# STEADYWATER BROOK STORMWATER MANAGEMENT PLAN
# TOWN OF CONCEPTION BAY SOUTH

## FINAL

**Conception Bay South, NL**

**Prepared for:**
Town of Conception Bay South
106 Conception Bay Highway
Conception Bay South, NL
A1W 3A5

**Prepared by:**
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1133 Topsail Road
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PEG Newfoundland and Labrador PROFESSIONAL ENGINEERS AND GEOSCIENTISTS
TRACY LYNN J. GOOSNEY
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2015/06/09
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**Project No. 512537**

**June 9, 2015**

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## Executive Summary

The Town of Conception Bay South has commissioned BAE-Newplan Group Limited to develop a stormwater management plan for the Steadywater Brook drainage basin. Included in this report is an analysis of each structure on Steadywater Brook. As well, floodplain analysis is provided in areas of high concern. This study and the associated recommendations are intended to be used as the master plan for storm water management and stormwater infrastructure upgrades for the basin.

Steadywater Brook runs from Gull Pond, through the town of Conception Bay South, and outlets to Conception Bay via Butler's Pond. There are three significant ponds on the system, however there are several wetlands that aid in stormwater retention.

A total of nine (9) drainage structures were identified on Steadywater Brook. Of these, four (4) were identified as being undersized for both current and ultimate development conditions. Future development conditions were established based on the zoning detailed by the latest Town of Conception Bay South development plan.

It is recommended that infrastructure that is undersized be upgraded for the current development conditions at a minimum. Serious consideration should be given to upgrading to meet future ultimate development flows as presented in the report. Corrugated Metal can be used for larger culverts however HDPE is the preferred material for new culvert installations. Single barrels are preferred over multiple barrels.

A 15m buffer on either side of the future development 100-year floodplain shall be maintained with no further development within. Stormwater retention has been considered however no solutions have been effective at minimizing flooding downstream. The option remains for the Town to purchase the affected properties to minimize risk in case of flooding. Any proposed development should be reviewed in conjunction with the present stormwater master plan in order to minimize the risk of future flooding problems.

# Table of Contents

# List of Tables



# List of Figures

# 1.0 INTRODUCTION

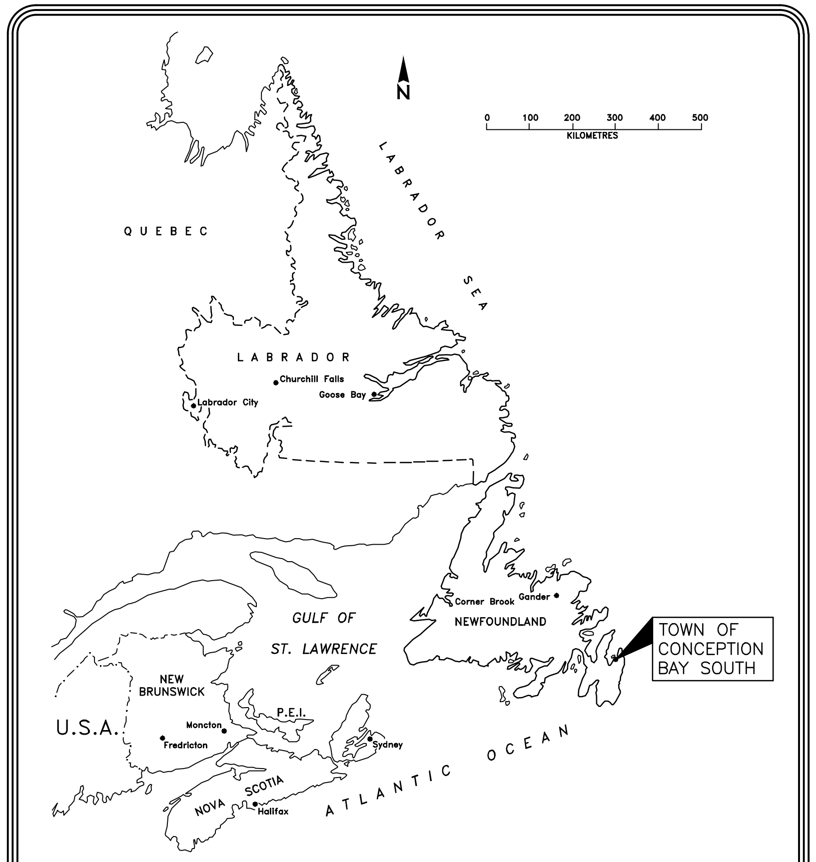
## 1.1. General

The Town of Conception Bay South (CBS) is located on the Avalon Peninsula, west of the Capital City of St. John's. It has experienced growth over the past number of years due to its proximity to St. John's and the economic prosperity of the North-East Avalon region.

The population of Conception Bay South in 2011 was 24,848 people, up from 21,966 in 2006. As the town grows and the land changes, stormwater management becomes an ever growing concern. The Town of Conception Bay South has commissioned BAE Newplan Group to develop a stormwater management plan for the Steadywater Brook basin; this basin being identified as a critical flooding area in the town.

The town has 23 drainage basins in total. The Steadywater Brook basin has a catchment area of 689.5 ha. It flows from Gull Pond, outside the limits of the Town of Conception Bay South, to Butler's Pond. A barachois separates Butler's Pond from the waters of Conception Bay. A site plan is shown in Figure 1.1.

Most of the storm system in CBS is ditched, however new developments are required to implement piped storm sewers. Steadywater Brook basin is a mature area of Town, and most of the stormwater is conveyed through ditching and culverts.




LOCATION PLAN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**STEADYWATER BROOK STORM WATER MANAGEMENT PLAN**

TITLE
**FIGURE 1.1 SITE PLAN**

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## 1.2. Study Objectives

The primary objective of this study is to provide a document that will stand as the Towns' plan for stormwater management of the Steadywater Brook basin. This study will consider both current and future (ultimate) development situations, detailing infrastructure which requires upgrading. Additionally, floodplain analysis in critical areas will be considered and engineering options will be evaluated to prevent flooding in habited areas.

The specific objectives of this study are as follows:

1. Identify the drainage basin contributing to Steadywater Brook;
2. Review the existing stormwater problems within the drainage basin;
3. Identify existing key drainage structures within the drainage basin and calculate existing flow capacities based on inlet control;
4. Calculate flows for each drainage basin for both current development and full development scenarios based on the Towns' Land Use Plan;
5. Identify drainage structures requiring upgrading and determine size and capacity of drainage structures to accommodate existing and ultimate development flows;
6. Identify critical areas requiring floodplain analysis;
7. Delineate both the 25-year and 100-year floodplain for current and full development flow conditions;
8. Identify critical flooding areas and evaluate solutions to correct existing stormwater problems;
9. Prepare a 1:10,000 scale base map outlining the drainage basin, plus detailed drawings showing drainage structures and reach locations; and
10. Prepare 1:5000 scale floodplain maps for both current (existing) and full (ultimate) development flow conditions.

## 1.3. Study Methodology

### 1.3.1. Information Collection

Preliminary basin information was determined from 1:2,500 municipal topographic mapping, 1:50,000 provincial topographic mapping, and land use mapping available from the Town of Conception Bay South. This mapping also formed a basis for the study drawings. Information collected from this mapping includes:

- Drainage Area for main basin;
- Sub-basin drainage areas and characteristics; and
- Stream lengths and average slopes for each reach.

Site visits were conducted by BNG Field Staff to identify and dimension main drainage structures. A survey was conducted on the main channel for input into the hydraulic model. Tributaries outside the developable areas in the Town were not surveyed. Pond outlets were surveyed so that models could be prepared to determine outflow.

Storm data was taken from the St. John's Subdivision Design Manual for both the 25-year and 100-year storms since there is none readily available from the Town of Conception Bay South. This data is located in Table 1.1 and Table 1.2. For culvert design, a 25-year storm is typically used. For bridge design and floodplain analysis, the 100-year storm is typically used. Climate observations have been showing that the 25-year storm is occurring more frequently than once in every 25 years. The same is true for the 100-year storm. For this study, both 25-year and 100-year storms are evaluated, however for major structure upgrading and design, the 100-year storm is considered only.

### 1.4. Existing Stormwater Issues

One area of concern for flooding is in the most downstream section, near Butler's Pond. Haggett's Turn and Concord Drive are directly on the banks of Butler's Pond. The outlet to the bay fills in with sub-rounded to rounded cobbles with the tide, so the only outlet is through seepage through the barachois, which can cause upstream flooding during storm events. This has been observed on several occasions during which Concord Drive and Haggett's Turn have flooded. For these extreme events, the Town of CBS has engaged an excavator to dredge the outlet, alleviating the flooding upstream. This outlet quickly fills in again under tidal action.

Another concern includes the wetland just upstream of Conception Bay Highway near Donnybrook Road and Nettab Drive. Commercial properties along Conception Bay Highway (Route 60) have been close to flooding in recent storms.

**Table 1.1: St. John's Subdivision Design Manual – 25-Year Return Period Storm**

| % Time | Cumulative Rainfall (mm) | | | | | |
|---|---|---|---|---|---|---|
| | ½ Hour | 1 Hour | 2 Hour | 6 Hour | 12 Hour | 24 Hour |
| 0.00% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 8.33% | 1.5 | 2.0 | 2.8 | 4.3 | 0.8 | 6.5 |
| 16.67% | 3.8 | 5.1 | 7.2 | 10.9 | 1.6 | 16.3 |
| 25.00% | 6.7 | 9.0 | 12.7 | 19.3 | 5.6 | 28.8 |
| 33.33% | 10.5 | 14.1 | 20.0 | 30.4 | 14.5 | 45.4 |
| 41.67% | 15.1 | 20.2 | 28.5 | 43.4 | 30.6 | 64.9 |
| 50.00% | 18.6 | 24.9 | 35.2 | 53.5 | 50.7 | 80.1 |
| 58.33% | 19.8 | 26.5 | 37.4 | 57.0 | 65.1 | 85.2 |
| 66.67% | 20.7 | 27.7 | 39.2 | 59.6 | 73.2 | 89.1 |
| 75.00% | 21.4 | 28.7 | 40.5 | 61.7 | 77.2 | 92.2 |
| 83.33% | 21.9 | 29.4 | 41.5 | 63.1 | 78.8 | 94.4 |
| 91.67% | 22.2 | 29.7 | 42.0 | 63.8 | 79.6 | 95.4 |
| 100.00% | 22.3 | 29.9 | 42.2 | 64.2 | 80.4 | 96.0 |

**Table 1.2: St. John's Subdivision Design Manual - 100-year Return Period Storm**

| % Time | Cumulative Rainfall (mm) | | | | | |
|---|---|---|---|---|---|---|
| | ½ Hour | 1 Hour | 2 Hour | 6 Hour | 12 Hour | 24 Hour |
| 0.00% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 8.33% | 2.3 | 3.0 | 4.3 | 6.0 | 1.1 | 8.9 |
| 16.67% | 5.8 | 7.4 | 10.8 | 15.0 | 2.2 | 22.4 |
| 25.00% | 10.2 | 13.2 | 19.1 | 26.5 | 7.6 | 39.7 |
| 33.33% | 16.0 | 20.7 | 30.0 | 41.7 | 19.4 | 62.4 |
| 41.67% | 22.9 | 29.6 | 42.9 | 59.7 | 41.0 | 89.3 |
| 50.00% | 28.3 | 36.5 | 52.9 | 73.6 | 68.0 | 110.1 |
| 58.33% | 30.1 | 38.9 | 56.3 | 78.3 | 87.5 | 117.1 |
| 66.67% | 31.5 | 40.6 | 58.8 | 81.8 | 98.3 | 122.5 |
| 75.00% | 32.6 | 42.1 | 60.9 | 84.7 | 103.7 | 126.8 |
| 83.33% | 33.3 | 43.1 | 62.3 | 86.7 | 105.8 | 129.8 |
| 91.67% | 33.7 | 43.5 | 63.0 | 87.7 | 106.9 | 131.2 |
| 100.00% | 33.9 | 43.8 | 63.4 | 88.2 | 108.0 | 132.0 |

# 2.0 ANALYSIS AND RESULTS

## 2.1. Hydrologic Modeling

### 2.1.1. General

Hydrologic modeling was conducted to determine the existing and ultimate development flows through the Steadywater Brook basin. HEC-HMS (Hydrologic Engineering Center – Hydrologic Modeling System) is a software issued by the United States Army Corps of Engineers. Sub-basin and reach characteristics are input into HEC-HMS, along with precipitation data for the selected design storms. The program computes the run-off from each sub-basin, generates an outflow hydrograph for each sub-basin, and routes it through the system.

The output from HEC-HMS constitutes the existing and ultimate development flows for the structure capacity checks and floodplain analysis.

### 2.1.2. Analysis

The drainage basin for Steadywater Brook was broken down into sub-basins based on drainage locations and land uses. Figure 2.1 illustrates the land use designations for the Town of Conception Bay South. A sub-basin key plan is shown in Figure 2.2; detailed sub-basins are shown in Figure 2.3, Figure 2.4, Figure 2.5, Figure 2.6, and Figure 2.7. Table 2.1 details the characteristics for each sub-basin for both current and ultimate development scenarios.

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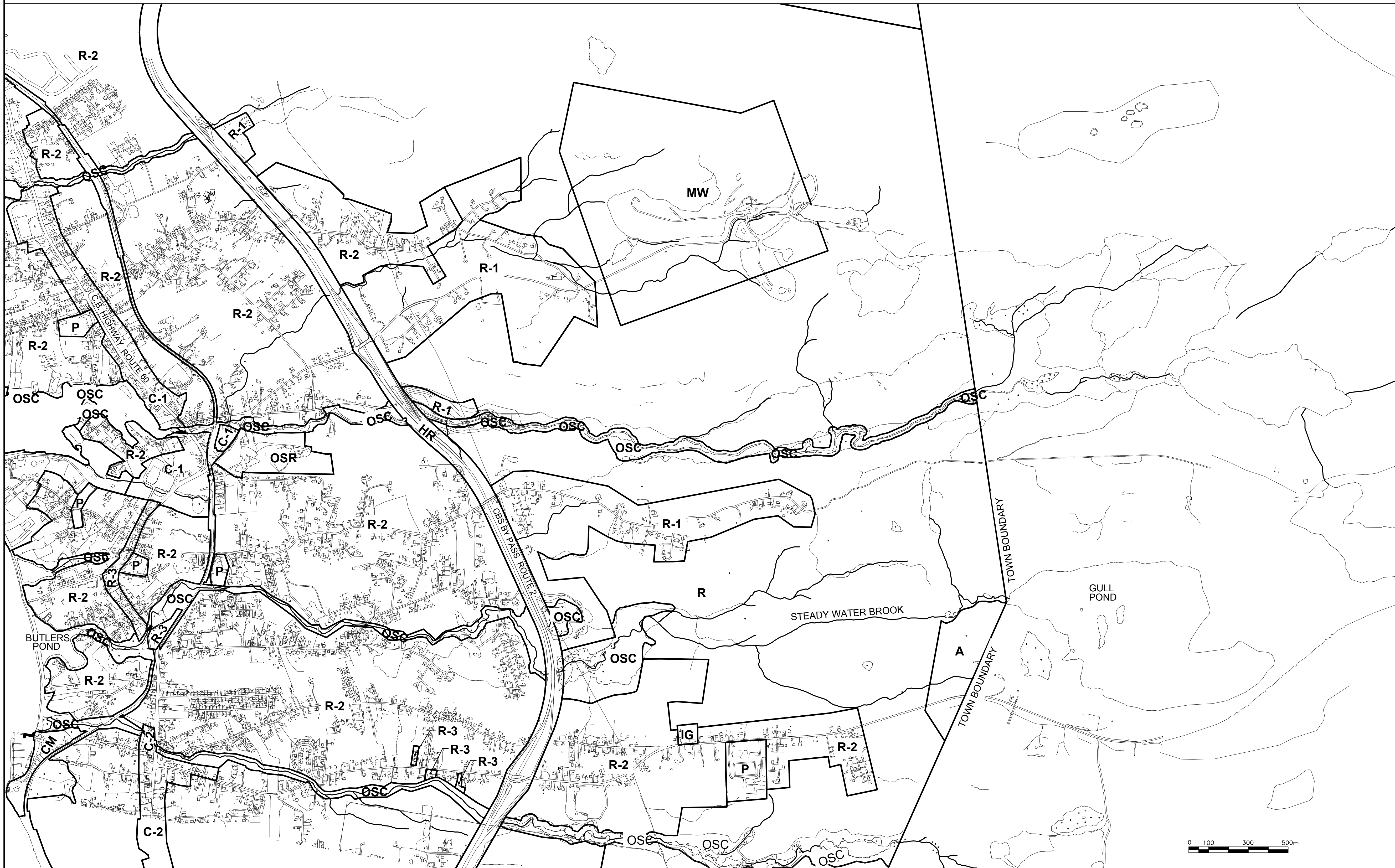


LAND USE LEGEND

| SYMBOL | DESCRIPTION |
|---|---|
| R-1 | RESIDENTIAL LOW DENSITY |
| R-2 | RESIDENTIAL MEDIUM DENSITY |
| R-3 | RESIDENTIAL MIXED |
| C-1 | COMMERCIAL MAIN STREET |
| C-2 | COMMERCIAL GENERAL |
| CM | COMMERCIAL MARINE |
| IG | INDUSTRIAL GENERAL |
| OSR | OPEN SPACE RECREATION |
| OSC | OPEN SPACE CONSERVATION |
| MW | MINERAL WORKING |
| R | RURAL |
| A | AGRICULTURE |
| P | PUBLIC USE |
| HR | HIGHWAY RESERVE |

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FIGURE 2.1 LAND USE PLAN

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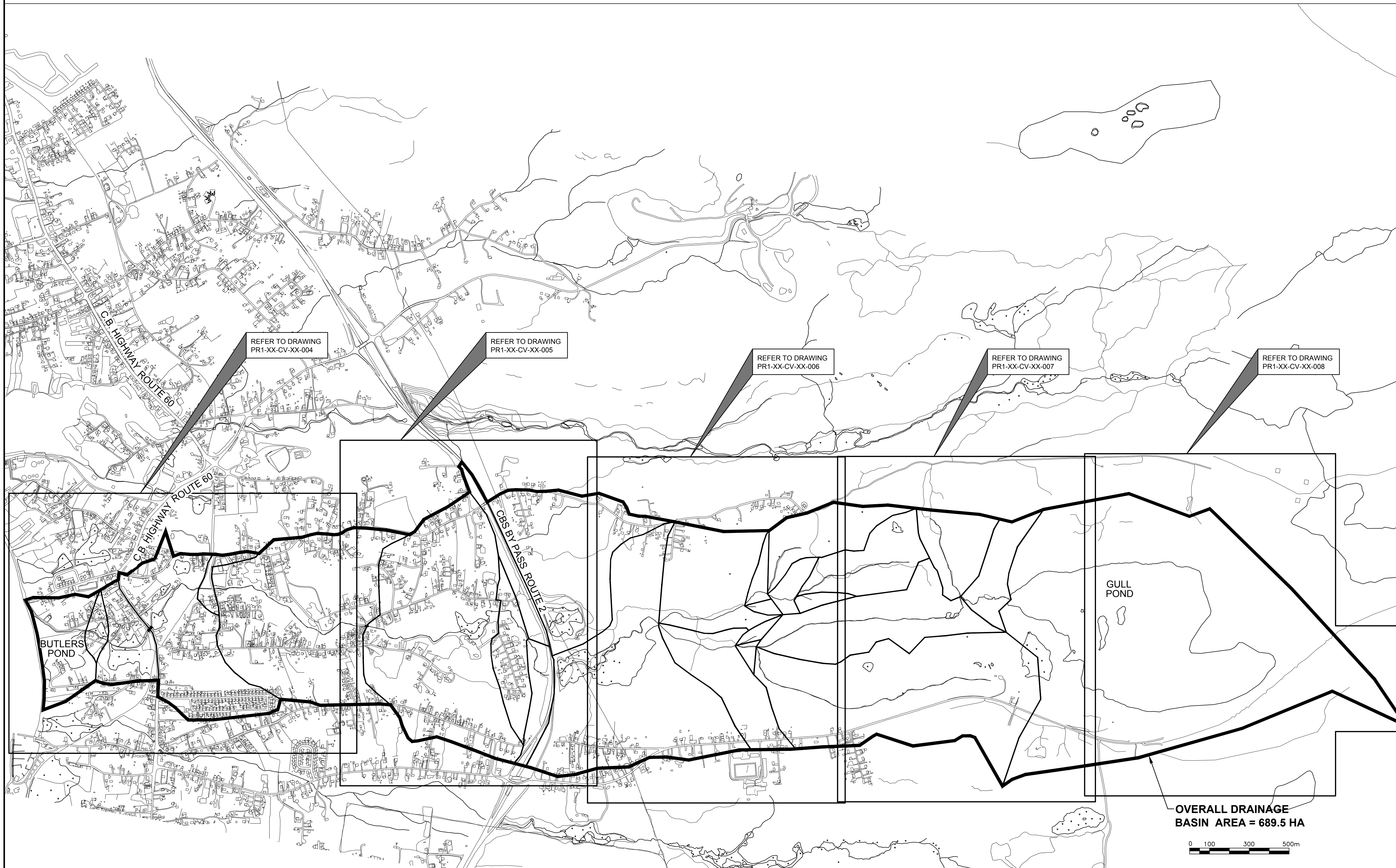


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**FIGURE 2.2 DRAINAGE BASIN KEY PLAN**

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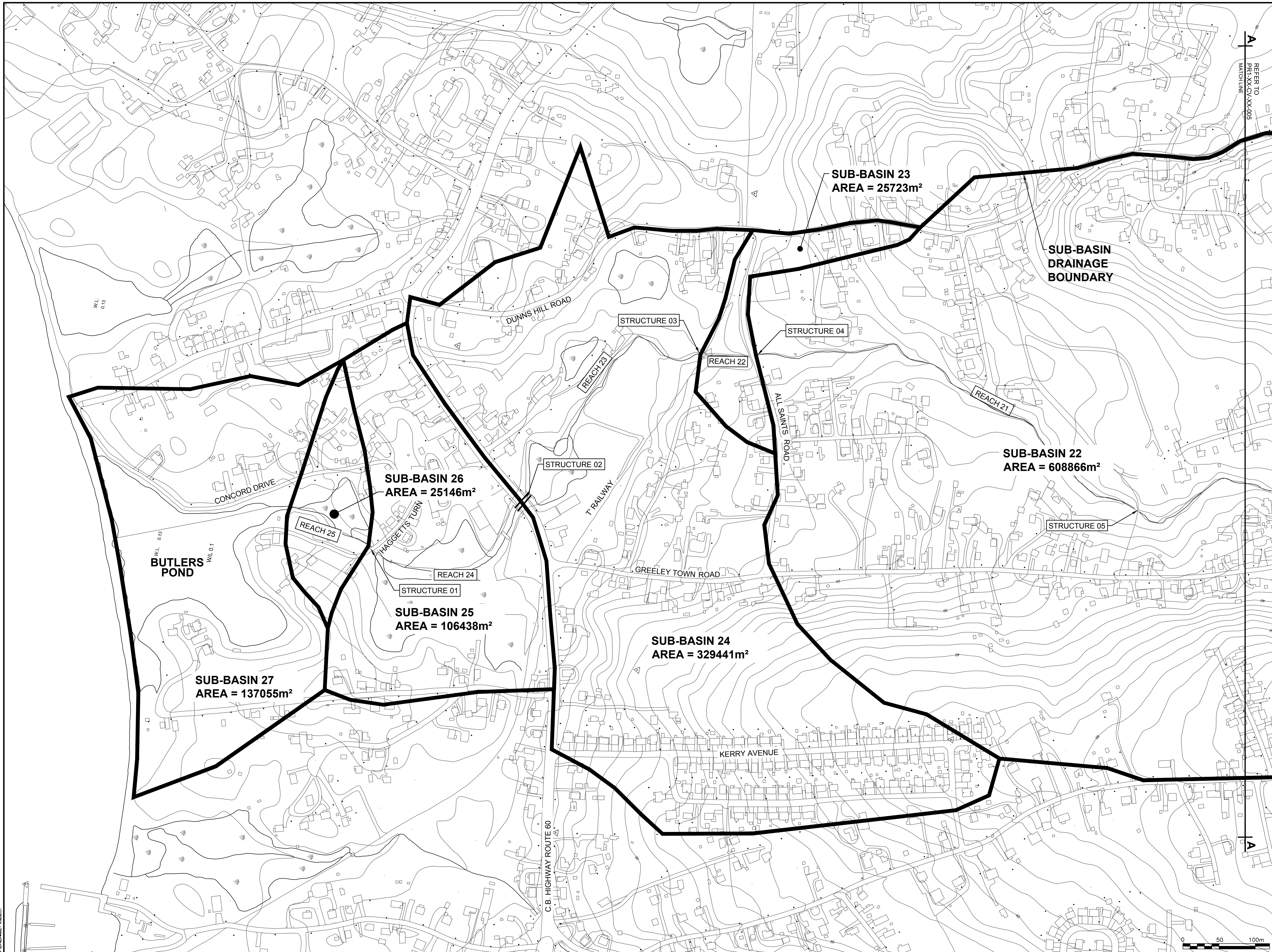




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FIGURE 2.3
DRAINAGE BASIN PLAN
1 OF 5

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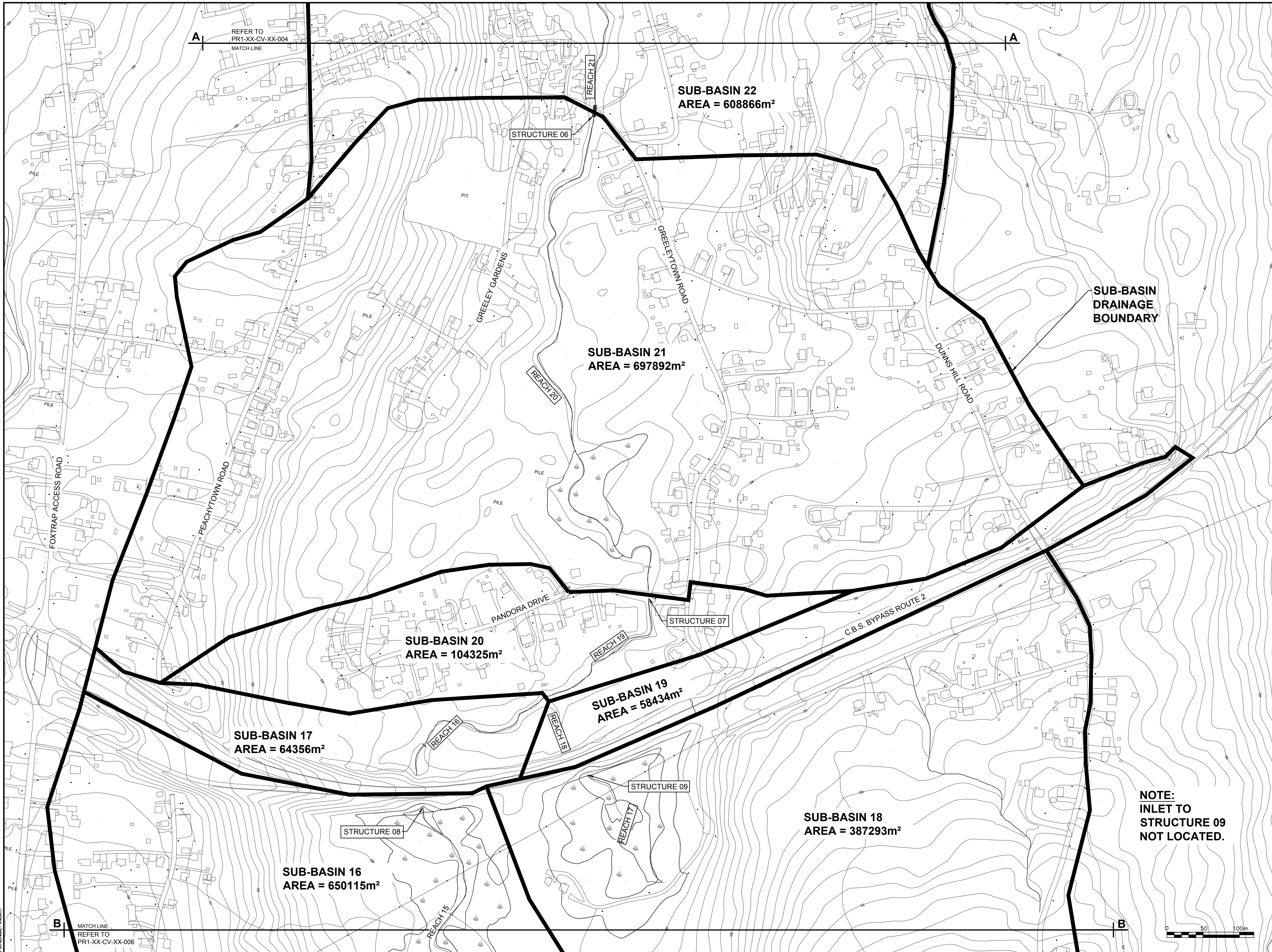


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**FIGURE 2.4 DRAINAGE BASIN PLAN 2 OF 5**

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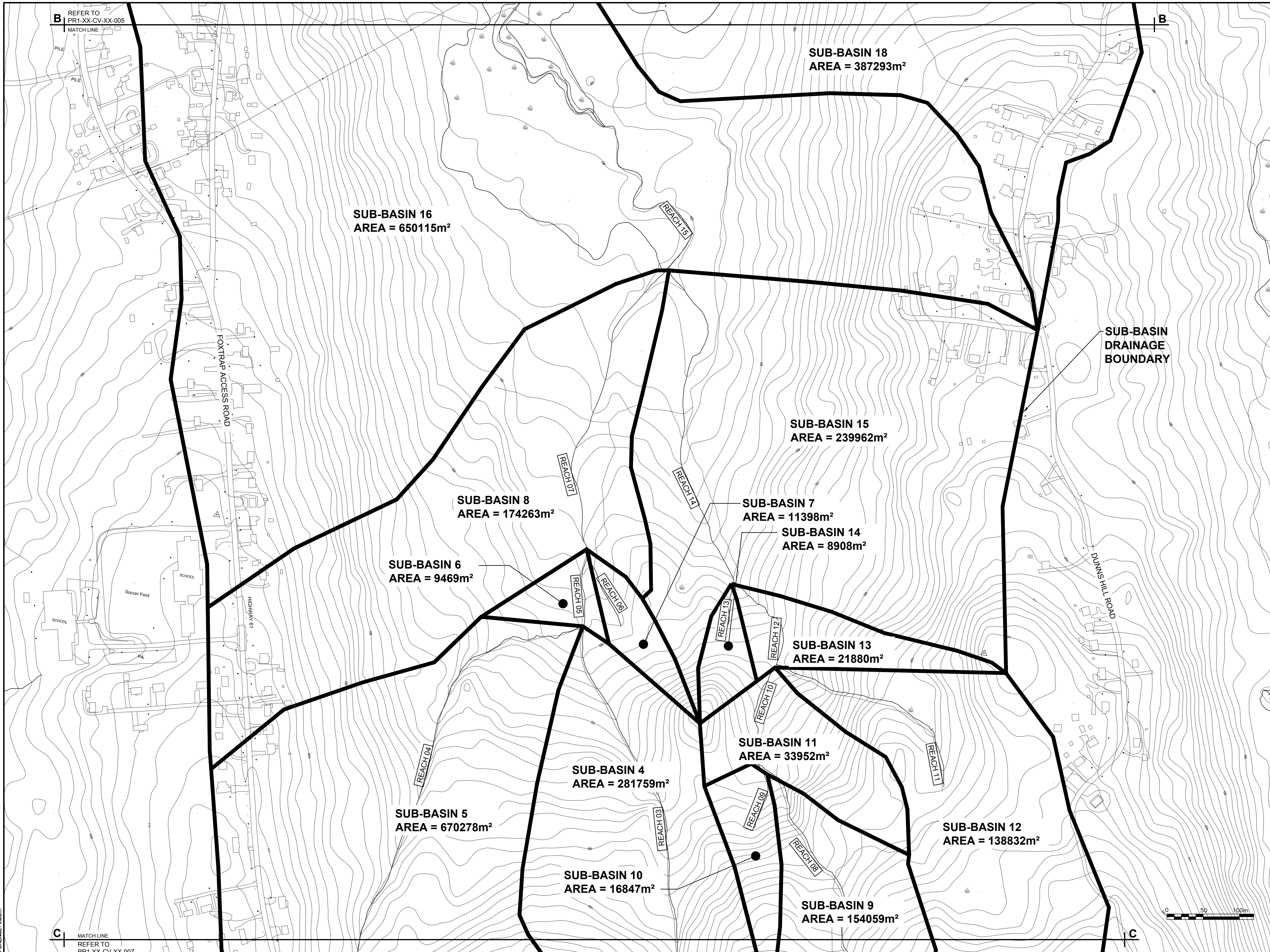


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TITLE
**FIGURE 2.5 DRAINAGE BASIN PLAN 3 OF 5**

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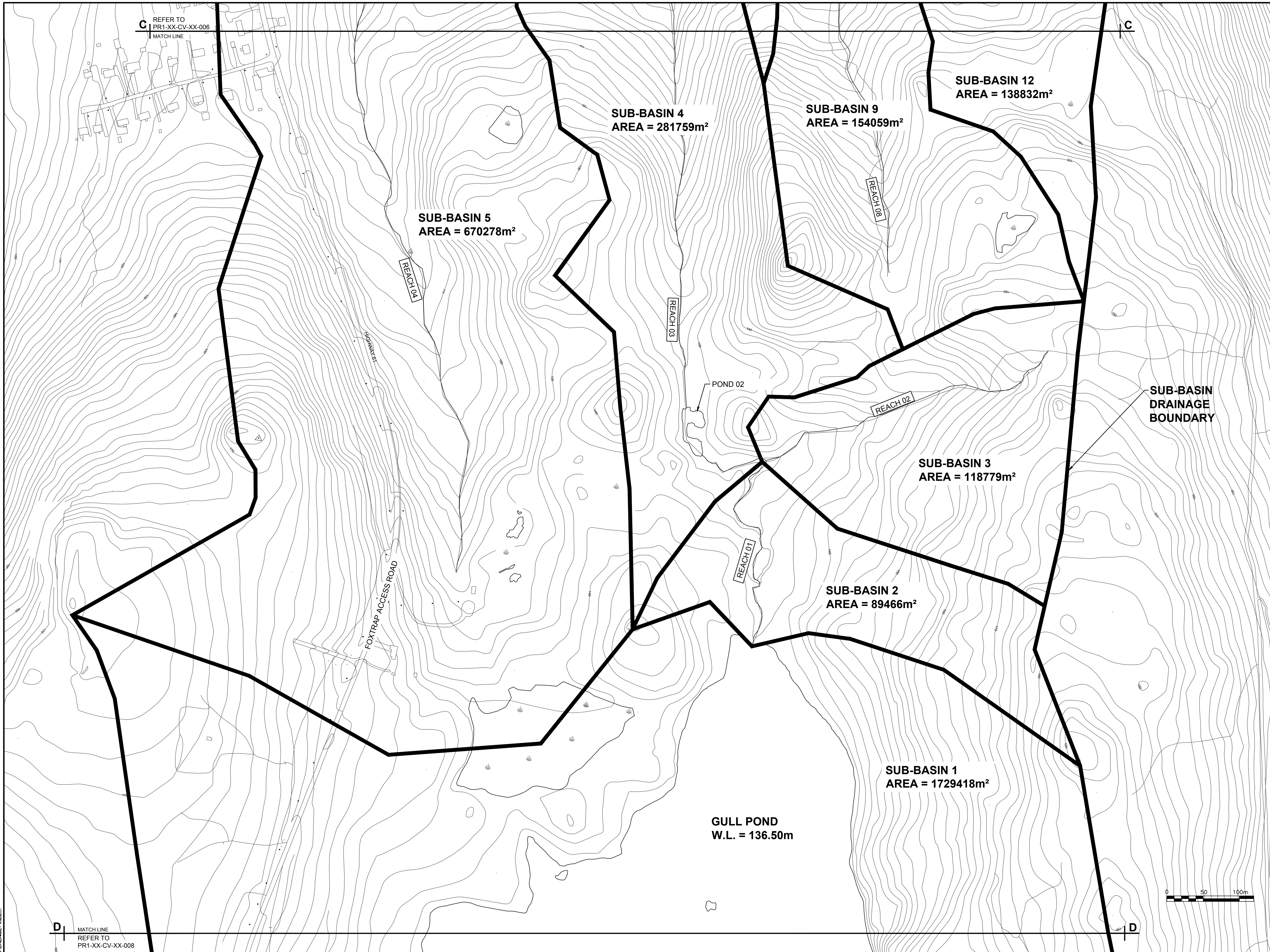


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FIGURE 2.6
DRAINAGE BASIN PLAN
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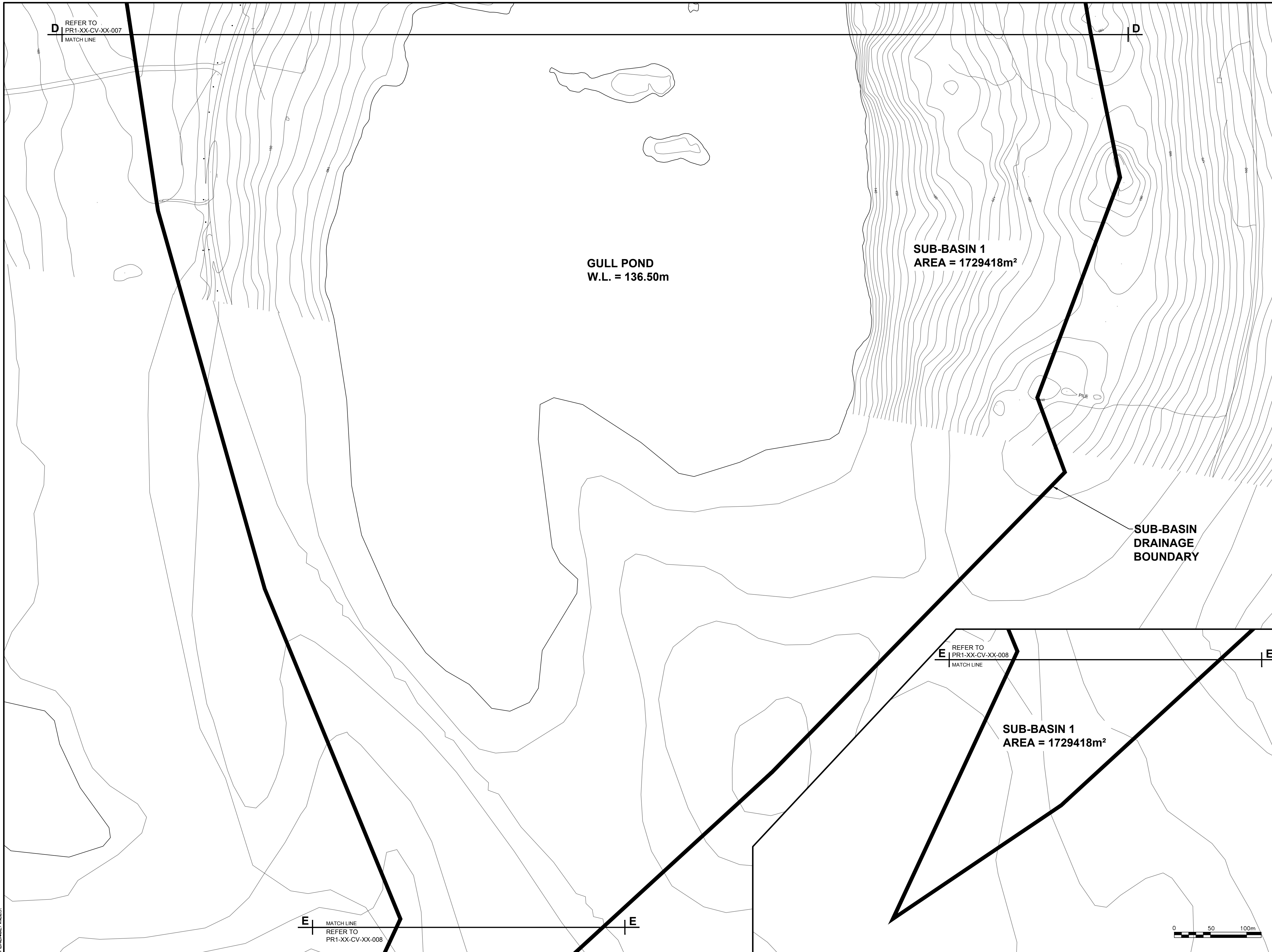


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FIGURE 2.7
DRAINAGE BASIN PLAN
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| SCALE | AS SHOWN | BNG PROJ. No. | 512537 | | |
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DRAWING No. PR 1 – XX – CV – XX – 008 REV. C01

**Table 2.1: Sub-Basin Characteristics**

| Sub-basin | Drains Into | Drainage Area (m²) | Current or Ultimate | Description | Curve No. |
|---|---|---|---|---|---|
| SUB01 | RES01 | 1,729,418 | Current | 1% Road, 35% Pond, 5% Grassland, 59% Forest | 71 |
| | | | Ultimate | 1% Road, 35% Pond, 5% Grassland, 59% Forest | 71 |
| SUB02 | REACH01 | 89,466 | Current | 100% Forest | 55 |
| | | | Ultimate | 100% Forest | 55 |
| SUB03 (Trib.)* | REACH02/ REACH03 | 118,779 | Current | 100% Forest | 55 |
| | | | Ultimate | 100% Forest | 55 |
| SUB04 | REACH03 | 281,759 | Current | 0.5% Pond, 99.5% Forest | 55 |
| | | | Ultimate | 0.5% Pond, 99.5% Forest | 55 |
| SUB05 (Trib.)* | REACH04/ REACH05 | 670,278 | Current | 10% R-2 Developed, 1% Road, 89% Forest | 57 |
| | | | Ultimate | 10% R-2 Developed, 1% Road, 89% Forest | 57 |
| SUB06 | REACH05 | 9,469 | Current | 100% Forest | 55 |
| | | | Ultimate | 100% Forest | 55 |
| SUB07 (Trib.)* | REACH06/ REACH07 | 11,398 | Current | 100% Forest | 55 |
| | | | Ultimate | 100% Forest | 55 |
| SUB08 | REACH07 | 174,263 | Current | 15% R-2 Dev, 7% R-2 Undev, 2% P, 76% Forest | 59 |
| | | | Ultimate | 22% R-2 Dev, 2% P, 76% Forest | 60 |
| SUB09 (Trib.)* | REACH08/ REACH15 | 154,059 | Current | 100% Forest | 55 |
| | | | Ultimate | 100% Forest | 55 |
| SUB10 (Trib.)* | REACH09/ REACH15 | 16,847 | Current | 100% Forest | 55 |
| | | | Ultimate | 100% Forest | 55 |
| SUB11 (Trib.)* | REACH10/ REACH15 | 33,952 | Current | 100% Forest | 55 |
| | | | Ultimate | 100% Forest | 55 |
| SUB12 (Trib.)* | REACH11/ REACH15 | 138,832 | Current | 6% R-1 Undeveloped, 94% Forest | 55 |
| | | | Ultimate | 6% R-1 Developed, 94% Forest | 56 |
| SUB13 (Trib.)* | REACH12/ REACH15 | 21,880 | Current | 100% Forest | 55 |
| | | | Ultimate | 100% Forest | 55 |
| SUB14 (Trib.)* | REACH13/ REACH15 | 8,908 | Current | 100% Forest | 55 |
| | | | Ultimate | 100% Forest | 55 |
| SUB15 (Trib.)* | REACH14/ REACH15 | 239,962 | Current | 12% R-1 Developed, 1% OSC, 87% Forest | 57 |
| | | | Ultimate | 12% R-1 Developed, 1% OSC, 87% Forest | 57 |
| SUB16 | REACH15 | 650,115 | Current | 3% R-1 Dev, 1% R-1 Undev, 7% OSC, 12% Pond, 23% R-2 Dev, 23% R-2 Undev, 2% IG, 1% P, 4% Road, 24% Forest | 70 |
| | | | Ultimate | 4% R-1 Dev, 7% OSC, 12% Pond, 46% R-2 Dev, 2% IG, 1% P, 4% Road, 24% Forest | 73 |
| SUB17 | REACH16 | 64,351 | Current | 22% OSC, 3% R-2 Dev, 32% R-2 Undev, 43% Road | 74 |

| Sub-basin | Drains Into | Drainage Area (m²) | Current or Ultimate | Description | Curve No. |
|---|---|---|---|---|---|
| | | | Ultimate | 22% OSC, 35% R-2 Developed, 43% Road | 78 |
| SUB18 (Trib.)* | REACH17/ REACH19 | 387,293 | Current | 1% OSC, 5% Swamp, 10% Road, 24% R-1 Dev, 43% R-1 Undev, 17% Forest | 68 |
| | | | Ultimate | 1% OSC, 5% Swamp, 10% Road, 67% R-1 Dev, 17% Forest | 74 |
| SUB19 (Trib.)* | REACH18/ REACH19 | 58,434 | Current | 66% Road, 20% R-2 Undeveloped, 14% OSC | 80 |
| | | | Ultimate | 66% Road, 20% R-2 Developed, 14% OSC | 82 |
| SUB20 | REACH19 | 104,325 | Current | 9% OSC, 70% R-2 Developed, 21% R-2 Undeveloped | 71 |
| | | | Ultimate | 9% OSC, 91% R-2 Developed | 74 |
| SUB21 | REACH20 | 697,892 | Current | 3% OSC, 2% Swamp, 65% R-2 Dev, 30% R-2 Undev. | 71 |
| | | | Ultimate | 3% OSC, 2% Swamp, 95% R-2 Developed | 75 |
| SUB22 | REACH21 | 608,866 | Current | 4% OSC, 1% P, 64% R-2 Dev, 31% R-2 Undev. | 70 |
| | | | Ultimate | 4% OSC, 1% P, 95% R-2 Developed | 75 |
| SUB23 | REACH22 | 25,723 | Current | 20% OSC, 16% P, 64% R-2 Developed | 75 |
| | | | Ultimate | 20% OSC, 16% P, 64% R-2 Developed | 75 |
| SUB24 | REACH23 | 329,441 | Current | 6% OSC, 3% Swamp, 1% P, 3% R-3, 87% R-2 Dev. | 75 |
| | | | Ultimate | 6% OSC, 3% Swamp, 1% P, 3% R-3, 87% R-2 Dev. | 75 |
| SUB25 | REACH24 | 106,438 | Current | 8% OSC, 23% Swamp, 20% R-3, 49% R-2 Developed | 82 |
| | | | Ultimate | 8% OSC, 23% Swamp, 20% R-3, 49% R-2 Developed | 82 |
| SUB26 | REACH25 | 25,146 | Current | 18% OSC, 12% Swamp, 70% R-2 Developed | 75 |
| | | | Ultimate | 18% OSC, 12% Swamp, 70% R-2 Developed | 75 |
| SUB27 | OUTLET | 137,055 | Current | 5% OSC, 25% Pond, 70% R-2 Developed | 80 |
| | | | Ultimate | 5% OSC, 25% Pond, 70% R-2 Developed | 80 |

*Note: Tributaries outside developable area, either due to land characteristics or land use, were omitted from analysis. The first Reach listed is the tributary name and the second Reach listed is the main channel segment to which the tributary drains.

A single HEC-HMS model was created, with two separate basins denoting Current Development and Ultimate Development. Each basin contained sub-basins, reaches, reservoirs, and junctions. Only the main channel was modeled, tributaries were excluded. Data for each of these components were determined during our preliminary information gathering and collected during site visits. The analysis was completed based on the data listed in Table 1.1 and Table 1.2 for the 25-year and 100-year storms for ½, 1, 2, 6, 12, and 24 hour durations.

Curve numbers were calculated primarily from land use mapping from the Town of CBS, however aerial photography and topographic mapping were used to determine the level of development for each region. Any Residential, Commercial, or Industrial areas (from land use map, see Figure 2.1) were assumed 100% developed for ultimate development. Upstream of the Conception Bay South Bypass (Route 2), much of the land is zoned Rural and Agricultural. This land is considered undevelopable in the analysis and no change was made between current and ultimate development.

There are three significant ponds on Steadywater Brook: Gull Pond, a small pond just downstream of Gull Pond (referred to as Pond 2) and Butler's Pond. Additionally, there are several wet, boggy areas which could not be accurately surveyed. These areas were conservatively not considered as storage areas in our analysis.

HEC-HMS requires a defined stage discharge relationship for each storage area. For Gull Pond and Pond 2, discharge curves were developed from hydraulic models using survey data from the outflow of the ponds. A steady state analysis was performed on each of these outlets to generate stage-discharge curves for input into the hydrologic model.

For Butler's Pond, the existing rock barachois separating the pond and the bay acts as an outlet as water freely flows through the permeable rock. In a flooding scenario, the water would overtop the barachois. A worst-case tidal situation was assumed, which corresponds to a Higher High Water in marine terminology. Butler's Pond was assumed to have the same initial water level as Conception Bay. A stage discharge curve of the barachois was developed based on this initial elevation of 1.0m geodetic (1.6m chart), corresponding to zero discharge (Fisheries and Oceans Canada, 1987). The area of Butler's Pond was assumed to be constant with depth. The method of discharge from Butler's Pond varied with depth, which included both flow through and over the barachois. A permeability of $10^{-1}$ m/s was assumed through the rock, which represents poorly graded rock and gravel (Bowles, 1996). For flow over the barachois, the weir equation was used with a weir coefficient of 1.7 (Mays, 2005).

The SCS (Soil Conservation Center) method was used to evaluate the run-off for each of the sub-basins. Current land use and projected future land use based on zoning were described using SCS curve numbers. The Muskingum-Cunge routing method was used to model the reaches (streams).

For each of the existing and ultimate development scenarios, separate simulations were created for each storm duration for both the 25-year and 100-year storm. The storm duration which produced the highest runoff was selected as the design flow. These results were hand checked using the rational method applied to the 100-year intensities taken from the 1992 St. John's IDF (intensity-duration-frequency) Curves and were determined to be representative.

### 2.1.3. Results

The results from the modeling are shown in Table 2.2. This table shows the flows for both existing and ultimate development situations, for the 25-year and 100-year storms. It should be noted that not all reaches on the brook were included in the model. The tributaries off the main channel were excluded from the analysis because they were in areas which are undevelopable due to land characteristics and land use. The location of the reaches can be seen in the Drainage Basin Plans (Figures 2.2 through 2.7). Detailed hydrologic model results are found in Appendix A.

**Table 2.2: Flood Flow Results from Hydrologic Modeling**

| Reach | Current Development | | | | Ultimate Development | | | |
|---|---|---|---|---|---|---|---|---|
| | 25-Year Flood | | 100-Year Flood | | 25-Year Flood | | 100-Year Flood | |
| | Flow $m^3/s$ | Storm Duration (hrs) | Flow $m^3/s$ | Storm Duration (hrs) | Flow $m^3/s$ | Storm Duration (hrs) | Flow $m^3/s$ | Storm Duration (hrs) |
| REACH01 | 1.03 | 12 | 1.41 | 12 | 1.03 | 12 | 1.41 | 12 |
| REACH03 | 1.23 | 12 | 1.86 | 24 | 1.23 | 12 | 1.86 | 24 |
| REACH05 | 1.69 | 12 | 2.96 | 12 | 1.69 | 12 | 2.96 | 12 |
| REACH07 | 1.84 | 12 | 3.29 | 12 | 1.85 | 12 | 3.30 | 12 |
| REACH15 | 3.35 | 12 | 6.23 | 12 | 3.55 | 12 | 6.54 | 6 |
| REACH16 | 3.45 | 12 | 6.41 | 12 | 3.66 | 12 | 6.74 | 6 |
| REACH19 | 4.37 | 12 | 8.24 | 6 | 4.81 | 12 | 9.09 | 6 |
| REACH20 | 5.65 | 12 | 10.85 | 6 | 6.33 | 12 | 12.24 | 6 |
| REACH21 | 6.64 | 12 | 12.88 | 6 | 7.58 | 12 | 14.81 | 6 |
| REACH22 | 6.67 | 12 | 12.93 | 6 | 7.61 | 12 | 14.86 | 6 |
| REACH23 | 7.21 | 12 | 13.92 | 6 | 8.22 | 12 | 16.09 | 6 |
| REACH24 | 7.37 | 12 | 13.93 | 6 | 8.40 | 12 | 16.15 | 6 |
| REACH25 | 7.40 | 12 | 13.97 | 6 | 8.43 | 12 | 16.20 | 6 |

## 2.2. <u>Drainage Structure Capacity Calculation</u>

### 2.2.1. General

Nine structures were located on Steadywater Brook through field investigations. These are listed in Table 2.3 below.

**Table 2.3: Existing Structure Descriptions**

| Structure No. | Reach | Type | Size | Street Crossing |
|---|---|---|---|---|
| Structure 1 | R24 | Two - Corrugated Metal Pipe (CMP) Pipe Arch | 2 @ 1.8m width x 1.2m height | Haggett's Turn |
| Structure 2 | R23 | Two – Structural Plate Pipe Arch | 2 @ 3.5m width x 2.0m height | Conception Bay Highway Route 60 |
| Structure 3 | R22 | Bridge with Abutment | 1 @ 3.6m width x 2.1m height | T'railway |
| Structure 4 | R21 | One - Corrugated Metal Pipe (CMP) Pipe Arch | 1 @ 3.3m width x 2.1m height | All Saint's Road |
| Structure 5 | R20 | One - Round Steel Pipe | 1 @ 1.8m diameter | Foot Path from Greeleytown Road |
| Structure 6 | R20 | Three - Corrugated Metal Pipe (CMP) Round Pipe | 3 @ 1.2m diameter | Greeleytown Road |
| Structure 7 | R19 | Two – Corrugated Metal Pipe (CMP) Pipe Arch | 2 @ 1.8m width x 1.2m height | Pandora Drive |
| Structure 8 | R15 | One – Corrugated Metal Pipe (CMP) Round Pipe | 1 @ 2.3m diameter | Conception Bay Bypass Route 2 |
| Structure 9[1] | R15 | One – Corrugated Metal Pipe (CMP) Round Pipe | 1 @ 0.6m diameter | Conception Bay Bypass Route 2 |

[1] Unable to locate the inlet of structure No. 9. This structure was excluded from the capacity analysis.

### 2.2.2. Results

The capacity of each of the eight critical structures was calculated and compared to the flood flows found in Table 2.2. Only the 100-year storm was considered for these structure capacity calculations. A summary of the results is found in Table 2.4.

For culverts requiring upgrading, preference was given to High Density Poly-Ethylene (HDPE) material due to its longevity. However, the flows through the stream were too high to accommodate the small diameters offered in HDPE. Second priority was given to fitting a single barrel over multiple barrels. It was assumed that no major roadwork would be necessary to upgrade the culverts. In one case, there was minimal clearance between the road elevation and stream bed, hence multiple barrels were required. For most cases, due to large flows, circular or pipe arch culverts in such large sizes were not available. Box Culverts were used to account for low clearance and high flows. All culverts were sized assuming inlet control. It is recommended that headwalls with wingwalls be installed on any upgrade, however several culverts require specific wingwalls as noted below.

**Table 2.4: Structure Capacity Calculations Results**

| Structure No. | Type | Existing Structure (mm) | Total Existing Capacity ($m^3/s$) | Current Dev. Flow ($m^3/s$) | Diameter of Culvert Required[1] (mm) | Ultimate Dev. Flow ($m^3/s$) | Diameter of Culvert Required[1] (mm) |
|---|---|---|---|---|---|---|---|
| Structure 1 | 2 – CM Pipe Arch | 2 - 1800 x 1200 | 4.9 | 13.93 | 2 - 3950 x 1220 Bridge Plate Box Culvert | 16.15 | 2 – 3950 x 1220 Bridge Plate Box Culvert[2] |
| Structure 2 | 2- Structural Plate Arch | 2 – 3500 x 2000 | 24.8 | 13.92 | No upgrade required | 16.09 | No upgrade required |
| Structure 3 | Bridge | 3600 wide x 2100 deep | 32.1 | 12.93 | No upgrade required | 14.86 | No upgrade required |
| Structure 4 | 1 – CM Pipe Arch | 1 – 3300 x 2100 | 9.5 | 12.88 | 1 – 4250 x 1800 Bridge Plate Box Culvert | 14.81 | 1 – 4800 x 1800 Bridge Plate Box Culvert |
| Structure 5[3] | 1 – Round Steel Pipe | 1 – 1800 | 5.3 | 5.65 | No upgrade required | 6.33 | No upgrade required |
| Structure 6 | 3 – Round CM Pipe | 3 – 1200 | 5.4 | 10.85 | 1 – 4100 x 1600 Bridge Plate Box Culvert | 12.24 | 1 – 4600 x 1600 Bridge Plate Box Culvert |
| Structure 7 | 2 – CM Pipe Arch | 2 – 1800 x 1200 | 4.8 | 8.24 | 1 – 4000 x 1220 Bridge Plate Box Culvert | 9.09 | 1 – 4000 x 1220 Bridge Plate Box Culvert[2] |
| Structure 8 | 1 – Round CM Pipe | 1 – 2300 | 8.5 | 6.23 | No upgrade required | 6.54 | No upgrade required |

[1] Culverts dimensioned based on Armtec products
[2] Need Wingwalls with 30º to 75º Flare
[3] Structure 5 was analyzed for the 25-year flow.

Structure 1

Structure number 1 is the most downstream control point, located on Haggett's Turn, close to Butler's Pond. The location is shown on Figure 2.3. Currently there are two Corrugated Metal (CM) Pipe Arch culverts with dimensions 1.8m width by 1.2m height each. This is significantly undersized for both the current and ultimate flood flows. The difference between the road elevation and the stream bed in this area is only 1.71m. Minimum cover over culverts is typically 450mm, which means the maximum height for a culvert is 1.26m. This is a considerable constraint, especially considering the high flow rates.

There are several options. If a culvert is desired, multiple barrels would be necessary. To pass the ultimate development flow, two bridge plate box culverts are required, with 30º - 75º wingwall flares, dimensions of 3.95m width and 1.22m height.

Structure 2

Structure 2 consists of two culverts located on the Conception Bay Highway Route 60 as shown in Figure 2.3. This structure is currently two multi-plate metal arches, with dimensions 3.5m wide and 2m high. This structure has adequate capacity to handle both the current and ultimate development flood flows as listed above.

Structure 3

Structure 3 is a bridge over the T'railway, see Figure 2.3. It has a width of 3.6m at its narrowest point and a height of 2.1m in the centre of the brook. Manning's equation was used to determine the capacity of this structure. Information was taken from mapping and visual inspection of the river. To determine the capacity, it was assumed the bridge would run full. This resulted in a capacity of 32.1 $m^3/s$, which is more than double the ultimate development flow rate of 14.86 $m^3/s$. There is no need to upgrade this structure.

Structure 4

Structure 4 is a culvert located on All Saint's Road, see Figure 2.3. Currently, there is a single barrel CM Pipe Arch with dimensions 3.3m width and 2m height. This is undersized for both the current and ultimate development flows.

The difference in road and stream bed elevation is 2.45m. With a minimum cover of 450mm, the maximum height for a culvert is 2.0m. A bridge plate box culvert sized 4.8m width by 1.8m height will handle the ultimate development flows.

Structure 5

This structure is a small 1.8m diameter round steel pipe over a foot path from Greeleytown Road, the location is shown on Figure 2.3. This is significantly undersized for the 100-year flows through the brook however it is recommended to size this structure for only the 25-year flow due to its location. Currently, the culvert can pass the 25-year flow with a headwater to diameter ratio (HW/D) of 1.07, meaning there will be a freeboard of over 1.5m. For future development conditions, the HW/D is 1.2, and a freeboard of 1.3m will be maintained. Upgrades are not required on this structure.

Structure 6

Structure 6 is located on Greeleytown Road and consists of 3 round CM pipes each 1.2m diameter, see Figure 2.4 for location. The capacity of each of these pipes is 1.8 $m^3/s$ with a combined capacity of 5.4 $m^3/s$. This is less than both the current and ultimate development flows. The elevation difference between the road and stream bed is 2.04m. With a 450mm minimum cover, the maximum culvert height is 1.59m. For ultimate development flows, a 4.6m wide by 1.6m high bridge plate box culvert will be required here.

Structure 7

Structure 7 consists of two CM pipe arches 1.8m wide by 1.2m high, located on Pandora Drive, the location is shown on Figure 2.4. The combined capacity of these two culverts is 4.8 $m^3/s$. The ultimate development flow is 9.09 $m^3/s$, which is approximately double the capacity. This culvert will require upgrading.

The clearance between the stream bed and road elevation is 1.62 m, with a 450mm culvert cover, the maximum culvert height is 1.17m. It is recommended to install a 4m wide by 1.22m high bridge plate box culvert with 30º - 75º wingwalls. Even with this culvert, there will be flooding during storm events. A freeboard of 320mm will be maintained during the 100-year ultimate development scenario. Alternatively, a bridge in this location would allow the flow to pass freely.

Structure 8

This structure is a large 2.3m diameter round CMP culvert located on the Conception Bay Bypass Highway Route 2, see Figure 2.4. The capacity of this structure is 8.5 m³/s. The ultimate development flow is 6.54 m³/s. This culvert requires no upgrades as it can pass both the current and ultimate development flows.

Structure 9

Structure 9 is a small round CMP culvert located on the Conception Bay Bypass Route 2. Multiple site visits were conducted and the inlet of this 600mm diameter pipe was never found. It is suspected that this culvert is solely for cross drainage. Because of this, it was excluded from our structure sizing exercise and the drainage from the basins into this culvert were assumed to route directly through the larger 2.3m diameter culvert.

### 2.2.3. Future Development

Each reach was analyzed to determine the required structure size for future developments. A maximum height of 2m was used in the recommended culvert selection. See Table 2.5 below.

**Table 2.5: Culvert Recommendations Based on Reach Flows**

| Reach. | Current Dev. Flow (m³/s) | Minimum Flow Area (m²) | Culvert Recommendation (mm) | Ultimate Dev. Flow (m³/s) | Required Flow Area (m²) | Culvert Recommendation (mm) |
|---|---|---|---|---|---|---|
| REACH01 | 1.41 | 0.87 | CMP ROUND 1050 | 1.41 | 0.87 | CMP ROUND 1050 |
| REACH03 | 1.86 | 1.13 | CMP ROUND 1200 | 1.86 | 1.13 | CMP ROUND 1200 |
| REACH05 | 2.96 | 1.77 | CMP ROUND 1500 | 2.96 | 1.77 | CMP ROUND 1500 |
| REACH07 | 3.29 | 1.77 | CMP ROUND 1500 | 3.30 | 1.77 | CMP ROUND 1500 |
| REACH15 | 6.29 | 3.42 | CMP ARCH 2490x1750 | 6.54 | 3.60 | CMP ARCH 2490x1750 |
| REACH16 | 6.41 | 3.50 | CMP ARCH 2490x1750 | 6.74 | 3.75 | CMP ARCH 2490x1750 |
| REACH19 | 8.24 | 4.38 | CMP ARCH 2900x1960 | 9.09 | 4.66 | CMP ARCH 2900x1960 |
| REACH20 | 10.85 | 5.35 | CMP ARCH 2900x1960 | 12.24 | 5.50 | CMP ARCH 3980x2210 |
| REACH21 | 12.88 | 5.60 | BP BOX 4100x1600 | 14.81 | 6.80 | BP BOX 4250x2000 |
| REACH22 | 12.93 | 5.65 | BP BOX 4100x1800 | 14.86 | 6.85 | BP BOX 4250x2000 |
| REACH23 | 13.92 | 6.40 | BP BOX 4250x1800 | 16.09 | 7.08 | BP BOX 4250x2000 |
| REACH24 | 13.93 | 6.40 | BP BOX 4250x1800 | 16.12 | 7.10 | BP BOX 4250x2000 |
| REACH25 | 13.97 | 6.45 | BP BOX 4250x1800 | 16.20 | 7.13 | BP BOX 4250x2000 |

*Note: Headwalls with wingwalls are recommended on all structures.

## 2.3. Hydraulic Modeling

### 2.3.1. General

Hydraulic modeling was requested to determine the extent of flooding in a storm event. Both the 25-year and 100-year storms were considered in this analysis. HEC-RAS, a software developed by the US Army Corps of Engineers, was employed to route the flow data generated from HEC-HMS through a user-defined channel to calculate water levels. Water levels from HEC-RAS were exported to AutoCAD to determine the floodplain. Cross section data for the HEC-RAS model was surveyed and physical properties were estimated based on field observations.

### 2.3.2. Analysis

The area around and downstream of the CBS Bypass Route 2 was included in the model as this area is currently developed with several properties lying close to the suspected floodplain.

HEC-RAS has the capability of running both steady and unsteady analyses. A steady state analysis was used and flows for each individual cross section were input to account for attenuation. Cross sections are shown in Figure 2.8.

While Structure 9 was excluded from the hydrologic model, the structure along with the tributary to the main channel was included in the HEC-RAS model since there are several homes in the area.

The following scenarios were modeled and floodplains generated:

1. Current Development: 25-Year and 100-Year Flow
2. Future (Ultimate) Development: 25-Year and 100-Year Flow
3. Future (Ultimate) Development, 25-Year and 100-Year Flow, assuming structures upgraded

Boundary conditions were developed for both upstream and downstream points so that a mixed flow regime could be used. Normal depth was assumed upstream for both the main channel and tributary. The upstream slope for the main channel was 0.0211 m/s and for the tributary 0.014 m/m. The downstream boundary conditions for each scenario were the water levels for Butler's Pond generated from HEC-HMS.

Manning's 'n' values were selected from standardized tables based on field observations. For the main channel, a value of 0.04 was used to denote a channel with gravels, cobbles and a few boulders. For the overbanks, 0.07 was used for medium to dense brush in winter (USACE, 2010).

No storage areas were considered in this analysis since the varied flow values have accounted for storage from HEC-HMS.

Interpolation between sections was used due to the instability that arises in the model when sections are too far apart.

Levees and ineffective flow areas were employed where required to limit the flow to the main channel.

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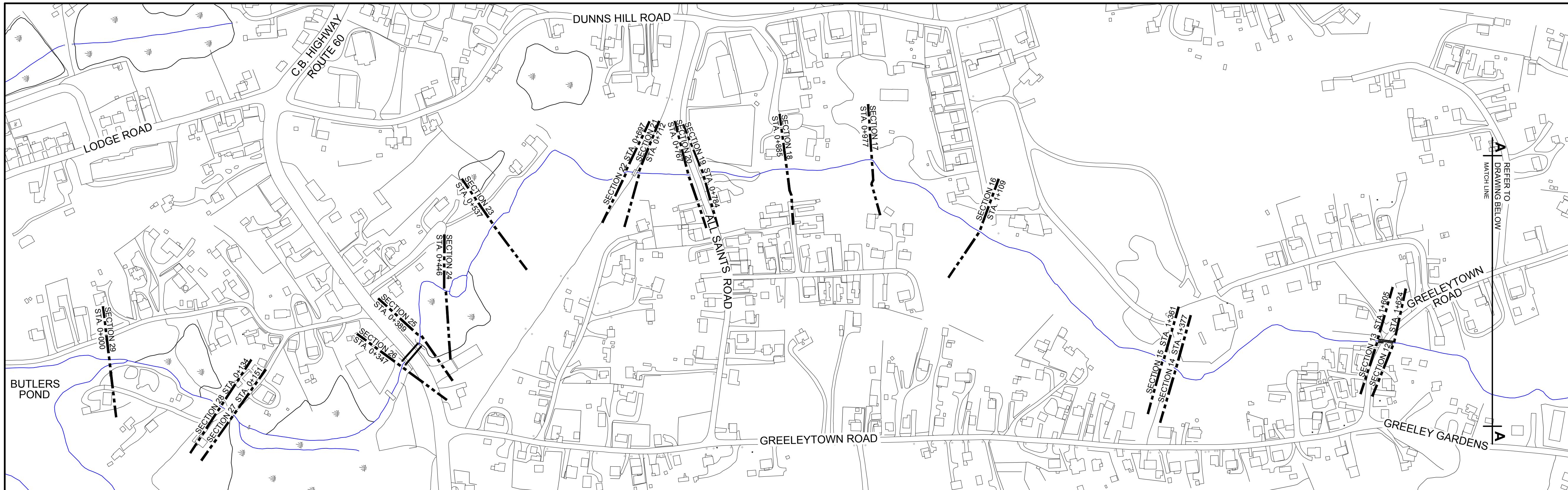
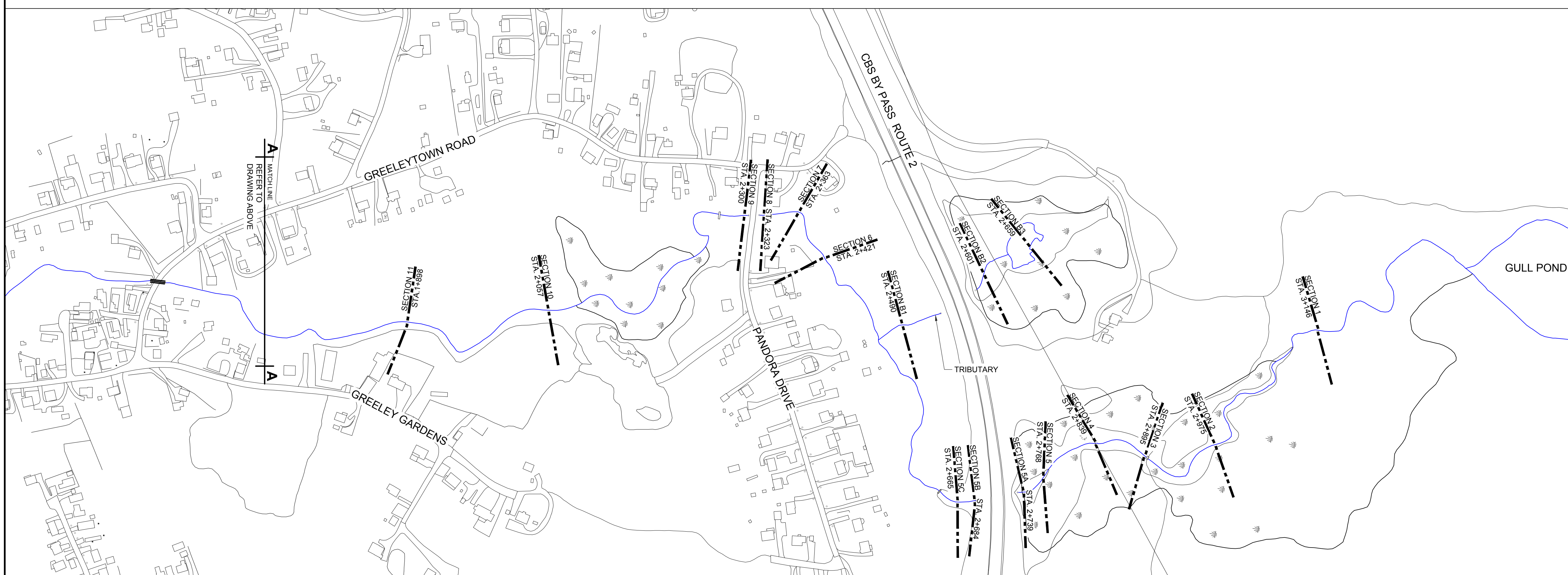



## SECTION PLAN

0 50 100m




## SECTION PLAN

0 50 100m

REFERENCE FILES:

| REV. | REVISIONS | REVISED BY | APP. BY | DATE |
|---|---|---|---|---|
| C01 | ISSUED FOR FINAL REPORT | | | 15/06/09 |

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CLIENT
**TOWN OF CONCEPTION BAY SOUTH**

PROJECT
**STEADYWATER BROOK STORM WATER MANAGEMENT PLAN**

TITLE
**FIGURE 2.8 CROSS SECTION LOCATION PLAN**

| | | | | | |
|---|---|---|---|---|---|
| DESIGNED BY | T.G. | CHECKED BY | | DATE | 14/02/21 |
| DRAWN BY | N.B. | APPROVED BY | | DATE | 14/02/21 |
| SCALE | AS SHOWN | BNG PROJ. No. | 512537 | | |
| | | CLIENT PROJ. No. | | | |

DRAWING No. PR 1 – XX – CV – XX – 009 REV. C01

### 2.3.3. Results

The results from the above scenarios are shown in Figure 2.9, Figure 2.10, and Figure 2.11. Full size drawings are located in Appendix C. Detailed reports from HEC-RAS are located in Appendix B.

For each scenario, the 25-year and 100-year flood lines are shown. As well, a 15 m buffer line is shown on either side of the 100-year floodplain.

Current Development

Figure 2.9 shows the floodplain for the current development scenario for both the 25-year and 100-year return periods. All residences and commercial buildings located within the floodplain and 15 m buffer zone have been identified. Buildings labeled as Auxiliary Buildings in the interactive town mapping provided by the town were not included.

No significant flooding is noted for the 25-year return period. The 100-year flood will overtop the banks and flood several properties. A commercial property on the Conception Bay Highway (Route 60) will flood as well as several residential properties upstream of the Greeleytown Road crossing. None of the culverts will overtop.

Near Butler's Pond, Concord Drive and Haggett's Turn will flood in the 25-year and 100-year storms. The homes on these roads do not appear to be affected in either storm.

Future Development

Figure 2.10 shows the floodplain for the future development scenario for both the 25-year and 100-year return periods.

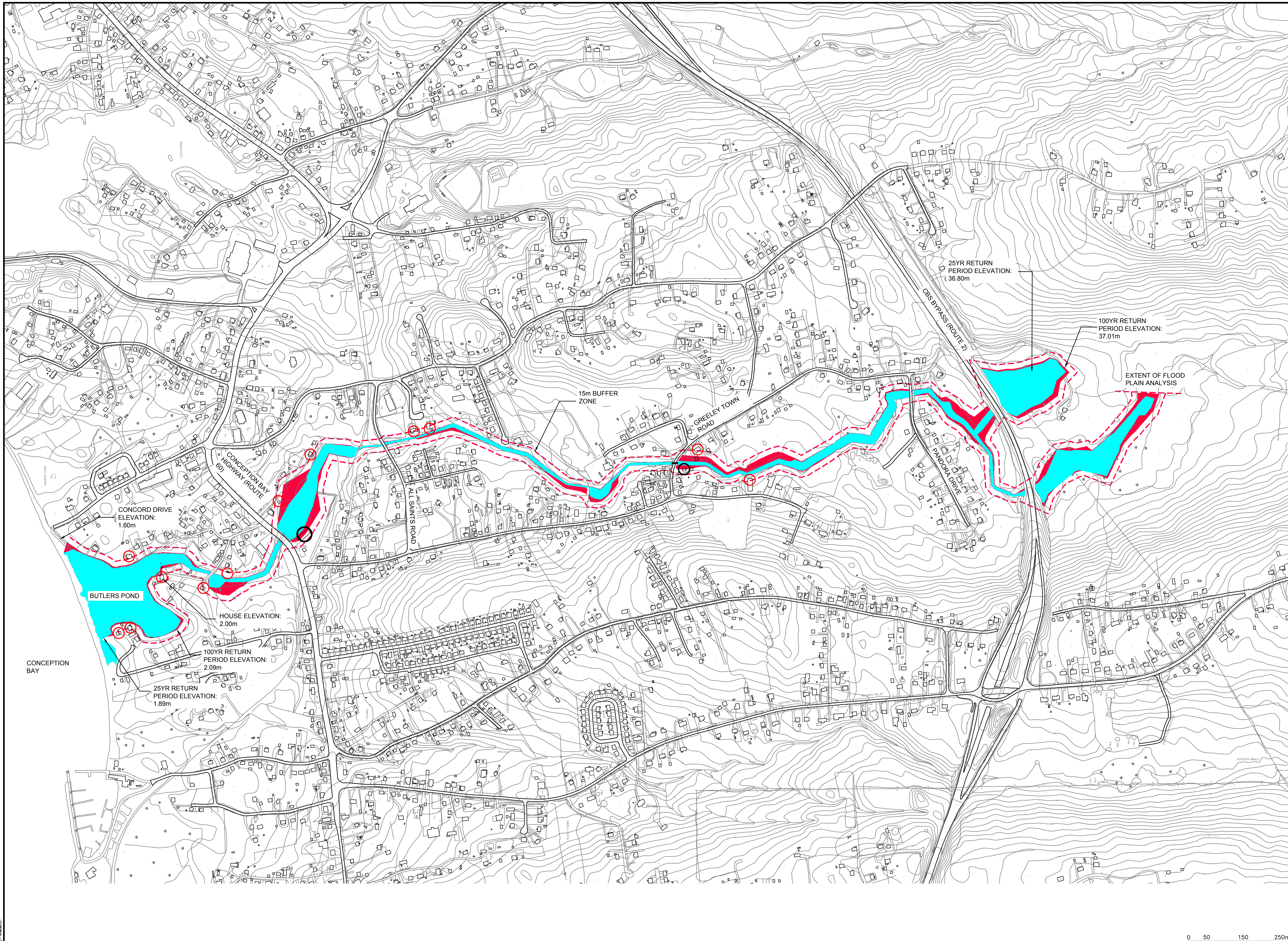
Flooding on Greeleytown Road near the stream crossing and on Conception Bay Highway Route 60 remains a growing concern with the additional runoff from ultimate development. None of the culverts will overtop.

Concord Drive and Haggett's Turn will flood in both 25-year and 100-year storms. Several residential properties on Haggett's Turn and Batten's Road appear to flood.

Future Development with Structure Upgrades

Figure 2.11 shows the floodplain for future development conditions with structure upgrades. Upstream of Greeleytown Road, the extent of flooding has significantly reduced. Only one property appears to be affected (as opposed to 3-4 properties if no structure upgrades were completed).

Above Conception Bay Highway (Route 60), flooding still occurs during the 100-year storm, however the 25-year storm will not flood the neighboring properties.

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25 YEAR RETURN PERIOD

100 YEAR RETURN PERIOD

15m BUFFER ZONE

RESIDENCES OR COMMERCIAL BUILDINGS LOCATED WITHIN FLOOD PLAIN 15m BUFFER. BASED ON TOWN MAPPING (2001)

RESIDENCES OR COMMERCIAL BUILDINGS LOCATED WITHIN FLOOD PLAIN. BASED ON TOWN MAPPING (2001)

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**TOWN OF CONCEPTION BAY SOUTH**

PROJECT

**STEADYWATER BROOK STORM WATER MANAGEMENT PLAN**

TITLE

**FIGURE 2.9 FLOODPLAIN CURRENT DEVELOPMENT**

| | | | | | |
|---|---|---|---|---|---|
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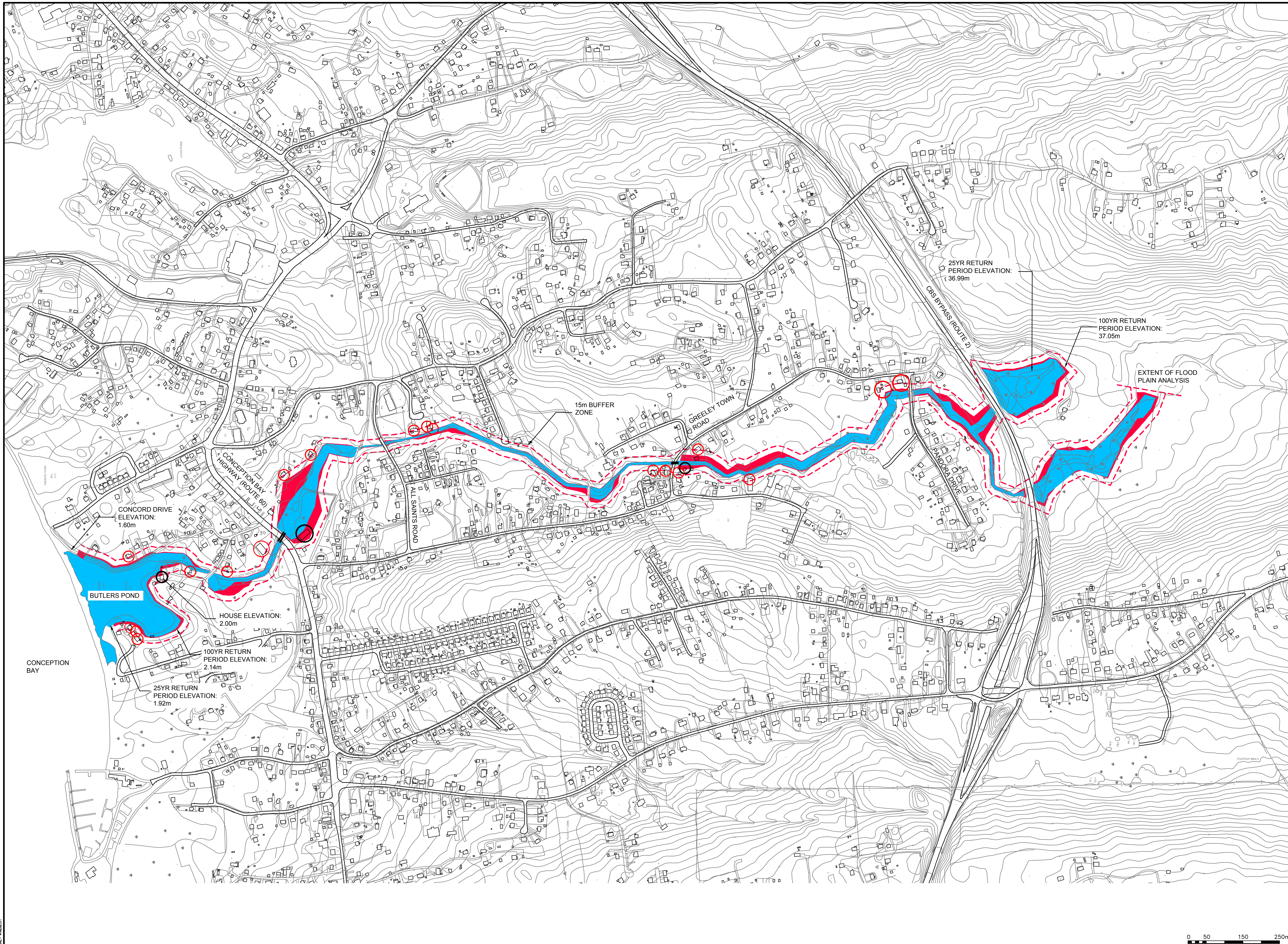




25 YEAR RETURN PERIOD

100 YEAR RETURN PERIOD

15m BUFFER ZONE

RESIDENCES OR COMMERCIAL BUILDINGS LOCATED WITHIN FLOOD PLAIN 15m BUFFER. BASED ON TOWN MAPPING (2001)

RESIDENCES OR COMMERCIAL BUILDINGS LOCATED WITHIN FLOOD PLAIN. BASED ON TOWN MAPPING (2001)

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# FIGURE 2.10 FLOODPLAIN FUTURE DEVELOPMENT

| | | | | | |
|---|---|---|---|---|---|
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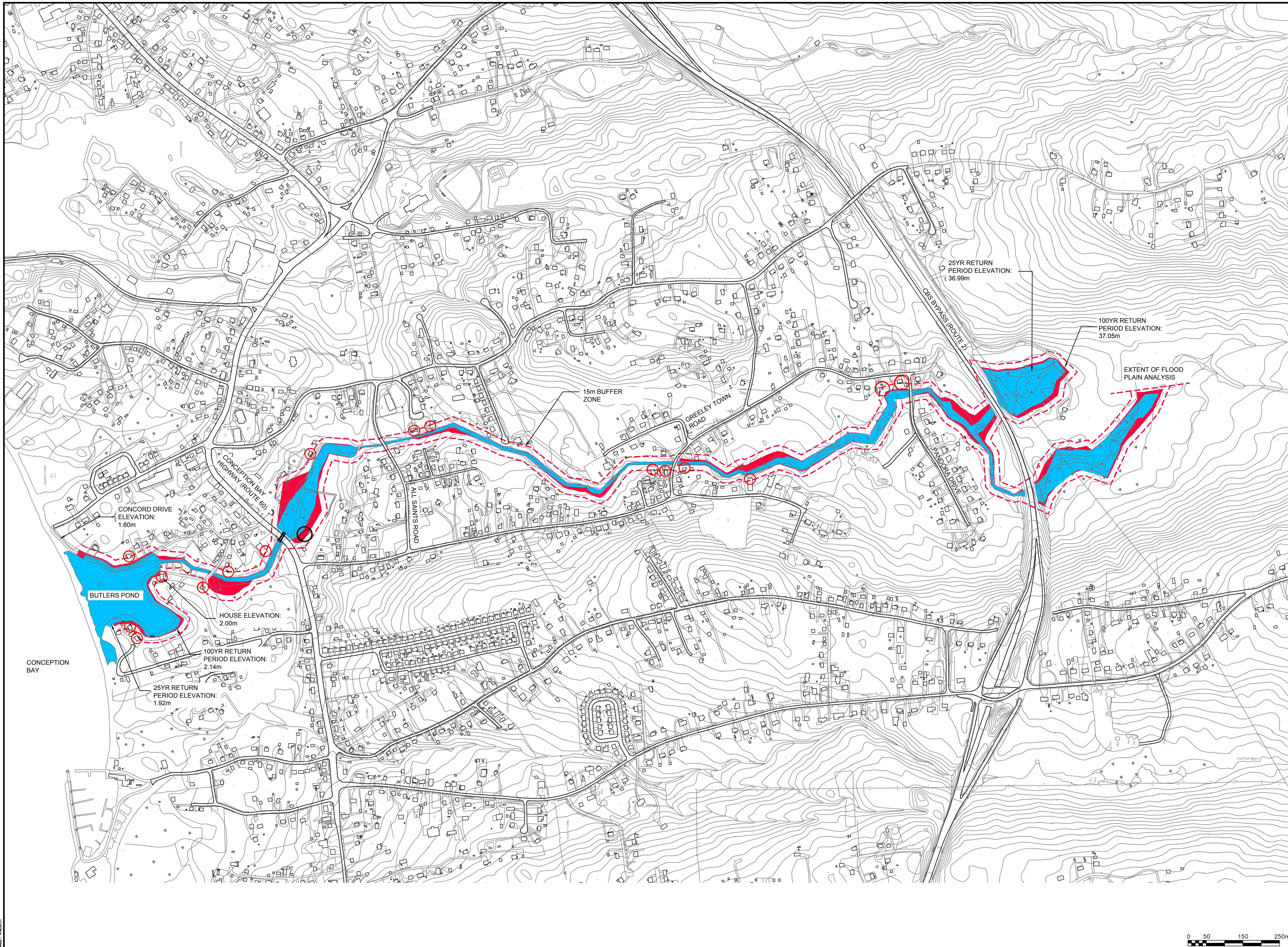


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- 25 YEAR RETURN PERIOD
- 100 YEAR RETURN PERIOD
- 15m BUFFER ZONE
- RESIDENCES OR COMMERCIAL BUILDINGS LOCATED WITHIN FLOOD PLAIN 15m BUFFER. BASED ON TOWN MAPPING (2001)
- RESIDENCES OR COMMERCIAL BUILDINGS LOCATED WITHIN FLOOD PLAIN. BASED ON TOWN MAPPING (2001)

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FIGURE 2.11-FLOOD PLAIN FUTURE DEVELOPMENT WITH STRUCTURE UPGRADES

| | | | |
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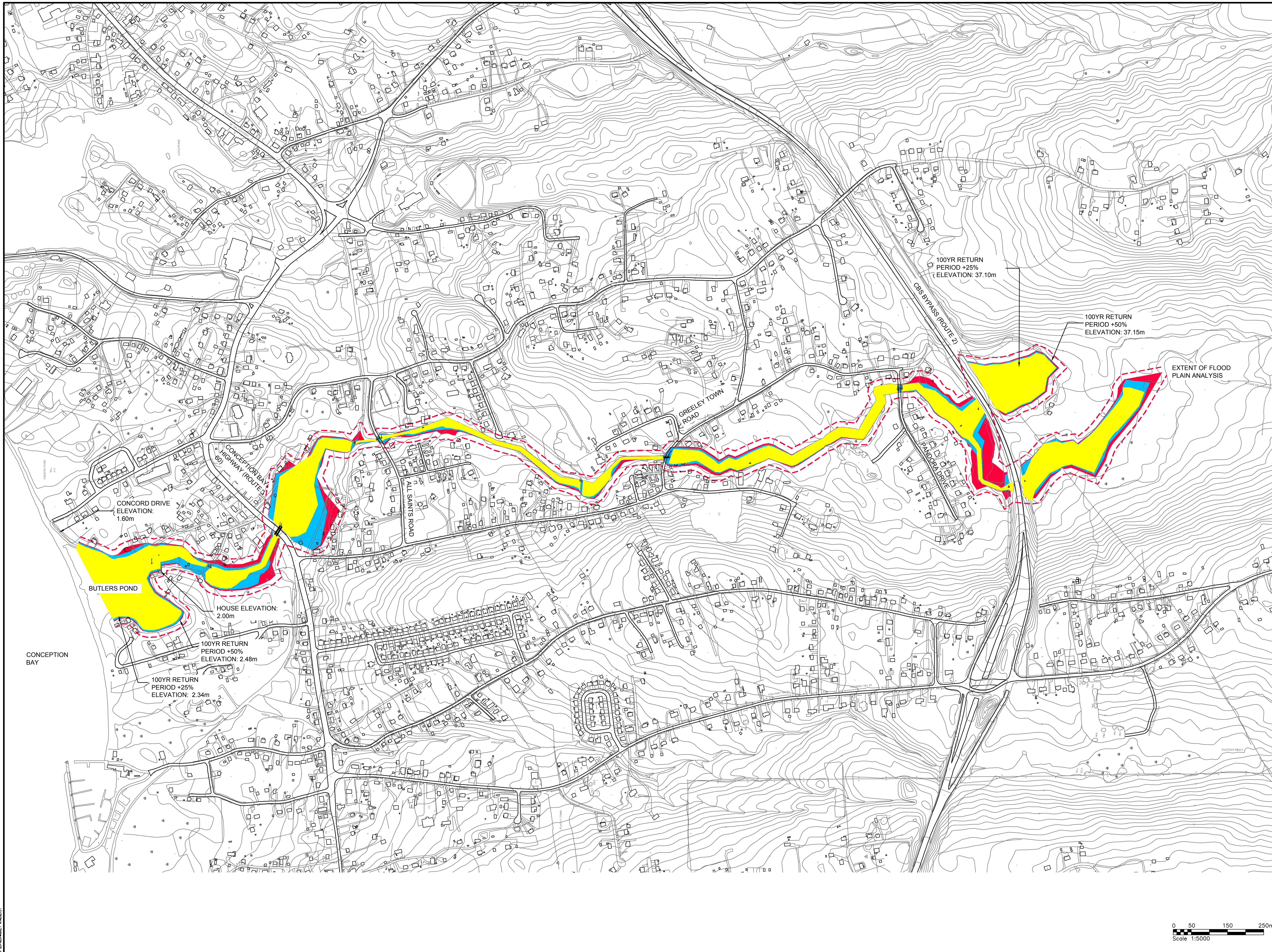
## 2.4. Sensitivity Analysis

### 2.4.1. Flow Sensitivity Analysis

In recent years, there has been an increased incidence of storms with higher return periods than expected. Due to this, a flow rate sensitivity analysis was examined. The 100-year precipitation data from Table 1.2 was increased by 25% and 50% and both hydrologic and hydraulic modeling completed with these increased values. Figure 2.12 shows the floodplain for Future Development with Increased Flows.

The main areas of concern remain as the regions above Greeleytown Road, above Conception Bay Highway, and around Butler's Pond. Flooding extends past the banks and more private property will be affected. Approximately 4-6 residences above Greeleytown Road will be impacted. Several commercial and residential properties on the Conception Bay Highway will flood as well. Haggett's Turn and Concord Drive will flood and several homes on these streets, as well as on Batten's Road, will be affected.

As well, Pandora Drive, Greeleytown Road, All Saint's Road, and Haggett's Turn will flood at their crossings, causing serious accessibility and emergency egress issues.

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- 100 YEAR RETURN PERIOD
- 100 YEAR RETURN PERIOD +25%
- 100 YEAR RETURN PERIOD +50%
- 15m BUFFER ZONE

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**FIGURE 2.12-FLOODPLAIN FUTURE DEVELOPMENT WITH INCREASED FLOWS**

| | | | | | |
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#### 2.4.2. Permeability Sensitivity Analysis

Sensitivity analysis was also conducted on the rate of permeability through the barachois on Butler's Pond. A value of $10^{-1}$ m/s was assumed in this study. To determine if this is an acceptable value, values of $10^{0}$ m/s and $10^{-2}$ m/s were input into HEC-HMS to determine the sensitivity. Table 2.6 below illustrates the effect on water levels at Butler's Pond.

**Table 2.6: Water Levels at Butler's Pond - Permeability Sensitivity**

| | **Permeability (K)** | | |
|---|---|---|---|
| **Development Scenario** | **K = $10^{-2}$ m/s** | **K = $10^{-1}$ m/s** | **K = $10^{0}$ m/s** |
| Current Development | 2.11 m | 2.09 m | 1.82 m |
| Future Development | 2.16 m | 2.00 m | 1.86m |

The variation in water levels between the $10^{-2}$ and $10^{-1}$ permeability values is only 16 cm for the future development scenario. The $10^{0}$ permeability exhibits greater variance, however it produces a lower water level than the other two values. In the interest of being conservative, a permeability of $10^{-1}$ m/s is a reasonable assumption.

### 2.5. <u>Stormwater Retention and Flood Protection</u>

#### 2.5.1. Stormwater Retention

Stormwater retention would be beneficial for areas prone to flooding. From the floodplain analysis, noted properties which would flood in a 100-year return period include those areas upstream of the Conception Bay Highway Route 60 and upstream of the Greeleytown Road culvert.

Retention could alleviate the flooding on these properties. There is open space upstream of the culvert on Greeleytown Road where a dam could be constructed to pond water and release gradually. A dam in this location would be limited to the 30m contour so as to avoid flooding in other areas along the reach. Hydrologic and hydraulic modeling was conducted and the results are in Table 2.7 as follows.

**Table 2.7: Water Levels with Retention**

| | **Water Level @ Greeleytown Road** | **Water Level @ CB Highway Rte 60** |
|---|---|---|
| Without Retention | 28.83 m | 3.35 m |
| With Retention | 28.79 m | 3.17 m |
| ***Difference*** | ***0.04 m*** | ***0.18 m*** |

There is little impact downstream from retaining the water in the location proposed. At Greeleytown Road there will be a 4 cm reduction in water levels and at Conception Bay Highway only 18 cm. The potential benefit is not significant enough to warrant the construction and maintenance of a dam.

Other areas were considered, specifically above the Conception Bay South Bypass Highway Route 2. The marshy area just upstream of the highway would be an ideal place for retention, however there are existing low-lying houses on Rocky Place which would be flooded if retention was allowed in this area. Further upstream, the brook runs through a valley with a fairly steep side slope. A dam in this area would provide little storage. Retention on this stream is not a viable option to prevent flooding, therefore no recommendations are made.

### 2.5.2. Flood Prevention

Properties prone to flooding were assessed for flood protection by barrier construction. A commercial property on Conception Bay Highway currently used as an Auto Parts Shop is particularly sensitive to increases in water levels. An option to prevent flooding on this property is to construct a barrier alongside the stream, preventing high water from reaching the property. Through our analysis, it was found that a barrier would indeed protect this property, however it would push the water to the east side of the stream and the properties on Donny Brook Road would flood. Barriers on both sides of the stream would restrict flooding either side however water would likely pool behind these barriers and cause flooding to other properties. The barrier itself would also be a large investment for little expected return.

Alternatively, an overflow culvert was considered across Conception Bay Highway Route 60. In order for this to be an option, the tailwater would have to be significantly less than the headwater during a flood event. From the hydraulic model, this was not the case. The tailwater was approximately 300mm lower than the headwater across the culvert in a 100-year flood scenario. This is not a viable option to prevent flooding.

### 2.5.3. Zero Net Runoff

Consideration was given throughout this study on the advantages of implementing a zero net runoff policy. A zero net runoff policy would require that all future development implement retention to maintain the existing development runoff flows. If the flooding caused by future development was much more extensive than the current development, this policy would be beneficial to prevent future stormwater management issues. However this is not the case for the Steadywater Brook basin; the future, full development runoff (assuming no retention) will not flood any additional homes. A zero net policy would increase the cost to any developers wishing to build in the area by requiring retention structures, as well as increase the cost to the Town for maintenance. The benefit of the policy does not appear to justify the cost of the program, therefore this policy is not recommended at this time.

# 3.0 CONCLUSIONS AND RECOMMENDATIONS

## 3.1. Infrastructure Upgrades

Drainage structures should at minimum be upgraded to pass the current development flows as calculated in this report. Given the current pace of development, consideration should be given to upgrading the structures to allow for ultimate development flow to reduce the need for secondary improvements as development occurs. While HDPE is the preferred material for new culverts, bridge plate box culverts are recommended due to the high flows through the brook. Single barrels are recommended over multiple barrels if feasible. Upgraded structures should include proper headwalls and wingwalls.

Consideration should also be given to a new outlet design for Butler's Pond to avoid flooding issues on Concord Drive and Haggett's Turn. These homes are low-lying and are susceptible to flooding in extreme events. One potential option is to design and construct two perpendicular breakwaters as illustrated in Figure 3.1. This would reduce infilling of the outlet with cobble under tidal action. A budgetary estimate has been provided for this upgrade (see Section 4.1), however a study of Conception Bay, detailing tidal and wave action, will be required to determine the actual design criteria.

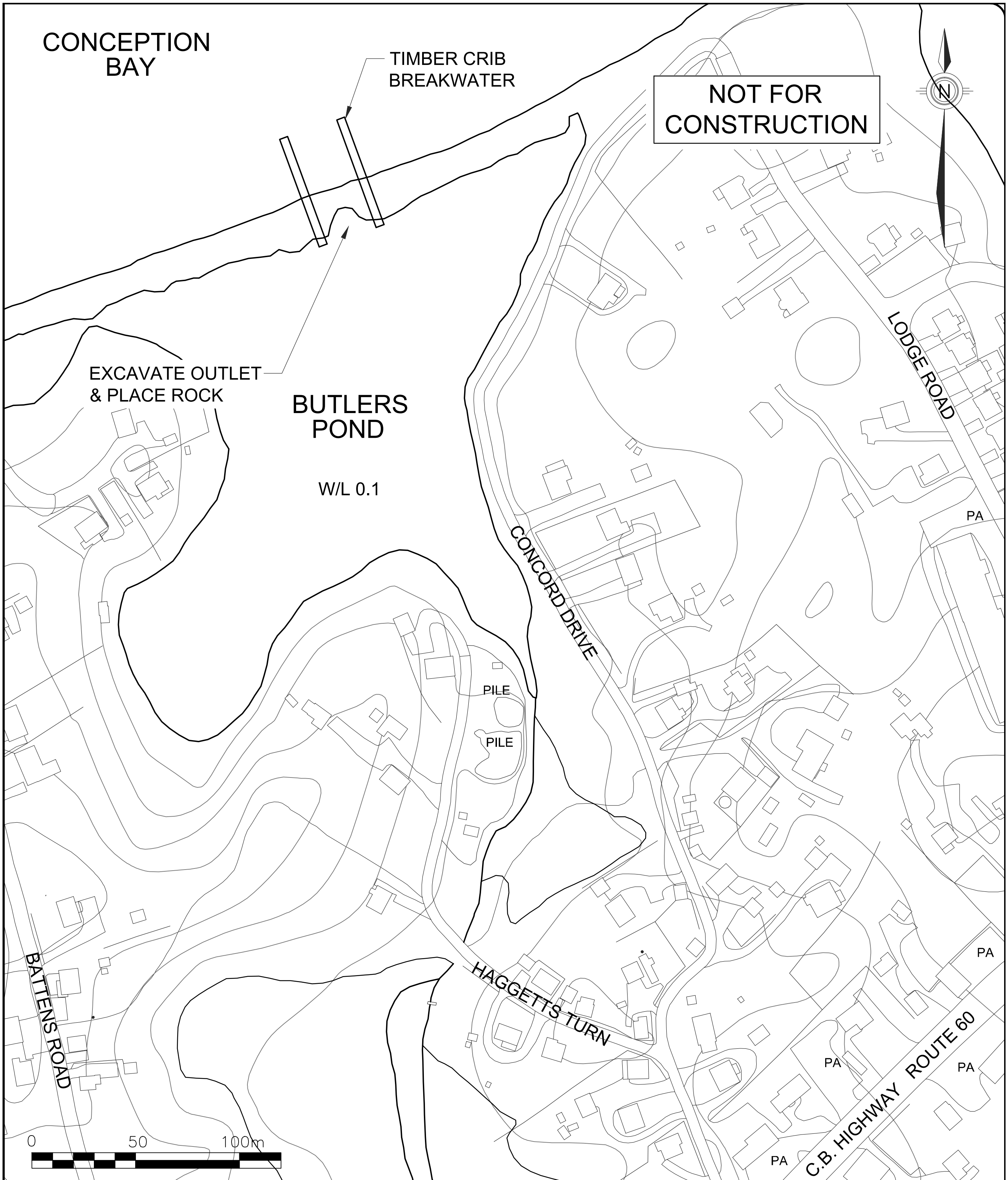
## 3.2. Floodplain Buffers

It is recommended that a 15 m buffer zone on either side of the 100-year flood line shall be maintained. No further development shall be permitted inside this buffer zone. Likewise, it is also recommended that existing wetlands be preserved and that development that would impact upon the wetlands be limited.

Some existing development currently lies within the 15 m buffer zone as illustrated on the floodplain drawings. These properties have been analyzed for flood protection, however none of the options evaluated appear to prevent flooding, so there is little that can be done with the exception of relocating the existing development outside the buffer zone.

## 3.3. Stormwater Retention

Stormwater retention was considered in several areas, however due to geography, no viable option is proposed to reduce flooding downstream.

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PROJECT:
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FIGURE 3.1
PROPOSED OUTLET
BUTLER'S POND

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## 3.4. Flood Prevention

Options were considered to prevent flooding on properties alongside the Conception Bay Highway, including constructing barriers or adding overflow culverts. None of these appear to alleviate the high waters during a flood situation.

## 3.5. Flood Protection

The Town has several options for protecting vulnerable properties. Depending on the location and elevation of the affected homes, the houses could be raised past the water elevation, protecting the main living space. However basements would remain vulnerable and sump pumps, if not already installed, would be necessary.

Another option for the Town is to offer to purchase the few properties which lie in the 100-year floodplain at fair market value. The purchased land would be designated as Open Space and development prohibited based on the Town's Development Regulations.

## 3.6. Future Development

### 3.6.1. Future Infrastructure

New stormwater infrastructure on the Steadywater Brook system should conform to the minimum requirements set out in Table 2.5. While the type of structure is a recommendation only, the structure shall be required to handle the flood of the magnitude shown.

### 3.6.2. Design Storm

It is recommended that all major stormwater infrastructure, including all road culverts and bridges crossing Steadywater Brook, be designed for a 100-year return period.

### 3.6.3. Stormwater Master Plan

It is advised that the Town refer to this document in reviewing and approving any development occurring in the Steadywater Brook basin.

# 4.0 IMPLEMENTATION PLAN

## 4.1. Structure Upgrades

Due to possible funding and time constraints, the structures slated for development as listed in Section 2.2.2 were graded on their upgrade priority. The location of each structure was examined and classified as follows:

- High Importance Level – Main thoroughfare, collector or arterial
- Medium-High Importance Level – Local with through traffic
- Medium Importance Level – Local, Cul-De-Sac, no through traffic
- Medium-Low Importance Level – Non-paved local, no through traffic
- Low Importance Level – Foot path, no traffic

For each structure, the percentage by which it is undersized was calculated. Then they were classified based on the priority levels as follows:

- Priority Level 1: Undersized by more than 100%
- Priority Level 2: Undersized by 50% - 100%
- Priority Level 3: Undersized by less than 50%.

See culvert upgrade classification information in Table 4.1.

**Table 4.1: Structure Upgrade Priority**

| Structure | Location | Importance Level | Priority Level |
|---|---|---|---|
| Structure 1 | Haggett's Turn | Medium | 1 |
| Structure 4 | All Saint's Road | Medium-High | 3 |
| Structure 6 | Greeleytown Road | Medium-High | 1 |
| Structure 7 | Pandora Drive | Medium | 2 |

The structures with the highest priority level are Structure 1 on Haggett's Turn and Structure 6 on Greeleytown Road.

## 4.2. Outlet to Bay

The outlet from Butler's Pond to Conception Bay is critical to prevent flooding on Haggett's Turn and Concord Drive. The estimate provided in this report is only an order of magnitude estimate as detailed design may dictate further work.

To complete a detailed design, a study is required detailing water levels, wave, and tides on Conception Bay.

## 4.3. Budget Estimate for Upgrades

A budget estimate was prepared to include the culvert upgrades as recommended in Section 2.2.2 and Butler's Pond outlet construction. This order of magnitude estimate is shown in Table 4.2. It should be noted that the estimate for Butler's Pond outlet is based on preliminary assumptions which need to be verified by a thorough marine study and detailed design.

**Table 4.2: Budget Estimate for Upgrades**

| | **Upgrade Option** | | | | |
|---|---|---|---|---|---|
| **Component** | **Structure 1** | **Structure 4** | **Structure 6** | **Structure 7** | **Outlet to Butler's Pond** |
| Upgrade Cost | $112,000 | $73,000 | $91,000 | $66,000 | $974,000 |
| Contingency (20%) | $22,000 | $15,000 | $18,000 | $13,000 | $195,000 |
| HST (13%) | $17,000 | $11,000 | $14,000 | $10,000 | $152,000 |
| Engineering (15%) | $23,000 | $15,000 | $18,000 | $13,000 | $198,000 |
| ***Total*** | ***$174,000*** | ***$114,000*** | ***$142,000*** | ***$103,000*** | ***$1,519,000*** |

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