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'Final' Report for:

ROCKY VIEW COUNTY

CONRICH MASTER DRAINAGE PLAN

HAMLET AMENDMENT UPDATE

Date: May 23, 2024
Project # 2285-046-03

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Rocky View County

May 23, 2024

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Rocky View County, Alberta
T4A 0X2

File: N:\22\85\046-03\Conrich MDP.R01

Attention: Steve Altena, P.Eng., MPlan
Supervisor – Engineering Services

Dear Mr. Altena:

Re: Conrich Master Drainage Plan – Hamlet Amendment Update – Final Report

MPE a division of Englobe herein submits the Final Report for the Conrich Master Drainage Plan (MDP) Hamlet Amendment Update, as requested by Rocky View County.

This report contains our findings and recommendations regarding stormwater servicing for the future build-out of the Conrich area, reflecting the latest Conrich Area Structure Plan. This plan also provides guidance to prospective developers and the community on the stormwater management options for the region.

Please contact the undersigned at 403-769-6212 for any questions that you may have.

Yours truly,

MPE a division of Englobe

David Seeliger, P.Eng.
Senior Water Resources Engineer

DS/tm
Enclosure

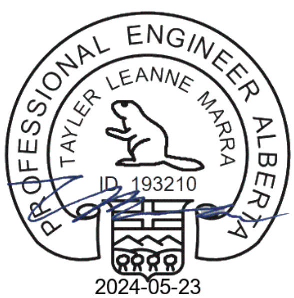
CORPORATE AUTHORIZATION

This report has been prepared by MPE a division of Englobe under authorization of Rocky View County. The material in this report represents the best judgment of MPE a division of Englobe given the available information. Any use that a third party makes of this report, or reliance on or decisions made based upon it is the responsibility of the third party. MPE a division of Englobe accepts no responsibility for damages, if any, suffered by a third party as a result of decisions made or actions taken based upon this report.

Should any questions arise regarding content of this report, please contact the undersigned.

MPE a division of Englobe

PREPARED BY: **REVIEWED BY:**



PERMIT TO PRACTICE
MPE, a division of Englobe Corp.
Signature
APEGA ID 138342
Date May 23, 2024
PERMIT NUMBER: P 7841
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

Tayler Marra, P.Eng. David Seeliger, P.Eng.

Professional Seal Professional Seal Corporate Permit

EXECUTIVE SUMMARY

The Hamlet of Conrich and the surrounding area, located on the eastern side of Rocky View County (RVC), is identified as a future development growth node. This is due to its proximity to the City of Calgary, major transportation routes including Highway 1, Stoney Trail and the Canadian National Railway (CN Rail) Intermodal Hub and Logistics Park. RVC retained MPE Engineering Ltd. (MPE) to develop an overall stormwater framework for future development in the region, based on the Area Structure Plan (ASP) for Conrich. An assessment of the stormwater infrastructure requirements is necessary to assist in the planning of an orderly development strategy for the area. The Master Drainage Plan (MDP) determines requirements to manage stormwater using Best Management Practices (BMPs) and identifies conveyance routes towards the ultimate outfall location.

The Conrich ASP study area covers approximately 4,410 ha with a portion of the area naturally draining towards the Western Irrigation District (WID) Secondary B and C canals, and the remaining area south to be eventually intercepted by the Western Headworks (WH) Canal. The topography of the area is fairly flat with few defined drainage courses. As in most parts of RVC, much of the existing development has adopted rural stormwater management practices, incorporating culverts, ditches, and natural conveyance systems.

Development such as residential, industrial, and other land uses can increase stormwater runoff volumes up to 10 to 20 times the pre-development levels. Developing appropriate stormwater management strategies, such as Low Impact Development (LID) Practices, stormwater reuse methods and conveyance systems that enable stormwater to be treated as a resource, is important to minimize the downstream impacts.

The Conrich MDP provides implementation strategies to ensure sustainable and orderly development of future growth. It identifies opportunities, constraints, and design parameters for managing existing and future drainage infrastructure. This MDP will also serve as a guiding tool to identify critical drainage corridors that would be best suited to accommodate future development. The Conrich Drainage System is defined as the stormwater infrastructure outside of individual developments that will be constructed to convey runoff from the Conrich ASP area to its ultimate outfall location (the Co-operative Stormwater Management Initiative [CSMI] System).

The key methods and analyses utilized during the preparation of this MDP involved the following:

- Preparation of an inventory and assessment of existing wetlands.
- Setting stormwater Unit Area Release Rates (UARRs), Volume Control Targets (VCTs) and water quality requirements for the Conrich area based on a review of the CSMI System.
- Defining LID practices and stormwater reuse options to help future developments achieve the required VCTs.
- Outlining interim measures that can be utilized prior to the full drainage conveyance system being constructed.
- Identifying drainage conveyance alignments to direct the runoff from the Conrich ASP area to the CSMI System.
- Preparation of probable cost estimates for the proposed storm drainage infrastructure.

The key recommendations resulting from this study are summarized as follows:

<u>Stormwater Management Policies for the Future Development in the Conrich ASP Area</u>

All proposed development should prepare a Stormwater Management Plan which addresses the following:

1. Stormwater BMPs, LID practices and wet ponds/constructed wetlands with detention storage adequately sized to restrict discharges to meet the CSMI targets of maximum 1:100 year UARR of 0.8 L/s/ha or lower, an annual average VCT of 40 mm/year and a Total Suspended Solids (TSS) removal of 85% of particles 50 microns and larger.
2. LID practices and stormwater management practices should be adequately sized, using primarily evaporative losses (as infiltration capacity is usually severely limited).
3. Construct local Stormwater Management Facilities (SWMF) in preference to regional facilities unless multiple developments desire to combine their stormwater systems and have demonstrated the ability to do so successfully.
4. Promote a local stormwater reuse scheme that employs strategies to optimize the use potential and provides flexibility in delivering stormwater from source or storage location to the end user or areas of demands.

Management of Natural Wetlands and Sensitive Watercourses

Natural wetlands that are to be retained within the development areas should be managed by:

5. Being integrated into the development water balance in a manner to maintain the wetlands pre-development hydrological regime, including volume and hydro period.
6. Only directing adequately treated stormwater runoff into the wetlands if using these facilities for a component of detention storage during significant flood events such as a 1:100 year event, or in emergency situations subject to the approval of the approving authority.

Interim Stormwater Management Facilities

When the downstream conveyance systems have not yet been established, proposed developments should adequately manage stormwater to minimize impacts on the adjacent or downstream drainage systems. This may include:

7. Adequately designing zero-release systems prior to an outlet location being constructed.
8. Incorporating interim temporary pumping to infrastructure that is constructed.
9. Abiding by the CSMI interim restrictions as outlined in the CSMI Regional Stormwater Guidelines.

Study Recommendations

10. Stormwater management policies and principles outlined in this MDP should be included in future guiding documents and be incorporated into development requirements.

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1.0 INTRODUCTION

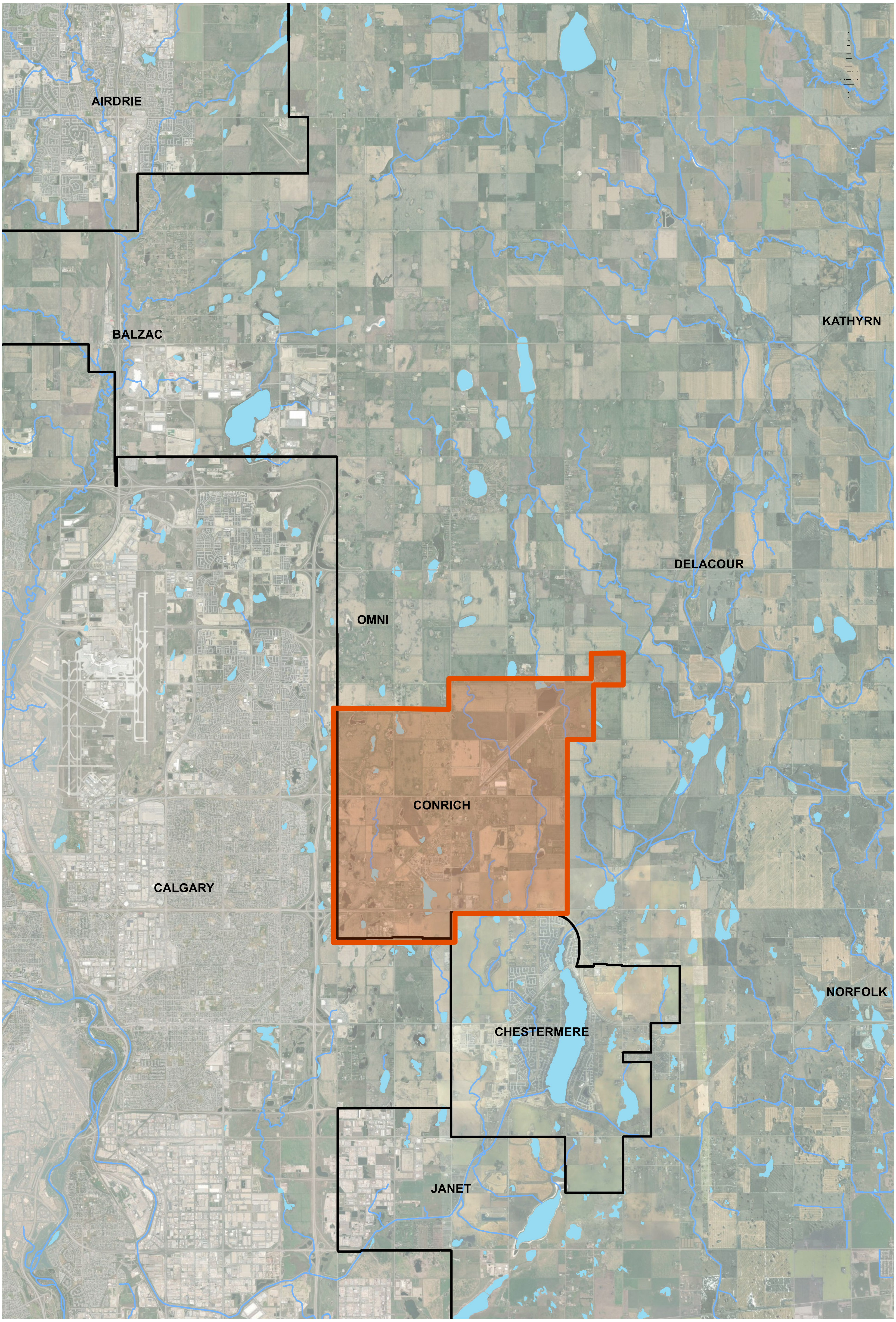
1.1 Background

The Hamlet of Conrich (Conrich) and the surrounding area, located on the eastern side of Rocky View County (RVC), is identified as a future development growth node. This expected growth is primarily due to its proximity to the City of Calgary and major transportation routes including Highway 1, Stoney Trail and the Canadian National Railway Intermodal Hub and Logistics Park (CN Rail Logistics Park). A Master Drainage Plan (MDP) is needed to ensure stormwater runoff can and will be managed effectively to promote sustainable and orderly development of future growth in the Conrich area.

RVC retained MPE Engineering Ltd. (MPE) to complete an MDP for the Conrich study area. This MDP is aimed to serve as a guiding tool to identify critical drainage corridors that would be ideally suited for the Conrich Drainage System. The Conrich Drainage System is defined as the stormwater infrastructure outside of the individual developments that will be constructed to convey runoff from the Conrich Area Structure Plan (ASP) area to its ultimate outfall location. The ultimate outfall location for the stormwater runoff in Conrich is the Cooperative Stormwater Management Initiative (CSMI) System, which will begin near the intersection of Township Road 250 and Range Road 282.

1.2 Study Area

The study area is located predominantly north of Highway 1 and immediately to the east of the City of Calgary, with a total area of approximately 4,410 ha (***Figure 1.1***). The current Hamlet of Conrich is near the center of the study area, and a number of residential and acreage developments are scattered throughout the rural area along with the CN Rail Logistics Park.



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CONRICH MASTER DRAINAGE PLAN STUDY LOCATION	DATE: MAY 2024	SCALE: 1:100,000
	JOB: 2285-046	FIGURE: 1

1.3 Scope of Work

The following points summarize the overall scope of work for this study:

- Review existing background information and previous reports.
- Conduct field reconnaissance of wetlands and drainage conveyance infrastructure.
- Delineate and characterize the sub-basins and sub-catchments within the study area.
- Identify the environmental sensitivities of wetlands and riparian zones.
- Recommend stormwater Unit Area Release Rates (UARRs) and Volume Control Targets (VCTs) for the Conrich ASP area based on a review of the CSMI requirements.
- Evaluate drainage constraints and issues relating to new drainage routes, particularly potential impacts on existing wetlands.
- Outline LID practices and stormwater reuse options to help future developments achieve the VCTs required for release to the CSMI System.
- Recommend how to incorporate interim servicing for new developments and ensure these facilities can be incorporated into the ultimate drainage strategy.
- Explore opportunities to retrofit existing zero release systems to meet the future development requirements.
- Prepare probable cost estimates for proposed Conrich Drainage System infrastructure.

1.4 Previous Studies

The following documents provide an overview of planning framework and physical, environmental, and natural characteristics of the Conrich area:

- Engineering Assessment of Preferred Stormwater Management Options, CSMI.
- Water Balance and Stream Erosion Assessment, CSMI.
- Modelling and Stage Development Report, CSMI.
- Master Site Development Plan, CN Rail Logistics Park.
- Revised Stormwater Implementation Plan for Phase-1 Buffalo Hills Development.
- Cambridge Estates Stormwater Management Plan.
- Conrich Area Structure Plan – Hamlet Amendment Update.
- Omni Master Drainage Plan.

2.0 EXISTING CONDITIONS

2.1 Existing Drainage Catchments

Drainage in the study area is characterized by numerous localized depression areas, which form wetlands with temporary or permanent water features. The study area ultimately drains to the Western Irrigation District (WID) irrigation canal system either in a southerly direction to the Western Headworks (WH) Canal, directly into Chestermere Lake via West Creek and the Rainbow Falls underdrain, or in a southeasterly direction into the B/C secondary canals.

Roads, railways, and side ditch formations have altered the natural flow paths creating backup and flow redirection in a number of locations within the study area. ***Figure 2.1*** shows current drainage paths, existing culverts, and catchment areas. Some of the main depression areas have been identified with separate catchments; however, there are many smaller local catchments that have not been delineated in the figure.

2.2 Catchment Hydrology

The study area has similar climatic and geotechnical characteristics to the adjacent Nose Creek catchment, which exhibits an average surface runoff of approximately 10-15 mm per year and limited infiltration to the underlying aquifers (CSMI Modelling and Stage Development Report, MPE 2020). The pre-development runoff volumes in Conrich could potentially be lower than the adjacent Nose Creek due to the slightly higher evapotranspiration, lower rainfall, and the presence of significant storage areas. On the other hand, the higher prevalence of clay till soils and shallow groundwater levels results in the low elevation areas being groundwater discharge zones as identified in the Rocky View Groundwater Assessment report (AECOM, 2011). The natural water cycle of the area is finely balanced with the majority of rainfall held in the soil profile and in localized depressions, which depletes over the growing season through evaporation and evapotranspiration.

Development in the study area interrupts this fine hydrological balance, resulting in increased runoff, creating local flooding and downstream impacts if not adequately considered in the stormwater management facilities. Many of the recently built subdivisions rely on evaporation methods to manage stormwater. Past experience has shown that these types of systems have been undersized, resulting in adjacent flooding of low-lying areas or to downstream conveyance streams.

2.3 Existing Land Use

The land use in the Hamlet of Conrich is mainly low-density country residential housing. The surrounding land is predominantly agricultural with some country residential acreages and several larger subdivision developments. The CN Rail Logistics Park has been built in the northeast portion of the study area with the intention of being the first stage of an industrial hub.

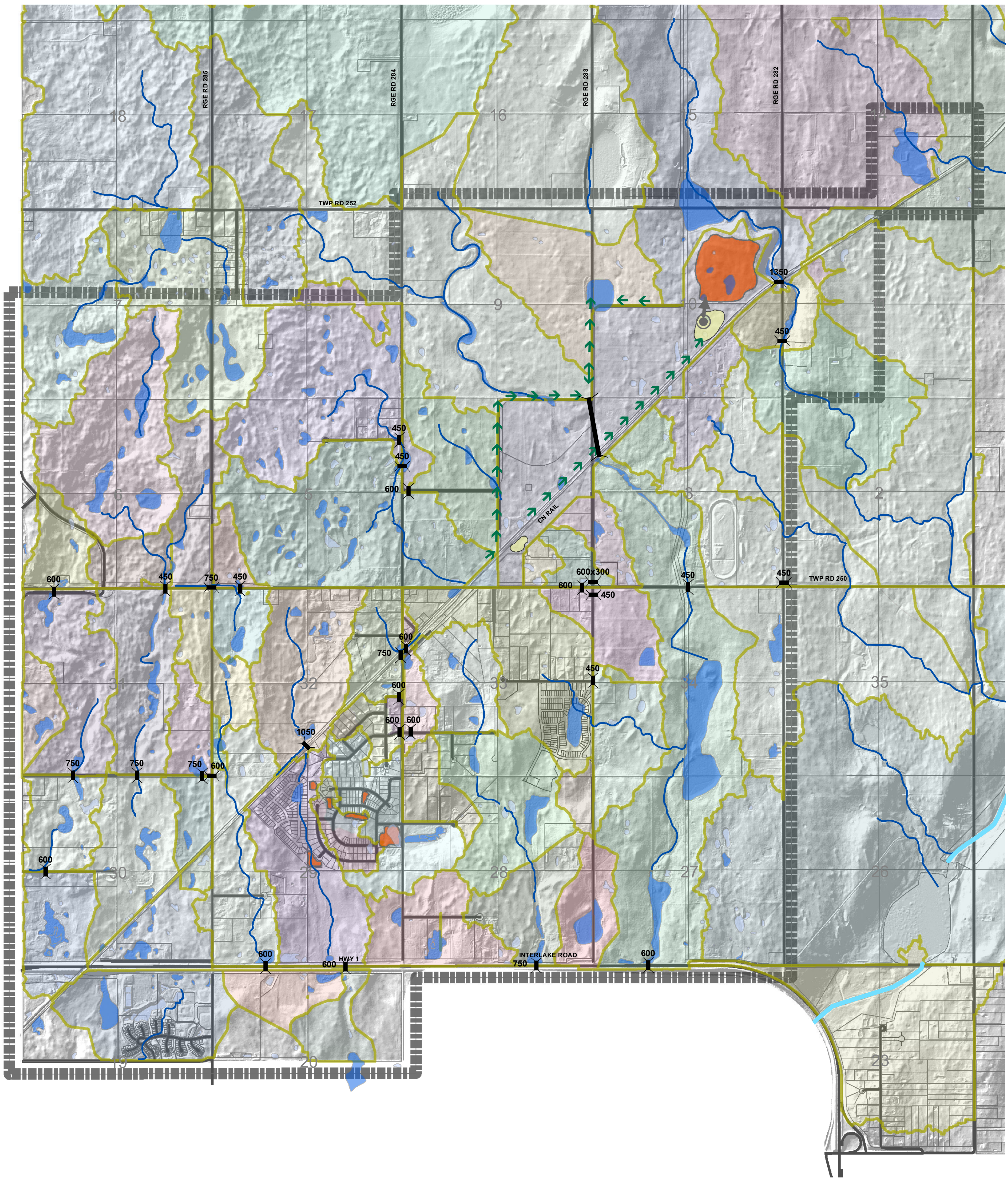
2.4 Existing Drainage Infrastructure

Stormwater runoff is primarily conveyed through ephemeral streams, overland flow paths downstream of natural wetlands, and ditches and culverts along local road alignments. Many of the older acreage subdivisions have limited controls for runoff discharge into streams or depression wetlands. The more recent developments (such as Cambridge Estates) have constructed local stormwater management retention facilities, such as stormwater ponds, with and without downstream release opportunities. The CN Rail Logistics Park development redirects stormwater from approximately four quarter sections into a central evaporation basin through a series of stormwater pipes, ditches, temporary storage areas, and pump systems.

2.4.1 Infrastructure Condition

Site inspections were carried out in 2014 to determine the size and condition of culverts crossing public roads as well as the general condition and arrangement of drainage ditches and swales within the existing developed areas of Conrich. The culverts that were inspected typically crossed RVC roads; however, some cross Alberta Transportation (AT) roads or the CN Rail line. The crossings mostly include CSP culverts typically in satisfactory condition; however, a number are in poor condition, blocked by sediment or having damaged culvert ends.

TWP 25 - RGE 28 - W4M



TWP 24 - RGE 28 - W4M

STUDY AREA
EXISTING DRAINAGE AREA
STORM DETENTION FACILITY
EVAPORATIVE STORAGE
EXISTING STORM FORCEMAIN
EXISTING STORM LIFT STATION
EXISTING DRAINAGE COURSE
EXISTING DITCHES
EXISTING CULVERT
WID B/C CANAL
TEMPORARY WETLANDS AND DUGOUTS
WETLAND (CLASS III AND ABOVE)

0 0.25 0.5 1 1.5 2 Km

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CONRICH MASTER DRAINAGE PLAN EXISTING CATCHMENT AREAS	DATE: MAY 2024	SCALE: 1:35,000
	JOB: 2285-046	FIGURE: 2.1

3.0 REGULATORY FRAMEWORK AND GUIDING DOCUMENTS

3.1 Area Structure Plan

Area Structure Plans (ASPs) set legislative framework, describe natural characteristics of a defined area, and underline the philosophy and goals of the plan. They provide policy framework for the natural environment, infrastructure, future physical forms, community development and implementation strategies. The proposed land use from the current Conrich ASP can be seen in ***Appendix A***. It provides guidance on land use planning and infrastructure servicing strategies (including this MDP) for the Conrich region.

3.2 WID Stormwater Guidelines

The WID has developed a stormwater guideline document which aims to protect the water quality of their irrigation system. The guidelines set strict water quality criteria for new developments that discharge stormwater into or towards the WID irrigation system. The WID canal system is currently stressed from a water quality perspective. For the WID to accept any new inflows, stormwater must be treated to a higher standard than outlined in the AEP guidelines.

The WID guidelines set multiple criteria to enable stormwater to be permitted to be discharged into WID infrastructure, such as a Total Phosphorus (TP) level of 0.03 mg/L or lower. Alternatively, a catch and release approach may be used where the runoff is stored in the stormwater facilities within the development during the irrigation season and then released during the off-season.

Currently, stormwater best management practices cannot reliably achieve TP levels below 0.1 mg/L. Therefore, mechanical treatment methods are the only currently acceptable method to permit runoff into the WID system during the irrigation system.

3.3 Cooperative Stormwater Management Initiative

The Cooperative Stormwater Management Initiative (CSMI) was formed to assist municipalities and the WID in working together to find an effective and feasible solution to provide an adequate stormwater outlet for existing and future development. In late 2011, the municipal partners and the WID ascertained there was a need to undertake a collaborative process with the aim to develop a sustainable Stormwater

Management (SWM) solution for the region that accommodates future land development. In 2020, CSMI became an official entity comprised of the WID, RVC, City of Calgary and the Town of Strathmore.

The aim of CSMI is to have the municipal and irrigation sectors work together, share resources, and develop a mutually beneficial solution. The preferred SWM alternative was to provide for:

1) Long-term sustainability of the WID irrigation system in support of agri-business in the region, and
2) Certainty of growth and stormwater system costs to municipalities in support of ongoing development and economic growth within the region.

CSMI has completed various studies to determine the infrastructure alignments, downstream impacts and staging requirements. These reports include:

- Engineering Assessment of Preferred Stormwater Management Options (MPE, 2014).
    - Explored a number of potential SWM alternatives and developed a preferred option.
- CSMI Water Balance and Stream Erosion Assessment (MPE, 2015).
    - Provided further guidance on the Volume Control Targets (VCTs) and constructed wetlands that have been recommended for the region.
- CSMI Modelling and Stage Development (MPE, 2020).
    - Analyzed the impacts the different CSMI stage restrictions would have on the development storage requirements.

3.3.1 CSMI Regional Stormwater Guidelines

The CSMI Regional Stormwater Guidelines have been prepared to support developers and municipalities on specific stormwater management requirements for development within the CSMI Region. This includes approval procedures, recommended modelling and design methodologies, and compliance requirements for developments. This document also includes details regarding staging restrictions that will apply to developments releasing into the CSMI North System (Conrich and Omni ASP Areas), which will be relaxed as subsequent CSMI Stages are constructed.

3.4 Alberta Environment and Parks (AEP)

Stormwater from proposed developments in the study area will discharge into natural streams or constructed swales. There are currently only a few formally constructed stormwater ponds for water quality treatment and water quantity control in the Conrich area. Any future stormwater management facilities such as stormwater ponds or constructed wetlands and proposed outfalls within the study area would need to be authorized and regulated by AEP under the *Water Act* (*WA*) and the *Environmental Protection and Enhancement Act (EPEA)*. Prior AEP approval is required before proposed subdivision development within the study area, including storm outfalls or stormwater management ponds or stormwater LID practices or BMPs are constructed.

In addition, Alberta's *Water Act* requires that an approval be obtained before undertaking a construction activity in a wetland. Currently, Alberta's priority is to reduce loss of wetlands by:

- Avoiding impacts to the wetland,
- Minimizing impacts and requiring applicable compensation, and
- Compensating for impacts that cannot be avoided or minimized.

The approval process and the use of wetland compensation are summarized as follows:

- Applicants should discuss their proposal, including options to avoid or minimize the impact on the wetland, with a wetlands specialist or restoration agency and the local municipality (i.e. RVC) before applying for Water Act approval.
- Applicants should also consult with AEP's Public Lands.
- An assessment and classification of the affected wetland must be completed if the wetland is to be destroyed or altered.

3.5 Water Reuse Policy in Alberta

3.5.1 Rainwater Reuse Policy

According to AEP, rainwater is considered precipitation that is collected for single-family residential use from surfaces such as rooftops. Harvesting rainwater for use is a non-regulated activity under both the *Water Act* and the EPEA. When rainwater is collected and used for toilet and/or urinal flushing in a single-family residential application, it must be done in accordance with the non-potable water requirements as outlined in the National Plumbing Code.

3.5.2 *Stormwater Reuse Policy*

Stormwater is runoff resulting from precipitation collected from vegetative surfaces, roads, parking lots in a municipality, or commercial and private developments, according to AEP. Stormwater may be considered as a “source of water”, and its use may require a license under the *Water Act* administered by AEP. However, AEP has developed a policy to permit stormwater reuse without requiring a license. Typically, AEP allows the difference between the pre and post-development evaporative losses to be reused under specific conditions (refer to *Public Health Guidelines for Water Reuse and Stormwater Use* [Alberta Health Services, 2021] for further detail).

This could allow more than half of the urban runoff to be used for stormwater reuse, however, there are a number of restrictions on the type and locations where this use is permitted. Stormwater reuse will be an important practice to achieve the level of VCTs and water quality requirements for the CSMI System.

3.6 Alberta Transportation

Alberta Transportation (AT) is responsible for primary and secondary highways and associated bridge infrastructures in the study area. The care of water with respect to road and bridge infrastructure includes stormwater, irrigation water and natural stream/river flows. Prior consultation with AT is required for future subdivision development proposals within the study area if any drainage infrastructure (e.g. bridge, culverts) across primary and secondary highways is impacted, needs replacing or upgrading.

3.7 Alberta Wetland Policy

The *Alberta Wetland Policy* encourages the avoidance of impacts to wetlands. Where impacts cannot be avoided, the provincial hierarchy recommends minimizing any impacts and replacing lost wetland value (Government of Alberta, 2013). Details on wetland impact mitigation strategies can be seen in ***Section 5.7.1.***

4.0 WETLANDS INVENTORY AND ASSESSMENT

4.1 Wetland Classification and Mapping

Wetlands previously mapped by RVC in the Conrich MDP area were classified based on the Stewart and Kantrud Wetland Classification System (Stewart and Kantrud, 1971). This classification system was adopted by Alberta Environment (2007) and the City of Calgary (2004) to address wetland classification, assessment and compensation in the region.

Reconnaissance-level field visits were conducted between September 18-20, 2012. A total of 134 wetland polygons mapped by RVC (i.e. reconnaissance sites) were visited (***Figure 4.1***). Photographs were taken at representative sites and botanical information sufficient to identify wetland class and dominant vegetation association(s) and physiognomy was collected. Ground truth information from field reconnaissance sites was used in combination with visual interpretation of two ortho-photos (1:5,000 scale - 2003 and 2010) to classify all wetlands mapped by RVC for the study area.

Precipitation in 2003 totalled 430.0 mm at the Calgary Airport Station, which is close to the yearly average precipitation between 1945 and 2011 of 425.5 mm/year (***Table 4.1, Appendix B***). Precipitation in 2010 was above average (454.5 mm). Interpretation of the two ortho-photos provided a good understanding of wetland conditions for an average year and a wet year.

Wetland boundaries were not modified and only a few large wetlands were added from this assessment. Wetland boundary assessment was outside of the scope of this project. It was, however, noted during field visits and during classification that:

1. Some wetlands were not mapped, in particular small and tilled wetlands,
2. Some wetlands were partially mapped (i.e. only the central wetter portion was mapped, but not the surrounding wet-meadow/low-prairie zones),
3. Some mapped wetlands were part of a single larger wetland.

Such issues should be addressed when specific and more detailed development planning is available. The wetland polygons mapped by RVC were classified according to the types shown in ***Table 4.1***.

Table 4.1: Wetland Classification

Wetland Class	Area
Permanent Wetland – Class V	51.8 ha (28 map polygons)
Semi-permanent Wetland – Class IV	80.5 ha (48 map polygons)
Semi-permanent Wetland – Class IV Tilled	8.1 ha (8 map polygons)
Seasonal Wetland – Class III	59.1 ha (72 map polygons)
Seasonal Wetland – Class III Tilled	32.6 ha (64 map polygons)
Temporary Wetland – Class II	7.0 ha (37 map polygons)
Temporary Wetland – Class II Tilled	32.3 ha (168 map polygons)
Dugout/Man-Made Pond	10.6 ha (64 map polygons)
Not a Wetland	3.3 ha (18 map polygons)

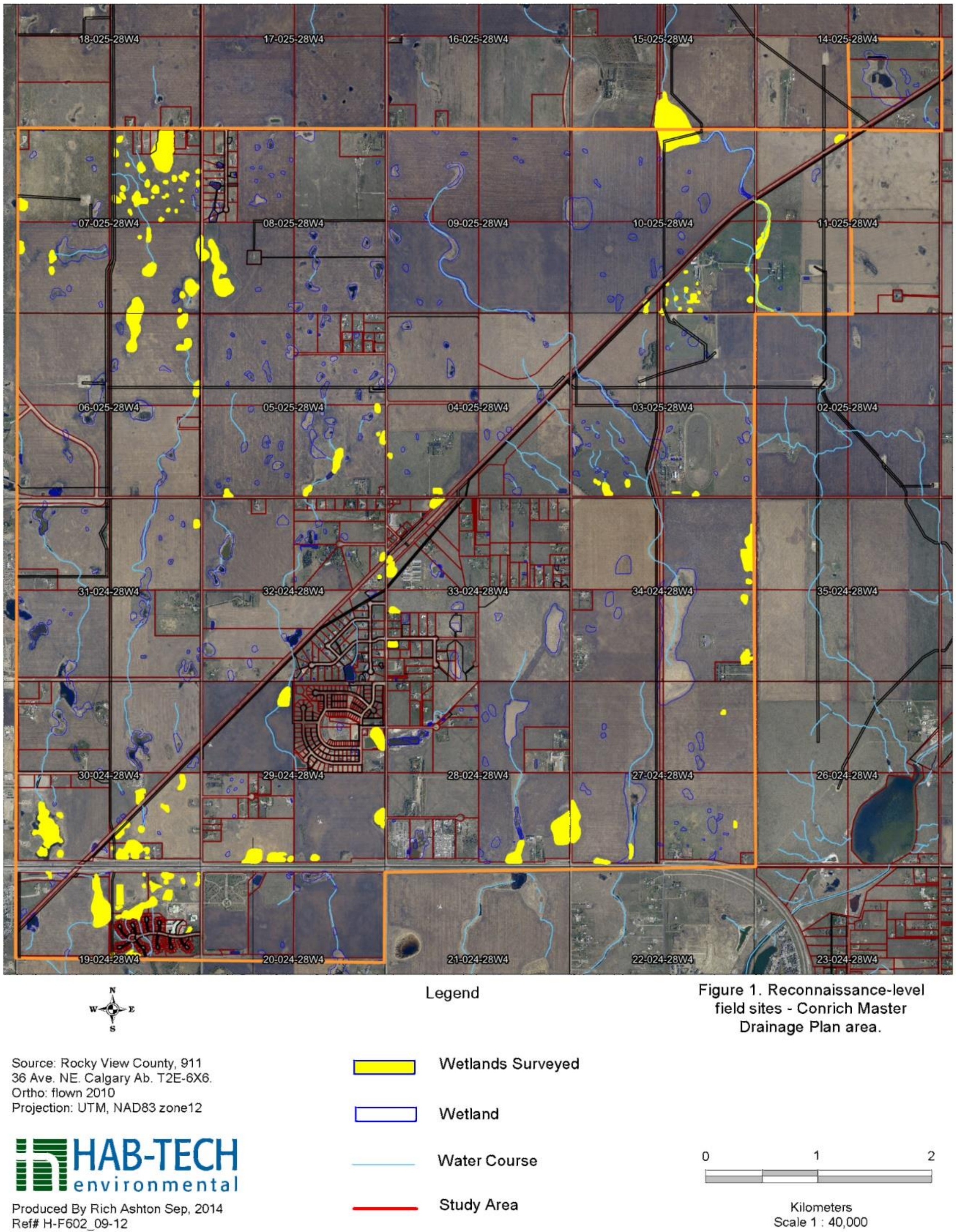
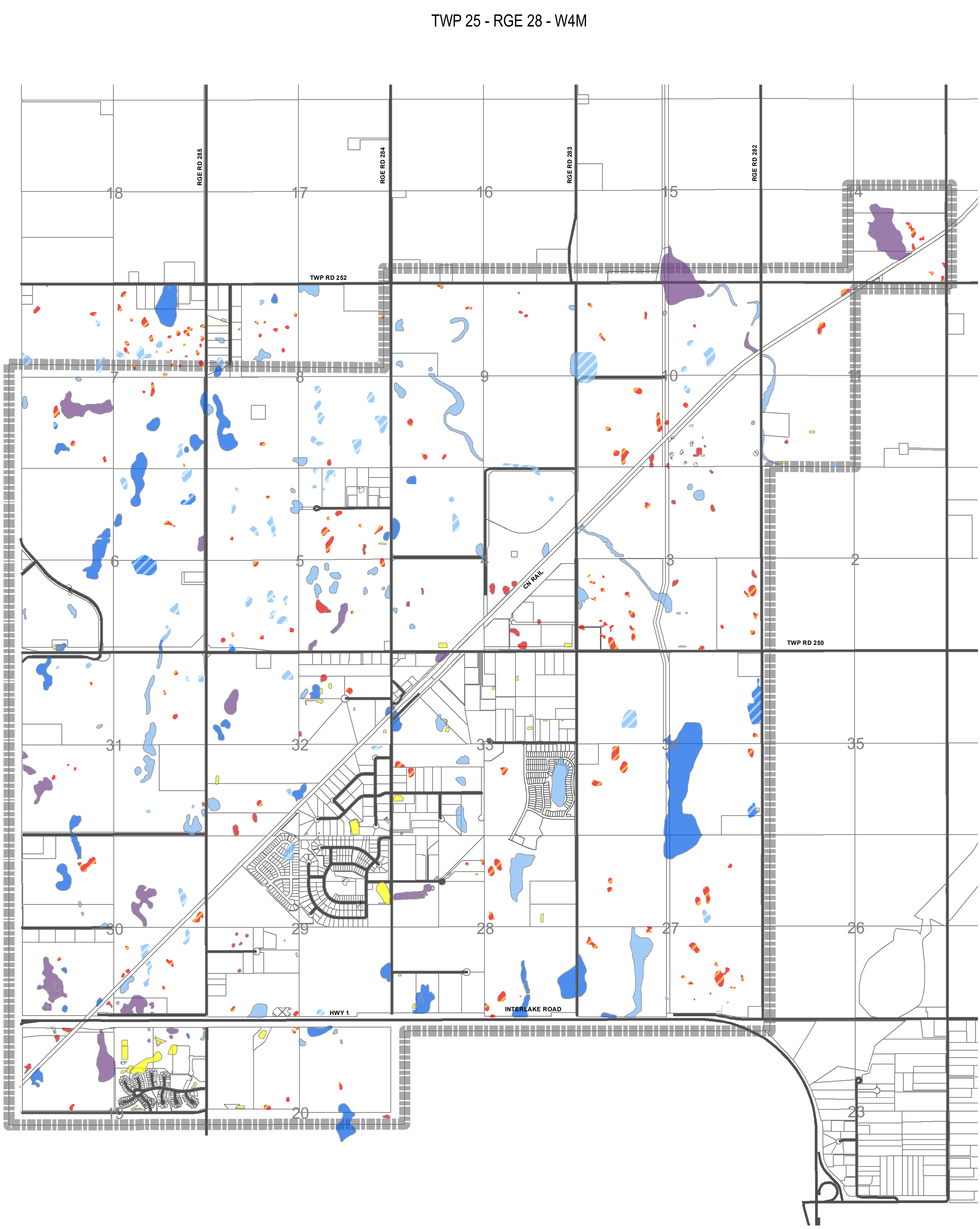


Figure 4.1: Reconnaissance Level Field Sites



STUDY
TEMPORARY WETLAND - CLASS II
TEMPORARY WETLAND - TILLED CLASS II
SEASONAL WETLAND - CLASS III
SEASONAL WETLAND - TILLED CLASS III
SEMI-PERMANENT WETLAND - CLASS IV
SEMI-PERMANENT WETLAND - TILLED CLASS IV
PERMANENT WETLAND - CLASS V
DUGOUT - MAN-MADE POND
NOT A WETLAND

0 0.25 0.5 1 1.5 2 Km

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CONRICH MASTER DRAINAGE PLAN
WETLAND CLASSIFICATION

DATE:	MAY 2024	SCALE:	1:35,000
JOB:	2285-046	FIGURE:	4.2

4.2 Wetland Type Descriptions

The classified wetlands and dugout/man-made ponds occupy approximately 282 ha (6%) of the Conrich ASP area (***Figure 4.2***). Permanent and semi-permanent wetlands are the largest wetlands, occupying a total of 140.4 ha (84 polygons), while seasonal and temporary wetlands are usually smaller and occupy 131.1 ha (341 polygons). Wetlands are, for the most part, embedded within a matrix of cultivated fields. As a result, 56% of the wetlands (i.e. 240 out of 425 wetlands) were found to be recently tilled. The majority of the tilled wetlands are temporary and seasonal wetlands. Descriptions of each mapped wetland type are below.

Temporary Wetlands (Class II)

Temporary wetlands are characterized by wet-meadow vegetation found in the deepest portion of the wetland and surface water is only maintained for a few weeks after the spring snowmelt or heavy rainfall events (Steward and Kantrud, 1971). A total of 205 of the wetlands mapped by RVC were classified as temporary wetlands and represent 39.3 ha of the study area. Temporary wetlands were divided into two groups.

The first group included temporary wetlands that have been recently and fully tilled (Temporary Wetland – Class II Tilled). A total of 168 temporary wetlands (Class II) covering 32.3 ha were tilled. These wetlands were dominated by agronomic species or were extensively covered by bare ground (>80%) with very scarce remnants of wetland vegetation. The vegetation that did remain was dominated by foxtail barley (*Hordeum jubatum*), toad rush (*J. bufonius*), and Nuttall's salt-meadow grass (*Puccinellia nuttalliana*) (**Photos 1 and 2 – *Appendix B***). Ecological integrity and functionality of these wetlands was severely compromised by the frequent tilling that impeded the development of natural wetland processes and habitat characteristics.

The second group included temporary wetlands that had not been cultivated in recent years. A total of 37 wetlands covering 7.0 ha were classified as Temporary Wetland – Class II. Such wetlands contained some of the following species: foxtail barley, Nuttall's salt-meadow grass, fine sedges (*Carex spp*), slough grass (*Beckmannia syzigachne*), dock species (*Rumex spp*), and red goosefoot (*Chenopodium rubrum*) (**Photos 3 and 4 – *Appendix B***). Other wetland species that were present in lesser amounts included short-awned foxtail (*Alopecurus aequatilis*) and common cattail (*Typha latifolia*).

Some of these wetlands were invaded by non-native species such as creeping thistle (*Cirsium arvense*), smooth brome (*Bromus inermis*), timothy (*Phleum pratense*), Kentucky blue grass (*Poa pratensis*), common dandelion (*Taraxacum officinale*), clover (*Trifolium sp.*), common smart weed (*Polygonum arenastrum*), Russian thistle (*Salsola kali*) and kochia (*Kochia scoparia*). Floristic and structural diversity of these wetlands is low due to past tillage or non-native plant invasion. As a result, these wetlands have low habitat suitability for wildlife, Species at Risk or rare plants. Ecological integrity of these wetlands is also low.

Seasonal Wetlands (Class III)

Seasonal wetlands are characterized by shallow-marsh vegetation occurring in the deepest portion of the wetland, as well as surface water usually being maintained in spring and early summer (Steward and Kantrud, 1971). A total of 136 of the wetlands mapped by RVC were classified as seasonal wetlands, which occupy 91.8 ha of the MDP area. These wetlands were divided into two groups.

The first group included seasonal wetlands that had been recently cultivated. A total of 64 wetlands covering 32.6 ha were classified as Seasonal Wetland – Class III Tilled. These wetlands were dominated by agronomic species and were highly degraded, with low native floristic and structural diversity. Shallow-marsh plant species found in the deepest portion of these wetlands were: slough grass, coarse sedges (*Carex spp*) and reed canary grass (*Phalaris arundinacea*) mixed with wet-meadow plant species such as foxtail barley, toad rush and Nuttall's salt-meadow grass (**Photos 5 and 6** – ***Appendix B***). Some of these wetlands were invaded by non-native species.

The second group included seasonal wetlands that had not been cultivated in recent years. However, most of them were likely cultivated in dry years in the past. A total of 72 wetlands covering 59.1 ha were classified as Seasonal Wetlands – Class III. Such wetlands were characterized by a shallow-marsh zone in the deepest portion of the wetlands dominated by some of the following species: slough grass, creeping spike-rush (*Eleocharis palustris*), needle spike-rush (*E. acicularis*), awned sedge (*Carex atherodes*), reed canary grass and golden dock (*Rumex maritimus*). Patches of common cattail occurred sporadically. Some of these wetlands included a carpet of pigtail moss (*Hypnum sp.*) and ragged moss (*Brachythecium sp.*) (**Photos 7 and 8** – ***Appendix B***).

Other wetland species that were frequently observed included: narrow-leaved water-plantain (*Alisma gramineum*), foxtail barley, toad rush, wire rush (*Juncus balticus*), Nuttall's salt-meadow grass and short-awned foxtail. Sparsely distributed and uncommonly recorded wetland species included: sow thistle, vernal water-starwort (*Callitriche verna*), narrow-leaved dock (*Rumex salicifolius*), wild mint (*Mentha arvensis*), common plantain (*Plantago major*) and bulrush (*Scirpus sp.*). Low-prairie and wet-meadow zones of these wetlands were usually cultivated or invaded by non-native plant species.

Semi-Permanent Wetlands (Class IV)

Semi-permanent wetlands are characterized by deep-marsh vegetation in the deepest portion of the wetland and surface water being maintained throughout spring and summer and sometimes into fall and winter (Steward and Kantrud, 1971). A total of 56 of the wetlands mapped by RVC were classified as semi-permanent and occupied 88.6 ha of the MDP area. These wetlands were divided into two groups.

The first group includes semi-permanent wetlands that had been completely cultivated in dry years. Eight wetlands covering 8.3 ha were classified as Semi-permanent Wetland – Class IV Tilled. These wetlands had been completely tilled in the past. As a result, litter cover was shallow and sparse, and structural and floristic diversity was limited (**Photo 9 – *Appendix B***). These wetlands were characterized by deep-marsh vegetation in the deepest portion of the wetland, which was dominated by common cattail and a carpet of ragged moss. The shallow-marsh zone of these wetlands was dominated by slough grass, foxtail barley, and mudwort (*Limosella aquatica*). The outer vegetation rings of wet-meadow/low prairie zones were tilled and wetland vegetation was scarce.

The second group includes semi-permanent wetlands that had not been cultivated in the deep-marsh and shallow marsh zones. A total of 48 wetlands covering 80.5 ha were classified as Semi-permanent Wetland – Class IV. The deepest portion of these wetlands was characterized by a shallow water or mudflats zone interspersed or surrounded by common cattail or bulrushes and a carpet of ragged moss. Duckweed (*Lemna minor*), mudwort, water smartweed (*Polygonum amphibium*), long-spiked water smartweed (*Polygonum coccineum*), cursed crowfoot (*Ranunculus sceleratus*), white-water crowfoot (*R. aquatilis var. capillaceus*), and northern water-starwort (*Callitriche hermaphroditica*) were found in standing water (**Photos 10, 11 and 12 – *Appendix B***).

The shallow-marsh zone, when present, was characterized by the same species described for the shallow-marsh zone of the Seasonal Wetland – Class III. Common species in the wet-meadow zone, when not cultivated were: foxtail barley, Nuttall's salt-meadow grass, fine sedges, marsh cress (*Rorippa sp.*), wire rush, long-styled rush (*Juncus longistylis*), toad rush, marsh cudweed (*Gnaphalium palustre*), narrow-leaved dock, common plantain, sow thistle and short-awned foxtail.

Permanent Wetlands (Class V)

Permanent wetlands are characterized by a deep-water zone with submerged vegetation in the deepest portion of the wetland and surface water is maintained throughout the year (Steward and Kantrud, 1971).

A total of 28 of the wetlands mapped by RVC were classified as Permanent Wetland and occupied 51.8 ha of the MDP area. Class V wetlands were characterized by a large open water zone (**Photos 13, 14 and 15 – *Appendix B***). Vegetation in the deep water zone is sparse to absent and dominated by common cattail. Duckweed, water smartweed, long-spiked water smartweed and crowfoot species were also found in patches of standing water. Patches or outer rings of shallow-marsh and wet-meadow vegetation are often present. Common plant species found on these zones were slough grass, foxtail barley, Nuttall's salt-meadow grass, awned sedge, reed canary grass and golden dock. Tall manna grass (*Glyceria grandis*) was sporadically observed.

Dugout/Man-Made Ponds

Even though dugouts and man-made ponds are not wetlands, they were mapped by RVC. A total of 64 Dugout/Man-Made Ponds were mapped, occupying 10.6 ha of the study area. Some dugouts were located in upland areas while some were located inside of natural wetlands. Man-made ponds were often wetlands prior to construction. Some of them supported scattered wetland vegetation such as common cattail, reed canary grass and foxtail barley (**Photos 16 and 17 – *Appendix B***).

Not Wetland Polygons

A total of 18 polygons mapped by the County as wetlands are no longer wetlands. These may have been ephemeral to temporal wetlands in the past; however, no basin or wetland vegetation was observed during the field visits (**Photos 18 and 19 – *Appendix B***).

4.3 Relative Importance of Wetland Types

According to Alberta's *Water Act* (Government of Alberta, 1996), all wetlands in the province are important hydrological, ecological and socio-economical features, regardless of class or type. This is reflected in the strict wetland policy that requires an approval and/or license to affect a water body including dredging, filling, diverting and drainage. RVC adopted policies in 2010 with the purpose of conserving and managing wetlands and riparian lands. These policies help RVC to fulfill its legislative mandate through meeting legal and statutory requirements for the protection of provincial water resources.

The definition of a water body in the *Water Act* is as follows:

> *"Water body means any location when water flows or is present, whether or not the flow or the presence of water is continuous, intermittent or occurs only during flood, and includes but is not limited to wetlands and aquifers".*

The importance of individual wetlands is often measured using the concept of wetland functionality (Bond *et al*., 1992; Clairain, 2002; Fennessy *et al*., 2004; City of Calgary, 2004). Wetland functionality provides the basic knowledge to assess the relative importance of specific wetlands and the impacts of specific proposed developments. Wetland impact assessments are one of the requirements to apply for an approval to disturb a wetland (Alberta Environment, 2007) and determine compensation and mitigation activities.

Factors used to measure relative functional value of wetlands include hydrological, biological/ecological, and socio-economical factors. ***Table 2 (Appendix B*)** lists some of the most important factors to take into consideration when assessing the functionality of a wetland.

Assessment of the relative importance of individual wetlands lies outside of the scope of this project as it is not applicable to this level of sub-regional planning and wetland classification. However, there are some inherent differences in the level of ecological importance of the wetland types mapped in ***Figure 4.2*** and described above including:

1. Regional rarity.
2. Wetland native ecological integrity.

3. Plant and wildlife biodiversity potential.
4. Size and connectivity.

Regional Rarity

Native habitats considered to be in short supply (rare) in a regional context are considered to be more significant than abundant habitats in the context of preserving landscape diversity and the plant and animal species that these landscapes support (Noss, 1993; Council on Environmental Quality, 1993; Noss and Cooperrider, 1994). Even though all wetlands are considered uncommon at a regional level, the least common wetlands in the study area are permanent wetlands (n=28) followed by semi-permanent wetlands (n=56).

Wetland Native Ecological Integrity

Invasion of native habitats by non-indigenous or "introduced" species of plants can result in a loss of native plant species, changes in community structure and function, and alterations in the physical structure of the system (Drake *et al*., 1989; Desserud and Naeth, 2010).

Habitat loss (agricultural land clearing and tillage) is the main disturbance factor observed in the study area. As such, tilled wetlands have a lower ecological integrity than non-tilled wetlands. However, tilled wetlands have the potential to partially recover their native ecological integrity after agricultural activities cease (Bartzen *et al*., 2010). Moreno-Mateos *et al*. (2012) concluded that after disturbance occurs, wetlands either recover very slowly or move towards alternative states that differ from reference conditions. Such alternative states, even though not pristine, can nonetheless provide important ecosystem services such as water storage, reduction in sedimentation and nutrient loading, plant biodiversity, carbon sequestration (Gleason *et al*., 2011) and wildlife habitat (Begley *et al*., 2012).

Plant and Wildlife Biodiversity Potential

Ecosystems that support a high level of diversity of plant species tend to be structurally diverse and productive (Meffe and Carroll, 1997). These areas in turn support a wide variety and abundance of insect and animal forms. Permanent and semi-permanent wetlands generally present a higher number of vegetation zones than seasonal and temporal wetlands. Each vegetation zone contains unique plant communities and structural assemblages providing a variety of habitats for wildlife species. They together have the potential to provide numerous reproductive, forage and cover opportunities or “niches” for survival and reproduction for several wildlife species.

Size and Connectivity

Large wetlands or wetland complexes offer secure “core” areas for certain wetland wildlife species. Small wetlands that lack “core” areas are more prone to isolation and fragmentation. In addition, small and isolated wetlands are not able to support all the species and number of individuals that a large wetland does. The largest wetlands in the study area are permanent and semi-permanent wetlands with average sizes of 1.8 ha and 1.6 ha, respectively.

5.0 OPPORTUNITIES, CONSTRAINTS AND DESIGN CONSIDERATIONS

In developing this MDP, an understanding of the opportunities and constraints will help shape the strategies considered to manage stormwater within the area. These opportunities and constraints must consider aspects of both the Conrich Drainage System and the CSMI System, which will be utilized as criteria to size the infrastructure. A summary of the key opportunities and constraints is shown in ***Table 5.1***.

Table 5.1: Opportunities and Constraints for Conrich Stormwater Management

OPPORTUNITIES	CONSTRAINTS
• Stormwater reuse • LID practices • Staging to enable downstream conveyance to be created • Natural wetland and stream protection • CSMI as a stormwater outfall solution • Directing treated stormwater to natural wetlands	• The CSMI System outfall location, timing of construction, and ultimate and interim release restrictions • Conrich Drainage System construction timing • WID stormwater guidelines • Natural wetlands and streams • Roads and natural topography • Private properties needed for ROW and land acquisition • Servicing costs • AEP Wetland Policy • AEP reuse policy

5.1 Future Stormwater Management Requirements

Potential developments will need to be planned and sited to minimize the potential impacts on environmentally sensitive areas such as wetlands, stormwater reuse systems and to meet the requirements of the ultimate outfall to the CSMI System. The MDP looks primarily at the stormwater concerns in respect to flow conveyance, flood management and water quality. Policies have been developed and recommended to control the peak flow and volume and to improve water quality from a development.

The key stormwater management requirements include:

- Provide a stormwater conveyance system that directs stormwater flows above pre-development levels away from natural wetlands and streams that will be retained.
- Adopt Low Impact Development (LID) Practices to reduce runoff volumes to the required 40 mm/year target and to improve water quality.
- Include constructed wetlands, wet ponds and other measures to provide detention storage to control peak flows to a maximum discharge rate of 0.8 L/s/ha.
- Winter runoff to be retained within the ultimate and interim stormwater management systems for each development until it is permitted to be released during the spring thaw.
- Consider LID practices and constructed wetlands to provide a high level of pre-treatment and a pre-development flow regime to these natural wetland areas.

By complying with the above requirements, improvements to the runoff water quality will be achieved for new downstream stormwater management facilities, assisting the further reuse of stormwater or discharge to the system.

5.2 Interim Drainage Solutions

There will be different restrictions on the release of stormwater from the Conrich developments depending on the timing of the construction of the Conrich Drainage System as well as the CSMI System. The following sections outline options that can be utilized prior to the completion of these systems.

5.2.1 Prior to Conrich Drainage System Completion

Until the construction of the Conrich Drainage System is complete, interim drainage solutions will need to be provided for the early developments. The timeline for these interim solutions to remain in place will depend on the location of these developments, as well as the staging of the Conrich Drainage System alignments. The interim drainage solution options include:

1. Zero-release systems.
2. Temporary pumping to the Conrich Drainage System or CSMI System.

<u>Zero-Release Systems</u>

This option has been utilized by multiple existing developments, which involves avoiding release of any stormwater from a site, but instead relying on evaporative measures to control levels within the storage facilities. However, the stormwater measures required to accomplish a zero-release system have been typically underestimated, resulting in additional flooding issues. If a zero-release system is designed effectively, this provides an acceptable interim solution prior to the Conrich Drainage System being constructed to convey the runoff from a site to the CSMI System. This solution can also be utilized prior to the CSMI System being ready to accept stormwater flows.

Expected increases to storage facility footprint areas for zero-release system have been explored for the CSMI Region. Increases to accommodate a zero-release system in comparison to a development that releases to the CSMI System (includes LID Practices to meet VCTs) include the following:

- Without the use of LID Practices and stormwater reuse = approximately six to eight times.
- With use of LID Practices and stormwater reuse = approximately two times.

Interim Pumping

Pumping from an onsite storage facility to either the Conrich Drainage System or the CSMI System directly may be a feasible option depending on the location of the development and the infrastructure constructed at the time. Whether this pumping conveys the flow to the Conrich Drainage System or the CSMI System, the CSMI interim restrictions outlined in *the CSMI Regional Stormwater Guidelines* must also be followed.

5.2.2 Prior to CSMI System Completion

The CSMI System requires interim release restrictions until it becomes fully operational without utilizing the WID canals as interim release locations. These requirements are in addition to the ultimate UARR, VCTs and water quality requirements and must be adhered to if releasing to the CSMI System.

The CSMI Regional Stormwater Guidelines provides details regarding the staging restrictions that will apply to developments releasing into the CSMI North System specifically, as this is the part of the system being utilized by the Conrich area. These release requirements will evolve as subsequent CSMI Stages are constructed.

5.2.3 Staging Considerations

As the conveyance infrastructure in both the Conrich Drainage System and the CSMI System continues to be constructed, release requirements become less stringent (i.e. zero-release to off-season release to continuous release). Another approach to managing interim conditions involves staging development so that the ultimate pond size is adequate to manage stormwater during these more constrained stages. If developers can plan the stages in such a way, this can avoid oversizing infrastructure to meet the more constrained release requirements.

5.3 Retrofitting Existing Systems

Many of the recently built subdivisions have been designed to achieve a zero or pre-development release configuration when managing stormwater. These systems typically use evaporation ponds, but some developments also use irrigation. Past experience has shown that some of these developments have undersized their storage facilities, resulting in adjacent flooding of low-lying areas or to downstream conveyance systems. It is recommended that these systems be retrofitted to meet the requirements outlined in this MDP, including a controlled discharge when both the Conrich Drainage System and the CSMI System are in place.

The steps and considerations required to retrofit these existing systems include:

- Provide additional measures to allow detention storage to control peak flows to a maximum UARR of 0.8 L/s/ha.
- Consider the interim restrictions and options outlined in ***Section 5.2***.
- Maintain existing LID practices where applicable to help lessen runoff volume.
  Note: Existing developments will not be required to achieve the CSMI average VCT of 40 mm/year unless the site is developing further.

5.4 Stormwater Management Facilities Approach

A discussion on regional versus local Stormwater Management Facilities (SWMF) is required to determine the best approach to developing the drainage network through Conrich in the long term. Both approaches have their advantages and disadvantages. The approaches can be compared using the following criteria: cost, staging, right-of-way (ROW) and easements required for the facility, ROW and easements required downstream of the development/facility, major runoff event conveyance, suitability for water reuse, and operation, maintenance and approvals required.

5.4.1 Summary of Comparison Between Regional and Local SWMF

Considering ease of approval and minimizing ongoing O&M costs, the regional scale facility is an attractive concept if it can be practically applied in a study area. However, it does entail greater upfront costs and either RVC or an individual developer will have to agree to fund a certain facility with future cost recovery. It may be very difficult to get the development industry to agree to the major initial costs of Regional SWMFs, with a possibly protracted cost recovery time. Further, the ROW/easement for stormwater conveyance routes through intermediate landowners may be difficult if not impossible to obtain if the landowners are not at the same stage of development.

The local SWMF approach reduces the upfront cost as well as the staging concerns impacting conveyance to the facilities. This also provides ease during design as developers can focus on their site individually, which, due to the VCT, will typically involve a type of stormwater reuse either on lot or utilizing the SWMF. In addition to these benefits, if a flooding issue arises, local facilities will make it easier to determine the cause. In summary, the local facility approach is the most attractive option for the Conrich ASP area. It is also an option for developers to collaborate and combine their SWMF if the site topography allows it.

5.5 Omni Upstream Contribution

The Omni ASP area is approximately 518 ha in size and is located north of Conrich. The future development in Omni is proposed to be commercial, industrial and residential lands and will also utilize the CSMI System as the outfall for its runoff. The *Omni Master Drainage Plan* (MPE, 2017) outlines its recommended stormwater conveyance alignment, which includes utilizing a portion of the Conrich alignment to connect to the CSMI System. The Conrich Drainage System should allow for Omni flows to utilize the northern most alignment at a UARR of 0.8 L/s/ha. Where infrastructure is shared, costs should also be split to ensure the appropriate levies can be calculated.

5.6 Stormwater Best Management Practices

To minimize impacts on sensitive wetlands and to achieve the volume and water quality targets from development, two key types of stormwater management practices can be employed:

- End-of-Pipe Solutions.
- Source Control Practices (SCPs).

5.6.1 End-of-Pipe Solutions

End-of-Pipe Solutions control the flow rate and treat stormwater at the outlet of a drainage system before reaching the receiving conveyance system. These solutions are more traditional stormwater practices and play an important role in the stormwater system design. Examples of these solutions can be seen in ***Table 5.2.***

Table 5.2: End-of-Pipe Solutions

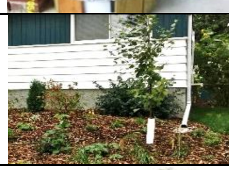
End of Pipe Solutions		**Description**
Dry Ponds		Impoundment areas used to temporarily detain stormwater runoff, restricting the downstream discharge to pre-determined rates and reducing downstream flooding and erosion potential. Less suitable where high groundwater exists.
Wet Ponds Photo Source: www.calgary.ca		Pond active storage is used temporarily to detain stormwater runoff and promote settlement of runoff pollutants, as well as to the restrict downstream discharge to predetermined rates to reduce downstream flooding and erosion potential. Storage can also be retained for irrigation or other approved reuse purposes.
Engineering Existing Natural Wetlands Photo Source: www.riparian.ca		Modified natural wetlands with forebays, outlet control structures or other engineered components used to increase stormwater storage and treatment capabilities. Requires AEP approval.
Constructed Stormwater Wetlands		Wetlands designed and constructed specifically for stormwater management purposes and to provide some ecological amenity value. Grading encourages large shallow areas with wetland meadow plantings.
Naturalized Storm Pond Photo Source: www.nativeplantsolut ions.ca		Naturalized storm ponds have the same hydraulic function as a wet pond but generally feature flatter side slopes and are vegetated with native wetland and riparian plantings.

Controls on the outlets used in conjunction with the End-of-Pipe Solutions outlined in ***Table 5.2***, such as dual orifice structures, can assist in limiting flows in different events to minimize downstream erosion of small streams.

5.6.2 Source Control Practices

Low Impact Development (LID) practices are an emerging science in stormwater management and include planning through site design and the application of Source Control Practices (SCPs). SCPs provide a range of benefits from the retention of incident rainfall and runoff from adjacent impervious surfaces to the treatment of runoff to improve water quality. SCPs can be applied at the individual lot level or on multiple lots that drain a small area. Examples of these practices can be seen in ***Table 5.3***.

Table 5.3: Source Control Practices

Source Control Measures		Description
Swales/ Bioswales		Shallow grassed channels that accept flows from small areas of adjacent paved surfaces. These provide flow attenuation as well as treatment of stormwater through settling, fine filtration, extended detention, and some biological uptake.
Green Roofs		Veneers of living vegetation installed on top of buildings. These manage stormwater through a variety of hydrologic processes that otherwise take place at ground level.
Rainwater Harvesting Photo Source: Joel Cantu, Houston, Texas		Collection of runoff from a roof area or other impermeable surface before discharge onto the ground into a storm sewer system.
Resilient (Absorbent) Landscaping and Rain Gardens		Ability of topsoil to effectively store and slowly release water is dependent on soil texture, structure, depth, organic matter content and biota. Rain gardens are comprised of resilient landscape with a shallow depression. They are most effective when involving the redirection of downspouts from the roof.
Soil Cells and Tree Trenches		Soil cells provide adequate soil volume for healthy tree growth under hard pavements. Stormwater is directed to soil cells to provide a source of water and water quality treatment. Tree trenches are similar in function by directing stormwater to trees but may not be located under hard pavements.
Permeable Pavement Photo Source: www.quietnature.ca		A permeable surface that allows precipitation and runoff from adjacent areas to percolate into the ground beneath.

5.6.3 Suitability and Performance of Stormwater BMPs

In addition to hydrologic/hydraulic loading rates, the effectiveness of the various BMPs will depend on the level of maintenance and operation compliance that is achieved. In order to identify suitable LID practices for a development, several factors need to be considered including function (i.e. volume reduction/water quality treatment capabilities), operation and maintenance requirements, and location (i.e. on public or private land). The location is important as the owner is typically responsible for the future maintenance and therefore the long-term performance of a facility. The performance of potential stormwater management practices based on an assessment by MPE is summarized in ***Table 5.4***.

Table 5.4: Stormwater BMP Performance Matrix

Stormwater Best Management Practice	Pollutant Removal	Volume Reduction	Peak Flow Reduction	Maintenance Requirements	Operation Requirements	Capital Cost	Suitability on Private Land	Suitability on Public Land
Dry Ponds	L	L	H	L	L	M	M	M
Wet Ponds	M	L	H	M	L	H	L	H
Engineered Existing Natural Wetlands	M	L - M	M - H	M - H	L	M	L - M	H
Constructed Stormwater Wetlands	H	L - M	M - H	M - H	L	H	L - M	H
Naturalized Storm Pond	H	L - M	M - H	M	L	M	M	H
Swales / Bioswales	M	L - M	M	M	L	L	L	H
Green Roof	L	M - H	L - M	M - H	L	H	H	L
Rainwater Harvesting	M	M	L	M	H	H	H	L
Resilient Landscaping and Rain Gardens	H	H	M	L	L	L	H	M
Soil Cells and Tree Trenches	H	H	M	M	L	M	H	H
Permeable Pavement	M	L - M	M - H	M - H	L	H	M	M

Performance Notation: L – Low, M – Medium, H – High, N/A – Not Applicable

LID practices have been shown to be effective in controlling the volume of stormwater generated either on its own or in combination with wet ponds/wetlands. Many of the preferred LID practices are mainly located on private lots, which raise questions on their long-term operation and performance. Therefore, consideration should be given to how socially acceptable specific LID practices are and the likelihood that they will remain operational. Consideration is also given to what potential mechanisms or encouragement/incentives can be provided to ensure they remain operational over the longer term.

Suitability Based on Development Type

A suitability assessment of the range of SCPs potentially being applied to various types of development within the study area is presented in ***Table 5.5***. The key conclusion is that specific practices are more suited to certain types of development.

Table 5.5: Suitability of Source Control Practices

Stormwater Source Control Practice	Development Type									Maintenance Primarily by Municipal/Private
	Residential	Multi Residential	Retail/ Commercial	Industrial	Country Residential	Parks & Recreation	Cluster	Small Development	Large Development	
Swales / Bioswales	M	L	M	H	H	H	M	H	M	M
Green Roof	L	M	H	M	L	L	L	L	L	P
Rainwater Harvesting	M - H	H	H	M - H	H	L	M	M - H	M	P
Resilient Landscaping and Rain Gardens	M - H	L	L	M	H	H	H	H	H	P
Soil Cells and Tree Trenches	M - H	M	H	M	L	L	M	H	M - H	P/M
Permeable Pavement	M	L - M	L - M	L	L	L	L	M	L	P/M

Notation: L – Low, M – Medium, H – High, M – Municipal, P – Private

5.7 Stormwater Management Considerations for Wetlands and Natural Streams

Potential impacts of stormwater drainage and management to wetlands or natural streams in the study area include:

- Increase of surface water runoff because of impervious surfaces.
- Reduction of water due to isolation from the local upland catchment.
- Decrease in water quality entering the wetland or stream as contaminants, sediments and nutrients are transported by stormwater. Aquatic and semi-aquatic wildlife and fish habitat may be affected.
- Increase in the erosion potential.

- Reduction of floodwater storage capacity.
- Altered plant composition and wildlife habitat.

5.7.1 Wetland Considerations and Mitigation Strategies

Changes in water regime and water permanence have the greatest potential to alter wetland plant structure and composition and therefore wildlife habitat and populations. Increased water input into wetlands will generally result in reductions in low-prairie, wet-meadow, shallow-marsh, and deep-marsh wetland zones, and increases in open water. Reduction of plant and structural diversity provided by the different wetland zones will result in a more homogeneous environment where wildlife habitats are reduced or lost.

According to the Provincial Wetland Restoration/Compensation Guide (Alberta Environment, 2007), mitigation is the process to reduce loss of wetlands by:

- Avoiding impacts to wetlands;
- Minimizing impacts and requiring applicable compensation; and
- Compensating for impacts that cannot be avoided or minimized.

Avoiding impacts to wetlands is the most desirable mitigation strategy. However, when avoidance is not possible, then minimizing impacts is preferred. Mitigation measures to minimize impacts on wetlands should consider the protection, maintenance or enhancement of wetland conditions such as water quality, flow regime, wetland zonation, plant and wildlife diversity and potential to harbor species at risk.

When avoidance and minimization is not possible, then compensation should be taken into consideration. Wetland compensation supports the concept of no further loss of wetland area in the province by restoring wetlands to replace those impacted by development. Wetland restoration is done by wetland restoration agencies (i.e. Ducks Unlimited).

Integration of existing wetlands into future development areas will be an important consideration. Historically it is common to fill in wetlands to make way for development. The successful management of wetlands in future urban areas will be dependent on maintaining an acceptable hydraulic regime that mimics pre-development conditions.

5.7.2 Natural Streams Considerations

Similarly, there are several water courses that generally drain from north to south, which feed linear wetlands and provide water to downstream users. It would be the intent that pre-development flows would be maintained along environmentally sensitive areas. This may involve constructing the main stormwater conveyance parallel to these natural areas, or where flow is diverted in a different direction, provide base flow controls and associated treatment devices to maintain pre-development flows.

5.8 Stormwater Reuse Strategy

A significant volume of stormwater runoff will be generated from the fully developed study area. A proportion of this volume could be captured for reuse if the systems are appropriately designed and managed. This includes ensuring suitable water pre-treatment using LID practices and conventional techniques to provide reasonable water quality. The following types of stormwater reuses were identified as possibilities for the Conrich study area:

- Maintaining existing wetlands.
- Irrigation of green space (Municipal Reserve [MR], ROW, and on lot).
- Non-potable water supply (toilet flushing and other uses).

A number of these approaches have been explored further and utilized in modelled examples in the *CSMI Regional Stormwater Guidelines*.

5.8.1 Maintaining Existing Wetlands

Some existing wetlands in the area are likely to be Class III and Class IV and may be maintained within the future development. Stormwater runoff should not be directly conveyed to these wetlands as the quality and quantity cannot be controlled properly. It is proposed that stormwater is first conveyed to the constructed facilities and then a controlled portion is allowed to be directed to the retained natural wetlands. The volume, timing, and water quality will depend on the development's objectives and would need to align with RVC and the *Alberta Wetland Policy*.

5.8.2 Irrigation of Green Space

Irrigation is a common stormwater reuse method, effective in both volume control and water quality improvement. Irrigation can be applied on MR land and other pervious surfaces, which should employ resilient landscape (thicker topsoil) to increase in the water holding capacity of the soil and enable more optimal plant growth and higher annual evapotranspiration. Within commercial and industrial developments, irrigation on lots, although beneficial, may achieve a small reduction in the overall runoff volume due to the limited pervious surfaces available. Other options include applying stormwater to impervious areas to promote evaporative losses and obtain heat island mitigation benefits; however, this may have other technical and regulatory issues.

5.8.3 Non-Potable Water Supply

Stormwater can also be supplied to buildings for toilet flushing and other non-potable uses, which decreases both potable water demand and runoff volume. This reuse could be achieved using an on-lot cistern or by providing a “purple” pipe system from a SWMF. Previous experience within RVC indicates that active on-lot controls, such as irrigation, are often not reliable. Therefore, RVC would consider providing a system that is controlled by the municipality that could distribute the recycled stormwater to the individual lots and MR space. This approach may need further enabling policies for this type of stormwater reuse to be progressed.

5.8.4 Local vs. Regional Reuse Approach

As the local stormwater management facility approach is the most attractive option for the Conrich ASP area, the reuse systems should also be localized within the Conrich ASP area. This also aligns with the current AEP recommendations that stormwater reuse be applied within the catchment it originated from in order to avoid requiring a license.

6.0 IMPLEMENTATION STRATEGIES

The strategy for implementing the MDP required the review of topography and existing drainage patterns of the study area. The two alignments for the Conrich Drainage System shown in ***Figure 6.1*** and ***Figure 6.2*** were chosen based on the following requirements:

- Provide stormwater conveyance servicing to every quarter section.
  - Identify potential local SWMF locations, assuming minimum of one location per quarter section.
- Intercept existing drainage systems.
- Avoid obstructions and permanent infrastructure such as the CN Railway.
- Utilize natural lows and defined drainage courses.
- Bypass Class III wetlands or higher.
- Consider the CSMI System requirements and its implications.
- Achieve minimum grades and excavation depths.
- Explore alternative approaches such as linear wetlands/pond, which may be preferable to very flat conveyance swales.
- Include flows from the Omni ASP area.
- Minimize locations where gravity conveyance is not an option.
- Protect the natural West Creek ephemeral stream system.

In addition to the above requirements, the second alignment utilized the current phasing plans to avoid requiring easements through areas not planning to develop in the near future.

6.1 Drainage Alignment Description

The Conrich Drainage System alignments have been developed to a conceptual level based on generally connecting to lowest areas of each quarter section. Wherever possible, open ditch alignments were identified based on topography and existing constraints such as development, wetlands, and road ROWs. Piped sections and lift stations with forcemains were included where topographical and other constraints were difficult to overcome.

The alignments developed generally follow the natural topography south, before directing flows east and north to the CSMI System connection point near Township Road 250. In locations where achieving minimum grades are challenging, alternative approaches such as linear wetland/pond may be preferable to very flat conveyance swales. Alignment 2 attempted to avoid requiring easements through a long-term development area on the east side of the Hamlet for the main conveyance infrastructure required for large portions of the early phases of development. Further details of the Conrich Drainage System alignments and concept design information is provided in ***Appendix C***.

The alignments have been developed at a conceptual level and are likely to be modified over time to accommodate development timing and grading requirements for individual sites. It is likely that additional underground piped sections may be employed to enable ROW to be secured through downstream lands holdings. Therefore, cost estimates have been developed below that considers a piped alternative to an open ditch conveyance system. While a pipe system would generally be more efficient from a land take perspective, careful consideration should be given to providing a safe overland flow path for the development and upstream developments when a subdivision is being designed.

6.1.1 Omni Upstream Contribution

The northwest portion of the Conrich Drainage System (Drainage Course 3) will accept inflow from the Omni ASP Area to convey the runoff from this area to the CSMI System. The contributing area is estimated to be a total of 777 ha, which includes 520 ha within the Omni ASP area, as well as four additional quarter sections between Omni and Conrich that are assumed to be built out in the future. This area will also be assumed to release at the required rate of 0.8 L/s/ha, resulting in an addition flow of 0.62 m^3/s. The cost of the portions of the Conrich Drainage System that Omni flows will utilize will be shared based on a flow contribution calculation.

6.1.2 Canadian National Rail Logistics Park

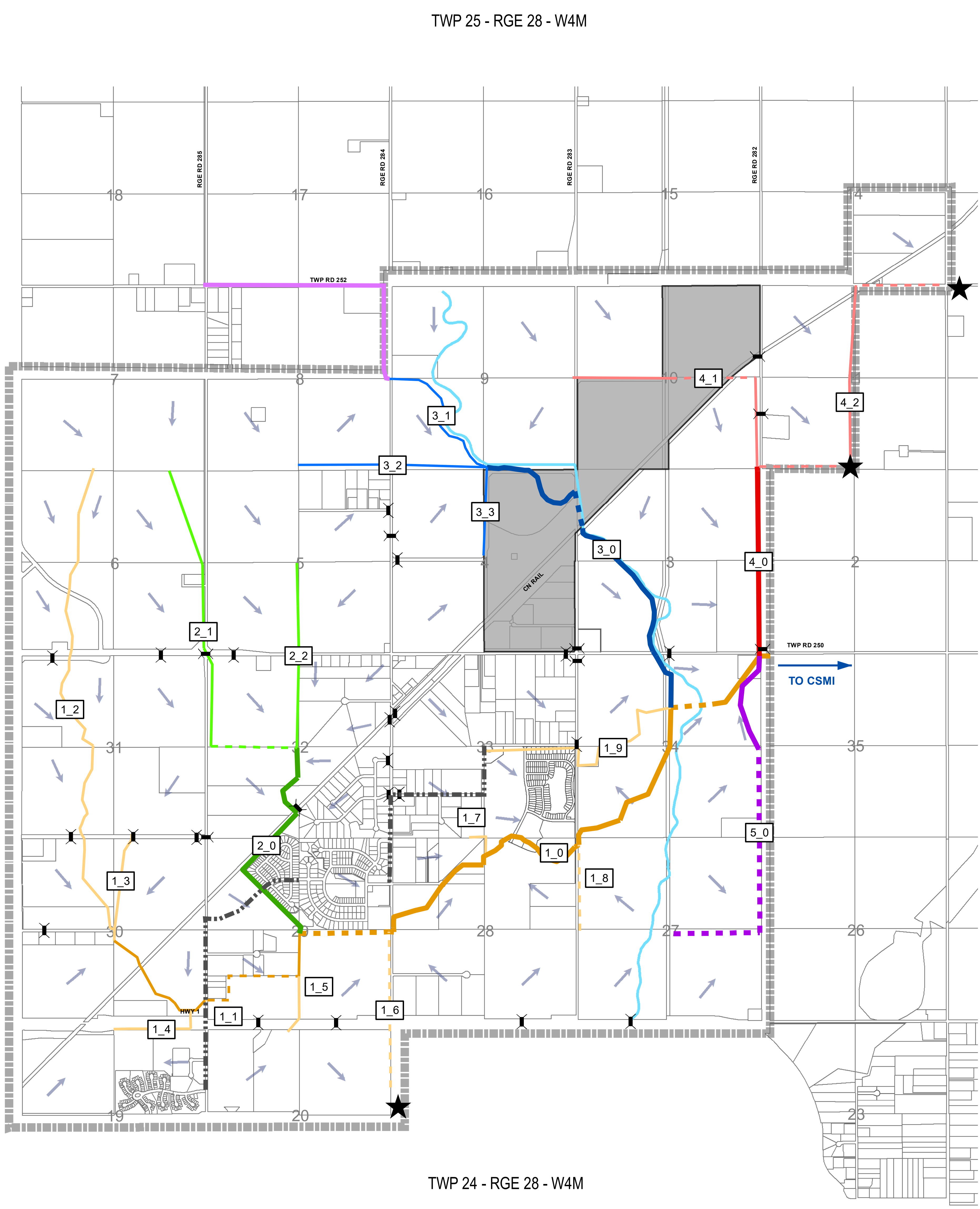
Currently, the CN Rail Logistics Park conveys its stormwater to a pond in the northeast corner of its site. The Conrich Drainage System alignments have assumed that this area will connect to Drainage Course 4 and be conveyed to the CSMI System along with new Conrich developments.

6.1.3 West Creek System Protection

The West Creek System is a natural watercourse that runs through the Conrich ASP area from the north boundary to the south boundary. Minimizing the impact of the future Conrich development has on this natural system is the desired mitigation strategy. The Conrich Drainage System must attempt to minimize the risks to West Creek's water quality, flow regime, wetland zonation, plant and wildlife diversity and potential to harbor species at risk.

To minimize these risks, it is proposed that the Conrich Drainage System alignments that follow West Creek will run parallel at the desired setback distance considering the topography of the alignment. One of the existing two culverts through the CN Logistic Park that currently convey West Creek flows is proposed to be utilized for stormwater to keep urban and rural runoff separated under most flow conditions. When crossing West Creek, the detailed design should explore feasible options to avoid in-stream work and utilize a siphon structure to be constructed below the channel bed so the existing water regime would not be disturbed.

Further studies must be completed to ensure that appropriate pre-development flows are maintained in the West Creek System after development in the Conrich and Omni ASP Area.



DRAINAGE COURSE 1 (1_0)

DRAINAGE COURSE 1 (1_1)

DRAINAGE COURSE 1 (1_2 TO 1_9)

DRAINAGE COURSE 2 (2_0)

DRAINAGE COURSE 2 (2_1 TO 2_2)

DRAINAGE COURSE 3 (3_0)

DRAINAGE COURSE 3 (3_1 TO 3_3)

DRAINAGE COURSE 4 (4_0)

DRAINAGE COURSE 4 (4_1 TO 4_2)

DRAINAGE COURSE 5 (5_0)

PIPE

DITCH

EXISTING CULVERT

FLOW

PROPOSED STORM LIFT STATION

CN RAIL SITE

WEST CREEK

EXISTING WATER MAIN

OMNI OUTFALL

STUDY

N

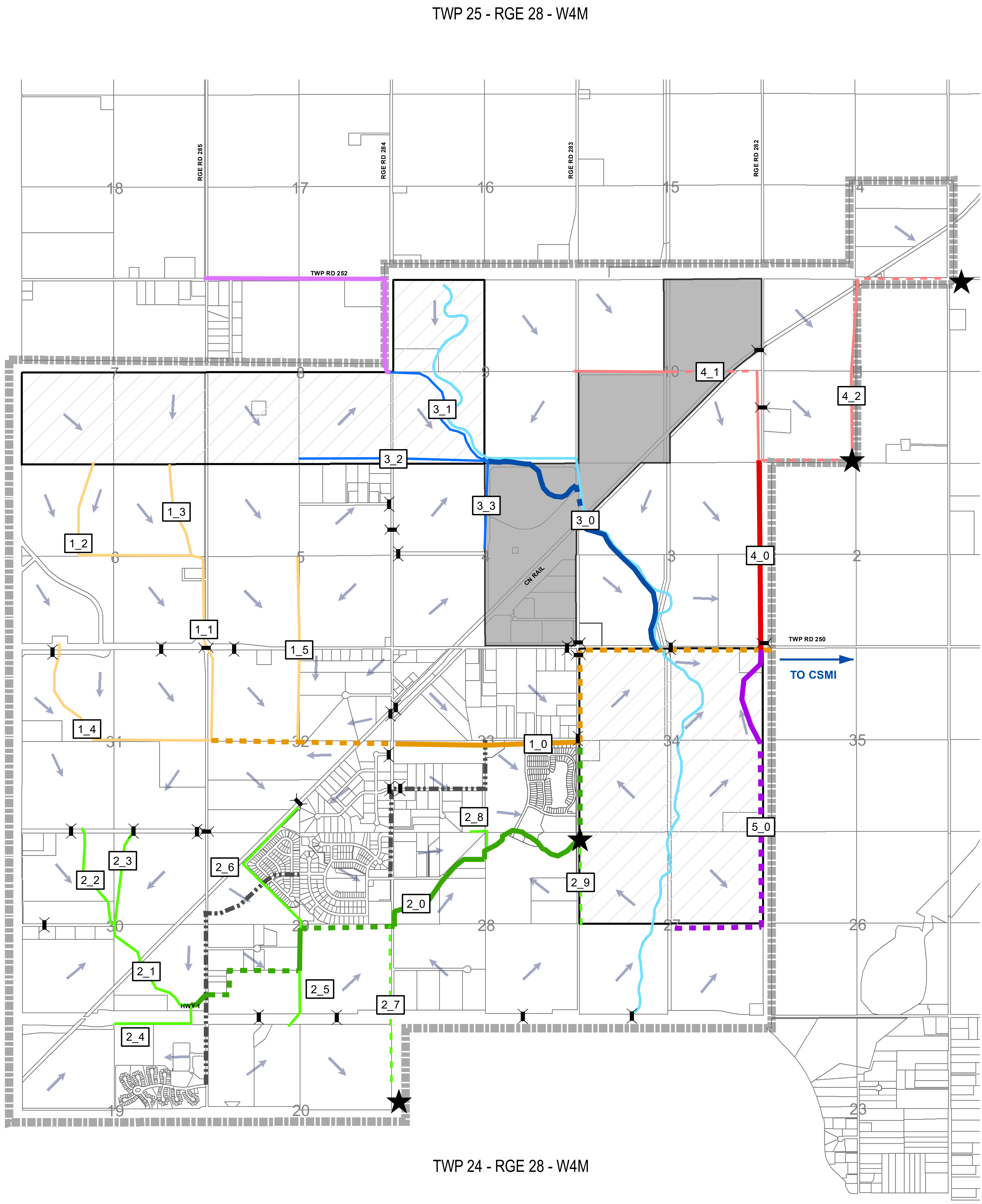
0 200 400 800 1,200 1,600 m

ROCKY VIEW COUNTY
Cultivating Communities

MPE
a division of Englobe

CONRICH MASTER DRAINAGE PLAN
CONRICH DRAINAGE ALIGNMENT 1

DATE:	MAY 2024	SCALE:	1:35,000
JOB:	2285-046	FIGURE:	6.1



DRAINAGE COURSE 1 (1_0)

DRAINAGE COURSE 1 (1_1 TO 1_5)

DRAINAGE COURSE 2 (2_0)

DRAINAGE COURSE 2 (2_1 TO 2_9)

DRAINAGE COURSE 3 (3_0)

DRAINAGE COURSE 3 (3_1 TO 3_3)

DRAINAGE COURSE 4 (4_0)

DRAINAGE COURSE 4 (4_1 TO 4_2)

DRAINAGE COURSE 5 (5_0)

PIPE

DITCH

EXISTING CULVERT

FLOW

PROPOSED STORM LIFT STATION

CN RAIL SITE

WEST CREEK

EXISTING WATER MAIN

OMNI OUTFALL

LONG-TERM DEVELOPMENT

STUDY AREA

N

0 200 400 800 1,200 1,600 m

ROCKY VIEW COUNTY
Cultivating Communities

MPE
a division of Englobe

CONRICH MASTER DRAINAGE PLAN CONRICH DRAINAGE ALIGNMENT 2	DATE: MAY 2024	SCALE: 1:35,000
	JOB: 2285-046	FIGURE: 6.2

6.2 Conrich Drainage System Cost Estimates

In order to provide an estimated cost for the Conrich Drainage System options, the following assumptions were made to cater for the 1:100 year design event:

- Local SWMF release rate: 0.8 L/s/ha
- Average Channel Side Slopes: 4H:1V
- Maximum depth of flow in the channel: 0.5 - 1 m
- Additional channel width for easement: 6 m on either side
- $200,000 per hectare for easements/ROWs

Based on the above assumptions, the cost estimates for the Conrich Drainage System alignments are provided in ***Table 6.1*** and ***Table 6.2*** and a detailed breakdown of each option can be seen in ***Appendix C***.

Table 6.1: Conrich Drainage System Cost Estimate – Alignment 1

Drainage Route	Channel Cost ($)	Culvert, Pipe and/or Lift Station Cost ($)	Easement Acquisition ($)	Drainage Course Cost ($)
1_0 (4.3km)	$ 900,000	$ 3,502,000	$ 2,378,000	$ 18,740,000
1_1 (2.7km)	$ 485,000	$ 836,000	$ 1,040,000	
1_2 (4.4km)	$ 697,000	$ 113,000	$ 2,114,000	
1_3 (0.9km)	$ 128,000	$ 19,000	$ 413,000	
1_4 (0.8km)	$ 64,000	$ 45,000	$ 330,000	
1_5 (0.5km)	$ 27,000	$ 62,000	$ 174,000	
1_6 (1.4km)	-	$ 996,000	$ 165,000	
1_7 (0.3km)	$ 132,000	-	$ 207,000	
1_8 (0.8km)	-	$ 392,000	$ 91,000	
1_9 (2.4km)	$ 1,601,000	$ 20,000	$ 1,809,000	
2_0 (2.5km)	$ 1,496,000	$ 26,000	$ 1,711,000	$ 6,787,000
2_1 (3.3km)	$ 585,000	$ 414,000	$ 1,467,000	
2_2 (1.6km)	$ 271,000	-	$ 817,000	
3_0 (3.3km)	$ 603,000	$ 68,000	$ 1,590,000	$ 5,488,000
3_1 (1.4km)	$ 445,000	$ 18,000	$ 820,000	
3_2 (1.7km)	$ 576,000	-	$ 1,031,000	
3_3 (1.3km)	-	-	$ 337,000	
4_0 (1.7km)	$ 397,000	$ 46,000	$ 870,000	$ 6,815,000
4_1 (2.4km)	$ 447,000	$ 566,000	$ 1,043,000	
4_2 (3.2km)	$ 249,000	$ 2,214,000	$ 983,000	
5_0 (3.3km)	$ 250,000	$ 1,090,000	$ 816,000	$ 2,156,000
Subtotal	$ 9,353,000	$ 10,427,000	$ 20,206,000	$ 39,986,000
Design (15%)	$ 1,403,000	$ 1,564,000	-	$ 2,967,000
Contingency (Land 10%, Infrastructure 25%)	$ 2,338,000	$ 2,607,000	$ 2,021,000	$ 6,966,000
Total	**$ 13,094,000**	**$ 14,598,000**	**$ 22,227,000**	
			Grand Total	**$ 49,919,000**

Table 6.2: Conrich Drainage System Cost Estimate – Alignment 2

Drainage Route	Channel Cost ($)	Culvert, Pipe and/or Lift Station Cost ($)	Easement Acquisition Cost ($)	Drainage Course Cost ($)
1_0 (2.8km)	$ 268,000	$ 8,093,000	$ 1,282,000	$ 15,364,000
1_1 (1.7km)	$ 224,000	$ 22,000	$ 758,000	
1_2 (1.8km)	$ 217,000	-	$ 838,000	
1_3 (0.8km)	$ 131,000	-	$ 418,000	
1_4 (2.0km)	$ 704,000	$ 44,000	$ 1,205,000	
1_5 (1.6km)	$ 319,000	-	$ 841,000	
2_0 (5.1km)	$ 203,000	$ 3,183,000	$ 1,428,000	$ 10,763,000
2_1 (0.7km)	$ 135,000	$ 39,000	$ 478,000	
2_2 (1.0km)	$ 63,000	$ 34,000	$ 377,000	
2_3 (0.9km)	$ 128,000	$ 19,000	$ 413,000	
2_4 (0.8km)	$ 50,000	$ 45,000	$ 317,000	
2_5 (0.5km)	$ 58,000	$ 62,000	$ 203,000	
2_6 (1.5km)	$ 854,000	$ 19,000	$ 1,059,000	
2_7 (1.4km)	-	$ 929,000	$ 165,000	
2_8 (0.3km)	$ 23,000	-	$ 132,000	
2_9 (0.8km)	-	$ 236,000	$ 91,000	
3_0 (2.7km)	$ 511,000	$ 68,000	$ 1,329,000	$ 4,859,000
3_1 (1.4km)	$ 292,000	$ 18,000	$ 697,000	
3_2 (1.7km)	$ 576,000	-	$ 1,031,000	
3_3 (1.3km)	-	-	$ 337,000	
4_0 (1.7km)	$ 397,000	$ 46,000	$ 870,000	$ 6,987,000
4_1 (2.4km)	$ 447,000	$ 566,000	$ 1,043,000	
4_2 (3.2km)	$ 249,000	$ 2,386,000	$ 983,000	
5_0 (3.3km)	$ 66,000	$ 1,028,000	$ 669,000	$ 1,825,000
Subtotal	$ 5,915,000	$ 16,919,000	$ 16,964,000	$ 39,798,000
Design (15%)	$ 890,000	$ 2,540,000	-	$ 3,430,000
Contingency (Land 10%, Infrastructure 25%)	$ 1,480,000	$ 4,230,000	$ 1,700,000	$ 7,410,000
Total	**$ 8,285,000**	**$ 23,689,000**	**$ 18,664,000**	
			Grand Total	**$ 50,638,000**

6.2.1 All Pipe Option

Depending on the type of developments and their layouts, it is often not desirable to utilize an open channel system to convey regional stormwater flows due to land costs, grading, aesthetics, and maintenance requirements. An option has been explored at a high-level to determine the additional cost if the entire Conrich Drainage System utilized pipes for Alignment 1. All pipes except forcemains are assumed to be concrete, and the easement top width is set at 6 m instead of being determined based on the top width of the channels. The cost estimate for this option of the Conrich Drainage System is provided in ***Table 6.3*** below and a detailed breakdown is provided in ***Appendix D***.

Table 6.3: Conrich Drainage System Cost Estimate – All Pipe Option (Alignment 1)

Drainage Route	Pipe and/or Lift Station Cost ($)	Easement Acquisition ($)	Drainage Course Cost ($)
1_0	$11,050,000	$ 657,000	$20,909,000
1_1	$ 2,473,000	$ 319,000	
1_2	$ 1,966,000	$ 531,000	
1_3	$ 289,000	$ 104,000	
1_4	$ 287,000	$ 102,000	
1_5	$ 180,000	$ 63,000	
1_6	$ 996,000	$ 165,000	
1_7	$ 108,000	$ 38,000	
1_8	$ 392,000	$ 91,000	
1_9	$ 809,000	$ 289,000	
2_0	$ 1,722,000	$ 285,000	$ 4,300,000
2_1	$ 1,181,000	$ 398,000	
2_2	$ 518,000	$ 196,000	
3_0	$ 3,412,000	$ 436,000	$ 6,068,000
3_1	$ 1,013,000	$ 164,000	
3_2	$ 496,000	$ 200,000	
3_3	-	$ 337,000	
4_0	$ 1,424,000	$ 200,000	$ 8,005,000
4_1	$ 2,138,000	$ 288,000	
4_2	$ 3,577,000	$ 378,000	
5_0	$ 1,565,000	$ 395,000	$ 1,960,000
Subtotal	$35,596,000	$ 5,636,000	$41,232,000
Design (15%)	$ 5,339,000	-	$ 5,339,000
Contingency (Land 10%, Infrastructure 25%)	$ 8,899,000	$ 564,000	$ 9,463,000
Total	**$49,834,000**	**$ 6,200,000**	
		Grand Total	**$56,034,000**

It can be seen that the total cost of the system increased by $6,115,000 when modifying Alignment 1 to include only piped conveyance infrastructure.

6.2.2 Omni Cost Sharing

As the Omni ASP area will also utilize a portion of the Conrich Drainage System to convey its runoff to CSMI, the levies collected for this infrastructure should account for the cost sharing. The cost of this infrastructure is assumed to be shared according to the future flows utilizing it, which is proportionate to the future area. ***Table 6.4*** and ***Table 6.5*** shows the total cost of the infrastructure that Omni utilizes for Alignment 1 and Alignment 2, as well as the cost proportions for the two ASP areas, further detail can be seen in ***Appendix C***.

Table 6.4: Omni Shared Infrastructure Costs – Alignment 1

Drainage Route	Cost of Shared Infrastructure[1] ($)	Omni Cost ($)	Conrich Cost ($)
1_0	$3,488,000	$ 468,000	$3,021,000
3_0	$2,946,000	$2,045,000	$ 901,000
3_1	$1,200,000	$ 910,000	$ 291,000
Total	**$7,634,000**	**$3,423,000**	**$4,213,000**

1: Includes design, contingency and land costs.

Table 6.5: Omni Shared Infrastructure Costs – Alignment 2

Drainage Route	Cost of Shared Infrastructure[1] ($)	Omni Cost ($)	Conrich Cost ($)
1_0	$5,811,000	$ 803,000	$5,008,000
3_0	$2,271,000	$1,621,000	$ 650,000
3_1	$1,200,000	$ 910,000	$ 291,000
Total	**$9,282,000**	**$3,334,000**	**$5,949,000**

1: Includes design, contingency and land costs.

6.3 Development Staging

The proposed Conrich Drainage System generally grades in an easterly direction. Therefore, to optimize the required conveyance infrastructure, development staging is most suited to be completed from east to west to allow the alignment to be constructed from downstream to upstream. This strategy generally fits in with segments of the current staging plans described in the Conrich ASP; however, development timing is not typically driven by stormwater requirements. Alignment 2 allows the main conveyance infrastructure that will service many of the Phase 1 development areas to avoid requiring easements through the long-term development areas. Interim solutions may also be utilized for both future developments and existing developments prior to the ultimate drainage infrastructure being constructed (***Section 5.2.1***).

Any works or stages should accommodate and be aligned with the ultimate alignments so that unreasonable constraints are not placed on specific development areas. This includes maintaining regional pre-development flows along the natural streams and in specific locations such as West Creek, separating the urban runoff from the offsite flows, particularly in areas of environmental significance.

6.4 Stormwater Management Policies and Principles for Future Development

If development and land use practices are not managed carefully, negative impacts to natural wetlands, watercourses and the downstream receiving infrastructure can result. The key stormwater management strategies for the Conrich ASP area are presented below:

- Low Impact Development (LID) practices should be considered within all future subdivision and/or developments to improve the quality of stormwater runoff for potential reuse or to meet downstream water quality criteria.
- Construction of wet ponds or constructed wetlands to manage peak flows and provide opportunities for stormwater reuse.
- Manage stormwater systems to maintain the pre-development hydrological regimes of natural wetlands under typical conditions, with the ability to provide additional storage for significant events such as the 1 in 100 year flood event, subject to RVC and AEP approval.
- Implementation of reuse techniques and BMPs for stormwater control should be encouraged to meet RVC's non-potable water for irrigation policy.
- The use of fertilizers, pesticides and herbicides (other than to control noxious weeds) shall be discouraged within the study area to improve the water quality of the runoff.
- Adequate sizing of stormwater management practices for new development where no adequate outfall exists, including limiting discharges to the pre-development runoff volume.

To provide an orderly and planned stormwater management system for the Conrich area, a set of stormwater management objectives and guiding principles have been developed to assist the sustainable development and management of the region.

6.4.1 Objectives

The development of the Conrich area should be managed in ways to achieve the following stormwater management and environmental protection objectives:

Objective 1 Management of natural watercourses, floodplains, and wetlands that are to be retained to protect and maintain:

a) Water quality,
b) Flow regime,
c) Environmental values (biodiversity, species at risk) and ecological functions of wetland and watercourse habitat.

Objective 2 Promote developments which:

a) Ensure the management of stormwater that promotes the maintenance of pre-development flow regimes, native vegetation and wildlife to natural wetlands that are to be retained,
b) Prevents soil erosion and water pollution,
c) Protects water quality and riparian zones by providing adequate setback distances from watercourses and wetlands,
d) Encourages stormwater reuse,
e) Meets AEP Stormwater Guidelines and other relevant guiding documents.

Objective 3 Integrate stormwater management hierarchically to achieve the objectives at the:

a) Catchment level,
   i. Water quality of the WID irrigation or drainage systems,
   ii. Protection of natural wetlands and water courses.
b) Development and drainage system level,
   i. Development meets the UARR objectives in this report or a lesser unit flow rate given existing downstream constraints,
   ii. Development meets the overall water quality objectives,
   iii. Prevents erosion.
c) Lot level,

i. Reduces runoff volume,
ii. Mitigates peak flows,
iii. Minimizes pollution generation.

Objective 4 Provide stormwater management facilities that:

a) Minimize public and private operation and maintenance requirements,
b) Provide long-term compliance for practices and facilities located on private land,
c) Interim facilities and associated works be compatible with the long-term drainage strategy of the area,
d) Vest the ownership and maintenance of communal facilities with RVC,
e) Maintain infrastructure in a serviceable and safe state.

6.4.2 Principles

The following principles should be incorporated into the planning, design, construction and management of new developments within the Conrich area specifically related to the management of peak flows, protection of natural wetland and riparian ecosystems and the integration of stormwater management strategies.

1. Land developments to:

   a) Be located outside the 1:100 year flood risk area,
   b) Provide riparian buffers to natural wetlands and watercourses,
   c) Encourage rainwater and stormwater reuse for lawn irrigation and other consumptive uses,
   d) Provide water quality improvement/enhancement practices as recommended/required by AEP and CSMI.

2. Stormwater management systems should be designed and located to:

   a) Protect natural wetlands and watercourses,
   b) Prevent erosion,
   c) Protect downstream systems by:

i. Detaining the 1:100 year flood event to a maximum UARR of 0.8 L/s/ha for the entire Conrich Study Area,
ii. Detaining the 1:100 year flood event to a lower release rate where the downstream constraints have been identified as a bottleneck in drainage conveyance,
iii. Meeting water quality targets to permit stormwater reuse and minimize impacts on the downstream conveyance system or receiving stream/canal.

3. Country Residential and Residential developments should incorporate stormwater management techniques and strategies where appropriate, that:

   a) Encourage the on-site retention and use of stormwater (may require AEP approval),
   b) Direct runoff from impervious surfaces onto resilient landscapes, infiltration and natural undisturbed areas,
   c) Convey excess stormwater runoff from developed areas as much as possible using bio-swales, constructed road ditches, and culverts.

4. Industrial/Commercial Development areas shall manage stormwater by:

   a) Adopting stormwater BMPs such as rainwater reuse, bioretention systems and other SCPs,
   b) Providing water quality treatment devices on industrial/commercial sites to remove oil, grit and sediment.

5. Installation, Maintenance, Operation and Compliance of Stormwater Management Infrastructure:

   a) LID practices specified on private lots shall be enforced through the building application process,
   b) Constructed wetlands and wet ponds shall be vested to RVC,
   c) Practical advice and guidelines on the installation and maintenance of the most promising LID practices should be provided to landowners and property managers,
   d) Consider policies and bylaws which encourage or enforce compliance of private on-site facilities,

e) Develop strategies to manage/rectify existing drainage issues that have been identified in the MDP,

f) Investigate opportunities to rectify existing capacity constraints as a component of future development proposals,

g) Provide periodic review of existing infrastructure to assess the condition and structural adequacy of major culvert and bridge structures under County roads.

6. The Municipality should develop an enforcement and maintenance program to:

a) Annually inspect, monitor and document drainage facility operation,

b) Carry out minor maintenance of conveyance systems such as removal of debris and sediment accumulation from culverts,

c) Allocate funding for major maintenance of stormwater facilities (i.e. silt removal),

d) Monitor long-term performance and compliance of private on-site facilities,

e) Develop minimum performance guidelines for property owners.

7.0 RECOMMENDATIONS

7.1 Stormwater Management Policies for Development of the Conrich ASP Area

All proposed development should prepare a Stormwater Management Plan which addresses the following:

1. Stormwater BMPs, LID practices and wet ponds/constructed wetlands with detention storage to be adequately sized in order to restrict discharges to meet the CSMI targets of maximum 1:100 year UARR of 0.8 L/s/ha or lower, an annual average runoff volume target of 40 mm/year and a TSS removal of 85% of particles 50 microns and larger.
2. LID practices and stormwater management practices should be adequately sized, using primarily evaporative losses (as infiltration capacity is usually severely limited).
3. Utilizing local stormwater management facilities in preference to regional facilities unless multiple developments desire to combine their stormwater systems and have demonstrated the ability to do so successfully.
4. Promote a local stormwater reuse scheme within the Conrich ASP area that employs strategies to optimize the use potential and provides flexibility in delivering stormwater from source or storage location to the end user or areas of demands.

7.2 Management of Natural Wetlands

Natural wetlands that are to be retained within the development areas should be managed by:

5. Being integrated into the development water balance in a manner to maintain the wetlands pre-development hydrological regime, including volume and hydro period.
6. Only directing adequate treated stormwater runoff into the wetlands if using these facilities for a component of detention storage during significant flood events such as a 1:100 year event or in emergency situations subject to the approval of the approving authority.

7.3 Interim Stormwater Management Facilities

When the downstream conveyance systems have not yet been fully established, proposed developments should adequately manage stormwater to minimize impacts on the adjacent or downstream drainage systems. This may include:

7. Adequately designing zero-release systems prior to an outlet location being constructed.

8. Incorporating interim pumping to convey the runoff to infrastructure that is constructed.
9. Abiding by the CSMI interim restrictions as outlined in the *CSMI Regional Stormwater Guidelines*.

7.4 Further Study Recommendations

10. Stormwater management policies and principles outlined in this MDP should be included in future guiding documents and be incorporated into development requirements.

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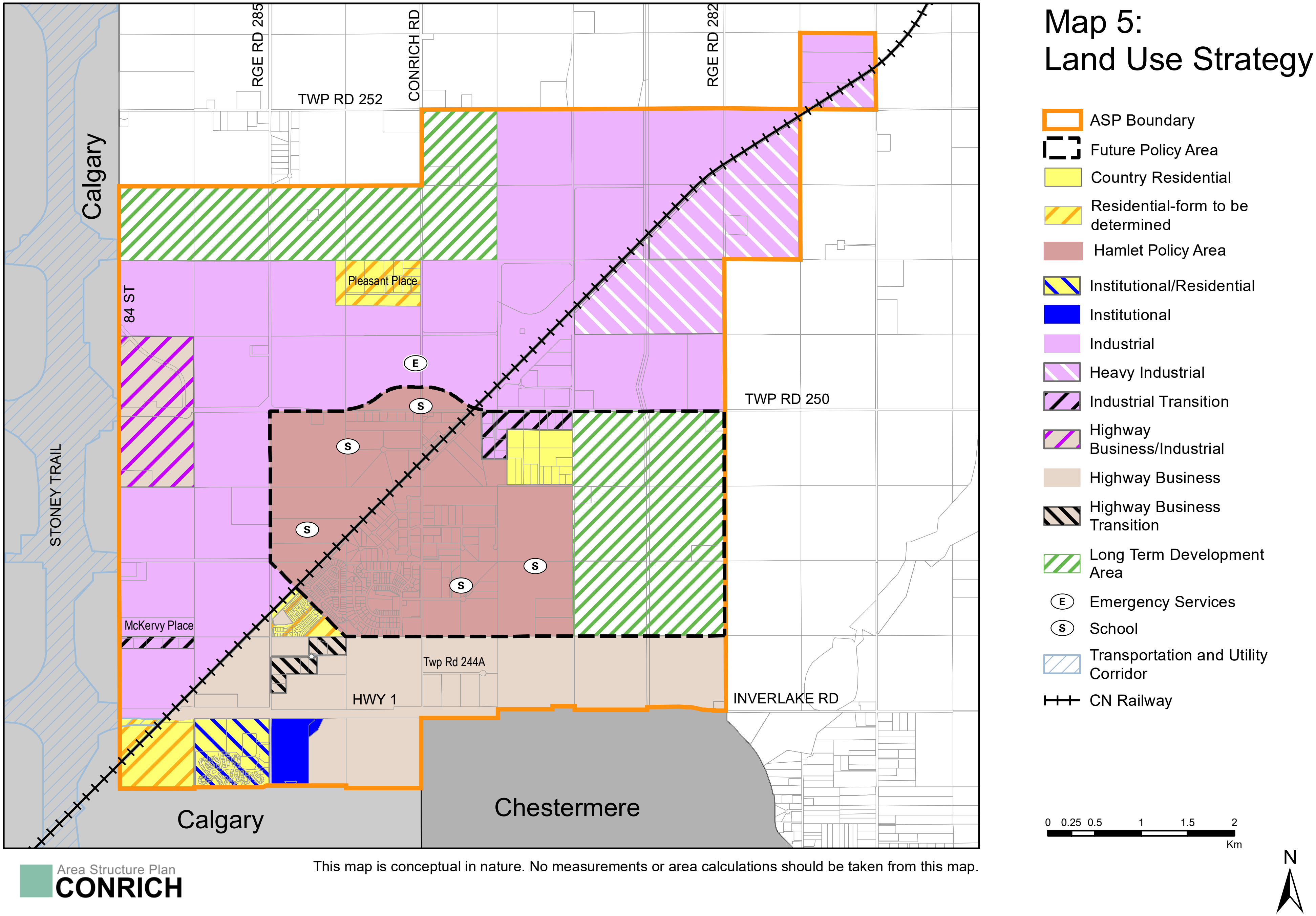
APPENDIX A

Land Use Map for Conrich

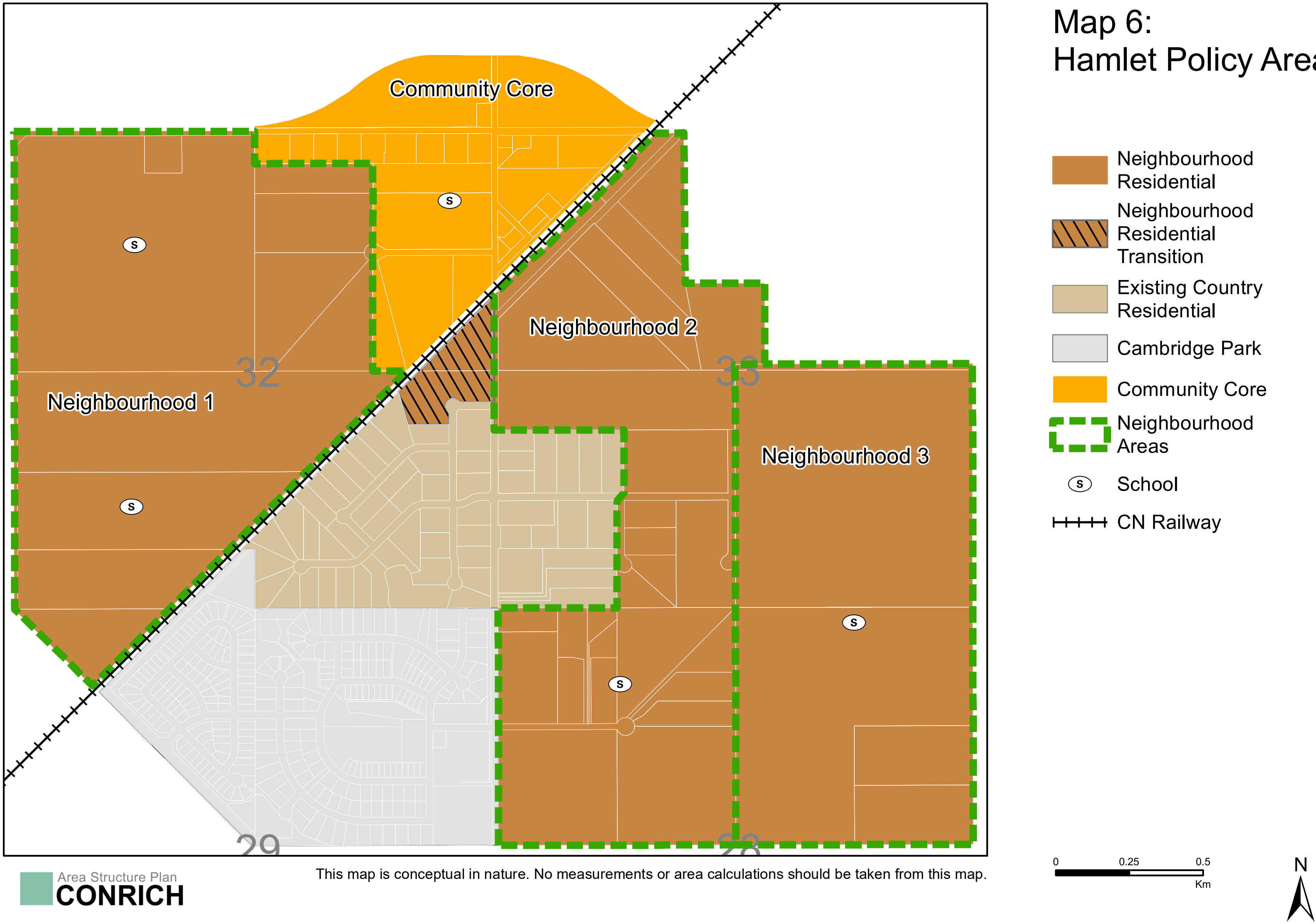
Map 5: Land Use Strategy



Area Structure Plan
CONRICH

This map is conceptual in nature. No measurements or area calculations should be taken from this map.

Map 6: Hamlet Policy Area



This map is conceptual in nature. No measurements or area calculations should be taken from this map.

Area Structure Plan
CONRICH

APPENDIX B

Wetland Assessment Report Tables and Photographs

Table 1. Total precipitation - Calgary Airport Station													
Year	Precipitation by Month (mm)[1]												Total (mm)
	January	February	March	April	May	June	July	August	September	October	November	December	
1945	18.3	30.7	37.8	39.4	83.1	64	56.1	99.8	76.5	24.9	42.7	26.7	**600**
1946	6.9	5.8	19.3	1.5	53.8	95.5	65.8	86.4	44.2	28.4	38.6	24.6	**470.8**
1947	16	39.4	31.2	20.3	36.8	124	30.5	78	46.5	21.6	48.8	10.4	**503.5**
1948	17.8	41.7	31.8	61.2	119.9	70.1	32.5	43.9	10.2	0.8	11.2	12.7	**453.8**
1949	41.4	9.9	14.7	1.5	14.5	48.8	28.7	16.5	15.5	33.8	0	38.9	**264.2**
1950	13.7	14.7	39.1	23.9	21.1	47.5	133.6	77.5	13.5	34.5	19.6	4.1	**442.8**
1951	22.9	33.5	21.3	59.7	52.3	133.1	129.3	165.6	49.3	61.5	7.1	38.9	**774.5**
1952	12.4	31	35.3	21.3	45.7	147.1	78	36.3	20.6	8.6	6.9	0.8	**444**
1953	24.1	38.6	20.1	77	44.2	149.4	65.8	54.9	27.4	0.5	7.4	30	**539.4**
1954	44.2	25.1	36.8	40.4	57.9	84.6	20.1	238.3	28.4	4.6	3.3	1.5	**585.2**
1955	5.6	29.5	28.4	63.5	68.3	15	70.9	8.6	61	4.6	9.1	38.1	**402.6**
1956	34.5	11.2	24.9	29	30.2	130.6	38.6	79.2	21.1	21.1	12.2	21.3	**453.9**
1957	25.1	13.7	16.8	26.2	21.1	64	41.7	78.7	26.9	50.3	24.1	5.3	**393.9**
1958	7.9	19.6	25.1	42.7	15.5	97	60.7	17.3	57.2	2	17.3	6.4	**368.7**
1959	11.2	17.5	8.1	25.9	46.2	116.6	58.4	65.8	18	9.7	37.3	14	**428.7**
1960	19.8	31.2	5.8	30.2	52.8	86.1	42.7	41.7	11.7	19.8	12.7	17.5	**372**
1961	5.6	30	4.8	37.8	42.7	9.9	153.7	26.7	22.1	41.4	3.8	12.4	**390.9**
1962	11.7	11.2	10.4	15	56.9	45.2	33.3	51.3	26.9	9.7	4.3	7.6	**283.5**
1963	25.4	7.9	14.2	19.1	19.6	146.3	90.4	16.8	50.5	0	13.2	21.1	**424.5**
1964	1.8	2	8.4	13.2	63.8	101.6	72.1	8.1	57.4	18	20.8	24.1	**391.3**
1965	11.7	16	16	12.4	44.2	169.9	117.6	69.9	81.5	11.4	31	7.6	**589.2**
1966	10.2	5.3	4.8	42.7	58.4	79.2	113.3	30.5	4.6	14.5	33.8	5.6	**402.9**
1967	20.6	9.7	19.6	26.9	61	54.1	7.6	14.5	1.5	18.3	6.4	15.2	**255.4**
1968	14.2	2.3	18.5	18.5	49.8	54.9	66.5	25.7	61.7	18.3	3	23.6	**357**
1969	14.2	12.4	6.6	56.4	29.5	126.5	75.2	15.5	52.3	31.8	4.3	2.8	**427.5**
1970	12.4	9.4	23.1	35.3	19.1	159	57.4	6.6	23.4	24.1	17	9.7	**396.5**
1971	24.1	10.4	27.2	18	18	95	73.4	29.7	40.4	25.7	1.5	27.4	**390.8**
1972	17.3	21.6	11.2	16.8	31	140.5	71.4	56.4	56.1	18.5	5.1	35.6	**481.5**
1973	3.3	18.5	9.7	25.7	28.2	86.1	38.1	83.6	27.7	7.1	23.4	8.6	**360**
1974	24.1	3.3	17	50.5	71.1	18.8	38.4	64	37.1	11.2	6.6	4.1	**346.2**
1975	7.1	12.4	22.6	15.5	68.1	70.9	63	27.7	22.9	15.5	7.6	35.1	**368.4**

Table 1. Cont.

Year	Precipitation by Month (mm)[1]												Total
	January	February	March	April	May	June	July	August	September	October	November	December	
1976	4.8	12.4	10.4	13.7	55.9	60.5	69.6	92.5	38.1	15.5	21.1	10.9	**405.4**
1977	22.5	0.2	6.4	5.6	97	29.3	63.3	92.1	77.5	4.3	8.6	13.7	**420.5**
1978	28.4	10.8	6.6	79.2	75.8	59.6	55.8	104.7	82.3	8.6	12.7	8.7	**533.2**
1979	7.3	8	10.2	37	41.4	47.5	46.3	28.5	19.9	19.8	4.3	15	**285.2**
1980	12.6	10.6	14	22.2	95.1	103.6	50	31.3	41	31.2	16.2	18.4	**446.2**
1981	4.7	8.7	35.6	2.6	142.1	68.9	127	28.4	40.1	38.2	7	4	**507.3**
1982	22.6	10.4	27	12	81.8	86.8	75.1	24	62.8	3.7	6.6	8.1	**420.9**
1983	8.8	5.6	22.7	55.2	9.6	47.8	59	42	16	4.1	10.6	13.4	**294.8**
1984	9.9	2.6	20.3	15.5	65.8	73	24.6	16.4	108.2	18.3	5.3	7.3	**367.2**
1985	3.4	15.9	2.8	23.9	21.9	40.9	53.2	66.2	123.8	16.7	11.3	8.7	**388.7**
1986	0.7	11.3	5.8	11.4	67.5	81.1	93.7	21.7	145.6	10.6	11.7	1.2	**462.3**
1987	1.3	2.8	20.1	22.4	12.7	21.8	126.3	102.9	29.2	2	5.4	4.9	**351.8**
1988	4.3	4.3	19.8	1.5	16	84.6	46.8	163.9	43.5	8	7.1	4.9	**404.7**
1989	23.4	12.4	*N/A**	22.8	41.2	80.7	50.6	61.6	41.4	6	17.2	21.8	**379.1**
1990	5.6	6.4	8.7	21.2	100.2	61.3	83.7	58.3	7.5	12.9	20.7	11.7	**398.2**
1991	7.4	14.9	21	7.1	96.1	113.2	29.6	64.2	25.9	15.8	9.6	1.8	**406.6**
1992	2.2	3.6	7.9	24.6	46.2	177.2	76.2	41.5	48.1	14.6	38.8	14	**494.9**
1993	5.8	12.5	17.8	6.5	61.9	118.4	87	92.3	24.3	9	10.4	3.6	**449.5**
1994	10.6	9.6	8.1	12.6	62.5	68.4	38	84.4	10.4	31.4	13.9	5.2	**355.1**
1995	2.8	2.1	7.3	31.8	71.9	43.4	133.4	34.2	27.9	14.4	22.7	22.9	**414.8**
1996	27.8	3	35.4	18.5	51.5	59.2	41.9	21	46.4	23.4	30	18.3	**376.4**
1997	18.5	3.7	17.1	12.6	100.7	138.4	16.9	57.8	37.8	14.8	0.6	6.3	**425.2**
1998	15.6	4	59.4	41.2	86.4	110.4	132.2	18	26	11.4	14.1	19	**537.7**
1999	11.3	0	6.4	72.8	52.8	95.4	103.8	89.2	9.1	3.6	12.4	1.8	**458.6**
2000	10.2	20.6	25.5	17	28.8	109.8	66.8	63.9	53.6	1.8	5.8	8.8	**412.6**
2001	2	7.7	12.3	19.2	30.5	121.4	58.8	14.2	13	17.9	16.6	4.8	**318.4**
2002	11.4	9.4	16.6	20.5	34	58.6	34.6	57.4	58.2	23.6	10	10.2	**344.5**
2003	5.6	21.7	15.8	81.8	34.5	104.8	42.2	39.3	39.6	30.8	13.2	0.7	**430**
2004	16.9	2.2	10.9	18	55.6	98.2	54.2	58.6	30.4	24.1	3.4	14.3	**386.8**
2005	10.2	10.6	14.6	8.4	18.8	247.6	19.8	98.2	86	10.8	12.2	2.4	**539.6**

Table 1. Cont.

Year	Precipitation by Month (mm)[1]												Total
	January	February	March	April	May	June	July	August	September	October	November	December	
2006	6.2	20	7.2	29.4	37	122.8	51.4	33.2	62	24.2	21.6	4.8	**419.8**
2007	7.6	25	19.6	46.4	90.8	165.8	25.2	54.4	44.2	13.6	9.4	6.4	**508.4**
2008	8.8	11.8	8.8	35.8	102.2	113.3	77.1	53.6	27.8	8.4	19.2	35.8	**502.6**
2009	7.4	12.2	41	11.4	14.2	42.6	70.6	62.2	2.2	30.8	5.4	28	**328**
2010	10	6.6	1.3	52	63.8	63.8	66	86.6	62.4	11.2	21	9.8	**454.5**
2011	16.6	17.2	20.1	56.4	87.6	78.6	108.4	83	10.6	14	10.8	15.4	**518.7**

[1] Snow that has fallen is melted and this amount of liquid water is recorded in millimetres and added to any other amounts from other forms of precipitation

Source: http://www.climate.weatheroffice.gc.ca/climateData/dailydata_e.html?StationID=2205&timeframe=2&Month=8&Year=1945&cmdB1=Go&Day=1

Table 2. Wetland Functions Overview

Wetland Function
Hydrological Function
Contribute to recharge or discharge of water supply aquifers
Flood protection
Erosion control
Usable surface water
Storage of agricultural run-off
Containment of toxics: surface run-off/discharge flow
Sediment flow stabilization
Biological/Ecological Function
Habitat for migratory birds
Habitat for amphibians and reptiles
Habitat for vertebrate species at risk
Habitat for supporting rare plant species
Habitat for supporting rare plant communities
Support of plant species diversity
Support of vegetation structural diversity
Ecological integrity
Socio-Economical Function
Contribute to visual diversity of landscape
Recreational opportunities
Education and nature interpretation
Accessibility to public
Contribution to crop irrigation
Tourism or other commercial use
Source of domestic or industrial water supply

APPENDIX C

Conveyance Sizing and Cost Estimate

FROM 2022 AT Unit Price Average Reports

CSP

Size	Supply	Supply and Install
450		$ 401.68
600		$ 408.13
750		$ 571.03
900		$ 755.84
1050		$ 804.40
1200		$ 1,490.08

FROM 2022 City of Calgary Development Agreement Standard

Concrete

Size	Supply	Supply and Install
450	$ 98.00	$ 311.00
600	$ 235.00	$ 492.00
750	$ 389.00	$ 700.00
900	$ 549.00	$ 907.00
1050	$ 895.00	$ 1,324.00
1200	$ 1,195.00	$ 1,710.00

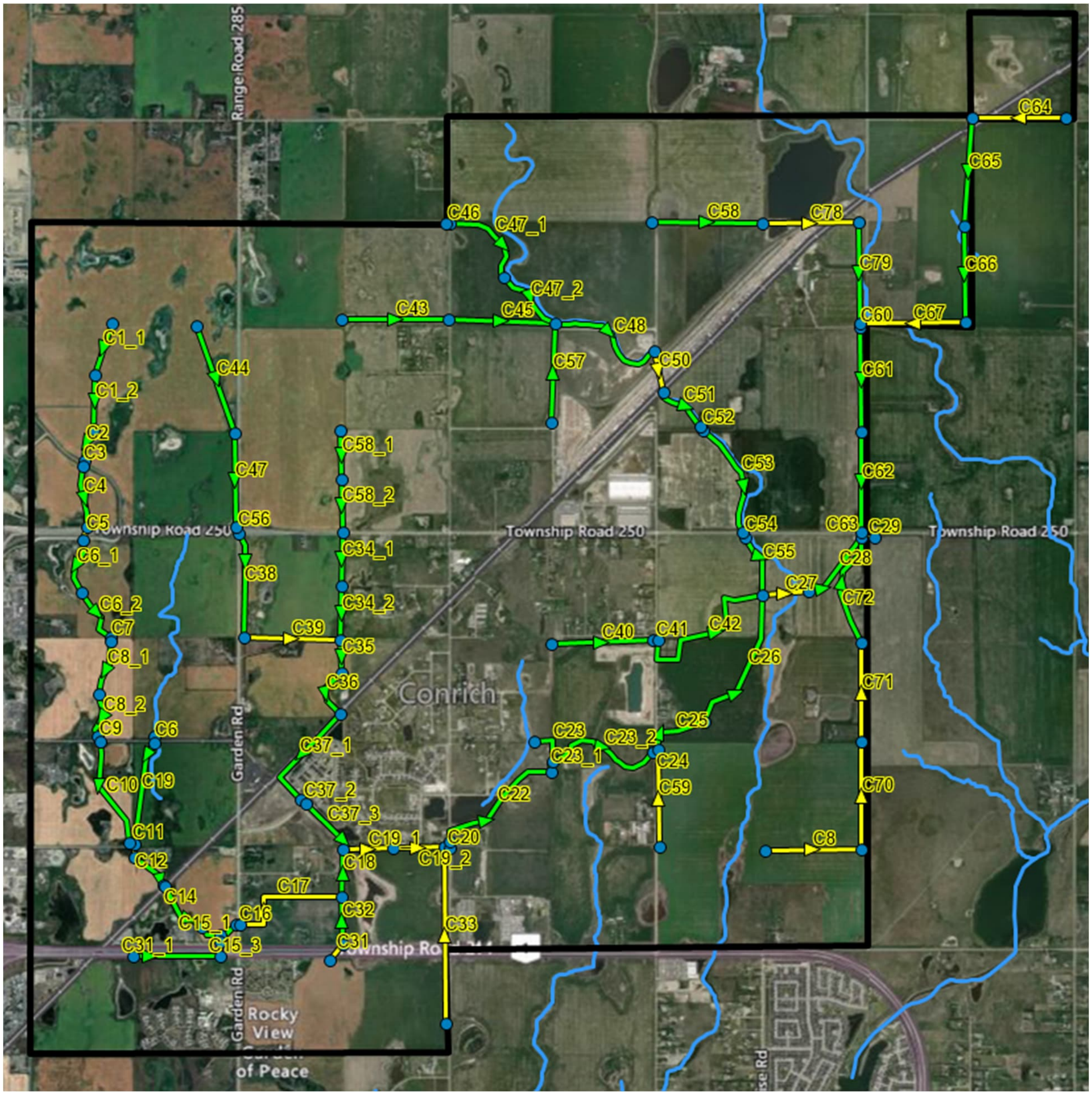
PVC

Size	Supply	Supply and Install
250	$ 80.00	$ 240.00
300	$ 121.00	$ 289.00
375	$ 175.00	$ 368.00
450	$ 285.00	$ 498.00
525	$ 398.00	$ 632.00
1050	$ 1,548.00	$ 1,977.00

Manholes - assume one at each end and every 150m

5A	$ 3,420.00	up to 600mm pipe
1-S 1.2-1.2	$ 6,424.00	up to 900mm pipe
1-S 1.5-1.5	$ 8,614.00	up to 1200mm pipe

ALIGNMENT 1



Range Road 285
Township Road 250
Garden Rd
Conrich
Rocky View
Garden of Peace
C1_1
C1_2
C2
C3
C4
C5
C6_1
C6_2
C7
C8_1
C8_2
C9
C6
C10
C19
C11
C12
C14
C15_1
C15_3
C16
C17
C31_1
C31
C32
C18
C19_1
C19_2
C20
C22
C33
C23
C23_1
C23_2
C24
C59
C25
C26
C8
C70
C71
C72
C27
C28
C29
C63
C54
C55
C53
C52
C51
C50
C48
C57
C45
C47_2
C47_1
C46
C43
C44
C47
C56
C38
C39
C35
C36
C37_1
C37_2
C37_3
C34_1
C34_2
C58_1
C58_2
C40
C41
C42
C58
C78
C79
C60
C67
C61
C62
C64
C65
C66

Drainage Route	Profile	From Station	To Station	Elevation u/s (m)	Elevation d/s (m)	Length (m)	Slope (%)	Design Q (m3/s)	Capacity (m3/s)	Easement Top Width (m)	Channel Earthworks (m3)	Culvert Sizing (mm)	Channel Cost ($)	Culvert Cost or Lift Station ($)	ROW Land Acquisition ($)	Channel Cost ($) (Ex Eng. & Con.)	Culvert, Pipe & or Lift Station Cost ($) (Ex Eng. & Con.)	Easements Cost ($) (Ex Con.)
1_0	Pipe	0=000	0+392	1055	1055	392	0.12	1.35		6.0		1,200		696,162	47,040	$ 900,000	$ 3,502,000	$ 2,378,000
	Pipe	0+392	0+788	1055	1054	396	0.09	1.35		6.0		1,200		703,002	47,520			
	Culvert	0+788	0+831	1054	1054	43	0.84	1.45		6.0		900		64,706	5,136			
	Culvert	0+831	0+873	1054	1054	42	0.99	1.50		6.0		900		64,204	5,097			
	Ditch	0+873	1+943	1054	1052	1070	0.15	1.55	3.2	25.0	10,433		166,920		535,000			
	Ditch	1+943	2+037	1052	1052	93	0.11	1.61	2.8	25.0	910		14,562		46,674			
	Ditch	2+037	3+015	1052	1051	979	0.11	1.71	2.8	25.0	9,542		152,678		489,352			
	Culvert	3+015	3+055	1051	1051	40	0.36	1.76		6.0		900		60,638	4,814			
	Ditch	3+055	3+543	1051	1049	487	0.41	1.86	5.3	25.0	4,753		76,048		243,745			
	Ditch	3+543	4+384	1049	1044	842	0.56	1.92	6.2	29.0	14,306		228,892		488,078			
	Pipe	3+248	3+615	1044	1043	367	0.20	3.20		6.0		1,050		1,483,566	44,040			
	Ditch	3+615	4+236	1043	1041	621	0.37	3.20	5.0	33.0	16,296		260,744		409,740			
	Culvert	4+236	4+332	1041	1041	96	0.12	4.43		6.0		1,200		429,143	11,520			
					1041													
1_1	Culvert	0=000	0+103	1064	1063	103	0.73	0.41		6.0		750		58,886	12,375	$ 485,000	$ 836,000	$ 1,040,000
	Ditch	0+103	0+428	1063	1060	325	1.04	0.47	1.7	25.0	3,164		50,627		162,268			
	Culvert	0+428	0+442	1060	1059	15	1.06	0.47		6.0		750		8,448	1,775			
	Ditch	0+442	0+896	1059	1059	454	0.10	0.47	1.1	29.0	7,715		123,442		263,223			
	Ditch	0+896	1+075	1059	1059	179	0.10	0.47	1.1	37.0	6,696		107,128		132,125			
	Ditch	1+075	1+243	1059	1059	168	0.10	0.57	1.1	37.0	6,308		100,930		124,481			
	Culvert	1+243	1+265	1059	1059	21	0.41	0.62		6.0		750		12,276	2,580			
	Pipe	1+265	2+280	1059	1056	1015	0.25	0.62		6.0		750		755,468	121,800			
	Ditch	2+280	2+657	1056	1055	378	0.20	0.73	1.6	29.0	6,424		102,777		219,156			
1_2	Ditch	0=000	0+423	1085	1084	423	0.11	0.05	0.5	29.0	7,194		115,098		245,430	$ 697,000	$ 113,000	$ 2,114,000
	Ditch	0+423	0+841	1084	1079	417	1.37	0.05	1.9	25.0	4,070		65,117		208,709			
	Ditch	0+841	1+107	1079	1076	266	1.19	0.10	1.8	21.0	1,199		19,178		111,873			
	Culvert	1+107	1+154	1076	1075	47	0.12	0.10		6.0		450		18,872	5,638			
	Ditch	1+154	1+636	1075	1074	482	0.24	0.10	0.8	21.0	2,170		34,720		202,532			
	Culvert	1+636	1+741	1074	1074	105	0.11	0.16		6.0		600		42,957	12,630			
	Ditch	1+741	2+178	1074	1074	437	0.12	0.16	0.6	25.0	4,259		68,143		218,408			
	Ditch	2+178	2+638	1074	1069	460	0.92	0.16	1.6	25.0	4,485		71,756		229,988			
	Culvert	2+638	2+670	1069	1069	32	0.73	0.21		6.0		600		12,891	3,790			
	Ditch	2+670	3+105	1069	1067	435	0.47	0.21	1.1	21.0	1,957		31,319		182,696			
	Ditch	3+105	3+458	1067	1065	353	0.47	0.21	1.1	25.0	3,442		55,076		176,526			
	Culvert	3+458	3+510	1065	1065	52	0.15	0.26		6.0		600		21,359	6,280			
	Ditch	3+510	4+379	1065	1064	869	0.14	0.26	0.6	29.0	14,776		236,416		504,123			
	Culvert	4+379	4+419	1064	1064	40	1.17	0.31		6.0		600		16,131	4,743			
1_3	Culvert	0=000	0+046	1065	1064	46	0.26	0.05		6.0		450		18,525	5,534	$ 128,000	$ 19,000	$ 413,000
	Ditch	0+046	0+860	1064	1064	814	0.08	0.05	0.5	25.0	7,940		127,042		407,185			
1_4	Ditch	0=000	0+679	1060	1059	679	0.11	0.05	0.2	21.0	3,056		48,888		285,180	$ 64,000	$ 45,000	$ 330,000
	Culvert	0+679	0+789	1059	1059	110	0.10	0.10		6.0		450		44,282	13,229			
	Ditch	0+789	0+843	1059	1059	54	0.10	0.10	0.5	29.0	916		14,655		31,250			
1_5	Culvert	0=000	0+154	1057	1057	154	0.35	0.05		6.0		450		61,839	18,474	$ 27,000	$ 62,000	$ 174,000
	Ditch	0+154	0+523	1057	1056	369	0.23	0.05	0.8	21.0	1,660		26,568		154,980			
1_6	Forcemain	0=000	1+368	1053	1054	1368	-0.10	0.05		6.0		300		995,352	164,160	$ -	$ 996,000	$ 165,000
1_7	Ditch	0=000	0+313	1055	1052	313	0.84	0.05	1.5	33.0	8,205		131,287		206,307	$ 132,000	$ -	$ 207,000
1_8	Pipe	0=000	0+755	1052	1051	755	0.15	0.10		6.0		600		391,980	90,600	$ -	$ 392,000	$ 91,000
1_9	Ditch	0=000	0+793	1056	1052	793	0.45	0.05	1.1	33.0	20,813		333,006		523,295	$ 1,601,000	$ 20,000	$ 1,809,000
	Culvert	0+793	0+841	1052	1052	48	0.23	0.10		6.0		450		19,222	5,742			
	Ditch	0+841	2+402	1052	1045	1561	0.47	0.10	1.1	41.0	79,214		1,267,423		1,279,910			
2_0	Ditch	0=000	0+263	1063	1061	263	0.60	0.47	1.3	25.0	2,560		40,956		131,268	$ 1,496,000	$ 26,000	$ 1,711,000
	Ditch	0+379	1+020	1063	1060	642	0.35	0.52	1.0	29.0	10,910		174,555		372,214			
	Ditch	1+020	1+956	1060	1057	936	0.31	0.57	0.9	45.0	61,776		988,416		842,400			
	Culvert	1+956	2+001	1057	1057	45	0.32	0.57		6.0		750		25,696	5,400			
	Ditch	2+001	2+487	1057	1056	486	0.31	0.57	0.9	37.0	18,225		291,600		359,640			

2_1	Ditch	0=000	0+941	1077	1075	941	0.25	0.05	0.8	25.0	9,173		146,763		470,394	$ 585,000	$ 414,000	$ 1,467,000
	Ditch	0+941	1+674	1075	1070	733	0.69	0.10	1.4	33.0	19,240		307,835		483,740			
	Culvert	1+674	1+725	1070	1069	52	2.20	0.16		6.0		450		20,732	6,194			
	Ditch	1+725	2+556	1069	1066	831	0.37	0.16	1.0	25.0	8,098		129,575		415,303			
	Culvert	2+556	3+312	1066	1063	756	0.42	0.21		6.0		600		392,472	90,720			
2_2	Ditch	0=000	0+379	1073	1068	379	1.21	0.05	1.8	21.0	1,704		27,267		159,059	$ 271,000	$ -	$ 817,000
	Ditch	0+379	0+789	1068	1068	410	0.17	0.10	0.7	25.0	4,001		64,019		205,189			
	Ditch	0+789	1+211	1068	1064	422	0.93	0.16	1.6	29.0	7,170		114,721		244,627			
	Ditch	1+211	1+626	1064	1063	415	0.26	0.16	0.8	25.0	4,049		64,777		207,619			
3_0 (Omni Share)	Ditch	0=000	0+975	1056	1052	975	0.44	1.04	1.1	21.0	4,388		70,215		409,588	$ 603,000	$ 68,000	$ 1,590,000
	ex. Pipe	0+975	1+304	1052	1051	329	0.30	1.04	1.4	13.0		900			85,529			
	Ditch	1+304	1+731	1051	1049	427	0.46	1.04	1.1	25.0	4,161		66,577		213,389			
	Culvert	1+731	1+770	1049	1049	39	0.55	1.08		6.0		900		29,242	4,643			
	Ditch	1+770	2+687	1049	1047	917	0.22	1.08	1.7	29.0	15,587		249,396		531,800			
	Culvert	2+687	2+734	1047	1047	47	0.20	1.13		6.0		1,050		38,099	5,684			
	Ditch	2+734	3+248	1047	1044	514	0.53	1.13	2.6	33.0	13,495		215,928		339,315			
					1041													
3_1	Culvert	0=000	0+031	1066	1066	31	0.96	0.67		6.0		750		17,610	3,701	$ 445,000	$ 18,000	$ 820,000
	Ditch	0+031	0+795	1066	1060	764	0.72	0.73	1.4	29.0	12,988		207,808		443,120			
	Ditch	0+795	1+359	1060	1056	564	0.67	0.78	1.4	33.0	14,805		236,880		372,240			
3_2	Ditch	0=000	0+825	1071	1067	825	0.41	0.05	1.1	29.0	14,022		224,345		478,383	$ 576,000	$ -	$ 1,031,000
	Ditch	0+825	1+662	1067	1056	837	1.32	0.10	1.9	33.0	21,975		351,593		552,503			
3_3	ex. Ditch	0=000	1+296	1061	1059	1296	0.14	0.05	0.6	13.0					336,897	$ -	$ -	$ 337,000
4_0	Culvert	0=000	0+039	1048	1047	39	0.51	0.87		6.0		750		22,270	4,680	$ 397,000	$ 46,000	$ 870,000
	Ditch	0+039	0+850	1047	1043	811	0.52	0.87	1.2	33.0	21,289		340,620		535,260			
	Ditch	0+850	1+623	1043	1042	773	0.13	0.92	1.3	21.0	3,479		55,656		324,660			
	Culvert	1+623	1+664	1042	1042	41	0.26	0.97		6.0		750		23,697	4,980			
4_1	Ditch	0=000	0+859	1053	1052	859	0.16	0.05	0.7	29.0	14,603		233,648		498,220	$ 447,000	$ 566,000	$ 1,043,000
	Pipe	0+859	1+612	1052	1048	753	0.53	0.34	1.2	6.0		750		565,644	90,360			
	Ditch	1+612	2+395	1048	1048	783	0.06	0.34	0.4	29.0	13,311		212,976		454,140			
4_2	Forcemain	0=000	0+736	1041	1045	736	-0.54	0.05		6.0		250		776,675	88,338	$ 249,000	$ 2,214,000	$ 983,000
	Ditch	0+736	1+574	1045	1043	838	0.20	0.05	0.7	25.0	8,168		130,687		418,870			
	Ditch	1+574	2+328	1043	1040	754	0.39	0.10	1.0	25.0	7,354		117,668		377,140			
	Forcemain	2+328	3+148	1040	1048	820	-0.90	0.16		6.0		300		1,436,980	98,400			
5	Pipe	0=000	0+758	1045	1044	758	0.18	0.05		6.0		450		256,258	90,960	$ 250,000	$ 1,090,000	$ 816,000
	Pipe	0+758	1+596	1044	1043	838	0.12	0.16		6.0		600		432,792	100,554			
	Pipe	1+596	2+368	1043	1042	772	0.10	0.16		6.0		600		400,498	92,677			
	Ditch	2+368	3+284	1042	1041	916	0.10	0.21	0.5	29.0	15,574		249,188		531,356			

Pond release rate (L/s/ha) = 0.8

Mannings n 0.04
Flow depth 1 m
Side slopes 4

Ditch Excavation cost $ 16.00 $/m3
hectare of land $ 200,000

lift station $ 600,000

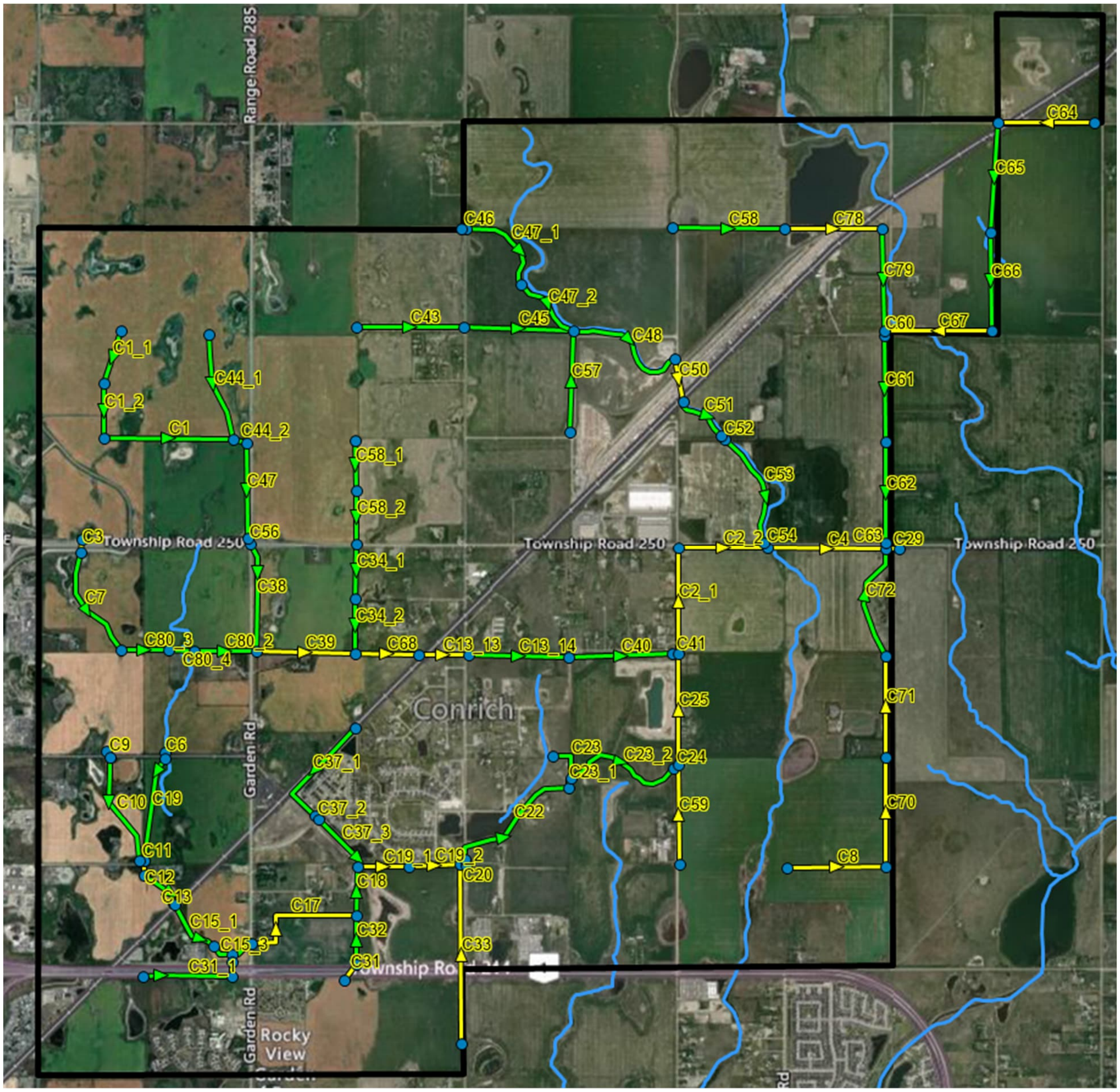
PVC
CSP
Con pipe

Additional width for easement 6 m
easment width for pipe 6 m

Drainage Route	Notes	Type	Name	From Station	To Station	Elevation U/s (m)	Elevation d/s (m)	Elevation drop (m)	Length (m)	Slope (%)	Local Basin Area (ha)	U/s Regional Basin Area (ha)	Basin catch area	Design Q (m3/s)	Ditch Flow Depth	Ditch Flow Area (m2)	Ditch Wetted Perimeter (m)	Ditch Flow Capacity (m3/s)	Average depth to EG (m)	Base Width (m)	Easement Top Width (m)	Excavation Volume (m3)	Land Area (ha)	Culvert Sizing (mm)	#	Channel Cost ($)	Culvert, Pipe and/or Lift Station Cost ($)	ROW Land Acquisition Cost ($)	TOTALS Channel Cost ($)	TOTALS Culvert, Pipe and/or Lift Station Cost ($)	TOTALS ROW Land Acquisition Cost ($)
1_0	add 1_1, 2_0	Pipe	C19_1	0+000	0+392	1055.3	1054.8	0.457	392	0.12	64.75	1618.75	1683.5	1.35		0.0	1.5	0.0	2.5	1.5	6			1200	1	$ -	$ 696,162	$ 47,040			
		Pipe	C19_2	0+392	0+788	1054.8	1054.4	0.365	396	0.09	0	1683.5	1683.5	1.35		0.0	1.5	0.0	2.5	1.5	6			1200	1	$ -	$ 703,002	$ 47,520			
	add 1_6	Culvert	C20	0+788	0+831	1054.4	1054.1	0.361	43	0.84	64.75	1748.25	1813	1.45		0.0	1.0	0.0	1.5	1	6			900	2	$ -	$ 64,706	$ 5,136			
		Culvert	C21	0+831	0+873	1054.1	1053.7	0.42	42	0.99	64.75	1813	1877.75	1.50		0.0	1.0	0.0	2	1	6			900	2	$ -	$ 64,204	$ 5,097			
		Ditch	C22	0+873	1+943	1053.7	1052.1	1.601	1070	0.15	64.75	1877.75	1942.5	1.55	1	5.0	9.2	3.2	1.5	1	25	10433				$ 166,920		$ 535,000			
		Ditch	C23_1	1+943	2+037	1052.1	1051.9	0.105	93	0.11	64.75	1942.5	2007.25	1.61	1	5.0	9.2	2.8	1.5	1	25	910				$ 14,562		$ 46,674			
	add 1_7	Ditch	C23_2	2+037	3+015	1051.9	1050.8	1.104	979	0.11	64.75	2072	2136.75	1.71	1	5.0	9.2	2.8	1.5	1	25	9542				$ 152,678		$ 489,352			
		Culvert	C24	3+015	3+055	1050.8	1050.7	0.144	40	0.36	64.75	2136.75	2201.5	1.76		0.0	1.0	0.0	1.5	1	6			900	2	$ -	$ 60,638	$ 4,814			
	add 1_8	Ditch	C25	3+055	3+543	1050.7	1048.7	2.001	487	0.41	0	2331	2331	1.86	1	5.0	9.2	5.3	1.5	1	25	4753				$ 76,048		$ 243,745			
		Ditch	C26	3+543	4+384	1048.7	1044.0	4.749	842	0.56	64.75	2331	2395.75	1.92	1	5.0	9.2	6.2	2	1	29	14306				$ 228,892		$ 488,078			
	add 1_9 and 3_0	Pipe	C27	3+248	3+615	1044.0	1043.2	0.75	367	0.20	64.75	3934	3998.75	3.20		0.0	1.0	0.0	2.5	1	6			1050	3	$ -	$ 1,483,566	$ 44,040			
		Ditch	C28	3+615	4+236	1043.2	1040.9	2.283	621	0.37	0	3998.75	3998.75	3.20	1	5.0	9.2	5.0	2.5	1	33	16296				$ 260,744		$ 409,740			
	add 4_0, 5_0 - to CSMI	Culvert	C29	4+236	4+332	1040.9	1040.8	0.117	96	0.12	64.75	5473	5537.75	4.43		0.0	2.0	0.0	2.5	2	6			1200	3	$ -	$ 429,143	$ 11,520			
	CSMI Connection Invert						1040.8																						$900,000	$3,502,000	$2,378,000
1_1	add 1_2, 1_3	Culvert	C12	0+000	0+103	1063.8	1063.0	0.754	103	0.73	64.75	453.25	518	0.41		0.0	1.0	0.0	1.5	1	6			750	1	$ -	$ 58,886	$ 12,375			
		Ditch	C13	0+103	0+428	1063.0	1059.6	3.391	325	1.04	64.75	518	582.75	0.47	0.5	1.5	5.1	1.7	1.5	1	25	3164				$ 50,627		$ 162,268			
		Culvert	C14	0+428	0+442	1059.6	1059.5	0.157	15	1.06	0	582.75	582.75	0.47		0.0	1.0	0.0	2.5	1	6			750	1	$ -	$ 8,448	$ 1,775			
		Ditch	C15_1	0+442	0+896	1059.5	1059.0	0.455	454	0.10	0	582.75	582.75	0.47	0.7	2.7	6.8	1.1	2	1	29	7715				$ 123,442		$ 263,223			
		Ditch	C15_3	0+896	1+075	1059.0	1058.8	0.179	179	0.10	0	582.75	582.75	0.47	0.7	2.7	6.8	1.1	3	1	37	6696				$ 107,128		$ 132,125			
	add 1_4	Ditch	C15_4	1+075	1+243	1058.8	1058.7	0.168	168	0.10	0	712.25	712.25	0.57	0.7	2.7	6.8	1.1	3	1	37	6308				$ 100,930		$ 124,481			
		Culvert	C16	1+243	1+265	1058.7	1058.6	0.088	21	0.41	64.75	712.25	777	0.62		0.0	1.0	0.0	3.5	1	6			750	1	$ -	$ 12,276	$ 2,580			
		Pipe	C17	1+265	2+280	1058.6	1056.0	2.562	1015	0.25	0	777	777	0.62		0.0	1.0	0.0	2.5	1	6			750	1	$ -	$ 755,468	$ 121,800			
	add 1_5 - to 1_0	Ditch	C18	2+280	2+657	1056.0	1055.3	0.743	378	0.20	64.75	841.75	906.5	0.73	0.7	2.7	6.8	1.6	2	1	29	6424				$ 102,777		$ 219,156	$485,000	$836,000	$1,040,000
1_2		Ditch	C1_1	0+000	0+423	1084.8	1084.4	0.45	423	0.11	64.75	0	64.75	0.05	0.5	1.5	5.1	0.5	2	1	29	7194				$ 115,098		$ 245,430			
		Ditch	C1_2	0+423	0+841	1084.4	1078.7	5.702	417	1.37	0	64.75	64.75	0.05	0.5	1.5	5.1	1.9	1.5	1	25	4070				$ 65,117		$ 208,709			
		Ditch	C2	0+841	1+107	1078.7	1075.5	3.178	266	1.19	64.75	64.75	129.5	0.10	0.5	1.5	5.1	1.8	1	1	21	1199				$ 19,178		$ 111,873			
		Culvert	C3	1+107	1+154	1075.5	1075.5	0.057	47	0.12	0	129.5	129.5	0.10		0.0	1.0	0.0	1	1	6			450	1	$ -	$ 18,872	$ 5,638			
		Ditch	C4	1+154	1+636	1075.5	1074.3	1.138	482	0.24	0	129.5	129.5	0.10	0.5	1.5	5.1	0.8	1	1	21	2170				$ 34,720		$ 202,532			
		Culvert	C5	1+636	1+741	1074.3	1074.2	0.121	105	0.11	64.75	129.5	194.25	0.16		0.0	1.0	0.0	1.5	1	6			600	1	$ -	$ 42,957	$ 12,630			
		Ditch	C6_1	1+741	2+178	1074.2	1073.7	0.514	437	0.12	0	194.25	194.25	0.16	0.5	1.5	5.1	0.6	1.5	1	25	4259				$ 68,143		$ 218,408			
		Ditch	C6_2	2+178	2+638	1073.7	1069.4	4.247	460	0.92	0	194.25	194.25	0.16	0.5	1.5	5.1	1.6	1.5	1	25	4485				$ 71,756		$ 229,988			
		Culvert	C7	2+638	2+670	1069.4	1069.2	0.23	32	0.73	64.75	194.25	259	0.21		0.0	1.0	0.0	1	1	6			600	1	$ -	$ 12,891	$ 3,790			
		Ditch	C8_1	2+670	3+105	1069.2	1067.2	2.059	435	0.47	0	259	259	0.21	0.5	1.5	5.1	1.1	1	1	21	1957				$ 31,319		$ 182,696			
		Ditch	C8_2	3+105	3+458	1067.2	1065.5	1.67	353	0.47	0	259	259	0.21	0.5	1.5	5.1	1.1	1.5	1	25	3442				$ 55,076		$ 176,526			
		Culvert	C9	3+458	3+510	1065.5	1065.4	0.078	52	0.15	64.75	259	323.75	0.26		0.0	1.0	0.0	2	1	6			600	1	$ -	$ 21,359	$ 6,280			
		Ditch	C10	3+510	4+379	1065.4	1064.2	1.186	869	0.14	0	323.75	323.75	0.26	0.5	1.5	5.1	0.6	2	1	29	14776				$ 236,416		$ 504,123			
	to 1_1	Culvert	C11	4+379	4+419	1064.2	1063.8	0.463	40	1.17	64.75	323.75	388.5	0.31		0.0	1.0	0.0	2	1	6			600	1	$ -	$ 16,131	$ 4,743	$697,000	$113,000	$2,114,000
1_3		Culvert	C6	0+000	0+046	1064.5	1064.4	0.122	46	0.26	64.75	0	64.75	0.05		0.0	1.0	0.0	0.5	1	6			450	1	$ -	$ 18,525	$ 5,534			
	to 1_1	Ditch	C19	0+046	0+860	1064.4	1063.8	0.624	814	0.08	0	64.75	64.75	0.05	0.5	1.5	5.1	0.5	1.5	1	25	7940				$ 127,042		$ 407,185	$128,000	$19,000	$413,000
1_4		Ditch	C31_1	0+000	0+679	1059.7	1059.0	0.714	679	0.11	64.75	0	64.75	0.05	0.3	0.7	3.5	0.2	1	1	21	3056				$ 48,888		$ 285,180			
		Culvert	C31_3	0+679	0+789	1059.0	1058.9	0.113	110	0.10	64.75	64.75	129.5	0.10		0.0	1.0	0.0	2	1	6			450	1	$ -	$ 44,282	$ 13,229			
	to 1_1	Ditch	C31_4	0+789	0+843	1058.9	1058.8	0.055	54	0.10	0	129.5	129.5	0.10	0.5	1.5	5.1	0.5	2	1	29	916				$ 14,655		$ 31,250	$64,000	$45,000	$330,000
1_5		Culvert	C31	0+000	0+154	1057.4	1056.9	0.534	154	0.35	64.75	0	64.75	0.05		0.0	1.0	0.0	1.5	1	6			450	1	$ -	$ 61,839	$ 18,474			
	to 1_1	Ditch	C32	0+154	0+523	1056.9	1056.0	0.856	369	0.23	0	64.75	64.75	0.05	0.5	1.5	5.1	0.8	1	1	21	1660				$ 26,568		$ 154,980	$27,000	$62,000	$174,000
1_6	to 1_0	Forcemain	C33	0+000	1+368	1053.0	1054.4	-1.435	1368	-0.10	64.75	0	64.75	0.05		0.0	1.0		2	1	6			300	1	$ -	$ 995,352	$ 164,160	$0	$996,000	$165,000
1_7	to 1_0	Ditch	C23	0+000	0+313	1054.6	1051.9	2.64	313	0.84	64.75	0	64.75	0.05	0.5	1.5	5.1	1.5	2.5	1	33	8205				$ 131,287		$ 206,307	$132,000	$0	$207,000
1_8	to 1_0	Pipe	C59	0+000	0+755	1051.8	1050.7	1.144	755	0.15	129.5	0	129.5	0.10		0.0	1.0	0.0	4	1	6			600	1	$ -	$ 391,980	$ 90,600	$0	$392,000	$91,000
1_9		Ditch	C40	0+000	0+793	1055.7	1052.1	3.598	793	0.45	64.75	0	64.75	0.05	0.5	1.5	5.1	1.1	2.5	1	33	20813				$ 333,006		$ 523,295			
		Culvert	C41	0+793	0+841	1052.1	1052.0	0.109	48	0.23	64.75	64.75	129.5	0.10		0.0	1.0	0.0	2.5	1	6			450	1	$ -	$ 19,222	$ 5,742			
	to 1_0	Ditch	C42	0+841	2+402	1052.0	1044.6	7.36	1561	0.47	0	129.5	129.5	0.10	0.5	1.5	5.1	1.1	3.5	1	41	79214				$ 1,267,423		$ 1,279,910	$1,601,000	$20,000	$1,809,000
2_0	add 2_1, 2_2	Ditch	C35	0+000	0+263	1062.6	1061.0	1.564	263	0.60	129.5	453.25	582.75	0.47	0.5	1.5	5.1	1.3	1.5	1	25	2560				$ 40,956		$ 131,268			
		Ditch	C36	0+379	1+020	1062.6	1060.3	2.229	642	0.35	64.75	582.75	647.5	0.52	0.5	1.5	5.1	1.0	2	1	29	10910				$ 174,555		$ 372,214			
		Ditch	C37_1	1+020	1+956	1060.3	1057.4	2.927	936	0.31	64.75	647.5	712.25	0.57	0.5	1.5	5.1	0.9	4	1	45	61776				$ 988,416		$ 842,400			
		Culvert	C37_2	1+956	2+001	1057.4	1057.3	0.142	45	0.32	0	712.25	712.25	0.57		0.0	1.0	0.0	6	1	6			750	1	$ -	$ 25,696	$ 5,400			
	to 1_0	Ditch	C37_3	2+001	2+487	1057.3	1055.8	1.522	486	0.31	0	712.25	712.25	0.57	0.5	1.5	5.1	0.9	3	1	37	18225				$ 291,600		$ 359,640			
																													$1,496,000	$26,000	$1,711,000
2_1		Ditch	C44	0+000	0+941	1077.3	1075.0	2.314	941	0.25	64.75	0	64.75	0.05	0.5	1.5	5.1	0.8	1.5	1	25	9173				$ 146,763		$ 470,394			
		Ditch	C47	0+941	1+674	1075.0	1069.9	5.038	733	0.69	64.75	64.75	129.5	0.10	0.5	1.5	5.1	1.4	2.5	1	33	19240				$ 307,835		$ 483,740			
		Culvert	C56	1+674	1+725	1069.9	1068.8	1.136	52	2.20	64.75	129.5	194.25	0.16		0.0	1.0	0.0	2	1	6			450	1	$ -	$ 20,732	$ 6,194			
		Ditch	C38	1+725	2+556	1068.8	1065.8	3.044	831	0.37	0	194.25	194.25	0.16	0.5	1.5	5.1	1.0	1.5	1	25	8098				$ 129,575		$ 415,303			
	to 2_0	Culvert	C39	2+556	3+312	1065.8	1062.6	3.181	756	0.42	64.75	194.25	259	0.21		0.0	1.0	0.0	3	1	6			600	1	$ -	$ 392,472	$ 90,720	$585,000	$414,000	$1,467,000
2_2		Ditch	C58_1	0+000	0+379	1072.8	1068.3	4.567	379	1.21	64.75	0	64.75	0.05	0.5	1.5	5.1	1.8	1	1	21	1704				$ 27,267		$ 159,059			
		Ditch	C58_2	0+379	0+789	1068.3	1067.6	0.707	410	0.17	64.75	64.75	129.5	0.10	0.5	1.5	5.1	0.7	1.5	1	25	4001				$ 64,019		$ 205,189			
		Ditch	C34_1	0+789	1+211	1067.6	1063.7	3.906	422	0.93	64.75	129.5	194.25	0.16	0.5	1.5	5.1	1.6	2	1	29	7170				$ 114,721		$ 244,627			
	to 2_0	Ditch	C34_2	1+211	1+626	1063.7	1062.6	1.092	415	0.26	0	194.25	194.25	0.16	0.5	1.5	5.1	0.8	1.5	1	25	4049				$ 64,777		$ 207,619	$271,000	$0	$817,000
3_0 (Omni Share)	add 3_1, 3_2, 3_3	Ditch	C48	0+000	0+975	1056.3	1052.1	4.257	975	0.44	129.5	1165.5	1295	1.04	0.5	1.5	5.1	1.1	1	1	21	4388				$ 70,215		$ 409,588			
		ex. Pipe	C50	0+975	1+304	1052.1	1051.0	1.09	329	0.30	0	1295	1295	1.04	0.6	2.0	5.9	1.4	0	1	13	0		900	1	$ -		$ 85,529			
		Ditch	C51	1+304	1+731	1051.0	1049.0	1.954	427	0.46	0	1295	1295	1.04	0.5	1.5	5.1	1.1	1.5	1	25	4161				$ 66,577		$ 213,389			
		Culvert	C52	1+731	1+770	1049.0	1048.8	0.214	39	0.55	49	1295	1344	1.08		0.0	1.0	0.0	1.5	1	6			900	1	$ -	$ 29,242	$ 4,643			
		Ditch	C53	1+770	2+687	1048.8	1046.8	2.042	917	0.22	0	1344	1344	1.08	0.7	2.7	6.8	1.7	2	1	29	15587				$ 249,396		$ 531,800			
		Culvert	C54	2+687	2+734	1046.8	1046.7	0.093	47	0.20	64.75	1344	1408.75	1.13		0.0	1.0	0.0	1	1	6			1050	1	$ -	$ 38,099	$ 5,684			
		Ditch	C55	2+734	3+248	1046.7	1044.0	2.735	514	0.53	0	1408.75	1408.75	1.13	0.7	2.7	6.8	2.6	2.5	1	33	13495				$ 215,928		$ 339,315			
							1040.8																						$603,000	$68,000	$1,590,000
3_1	add Omni	Culvert	C46	0+000	0+031	1065.9	1065.6	0.296	31	0.96	64.75	777	841.75	0.67		0.0	1.0	0.0	1	1	6			750	1	$ -	$ 17,610	$ 3,701			
		Ditch	C47_1	0+031	0+795	1065.6	1060.1	5.502	764	0.72	64.75	841.75	906.5	0.73	0.5	1.5	5.1	1.4	2	1	29	12988				$ 207,808		$ 443,120			
	to 3_0	Ditch	C47_2	0+795	1+359	1060.1	1056.3	3.785	564	0.67	64.75	906.5	971.25	0.78	0.5	1.5	5.1	1.4	2.5	1	33	14805				$ 236,880		$ 372,240	$445,000	$18,000	$820,000

3_2		Ditch	C43	0+000	0+825	1070.8	1067.4	3.39	825	0.41	64.75	0	64.75	0.05	0.5	1.5	5.1	1.1	2	1	29	14022			$ 224,345		$ 478,383			
	to 3_0	Ditch	C45	0+825	1+662	1067.4	1056.3	11.083	837	1.32	64.75	64.75	129.5	0.10	0.5	1.5	5.1	1.9	2.5	1	33	21975			$ 351,593		$ 552,503	$576,000	$0	$1,031,000
3_3	to 3_0	ex. Ditch	C57	0+000	1+296	1060.5	1058.7	1.84	1296	0.14	64.75	0	64.75	0.05	0.5	1.5	5.1	0.6	0	1	13	0			$ -		$ 336,897			$337,000
4_0	add 4_1, 4_2	Culvert	C60	0+000	0+039	1047.5	1047.3	0.2	39	0.51	469	616.75	1085.75	0.87		0.0	1.0	0.0	1	1	6		750	1	$ -	$ 22,270	$ 4,680			
		Ditch	C61	0+039	0+850	1047.3	1043.1	4.227	811	0.52	0	1085.75	1085.75	0.87	0.5	1.5	5.1	1.2	2.5	1	33	21289			$ 340,620		$ 535,260			
		Ditch	C62	0+850	1+623	1043.1	1042.1	0.986	773	0.13	64.75	1085.75	1150.5	0.92	0.7	2.7	6.8	1.3	1	1	21	3479			$ 55,656		$ 324,660			
	to 1_0	Culvert	C63	1+623	1+664	1042.1	1042.0	0.109	41	0.26	64.75	1150.5	1215.25	0.97		0.0	1.0	0.0	2	1	6		750	1	$ -	$ 23,697	$ 4,980			
																												$397,000	$46,000	$870,000
4_1		Ditch	C58	0+000	0+859	1053.4	1052.0	1.397	859	0.16	64.75	0	64.75	0.05	0.5	1.5	5.1	0.7	2	1	29	14603			$ 233,648		$ 498,220			
	add CN site	Pipe	C78	0+859	1+612	1052.0	1048.0	4	753	0.53	357.75	64.75	422.5	0.34	0.5	1.5	5.1	1.2	5	1	6		750	1	$ -	$ 565,644	$ 90,360			
	to 4_0	Ditch	C79	1+612	2+395	1048.0	1047.5	0.5	783	0.06	0	422.5	422.5	0.34	0.5	1.5	5.1	0.4	2	1	29	13311			$ 212,976		$ 454,140	$447,000	$566,000	$1,043,000
4_2		Forcemain	C64	0+000	0+736	1040.7	1044.7	-3.969	736	-0.54	64.75	0	64.75	0.05		0.0	1.0		1.5	1	6		250	1	$ -	$ 776,675	$ 88,338			
		Ditch	C65	0+736	1+574	1044.7	1043.0	1.642	838	0.20	0	64.75	64.75	0.05	0.5	1.5	5.1	0.7	1.5	1	25	8168			$ 130,687		$ 418,870			
		Ditch	C66	1+574	2+328	1043.0	1040.1	2.917	754	0.39	64.75	64.75	129.5	0.10	0.5	1.5	5.1	1.0	1.5	1	25	7354			$ 117,668		$ 377,140			
	to 4_0	Forcemain	C67	2+328	3+148	1040.1	1047.5	-7.39	820	-0.90	64.75	129.5	194.25	0.16		0.0	1.0		1.5	1	6		300	1	$ -	$ 1,436,980	$ 98,400	$249,000	$2,214,000	$983,000
5		Pipe	C8	0+000	0+758	1045.0	1043.6	1.4	758	0.18	64.75	0	64.75	0.05		0.0	1.0	0.0	4	1	6		450	1	$ -	$ 256,258	$ 90,960			
		Pipe	C70	0+758	1+596	1043.6	1042.6	0.995	838	0.12	129.5	64.75	194.25	0.16		0.0	1.0	0.0	5	1	6		600	1	$ -	$ 432,792	$ 100,554			
		Pipe	C71	1+596	2+368	1042.6	1041.8	0.772	772	0.10	0	194.25	194.25	0.16		0.0	1.0	0.0	5	1	6		600	1	$ -	$ 400,498	$ 92,677			
	to 1_0	Ditch	C72	2+368	3+284	1041.8	1040.9	0.916	916	0.10	64.75	194.25	259	0.21	0.5	1.5	5.1	0.5	2	1	29	15574			$ 249,188		$ 531,356			
																												$250,000	$1,090,000	$816,000
																											Subtotal	$ 9,353,000	$ 10,427,000	$ 20,206,000
																											Design (15%)	$ 1,403,000	$ 1,564,000	
																											Contingency (Land 10%, Infrastructure 25%)	$ 2,338,000	$ 2,607,000	$ 2,021,000
																											Total	$ 13,094,000	$ 14,598,000	$ 22,227,000
																													Grand Total	$ 49,919,000

ALIGNMENT 2



Range Road 285
Township Road 250
Township Road 250
Township Road 250
Garden Rd
Garden Rd
Conrich
Rocky View
C64
C65
C66
C67
C60
C46
C47_1
C47_2
C58
C78
C79
C43
C45
C48
C57
C50
C51
C52
C53
C61
C62
C1_1
C1_2
C1
C44_1
C44_2
C47
C56
C3
C38
C58_1
C58_2
C34_1
C34_2
C2_2
C54
C4
C63
C29
C2_1
C72
C7
C80_3
C80_4
C80_2
C39
C68
C13_13
C13_14
C40
C41
C25
C71
C9
C6
C37_1
C23
C23_2
C24
C23_1
C10
C19
C37_2
C22
C59
C70
C11
C37_3
C12
C19_1
C19_2
C20
C8
C13
C18
C17
C15_1
C32
C15_3
C33
C31_1
C31

Drainage Route	Profile	From Station	To Station	Elevation u/s (m)	Elevation d/s (m)	Length (m)	Slope (%)	Design Q (m3/s)	Capacity (m3/s)	Easement Top Width (m)	Channel Earthworks (m3)	Culvert Sizing (mm)	Channel Cost ($)	Culvert Cost or Lift Station ($)	ROW Land Acquisition ($)	Channel Cost ($) (Ex Eng. & Con.)	Culvert, Pipe & or Lift Station Cost ($) (Ex Eng. & Con.)	Easements Cost ($) (Ex Con.)
1_0	Pipe	0=000	0+756	1066	1063	756	0.42	0.41		6.0		600		392,309	90,680	$ 268,000	$ 8,093,000	$ 1,282,000
	Pipe	0+756	1+244	1063	1060	488	0.55	0.67		6.0		900		468,314	58,560			
	Pipe	1+244	1+625	1060	1059	381	0.23	0.67		6.0		900		364,861	45,723			
	Ditch	1+625	2+397	1059	1057	773	0.27	0.67	0.9	29.0	13,137		210,187		448,194			
	Ditch	2+397	3+190	1057	1052	793	0.61	0.73	1.3	21.0	3,568		57,087		333,006			
	Culvert	3+190	3+238	1052	1052	48	0.23	0.83		6.0		1,050		38,493	5,742			
	Pipe	3+238	4+048	1052	1049	810	0.36	2.02		6.0		900		1,508,352	97,231			
	Pipe	4+048	4+728	1049	1047	680	0.36	2.02		6.0		900		1,265,018	81,559			
	Pipe	2+734	3+644	1047	1041	910	0.63	3.15		6.0		1,050		3,673,984	109,175			
	Culvert	2+734	2+830	1041	1041	96	0.12	4.09		6.0		1,050		381,312	11,520			
1_1	Ditch	0=000	0+105	1075	1075	105	0.25	0.21	0.8	21.0	472		7,557		44,082	$ 224,000	$ 22,000	$ 758,000
	Ditch	0+105	0+838	1075	1070	733	0.71	0.21	1.4	29.0	12,460		199,360		425,105			
	Culvert	0+838	0+890	1070	1069	52	1.88	0.26		6.0		600		21,065	6,194			
	Ditch	0+890	1+720	1069	1066	831	0.37	0.26	1.0	17.0	1,038		16,612		282,406			
1_2	Ditch	0=000	0+423	1084	1083	423	0.11	0.05	0.5	29.0	7,194		115,098		245,430	$ 217,000	$ -	$ 838,000
	Ditch	0+423	0+841	1083	1079	417	1.06	0.05	1.7	21.0	1,878		30,054		175,315			
	Ditch	0+841	1+834	1079	1075	993	0.35	0.10	1.0	21.0	4,470		71,525		417,228			
1_3	Ditch	0=000	0+835	1077	1075	835	0.25	0.05	0.8	25.0	8,141		130,250		417,470	$ 131,000	$ -	$ 418,000
1_4	Culvert	0=000	0+109	1074	1074	109	0.25	0.05		6.0		450		43,633	13,035	$ 704,000	$ 44,000	$ 1,205,000
	Ditch	0+109	0+990	1074	1069	881	0.49	0.05	1.2	33.0	23,130		370,088		581,566			
	Ditch	0+990	1+356	1069	1068	366	0.40	0.10	1.0	29.0	6,223		99,568		212,315			
	Ditch	1+356	1+554	1068	1068	198	0.13	0.16	0.6	41.0	10,043		160,688		162,271			
	Ditch	1+554	2+024	1068	1066	470	0.42	0.16	1.1	25.0	4,585		73,367		235,150			
1_5	Ditch	0=000	0+379	1070	1068	379	0.43	0.05	1.1	33.0	9,941		159,059		249,949	$ 319,000	$ -	$ 841,000
	Ditch	0+379	0+789	1068	1068	410	0.17	0.10	0.7	25.0	4,001		64,019		205,189			
	Ditch	0+789	1+211	1068	1064	422	0.93	0.16	1.6	25.0	4,112		65,796		210,885			
	Ditch	1+211	1+626	1064	1063	415	0.26	0.26	0.8	21.0	1,869		29,897		174,400			
2_0	Ditch	0=000	0+168	1059	1059	168	0.10	0.36	0.5	25.0	1,640		26,242		84,109	$ 203,000	$ 3,183,000	$ 1,428,000
	Culvert	0+168	0+190	1059	1059	21	0.41	0.41		6.0		600		8,774	2,580			
	Pipe	0+190	1+205	1059	1056	1015	0.25	0.41		6.0		750		755,659	121,833			
	Ditch	1+205	1+583	1056	1055	378	0.20	0.52	0.7	21.0	1,700		27,206		158,700			
	Pipe	1+583	1+975	1055	1055	392	0.12	0.73		6.0		900		375,042	47,070			
	Pipe	1+975	2+371	1055	1054	396	0.09	0.73		6.0		900		378,425	47,517			
	Culvert	2+371	2+414	1054	1054	43	0.84	0.83		6.0		900		32,353	5,136			
	Culvert	2+414	2+456	1054	1054	42	0.99	0.88		6.0		900		32,102	5,097			
	Ditch	2+456	3+527	1054	1052	1070	0.15	0.88	1.0	21.0	4,817		77,074		449,598			
	Ditch	3+527	3+620	1052	1052	93	0.11	0.93	1.2	17.0	117		1,867		31,738			
	Ditch	3+620	4+599	1052	1051	979	0.11	0.98	1.2	21.0	4,404		70,467		411,055			
	Culvert	4+599	4+639	1051	1051	40	0.36	1.04		6.0		900		36,382	4,814			
	Forcemain	4+639	5+126	1051	1052	487	-0.27	1.14		6.0		1,050		1,563,766	58,499			
2_1	Culvert	0=000	0+103	1064	1063	103	0.73	0.21		6.0		450		32,071	12,375	$ 135,000	$ 39,000	$ 478,000
	Ditch	0+103	0+426	1063	1060	323	1.05	0.26	1.7	25.0	3,150		50,395		161,522			
	Culvert	0+426	0+442	1060	1059	15	1.05	0.26		6.0		450		6,216	1,857			
	Ditch	0+052	0+506	1060	1059	454	0.14	0.26	0.6	25.0	4,425		70,798		226,916			
	Ditch	0+506	0+685	1059	1059	179	0.10	0.26	0.5	21.0	803		12,855		74,990			
2_2	Culvert	0=000	0+052	1065	1065	52	0.15	0.05		6.0		450		21,022	6,280	$ 63,000	$ 34,000	$ 377,000
	Ditch	0+052	0+922	1065	1064	869	0.14	0.05	0.6	21.0	3,911		62,581		365,054			
	Culvert	0+922	0+961	1064	1064	40	1.17	0.10		6.0		450		12,292	4,743			
2_3	Culvert	0=000	0+046	1065	1064	46	0.29	0.05		6.0		450		18,525	5,534	$ 128,000	$ 19,000	$ 413,000
	Ditch	0+046	0+860	1064	1064	814	0.08	0.05	0.5	25.0	7,940		127,042		407,185			
2_4	Ditch	0=000	0+679	1060	1059	679	0.11	0.10	0.5	21.0	3,054		48,872		285,085	$ 50,000	$ 45,000	$ 317,000
	Culvert	0+679	0+789	1059	1059	110	0.10	0.10		6.0		450		44,282	13,229			

	Ditch	0+789	0+843	1059	1059	54	0.10	0.10	0.5	17.0	67		1,078		18,319			
2_5	Culvert	0=000	0+154	1057	1057	154	0.35	0.05		6.0		450		61,839	18,474	$ 58,000	$ 62,000	$ 203,000
	Ditch	0+154	0+523	1057	1056	369	0.23	0.05	0.8	25.0	3,598		57,564		184,500			
2_6	Ditch	0=000	0+936	1060	1057	936	0.31	0.10	0.9	37.0	35,094		561,511		692,530	$ 854,000	$ 19,000	$ 1,059,000
	Culvert	0+936	0+981	1057	1057	45	0.31	0.16		6.0		450		18,192	5,435			
	Ditch	0+981	1+468	1057	1055	487	0.42	0.16	1.1	37.0	18,248		291,976		360,103			
2_7	Forcemain	0=000	1+368	1053	1054	1368	-0.10	0.05		6.0		250		928,380	164,190	$ -	$ 929,000	$ 165,000
2_8	Ditch	0=000	0+313	1055	1052	313	0.84	0.05	1.5	21.0	1,407		22,506		131,287	$ 23,000	$ -	$ 132,000
2_9	Pipe	0=000	0+756	1052	1051	756	0.15	0.05		6.0		450		255,543	90,684	$ -	$ 256,000	$ 91,000
3_0	Ditch	0=000	0+975	1056	1052	975	0.44	0.98	1.1	29.0	16,579		265,257		565,621	$ 511,000	$ 68,000	$ 1,329,000
	ex. Pipe	0+975	1+304	1052	1051	329	0.30	0.98		13.0		900			85,529			
	Ditch	1+304	1+731	1051	1049	427	0.46	0.98	1.1	33.0	11,203		179,246		281,673			
	Culvert	1+731	1+770	1049	1049	39	0.55	1.02		6.0		900		29,242	4,643			
	Ditch	1+770	2+687	1049	1047	917	0.22	1.02	1.7	21.0	4,126		66,017		385,097			
	Culvert	2+687	2+734	1047	1047	47	0.20	1.08		6.0		1,050		38,099	5,684			
3_1	Culvert	0=000	0+031	1066	1066	31	0.96	0.67		6.0		750		17,610	3,701	$ 292,000	$ 18,000	$ 697,000
	Ditch	0+031	0+795	1066	1060	764	0.72	0.73	1.4	21.0	3,438		55,008		320,880			
	Ditch	0+795	1+359	1060	1056	564	0.67	0.78	1.4	33.0	14,805		236,880		372,240			
3_2	Ditch	0=000	0+825	1071	1067	825	0.41	0.05	1.1	29.0	14,022		224,345		478,383	$ 576,000	$ -	$ 1,031,000
	Ditch	0+825	1+662	1067	1056	837	1.32	0.10	1.9	33.0	21,975		351,593		552,503			
3_3	ex. Ditch	0=000	1+296	1061	1059	1296	0.14	0.10	0.6	13.0					336,897	$ -	$ -	$ 337,000
4_0	Culvert	0=000	0+039	1048	1047	39	0.51	0.58		6.0		750		22,270	4,680	$ 397,000	$ 46,000	$ 870,000
	Ditch	0+039	0+850	1047	1043	811	0.52	0.58	1.2	33.0	21,289		340,620		535,260			
	Ditch	0+850	1+623	1043	1042	773	0.13	0.63	1.3	21.0	3,479		55,656		324,660			
	Culvert	1+623	1+664	1042	1042	41	0.26	0.69		6.0		750		23,697	4,980			
4_1	Ditch	0=000	0+859	1053	1052	859	0.16	0.10	0.7	29.0	14,603		233,648		498,220	$ 447,000	$ 566,000	$ 1,043,000
	Pipe	0+859	1+612	1052	1048	753	0.53	0.39		6.0		750		565,644	90,360			
	Ditch	1+612	2+395	1048	1048	783	0.06	0.39	0.4	29.0	13,311		212,976		454,140			
4_2	Forcemain	0=000	0+736	1041	1045	736	-0.54	0.05		6.0		250		776,675	88,338	$ 249,000	$ 2,386,000	$ 983,000
	Ditch	0+736	1+574	1045	1043	838	0.20	0.05	0.7	25.0	8,168		130,687		418,870			
	Ditch	1+574	2+328	1043	1040	754	0.39	0.10	1.0	25.0	7,354		117,668		377,140			
	Forcemain	2+328	3+148	1040	1048	820	-0.90	0.16		6.0		450		1,608,360	98,400			
5_0	Pipe	0=000	0+758	1045	1044	758	0.18	0.05		6.0		450		256,258	90,960	$ 66,000	$ 1,090,000	$ 669,000
	Pipe	0+758	1+596	1044	1043	838	0.12	0.16		6.0		600		432,792	100,554			
	Pipe	1+596	2+368	1043	1042	772	0.10	0.16		6.0		600		400,498	92,677			
	Ditch	2+368	3+284	1042	1041	916	0.10	0.21	0.5	21.0	4,123		65,961		384,775			

Pond release rate (L/s/ha) = 0.8

Mannings n 0.04
Flow depth 1 m
Side slopes 4

Ditch Excavation cost $ 16.00 $/m3

hectare of land $ 200,000

lift station $ 600,000

PVC
CSP
Conc pipe

Additional width for easement 6 m

easment width for pipe 6 m

Drainage Course	Notes	Type	Name	From Station	To Station	Elevation U/s (m)	Elevation d/s (m)	Elevation drop (m)	Length (m)	Slope (%)	Local Basin Area (ha)	U/s Regional Basin Area (ha)	Basin catch area	Design Q (m3/s)	Ditch Flow Depth	Ditch Flow Area (m2)	Ditch Wetted Perimeter (m)	Ditch Flow Capacity (m3/s)	Average depth to EG (m)	Base Width (m)	Easement Top Width (m)	Excavation Volume (m3)	Land Area (ha)	Culvert Sizing (mm)	#	Channel Cost ($)	Culvert, Pipe and/or Lift Station Cost ($)	ROW Land Acquisition Cost ($)	TOTALS Channel Cost ($)	TOTALS Culvert, Pipe and/or Lift Station Cost ($)	TOTALS ROW Land Acquisition Cost ($)
1_0	add 1_1, 1_4	Pipe	C39	0+000	0+756	1065.76	1062.58	3.181	756	0.42	0	518	518	0.41					4.5	1	6			600	1		$ 392,309	$ 90,680			
	add 1_5	Pipe	C68	0+756	1+244	1062.58	1059.90	2.677	488	0.55	0	841.75	841.75	0.67					5	1	6			900	1		$ 468,314	$ 58,560			
		Pipe	C13_13	1+244	1+625	1059.90	1059.02	0.881	381	0.23	0	841.75	841.75	0.67					2.5	1	6			900	1		$ 364,861	$ 45,723			
		Ditch	C13_14	1+625	2+397	1059.02	1056.94	2.084	773	0.27	0	841.75	841.75	0.67	0.5	1.5	5.1	0.9	2	1	29	13137				$ 210,187		$ 448,194			
		Ditch	C40	2+397	3+190	1056.94	1052.10	4.833	793	0.61	64.75	841.75	906.5	0.73	0.5	1.5	5.1	1.3	1	1	21	3568				$ 57,087		$ 333,006			
		Culvert	C41	3+190	3+238	1052.10	1051.99	0.109	48	0.23	129.5	906.5	1036	0.83					2.5	1	6			1050	1		$ 38,493	$ 5,742			
	add 2	Pipe	C2_1	3+238	4+048	1051.99	1049.10	2.889	810	0.36	64.75	2460.5	2525.25	2.02					4	1	6			900	2		$ 1,508,352	$ 97,231			
		Pipe	C2_2	4+048	4+728	1049.10	1046.69	2.417	680	0.36	0	2525.25	2525.25	2.02					3	1	6			900	2		$ 1,265,018	$ 81,559			
	add 3	Pipe	C4	2+734	3+644	1046.7	1040.9	5.77	910	0.63	64.75	3869.25	3934	3.15					2.5	1	6			1050	3		$ 3,673,984	$ 109,175			
	add 4, 5 - to CSMI	Culvert	C29	2+734	2+830	1040.9	1040.8	0.117	96	0.12	64.75	5050.5	5115.25	4.09					2	2	6			1050	3		$ 381,312	$ 11,520			
	CSMI Connection Invert						1040.8																						$268,000	$8,093,000	$1,282,000
1_1	add 1_2, 1_3	Ditch	C44_2	0+000	0+105	1075.23	1074.98	0.258	105	0.25	64.75	194.25	259	0.21	0.5	1.5	5.1	0.8	1	1	21	472				$ 7,557		$ 44,082			
		Ditch	C47	0+105	0+838	1074.98	1069.77	5.205	733	0.71	0	259	259	0.21	0.5	1.5	5.1	1.4	2	1	29	12460				$ 199,360		$ 425,105			
		Culvert	C56	0+838	0+890	1069.77	1068.80	0.969	52	1.88	64.75	259	323.75	0.26					1	1	6			600	1		$ 21,065	$ 6,194			
	to 1_0	Ditch	C38	0+890	1+720	1068.80	1065.76	3.044	831	0.37	0	323.75	323.75	0.26	0.5	1.5	5.1	1.0	0.5	1	17	1038				$ 16,612		$ 282,406	$224,000	$22,000	$758,000
1_2		Ditch	C1_1	0+000	0+423	1083.59	1083.13	0.454	423	0.11	64.75	0	64.75	0.05	0.5	1.5	5.1	0.5	2	1	29	7194				$ 115,098		$ 245,430			
		Ditch	C1_2	0+423	0+841	1083.13	1078.70	4.437	417	1.06	0	64.75	64.75	0.05	0.5	1.5	5.1	1.7	1	1	21	1878				$ 30,054		$ 175,315			
	to 1_1	Ditch	C1	0+841	1+834	1078.70	1075.23	3.461	993	0.35	64.75	64.75	129.5	0.10	0.5	1.5	5.1	1.0	1	1	21	4470				$ 71,525		$ 417,228	$217,000	$0	$838,000
1_3	to 1_1	Ditch	C44_1	0+000	0+835	1077.29	1075.23	2.056	835	0.25	64.75	0	64.75	0.05	0.5	1.5	5.1	0.8	1.5	1	25	8141				$ 130,250		$ 417,470	$131,000	$0	$418,000
1_4		Culvert	C3	0+000	0+109	1074.05	1073.77	0.275	109	0.25	64.75	0	64.75	0.05					1	1	6			450	1		$ 43,633	$ 13,035			
		Ditch	C7	0+109	0+990	1073.77	1069.44	4.33	881	0.49	0	64.75	64.75	0.05	0.5	1.5	5.1	1.2	2.5	1	33	23130				$ 370,088		$ 581,566			
		Ditch	C80_3	0+990	1+356	1069.44	1067.99	1.452	366	0.40	64.75	64.75	129.5	0.10	0.5	1.5	5.1	1.0	2	1	29	6223				$ 99,568		$ 212,315			
		Ditch	C80_4	1+356	1+554	1067.99	1067.74	0.251	198	0.13	64.75	129.5	194.25	0.16	0.5	1.5	5.1	0.6	3.5	1	41	10043				$ 160,688		$ 162,271			
	to 1_0	Ditch	C80_2	1+554	2+024	1067.74	1065.76	1.979	470	0.42	0	194.25	194.25	0.16	0.5	1.5	5.1	1.1	1.5	1	25	4585				$ 73,367		$ 235,150	$704,000	$44,000	$1,205,000
1_5		Ditch	C58_1	0+000	0+379	1069.90	1068.28	1.618	379	0.43	64.75	0	64.75	0.05	0.5	1.5	5.1	1.1	2.5	1	33	9941				$ 159,059		$ 249,949			
		Ditch	C58_2	0+379	0+789	1068.28	1067.58	0.707	410	0.17	64.75	64.75	129.5	0.10	0.5	1.5	5.1	0.7	1.5	1	25	4001				$ 64,019		$ 205,189			
		Ditch	C34_1	0+789	1+211	1067.58	1063.67	3.906	422	0.93	64.75	129.5	194.25	0.16	0.5	1.5	5.1	1.6	1.5	1	25	4112				$ 65,796		$ 210,885			
	to 1_0	Ditch	C34_2	1+211	1+626	1063.67	1062.58	1.092	415	0.26	129.5	194.25	323.75	0.26	0.5	1.5	5.1	0.8	1	1	21	1869				$ 29,897		$ 174,400	$319,000	$0	$841,000
2_0	add 2_1, 2_4	Ditch	C15_4	0+000	0+168	1058.8	1058.7	0.168	168	0.10	0	453.25	453.25	0.36	0.5	1.5	5.1	0.5	1.5	1	25	1640				$ 26,242		$ 84,109			
		Culvert	C16	0+168	0+190	1058.7	1058.6	0.088	21	0.41	64.75	453.25	518	0.41					3	1	6			600	1		$ 8,774	$ 2,580			
		Pipe	C17	0+190	1+205	1058.6	1056.0	2.562	1015	0.25	0	518	518	0.41					3.5	1	6			750	1		$ 755,659	$ 121,833			
	add 2_5	Ditch	C18	1+205	1+583	1056.0	1055.3	0.743	378	0.20	64.75	582.75	647.5	0.52	0.5	1.5	5.1	0.7	1	1	21	1700				$ 27,206		$ 158,700			
	add 2_6	Pipe	C19_1	1+583	1+975	1055.3	1054.8	0.457	392	0.12	64.75	841.75	906.5	0.73					5.5	1	6			900	1		$ 375,042	$ 47,070			
		Pipe	C19_2	1+975	2+371	1054.8	1054.4	0.365	396	0.09	0	906.5	906.5	0.73					4	1	6			900	1		$ 378,425	$ 47,517			
	add 2_7	Culvert	C20	2+371	2+414	1054.4	1054.1	0.361	43	0.84	64.75	971.25	1036	0.83					2	1	6			900	1		$ 32,353	$ 5,136			
		Culvert	C21	2+414	2+456	1054.1	1053.7	0.42	42	0.99	64.75	1036	1100.75	0.88					1.5	1	6			900	1		$ 32,102	$ 5,097			
		Ditch	C22	2+456	3+527	1053.7	1052.1	1.601	1070	0.15	0	1100.75	1100.75	0.88	0.6	2.0	5.9	1.0	1	1	21	4817				$ 77,074		$ 449,598			
		Ditch	C23_1	3+527	3+620	1052.1	1051.9	0.105	93	0.11	64.75	1100.75	1165.5	0.93	0.7	2.7	6.8	1.2	0.5	1	17	117				$ 1,867		$ 31,738			
	add 2_8	Ditch	C23_2	3+620	4+599	1051.9	1050.8	1.104	979	0.11	0	1230.25	1230.25	0.98	0.7	2.7	6.8	1.2	1	1	21	4404				$ 70,467		$ 411,055			
		Culvert	C24	4+599	4+639	1050.8	1050.7	0.144	40	0.36	64.75	1230.25	1295	1.04					1.5	1	6			900	1		$ 36,382	$ 4,814			
	add 2_9, to 1_0	Forcemain	C25	4+639	5+126	1050.7	1052.0	-1.293	487	-0.27	64.75	1359.75	1424.5	1.14					2	1	6			1050	1		$ 1,563,766	$ 58,499			
																													$ 203,000	$ 3,183,000	$ 1,428,000
2_1	add 2_2, 2_3	Culvert	C12	0+000	0+103	1063.8	1063.0	0.754	103	0.73	64.75	194.25	259	0.21					1	1	6			450	1		$ 32,071	$ 12,375			
		Ditch	C13	0+103	0+426	1063.0	1059.6	3.386	323	1.05	64.75	259	323.75	0.26	0.5	1.5	5.1	1.7	1.5	1	25	3150				$ 50,395		$ 161,522			
		Culvert	C14	0+426	0+442	1059.6	1059.5	0.162	15	1.05	0	323.75	323.75	0.26					2.5	1	6			450	1		$ 6,216	$ 1,857			
		Ditch	C15_1	0+052	0+506	1059.6	1059.0	0.617	454	0.14	0	323.75	323.75	0.26	0.5	1.5	5.1	0.6	1.5	1	25	4425				$ 70,798		$ 226,916			
	to 2_0	Ditch	C15_3	0+506	0+685	1059.0	1058.8	0.179	179	0.10	0	323.75	323.75	0.26	0.5	1.5	5.1	0.5	1	1	21	803	1			$ 12,855		$ 74,990	$ 135,000	$ 39,000	$ 478,000
2_2		Culvert	C9	0+000	0+052	1065.5	1065.4	0.078	52	0.15	64.75	0	64.75	0.05					3.5	1	6			450	1		$ 21,022	$ 6,280			
		Ditch	C10	0+052	0+922	1065.4	1064.2	1.186	869	0.14	0	64.75	64.75	0.05	0.5	1.5	5.1	0.6	1	1	21	3911				$ 62,581		$ 365,054			
	to 2_1	Culvert	C11	0+922	0+961	1064.2	1063.8	0.463	40	1.17	64.75	64.75	129.5	0.10					2	1	6			450	1		$ 12,292	$ 4,743	$ 63,000	$ 34,000	$ 377,000
2_3		Culvert	C6	0+000	0+046	1064.5	1064.4	0.132	46	0.29	64.75	0	64.75	0.05					0.5	1	6			450	1		$ 18,525	$ 5,534			
	to 2_1	Ditch	C19	0+046	0+860	1064.4	1063.8	0.624	814	0.08	0	64.75	64.75	0.05	0.5	1.5	5.1	0.5	1.5	1	25	7940				$ 127,042		$ 407,185			
																													$ 128,000	$ 19,000	$ 413,000
2_4		Ditch	C31_1	0+000	0+679	1059.7	1059.0	0.714	679	0.11	129.5	0	129.5	0.10	0.5	1.5	5.1	0.5	1	1	21	3054				$ 48,872		$ 285,085			
		Culvert	C31_3	0+679	0+789	1059.0	1058.9	0.113	110	0.10	0	129.5	129.5	0.10					3	1	6			450	1		$ 44,282	$ 13,229			
	to 2_0	Ditch	C31_4	0+789	0+843	1058.9	1058.8	0.055	54	0.10	0	129.5	129.5	0.10	0.5	1.5	5.1	0.5	0.5	1	17	67				$ 1,078		$ 18,319	$ 50,000	$ 45,000	$ 317,000
2_5		Culvert	C31	0+000	0+154	1057.4	1056.9	0.534	154	0.35	64.75	0	64.75	0.05					2	1	6			450	1		$ 61,839	$ 18,474			
	to 2_0	Ditch	C32	0+154	0+523	1056.9	1056.0	0.856	369	0.23	0	64.75	64.75	0.05	0.5	1.5	5.1	0.8	1.5	1	25	3598				$ 57,564		$ 184,500	$ 58,000	$ 62,000	$ 203,000
2_6		Ditch	C37_1	0+000	0+936	1060.3	1057.4	2.927	936	0.31	129.5	0	129.5	0.10	0.5	1.5	5.1	0.9	3	1	37	35094				$ 561,511		$ 692,530			
		Culvert	C37_2	0+936	0+981	1057.4	1057.3	0.142	45	0.31	64.75	129.5	194.25	0.16					6	1	6			450	1		$ 18,192	$ 5,435			
	to 2_0	Ditch	C37_3	0+981	1+468	1057.3	1055.3	2.022	487	0.42	0	194.25	194.25	0.16	0.5	1.5	5.1	1.1	3	1	37	18248				$ 291,976		$ 360,103	$ 854,000	$ 19,000	$ 1,059,000
2_7	to 2_0	Forcemain	C33	0+000	1+368	1053.0	1054.4	-1.435	1368	-0.10	64.75	0	64.75	0.05					4	1	6			250	1		$ 928,380	$ 164,190	$ -	$ 929,000	$ 165,000
2_8	to 2_0	Ditch	C23	0+000	0+313	1054.6	1051.9	2.64	313	0.84	64.75	0	64.75	0.05	0.5	1.5	5.1	1.5	1	1	21	1407				$ 22,506		$ 131,287	$ 23,000	$ -	$ 132,000
2_9	to 2_0	Pipe	C59	0+000	0+756	1051.8	1050.7	1.144	756	0.15	64.75	0	64.75	0.05					6	1	6			450	1		$ 255,543	$ 90,684	$ -	$ 256,000	$ 91,000
3_0 (Omni Share)	add 3_1, 3_2, 3_3	Ditch	C48	0+000	0+975	1056.3	1052.1	4.257	975	0.44	0	1230.25	1230.25	0.98	0.5	1.5	5.1	1.1	2	1	29	16579				$ 265,257		$ 565,621			
		ex. Pipe	C50	0+975	1+304	1052.1	1051.0	1.09	329	0.30	0	1230.25	1230.25	0.98		0.0	1.0	0.0	0	1	13	0		900	1			$ 85,529			
		Ditch	C51	1+304	1+731	1051.0	1049.0	1.954	427	0.46	0	1230.25	1230.25	0.98	0.5	1.5	5.1	1.1	2.5	1	33	11203				$ 179,246		$ 281,673			
		Culvert	C52	1+731	1+770	1049.0	1048.8	0.214	39	0.55	49	1230.25	1279.25	1.02					1.5	1	6			900	1		$ 29,242	$ 4,643			
		Ditch	C53	1+770	2+687	1048.8	1046.8	2.042	917	0.22	0	1279.25	1279.25	1.02	0.7	2.7	6.8	1.7	1	1	21	4126				$ 66,017		$ 385,097			
	to 1_0	Culvert	C54	2+687	2+734	1046.8	1046.7	0.093	47	0.20	64.75	1279.25	1344	1.08					1.5	1	6			1050	1		$ 38,099	$ 5,684			
																													$511,000	$68,000	$1,329,000
3_1	add Omni	Culvert	C46	0+000	0+031	1065.9	1065.6	0.296	31	0.96	64.75	777	841.75	0.67					2	1	6			750	1		$ 17,610	$ 3,701			
		Ditch	C47_1	0+031	0+795	1065.6	1060.1	5.502	764	0.72	64.75	841.75	906.5	0.73	0.5	1.5	5.1	1.4	1	1	21	3438				$ 55,008		$ 320,880			
	to 3_0	Ditch	C47_2	0+795	1+359	1060.1	1056.3	3.785	564	0.67	64.75	906.5	971.25	0.78	0.5	1.5	5.1	1.4	2.5	1	33	14805				$ 236,880		$ 372,240	$292,000	$18,000	$697,000
3_2		Ditch	C43	0+000	0+825	1070.8	1067.4	3.39	825	0.41	64.75	0	64.75	0.05	0.5	1.5	5.1	1.1	2	1	29	14022				$ 224,345		$ 478,383			

3_2	to 3_0	Ditch	C45	0+825	1+662	1067.4	1056.3	11.083	837	1.32	64.75	64.75	129.5	0.10	0.5	1.5	5.1	1.9	2.5	1	33	21975			$ 351,593		$ 552,503	$576,000	$0	$1,031,000
3_3	to 3_0	ex. Ditch	C57	0+000	1+296	1060.5	1058.7	1.84	1296	0.14	129.5	0	129.5	0.10	0.5	1.5	5.1	0.6	0	1	13	0			$ -		$ 336,897			$ 337,000
4_0	add 4_1	Culvert	C60	0+000	0+039	1047.5	1047.3	0.2	39	0.51	46.5	681.5	728	0.58					1	1	6		750	1		$ 22,270	$ 4,680			
		Ditch	C61	0+039	0+850	1047.3	1043.1	4.227	811	0.52	0	728	728	0.58	0.5	1.5	5.1	1.2	2.5	1	33	21289			$ 340,620		$ 535,260			
		Ditch	C62	0+850	1+623	1043.1	1042.1	0.986	773	0.13	64.75	728	792.75	0.63	0.7	2.7	6.8	1.3	1	1	21	3479			$ 55,656		$ 324,660			
	to 1_0	Culvert	C63	1+623	1+664	1042.1	1042.0	0.109	41	0.26	64.75	792.75	857.5	0.69					2	1	6		750	1		$ 23,697	$ 4,980			
																												$397,000	$46,000	$870,000
4_1		Ditch	C58	0+000	0+859	1053.4	1052.0	1.397	859	0.16	129.5	0	129.5	0.10	0.5	1.5	5.1	0.7	2	1	29	14603			$ 233,648		$ 498,220			
	add CN site	Pipe	C78	0+859	1+612	1052.0	1048.0	4	753	0.53	357.75	129.5	487.25	0.39					5	1	6		750	1		$ 565,644	$ 90,360			
	to 4_0	Ditch	C79	1+612	2+395	1048.0	1047.5	0.5	783	0.06	0	487.25	487.25	0.39	0.5	1.5	5.1	0.4	2	1	29	13311			$ 212,976		$ 454,140	$447,000	$566,000	$1,043,000
4_2		Forcemain	C64	0+000	0+736	1040.7	1044.7	-3.969	736	-0.54	64.75	0	64.75	0.05					2	1	6		250	1		$ 776,675	$ 88,338			
		Ditch	C65	0+736	1+574	1044.7	1043.0	1.642	838	0.20	0	64.75	64.75	0.05	0.5	1.5	5.1	0.7	1.5	1	25	8168			$ 130,687		$ 418,870			
		Ditch	C66	1+574	2+328	1043.0	1040.1	2.917	754	0.39	64.75	64.75	129.5	0.10	0.5	1.5	5.1	1.0	1.5	1	25	7354			$ 117,668		$ 377,140			
	to 4_0	Forcemain	C67	2+328	3+148	1040.1	1047.5	-7.39	820	-0.90	64.75	129.5	194.25	0.16					1.5	1	6		450	1		$ 1,608,360	$ 98,400	$249,000	$2,386,000	$983,000
5		Pipe	C8	0+000	0+758	1045.0	1043.6	1.4	758	0.18	64.75	0	64.75	0.05					4	1	6		450	1		$ 256,258	$ 90,960			
		Pipe	C70	0+758	1+596	1043.6	1042.6	0.995	838	0.12	129.5	64.75	194.25	0.16					5	1	6		600	1		$ 432,792	$ 100,554			
		Pipe	C71	1+596	2+368	1042.6	1041.8	0.772	772	0.10	0	194.25	194.25	0.16					5	1	6		600	1		$ 400,498	$ 92,677			
	to 1_0	Ditch	C72	2+368	3+284	1041.8	1040.9	0.916	916	0.10	64.75	194.25	259	0.21	0.5	1.5	5.1	0.5	1	1	21	4123			$ 65,961		$ 384,775			
																												$66,000	$1,090,000	$669,000
																											Subtotal	$ 5,915,000	$ 16,919,000	$ 16,964,000
																											Design (15%)	$ 890,000	$ 2,540,000	
																											Contingency (Land 10%, Infrastructure 25%)	$ 1,480,000	$ 4,230,000	$ 1,700,000
																											Total	$ 8,285,000	$ 23,689,000	$ 18,664,000
																													Grand Total	$ 50,638,000

OMNI COST SHARE

OPTION 1 (OMNI SHARE)												
			Omni Area	Conrich Area	Omni %	Conrich %	Total Cost	Omni Cost	Conrich Cost	Total Cost	Omni Cost	Conrich Cost
	Culvert	C46	520	64.75	89%	11%	$ 28,725	$ 25,544	$ 3,181			
3_1	Ditch	C47_1	520	129.5	80%	20%	$ 429,979	$ 344,248	$ 85,731	$ 1,200,000	$ 910,000	$ 291,000
	Ditch	C47_2	520	194.25	73%	27%	$ 741,096	$ 539,545	$ 201,551			
	Ditch	C48	520	194.25	73%	27%	$ 993,543	$ 723,335	$ 270,208			
	Culvert	C50	520	194.25	73%	27%	$ 94,082	$ 68,495	$ 25,587			
	Ditch	C51	520	194.25	73%	27%	$ 560,785	$ 408,272	$ 152,513			
3_0	Culvert	C52	520	243.25	68%	32%	$ 46,046	$ 31,371	$ 14,675	$ 2,946,000	$ 2,045,000	$ 901,000
	Ditch	C53	520	243.25	68%	32%	$ 516,030	$ 351,569	$ 164,460			
	Culvert	C54	520	308	63%	37%	$ 59,590	$ 37,424	$ 22,166			
	Ditch	C55	520	308	63%	37%	$ 675,546	$ 424,256	$ 251,290			
	Pipe	C27	520	3221.75	14%	86%	$ 2,125,436	$ 295,377	$ 1,830,059			
1_0	Ditch	C28	520	3221.75	14%	86%	$ 815,755	$ 113,367	$ 702,387	$ 3,488,000	$ 468,000	$ 3,021,000
	Culvert	C29	520	4338.25	11%	89%	$ 546,509	$ 58,495	$ 488,014			
										$ 7,634,000	$ 3,423,000	$ 4,213,000

OPTION 2 (OMNI SHARE)												
			Omni Area	Conrich Area	Omni %	Conrich %	Total Cost	Omni Cost	Conrich Cost	Total Cost	Omni Cost	Conrich Cost
	Culvert	C46	520	64.75	89%	11%	$ 28,725	$ 25,544	$ 3,181			
3_1	Ditch	C47_1	520	129.5	80%	20%	$ 429,979	$ 344,248	$ 85,731	$ 1,200,000	$ 910,000	$ 291,000
	Ditch	C47_2	520	194.25	73%	27%	$ 741,096	$ 539,545	$ 201,551			
	Ditch	C48	520	194.25	73%	27%	$ 993,543	$ 723,335	$ 270,208			
	Culvert	C50	520	194.25	73%	27%	$ 94,082	$ 68,495	$ 25,587			
3_0	Ditch	C51	520	194.25	73%	27%	$ 560,785	$ 408,272	$ 152,513	$ 2,271,000	$ 1,621,000	$ 650,000
	Culvert	C52	520	243.25	68%	32%	$ 46,046	$ 31,371	$ 14,675			
	Ditch	C53	520	243.25	68%	32%	$ 516,030	$ 351,569	$ 164,460			
	Culvert	C54	520	308	63%	37%	$ 59,590	$ 37,424	$ 22,166			
1_0	Pipe	C4	520	3157	14%	86%	$ 5,263,670	$ 744,386	$ 4,519,283	$ 5,811,000	$ 803,000	$ 5,008,000
	Culvert	C29	520	4338.25	11%	89%	$ 546,509	$ 58,495	$ 488,014			
										$ 9,282,000	$ 3,334,000	$ 5,949,000

APPENDIX D

Cost Estimate – Alignment 1 – All Pipe Option

FROM 2022 AT Unit Price Average Reports

CSP

Size	Supply	Supply and Install
450		$ 401.68
600		$ 408.13
750		$ 571.03
900		$ 755.84
1050		$ 804.40
1200		$ 1,490.08

Channel excavation	$ 13.58

FROM 2022 City of Calgary Development Agreement Standard

Concrete

Size	Supply	Supply and Install
300	$ 67.00	$ 235.00
350	$ 86.00	$ 279.00
450	$ 98.00	$ 311.00
600	$ 235.00	$ 492.00
750	$ 389.00	$ 700.00
900	$ 549.00	$ 907.00
1050	$ 895.00	$ 1,324.00
1200	$ 1,195.00	$ 1,710.00
1350	$ 1,490.00	$ 2,108.00
1500	$ 1,825.00	$ 2,567.00
1650	$ 2,153.00	$ 3,043.00
1800	$ 2,495.00	$ 3,563.00

Manholes - assume one at each end and every 150m

5A	$ 3,420.00	up to 600mm pipe
1-S 1.2-1.2	$ 6,424.00	up to 900mm pipe
1-S 1.5-1.5	$ 8,614.00	up to 1200mm pipe

PVC

Size	Supply	Supply and Install
250	$ 80.00	$ 240.00
300	$ 121.00	$ 289.00
375	$ 175.00	$ 368.00
450	$ 285.00	$ 498.00
525	$ 398.00	$ 632.00

Drainage Route	Profile	Name	From Station	To Station	Elevation u/s (m)	Elevation d/s (m)	Length (m)	Slope (%)	Design Q (m3/s)	Capacity (m3/s)	Easement Top Width (m)	Culvert Sizing (mm)	Culvert Cost or Lift Station ($)	ROW Land Acquisition ($)	Culvert, Pipe & or Lift Station Cost ($) (Ex Eng. & Con.)	Easements Cost ($) (Ex Con.)
1_0	Ditch	C19_1	0=000	0+392	1055	1055	392	0.11	1.35	1.5	6.0	1,200	696,162	47,040	$ 11,050,000	$ 657,000
	Ditch	C19_2	0+392	0+788	1055	1054	396	0.10	1.35	1.4	6.0	1,200	703,002	47,520		
	Culvert	C20	0+788	0+831	1054	1054	43	0.84	1.45	4.2	6.0	1,200	81,809	5,136		
	Culvert	C21	0+831	0+873	1054	1054	42	0.99	1.50	4.6	6.0	1,200	81,241	5,097		
	Ditch	C22	0+873	1+943	1054	1052	1070	0.15	1.55	1.8	6.0	1,200	1,898,612	128,400		
	Ditch	C23_1	1+943	2+037	1052	1052	93	0.16	1.61	1.9	6.0	1,200	168,239	11,202		
	Ditch	C23_2	2+037	3+015	1052	1051	979	0.14	1.71	1.7	6.0	1,200	1,733,880	117,444		
	Culvert	C24	3+015	3+055	1051	1050	40	0.25	1.76	2.3	6.0	1,200	77,207	4,814		
	Ditch	C25	3+055	3+543	1050	1049	487	0.35	1.86	2.7	6.0	1,200	868,062	58,499		
	Ditch	C26	3+543	4+384	1049	1044	842	0.56	1.92	3.5	6.0	1,200	1,490,671	100,982		
	Pipe	C27	4+384	4+751	1044	1043	367	0.20	3.20	3.8	6.0	1,500	967,931	44,040		
	Ditch	C28	4+751	5+372	1043	1041	621	0.37	3.20	6.5	6.0	1,650	1,932,219	74,498		
	Culvert	C29	5+372	5+468	1041	1041	96	0.12	4.09	4.7	6.0	1,800	350,662	11,520		
						1041										
1_1	Culvert	C12	0=000	0+103	1064	1063	103	0.73	0.41	1.1	6.0	750	78,610	12,375	$ 2,473,000	$ 319,000
	Ditch	C13	0+103	0+428	1063	1060	325	1.04	0.47	1.3	6.0	750	246,447	38,944		
	Culvert	C14	0+428	0+442	1060	1059	15	1.06	0.47	1.4	6.0	750	16,780	1,775		
	Ditch	C15_1	0+442	0+896	1059	1059	454	0.10	0.47	0.7	6.0	900	437,322	54,460		
	Ditch	C15_3	0+896	1+075	1059	1059	179	0.10	0.47	0.7	6.0	900	174,790	21,426		
	Ditch	C15_4	1+075	1+243	1059	1059	168	0.10	0.57	0.7	6.0	900	165,421	20,186		
	Culvert	C16	1+243	1+265	1059	1059	21	0.41	0.62	1.4	6.0	900	25,923	2,580		
	Ditch	C17	1+265	2+280	1059	1056	1015	0.25	0.62	1.1	6.0	900	965,573	121,800		
	Ditch	C18	2+280	2+658	1056	1055	378	0.20	0.73	0.9	6.0	900	362,118	45,360		
1_2	Ditch	C1_1	0=000	0+423	1085	1084	423	0.11	0.05	0.1	6.0	350	128,321	50,779	$ 1,966,000	$ 531,000
	Ditch	C1_2	0+423	0+841	1084	1079	417	1.37	0.05	0.2	6.0	350	126,719	50,090		
	Ditch	C2	0+841	1+107	1079	1076	266	1.19	0.10	0.2	6.0	350	81,156	31,964		
	Culvert	C3	1+107	1+154	1076	1075	47	0.12	0.10	0.1	6.0	450	18,031	5,638		
	Ditch	C4	1+154	1+636	1075	1074	482	0.24	0.10	0.2	6.0	450	163,650	57,866		
	Culvert	C5	1+636	1+741	1074	1074	105	0.11	0.16	0.2	6.0	600	55,204	12,630		
	Ditch	C6_1	1+741	2+178	1074	1074	437	0.12	0.16	0.2	6.0	600	225,173	52,418		
	Ditch	C6_2	2+178	2+638	1074	1069	460	0.92	0.16	0.7	6.0	600	239,988	55,197		
	Culvert	C7	2+638	2+670	1069	1069	32	0.73	0.21	0.6	6.0	600	18,960	3,790		
	Ditch	C8_2	3+105	3+458	1067	1065	353	0.47	0.21	0.5	6.0	600	183,962	42,366		
	Culvert	C9	3+458	3+510	1065	1065	52	0.15	0.26	0.3	6.0	600	29,168	6,280		
	Ditch	C10	3+510	4+379	1065	1064	869	0.14	0.26	0.3	6.0	600	448,155	104,301		
	Culvert	C11	4+379	4+419	1064	1064	40	1.17	0.31	0.8	6.0	600	22,866	4,743		
1_3	Culvert	C6	0=000	0+046	1065	1064	46	0.26	0.05	0.1	6.0	300	14,258	5,534	$ 289,000	$ 104,000
	Ditch	C19	0+046	0+860	1064	1064	814	0.08	0.05	0.1	6.0	450	273,789	97,724		
1_4	Ditch	C31_1	0=000	0+679	1060	1059	679	0.11	0.05	0.1	6.0	450	228,269	81,480	$ 287,000	$ 102,000
	Culvert	C31_3	0+679	0+789	1059	1059	110	0.10	0.10	0.1	6.0	450	37,706	13,229		
	Ditch	C31_4	0+789	0+843	1059	1059	54	0.10	0.10	0.1	6.0	450	20,177	6,466		
1_5	Culvert	C31	0=000	0+154	1057	1057	154	0.35	0.05	0.2	6.0	450	54,734	18,480	$ 180,000	$ 63,000
	Ditch	C32	0+154	0+523	1057	1056	369	0.23	0.05	0.2	6.0	450	125,019	44,280		
1_6	Forcemain	C33	0=000	1+368	1053	1054	1368	-0.10	0.05		6.0	300	995,352	164,160	$ 996,000	$ 165,000
1_7	Ditch	C23	0=000	0+313	1055	1052	313	0.84	0.05	0.3	6.0	450	107,475	37,510	$ 108,000	$ 38,000
1_8	Culvert	C59	0=000	0+755	1052	1051	755	0.15	0.10	0.3	6.0	600	391,980	90,600	$ 392,000	$ 91,000
	Ditch	C40	0=000	0+793	1056	1052	793	0.45	0.05	0.2	6.0	450	267,103	95,145		

1_9	Culvert	C41	0+793	0+841	1052	1052	48	0.23	0.10	0.2	6.0	450	18,302	5,742	$ 809,000	$ 289,000
	Ditch	C42	0+841	2+402	1052	1045	1561	0.47	0.10	0.2	6.0	450	523,049	187,304		
2_0	Ditch	C35	0=000	0+263	1063	1061	263	0.60	0.47	0.6	6.0	600	136,008	31,504	$ 1,722,000	$ 285,000
	Ditch	C36	0+263	0+904	1063	1060	642	0.35	0.52	0.8	6.0	750	481,344	77,010		
	Ditch	C37_1	0+904	1+840	1060	1057	936	0.31	0.57	0.7	6.0	750	700,168	112,320		
	Culvert	C37_2	1+840	1+885	1057	1057	45	0.32	0.57	0.7	6.0	750	37,924	5,400		
	Ditch	C37_3	1+885	2+371	1057	1056	486	0.31	0.57	0.7	6.0	750	365,896	58,320		
2_1	Ditch	C44	0=000	0+941	1077	1075	941	0.25	0.05	0.1	6.0	300	245,025	112,894	$ 1,181,000	$ 398,000
	Ditch	C47	0+941	1+674	1075	1070	733	0.69	0.10	0.3	6.0	450	245,044	87,953		
	Culvert	C56	1+674	1+725	1070	1069	52	2.20	0.16	0.5	6.0	450	19,472	6,194		
	Ditch	C38	1+725	2+556	1069	1066	831	0.37	0.16	0.2	6.0	450	278,838	99,673		
	Culvert	C39	2+556	3+312	1066	1063	756	0.42	0.21	0.5	6.0	600	392,472	90,720		
2_2	Ditch	C58_1	0=000	0+379	1073	1068	379	1.21	0.05	0.1	6.0	300	99,257	45,445	$ 518,000	$ 196,000
	Ditch	C58_2	0+379	0+789	1068	1068	410	0.17	0.10	0.1	6.0	450	137,887	49,245		
	Ditch	C34_1	0+789	1+211	1068	1064	422	0.93	0.16	0.3	6.0	450	141,430	50,612		
	Ditch	C34_2	1+211	1+626	1064	1063	415	0.26	0.16	0.2	6.0	450	139,399	49,828		
3_0	Ditch	C48	0=000	0+975	1056	1052	975	0.44	1.04	1.4	6.0	900	929,483	117,025	$ 3,412,000	$ 436,000
	ex. Pipe	C50	0+975	1+304	1052	1051	329	0.30	1.04	1.4	13.0	900		85,529		
	Ditch	C51	1+304	1+731	1051	1049	427	0.46	1.04	1.4	6.0	900	406,359	51,213		
	Culvert	C52	1+731	1+770	1049	1049	39	0.55	1.08	1.6	6.0	900	41,514	4,643		
	Ditch	C53	1+770	2+687	1049	1047	917	0.22	1.08	1.5	6.0	1,050	1,258,940	110,028		
	Culvert	C54	2+687	2+734	1047	1047	47	0.20	1.13	1.4	6.0	1,050	69,133	5,684		
	Ditch	C55	2+734	3+248	1047	1044	514	0.53	1.13	2.4	6.0	1,050	706,383	61,694		
3_1	Culvert	C46	0=000	0+031	1066	1066	31	0.96	0.67	0.7	6.0	600	18,593	3,701	$ 1,013,000	$ 164,000
	Ditch	C47_1	0+031	0+795	1066	1060	764	0.72	0.73	1.1	6.0	750	573,344	91,680		
	Ditch	C47_2	0+795	1+359	1060	1056	564	0.67	0.78	1.1	6.0	750	420,496	67,680		
3_2	Ditch	C43	0=000	0+825	1071	1067	825	0.41	0.05	0.1	6.0	300	214,348	98,976	$ 496,000	$ 200,000
	Ditch	C45	0+825	1+662	1067	1056	837	1.32	0.10	0.4	6.0	450	280,866	100,455		
3_3	ex. Ditch	C57	0=000	1+296	1061	1059	1296	0.14	0.05	0.6	13.0			336,897	$ -	$ 337,000
4_0	Culvert	C60	0=000	0+039	1048	1047	39	0.51	0.53	0.9	6.0	750	33,724	4,680	$ 1,424,000	$ 200,000
	Ditch	C61	0+039	0+850	1047	1043	811	0.49	0.53	0.9	6.0	750	606,244	97,320		
	Ditch	C62	0+850	1+623	1043	1042	773	0.16	0.58	0.8	6.0	900	739,655	92,760		
	Culvert	C63	1+623	1+664	1042	1042	41	0.26	0.63	1.1	6.0	900	44,063	4,980		
											6.0					
4_1	Ditch	C58	0=000	0+859	1053	1052	859	0.16	0.05	0.1	6.0	450	287,669	103,080	$ 2,138,000	$ 288,000
	Pipe	C78	0+859	1+612	1052	1048	753	0.53	0.34	0.5	6.0	600	390,996	90,360		
	Ditch	C79	1+612	2+395	1048	1048	783	0.06	0.34	0.5	6.0	900	1,458,906	93,960		
4_2	Forcemain	C64	0=000	0+736	1041	1045	736	-0.54	0.05		6.0	250	776,675	88,338	$ 3,577,000	$ 378,000
	Ditch	C65	0+736	1+574	1045	1043	838	0.20	0.05	0.6	6.0	750	624,962	100,529		
	Ditch	C66	1+574	2+328	1043	1040	754	0.39	0.10	0.8	6.0	750	566,540	90,514		
	Forcemain	C67	2+328	3+148	1040	1048	820	-0.90	0.16		6.0	450	1,608,360	98,400		
5_0	Pipe	C8	0=000	0+758	1045	1044	758	0.18	0.05	0.1	6.0	450	256,258	90,960	$ 1,565,000	$ 395,000
	Pipe	C70	0+758	1+596	1044	1043	838	0.12	0.16	0.2	6.0	600	432,792	100,554		
	Pipe	C71	1+596	2+368	1043	1042	772	0.10	0.16	0.2	6.0	600	400,498	92,677		
	Ditch	C72	2+368	3+284	1042	1041	916	0.10	0.21	0.2	6.0	600	474,676	109,936		

Pond release rate (L/s/ha) = 0.8

Mannings n 0.04
Flow depth 1 m
Side slopes 4

lift station $ 600,000

hectare of land $ 200,000

Additional width for easement 6 m

easment width for pipe 6 m

TOTALS

Drainage Course	Notes	Type	Name	From Station	To Station	Elevation U/s (m)	Elevation d/s (m)	Elevation drop (m)	Length (m)	Slope (%)	Local Basin Area (ha)	U/s Regional Basin Area (ha)	Basin catch area	Design Q (m3/s)	Ditch Flow Depth	Pipe Flow Area (m2)	Pipe Hydraulic Radius	Pipe Flow Capacity (m3/s)	Average depth to EG (m)	Base Width (m)	Easement Top Width (m)	Excavation Volume (m3)	Culvert Sizing (mm)	#	Channel Cost ($)	Pipe Cost or Lift Station Cost ($)	ROW Land Acquisition Cost ($)	Pipe Cost or Lift Station Cost ($)	ROW Land Acquisition Cost ($)
1_0	add 1_1 and 2_0	Ditch	C19_1	0+000	0+392	1055.3	1054.8	0.435	392	0.11	64.75	1618.75	1683.5	1.35		1.130	0.300	1.534			6		1200	1	0	$ 696,162	$ 47,040		
		Ditch	C19_2	0+392	0+788	1054.8	1054.4	0.387	396	0.10	0	1683.5	1683.5	1.35		1.130	0.300	1.440			6		1200	1	0	$ 703,002	$ 47,520		
	add 1_6	Culvert	C20	0+788	0+831	1054.4	1054.1	0.361	43	0.84	64.75	1748.25	1813	1.45		1.130	0.300	4.229			6		1200	1	0	$ 81,809	$ 5,136		
		Culvert	C21	0+831	0+873	1054.1	1053.7	0.42	42	0.99	64.75	1813	1877.75	1.50		1.130	0.300	4.580			6		1200	1	0	$ 81,241	$ 5,097		
		Ditch	C22	0+873	1+943	1053.7	1052.1	1.601	1070	0.15	64.75	1877.75	1942.5	1.55		1.130	0.300	1.781			6		1200	1	0	$ 1,898,612	$ 128,400		
		Ditch	C23_1	1+943	2+037	1052.1	1051.9	0.153	93	0.16	64.75	1942.5	2007.25	1.61		1.130	0.300	1.864			6		1200	1	0	$ 168,239	$ 11,202		
	add 1_7	Ditch	C23_2	2+037	3+015	1051.9	1050.5	1.4	979	0.14	64.75	2072	2136.75	1.71		1.130	0.300	1.742			6		1200	1	0	$ 1,733,880	$ 117,444		
		Culvert	C24	3+015	3+055	1050.5	1050.4	0.1	40	0.25	64.75	2136.75	2201.5	1.76		1.130	0.300	2.299			6		1200	1	0	$ 77,207	$ 4,814		
	add 1_8	Ditch	C25	3+055	3+543	1050.4	1048.7	1.701	487	0.35	0	2331	2331	1.86		1.130	0.300	2.720			6		1200	1	0	$ 868,062	$ 58,499		
		Ditch	C26	3+543	4+384	1048.7	1044.0	4.749	842	0.56	64.75	2331	2395.75	1.92		1.130	0.300	3.460			6		1200	1	0	$ 1,490,671	$ 100,982		
	add 1_9 and 3_0	Pipe	C27	4+384	4+751	1044.0	1043.2	0.75	367	0.20	64.75	3934	3998.75	3.20		1.766	0.375	3.775			6		1500	1	0	$ 967,931	$ 44,040		
		Ditch	C28	4+751	5+372	1043.2	1040.9	2.283	621	0.37	0	3998.75	3998.75	3.20		2.137	0.413	6.529			6		1650	1	0	$ 1,932,219	$ 74,498		
	add 4_0 and 5_0, to CSMI	Culvert	C29	5+372	5+468	1040.9	1040.8	0.117	96	0.12	64.75	5050.5	5115.25	4.09		2.543	0.450	4.740			6		1800	1	0	$ 350,662	$ 11,520		
	CSMI Connection Invert						1040.8																					$11,050,000	$657,000
1_1	add 1_2 and 1_3	Culvert	C12	0+000	0+103	1063.8	1063.0	0.754	103	0.73	64.75	453.25	518	0.41		0.442	0.188	1.124			6		750	1	0	$ 78,610	$ 12,375		
		Ditch	C13	0+103	0+428	1063.0	1059.6	3.391	325	1.04	64.75	518	582.75	0.47		0.442	0.188	1.344			6		750	1	0	$ 246,447	$ 38,944		
		Culvert	C14	0+428	0+442	1059.6	1059.5	0.157	15	1.06	0	582.75	582.75	0.47		0.442	0.188	1.355			6		750	1	0	$ 16,780	$ 1,775		
		Ditch	C15_1	0+442	0+896	1059.5	1059.0	0.455	454	0.10	0	582.75	582.75	0.47		0.636	0.225	0.677			6		900	1	0	$ 437,322	$ 54,460		
		Ditch	C15_3	0+896	1+075	1059.0	1058.8	0.179	179	0.10	0	582.75	582.75	0.47		0.636	0.225	0.677			6		900	1	0	$ 174,790	$ 21,426		
	add 1_4	Ditch	C15_4	1+075	1+243	1058.8	1058.7	0.168	168	0.10	0	712.25	712.25	0.57		0.636	0.225	0.676			6		900	1	0	$ 165,421	$ 20,186		
		Culvert	C16	1+243	1+265	1058.7	1058.6	0.088	21	0.41	64.75	712.25	777	0.62		0.636	0.225	1.368			6		900	1	0	$ 25,923	$ 2,580		
		Ditch	C17	1+265	2+280	1058.6	1056.0	2.562	1015	0.25	0	777	777	0.62		0.636	0.225	1.074			6		900	1	0	$ 965,573	$ 121,800		
	add 1_5, to 1_0	Ditch	C18	2+280	2+658	1056.0	1055.3	0.743	378	0.20	64.75	841.75	906.5	0.73		0.636	0.225	0.948			6		900	1	0	$ 362,118	$ 45,360	$2,473,000	$319,000
1_2		Ditch	C1_1	0+000	0+423	1084.8	1084.4	0.45	423	0.11	64.75	0	64.75	0.05		0.096	0.088	0.056			6		350	1		$ 128,321	$ 50,779		
		Ditch	C1_2	0+423	0+841	1084.4	1078.7	5.702	417	1.37	0	64.75	64.75	0.05		0.096	0.088	0.201			6		350	1	0	$ 126,719	$ 50,090		
		Ditch	C2	0+841	1+107	1078.7	1075.5	3.178	266	1.19	64.75	64.75	129.5	0.10		0.096	0.088	0.188			6		350	1	0	$ 81,156	$ 31,964		
		Culvert	C3	1+107	1+154	1075.5	1075.5	0.057	47	0.12	0	129.5	129.5	0.10		0.159	0.113	0.117			6		450	1	0	$ 18,031	$ 5,638		
		Ditch	C4	1+154	1+636	1075.5	1074.3	1.138	482	0.24	0	129.5	129.5	0.10		0.159	0.113	0.164			6		450	1	0	$ 163,650	$ 57,866		
		Culvert	C5	1+636	1+741	1074.3	1074.2	0.121	105	0.11	64.75	129.5	194.25	0.16		0.283	0.150	0.246			6		600	1	0	$ 55,204	$ 12,630		
		Ditch	C6_1	1+741	2+178	1074.2	1073.7	0.514	437	0.12	0	194.25	194.25	0.16		0.283	0.150	0.249			6		600	1	0	$ 225,173	$ 52,418		
		Ditch	C6_2	2+178	2+638	1073.7	1069.4	4.247	460	0.92	0	194.25	194.25	0.16		0.283	0.150	0.697			6		600	1	0	$ 239,988	$ 55,197		
		Culvert	C7	2+638	2+670	1069.4	1069.2	0.23	32	0.73	64.75	194.25	259	0.21		0.283	0.150	0.619			6		600	1	0	$ 18,960	$ 3,790		
		Ditch	C8_1	2+670	3+105	1069.2	1067.2	2.059	435	0.47	0	259	259	0.21		0.283	0.150	0.499			6		600	1	0	$ 224,275	$ 52,199		
		Ditch	C8_2	3+105	3+458	1067.2	1065.5	1.67	353	0.47	0	259	259	0.21		0.283	0.150	0.499			6		600	1	0	$ 183,962	$ 42,366		
		Culvert	C9	3+458	3+510	1065.5	1065.4	0.078	52	0.15	64.75	259	323.75	0.26		0.283	0.150	0.280			6		600	1	0	$ 29,168	$ 6,280		
		Ditch	C10	3+510	4+379	1065.4	1064.2	1.186	869	0.14	0	323.75	323.75	0.26		0.283	0.150	0.268			6		600	1	0	$ 448,155	$ 104,301		
	to 1_1	Culvert	C11	4+379	4+419	1064.2	1063.8	0.463	40	1.17	64.75	323.75	388.5	0.31		0.283	0.150	0.785			6		600	1	0	$ 22,866	$ 4,743	$1,966,000	$531,000
1_3		Culvert	C6	0+000	0+046	1064.5	1064.4	0.122	46	0.26	64.75	0	64.75	0.05		0.071	0.075	0.059			6		300	1	0	$ 14,258	$ 5,534		
	to 1_1	Ditch	C19	0+046	0+860	1064.4	1063.8	0.624	814	0.08	0	64.75	64.75	0.05		0.159	0.113	0.093			6		450	1	0	$ 273,789	$ 97,724	$289,000	$104,000
1_4		Ditch	C31_1	0+000	0+679	1059.7	1059.0	0.714	679	0.11	64.75	0	64.75	0.05		0.159	0.113	0.109			6		450	1	0	$ 228,269	$ 81,480		
		Culvert	C31_3	0+679	0+789	1059.0	1058.9	0.113	110	0.10	64.75	64.75	129.5	0.10		0.159	0.113	0.108			6		450	1	0	$ 37,706	$ 13,229		
	to 1_1	Ditch	C31_4	0+789	0+843	1058.9	1058.8	0.055	54	0.10	0	129.5	129.5	0.10		0.159	0.113	0.108			6		450	1	0	$ 20,177	$ 6,466	$287,000	$102,000
1_5		Culvert	C31	0+000	0+154	1057.4	1056.9	0.534	154	0.35	64.75	0	64.75	0.05		0.159	0.113	0.198			6		450	1	0	$ 54,734	$ 18,480		
	to 1_1	Ditch	C32	0+154	0+523	1056.9	1056.0	0.856	369	0.23	0	64.75	64.75	0.05		0.159	0.113	0.162			6		450	1	0	$ 125,019	$ 44,280	$180,000	$63,000
1_6	to 1_0	Forcemain	C33	0+000	1+368	1053.0	1054.4	-1.435	1368	-0.10	64.75	0	64.75	0.05		0.0	0.0				6		300	1	0	$ 995,352	$ 164,160	$996,000	$165,000
1_7	to 1_0	Ditch	C23	0+000	0+313	1054.6	1051.9	2.64	313	0.84	64.75	0	64.75	0.05		0.159	0.113	0.309			6		450	1	0	$ 107,475	$ 37,510	$108,000	$38,000
1_8	to 1_0	Culvert	C59	0+000	0+755	1051.8	1050.7	1.144	755	0.15	129.5	0	129.5	0.10		0.283	0.150	0.282			6		600	1	0	$ 391,980	$ 90,600	$392,000	$91,000
1_9		Ditch	C40	0+000	0+793	1055.7	1052.1	3.598	793	0.45	64.75	0	64.75	0.05		0.159	0.113	0.227			6		450	1	0	$ 267,103	$ 95,145		
		Culvert	C41	0+793	0+841	1052.1	1052.0	0.109	48	0.23	64.75	64.75	129.5	0.10		0.159	0.113	0.161			6		450	1	0	$ 18,302	$ 5,742		
	to 1_0	Ditch	C42	0+841	2+402	1052.0	1044.6	7.36	1561	0.47	0	129.5	129.5	0.10		0.159	0.113	0.231			6		450	1	0	$ 523,049	$ 187,304	$809,000	$289,000
2_0	add 2_1, 2_2	Ditch	C35	0+000	0+263	1062.6	1061.0	1.564	263	0.60	129.5	453.25	582.75	0.47		0.283	0.150	0.560			6		600	1	0	$ 136,008	$ 31,504		
		Ditch	C36	0+263	0+904	1062.6	1060.3	2.229	642	0.35	64.75	582.75	647.5	0.52		0.442	0.188	0.775			6		750	1	0	$ 481,344	$ 77,010		
		Ditch	C37_1	0+904	1+840	1060.3	1057.4	2.927	936	0.31	64.75	647.5	712.25	0.57		0.442	0.188	0.735			6		750	1	0	$ 700,168	$ 112,320		
		Culvert	C37_2	1+840	1+885	1057.4	1057.3	0.142	45	0.32	0	712.25	712.25	0.57		0.442	0.188	0.739			6		750	1	0	$ 37,924	$ 5,400		
	to 1_0	Ditch	C37_3	1+885	2+371	1057.3	1055.8	1.522	486	0.31	0	712.25	712.25	0.57		0.442	0.188	0.736			6		750	1	0	$ 365,896	$ 58,320		
																												$1,722,000	$285,000
2_1		Ditch	C44	0+000	0+941	1077.3	1075.0	2.314	941	0.25	64.75	0	64.75	0.05		0.071	0.075	0.057			6		300	1	0	$ 245,025	$ 112,894		
		Ditch	C47	0+941	1+674	1075.0	1069.9	5.038	733	0.69	64.75	64.75	129.5	0.10		0.159	0.113	0.279			6		450	1	0	$ 245,044	$ 87,953		
		Culvert	C56	1+674	1+725	1069.9	1068.8	1.136	52	2.20	64.75	129.5	194.25	0.16		0.159	0.113	0.500			6		450	1	0	$ 19,472	$ 6,194		
		Ditch	C38	1+725	2+556	1068.8	1065.8	3.044	831	0.37	0	194.25	194.25	0.16		0.159	0.113	0.204			6		450	1	0	$ 278,838	$ 99,673		
	to 2_0	Culvert	C39	2+556	3+312	1065.8	1062.6	3.181	756	0.42	64.75	194.25	259	0.21		0.283	0.150	0.470			6		600	1	0	$ 392,472	$ 90,720	$1,181,000	$398,000
2_2		Ditch	C58_1	0+000	0+379	1072.8	1068.3	4.567	379	1.21	64.75	0	64.75	0.05		0.071	0.075	0.125			6		300	1	0	$ 99,257	$ 45,445		
		Ditch	C58_2	0+379	0+789	1068.3	1067.6	0.707	410	0.17	64.75	64.75	129.5	0.10		0.159	0.113	0.140			6		450	1	0	$ 137,887	$ 49,245		
		Ditch	C34_1	0+789	1+211	1067.6	1063.7	3.906	422	0.93	64.75	129.5	194.25	0.16		0.159	0.113	0.324			6		450	1	0	$ 141,430	$ 50,612		
	to 2_0	Ditch	C34_2	1+211	1+626	1063.7	1062.6	1.092	415	0.26	0	194.25	194.25	0.16		0.159	0.113	0.173			6		450	1	0	$ 139,399	$ 49,828	$518,000	$196,000
3_0	add 3_1, 3_2, 3_3	Ditch	C48	0+000	0+975	1056.3	1052.1	4.257	975	0.44	129.5	1165.5	1295	1.04	0.5	0.636	0.225	1.413	0	1	6		900	1	0	$ 929,483	$ 117,025		
		ex. Pipe	C50	0+975	1+304	1052.1	1051.0	1.09	329	0.30	0	1295	1295	1.04	0.6	2.0	5.9	1.4	0	1	13		900	1	0		$ 85,529		
		Ditch	C51	1+304	1+731	1051.0	1049.0	1.954	427	0.46	0	1295	1295	1.04		0.636	0.225	1.447			6		900	1	0	$ 406,359	$ 51,213		
		Culvert	C52	1+731	1+770	1049.0	1048.8	0.214	39	0.55	49	1295	1344	1.08		0.636	0.225	1.590			6		900	1	0	$ 41,514	$ 4,643		
		Ditch	C53	1+770	2+687	1048.8	1046.8	2.042	917	0.22	0	1344	1344	1.08		0.865	0.263	1.522			6		1050	1	0	$ 1,258,940	$ 110,028		
		Culvert	C54	2+687	2+734	1046.8	1046.7	0.093	47	0.20	64.75	1344	1408.75	1.13		0.865	0.263	1.429			6		1050	1	0	$ 69,133	$ 5,684		
	to 1_0	Ditch	C55	2+734	3+248	1046.7	1044.0	2.735	514	0.53	0	1408.75	1408.75	1.13		0.865	0.263	2.353			6		1050	1	0	$ 706,383	$ 61,694		
																												$3,412,000	$436,000
3_1	add Omni	Culvert	C46	0+000	0+031	1065.9	1065.6	0.296	31	0.96	64.75	777	841.75	0.67		0.283	0.150	0.711			6		600	1	0	$ 18,593	$ 3,701		
		Ditch	C47_1	0+031	0+795	1065.6	1060.1	5.502	764	0.72	64.75	841.75	906.5	0.73		0.442	0.188	1.116			6		750	1	0	$ 573,344	$ 91,680		
	to 3_0	Ditch	C47_2	0+795	1+359	1060.1	1056.3	3.785	564	0.67	64.75	906.5	971.25	0.78		0.442	0.188	1.077			6		750	1	0	$ 420,496	$ 67,680	$1,013,000	$164,000
3_2		Ditch	C43	0+000	0+825	1070.8	1067.4	3.39	825	0.41	64.75	0	64.75	0.05		0.071	0.075	0.073			6		300	1	0	$ 214,348	$ 98,976		
	to 3_0	Ditch	C45	0+825	1+662	1067.4	1056.3	11.083	837	1.32	64.75	64.75	129.5	0.10		0.159	0.113	0.387			6		450	1	0	$ 280,866	$ 100,455	$496,000	$200,000
3_3	to 3_0	ex. Ditch	C57	0+000	1+296	1060.5	1058.7	1.84	1296	0.14	64.75	0	64.75	0.05	0.5	1.5	5.1	0.6	0	1	13				0		$ 336,897		$337,000
4_0	add 4_1, 4_2	Culvert	C60	0+000	0+039	1047.5	1047.3	0.2	39	0.51	46.5	616.75	663.25	0.53		0.442	0.188	0.942			6		750	1	0	$ 33,724	$ 4,680		
		Ditch	C61	0+039	0+850	1047.3	1043.3	4	811	0.49	0	663.25	663.25	0.53		0.442	0.188	0.924			6		750	1	0	$ 606,244	$ 97,320		
		Ditch	C62	0+850	1+623	1043.3	1042.1	1.213	773	0.16	64.75	663.25	728	0.58		0.636	0.225	0.847			6		900	1	0	$ 739,655	$ 92,760		
	to 1_0	Culvert	C63	1+623	1+664	1042.1	1042.0	0.109	41	0.26	64.75	728	792.75	0.63		0.636	0.225	1.096			6		900	1	0	$ 44,063	$ 4,980		
																					6							$1,424,000	$200,000
		Ditch	C58	0+000	0+859	1053.4	1052.0	1.397	859	0.16	64.75	0	64.75	0.05		0.159	0.113	0.136			6		450	1	0	$ 287,669	$ 103,080		

4_1	add CN site	Pipe	C78	0+859	1+612	1052.0	1048.0	4	753	0.53	357.75	64.75	422.5	0.34		0.283	0.150	0.529			6	600	1	0	$ 390,996	$ 90,360		
	to 4_0	Ditch	C79	1+612	2+395	1048.0	1047.5	0.5	783	0.06	0	422.5	422.5	0.34		0.636	0.225	0.540			6	900	2	0	$ 1,458,906	$ 93,960	$2,138,000	$288,000
4_2		Forcemain	C64	0+000	0+736	1040.7	1044.7	-3.969	736	-0.54	64.75	0	64.75	0.05		0.0	1.0		1.5	1	6	250	1	0	$ 776,675	$ 88,338		
		Ditch	C65	0+736	1+574	1044.7	1043.0	1.642	838	0.20	0	64.75	64.75	0.05		0.442	0.188	0.582			6	750	1	0	$ 624,962	$ 100,529		
		Ditch	C66	1+574	2+328	1043.0	1040.1	2.917	754	0.39	64.75	64.75	129.5	0.10		0.442	0.188	0.818			6	750	1	0	$ 566,540	$ 90,514		
	to 4_0	Forcemain	C67	2+328	3+148	1040.1	1047.5	-7.39	820	-0.90	64.75	129.5	194.25	0.16		0.0	1.0		1.5	1	6	450	1	0	$ 1,608,360	$ 98,400	$3,577,000	$378,000
5		Pipe	C8	0+000	0+758	1045.0	1043.6	1.4	758	0.18	64.75	0	64.75	0.05		0.159	0.113	0.145			6	450	1	0	$ 256,258	$ 90,960		
		Pipe	C70	0+758	1+596	1043.6	1042.6	0.995	838	0.12	129.5	64.75	194.25	0.16		0.283	0.150	0.250			6	600	1	0	$ 432,792	$ 100,554		
		Pipe	C71	1+596	2+368	1042.6	1041.8	0.772	772	0.10	0	194.25	194.25	0.16		0.283	0.150	0.229			6	600	1	0	$ 400,498	$ 92,677		
	to 1_0	Ditch	C72	2+368	3+284	1041.8	1040.9	0.916	916	0.10	64.75	194.25	259	0.21		0.283	0.150	0.229			6	600	1	0	$ 474,676	$ 109,936		
																											$1,565,000	$395,000
																										Subtotal	$ 35,596,000	$ 5,636,000
																										Design (15%)	$ 5,339,000	
																										Contingency (Land 10%, Infrastructure 25%)	$ 8,899,000	$ 564,000
																										Total	$ 49,834,000	$ 6,200,000
																											Grand Total	$ 56,034,000