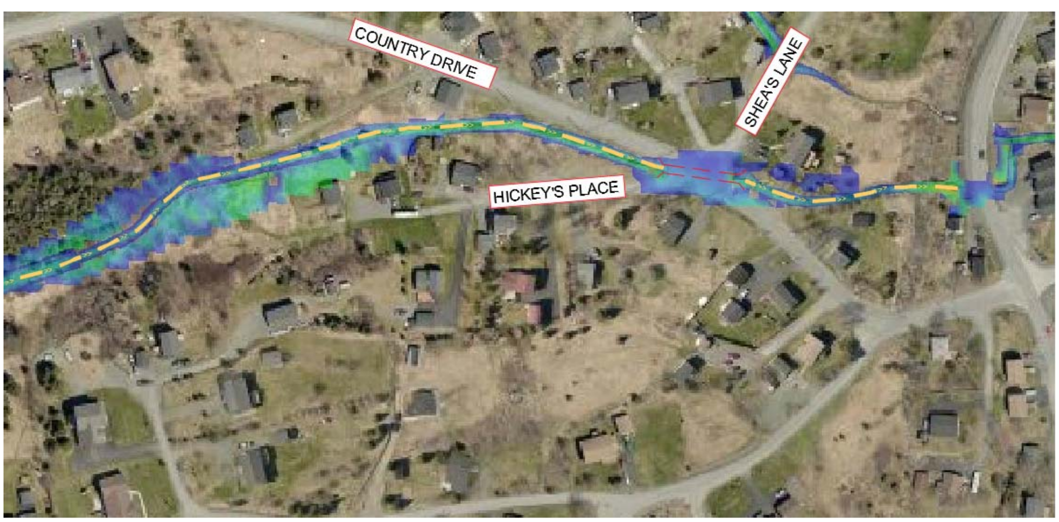

Figure 23: Flooding Occurring Near Hickey's Lane, Intersection of Country Drive/Hickey's Lane 100 Yr - 24 Hr CC

Further downstream in the area of Hickey's Place, several homes experience flooding due to runoff surpassing the banks of the adjacent natural stream. Due to the poor conveyance of the stream there is also some observable overland flow occurring at the intersection of Hickey's Lane and Country Drive.

It is also notable from the Figure 23 on the previous page that there is some overland land flow occurring at the intersection of Hickey's Lane and Country Drive.

Runoff leaving Whiteway Pond must pass through 600mm twin CSP culverts crossing country road. Running the 100 year climate change storms indicates that flooding will occur on this street during the 12 hour and 24 hour storm events. Directly downstream from Country Drive, the existing 1200mm CSP culvert on Russworthy Place is also under capacity resulting in flooding.

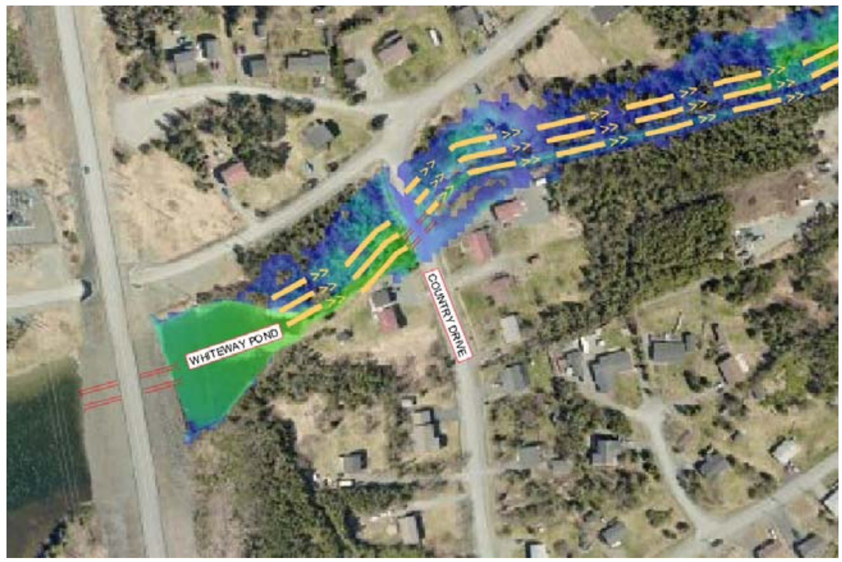

Figure 24: Twin Culverts - Country Drive Under Capacity

The floodplain in this area for the 24 hour storm event can be seen in Appendix E.

2.5 Watt's Pond Catchment – Existing Conditions

The Watt's Pond catchment area has been an area of concern for the Town of Torbay in the past, particularly in the area of Anstey's Cove Lane. A previous flood analysis of this area was completed in 2014 by Progressive Engineering & Consulting Inc. and out of that study it was recommended that an earth berm be constructed in the area to prevent flooding in this area. This catchment area includes the newly constructed Juniper Ridge Intermediate school. This catchment is one of the smallest catchments within the Town that consists primarily of residential areas, some forested areas as well as two major bodies of water; Watt's Pond and Withrod Pond.

Figure 25: Triple 600mm CSP Culverts on Crowe's Lane

The catchment captures runoff from Withrod Pond as well as Watt's Pond. The runoff from Withrod Pond is conveyed through adjacent marshy areas on either side of Crowe's Lane through four CSP culverts. Three of them being 600mm in diameter while the other is 900mm in diameter. The marshy area to the north east of Crowe's Lane feeds into Watt's Pond. The implementation of four culverts in this area indicates that there have been drainage issues in the past and these issues still exist. This road has washed out in the past.

After release of the 2014 Watt's Pond Flood Analysis report, a berm was constructed in the area and so far has worked adequately to prevent flooding in the area. It is important to note that at the time of the 2014 modelling analysis, the conventional 100 year storms were used to perform the modelling and as the basis for recommendation. In this report it was suggested that the existing storm sewer infrastructure (pipes, catch basins, etc) were very near capacity. By using the updated storms, it is clear that this infrastructure will be under capacity resulting in flooding.

When modelling the updated climate change storms it appears that there still exists the potential for flooding in this area. Runoff appears to be passing behind the berm and then accessing Anstey's Cove Lane and causing major flooding in that particular area. The stream located downstream has sufficient capacity to carry the amount of runoff from these major storm events, but according to the model it is not properly receiving the runoff because of issues upstream. This flooding can be observed in the Figure 26

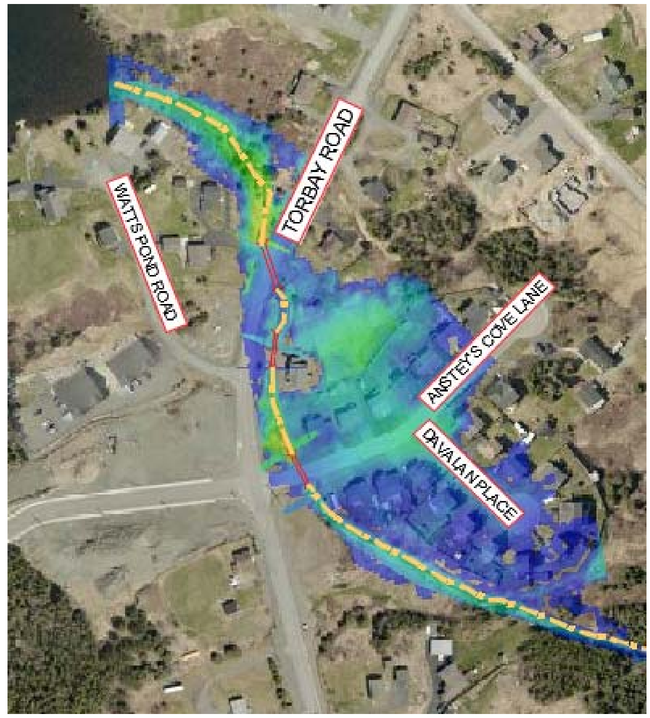

Figure 26: Flooding in the Anstey's Cove Lane Area 100 Yr - 24 Hr CC

The area of Crowe's Lane area also has some flooding issues that are observed in the three culverts of diameter 600mm and fourth culvert of diameter 900mm were implemented to provide proper drainage between two wetland areas. Running the 100 year climate change storms indicates that if this particular storm event were to occur another washout may occur as all four pieces of infrastructure are under capacity and unable to handle the amount of runoff it is receiving. This can be seen in the Figure 27

Figure 27: Flooding Occurring on Crowe's Lane 100 Yr - 24 Hr CC

2.6 Kennedy's Brook Catchment – Existing Conditions

This catchment primarily consists of newly constructed residential areas and little wooded/vegetative cover being present. The catchment extends as far south as St. John's International Airport. As a result this catchment overall is highly impervious. There are two major pieces of storm infrastructure in this catchment area. Both of these are large CSP culverts which cross Torbay road near Jack Byrne Arena. There is also a small detention pond structure at the rear of Jack Byrne arena which captures runoff from the parking lot of the arena and a drainage channel at the rear of the building. but the LIDAR data provided to PEC did not include data in this area.

Figure 28: 2000mm CSP Culvert - Torbay Road

The runoff from this catchment area meanders through the residential area of Karon Drive and Pine Ridge crescent, crossing streets through local culvert structures. This runoff is conveyed across a 2000mm CSP culvert on Torbay Road, shown in Figure 28. Upstream from this large CSP culvert, a 900mm culvert crosses Rosebud Street which appears to be partially compressed by a large rock, shown in Figure 29. This will reduce the capacity of the culvert and should be removed and the existing culvert should be replaced according to the recommendations made later in this report.

Figure 29: Rock Compressing Culvert - Rosebud Street

The floodplain for the Kennedy's Brook Catchment can be observed in Appendix E

Upon running the 100 Year climate change storms there was little observable overland flooding. On both Karon Drive and Pine Ridge Crescent there is some overland flow occurring across the streets due to roadside ditches being at capacity. There were some occasions where the streams experienced water overtopping their banks, but this was primarily in non-residential area so no property damage would occur.

Similar to the Big River Catchment, local structures are over capcity during the 100 year 2 hour storm event. This is to be expected given

Figure 5: Kennedy's Brook Catchment Area Floodplain

the severity of the storm. One area of concern is at the location of the 900mm culvert crossing Rosebud Street. The stream has runoff passing over it's banks and the culvert itself is under capacity. As a result overland flow occurs on civic # 29 Cordelia Crescent as well as the playground on Rosebud Street. This can be seen in Figure 30.

Given that this culvert should be replaced based on structural inspection, modification to the stream and infrastructure in this area could help mitigate this flooding issue.

3.0 Existing Conditions – Future Development

The previous section of the report presented an analysis of the current floodplain within the town under current landuse and current infrastructure. The Town of Torbay has seen recent subdivision developments in past years and future development will take place. As a result, it is important to note that a direct result of this increased development is increased volumes and flow rates of runoff. Given that there are currently issues with the existing conditions models whereby future development is not considered, it is expected that the current floodplains and stream water issues will worsen future development occurs.

PEC utilized the Town of Torbay's zoning map to approximate the areas of future development. Land uses within the model were updated and increased percent impervious coefficients were applied to relevant portions of the catchment area.

As expected, for all of the problem areas noted in the previous existing conditions model, the extents of flooding only worsen under increased development. This can be observed in the floodplain appendices located in Appendix F. A map of the Town's zoning areas can be observed in Appendix J.

These results will then set the stage for setting remedial actions and the placement of regional detention to accommodate future development. Proposed remedial upgrades, more specifically detention systems should not only address existing issues but be able to account for the increased amount of runoff as a result of future development.

The following discusses the expected future development within each of the Town's catchment areas and presents areas that are likely to see future development which may heavily impact the Town's infrastructure in the years to come followed by a brief discussion on how this impacts the modelling process.

3.1 Skipper's Landing – Future Development

Given the results of the existing conditions model for this catchment area, it is obvious that there are currently drainage issues. From reviewing zoning maps of the Town in this area, it is evident that future expansion is likely to take place on Cherrywood Drive as well as to the north in the vicinity of Eagle Ridge Drive and Flora Drive, all of which currently fall into the catchment area associated with Skipper's Landing. This can be seen in the zoning map Appendix in Appendix J. The XPSWMM model, which was updated to take into consideration this future expansion shows increased flooding in the areas described in the previous section. Notably, the amount of runoff in the marshy area to the north east of Skipper's Landing is further saturated with runoff resulting in increased overland flow onto the properties along Cherrywood Drive and results in significantly deeper water depths on Civic #30 Western Island Pond Drive.

Not only will this development impact the immediate area of Skipper's Landing but it will impact and further influence issues that currently exist in the Island Pond Brook Catchment.

3.2 Island Pond Brook – Future Development

Island Pond Brook is another catchment area which has shown some issues under existing conditions. Analyzing the zoning within this region, it is evident that future expansion may be seen experienced in a couple of areas. First, a large residential lot is planned south east of Cedarwood Lane. In the future, a potential residential subdivision area could be placed south of Forest River Road. The majority of the planned development in this portion of Town is likely to take place to the West of the Torbay Bypass Road.

The Town will require construction of a local detention pond for the subdivision development to take place off Forest River Road, which will detain runoff from that area specifically. This will help reduce the impacts downstream, however it only accounts for runoff included in this new development, which bypasses the stream adjacent to Forrest River road.

Under future conditions the amount of runoff downstream will increase tremendously. This will impact the existing issues present on Rattling Brook Drive and on Forest River Road. Without any infrastructure upgrades or form of detention the flooding conditions for Civic # 2 Bridge road can be expected to happen much more frequently and with more severe consequences.

3.3 Big River Catchment – Future Development

The Big River Catchment is the catchment with the least expected amount of expansion. The majority of the catchment area falls into the watershed of Great Pond or is zoned as open recreational space. There is an area off Bauline Line that is zoned as a Residential Large Lot. As a result this portion of the catchment was adjusted accordingly. As expected there is little difference between the existing conditions model and the model presented in this section for this catchment area.

This development will impact downstream infrastructure, specifically the culverts crossing low points along Bauline Line. However, the majority of this catchment is to the North of the residential area where rivers and streams converge and convey the runoff to the Town of Flatrock. If future development is to take place, it’s potential impact on downstream infrastructure within the Town of Flatrock should be looked at closely to ensure significant flooding does not occur. If significant issues are identified there is a tremendous amount of space for the implementation of detention ponds to the North of Bauline Line to help reduce the amount of runoff associated with these future developments. Future development would likely result in upsizing local culverts crossing Bauline line to ensure that they properly provide drainage between the two adjacent marsh areas.

3.4 Watt's Pond Catchment – Future Development

This catchment area along with Skipper's Landing were two catchments that have had visibile, reported issues with flooding under existing conditions in the past. The existing conditions models of these areas presented earlier confirmed these issues. The Watt's Pond catchment is relatively small when compared to the rest of the catchments within the Town. There are however a couple areas of notable potential locations for future residential areas. The first being to the west of Withrod Pond and the other surrounding Watts Pond near the newly constructed Juniper Ridge Intermediate School.

Given the extremity of the flooding conditions observed in the existing conditions model, it is obvious that special attention should be given to this catchment, along with Skipper's Landing to try and mitigate some of the issues associated with runoff drainage prior to commencing future development. By increasing development upstream of the Anstey's Cove Lane area, detrimental flooding conditions could occur during heavy rainfall.

3.5 Whiteway Pond – Future Development

The Whiteway Pond area has some issues under existing conditions as well. The zoning shows areas of potential development in this area, which will further strain existing storm sewer infrastructure within the catchment. There is an area currently zoned within this catchment as a residential subdivision area. The current floodplain under existing conditions shows significant overland flow resulting from a low capacity stream weaving through the area, shown in Figure 31.

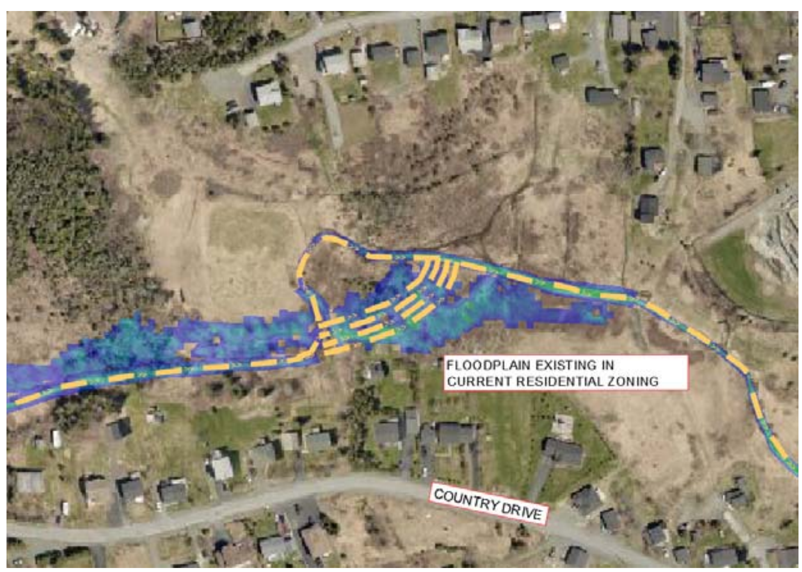

Figure 31: Floodplain In Potential Development Area

Given the existing elevations and floodplain shown on the previous page, it is recommended that development not take place in this area as it is prone to flood issues.

3.6 Kennedy's Brook – Future Development

This catchment had the fewest amount of notable infrastructure issues and overland flow problems. The existing conditions model showed a couple of instances where infrastructure was under capacity for the most severe storms.

Reviewing the Town's zoning map for this area indicates that there is a large area north of St. John's International Airport and south of Kelly's Lane that is zoned for a comprehensive industrial area. This means that if this area was fully built out to an industrial area it would tremendously increase the amount of runoff in this catchment. This could significantly impact infrastructure down stream in the town of Middle Cove – Outer Cove.

For modelling purposes in this report it is assumed that all of the runoff associated with a future industrial park would drain into existing infrastructure within the catchment, therefore increasing the overall percent impervious value associated with the catchment. Since it is zoned as a commercial/industrial area, it will impact the percent coefficient of the model more significantly than residential developments as the amount of hard surfaces is likely to be higher.

4.0 Upgraded Conditions Models

The following sections will discuss the development of upgraded conditions models. The purpose of these models is to propose remedial actions that will mitigate issues that are presented in the existing conditions model. With future developments expected to take place in the town it is important to take into consideration the effects of possible expansion of residential and industrial areas in the town. This would result in higher volumes of runoff in the town due to increased amount of hard impervious surfaces. The upgraded conditions models will use a higher percent impervious coefficient value to reflect the potential scenario for future runoff. Based on these conditions, remedial actions and concepts are proposed to help the Town make educated decisions regarding flood prevention and storm water detention to accommodate future development. These computations were completed by using the Connect Explorer application and observing the Town's zoning limits to help predict possible residential and industrial expansion in the town.

When analyzing existing infrastructure, if that particular piece of infrastructure is under capacity and overland flow is observed in the models, an analysis of the consequence of failure was completed. This means that if a particular piece of infrastructure is under capacity for the worst of the 100 year return period rainfall events, the resulting impacts downstream were observed. Generally, when a piece of infrastructure is under capacity it results in tremendous overland flow which could lead to road washouts and significant damage to nearby homes. If this is the case then a recommendation is made to replace and upsize this piece of infrastructure as the cost of doing so would be significantly less than the cost associated with damages caused by flooding in the area.

4.1 Suggested Remedial Actions

In the previous sections of this report, existing issues regarding the Town's storm sewer drainage system were outlined. The following sections address these issues and provide mitigation measures to help prevent flooding from occurring. Attached in the appendices are detailed concept drawings for the proposed remedial works and detention ponds as well as cost estimates of the remedial actions proposed for each catchment.

4.1.1 Big River Catchment

As mentioned previously, the natural stream flowing adjacent to the newly developed "New Street" tops its banks and appears to flow onto the new subdivision An earth berm could be constructed to properly prevent this from happening. The berm will essentially confine the flow to the stream and the surrounding wooded area instead of posing a threat to the surrounding properties.

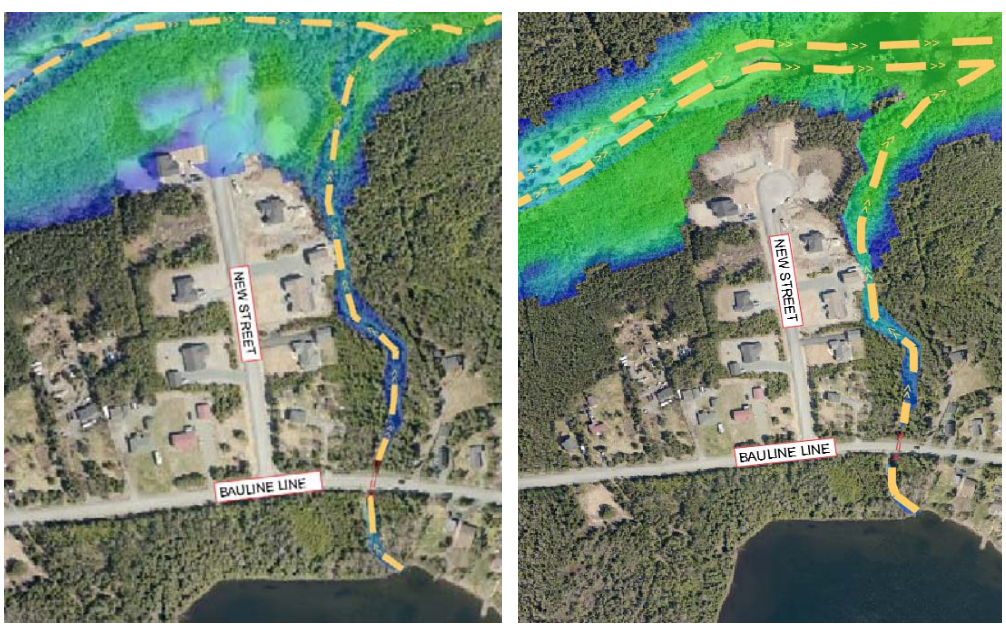

Figure 32: Forrest River Road Before Upgrades vs Forrest River Road After Upgrades

The berm was modelled in the XPSWMM software and the new floodplain for “New Street” can be seen in the Figure 32. This berm should be at least 3 m in height with side slopes at 2 to 1. A cross-section of this berm can be seen in the concept drawing included in Appendix G.

There is potential for residential development in the Pinch Creek Place area of the Town. Accounting for this increase in runoff, there appears to be an increased amount overland flow. To account for this, the stream should be modified to have the following cross-section when such development is to take place.

This new channel has a bottom width of 1m, a height of 1m and side slopes of 2 to 1. This cross-section allows for better drainage and reduces overland flow and properly routes runoff through the existing infrastructure, preventing flooding.

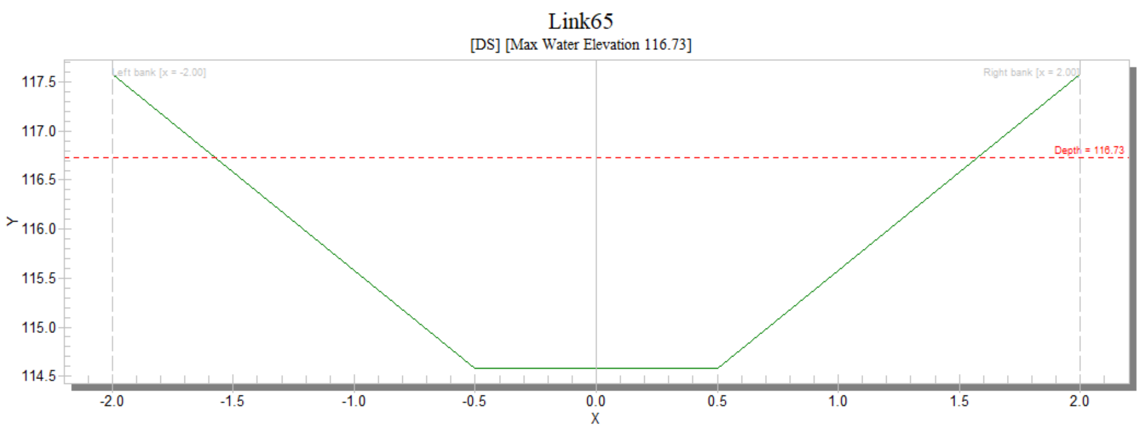

Figure 33: New Cross-Section

As mentioned previously, the twin 1000mm on Middle Three Island Pond Road are under capacity which would likely lead to a washout of the gravel road. However, the consequence of failure in this instance is fairly low due to the fact that there is little to no infrastructure in the immediate area. As a result the culvert was modelled using the 25 year design storms, which are typically used when sizing culverts. The 25 Year design storms showed that these culverts sufficiently convey runoff without any overland flow or flooding. As a result it is not pertinent to replace this piece of infrastructure and will not be included in cost estimates included later in this report.

Culverts crossing low-points along Bauline Line should be upsized in the event of a major storm event such as the ones modelled in this report. The consequence of failure in this instance could result in multiple road washouts and potential property damage near by. The twin culverts crossing near the local soccer field could be upsized to 1200mm CSP culverts and the 2000mm

CSP culvert near 441 Bauline line can be upsized to a 2000mm CSP culvert. These upgrades will be included in the estimate attached in Appendix I

The full effect of these mitigations can be observed in the upgraded conditions floodplain drawings in Appendix G

4.1.2 Whiteway Pond Catchment

In this catchment there are areas where natural streams that convey runoff out of the catchment are too shallow or too flat and as a result some overland flow occurs. The simplest and most cost effective method of mitigating this issue is to strategically place earth berms at points along the stream which are showing cases of overland flooding. This will help confine the runoff to these streams and allow for proper drainage, mitigating the risk of infrastructure damage from occurring due overland flow routing. Earth berms should be placed along the shore of Whiteway Pond and down the stream prior to Country Drive to provide proper drainage.

The twin culverts at Country Drive are under capacity resulting in significant overland flow which would potentially result in that portion of the road being washed out as well as infrastructure damage to the surrounding homes. This can be seen on drawing in Appendix E. The new 800 CSP culverts combined with the berms upstream would provide proper drainage from the pond while preventing infrastructure damage in the area. These culverts can be seen in the figure below, at capacity during the worst storm event.

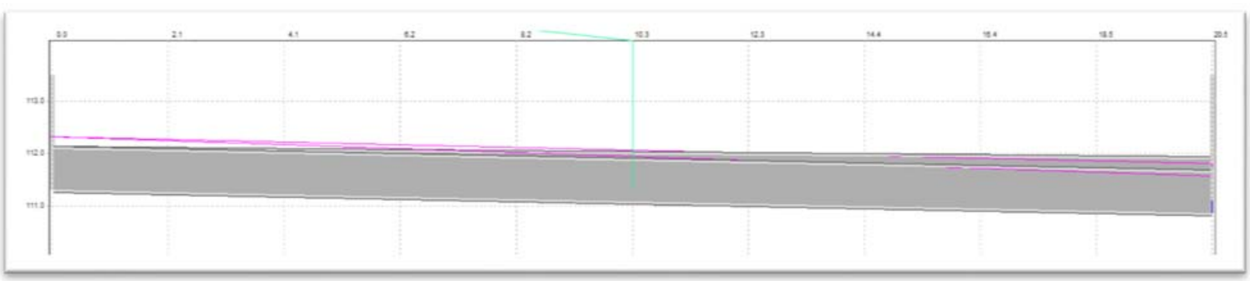

Figure 34: Twin 800 CSP Culverts - Country Drive

`Shown below is the before and after comparison of flood limits when these upsized culverts were ran in the models, note that the overland flow on Country Drive and surrounding properties is essentially eliminated from the placement of Earth Berms and the upsized culverts.

Downstream from Country Drive, the next major piece of infrastructure in this catchment is the 1200 CSP culvert on Russworthy Drive. Upstream of this culvert, in the previous models, the stream conveying runoff to the culverts inlet is under capacity resulting in overland flow. As a result, earth berms should be constructed to allow proper drainage and to ensure the runoff is properly fed through the 1200 CSP culvert. During the 100 Year – 24 Hour duration storm event, this structure appears to have sufficient capacity to convey runoff and no infrastructure damage is expected.

Figure 35: Country Drive Before Upgrades vs Country Drive After

Moving downstream from Russworthy Drive, the compressed twin culverts on Cannon Marsh are the next major piece of infrastructure. Both the models, taking into account future development and not taking into account future development, show significant overland flooding and infrastructure damage in this area under the 100 year 24 hour storm event. Given the structural condition of these culverts and the potential of flooding in the area if such a rainfall event should occur, the concrete barrier should be removed and these culverts should be replaced and upsized as soon as possible. An earth berm should be placed on both sides of the upstream side of the stream to confine the runoff to the existing stream to assist with routing runoff. This earth berm should be constructed with a height of 1.2m with side slopes of 2 to 1.

Given the significance of infrastructure damage if this event were to occur, it is recommended that these twin 600mm CSP culverts be replaced with twin 800 CSP culverts. Shown below is a before and after figure showing the extents of flooding prior to replacing these damaged culverts and no modifications to the existing stream.

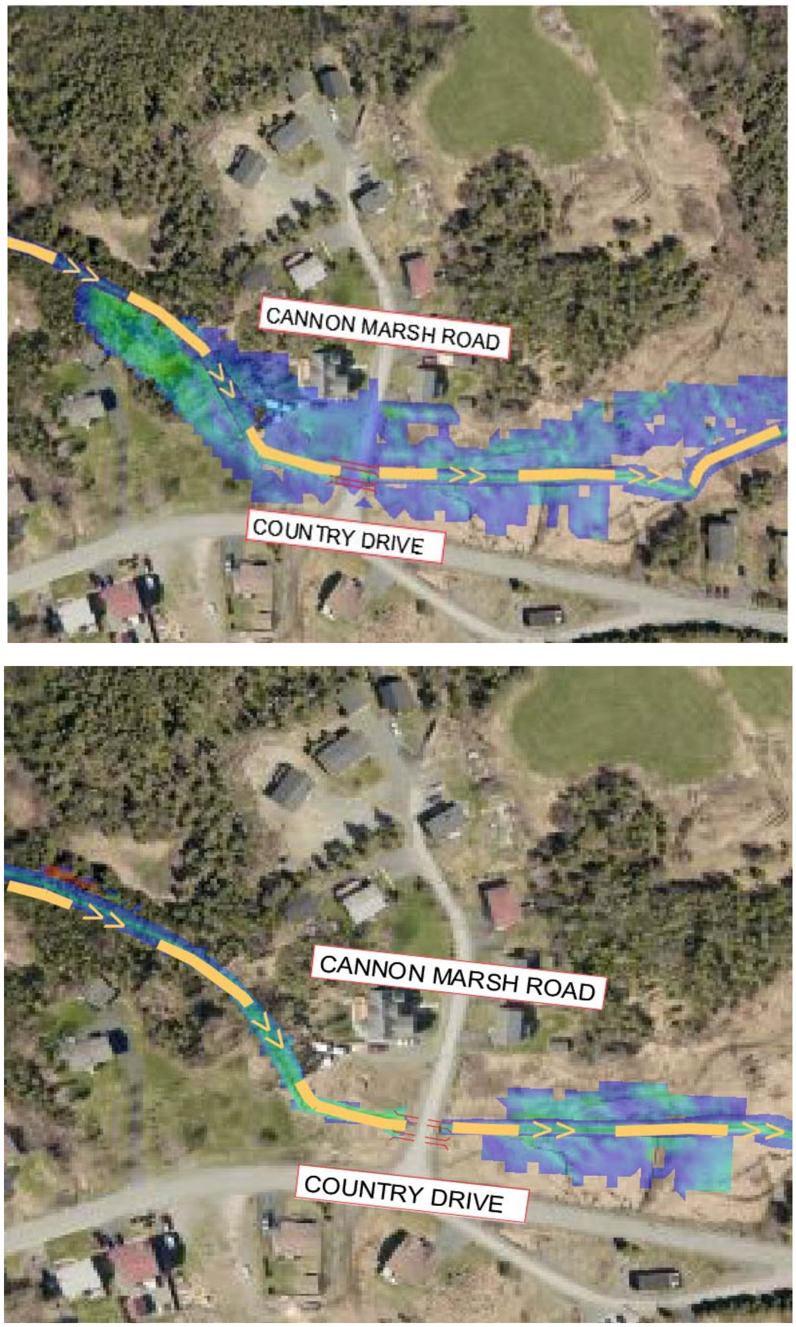

Figure 36: Cannon Marsh Road Before Upgrades vs Cannon Marsh Road After Upgrades

In the area of Hickey's Lane, the natural stream passing adjacent to Hickey's Lane appears to be at capacity and overland flow can be observed on the properties of nearby homes. The low capacity of this natural stream also allows poor conveyance through the existing 900mm CSP culvert, resulting in a potential washout in this intersection. By constructing a berm along the stream it confines the flow to the stream itself preventing overland flow and allowing for proper drainage through the 900mm CSP culvert, preventing property and infrastructure damage and prevents having to replace the existing culvert. This berm should be constructed at a minimum height of 1.2m with side slopes of 2 to 1.

Figure 37: Hickey's Lane Intersection Before Upgrades vs Hickey's Lane Intersection After Upgrades

The combination of the earth berms and upgraded infrastructure will help mitigate the potential for flood issues in the Whiteway Pond catchment, which can be observed in the upgraded floodplains in Appendix H

4.1.3 Skippers Landing Catchment

This catchment requires significant remedial action to mitigate potential flooding issues that have been well documented in this area. In a previous project PEC proposed to mitigate these flooding issues by altering the drainage channel at the rear of Skipper's Landing to allow for greater capacity as well as lowering the ditch below the basement elevations of the homes adjacent to the cutoff ditch. The alterations to the cutoff ditch include deepening and widening as observed in Appendix G. This will allow for additional capacity in the ditch and help prevent saturation of the adjacent soil. The proposed upgrades suggested by PEC also provides details on updating the presence of reverse graded roadside ditches to ensure proper drainage out of the area. This can be seen in greater detail in Appendix G. This will help prevent ditches from filling or remaining partially full after a rain event and prevent any backflow through weeping tiles or raising the water table in the area. These upgraded conditions can be observed in Appendix H To further prevent overland flow from the cutoff ditch at the rear of the properties, an earth berm could be constructed along the perimeter of the ditch to prevent flow from passing onto the adjacent properties in the event that the water levels should surpass the banks of the stream. The

Figure 38: Skipper's Landing Before Upgrade

Figure 39: Skipper's Landing After Upgrade

before and after floodplains for the 100 year 2 hour storm event can be seen in the Figures 38 and 39. Note the dramatic decrease in overland flow from both the cutoff ditch as well as the roadside ditches. The large detention pond structure helps reduce flow in the downstream marshy area. As well as preventing overland flow at the rear of homes on the eastern side of Skipper's Landing.

Building upon these previous recommendations, to help reduce flows downstream and to reduce ponding in the wooded/marshy area to the north east of Skippers Landing, a detention pond could be constructed to help detain some of the runoff that would occur during a heavy rainfall event. It is important to construct this detention pond structure to ensure that peak water levels are beneath the finished floor elevations of any houses in the area in the event that the water within the detention pond structure should reach an elevation high enough to saturate the surrounding soil which could possibly lead to basement flooding. To ensure a proper concept design, PEC conducted a detailed topographic survey to note the basement elevations of houses surrounding the proposed area. The detention pond must be able to accommodate the existing flood conditions associated with the most severe 100 year climate change storm as well as accounting for future development that may feed into the area. To ensure water levels are kept below basement elevations of surrounding homes, the detention pond has been divided into three main detention areas.

Prior to runoff entering the detention pond, there is currently a 600mm CSP culvert as well as 700mm CSP Culvert that convey runoff from the cutoff ditch at the rear of the homes to the marshy area to the east of Skipper's Landing. It is recommended that these culverts be upsized to twin 1400mm CSP culverts to properly provide drainage away from the area as the 100 year models show that these existing culverts are undersized. Bermed along the perimeter of the detention zone, the first area extends into the marshy area to the north east of Skipper's Landing. Gradually, excavation should occur as shown in the concept drawings to a depth of approximately 1m. A berm is placed along with an outlet control structure which passes flow onto the next detention zone. The second zone is a smaller detention zone which has been excavated by approximately 1.5m. A second berm is placed along with a second outlet control structure. From here the flow is passed onto the existing marsh land where berms along the surrounding property lines properly route flow through the existing 1200 CSP culver on Western Island Pond Road. For further clarity on this concept see the drawing attached in Appendix G

To prevent overland flow issues in this area, earth berms can be constructed along the property lines of homes on Cherrywood Drive and Western Island Pond Drive. The detention pond reduces runoff enough to prevent excessive water depths in these areas, meaning basement flooding is not an issue.

In the original models, the existing 1200 CSP culvert crossing Western Island Pond Drive was shown to be under capacity during the 100 year storm event. With the implementation of the detention pond, run off is detained and released more slowly, thereby reducing the volume of runoff significantly to ensure that the amount of infrastructure upgrades downstream is kept to a minimum. The new detention pond ensures that the existing 1200 CSP culvert crossing Western Island Pond Drive is at capacity, but not experiencing flooding during the worst storm event. The combination of the detention pond, placement of earth berms, alterations made to cutoff ditch and roadside ditches and infrastructure upgrades upstream prevent flooding from occurring on Skipper's Landing and at civic #30 Western Island Pond Drive.

4.1.4 Island Pond Brook Catchment

Building upon the problem areas presented in the previous two sections and the proposed infrastructure upgrades., there are several notable areas of concern within this catchment under existing conditions as well as residential expansion.

In series with the proposed detention pond structure discussed in the Skipper's Landing section, there is potential to develop a small area of detention by widening a small body of water to the east of Western Island Pond Drive.

This will provide some natural detention and help reduce flooding shown on Rattling Brook Road and Forrest River Road. Further downstream, just prior to the Torbay Bypass Road, a large detention pond structure could be implemented to prevent flooding downstream as well as accommodating future development upstream.

However, topographic survey of the surrounding homes suggests that the basement elevations of homes on the nearby cul-de-sac are very close to the top water elevation of the gully area adjacent to them. As a result very little storage volume for detention is available in this area. As a result to prevent flooding issues downstream there will need to be significant infrastructure upgrades and placement of earth berms along Island Pond Brook to prevent flooding issues present on Rattling Brook Drive and Forrest River Road.

As noted, there is considerable overland flow in the Rattling Brook Road/Forrest River Road area. This is due to the low capacity of the stream that conveys runoff from the area and the twin 1500mm CSP culverts are under capacity. This results in immediate flooding on Rattling Brook Road and could potentially lead to a washout. As a result it is recommended that berms should be

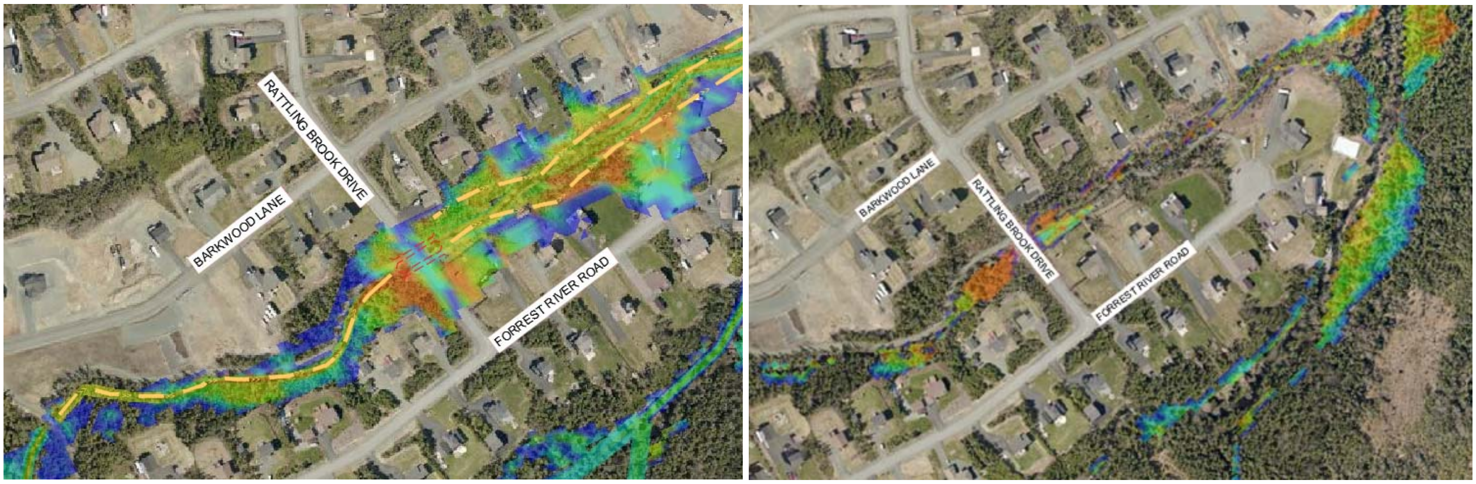

Figure 40: 100 Year 2 Hour Floodplain Before Upgrades vs After Upgrades

place on either side of the inlet and outlet portions of the streams to confine the runoff to the stream itself and to prevent runoff from spilling the banks of the stream. To ensure proper runoff it is also recommended that the twin 1500 mm CSP culverts be upgraded to twin 2000mm culverts. The consequence of failure in this scenario is severe as a road washout is likely as well as significant property damage. Further downstream, earth berms should be constructed on either side of the stream to prevent overland flow passing onto the end of Forrest River Road, causing further property and infrastructure damage. Shown on figure 40 is a before and after figure of the floodplain in the immediate area, showing that the remedial actions suggested will help prevent flooding issues should the 100 year storm event occur.

The upgraded twin 2000mm CSP are at capacity during the 100 year 2 hour storm event which can be seen in the profile below.

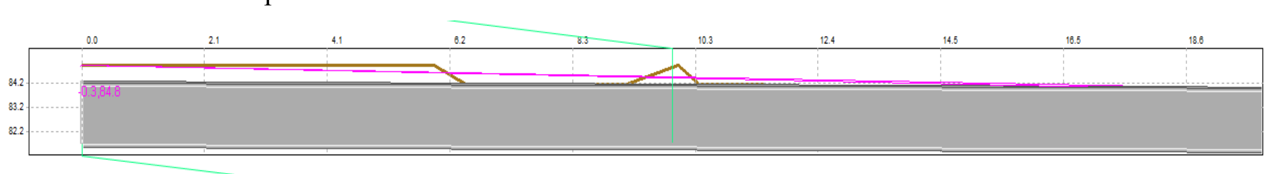

Figure 41: Twin 2000mm CSP Culverts at Capacity During 100 Year 2 Hour Climate Change Storm Event

Further downstream, there is the issue of the resident living on Bridge Road. With planned residential development upstream of this area, the amount of runoff entering this stream will only increase. A detention pond structure upstream would be ideal to capture this increase in runoff and discharge it at a rate that the downstream infrastructure can sufficiently handle. Given that the existing stream is flat and small in terms of capacity, some stream modification will have to take place in conjunction with the detention pond structure proposed. It is recommended that the northern side of the bank be widened by approximately 5m and deepend by approximately 1m as shown in the concept drawing attached in Appendix G.This allows for better drainage and will help route runoff away from the property. By widening the stream in this area in conjunction with the detention pond upstream, it allows for the runoff to be properly conveyed and prevents overland flooding issues in the area.

An ideal placement of a detention pond would be upstream on the western side of the Torbay Bypass Road, as shown in figure 43.There is a significant amount of land in this area that is not currently zoned for development.

An outlet control structure will permit enough flow to leave the detention pond during the 100 year 2 hour storm event such that the stream modified to the north east as well as the bridge `structure on Torbay road are not compromised. The bridge structure on Torbay Road has a lot of capacity and freeboard is not an issue during the 100 year storm events.

An earth berm can be constructed with a minimum height of approximately 5.5 m can be

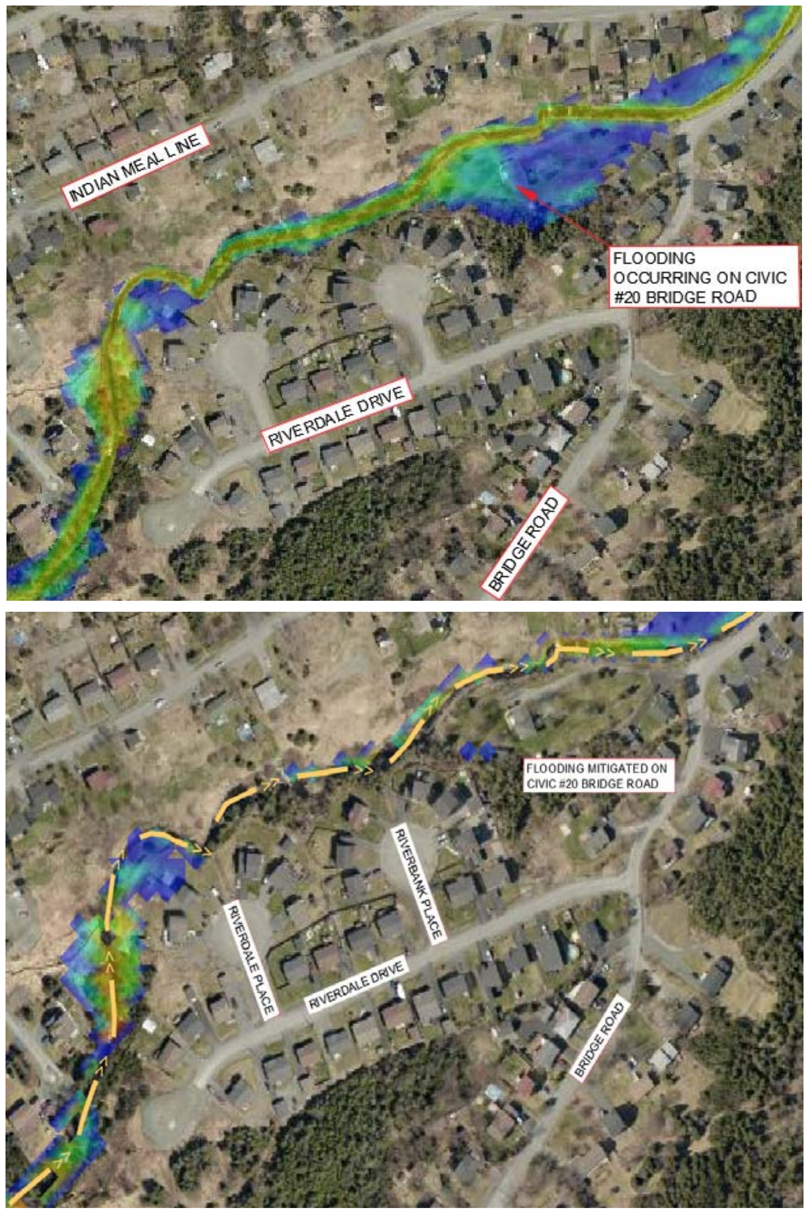

Figure 42: Bridge Road Before Upgrades vs Bridge Road After Upgrades

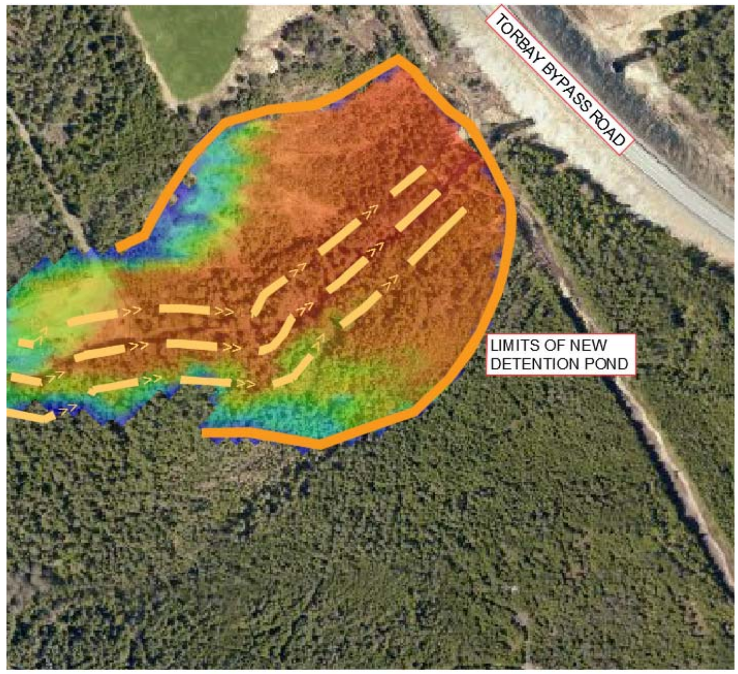

Figure 43: Potential Location for Detention Pond

constructed along the footprint shown to capture runoff from the developed areas upstream. As water levels rise to the outlet control structure, runoff will be permitted to leave the detention pond and flow through the large culvert structure through the Torbay Bypass Road.

Significant infrastructure upgrades and placement of a large detention pond would help reduce existing issues as well as accommodate and prepare the Town's storm sewer system for future development.

4.1.5 Kennedy's Brook Catchment

This is the catchment with the least amount of notable infrastructure issues and overland flow resulting from the 100 Year 2 Hour climate change storm, which impacted the existing conditions model the most.

Including the increased percent impervious coefficient associated with developing a new industrial area within the catchment resulted in a few pieces of infrastructure being under capacity.

Figure 44: Rosebud Street Before Upgrades vs Rosebud Street After Upgrades

Shown below, the stream conveying runoff in the Rosebud Street area spills it's banks upstream of Rosebud Street, resulting in overland flow on a nearby property as well as a nearby playground

Placing an earth berm with height of 1.5m and side slopes of 2 to 1 will help confine the runoff to the stream and allow for better drainage, preventing the overland flows mentioned. As mentioned earlier in the report the 900mm CSP culvert crossing Rosebud street should be replaced and upsized to a 1200mm CSP culvert due to the damage evident through field inspection and to accommodate for anticipated increases in runoff.

The future industrial lots will likely drain through the existing 2000mm CSP culvert crossing Torbay Road. Analyzing this future scenario through the XPSWMM model shows some over land flow occurring due to the stream surpassing its banks.

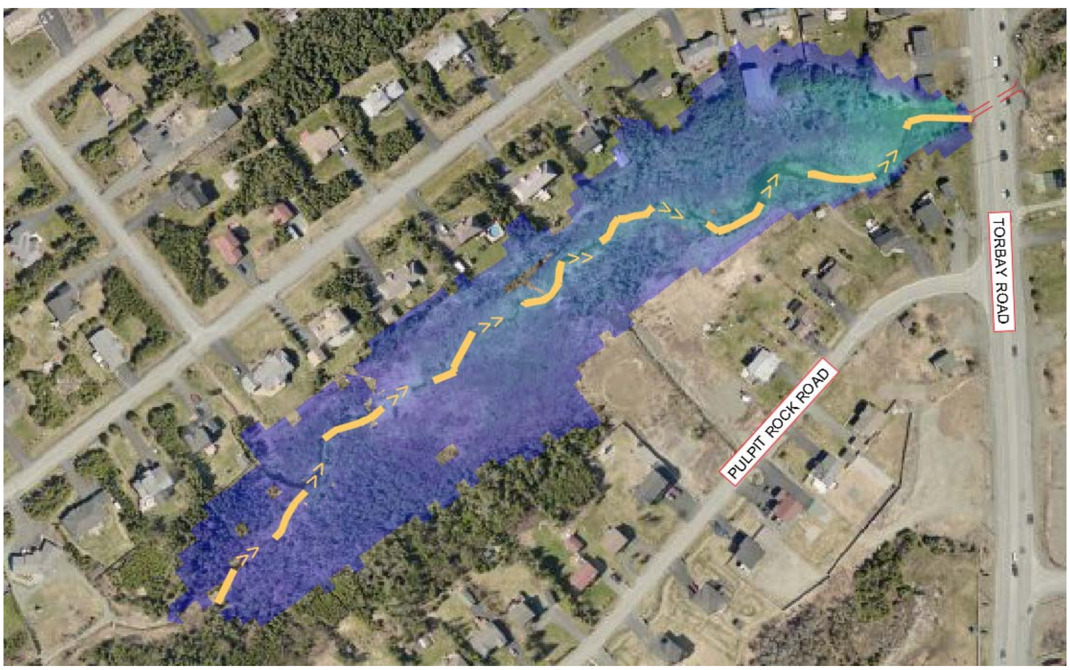

Figure 45: Floodplain Impacted by Potential Commercial Development

The floodplain shows some areas where the floodplain is encroaching on to nearby properties. In the event that future commercial development occurs upstream from this area, an earth berm can be constructed along the property lines of the homes of concern. Its important to analyze the potential impact that this commercial development would have on infrastructure downstream in the Town of Middle Cove – Outer Cove as it could create issues downstream. If a commercial area is to be developed, a local detention structure could be considered as well to detain runoff specific to the new area to help reduce impacts downstream.

Currently there are no major areas of considerable concern in this catchment area and runoff appears to be properly conveyed away from the area. It is to be expected that during storm events of a return period of 100 years that structures will be undersized, especially for the new climate change storms.

4.1.6 Watts Pond Catchment

1As mentioned earlier in the report, there are two main areas of concern within this catchment area. The first being the area of Crowe's Lane. This street currently has four CSP culverts to convey runoff from the upstream portion of the catchment area to a wetland which discharges into Watt's Pond. The existing conditions model showed a potential washout in this area as the stream conveying runoff into the culverts is small and flat. Further downstream the area of Anstey's Cove Lane shows signs of significant flooding and potential infrastructure damage. Considering potential residential expansion in the area, a form of detention pond would likely help service future expansion and mitigate existing issues within the area.

Figure 46: Ditch at Capacity - Bauline Line

The four CSP culverts crossing Crowe's Lane is an indication that there is some drainage issues in this area. A properly constructed stream would assist in allowing runoff to drain from the area. The stream should have a well defined cross-section such as the one shown on the following page:

Withrod Pond currently discharges through a culvert on Bauline line and enters a stream which discharges into the upstream wetland area of Crowe's Lane. The surround streets and landscape provide a natural berm around Withrod Pond.

Shown in figure 46, the small culvert structure, which was measured in the field to be compressed to approximately 400mm and has significant deterioration, is nearly full during the May 30th storm event. As a result it is recommended that a well defined stream be placed in this area to allow for proper drainage. This will prevent water levels from rising and potentially causing flooding along Bauline Line and will prevent saturation of the wetland surrounding Crowe's Lane.

A possible solution to the issue surrounding flooding on Anstey's Cove Lane would be to lower the water levels present in Withrod Pond and Watts Pond by 1 foot. The ponds will eventually adjust to the new water level .The decrease in water levels would allow for a large amount of storage and would help reduce flooding conditions in the area and prevent the need for significant infrastructure upgrade and replacement. Modelling the scenario where a foot of storage across both ponds is obtained shows that the flooding issues down stream on Anstey's Cove Lane are resolved. Downstream of Withrod Pond there is currently a small stream passing between Civic # 132 and 131 Bauline Line that currently conveys runoff from Withrod Pond. This stream is currently very small and should upgraded to have a cross-section with 1m depth, 1 to 1 side slopes and a bottom width of 1m. This will allow runoff to be properly conveyed away from the area while preventing flooding on Civic # 132 and Civic# 131 Bauline Line. The ditch running along Bauline Line meanders through a flat marshy area at the rear of Civc# 132 and 131 on Bauline Line. There is little elevation change between this marsh area and the existing top water elevation of Watt's Pond meaning if a new ditch is to be constructed in this area, it's slope will be very small. To properly convey runoff away from the area a widened cross-section with a minimum depth of 1m could be constructed. The older stream could be filled in and abandoned. With regards to the four culverts crossing Crowe's Lane, given the increased storage of Withrod Pond and the new ditch cross-section, twin 1400mm CSP culverts can be placed to provide drainage between the two adjacent marshy areas surrounding Crowe's Lane. Downstream of the upgraded culverts, the existing stream should be modified to have a total top width of approximately 40m, a bottom width of 20m and a minimum depth of 1m. Runoff will then enter Watt's Pond where the water elevation has been dropped by a foot, providing a foot of storage across the entire pond. This storage, in conjunction with the storage and upgrades upstream helps prevent overland flooding and infrastructure damage on Anstey's Cove Lane and Davalan Place. Shown on the following page is a before and after figure comparing the extents of the 100 year 24 hour floodplain.

Careful attention will be required for this concept as the ponds are likely fish habitats and mitigation measures would have to be implemented to ensure proper fish passage during low flows and may require the implementation of fish ladders and other design considerations. If possible, lowering the pond elevations of both Withrod and Watts Pond would be the best potential solution for this catchment area.

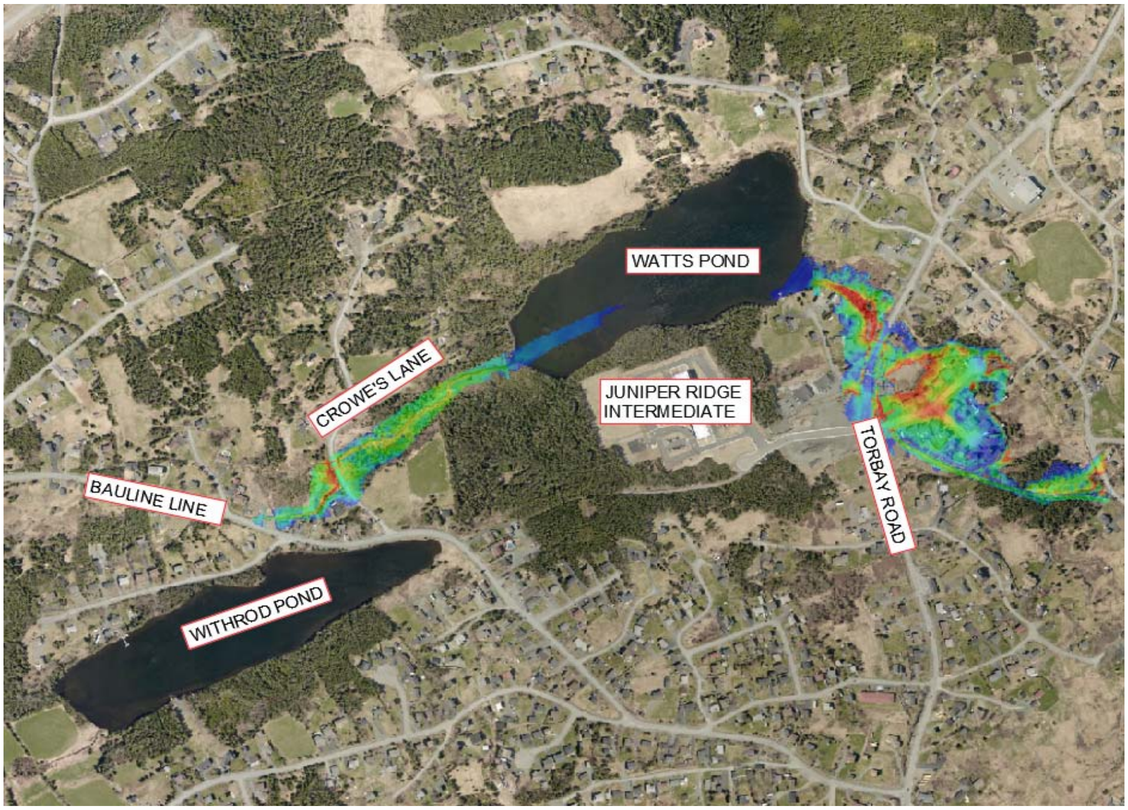

Figure 47: Watt's Pond Catchment Before Upgrades

Figure 48: Watt's Pond Catchment After Upgrades

5.0 Cost Estimates

The following section provides a summary of cost estimates regarding remedial actions described in the previous sections. The detailed cost estimates for these remedial actions can be observed in Appendix I for each of the catchment areas.

Skipper's Landing – Ditch Upgrades & Detention Pond, Culvert Upgrades, Berms

Total Cost (Detention Pond): $860,907.08

Total Cost (Ditch Re-grading, Cutoff Ditch Modifications): $110,048.10

Island Pond Brook – Berm, Culvert Replacements, Detention Pond, Stream Modification

Total Cost: $1,358,289.16

Whiteway Pond – Berm, Culvert Replacements, etc.

Total Cost - $532,792.92

Watt's Pond – Adjust Pond Levels, Stream Modification

Total Cost: $404,478.69

Kennedy's Brook – Berms and Infrastructure Replacement

Total Cost: $174,419.40

Big River – Berms and Infrastructure Replacement

Total Cost: $429,005.78

The most pertinent upgrades that require action are included in the Skipper's Landing area as this area has had reported flooding and drainage issues and currently has zoning in the surrounding area that is listed as potential residential developments. Immediately downstream, the Island Pond Brook Catchment will be significantly impacted by the infrastructure upgrades proposed for the Skipper's Landing area. There are a number of existing issues in this catchment area as well and the proposed upgrades in conjunction with the upgrades proposed for the Skipper's Landing area will significantly reduce runoff and prevent flooding issues that are both present and issues that can arise from future development.

The Watts Pond catchment has also been an issue for a number of years. With some some surrounding area zoned as residential development, the amount of runoff will only increase. The newly constructed Anstey's Cove Lane has had numerous issues in the past. These upgrades in this area are more advanced technically and will require careful consideration moving forward given the proposed adjustment of water levels in both Withrod and Watts Pond. If possible, these upgrades would significantly help reduce the amount of runoff in the area.

6.0 Conclusion

The discussion in this report combined with the attached appendices outline underlying issues with the Town's existing storm sewer infrastructure. The remedial upgrades suggested in this report should be implemented to prevent infrastructure damage, especially under conditions where future buildout is planned. In a future stage, detailed designs of these concepts should be completed.

The findings presented in this report are modelled using the most up to date storms from the City of St. John's which account for recent observable impacts from climate change.

The proposed detention pond structures will help reduce the amount of infrastructure upgrades downstream while accommodating for the increased amount of runoff that will result from increased development within the Town, which has been growing rapidly over the course of the last several years.