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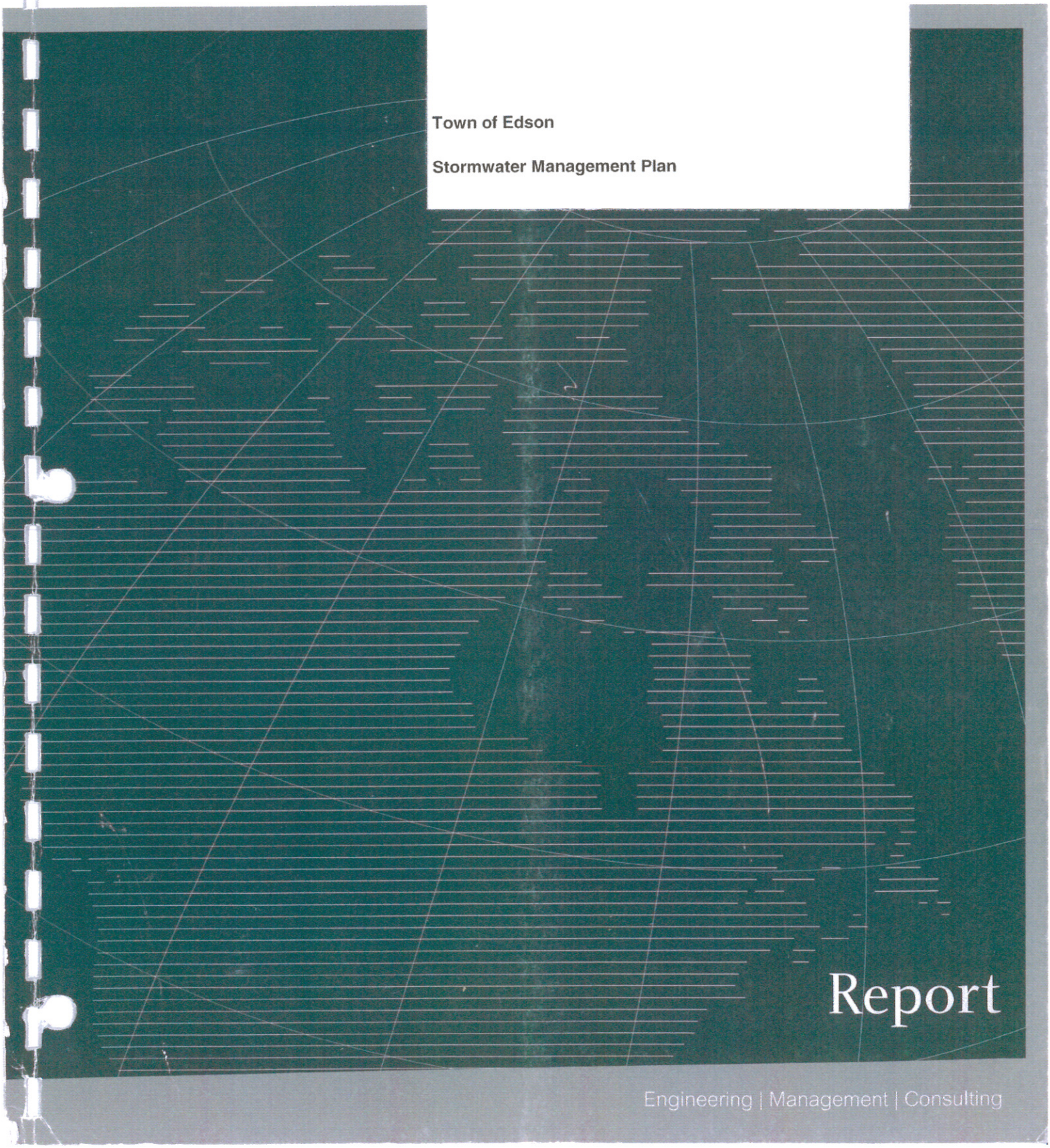
# Town of Edson

# Stormwater Management Plan



## Report

Engineering | Management | Consulting

UMA | AECOM

**Town of Edson**

**Stormwater Management Plan**

Prepared by:
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Job No.: 4193-030-00-03-4.6.1



July 2005

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July 11, 2005

File Name: 4193-030-00

Ajit Masand
Director of Engineering and Planning
Town of Edson
P.O. Box 6200
605 - 50 Street
Edson AB T7E 1T7

Dear Sir:

**Re: Town of Edson, Stormwater Management Plan**

We are pleased to submit our final report on the Stormwater Management Plan for the Town of Edson. We have incorporated the comments received during the review of the draft report.

If you have any questions or require any further information please call.

Sincerely,

**UMA Engineering Ltd.**

Marcel LeBlanc, P.Eng.
Director, Water Management
marcel.leblanc@uma.aecom.com

MRL:blb

Encl.

cc: D. Gilbertson, UMA Engineering Ltd.

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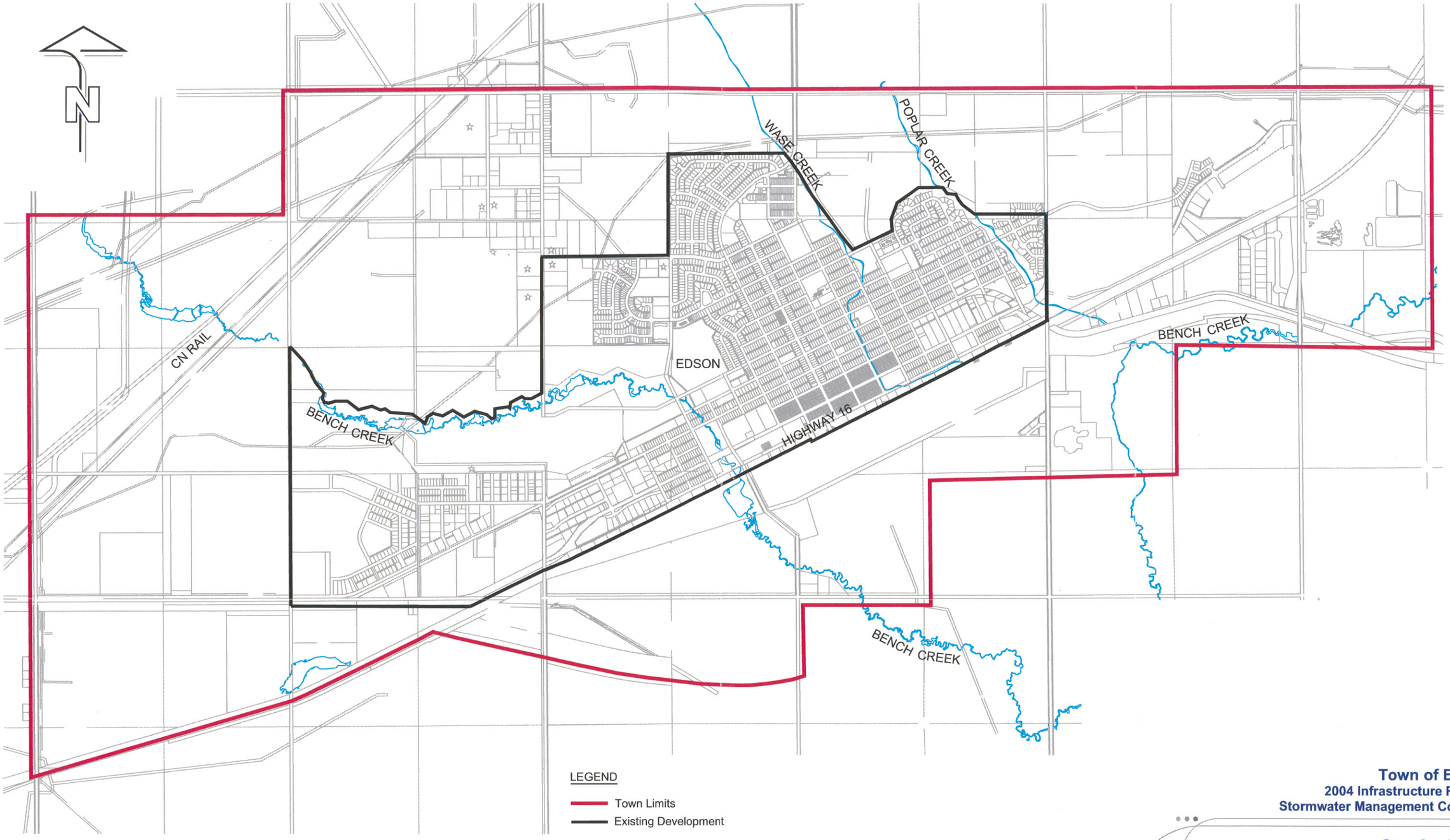
# 1.0 Introduction

This report examines the impacts of future expansion on the stormwater runoff within the Town of Edson and provides a stormwater management plan to address future development. This report does not address the existing stormwater management system.

The stormwater management plan will identify stormwater management facilities to provide storage during rainfall events and to control the flow being discharged into the receiving water courses.

Figure 1.1 shows the Town of Edson and the future development areas addressed in this study. It should be noted that this report is conceptual and a review will be required at the detailed design stage.

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**2004 Infrastructure Review**
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## Study Area

**Figure - 1.1**

## 2.0 Existing Topography and Drainage

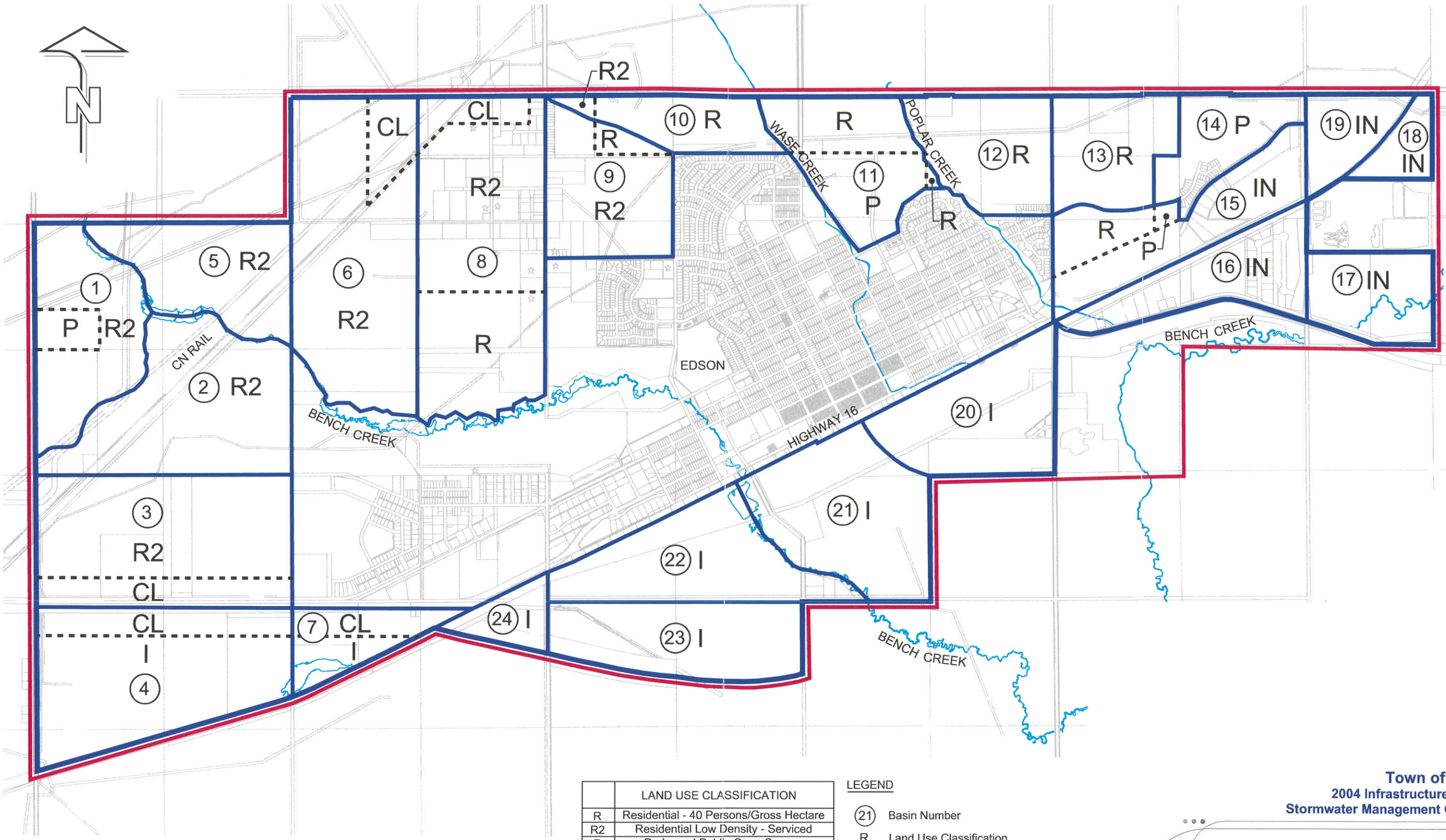
The currently undeveloped sections of land within the Edson town limits have a total area of approximately 1960.7 ha, all of which is to be developed in the future. This undeveloped portion, which encircles the currently developed portion of Edson drains into three creeks that run through the town. These creeks are Bench Creek, Wase Creek, and Poplar Creek. Each creek flows through the town in a south-easterly direction, with Wase Creek discharging into Poplar Creek followed by Poplar Creek discharging into Bench Creek.

The undeveloped portion has been delineated into 24 drainage basins; 18 draining to Bench Creek, 4 to Poplar Creek, and 2 to Wase Creek. A summary of the drainage basins and their areas is provided in Table 2-1 and shown on Figure 2.1.

**Table 2-1: Drainage Basin Area**

| Drainage Basin | Total Area (ha) | Receiving Watercourse |
|---|---|---|
| 1 | 82.5 | Bench Creek |
| 2 | 110.0 | Bench Creek |
| 3 | 132.4 | Bench Creek |
| 4 | 142.4 | Bench Creek |
| 5 | 239.7 | Bench Creek |
| 6 | 232.3 | Bench Creek |
| 7 | 42.7 | Bench Creek |
| 8 | 194.7 | Bench Creek |
| 9 | 67.7 | Bench Creek |
| 10 | 44.1 | Wase Creek |
| 11 | 70.2 | Wase Creek |
| 12 | 64.9 | Poplar Creek |
| 13 | 54.0 | Poplar Creek |
| 14 | 45.0 | Bench Creek |
| 15 | 80.8 | Poplar Creek |
| 16 | 64.5 | Poplar Creek |
| 17 | 49.3 | Bench Creek |
| 18 | 17.4 | Bench Creek |
| 19 | 30.2 | Bench Creek |
| 20 | 70.1 | Bench Creek |
| 21 | 92.6 | Bench Creek |
| 22 | 74.8 | Bench Creek |
| 23 | 81.8 | Bench Creek |
| 24 | 26.6 | Bench Creek |

It should be noted that for drainage basins 5, 6, and 8, the total area refers to the area within the town limits plus the undeveloped land north of the town that contributes rainfall runoff to the basin as well. In these instances this contribution was taken into account in our analysis. The drainage areas within the town limits are 67.8, 163.8 and 169.2 ha for drainage basins 5, 6, and 8 respectively. The additional contributing undeveloped areas outside the town limits are 171.9, 68.5, and 25.5 hectares for drainage basins 5, 6, and 8, respectively. The possibility of diverting flow from these areas should be examined during the design of the developments. Figure 2.2 shows the additional contributing area outside the town limits.




| | LAND USE CLASSIFICATION |
|---|---|
| R | Residential - 40 Persons/Gross Hectare |
| R2 | Residential Low Density - Serviced |
| P | Parks and Public Open Spaces |
| I | Industrial Unserviced |
| IN | Industrial |
| CL | Commercial/Light Industrial Mix |

LEGEND

- (21) Basin Number
- R Land Use Classification
- Town Limits
- Basin Boundary

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## Proposed Basin Boundaries

**Figure - 2.1**

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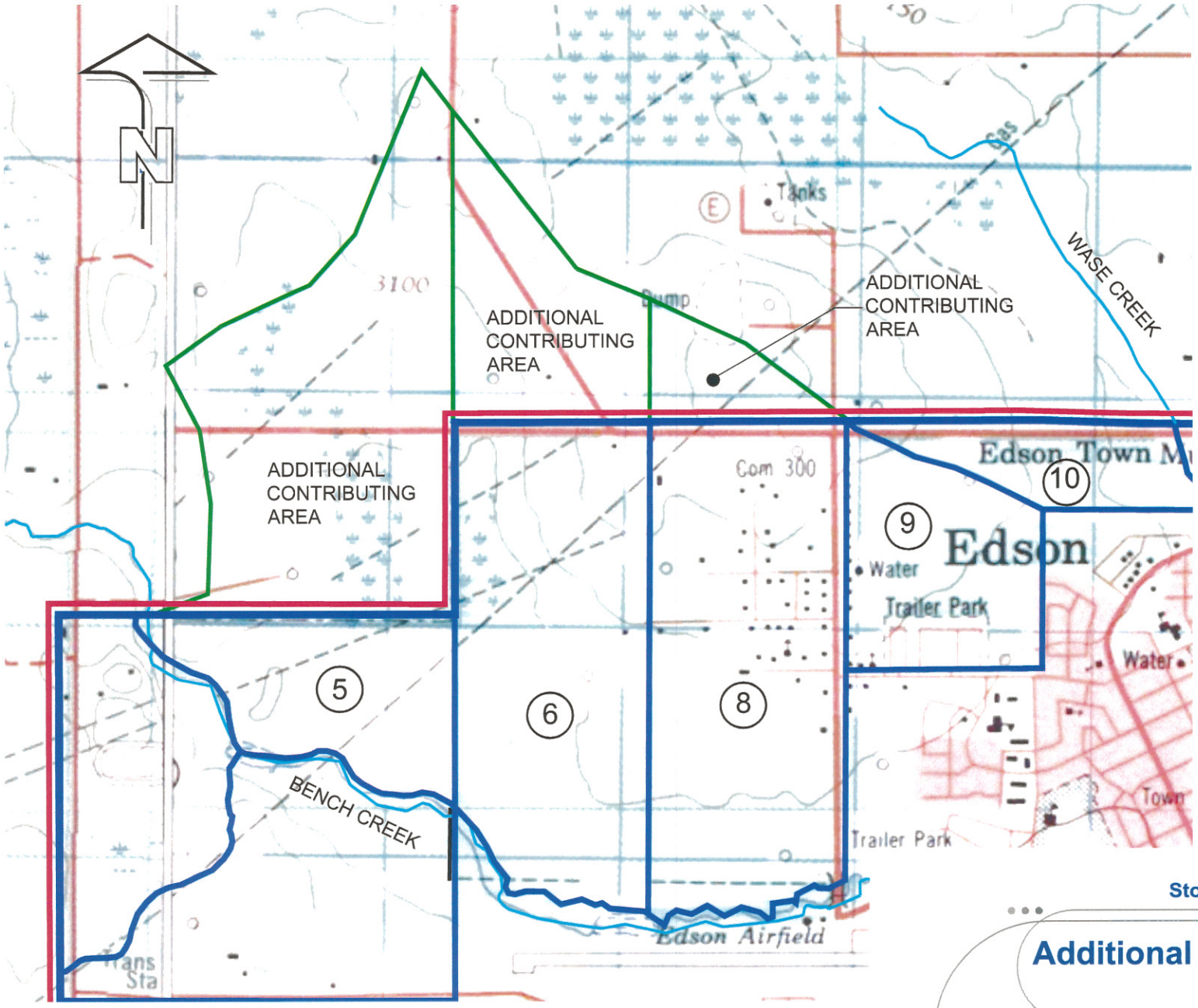


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## Additional Contributing Areas

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**Figure - 2.2**

# 3.0 Design Criteria

## 3.1 Allowable Discharge Rates

The flow in the Bench, Wase, and Poplar Creeks is not monitored and thus, in order to establish allowable discharge rates, a regional analysis was performed. Regional analysis is an accepted technique for hydrologic analysis that establishes a flow versus drainage area relationship. The analysis was conducted using flow records from Water Survey of Canada (WSC) gauge stations on creeks located in adjacent basins with similar physiographic and climatologic characteristics. The WSC maps were examined to determine which streamflow stations in proximity to Bench, Wase, and Poplar Creek have similar characteristics such as topography, basin slope, basin shape, existing storage, extent of development, and similar climatic conditions. Table 3-1 summarizes the WSC stations used in the analysis.

**Table 3-1: Selected Water Survey of Canada Stations**

| WSC Station Number | Station Name | Drainage Area ($km^2$) | Years of Record |
|---|---|---|---|
| 07AD004 | Whiskeyjack Creek near Hinton | 3.13 | 28 |
| 07AF003 | Wampus Creek near Hinton | 25.4 | 35 |
| 07AF004 | Deerlick Creek near Hinton | 14 | 24 |
| 07AF005 | Eunice Creek near Hinton | 17.1 | 25 |
| 07AF010 | Sundance Creek near Bickerdike | 174 | 29 |
| 07AH002 | Christmas Creek near Blue Ridge | 424 | 29 |
| 07BA002 | Rat Creek near Cynthia | 606 | 29 |
| 07BB009 | Connor Creek near Sangudo | 165 | 16 |
| 07BB014 | Coyote Creek near Cherhil | 57.8 | 20 |
| 07BB903 | Romeo Creek above Romeo Lake | 115 | 16 |

The annual maximum instantaneous discharge for each station for the period of record was used to perform a flow frequency analysis. The Consolidated Frequency Analysis (CFA) Program was used to determine the estimated 100-year peak flow at each station. The CFA software program can give output in four different statistical distributions. The distribution that was utilized was selected based on the fit of the curve to the historical data. Table 3-2 summarizes the results of the frequency analysis.

**Table 3-2: Frequency Analysis Summary**

| WSC Station Number | Station Name | Drainage Area | 100-year Peak Flow ($m^3/s$) |
|---|---|---|---|
| 07AD004 | Whiskeyjack Creek near Hinton | 3.13 | 1.13 |
| 07AF003 | Wampus Creek near Hinton | 25.4 | 33.4 |
| 07AF004 | Deerlick Creek near Hinton | 14 | 14.5 |
| 07AF005 | Eunice Creek near Hinton | 17.1 | 18.1 |
| 07AF010 | Sundance Creek near Bickerdike | 174 | 21.8 |
| 07AH002 | Christmas Creek near Blue Ridge | 424 | 56.3 |
| 07BA002 | Rat Creek near Cynthia | 606 | 134 |
| 07BB009 | Connor Creek near Sangudo | 165 | 18.2 |
| 07BB014 | Coyote Creek near Cherhil | 57.8 | 17.6 |
| 07BB903 | Romeo Creek above Romeo Lake | 115 | 21.2 |

The 100-year design flows for the selected stations were plotted against their drainage area. Based on the drainage area, the 100-year peak flow was estimated for each of the Creeks. Thus, the allowable discharges for Bench, Wase, and Poplar Creek were determined and are summarized in Table 3-3.

**Table 3-3: Allowable Discharge Rates**

| Creek Name | Drainage Area ($km^2$) | 100-year Peak Flow ($m^3/s$) | Allowable Discharge Rate (l/s/ha) |
|---|---|---|---|
| Bench | 86.2 | 24.5 | 2.8 |
| Wase | 8.03 | 5.80 | 7.2 |
| Poplar | 4.57 | 4.12 | 9.0 |

Based on these allowable discharge rates and the drainage basin area for each basin, the allowable rate of discharge for each proposed stormwater management facility was determined. Table 3-4 summarises these allowable rates.

**Table 3-4: Allowable Discharge Rates for Stormwater Management Facilities**

| Drainage Basin | Total Area (ha) | Receiving Watercourse | Allowable Discharge Rate ($m^3/s$) |
|---|---|---|---|
| 1 | 82.5 | Bench Creek | 0.23 |
| 2 | 110.0 | Bench Creek | 0.31 |
| 3 | 132.4 | Bench Creek | 0.37 |
| 4 | 142.4 | Bench Creek | 0.40 |
| 5 | 239.7 | Bench Creek | 0.67 |
| 6 | 232.5 | Bench Creek | 0.65 |
| 7 | 42.7 | Bench Creek | 0.12 |
| 8 | 194.7 | Bench Creek | 0.54 |
| 9 | 67.7 | Bench Creek | 0.19 |
| 10 | 44.1 | Wase Creek | 0.32 |
| 11 | 70.2 | Wase Creek | 0.51 |
| 12 | 64.9 | Poplar Creek | 0.58 |
| 13 | 54.0 | Poplar Creek | 0.49 |
| 14 | 45.0 | Bench Creek | 0.13 |
| 15 | 80.8 | Poplar Creek | 0.73 |
| 16 | 64.5 | Poplar Creek | 0.58 |
| 17 | 49.3 | Bench Creek | 0.14 |
| 18 | 17.4 | Bench Creek | 0.05 |
| 19 | 30.2 | Bench Creek | 0.08 |
| 20 | 70.1 | Bench Creek | 0.20 |
| 21 | 92.6 | Bench Creek | 0.26 |
| 22 | 74.8 | Bench Creek | 0.21 |
| 23 | 81.8 | Bench Creek | 0.23 |
| 24 | 26.6 | Bench Creek | 0.07 |

## 3.2 HYDROLOGIC PARAMETERS

The Edson Airport rainfall intensity-duration-frequency (IDF) curves were utilized to create the 5, 25, and 100-year Chicago (4 hour duration) and Huff (24 hour duration) rainfall events. These events were used in the hydrologic analysis to determine the storage needs for each drainage basin. The hydrologic analysis was carried out using the XP-SWMM model. The hydrologic parameters used in the model are summarized in Table 3-5.

**Table 3-5: Summary of Hydrologic Parameters**

| Description | Unit | Value |
|---|---|---|
| **Depression Storage** | | |
| Pervious Area | mm | 6.4 |
| Impervious Area | mm | 3.2 |
| **Manning's Coefficient** | | |
| Pervious Area | | 0.25 |
| Impervious Area | | 0.015 |
| **Infiltration** | | |
| Initial Rate | mm/hr | 100.0 |
| Final Rate | mm/hr | 5.0 |
| Decay Factor | 1/s | 0.00115 |

The percent impervious values for each basin were determined based on the future land use plan provided by the Town of Edson. Table 3-6 summarizes the land use classification and the corresponding percent imperviousness.

**Table 3-6: Summary of Land Use Classification and Percent Imperviousness**

| Land Use Classification | Percent Impervious |
|---|---|
| Residential – 40 persons/Gross Hectare (R) | 50 |
| Residential Low Density – Serviced (R2) | 30 |
| Parks and Public Open Space (P) | 10 |
| Industrial Unserviced (I) | 70 |
| Industrial (IN) | 70 |
| Commercial/Light Industrial Mix (CL) | 70 |
| Undeveloped | 0 |

The hydrologic parameters summarized in Tables 3-5 and 3-6 were used to establish runoff volumes and peak flows under future development conditions.

## 4.0 Stormwater Management Concept

The concept consists of stormwater management facilities in each of the basins that will discharge either to Bench, Poplar, or Wase Creek. The positioning of the ponds as defined in Figure 4.1 are preliminary only and can be refined during the design of the development.

The storm servicing concept was developed for the ultimate development condition. As detailed previously, all areas were defined based on the estimated future predominant land use provided by the Town of Edson.

XP-SWMM was used for the hydraulic and, as detailed previously, hydrologic analysis. The stormwater management concept was assessed for the 5, 25, and 100-year 4-hour and 24-hour design events. The summary of the hydrologic and hydraulic analysis is included in Appendix A.

Storage requirement were determined for all events. The pond designs are based on the 100-year 4-hour and 24-hour design events. In areas where the land use is mostly industrial the 100-year 24 hour rainfall event governs the storage requirement whereas in areas where residential land use is predominant the 100-year 4-hour rainfall event governs.

Table 4-1 summarizes the pond sizes and storage required for each basin. It should be noted that the storage volume shown in Table 4-1 refers only to the live storage and does not include the dead storage for each pond. Included in Appendix C is the required area for each pond including a buffer zone of 10 metres in width added around the pond perimeter. This buffer zone takes into account such items as access to the site and pond freeboard.

**Table 4-1: Pond Sizes and Required Storage**

| Drainage Basin | Basin Area (ha) | Storage Volume Required ($m^3$) | Pond Area (ha) | Allowable Discharge Rate ($m^3/s$) |
|---|---|---|---|---|
| 1 | 82.5 | 11,300 | 0.73 | 0.23 |
| 2 | 110.0 | 16,700 | 1.03 | 0.31 |
| 3 | 132.4 | 25,700 | 1.53 | 0.37 |
| 4 | 142.4 | 63,000 | 3.52 | 0.40 |
| 5 | 239.7 | 9,700 | 0.64 | 0.67 |
| 6 | 232.5 | 37,400 | 2.16 | 0.65 |
| 7 | 42.7 | 19,000 | 1.16 | 0.12 |
| 8 | 194.7 | 47,800 | 2.71 | 0.54 |
| 9 | 67.7 | 12,000 | 0.77 | 0.19 |
| 10 | 44.1 | 11,100 | 0.72 | 0.32 |
| 11 | 70.2 | 9,600 | 0.63 | 0.51 |
| 12 | 64.9 | 15,900 | 0.99 | 0.58 |
| 13 | 54.0 | 13,100 | 0.83 | 0.49 |
| 14 | 45.0 | 2,700 | 0.22 | 0.13 |

| Drainage Basin | Basin Area (ha) | Storage Volume Required ($m^3$) | Pond Area (ha) | Allowable Discharge Rate ($m^3/s$) |
|---|---|---|---|---|
| 15 | 80.8 | 21,900 | 1.32 | 0.73 |
| 16 | 64.5 | 18,600 | 1.14 | 0.58 |
| 17 | 49.3 | 21,800 | 1.31 | 0.14 |
| 18 | 17.4 | 7,500 | 0.51 | 0.05 |
| 19 | 30.2 | 13,200 | 0.84 | 0.08 |
| 20 | 70.1 | 30,400 | 1.78 | 0.20 |
| 21 | 92.6 | 40,000 | 2.30 | 0.26 |
| 22 | 74.8 | 32,000 | 1.87 | 0.21 |
| 23 | 81.8 | 35,200 | 2.04 | 0.23 |
| 24 | 26.6 | 11,400 | 0.74 | 0.07 |

The pond areas were established assuming that all of the storm water management facilities would be wet ponds with 2.5 metres of dead storage and 2.0 metres of live storage (based on Alberta Environment Stormwater Management Guidelines). To establish the surface area it was assumed that the ponds are square shaped, although this only for conceptual purposes. It must be noted that the use of wet ponds as storm water management facilities addresses not only the quantity but also the quality of the runoff water. This is due to the settling time that is provided by the wet ponds which lowers the turbidity of the water being discharged into the receiving water course.

For the stormwater management facilities located in drainage basins 3, 4, 7, 23, and 24, the pond discharge would have to be routed through a storm sewer or a ditch in order to outfall into Bench Creek. The ponds located in basins 14, 18, and 19 would also need to be routed in a similar manner to convey the discharge to Bench Creek. This is also the case for the pond in basin 13 for discharge into Poplar Creek. For the pond located in basin 9, the concept is based on pond discharge connected to the existing stormwater system. An analysis was completed with regards to the capacity and demand on the storm trunk which runs along 56 Street, the system that the basin 9 pond would connect to. It was determined that the 0.2 $m^3/s$ allowable discharge from the pond will not overload the storm trunk during the 5-year storm event.

As previously discussed, undeveloped areas north of the town limits contribute rainfall runoff to basins 5, 6 and 8. When these areas outside of the town become developed, stormwater management facilities will be required to control the flow to the allowable discharge rates. This should be reviewed with Yellowhead County.

A review was completed for the crossings at Bench, Wase and Poplar Creeks. Table 4-2 presents the crossing location and discharge capacity at each crossing. The culvert capacities in the General Engineering Study (Stanley, 1982) were reviewed and determined to be accurate except for the surcharge capacity of culvert 14 which was increased. The 5, 25 and 100-Year discharges at each crossing location were estimated assuming that runoff from future developments within the town is

controlled to the allowable discharge rates as indicated in this report, rates are presented in Table 4-3. Within Bench Creek, all crossings have sufficient capacity to convey the 100-year discharge. Within Wase and Poplar Creeks, except for culverts 9, 19 and 22, all other culverts do not have the capacity under surcharged conditions to convey the 100-year discharge. Culverts 10, 11, 13, 15 to 18, 20 and 23 have the capacity to convey the 5-year discharge, while the capacity of culvert 21 is slightly less than the 5-year design discharge. Culvert 14 can convey up to the 25-year discharge. When a crossing is to be upgraded, the upgrade should be designed to convey the 100-Year discharge.

**Table 4-2: Crossing Inventory**

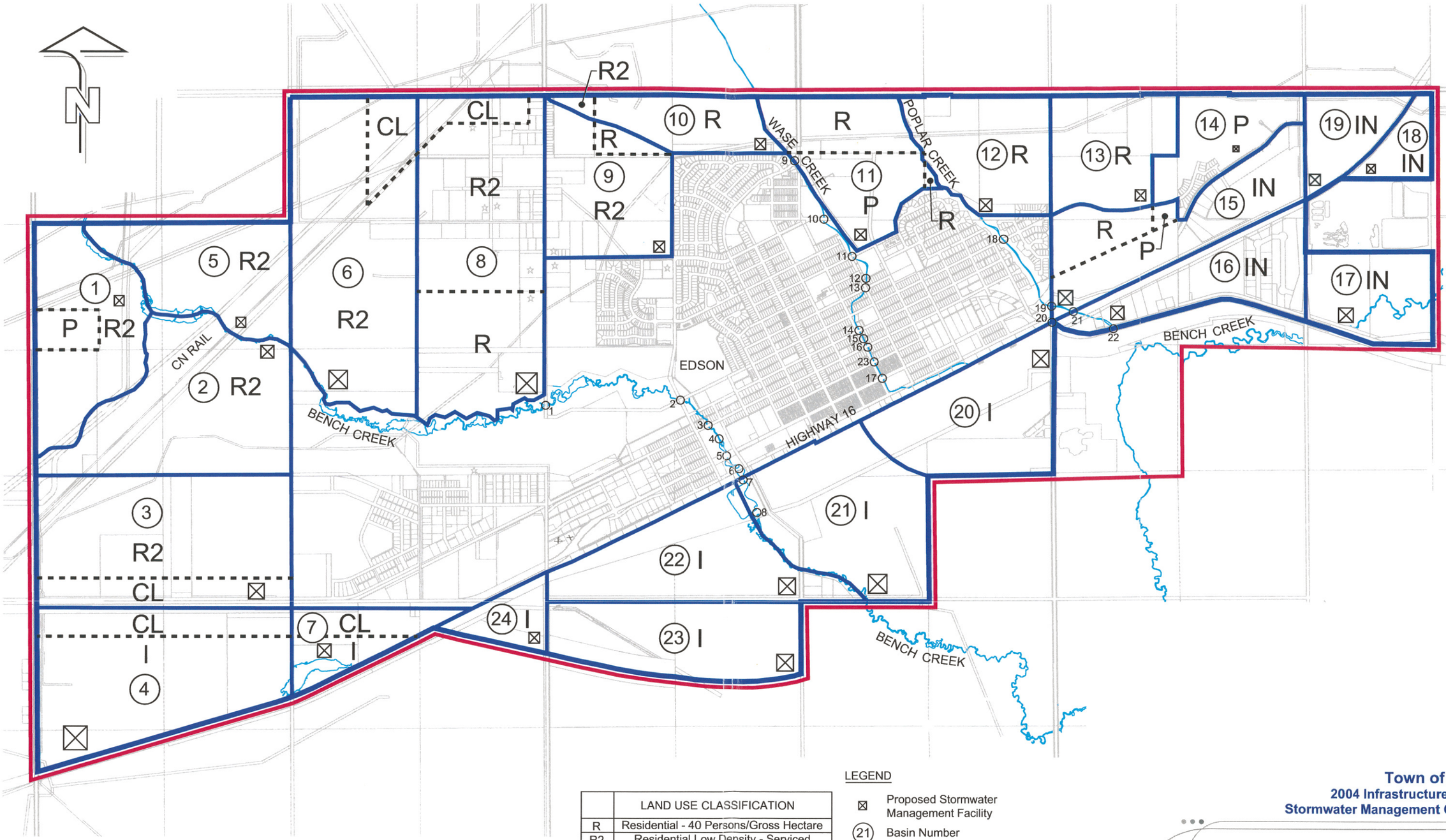
| Crossing | Location | Type | Size (m) | Capacity ($m^3/s$) | Surcharge Height (m) | Surcharge Capacity ($m^3/s$) | Comments |
|---|---|---|---|---|---|---|---|
| **Bench Creek** | | | | | | | |
| 1 | Bench Creek Crossing | Bridge | 8.5 x 3.0 | 41.7 | N/A | N/A | Beaver Dam U/S |
| 2 | 6 Ave & 55 St | CSP | 3.64 | 41.1 | 4.42 | 45.3 | Mitered Ends |
| 3 | 4 Ave & 55 St | Bridge | 8.5 x 3.0 | 41.7 | N/A | N/A | Good Condition |
| 4 | 3 Ave & 54 St | Foot Bridge | 16.8 x 1.8 | 16.0 | N/A | N/A | Good Condition |
| 5 | 2 Ave & 54 St | CSP | 3.65 | 41.4 | 5.33 | 53.8 | Mitered Ends |
| 6 | 1 Ave & 54 St | 2-CSP | 1.5 | - | - | - | Submerged |
| 7 | Bench Creek Crossing | Trestle | 22.0 x 4.0 | 110.5 | N/A | N/A | Good Condition |
| 8 | CNR Reservoir | Outlet Structure | - | - | - | - | Outlet Structure Removed |
| **Wase Creek** | | | | | | | |
| 9 | 19 Ave & 48 St | Pipe Arch | 2.1 x 1.5 | 4.82 | 4.27 | 12.5 | Projecting Ends |
| 10 | 12 Ave & 47 St | CSP | 1.07 | 1.56 | 2.59 | 2.83 | Projecting Ends |
| 11 | 9 Ave & 47 St | 2-CSP | 0.76 | 1.25 | 3.20 | 3.40 | Projecting Ends |
| 12 | - | - | - | - | - | - | - |
| 13 | 7 Ave & 47 St | 2-CSP | 0.91 | 2.04 | 2.13 | 3.68 | Projecting Ends |
| 14 | 5 Ave & 48 St | 2-CSP | 0.76 | 1.25 | 5.03 | 4.50 | Projecting Ends |
| 15 | 4 & 5 Ave & 48 St | CSP | 1.07 | 1.56 | 5.03 | 4.25 | Projecting Ends |
| 16 | 4 Ave & 48 St | CSP | 1.22 | 2.21 | 2.44 | 3.68 | Projecting Ends |
| 23 | 3 Ave & 48 St | CSP | 1.22 | 2.21 | 2.44 | 3.68 | - |
| 17 | 2 Ave & 48 St | CSP | 1.22 | 2.21 | 2.44 | 3.68 | Projecting Ends |
| 20 | Highway #16 | CSP | 1.22 | 2.21 | 4.27 | 5.10 | Projecting Ends |

| Crossing | Location | Type | Size (m) | Capacity ($m^3/s$) | Surcharge Height (m) | Surcharge Capacity ($m^3/s$) | Comments |
|---|---|---|---|---|---|---|---|
| **Poplar Creek** | | | | | | | |
| 18 | 6 Ave & 42 St | CSP | 0.91 | 1.02 | 3.96 | 2.83 | Projecting Ends |
| 19 | Bear Lake Road | CSP | 1.67 | 5.10 | 3.05 | 7.37 | Projecting Ends |
| **Downstream of the Confluence of Wase & Poplar Creek** | | | | | | | |
| 21 | CNR Crossing | CSP | 1.22 | 2.21 | 4.27 | 5.67 | Concrete Headwall |
| 22 | Highway #16 | CSP | 2.13 | 9.80 | 7.01 | 19.8 | Projecting Ends |

**Table 4-3: Crossing Design Discharges**

| Crossing | Discharge Magnitudes for Given Return Periods ($m^3/s$) | | | Crossing Capacity ($m^3/s$) |
|---|---|---|---|---|
| | 5-Year | 25-Year | 100-Year | |
| **Bench Creek** | | | | |
| 1 | 5.1 | 7.7 | 11.1 | 41.7 |
| 2 | 5.4 | 8.1 | 11.6 | 45.3 |
| 3 | 6.1 | 9.1 | 12.7 | 41.7 |
| 4 | 6.2 | 9.2 | 12.9 | 16.0 |
| 5 | 6.2 | 9.2 | 12.9 | 53.8 |
| 6 | 6.4 | 9.5 | 13.2 | - |
| 7 | 6.4 | 9.5 | 13.2 | 110.5 |
| 8 | 6.4 | 9.5 | 13.3 | - |
| **Wase Creek** | | | | |
| 9 | 1.8 | 3.6 | 5.9 | 12.5 |
| 10 | 1.9 | 3.7 | 6.1 | 2.8 |
| 11 | 2.3 | 4.2 | 6.7 | 3.4 |
| 12 | 2.5 | 4.4 | 7.0 | - |
| 13 | 2.5 | 4.4 | 7.0 | 3.7 |
| 14 | 2.6 | 4.5 | 7.1 | 4.5 |
| 15 | 2.7 | 4.6 | 7.2 | 4.3 |
| 16 | 2.7 | 4.6 | 7.2 | 3.7 |
| 23 | 2.7 | 4.7 | 7.3 | 3.7 |
| 17 | 2.7 | 4.7 | 7.3 | 3.7 |
| 20 | 3.2 | 5.4 | 8.3 | 5.1 |
| **Poplar Creek** | | | | |
| 18 | 2.1 | 3.4 | 5.2 | 2.8 |
| 19 | 2.4 | 3.9 | 5.8 | 7.4 |

| Crossing | Discharge Magnitudes for Given Return Periods ($m^3/s$) | | | Crossing Capacity ($m^3/s$) |
|---|---|---|---|---|
| | 5-Year | 25-Year | 100-Year | |
| **Downstream of the Confluence of Wase & Poplar Creek** | | | | |
| 21 | 6.2 | 9.8 | 14.8 | 5.7 |
| 22 | 6.6 | 10.3 | 15.4 | 19.8 |




| | LAND USE CLASSIFICATION |
|---|---|
| R | Residential - 40 Persons/Gross Hectare |
| R2 | Residential Low Density - Serviced |
| P | Parks and Public Open Spaces |
| I | Industrial Unserviced |
| IN | Industrial |
| CL | Commercial/Light Industrial Mix |

LEGEND

- ⊠ Proposed Stormwater Management Facility
- (21) Basin Number
- R Land Use Classification
- Town Limits
- Basin Boundary
- 17O Creek Crossing

**Town of Edson**
**2004 Infrastructure Review**
**Stormwater Management Concept**

# Proposed Stormwater Management Plan

**Figure - 4.1**

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## 5.0 Cost Estimate

A cost estimate, based on 2004 dollars, has been completed for the stormwater management ponds. Costs include only the storage and outlet system components. The cost summary for the stormwater management ponds is presented in Table 5-1. This cost summary includes 25% contingency and 10% engineering costs. Included in the cost estimate for each pond are costs for mobilization and demobilization, clearing and grubbing, topsoil, excavation and disposal, landscaping, and outlet structure. These costs do not include the cost associated with purchasing the land nor do they address the costs associated with the conveyance channels mentioned previously. The detailed costs are included in Appendix B.

**Table 5-1: Cost Estimate Summary**

| Item | Description | Amount |
|---|---|---|
| 1 | Pond 1 | $ 296,000 |
| 2 | Pond 2 | $ 398,000 |
| 3 | Pond 3 | $ 574,000 |
| 4 | Pond 4 | $1,330,000 |
| 5 | Pond 5 | $ 267,000 |
| 6 | Pond 6 | $ 808,000 |
| 7 | Pond 7 | $ 443,000 |
| 8 | Pond 8 | $1,019,000 |
| 9 | Pond 9 | $ 309,000 |
| 10 | Pond 10 | $ 292,000 |
| 11 | Pond 11 | $ 265,000 |
| 12 | Pond 12 | $ 383,000 |
| 13 | Pond 13 | $ 330,000 |
| 14 | Pond 14 | $ 146,000 |
| 15 | Pond 15 | $ 499,000 |
| 16 | Pond 16 | $ 435,000 |
| 17 | Pond 17 | $ 497,000 |
| 18 | Pond 18 | $ 227,000 |
| 19 | Pond 19 | $ 332,000 |
| 20 | Pond 20 | $ 668,000 |
| 21 | Pond 21 | $ 860,000 |
| 22 | Pond 22 | $ 700,000 |
| 23 | Pond 23 | $ 764,000 |
| 24 | Pond 24 | $ 298,000 |

## 6.0 Conclusions and Recommendations

With respect to the stormwater management plan, the following conclusions can be made:

- The currently undeveloped land within the Town of Edson limits has been delineated into 24 basins based on existing and proposed road ways, and topography. Eighteen of these basins convey runoff to Bench Creek, 4 basins convey runoff to Poplar Creek, and 2 basins convey runoff to Wase Creek.
- Based on the regional analysis, the allowable discharge rates for Bench Creek, Poplar Creek, and Wase Creek are 2.8 L/s/ha, 7.2 L/s/ha, and 9.0 L/s/ha, respectively.
- The land use within each basin was established based on the Future Predominant Land Use map provided by the Town of Edson.
- XP SWMM modelling software was utilized to determine the storage requirements of each of the recommended stormwater management facilities.
- Nine of the stormwater management facilities will require conveyance channels to allow discharge into the creeks in the Town of Edson. It is also recommended that pond 9 be connected to the existing stormwater management system at approximately 56$^{th}$ Street and 13$^{th}$ Avenue. The capacity of the existing system was assessed and it was determined to have the available capacity to convey the controlled discharge from the pond within basin 9.
- Each basin has been provided with a recommended stormwater management facility location. The locations were established based on existing topography. The actual location of the facility can be refined during the design stage.
- Wet ponds are recommended as they address not only water quantity, but water quality as well.
- The required storage volume and area of the stormwater management facilities have been established, as well as a cost estimate for each of the facilities. The cost estimates are based on 2004 dollars and include engineering and contingency. Land costs are not included.
- This analysis concentrates only on future development within the Town of Edson. The existing stormwater management system has not been assessed. The assessment of the existing system is recommended.
- If runoff from future developed areas draining to Bench Creek is controlled to the allowable discharge rate, crossings within Bench Creek will have sufficient capacity to convey the 100-year discharge. Crossings located within Wase and Poplar creek, except for crossings 9, 19, and 22, do not have sufficient capacity to convey the 100-year event even if runoff from future development is controlled to the allowable discharge rates within both basins.
- Culverts 10, 11, 13, 15 to 18, 20 and 23 within Wase and Poplar Creek will have the capacity to convey the 5-year discharge, while the capacity of culvert 21 is slightly less than the 5-year design discharge. Culvert 14 can convey up to the 25-year discharge. This is assuming that runoff from future developments will be controlled to the allowable rates within this report.

- When a crossing is to be upgraded, the upgrade should be designed to convey the 100-Year discharge.

## 7.0 Report Submittal

This report has been prepared and submitted by UMA Engineering Ltd., as documented below:

UMA PERMIT

PERMIT TO PRACTICE
UMA ENGINEERING LTD.
Signature
Date July 13/05
PERMIT NUMBER: P 0329
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

ENGINEER'S STAMP


**UMA ENGINEERING LTD.**
**THIRD PARTY DISCLAIMER**

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# Appendix A

# Summary of Hydrologic and Hydraulic Analysis

## Table A1: Hydrologic and Hydraulic Analysis Results for Basin 1

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34.0 | 0.25 | 7,000 | 5,100 | 0.15 |
| 5yr 24hr | 59.7 | 0.26 | 12,700 | 5,900 | 0.17 |
| 25yr 4 hr | 44.5 | 0.26 | 9,500 | 7,300 | 0.18 |
| 25yr 24hr | 75.5 | 0.26 | 16,300 | 7,900 | 0.19 |
| 100yr 4hr | 56.1 | 0.31 | 14,400 | 11,300 | 0.23 |
| 100yr 24hr | 88.4 | 0.28 | 20,300 | 10,600 | 0.22 |

## Table A2: Hydrologic and Hydraulic Analysis Results for Basin 2

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34.0 | 0.27 | 10,300 | 7,800 | 0.20 |
| 5yr 24hr | 59.7 | 0.29 | 18,800 | 9,400 | 0.22 |
| 25yr 4 hr | 44.5 | 0.28 | 14,000 | 11,000 | 0.24 |
| 25yr 24hr | 75.5 | 0.29 | 24,000 | 12,400 | 0.26 |
| 100yr 4hr | 56.1 | 0.34 | 20,800 | 16,700 | 0.30 |
| 100yr 24hr | 88.4 | 0.31 | 29,700 | 16,300 | 0.30 |

## Table A3: Hydrologic and Hydraulic Analysis Results for Basin 3

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34.0 | 0.32 | 14,600 | 11,800 | 0.24 |
| 5yr 24hr | 59.7 | 0.34 | 26,600 | 14,800 | 0.27 |
| 25yr 4 hr | 44.5 | 0.34 | 20,000 | 16,500 | 0.29 |
| 25yr 24hr | 75.5 | 0.34 | 34,000 | 19,500 | 0.32 |
| 100yr 4hr | 56.1 | 0.41 | 30,300 | 25,600 | 0.37 |
| 100yr 24hr | 88.4 | 0.36 | 42,700 | 25,700 | 0.37 |

## Table A4: Hydrologic and Hydraulic Analysis Results for Basin 4

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34.0 | 0.64 | 31,100 | 26,500 | 0.24 |
| 5yr 24hr | 59.7 | 0.66 | 56,400 | 39,800 | 0.30 |
| 25yr 4 hr | 44.5 | 0.66 | 41,800 | 36,500 | 0.29 |
| 25yr 24hr | 75.5 | 0.67 | 72,400 | 51,600 | 0.35 |
| 100yr 4hr | 56.1 | 0.72 | 57,400 | 50,400 | 0.35 |
| 100yr 24hr | 88.4 | 0.69 | 87,300 | 63,000 | 0.39 |

## Table A5: Hydrologic and Hydraulic Analysis Results for Basin 5

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34.0 | 0.08 | 6,400 | 3,600 | 0.40 |
| 5yr 24hr | 59.7 | 0.08 | 11,600 | 1,900 | 0.29 |
| 25yr 4 hr | 44.5 | 0.08 | 8,900 | 5,200 | 0.49 |
| 25yr 24hr | 75.5 | 0.08 | 14,800 | 2,600 | 0.35 |
| 100yr 4hr | 56.1 | 0.13 | 17,300 | 9,700 | 0.67 |
| 100yr 24hr | 88.4 | 0.09 | 20,400 | 4,500 | 0.46 |

## Table A6: Hydrologic and Hydraulic Analysis Results for Basin 6

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34.0 | 0.29 | 23,000 | 17,300 | 0.42 |
| 5yr 24hr | 59.7 | 0.30 | 41,800 | 21,600 | 0.48 |
| 25yr 4 hr | 44.5 | 0.30 | 31,200 | 24,400 | 0.51 |
| 25yr 24hr | 75.5 | 0.31 | 53,500 | 28,500 | 0.56 |
| 100yr 4hr | 56.1 | 0.36 | 46,300 | 37,400 | 0.65 |
| 100yr 24hr | 88.4 | 0.32 | 66,400 | 37,300 | 0.65 |

## Table A7: Hydrologic and Hydraulic Analysis Results for Basin 7

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34.0 | 0.64 | 9,400 | 8,100 | 0.07 |
| 5yr 24hr | 59.7 | 0.66 | 17,000 | 11,700 | 0.09 |
| 25yr 4 hr | 44.5 | 0.66 | 12,600 | 11,200 | 0.09 |
| 25yr 24hr | 75.5 | 0.67 | 21,700 | 15,500 | 0.10 |
| 100yr 4hr | 56.1 | 0.72 | 17,300 | 15,500 | 0.11 |
| 100yr 24hr | 88.4 | 0.70 | 26,300 | 19,000 | 0.12 |

## Table A8: Hydrologic and Hydraulic Analysis Results for Basin 8

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34.0 | 0.38 | 25,300 | 21,000 | 0.34 |
| 5yr 24hr | 59.7 | 0.40 | 46,100 | 27,900 | 0.40 |
| 25yr 4 hr | 44.5 | 0.40 | 34,900 | 29,700 | 0.42 |
| 25yr 24hr | 75.5 | 0.40 | 59,000 | 36,400 | 0.47 |
| 100yr 4hr | 56.1 | 0.49 | 53,000 | 46,200 | 0.53 |
| 100yr 24hr | 88.4 | 0.43 | 74,300 | 47,800 | 0.54 |

## Table A9: Hydrologic and Hydraulic Analysis Results for Basin 9

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34.0 | 0.29 | 6,800 | 5,300 | 0.12 |
| 5yr 24hr | 59.7 | 0.30 | 12,300 | 6,500 | 0.13 |
| 25yr 4 hr | 44.5 | 0.31 | 9,300 | 7,500 | 0.15 |
| 25yr 24hr | 75.5 | 0.31 | 15,700 | 8,600 | 0.16 |
| 100yr 4hr | 56.1 | 0.38 | 14,400 | 12,000 | 0.18 |
| 100yr 24hr | 88.4 | 0.33 | 20,000 | 11,600 | 0.18 |

## Table A10: Hydrologic and Hydraulic Analysis Results for Basin 10

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34.0 | 0.45 | 6,800 | 4,900 | 0.21 |
| 5yr 24hr | 59.7 | 0.47 | 12,400 | 4,700 | 0.20 |
| 25yr 4 hr | 44.5 | 0.48 | 9,500 | 7,000 | 0.25 |
| 25yr 24hr | 75.5 | 0.47 | 15,800 | 6,400 | 0.24 |
| 100yr 4hr | 56.1 | 0.57 | 14,200 | 11,100 | 0.31 |
| 100yr 24hr | 88.4 | 0.51 | 20,000 | 9,000 | 0.28 |

## Table A11: Hydrologic and Hydraulic Analysis Results for Basin 11

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34.0 | 0.27 | 6,600 | 4,000 | 0.33 |
| 5yr 24hr | 59.7 | 0.26 | 10,900 | 2,600 | 0.26 |
| 25yr 4 hr | 44.5 | 0.29 | 9,000 | 5,800 | 0.40 |
| 25yr 24hr | 75.5 | 0.28 | 15,000 | 3,700 | 0.31 |
| 100yr 4hr | 56.1 | 0.36 | 14,500 | 9,600 | 0.51 |
| 100yr 24hr | 88.4 | 0.31 | 19,400 | 5,600 | 0.39 |

## Table A12: Hydrologic and Hydraulic Analysis Results for Basin 12

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34.0 | 0.46 | 10,200 | 6,900 | 0.38 |
| 5yr 24hr | 59.7 | 0.48 | 18,500 | 6,000 | 0.35 |
| 25yr 4 hr | 44.5 | 0.49 | 14,200 | 10,100 | 0.46 |
| 25yr 24hr | 75.5 | 0.48 | 23,600 | 8,200 | 0.41 |
| 100yr 4hr | 56.1 | 0.58 | 21,200 | 15,900 | 0.59 |
| 100yr 24hr | 88.4 | 0.52 | 29,800 | 11,700 | 0.50 |

## Table A13: Hydrologic and Hydraulic Analysis Results for Basin 13

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34.0 | 0.46 | 8,100 | 5,700 | 0.32 |
| 5yr 24hr | 59.7 | 0.48 | 15,400 | 4,800 | 0.29 |
| 25yr 4 hr | 44.5 | 0.49 | 11,800 | 8,300 | 0.39 |
| 25yr 24hr | 75.5 | 0.48 | 19,700 | 6,700 | 0.34 |
| 100yr 4hr | 56.1 | 0.58 | 17,700 | 13,100 | 0.48 |
| 100yr 24hr | 88.4 | 0.52 | 24,800 | 9,600 | 0.41 |

## Table A14: Hydrologic and Hydraulic Analysis Results for Basin 14

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34.0 | 0.09 | 1,400 | 900 | 0.08 |
| 5yr 24hr | 59.7 | 0.10 | 2,600 | 500 | 0.06 |
| 25yr 4 hr | 44.5 | 0.10 | 2,000 | 1,300 | 0.09 |
| 25yr 24hr | 75.5 | 0.10 | 3,300 | 700 | 0.07 |
| 100yr 4hr | 56.1 | 0.16 | 4,200 | 2,700 | 0.12 |
| 100yr 24hr | 88.4 | 0.12 | 4,700 | 1,400 | 0.09 |

## Table A15: Hydrologic and Hydraulic Analysis Results for Basin 15

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34 | 0.59 | 16,200 | 10,700 | 0.50 |
| 5yr 24hr | 59.7 | 0.61 | 29,600 | 10,900 | 0.50 |
| 25yr 4 hr | 44.5 | 0.61 | 22,000 | 15,200 | 0.60 |
| 25yr 24hr | 75.5 | 0.62 | 37,800 | 14,700 | 0.59 |
| 100yr 4hr | 56.1 | 0.66 | 30,200 | 21,900 | 0.73 |
| 100yr 24hr | 88.4 | 0.64 | 45,800 | 19,000 | 0.67 |

## Table A16: Hydrologic and Hydraulic Analysis Results for Basin 16

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34.0 | 0.64 | 14,100 | 9,300 | 0.40 |
| 5yr 24hr | 59.7 | 0.66 | 25,700 | 10,000 | 0.41 |
| 25yr 4 hr | 44.5 | 0.66 | 18,900 | 13,200 | 0.49 |
| 25yr 24hr | 75.5 | 0.67 | 32,800 | 13,200 | 0.49 |
| 100yr 4hr | 56.1 | 0.70 | 25,500 | 18,600 | 0.58 |
| 100yr 24hr | 88.4 | 0.69 | 39,300 | 16,800 | 0.55 |

## Table A17: Hydrologic and Hydraulic Analysis Results for Basin 17

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34.0 | 0.64 | 10,800 | 9,200 | 0.09 |
| 5yr 24hr | 59.7 | 0.66 | 19,600 | 13,700 | 0.10 |
| 25yr 4 hr | 44.5 | 0.66 | 14,500 | 12,700 | 0.10 |
| 25yr 24hr | 75.5 | 0.67 | 25,100 | 17,900 | 0.12 |
| 100yr 4hr | 56.1 | 0.71 | 19,700 | 17,600 | 0.12 |
| 100yr 24hr | 88.4 | 0.69 | 30,200 | 21,800 | 0.13 |

## Table A18: Hydrologic and Hydraulic Analysis Results for Basin 18

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34.0 | 0.64 | 3,800 | 3,300 | 0.03 |
| 5yr 24hr | 59.7 | 0.66 | 7,000 | 4,600 | 0.04 |
| 25yr 4 hr | 44.5 | 0.66 | 5,200 | 4,500 | 0.04 |
| 25yr 24hr | 75.5 | 0.67 | 8,900 | 6,100 | 0.04 |
| 100yr 4hr | 56.1 | 0.71 | 7,000 | 6,200 | 0.04 |
| 100yr 24hr | 88.4 | 0.69 | 10,700 | 7,500 | 0.05 |

## Table A19: Hydrologic and Hydraulic Analysis Results for Basin 19

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34.0 | 0.64 | 6,600 | 5,600 | 0.05 |
| 5yr 24hr | 59.7 | 0.66 | 12,000 | 8,100 | 0.06 |
| 25yr 4 hr | 44.5 | 0.66 | 8,900 | 7,700 | 0.06 |
| 25yr 24hr | 75.5 | 0.67 | 15,400 | 10,700 | 0.07 |
| 100yr 4hr | 56.1 | 0.71 | 12,100 | 10,700 | 0.07 |
| 100yr 24hr | 88.4 | 0.69 | 18,500 | 13,200 | 0.08 |

## Table A20: Hydrologic and Hydraulic Analysis Results for Basin 20

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34.0 | 0.64 | 15,300 | 12,600 | 0.12 |
| 5yr 24hr | 59.7 | 0.66 | 27,800 | 19,300 | 0.15 |
| 25yr 4 hr | 44.5 | 0.65 | 20,500 | 17,500 | 0.14 |
| 25yr 24hr | 75.5 | 0.67 | 35,600 | 25,000 | 0.17 |
| 100yr 4hr | 56.1 | 0.70 | 27,400 | 23,800 | 0.17 |
| 100yr 24hr | 88.4 | 0.69 | 42,500 | 30,400 | 0.19 |

## Table A21: Hydrologic and Hydraulic Analysis Results for Basin 21

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34.0 | 0.64 | 20,100 | 16,600 | 0.16 |
| 5yr 24hr | 59.7 | 0.66 | 36,600 | 25,400 | 0.20 |
| 25yr 4 hr | 44.5 | 0.66 | 27,100 | 22,900 | 0.19 |
| 25yr 24hr | 75.5 | 0.67 | 46,900 | 33,000 | 0.23 |
| 100yr 4hr | 56.1 | 0.69 | 36,100 | 31,100 | 0.22 |
| 100yr 24hr | 88.4 | 0.68 | 56,100 | 40,000 | 0.25 |

## Table A22: Hydrologic and Hydraulic Analysis Results for Basin 22

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34.0 | 0.64 | 16,300 | 13,100 | 0.13 |
| 5yr 24hr | 59.7 | 0.66 | 29,600 | 20,300 | 0.16 |
| 25yr 4 hr | 44.5 | 0.66 | 21,900 | 18,100 | 0.15 |
| 25yr 24hr | 75.5 | 0.67 | 37,900 | 26,400 | 0.18 |
| 100yr 4hr | 56.1 | 0.69 | 28,900 | 24,600 | 0.18 |
| 100yr 24hr | 88.4 | 0.68 | 45,200 | 32,000 | 0.20 |

## Table A23: Hydrologic and Hydraulic Analysis Results for Basin 23

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34.0 | 0.64 | 17,800 | 14,500 | 0.14 |
| 5yr 24hr | 59.7 | 0.66 | 32,400 | 22,300 | 0.18 |
| 25yr 4 hr | 44.5 | 0.66 | 23,900 | 20,100 | 0.17 |
| 25yr 24hr | 75.5 | 0.67 | 41,400 | 29,000 | 0.20 |
| 100yr 4hr | 56.1 | 0.69 | 31,800 | 27,300 | 0.20 |
| 100yr 24hr | 88.4 | 0.68 | 49,500 | 35,200 | 0.22 |

## Table A24: Hydrologic and Hydraulic Analysis Results for Basin 24

| Rainfall Event | Rainfall Depth (mm) | Runoff / Rainfall Ratio | Runoff Volume ($m^3$) | Storage Volume ($m^3$) | Maximum Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 5yr 4 hr | 34.0 | 0.64 | 5,800 | 4,900 | 0.05 |
| 5yr 24hr | 59.7 | 0.66 | 10,600 | 7,100 | 0.06 |
| 25yr 4 hr | 44.5 | 0.66 | 7,800 | 6,700 | 0.05 |
| 25yr 24hr | 75.5 | 0.67 | 13,500 | 9,300 | 0.07 |
| 100yr 4hr | 56.1 | 0.70 | 10,500 | 9,200 | 0.06 |
| 100yr 24hr | 88.4 | 0.69 | 16,200 | 11,400 | 0.07 |

# Appendix B

# Cost Estimate

# Cost Breakdown for Ponds

## Pond 1

### Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 11,300 | $m^3$ |
| Dead Pond Storage | 6,940 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 0.73 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 0.7 | $ 5,475 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 2,200 | $ 11,000 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 16,040 | $ 112,280 |
| 5 | Landscaping | ha | $ 10,000.00 | 0.7 | $ 7,300 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 76,669 |
| | | | | **Total** | **$ 296,000** |

## Pond 2

### Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 16,700 | $m^3$ |
| Dead Pond Storage | 11,860 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 1.03 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 1.0 | $ 7,725 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 3,100 | $ 15,500 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 25,460 | $ 178,220 |
| 5 | Landscaping | ha | $ 10,000.00 | 1.0 | $ 10,300 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 103,161 |
| | | | | **Total** | **$ 398,000** |

Pond 3

Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 25,700 | $m^3$ |
| Dead Pond Storage | 20,640 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 1.53 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 1.5 | $ 11,475 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 4,600 | $ 23,000 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 41,740 | $ 292,180 |
| 5 | Landscaping | ha | $ 10,000.00 | 1.5 | $ 15,300 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 148,734 |
| | | | | **Total** | $ 574,000 |

Pond 4

Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 63,000 | $m^3$ |
| Dead Pond Storage | 60,050 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 3.52 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 3.5 | $ 26,400 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 10,600 | $ 53,000 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 112,450 | $ 787,150 |
| 5 | Landscaping | ha | $ 10,000.00 | 3.5 | $ 35,200 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 344,663 |
| | | | | **Total** | $ 1,330,000 |

Pond 5

Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 9,700 | $m^3$ |
| Dead Pond Storage | 5,560 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 0.64 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 0.6 | $ 4,800 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 1,900 | $ 9,500 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 13,360 | $ 93,520 |
| 5 | Landscaping | ha | $ 10,000.00 | 0.6 | $ 6,400 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 69,027 |
| | | | | **Total** | $ 267,000 |

Pond 6

Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 37,400 | $m^3$ |
| Dead Pond Storage | 32,630 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 2.16 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 2.2 | $ 16,200 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 6,500 | $ 32,500 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 63,530 | $ 444,710 |
| 5 | Landscaping | ha | $ 10,000.00 | 2.2 | $ 21,600 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 209,304 |
| | | | | **Total** | $ 808,000 |

Pond 7

Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 19,000 | $m^3$ |
| Dead Pond Storage | 14,050 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 1.16 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 1.2 | $ 8,700 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 3,500 | $ 17,500 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 29,550 | $ 206,850 |
| 5 | Landscaping | ha | $ 10,000.00 | 1.2 | $ 11,600 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 114,678 |
| | | | | Total | $ 443,000 |

Pond 8

Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 47,800 | $m^3$ |
| Dead Pond Storage | 43,620 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 2.71 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 2.7 | $ 20,325 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 8,100 | $ 40,500 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 83,320 | $ 583,240 |
| 5 | Landscaping | ha | $ 10,000.00 | 2.7 | $ 27,100 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 263,958 |
| | | | | Total | $ 1,019,000 |

Pond 9

Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 12,000 | $m^3$ |
| Dead Pond Storage | 7,550 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 0.77 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 0.8 | $ 5,775 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 2,300 | $ 11,500 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 17,250 | $ 120,750 |
| 5 | Landscaping | ha | $ 10,000.00 | 0.8 | $ 7,700 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 80,054 |
| | | | | **Total** | **$ 309,000** |

Pond 10

Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 11,100 | $m^3$ |
| Dead Pond Storage | 6,760 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 0.72 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 0.7 | $ 5,400 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 2,200 | $ 11,000 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 15,660 | $ 109,620 |
| 5 | Landscaping | ha | $ 10,000.00 | 0.7 | $ 7,200 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 75,677 |
| | | | | **Total** | **$ 292,000** |

Pond 11

Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 9,600 | $m^3$ |
| Dead Pond Storage | 5,480 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 0.63 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 0.6 | $ 4,725 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 1,900 | $ 9,500 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 13,180 | $ 92,260 |
| 5 | Landscaping | ha | $ 10,000.00 | 0.6 | $ 6,300 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 68,525 |
| | | | | **Total** | **$ 265,000** |

Pond 12

Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 15,900 | $m^3$ |
| Dead Pond Storage | 11,110 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 0.99 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 1.0 | $ 7,425 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 3,000 | $ 15,000 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 24,010 | $ 168,070 |
| 5 | Landscaping | ha | $ 10,000.00 | 1.0 | $ 9,900 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 99,188 |
| | | | | **Total** | **$ 383,000** |

**Pond 13**

Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 13,100 | $m^3$ |
| Dead Pond Storage | 8,540 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 0.83 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 0.8 | $ 6,225 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 2,500 | $ 12,500 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 19,140 | $ 133,980 |
| 5 | Landscaping | ha | $ 10,000.00 | 0.8 | $ 8,300 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 85,402 |
| | | | | **Total** | $ 330,000 |

**Pond 14**

Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 2,700 | $m^3$ |
| Dead Pond Storage | 510 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 0.22 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 0.2 | $ 1,650 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 0,700 | $ 3,500 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 2,510 | $ 17,570 |
| 5 | Landscaping | ha | $ 10,000.00 | 0.2 | $ 2,200 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 37,772 |
| | | | | **Total** | $ 146,000 |

**Pond 15**

Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 21,900 | $m^3$ |
| Dead Pond Storage | 16,870 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 1.32 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 1.3 | $ 9,900 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 4,000 | $ 20,000 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 34,770 | $ 243,390 |
| 5 | Landscaping | ha | $ 10,000.00 | 1.3 | $ 13,200 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 129,322 |
| | | | | **Total** | **$ 499,000** |

**Pond 16**

Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 18,600 | $m^3$ |
| Dead Pond Storage | 13,670 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 1.14 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 1.1 | $ 8,550 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 3,400 | $ 17,000 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 28,870 | $ 202,090 |
| 5 | Landscaping | ha | $ 10,000.00 | 1.1 | $ 11,400 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 112,714 |
| | | | | **Total** | **$ 435,000** |

**Pond 17**

Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 21,800 | $m^3$ |
| Dead Pond Storage | 16,770 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 1.31 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 1.3 | $ 9,825 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 3,900 | $ 19,500 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 34,670 | $ 242,690 |
| 5 | Landscaping | ha | $ 10,000.00 | 1.3 | $ 13,100 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 128,840 |
| | | | | **Total** | **$ 497,000** |

**Pond 18**

Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 7,500 | $m^3$ |
| Dead Pond Storage | 3,760 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 0.51 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 0.5 | $ 3,825 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 1,500 | $ 7,500 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 9,760 | $ 68,320 |
| 5 | Landscaping | ha | $ 10,000.00 | 0.5 | $ 5,100 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 58,711 |
| | | | | **Total** | **$ 227,000** |

**Pond 19**

Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 13,200 | $m^3$ |
| Dead Pond Storage | 8,630 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 0.84 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 0.8 | $ 6,300 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 2,500 | $ 12,500 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 19,330 | $ 135,310 |
| 5 | Landscaping | ha | $ 10,000.00 | 0.8 | $ 8,400 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 85,929 |
| | | | | **Total** | **$ 332,000** |

**Pond 20**

Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 30,400 | $m^3$ |
| Dead Pond Storage | 25,400 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 1.78 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 1.8 | $ 13,350 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 5,300 | $ 26,500 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 50,500 | $ 353,500 |
| 5 | Landscaping | ha | $ 10,000.00 | 1.8 | $ 17,800 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 172,953 |
| | | | | **Total** | **$ 668,000** |

**Pond 21**

Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 40,000 | $m^3$ |
| Dead Pond Storage | 35,360 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 2.30 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 2.3 | $ 17,250 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 6,900 | $ 34,500 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 68,460 | $ 479,220 |
| 5 | Landscaping | ha | $ 10,000.00 | 2.3 | $ 23,000 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 222,940 |
| | | | | **Total** | **$ 860,000** |

**Pond 22**

Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 32,000 | $m^3$ |
| Dead Pond Storage | 27,040 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 1.87 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 1.9 | $ 14,025 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 5,600 | $ 28,000 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 53,440 | $ 374,080 |
| 5 | Landscaping | ha | $ 10,000.00 | 1.9 | $ 18,700 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 181,232 |
| | | | | **Total** | **$ 700,000** |

**Pond 23**

Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 35,200 | $m^3$ |
| Dead Pond Storage | 30,340 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 2.04 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 2.0 | $ 15,300 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 6,100 | $ 30,500 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 59,440 | $ 416,080 |
| 5 | Landscaping | ha | $ 10,000.00 | 2.0 | $ 20,400 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 197,848 |
| | | | | **Total** | **$ 764,000** |

**Pond 24**

Design Parameters

| | | |
|---|---|---|
| Live Pond Storage | 11,400 | $m^3$ |
| Dead Pond Storage | 7,020 | $m^3$ |
| Side Slope | 5.0H:1V | |
| Max Depth of Pond for Live Storage | 2.0 | m |
| Required Area for Storage | 0.74 | ha |
| Outlet pipe | 375 | mm diameter |

| Item | Description | Unit | Unit Price | Estimated Quantity | Amount |
|---|---|---|---|---|---|
| 1 | Mobilization & Demobilization | ls | $ 20,000.00 | 1 | $ 20,000 |
| 2 | Clearing & Grubbing | ha | $ 7,500.00 | 0.7 | $ 5,550 |
| 3 | Topsoil | $m^3$ | $ 5.00 | 2,200 | $ 11,000 |
| 4 | Excavation and Disposal | $m^3$ | $ 7.00 | 16,220 | $ 113,540 |
| 5 | Landscaping | ha | $ 10,000.00 | 0.7 | $ 7,400 |
| 6 | Outlet Structure | ls | $ 50,000.00 | 1 | $ 50,000 |
| 7 | Outlet Pipe (incl manholes) | m | $ 260.00 | 50 | $ 13,000 |
| 8 | Engineering & Contingency | 35% | N/A | N/A | $ 77,172 |
| | | | | **Total** | **$ 298,000** |

# Appendix C

# Pond Areas Including Buffer Zones

| Drainage Basin | Pond Area (ha) | Pond Area with Buffer Zone (ha) |
|---|---|---|
| 1 | 0.73 | 1.11 |
| 2 | 1.03 | 1.48 |
| 3 | 1.53 | 2.06 |
| 4 | 3.52 | 4.31 |
| 5 | 0.64 | 1.00 |
| 6 | 2.16 | 2.79 |
| 7 | 1.16 | 1.63 |
| 8 | 2.71 | 3.41 |
| 9 | 0.77 | 1.16 |
| 10 | 0.72 | 1.10 |
| 11 | 0.63 | 0.99 |
| 12 | 0.99 | 1.43 |
| 13 | 0.83 | 1.23 |
| 14 | 0.22 | 0.45 |
| 15 | 1.32 | 1.82 |
| 16 | 1.14 | 1.61 |
| 17 | 1.31 | 1.81 |
| 18 | 0.51 | 0.84 |
| 19 | 0.84 | 1.25 |
| 20 | 1.78 | 2.35 |
| 21 | 2.30 | 2.95 |
| 22 | 1.87 | 2.46 |
| 23 | 2.04 | 2.65 |
| 24 | 0.74 | 1.12 |

Note: Buffer Zone includes a 10 m width around the entire Pond Perimeter.