Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

SMITH STORM BASIN STUDY
CITY OF GRANDE PRAIRIE

Report Prepared for:
CITY OF GRANDE PRAIRIE

Prepared by:
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November 2016
Grande Prairie, Alberta

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Report prepared for City of Grande Prairie, November 2016

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APEGA Permit to Practice
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DISCLAIMER

We certify that this report is accurate and complete and accords with the information available during the site investigation. Information obtained during the site investigation or provided by third parties is believed to be accurate but is not guaranteed. We have exercised reasonable skill, care, and diligence in assessing the information obtained during the preparation of this report.

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GLOSSARY	
Best Management Practice	The use of a management practice or facility application that provides an effective approach in the protection of the environment or receiving system from detrimental impacts. Typically one of a set of measures that demonstrates the most effective mitigation of impacts.
CAD	Computer Aided Design - the use of computer technology for design and design documentation.
Calibrate	To determine the accuracy of a model. This is typically done by adjusting the model inputs to achieve the expected model output for a given application.
Capacity	The maximum flow of water that can be conveyed by a sewer without causing surcharge. When a sewer is at capacity the hydraulic grade line will be equal to the top of the pipe.
Catch basin	An inlet on a street, parking area or depression area that intercepts stormwater and conveys it to the sewer system.
DEM	See Digital Elevation Model.
Depression area	A low-lying area in which stormwater can pond. If the depression area is on a road it is also known as a road sag.
Design Storm	A rainfall event with a specific probability of occurring within any given year (e.g. the 10 year design storm has a 1 in 10 chance of occurring within any given year), where the rainfall is assumed to occur in a specified distribution.
Digital Elevation Model (DEM)	A digital 3D representation of a terrain's surface created from terrain elevation data.
Drainage catchment	An area of land in which water flowing across the surface will drain through a specified point.
Dual Drainage	Consisting of both a minor storm drainage system and a major storm drainage system.
Foundation drain	A pipe installed to convey groundwater away from the foundation of a building.
Freeboard	The vertical distance between the maximum water elevation and a point of interest (typically ground elevation).
GIS	Geographic Information System - a system designed to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data.
Grading	The work of ensuring a level base, or one with a specified slope
Hydraulics	The science of the laws governing water or other liquids in motion
Hydraulic grade line (HGL)	The level of water flowing in an open channel. In a closed conduit (such as a sewer) flowing under pressure, the HGL is the level to which water would rise in a vertical tube inserted at any given point along the pipe.
Hydrology	The science of the occurrence, circulation, distribution, and properties of the waters of the earth and its atmosphere.
Major system	The system of overland drainage paths (e.g. streets, ditches, open channels) that convey flows in excess of the sewer system capacity. Also known as the overland drainage system.
Minor system	The components of the storm drainage system designed to carry runoff from more frequent storm events. These components typically include gutters, ditches, inlets and sewers.
Private drain connection	A pipe installed to convey flow from a building or parking area to the sewer system. The pipe may convey foundation drainage and flow from roof leaders or catch basins
Roof leader	A pipe installed to drain stormwater from the roof of a building. Also known as a downspout.
Sanitary sewer	A sewer that was designed to convey only sanitary sewage.
Stormwater	Water that accumulates on land as a result of storm (rainfall or snow) events. This includes runoff from roads, lawns, parking areas and roofs.

Stormwater management pond	A land depression created for the detention or retention for stormwater runoff for the purposes of controlling stormwater flows or for provision of water quality control.
Storm sewer	A sewer that was designed to convey only stormwater.
Surcharge	The condition in which the HGL in a sewer rises above the top of the pipe.
Topography	The surface shape, elevations and features of the land.
Trunk sewer	A large sewer that intercepts flow from a number of smaller sewers.

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1 INTRODUCTION

The City of Grande Prairie engaged Matrix Solutions Inc. to complete a hydrologic and hydraulic study of the stormwater management (SWM) system within the Smith Storm Basin and to make recommendations for addressing existing deficiencies. This report for the Smith Storm Basin Study provides a summary of the methods and the results of the project completed with recommendations for improvements to the existing stormwater system.

The study has included a review of the existing drainage system model (developed using XPSWMM software) including an upgrade of this model to include the major system component (i.e., create a dual drainage model). This model served as the main tool for analyzing the hydrologic and hydraulic responses of the Smith Basin stormwater system. This model was then used to assess the drainage conditions at specific areas of interest and to develop remedial measures to address concerns or potential system updates.

1.1 Study Area

The Smith Storm Basin Study area is depicted on Figure 1. This basin is a subcatchment of the Woody Channel drainage area. It comprises approximately 110 ha and is located in the heart of the City of Grande Prairie, encompassing portions of the Central Business District, Railtown, Smith, Hillside, and Highland Park. A wide variety of land uses are present in the basin, ranging from residential to industrial/commercial with open space consisting of school yard recreational spaces (soccer fields) and lands designated for future development. At this time much of the basin has been developed with the exception of some industrial areas in the southeast portion of the basin.

The basin generally drains from northwest to southeast and outlets to Woody Channel via outfalls at 88 Avenue at Resources Road, 92 Street, 90 Street, and Willow Drive. Woody Channel ultimately drains to Bear Creek outside of the City limits. Many of the streets within the Study Area have urban cross-section (i.e., curb and gutter) but some have retained a rural cross-section (i.e., ditches).

1.2 Study Objectives

In accordance with the Terms of Reference for this project and other correspondence with the City, the objective for this study are to complete the hydrologic and hydraulic analyses and prepare the deliverables associated with the following activities:

- reviewing and updating the drainage system model
  - determining the boundaries of Smith Storm Basin
  - reviewing the current system in its current condition
  - reviewing and update the hydrologic and hydraulic models based on the system review

- identifying issues and constraints
  - identifying locations of surcharge within the minor drainage system
  - determining the existence or extent of any ponding or flooding and assessing the impacts to private and public property
  - identifying and commenting on any systematic or site-specific constraints

- providing recommendations
  - recommending strategies to reduce the risk of flooding and surcharging, and to remedy other identified issues

- providing a preliminary design for extension of storm sewer along 92 Avenue, heading west and then north along Park Road until 9602 Park Road
- providing a preliminary design and costs
  - preparing preliminary designs for recommended measures
  - preparing preliminary cost estimates based on preliminary designs

1.3 Areas of Interest

Within the overall Study Area there are four areas of interest identified by the City around which the efforts of this study have been focused. The areas of interest are shown on Figure 1 and detailed below.

1.3.1 Storm Sewer Along Park Road and 92 Avenue

This area of interest consists of Park Road, from 96 Street to 92 Avenue, and 92 Avenue, from Park Road to 92 Street. The City has requested that the current study include a preliminary design for the drainage system associated with the pending upgrade from rural to urban cross-section in this area. There is also an existing surface drainage issue on 92 Avenue. Under existing conditions, this area is serviced by roadside ditches, which ultimately drain southerly to Woody Channel.

1.3.2 Railtown Drainage Ditch

Railtown is located on the east side of Resources Road and south of 92 Avenue. This development consists of small- to medium-sized commercial lots (zoned Commercial Arterial). Adjacent to the Canadian National Railway (CNR) corridor there is an existing drainage ditch, with associated municipal property and easement. The City has requested a review of the easement to ensure that the conveyance capacity of the ditch is compatible with the 1:100-year event in order to maximize the development potential along the length of the easement. The current study includes a review of the hydraulic capacity existing drainage ditch, as well as a review of future conditions drainage requirements and associated recommendations.

1.3.3 101 Avenue Development Potential

There is a property on the east side of the CNR corridor situated between 100 Avenue and Hillcrest Drive and is designated as having high potential for development. The potential development area is 1.3 ha. The current study includes an analysis of the available capacity in the drainage system downstream of this site. From this analysis, recommendations were made regarding the permissible peak outflows from this property under future conditions.

1.3.4 98 Avenue Ponding

The City has identified that there is a nuisance ponding issue at the dead end of 98 Avenue and east of 95 Street. The ponding at this location causes access and egress difficulty for the adjacent townhouse development. This study includes an assessment of flooding mechanisms and remedial measures for this area of interest.

2 BACKGROUND INFORMATION REVIEW

2.1 Design Standards

2.1.1 Historical Design Standards

"Prior to 1995, the City of Grande Prairie did not have a formal design criteria for storm drainage systems for use within the City limits. The design of storm drainage systems was based on historical versions of Alberta Environment guidelines, and generally-accepted practices. In 1995, the City of Grande Prairie adopted formal storm drainage design criteria as Section 23 of their *Standard Guidelines for Design and Development of Municipal Improvements*" (Associated Engineering 2004).

The majority of the infrastructure within the Smith Basin drainage system was constructed before 1995 (circa 1960 to 1980). The City has indicated that the minor drainage system within the Study Area was designed to convey peak flow generated during a 2-year design rainfall event.

2.1.2 City of Grande Prairie Design Manual

The City of Grande Prairie (2016) *Design Manual* indicates the following criteria for design of new stormwater drainage infrastructure:

- The minor system is to be designed using the 5-year design storm.
- The major system and detention facilities are to be designed using the 100-year design storm.
- The design storm for the minor system is to be calculated based on the 4-hour Chicago distribution.

- The depth of water for all roads should be less than the following:

    - local / collector roads: 350 mm
    - arterial roadways: 150 mm

2.2 Previous Studies

2.2.1 Woody Creek Study

The *Design Report, Woody Creek Study, Resources Road to 68th Avenue* (BLK 2006) report was used as a key background study for the current project. It provides a detailed evaluation of Woody Creek from Resources Road to 68 Avenue. It includes an assessment of the existing storm drainage system, a drainage strategy to improve existing conditions, an assessment of impacts from future development within the basin, and a drainage strategy for a fully developed basin.

The following numerical results provided in the Woody Creek Study report were used in the hydraulic assessment of the current study.

TABLE A Woody Creek Water Levels

Location	5-year Water Level (m)	100-year Water Level (m)
Resources Road Outfall	652.3	652.8
CNR Culvert Inlet	652.2	652.7
92 Street Culvert Inlet	652.0	652.4

The Woody Creek (referred to as Woody Channel in subsequent sections in this report) Study identified issues with the channel invert that result in sections of the channel being reverse-graded and preventing adequate slope for effective flow. This poorly graded section of Woody Creek causes backup into the storm sewer system and possible deposition issues. The study report provides recommendations for remediating the grading and slope issues within Woody Creek.

2.2.2 Storm Drainage Master Plan

In response to significant growth, the City undertook an update to its *Grande Prairie Storm Drainage Master Plan* (Focus 2013). The key components of the study were as follows:

- updating the existing XPSWMM storm drainage models of the City
- analyzing the existing stormwater drainage system
- reviewing the storm drainage system design standards
- reviewing existing rainfall and flow data
- reviewing operation and maintenance practices

- developing a SWM concept plan for future development areas

The report indicated that the majority of the revisions recommended in the 2004 *Storm Drainage Master Plan* (Associated Engineering 2004) had already been implemented. The assessment of the existing drainage system indicated that approximately a third of the existing storm sewer system is overloaded, with a utilization rate greater than 120% of the pipe capacity, during the 5-year design storm.

A review of this report indicated that the developed XP-SWMM model represented the minor systems only in combination with above ground storage to capture any surcharged volume of water out of the minor sewer systems. No major drainage system component was incorporated into the model to reflect the overland drainage routes.

2.3 Data Provided by City

A detailed understanding of the existing drainage system within the Study Area was required to complete the hydraulic analyses. Therefore, the City provided land use mapping, a Digital Elevation Model (DEM) developed from bare ground Light Detection and Ranging (LiDAR), and access to their MapViewer, an online GIS-based mapping tool including data for the City's existing shallow utility infrastructure.

The City provided the existing hydrologic and hydraulic models for the Smith Basin area. The City maintains hydrologic and hydraulic models of the existing drainage system using the XPSWMM software package. These models were originally developed as part of the 1995 *Storm Drainage Master Plan* (Associated Engineering 2004) and were revised and updated as part of the subsequent Master Drainage Plans in 2004 and 2013. In 2004 the models were calibrated and analysis was completed for the 100-year event in addition to the 5-year event. In 2013 the models were updated to reflect recent development and system upgrades.

2.4 Site Reconnaissance

Project team staff from Matrix visited Smith Basin to supplement the data provided by the City. Site visits were completed on August 11 and September 17, 2015; and January 20, February 1, March 8, and April 6, 2016. The aim of the earlier field days was to enhance the an overall understanding of the drainage system within the Study Area, with specific focus on the major drainage system to completed the dual drainage modelling (Section 3.1). The latter field days were focused on the specific areas of interest as noted by the City, and to confirm details as various locations where the completed models were presenting anomalies. Topographic survey was completed as necessary to reconcile these anomalies. A compendium of photographs from site visits is provided in Appendix A. During all site visits, Matrix personnel were required to comply with legislated, Matrix, and City of Grande Prairie health and safety standards.

Some items of note from the site visits include the following:

- There is a beaver pond in Woody Channel on the upstream side of the 92 Street culvert. This pond is creating a backwater pool to at least the CNR crossing upstream. This could be causing impacts to the drainage system within the Study Area.

- There is a significant amount of sediment buildup in roadside ditches throughout the Study Area. Much of this seems to have originated from construction works without sediment and erosion control measures. Some culverts under entrances and driveways are either damaged or filled with sediment and debris.

- Minor surface ponding is present in a number of areas. This is primarily due to maintenance issues.

3 HYDROLOGIC AND HYDRAULIC MODELLING

3.1 Minor and Major Drainage System Modelling

The City's hydrologic and hydraulic model is divided into segments to ensure model run times and file sizes are manageable. The current Study Area comprises portions of models 7 and 22. As such, both of these models were reviewed, revised and utilized in the assessment of the Smith Basin drainage system.

3.1.1 Review of Existing Model

The existing drainage system models provided by the City indicated a number of ponding locations and surcharged nodes during the 5-year event. These conditions are significantly and understandably exacerbated in the 100-year model output. However, the City indicated that the drainage system within the Smith Basin was designed for a 2-year event as it was primarily constructed before 1995. As a result, surcharging of the minor system during a 5-year event is expected.

The existing XPSWMM model provided by the City included only the minor drainage system. As the drainage system within the Study Area was designed for only the 2-year event, it was determined that a dual drainage model would be required to effectively assess the abilities of this system to convey the 5-year event. In discussion with the City, Matrix determined that this model upgrade would be included as part of the current study.

A number of quality control reviews were completed to ensure that the models have maintained their integrity over the two decades since their original development. As part of this review, a select number of drainage catchments were delineated from the latest DEM data provided by the City. These drainage catchments were compared to those in the existing model. Significant discrepancies were found. The steps taken to remedy this model deficiency are provided in the section below.

3.1.2 Methods

The revised XPSWMM files are provided in Appendix B.

3.1.2.1 Drainage Catchment Delineation

Based on the completed quality control reviews, Matrix determined that the drainage catchments within the hydrology component of the drainage system models needed to be revised. The drainage catchments were generated from DEM, provided by the City. The delineated catchments are shown on Figure 2. The "Generate Watershed" tool in Global Mapper uses the eight-direction pour point algorithm (D-8) to calculate the flow direction at each location, along with a bottom-up approach for determining flow direction through flat areas and a custom algorithm for automatically filling depressions in the terrain data. Using this tool, drainage catchments were delineated to each catch basin (based on City-provided shapefile) within the Study Area and upstream contributing areas.

Following the delineation of the drainage catchments, they were thoroughly reviewed using GIS- and CAD-based techniques and then imported into the hydrologic model, overwriting the corresponding catchment areas in the existing model.

3.1.2.2 Elevation Data Review

A quality assurance process was completed on pipe invert and ground surface elevations where the review process brought specifics into question. Primarily this consisted of field checks to confirm the existence of high and low points within the major drainage system. Additionally, a comparison with the modelled minor drainage system to the City's GIS data was completed. This comparison resulted in the addition of a pipe (on 92 Avenue and east of 92 Street) that was missing in the existing model.

3.1.2.3 Dual Drainage Modelling

To accurately reflect the flow patterns during a rainfall event and due to the limited capacity of the existing minor drainage system, it was determined that a dual drainage modelling of the drainage system would be beneficial for this Study Area. As such, model upgrades to incorporate the dual drainage component were included as part of this project.

Dual drainage models incorporate both the major and minor drainage system components into a single hydraulic model. When used properly, this analysis method provides insight into the interaction between, and utilization of, the different components (underground storm sewer and above ground surface drainage) of the drainage system.

Information about the major drainage system was acquired primarily through site visits. In urban settings, such as this, overland flow is conveyed on the roads, and sometimes in public utility lots. A typical roadway cross-section was developed and utilized for the overland conveyance links. For the purposes of modelling, it was assumed that the overland flow paths follow the alignment of the minor

system (i.e., the sewers are under the roads) and that there is a constant slope between the lid elevations of the modelled manholes. These are typical assumptions used in modelling at a basin scale.

The other main input requirement for dual drainage modelling is the interflow relationship between the major and minor drainage systems. This relationship represents the function of the inlets (catch basins). For this study, the inlet capacity at each identified catch basin was set equal to the 2-year design inflow as the City had informed Matrix that was the design capacity of the minor system in this area. Any excess flows were routed through the surface drainage systems (road surfaces).

3.2 HEC-RAS Modelling for Railtown Drainage Ditch

Overland drainage from the Railtown area is conveyed through a ditch located in an easement immediately west of the CNR corridor. The total length of the ditch is approximately 900 m starting approximately at 92 Avenue and extending south until the confluence with Woody Channel. The existing slope of the channel is 0.4% on average with the downstream section being slightly steeper than the upstream.

The ditch is straight and generally follows the easement boundaries in the upstream section. Further downstream the channel deviates west toward the Railtown property lines, leaving the easement limit. At the end of the ditch, the channel bends west and joins Woody Channel, cutting off the south portion of a property. The upper reaches of the ditch have a narrow cross-section including a V-ditch bottom. The lower reaches, which convey runoff from a larger catchment area, consist of a correspondingly larger cross-section. Upstream of the confluence with Woody Channel, the Railtown ditch has approximately a 3 m bottom width.

The City has expressed a desire to realign the ditch to maximize the developable property areas in Railtown and to enhance overland drainage by maintaining the conveyance capacity of the ditch to convey peak flow during a 1:100-year flood.

The ditch is a major system drainage feature and as such is expected to convey the 100-year design flow from the catchment areas, without flooding of the adjacent properties. To determine if the existing configuration is adequate to convey this flow, a hydrologic assessment and hydraulic model was completed using the HEC-RAS modelling software (Appendix B).

3.2.1 Hydrology and 1:100-Year Peak Flow

Subcatchments draining to the ditch were delineated using the methods described in Section 4.1.2.1. Subcatchments near that Railtown area that did not directly drain to the City's existing stormwater system were conservatively assumed to drain to the ditch allowing for future grading. Based on this assumption, the total drainage area for the ditch was estimate as 9.9 ha.

To determine the 100-year flow through the ditch, the rationale method was utilized to estimate peak flow conditions. The rationale method outlined in the equation below was used with intensities calculated based on the City's specified intensity duration frequency (IDF) curve for the 100-year rainfall event.

$$Q = 0.0028 * CiA$$

where:

Q= peak discharge (m^3/s)
C= runoff coefficient (dimensionless)
i = rainfall intensity (mm/hour)
A = drainage area (ha)

As the runoff from the Railtown subcatchments enters the ditch at different points along the alignment, the ditch was divided into upstream and downstream sections in the model. The upstream section receives runoff from 7.2 ha of subcatchment area and the downstream section receives runoff from an additional 2.7 ha. Table B summarizes the subcatchment areas for the upstream and downstream portion as well as the calculated peak flow rates. The peak flows calculated through the rational method were used in the HEC-RAS hydraulic assessment.

TABLE B Railtown Ditch Drainage Areas

Section	Catchment Area (ha)	Runoff Coefficient	Time of Concentration[2] (min)	1:100-Year Rainfall Intensity (mm/hour)	Peak Discharge (m^3/s)
Upstream	7.2	0.7	10	95.7	1.35
Downstream	9.9[1]	0.7	10	95.7	1.86[1]

Notes:
[1] Cumulative - includes upstream drainage area.
[2] City of Grande Prairie Guidelines specify a minimum time of concentration at 10 minutes.

3.2.2 Hydraulics

To simulate the hydraulics within the ditch, cross-sections were developed at 50 m intervals from the available topographic data. Steady state flow was specified at chainage 0+000 (upstream section) and chainage 0+400 (downstream section). The outlet boundary condition at Woody Channel was based on the 100-year water level reported in the Woody Creek Report (Section 2.2.1). A Manning roughness coefficient of 0.025 was used within the channel and banks conditions based on site photographs (Appendix A).

A design alternative for the proposed channel was modelled. The proposed channel has a typical trapezoidal cross-section with a 1 m bottom width and 2:1 side slopes. The invert elevation was lowered by 0.5 m to retain the 100-year flow within the channel.

4 RESULTS

4.1 Site Reconnaissance Results

Generally the overland drainage system needs to be maintained to continue to function properly. The implementation of sediment and erosion control requirements during construction could greatly reduce the amount of sediments accruing in the drainage system. In addition, regular maintenance of the existing drainage ditches and culverts and preventing catch basins from plugging with debris will significantly improve the performance of the minor and major drainage systems.

The results of the field investigations in this area identified some surface drainage issues, specifically along 92 Avenue between Park Road and 92 Street. This issue can be remedied through a regular maintenance program. Catch basins, culverts, and ditches need to be cleaned of sediment and adequately managed. Implementation of erosion and sediment control practices, including control during construction could greatly reduce future maintenance requirements.

On two of our site visits (September 2015 and April 2016) the presence of beaver activity in Woody Channel immediately upstream of the 92 Street crossing was observed. The City should consider removal of the existing beaver dam as the backwater created by the pond is resulting in undesirable outlet conditions for the storm sewers, which outlet to Woody Channel. In addition, it is likely causing sediment deposition, which may need to be addressed.

4.2 General Summary of Modelling results

The dual drainage model was used to simulate the 2- and 5-year design storm events. Storms larger than the 5-year are not well-represented in a model such as this because flow paths for storms of such magnitude do not necessarily correspond to the modelled minor system flow paths. Simulation results were assessed for surcharge and surface flow for 2- and 5-year design storms. The results of these assessments are depicted on Figures 3 and 4, for the 2- and 5-year events respectively.

The results of the 2-year design storm simulation indicate that less than 20% of the minor drainage system experiences surcharge during this event. Furthermore, the surcharged water elevations are all more than 1.3 m below ground surface, and as such do not pose a significant risk to flooding, including basement flooding.

The results of the 5-year design storm simulation indicate that still fewer than 20% of the minor drainage system experiences surcharge during this event. The surcharge during the 5-year event is slightly more severe than during the 2-year event, as is to be expected. During a 5-year event, three nodes present surcharge within 0.5 m of ground. However, still no surcharge to surface is evident. Based on the City's overland flow guidelines, the major results of the major drainage system modelling indicate that the surface flow is within acceptable limits.

By revising the drainage catchments in the hydrologic model and incorporating the dual drainage component into the hydraulic model of the drainage system, it is evident that no major ponding on the surface is expected during a 5-year event as indicated in the previous study.

4.3 Areas of Interest Results

As noted above, the City identified four areas of interest that were investigated and assessed with specific focus. The results for each of these areas are detailed below.

4.3.1 Storm Sewer Along Park Road and 92 Avenue

The developed dual drainage model was used to review the available capacity within the drainage system downstream of the proposed Park Road upgrades. A number of alternatives for outletting the Park Road runoff were reviewed. Considered outlet options included a ditch on Park Road south of 92 Avenue, and southerly sewers along 92 Street and Willow Drive. In discussions with the City and assessments using the dual drainage model, Matrix decided that the preferred outlet is 92 Street.

Various design iterations were simulated using the model. Design options were analyzed to ensure that an adequate level of service is provided while not causing unacceptable impacts to the downstream areas. Based on the criteria set out within the *Design Manual*, a 5-year level of service is required for the design of the new storm sewer. Storm sewer design was completed using the dual drainage model to ensure that any impacts from the existing downstream system were properly accounted for. As shown on Figures 5 and 6, proposed storm sewer sizes range from 300 mm south of 98 Avenue to 900 mm on 92 Avenue. In addition, connections are proposed between the new and existing 900 mm sewers on 92 Street. This will enable the most effective utilization of both sewers and thus maintain hydraulic grades lines as low as possible.

The major drainage along Park Road will be directed south along the Park Road Right of Way before Park Road where it turns east and intersects with 92 Avenue

4.3.1.1 Preliminary Cost Estimate

A cost estimate based on the preliminary design of proposed the Park Road storm sewer extension is provided in Appendix C. The estimate cost is approximately $ 2.5 million including 30% contingency, exclusive of GST.

4.3.2 Railtown Drainage Ditch

Proposed channel realignment and geometry was developed for the ditch based on the peak flow and easement boundaries. The new channel geometry was configured to best fit the existing geometry, reducing the volume of cut and fill, while trying to maintain the peak flows within the easement boundaries. The HEC-RAS model simulation with the proposed channel geometry shows the 100-year

flow being conveyed to Woody Channel without flooding. Figures 7 to 9 show the proposed channel geometry and the proposed 100-year water levels from the HEC-RAS simulation in the ditch.

The results of HEC-RAS model show that the existing ditch geometry does not have the capacity to retain and convey, without flooding, the 100-year peak flow from the surrounding subcatchments. Figures 8 and 9 highlight the ditch cross-sections and existing 100-year water level from the HEC-RAS model. As shown, the upstream portions of the ditch are likely to overflow the bank to the Railtown properties on the west side of the channel during a flood event. Flow is contained within the channel at the downstream sections but extends onto the private lands.

During the field reconnaissance on April 7, 2016, it was noted that some of the landowners adjacent to the Railtown ditch have begun development and grading of their properties. In particular there is a new retaining wall adjacent to the ditch immediately upstream of the confluence with Woody Channel (site photographs are provided in Appendix A). As a result new topographic data will be required before detailed design is completed.

4.3.2.1 Preliminary Cost Estimate

A cost estimate based on the preliminary design for the proposed Railtown ditch improvements is provided in Appendix C. The estimate cost is $80,000 including 30% contingency, exclusive of GST.

4.3.3 101 Avenue Development Potential

A review of the hydrologic and hydraulic modelling indicates that there is additional capacity in the existing minor drainage system during the 2-year event. The existing 2-year peak flow rate through the minor system on 101 Avenue adjacent to proposed development is 0.025 m^3/s. The limiting factor during the 2-year event within the pipe is not the existing capacity on 101 Avenue (0.161 m^3/s), but rather the backwater condition at the confluence with the pipe on 96 Street. The dual drainage model was used to determine the maximum allowable outflow from the proposed development during the 2-year event, without exceeding the pipe capacity at the confluence.

Based on the hydraulic assessment it was determined that up to 0.025 m^3/s could be released from the development without causing surcharge in the minor system at the intersection of 101 Avenue and 96 Street. As the potential development area is 1.3 ha, this equates to 0.0065 $m^3/s/ha$ (6.5 L/s/ha).

The City's *Design Manual* indicates that new developments should have an allowable outlet flow rate of 5 L/s/ha (paragraph 2.4.6, section 12, page 7); however, exceptions may be permitted by the City's Engineering Services Department. The results of this assessment indicate that at the City's discretion, an exception for this 1.3 ha property would be feasible up to a maximum release rate of 6.5 L/s/ha.

4.3.4 98 Avenue Ponding

Field reconnaissance by the study team has determined that the ponding at this site is a result of a local grading deficiency. There is a swale in the municipal right-of-way that generally flows from west to east from 98 Avenue to 93 Street. Currently runoff from the parking lot area cannot get to this swale due to a buildup of debris at the eastern end of 98 Avenue. Onsite grading works should be completed to ensure effective drainage from 98 Avenue, through the swale, to 93 Street.

4.4 Public Information Session to Present Results

A public information session was held on April 6, 2016. The information session was advertised on the City's website and in local new sources (i.e., Daily Herald Tribune newspaper and mygrandeprairienow.com). The information session was conducted as an informal open house where those who attended had the opportunity to review information panels on display and discuss the recommendations of the study with representatives of the project team. Staff from the City's Engineering Services Department, and representatives of Matrix's project team were in attendance at this meeting.

5 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions were drawn from the results of this study.

Site Reconnaissance

- There is a beaver pond in Woody Channel on the upstream side of the 92 Street culvert. This pond is creating a backwater pool to at least the CNR crossing upstream. This could cause impacts to the drainage system within the Study Area.

- There is a significant amount of sediment buildup in roadside ditches throughout the Study Area. Much of this seems to have originated from construction works without sediment and erosion control measures.

- Some culverts under entrances and access roads on private properties are either damaged or blocked with debris.

Drainage System Modelling

- The drainage catchments in the existing XPSWMM model were not consistent with the latest DEM data. The catchments have been revised accordingly.

- A dual drainage component was added to the XPSWMM model to account for the major system drainage component.

- The revised model indicates that no significant flooding issues result from the 5-year design storm event.

Park Road

- A number of design alternatives were considered for connecting the proposed storm sewer under the Park Road to the existing storm sewer under the 92 Street.

- A preliminary design is presented which conveys the minor system runoff from the 5-year design event along Park Road to 92 Avenue and ultimately south, along 92 Street to Woody Channel.

- Runoff conveyed by the major drainage system (Park Road) will be directed south along the Park Road Right of Way before Park Road where it turns east and intersects with 92 Avenue.

Railtown Drainage Ditch

- A HEC-RAS model of the existing ditch in Railtown was developed. This model showed that the existing ditch does not have sufficient capacity to convey the 100-year flow during future developed conditions without spilling onto the adjacent properties.

- A preliminary design is presented to contain the 100-year flow in a channel within the existing drainage easement.

- Ongoing development in this area will require updated topographic data before proceeding with detailed design.

101 Avenue Developments

- The available capacity (during the 2-year event) within the existing minor drainage system indicates that the potential 1.3 ha development area could have a maximum release rate of 6.5 L/s/ha without causing surcharge in the minor system at the intersection of 101 Avenue and 96 Street.

98 Avenue Ponding

- Ponding occurs at this location due to a grading deficiency. Minor grading works are required to convey runoff from 98 Avenue, along the drainage swale to 93 Street.

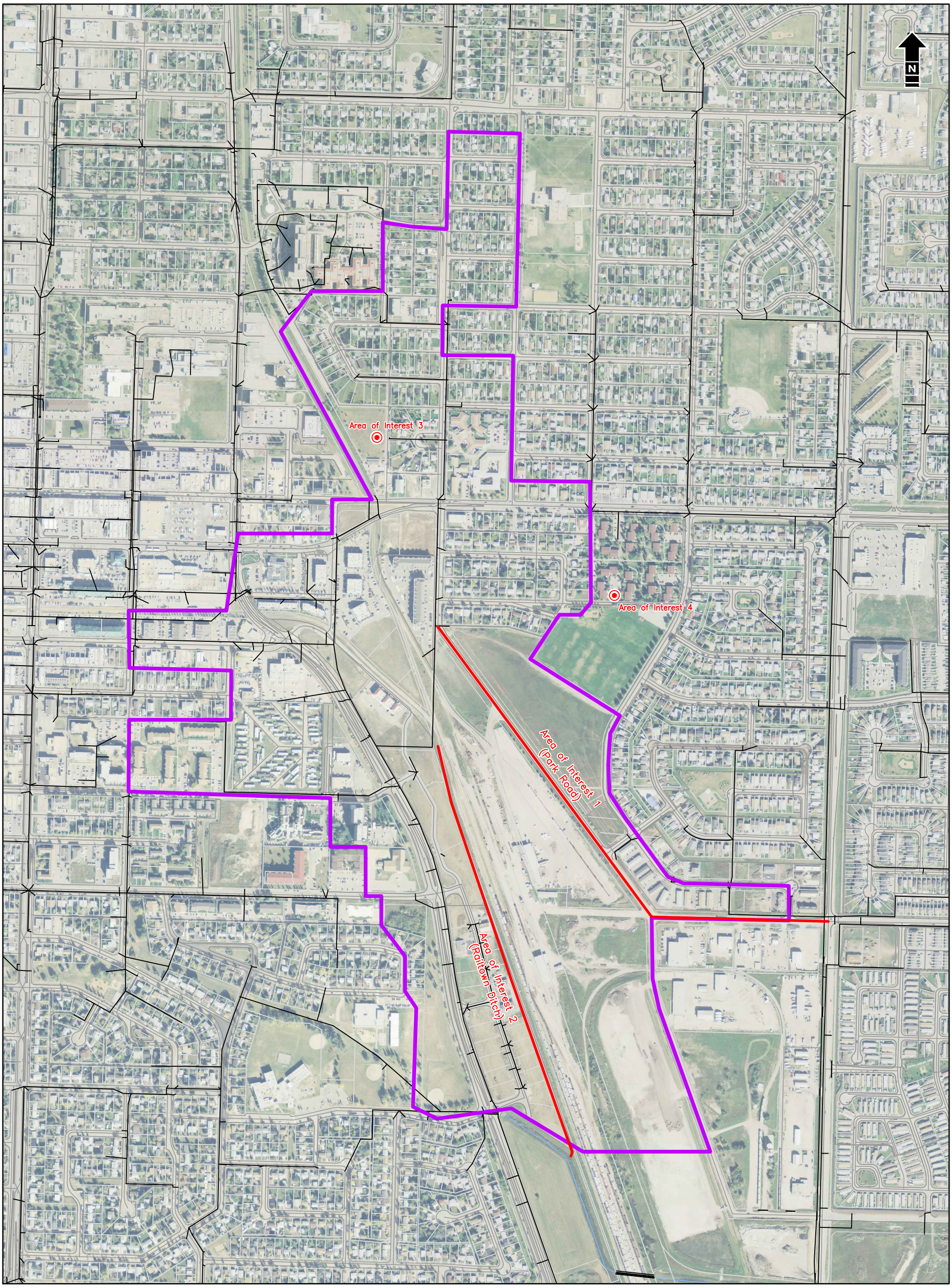
6 REFERENCES

Associated Engineering Alberta Ltd. (Associated Engineering). 2004. *City of Grande Prairie, Storm Drainage Master Plan.* Report prepared for the City of Grande Prairie. Edmonton, Alberta. October 2004.

Beairsto Lehners Ketchum Engineering and Survey Ltd. (BLK). 2006. Design Report, *Woody Creek Study, Resources Road to 68th Avenue*. Report prepared for the City of Grande Prairie. Grande Prairie, Alberta. November 2006.

City of Grande Prairie. 2016*. Design Manual.* Grande Prairie, Alberta.

Focus Corporation (Focus). 2013. *Grande Prairie Storm Drainage Master Plan*. Report prepared for City of Grande Prairie. Grande Prairie, Alberta. December 2013.



1:7500 Meters

75 0 75 150

UTM83-11

Study Area

Reference: Valtus Imagey Services dated August 12, 2012 to September 10, 2013. Base data from City of Grande Prairie.

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MARK L SHOME
November 7, 2016
Permit to Practice No.: P5540

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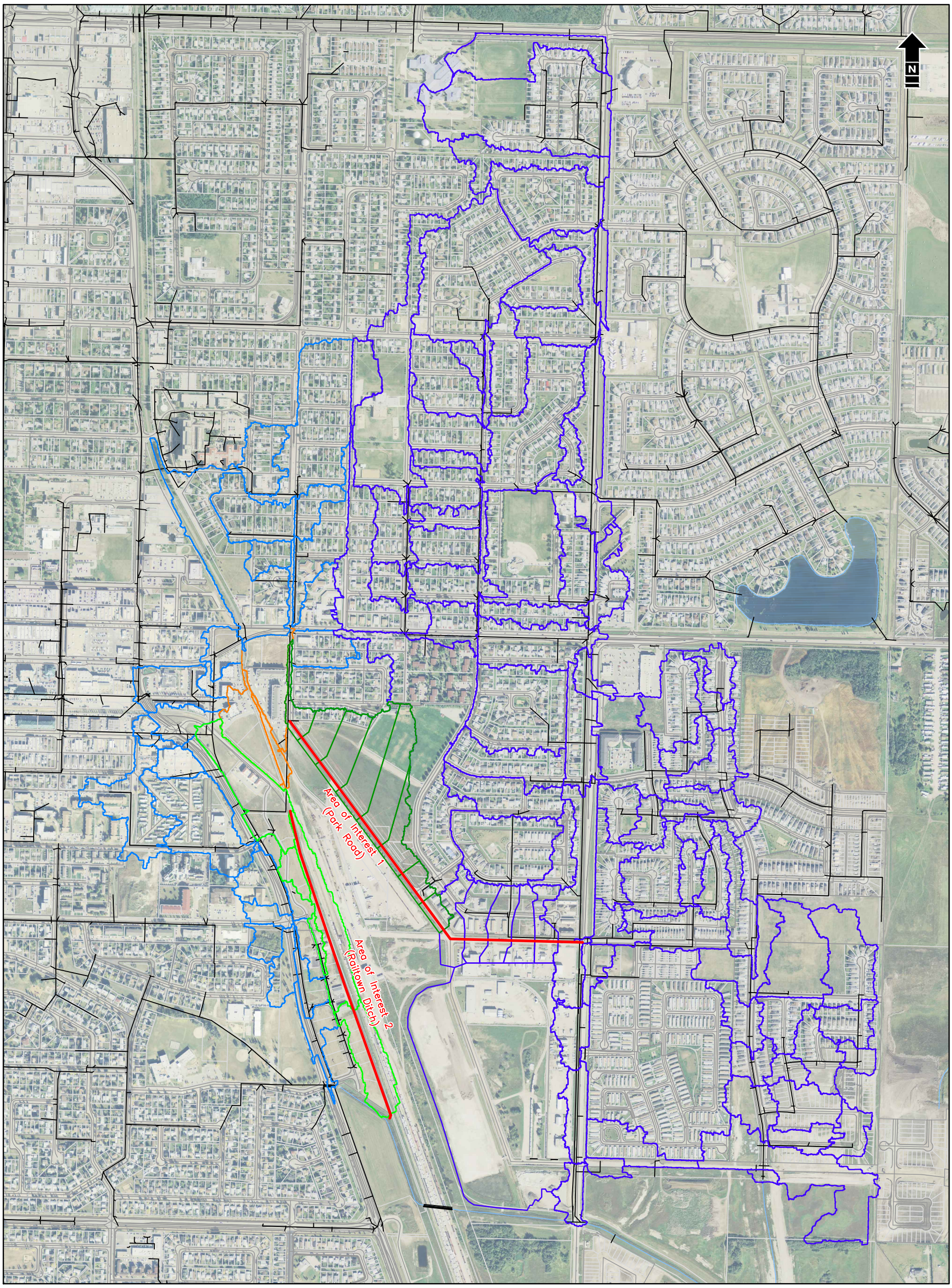
City of Grande Prairie
Smith Storm Basin Study

Overall Study Area

Date:	Project:	Technical:	Reviewer:	Drawn:
April 2016	21908-SP-16	K. Hofbauer	M. Shome	Z. Steele

Figure 1



1:10000 Meters

100 0 100 200

UTM83-11

Reference: Valtus Imagey Services dated August 12, 2012 to September 10, 2013. Base data from City of Grande Prairie.

- Study Area
- Sub-catchment areas - Model 7
- Sub-catchment areas - Model 22
- Sub-catchment areas - Park Road
- Sub-catchment areas - Railtown Ditch
- Sub-catchment areas - Isolated

PROFESSIONAL ENGINEER ALBERTA MARAS L. SHOME November 7, 2016

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City of Grande Prairie
Smith Storm Basin Study

Drainage Catchments

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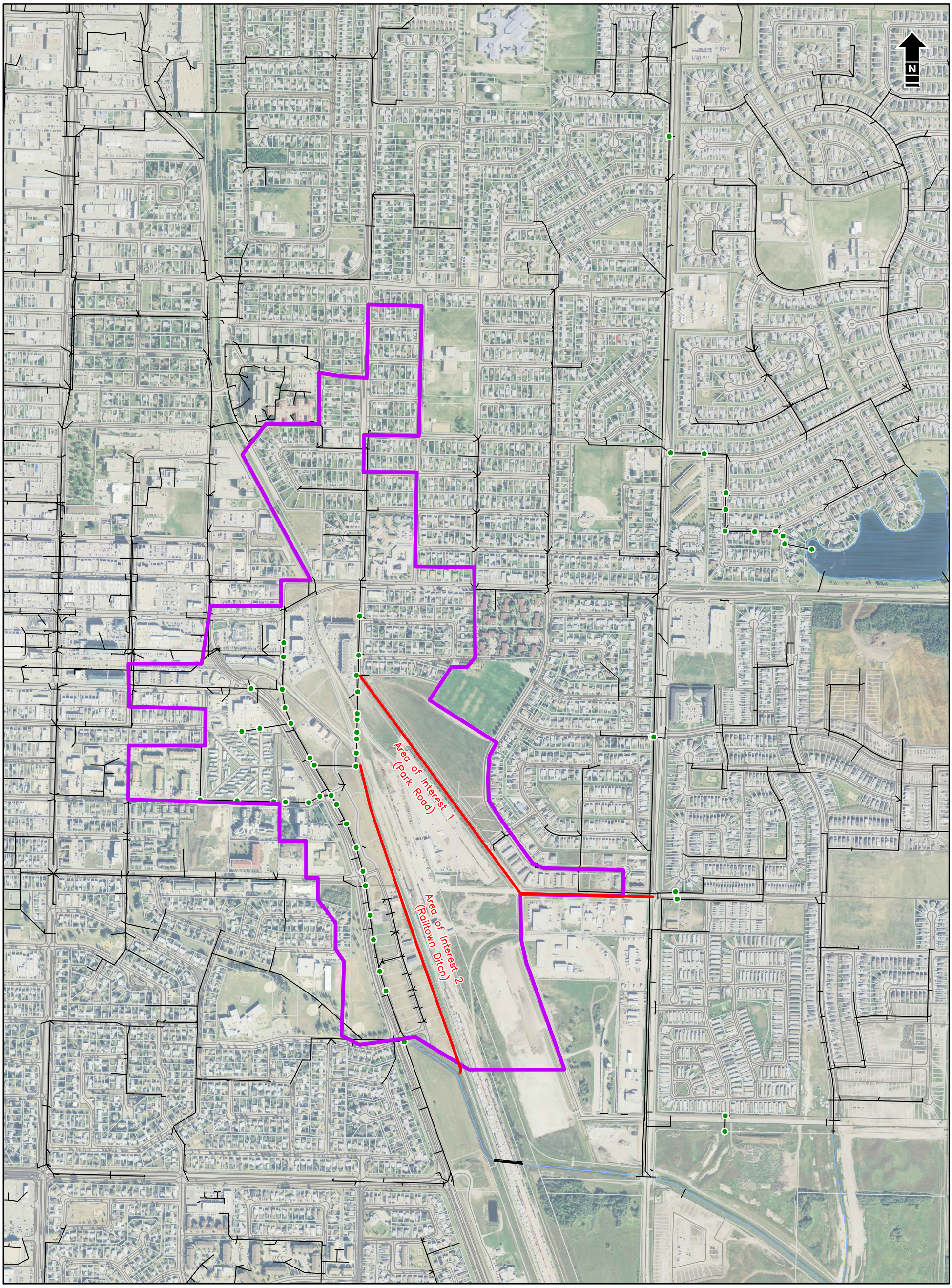
April 2016	21908-SP-16	K. Hofbauer	M. Shome	Z. Steele

Figure 2



1:10000 Meters

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UTM83-11

Study Area

Surcharged with more than 0.5 m Freeboard

Surcharged to within 0.5 m of Grade

Surcharged to Grade

Reference: Valtus Imagey Services dated August 12, 2012 to September 10, 2013. Base data from City of Grande Prairie.

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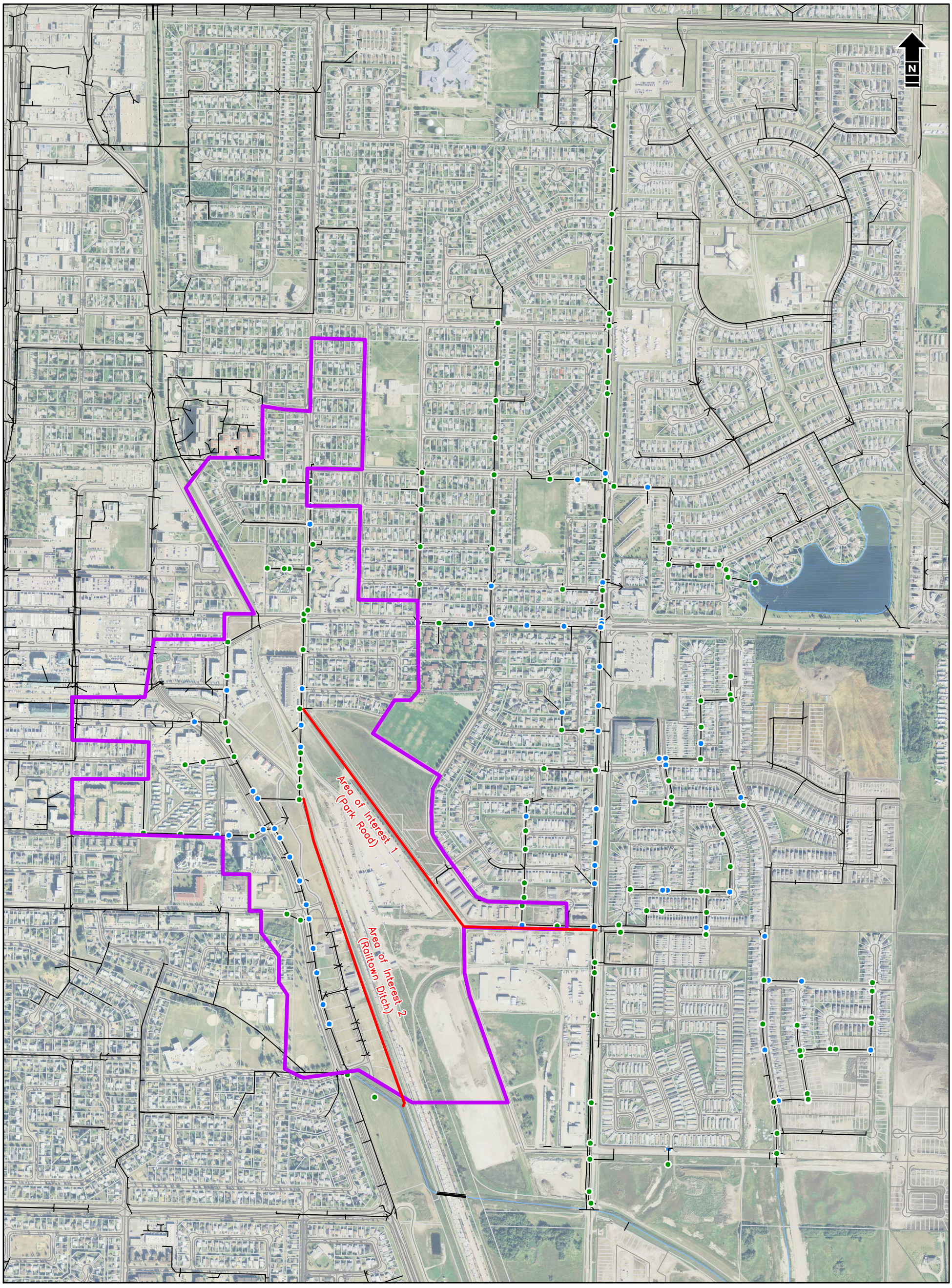
Smith Storm Basin Study

1:2 Year Surcharge

Date:	Project:	Technical:	Reviewer:	Drawn:
April 2016	21908-SP-16	K. Hofbauer	M. Shome	M.Lee

Figure 3



1:10000 Meters
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UTM83-11

Reference: Valtus Imagey Services dated August 12, 2012 to September 10, 2013. Base data from City of Grande Prairie.

Study Area

- Surcharged with more than 0.5 m Freeboard
- Surcharged to within 0.5 m of Grade
- Surcharged to Grade

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MARAS L. SHOME
November 7, 2016
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1:5 Year Surcharge

Date:	Project:	Technical:	Reviewer:	Drawn:
April 2016	21908-SP-16	K. Hofbauer	M. Shome	M.Lee

Figure 4

Sub-catchment areas

Reference: Valtus Imagey Services dated August 12, 2012 to September 10, 2013. Base data from City of Grande Prairie.

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1:3000 Meters
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UTM83-11

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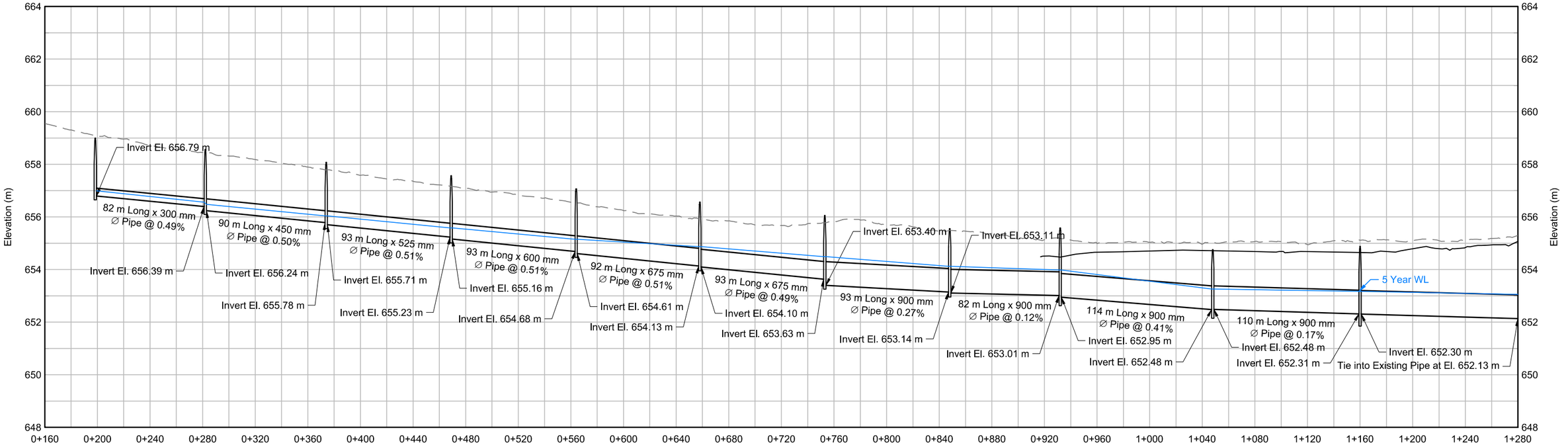
Smith Storm Basin Study

Park Road Plan

Date:	Project:	Technical:	Reviewer:	Drawn:
March 2016	21908-SP-16	K. Hofbauer	M. Shome	Z. Steele

Figure 5



A/5 **Profile**
Horizontal Scale 1:3000
Vertical Scale 1:150

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MINAS L. SHOME
November 7, 2016

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Reference: Valtus Imagey Services dated August 12, 2012 to September 10, 2013. Base data from City of Grande Prairie.

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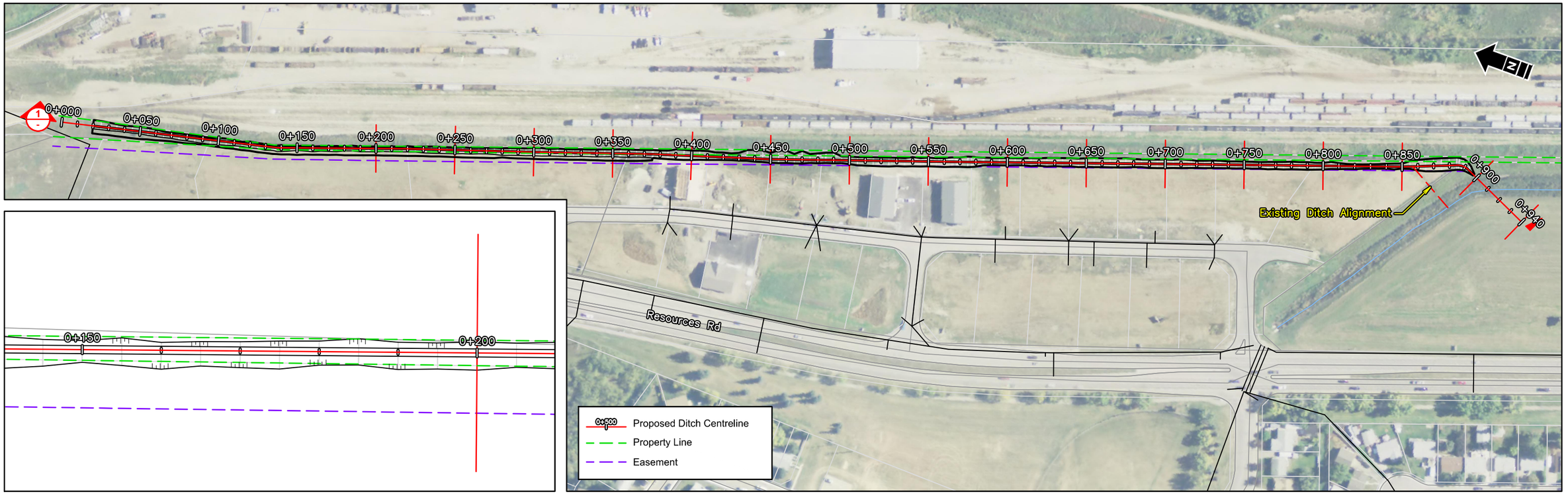
Smith Storm Basin Study

Park Road Profile

Date:	Project:	Technical:	Reviewer:	Drawn:
March 2016	21908-SP-16	K. Hofbauer	M. Shome	Z. Steele

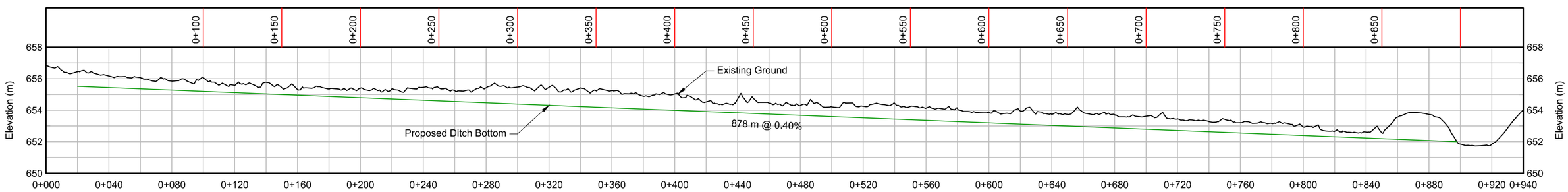
Figure 6



Detail
Scale 1:500

Site Plan

1:2500
25 0 25 50 Meters
UTM83-11



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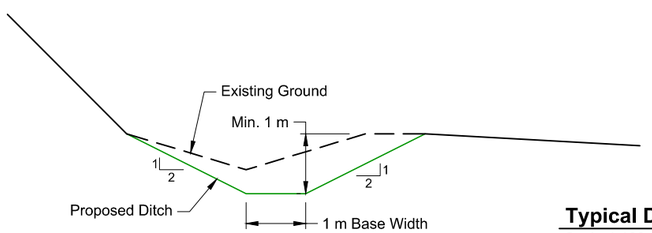

Typical Ditch Section
Scale 1:100

PROFESSIONAL ENGINEER ALBERTA
THOMAS L. SHOME
November 7, 2016

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Reference: Valtus Imagey Services dated August 12, 2012 to September 10, 2013. Base data from City of Grande Prairie.

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Smith Storm Basin Study

Railtown Ditch Plan and Profile

Date:	Project:	Technical:	Reviewer:	Drawn:
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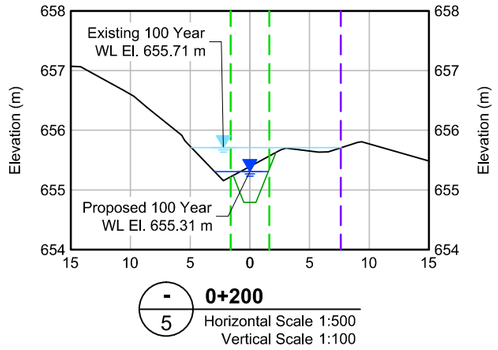
Figure 7



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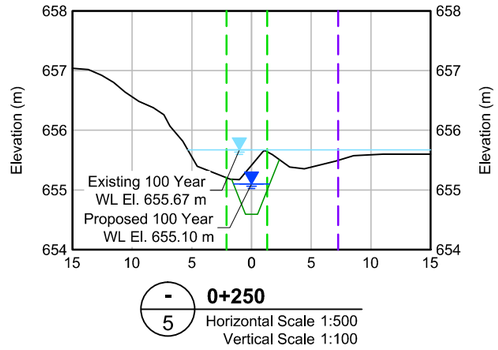

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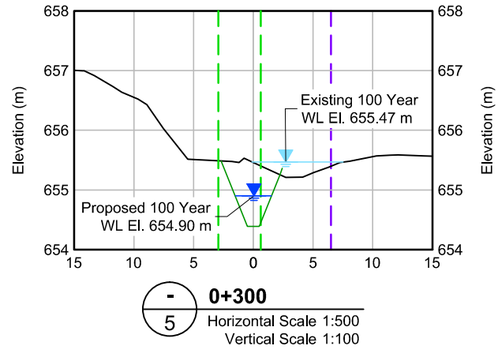

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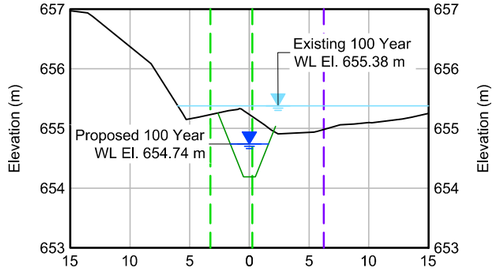

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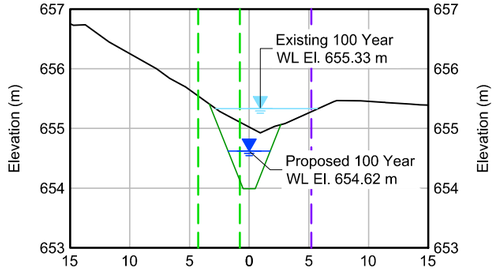

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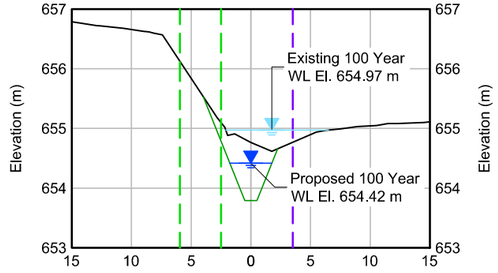

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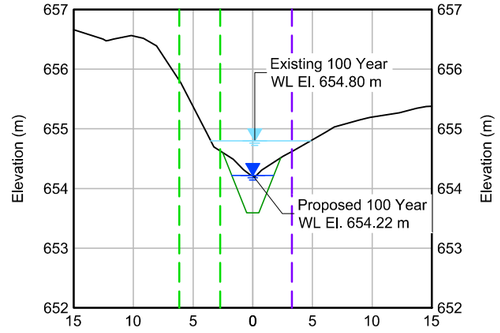

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Horizontal Scale 1:500
Vertical Scale 1:100

- Property Line
- Easement
- Existing Ground
- Proposed Ditch

PROFESSIONAL ENGINEER ALBERTA
MINAS L. SHOME
November 7, 2016

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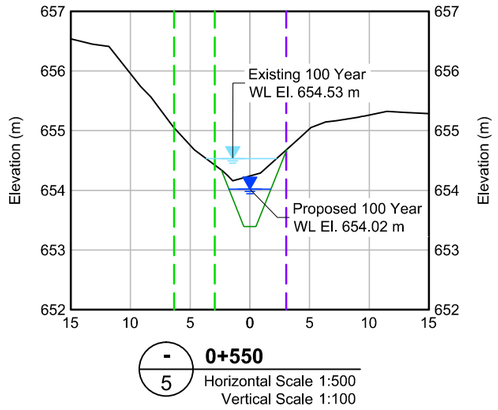
City of Grande Prairie
Smith Storm Basin Study

Railtown Ditch
Cross-sections (1 of 2)

Date:	Project:	Technical:	Reviewer:	Drawn:
March 2016	21908-SP-16	K. Hofbauer	M. Shome	Z. Steele

Figure 8



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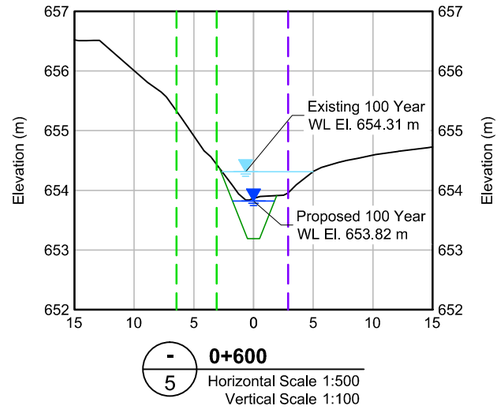

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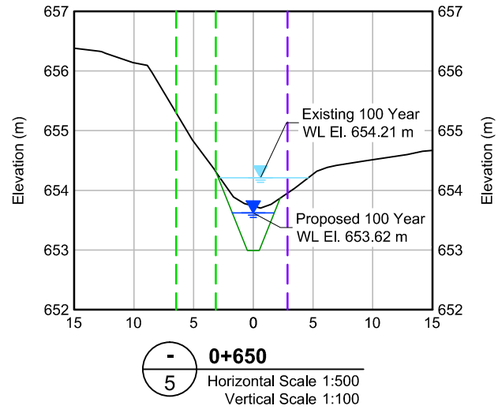

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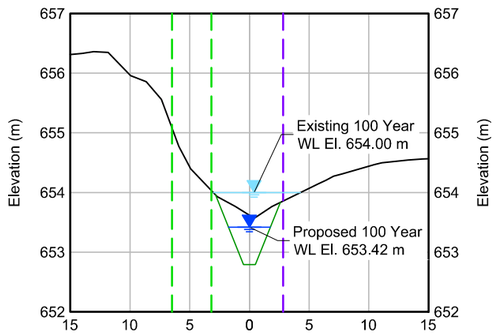

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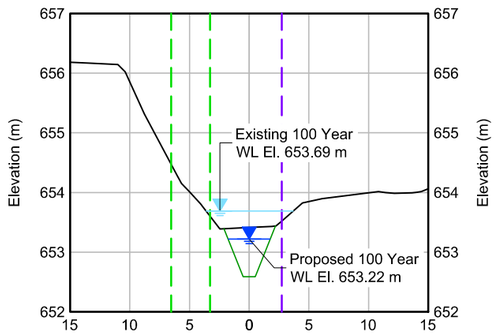

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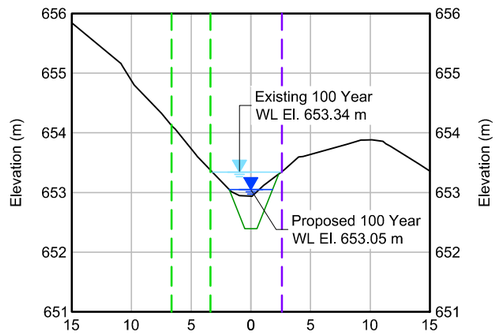

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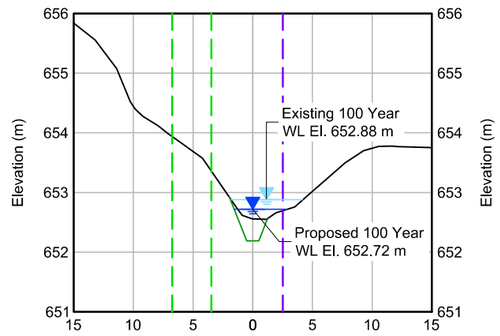

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Horizontal Scale 1:500
Vertical Scale 1:100

Property Line
Easement
Existing Ground
Proposed Ditch

PROFESSIONAL ENGINEER ALBERTA
MARK L. SHOME
November 7, 2016

Permit to Practice No.: P5540

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City of Grande Prairie
Smith Storm Basin Study

Railtown Ditch
Cross-sections (2 of 2)

Date:	Project:	Technical:	Reviewer:	Drawn:
March 2016	21908-SP-16	K. Hofbauer	M. Shome	Z. Steele

Figure 9

APPENDIX A
Site Photographs

Matrix Supplied
August 11, 2015

1. Woody Channel at 92 Street looking upstream (west)

Matrix Supplied
April 6, 2016

2. Woody Channel at 92 Street, looking upstream

Matrix Supplied
January 20, 2016

3. Woody Channel culvert at 92 Street looking downstream

Matrix Supplied
April 6, 2016

4. Outlet of Woody Channel culvert at 92 Street

Matrix Supplied
March 8, 2016

5. Woody Channel downstream of 92 Street culvert

Matrix Supplied
March 8, 2016

6. Park Road south of 92 Avenue near snow dump, looking south

Matrix Supplied
March 8, 2016

7. 92 Street at 84 Avenue looking north

Matrix Supplied
March 8, 2016

8. 92 Street at 84 Avenue looking south

Matrix Supplied
March 8, 2016

9. Easement south of 94 Avenue and 88A Street intersection

Matrix Supplied
March 8, 2016

10. 91A Street cul-de-sac south of 93 Avenue

Matrix Supplied
September 9, 2015

11. 92 Avenue south ditch west of 92A Street

Matrix Supplied
September 9, 2015

12. 92 Avenue south ditch west of 92A Street

Matrix Supplied
April 6, 2016

13. 92 Avenue south ditch west of 92A Street

Matrix Supplied
April 6, 2016

14. Blocked culvert along 92 Avenue south ditch west of 92A Street

Matrix Supplied
April 6, 2016

15. Culvert outlet along 92 Avenue south ditch west of 92A Street

Matrix Supplied
April 6, 2016

16. North side of 92 Avenue west of 92A Street

Matrix Supplied
April 6, 2016

17. Railtown Ditch confluence with Woody Channel, looking downstream

Matrix Supplied
April 6, 2016

18. Railtown Ditch confluence with Woody Channel, looking downstream

Matrix Supplied
September 9, 2015

19. Downstream end of Railtown ditch, looking upstream (north)

Matrix Supplied
September 9, 2015

20. Upstream Section of Railtown Ditch – looking downstream

Matrix Supplied
April 6, 2016

21. Railtown Ditch just upstream of Woody Channel confluence

Matrix Supplied
April 6, 2016

22. Railtown Ditch near new development

Matrix Supplied
September 9, 2015

23. Midway point of Railtown Ditch – looking upstream

Matrix Supplied
September 9, 2015

24. Catchbasin in grassed, low gradient swale located west of trailer park near 94 Avenue and 98th Street, viewing north

APPENDIX B
Hydrologic and Hydraulic Models
(Provided on Disc)

APPENDIX C
Cost Estimate Tables

Preliminary Design Cost Estimate -Park Road Sewer Extension

Project Name: Smith Storm Basin Study
Location: Grande Prairie, AB
Estimate By: Karen Hofbauer
Reviewed By: Manas Shome

Project No.: 21908
Date: July 22, 2016

BID QUANTITIES			Preliminary Estimate	
Description	Qty.	UNIT	UNIT AMOUNT	BID
Supply and install 300mm pipe	82	m	140	$ **11,480.00**
Supply and install 450mm pipe	90	m	200	$ **18,000.00**
Supply and install 525mm pipe	93	m	240	$ **22,320.00**
Supply and install 600mm pipe	93	m	300	$ **27,900.00**
Supply and install 675mm pipe	185	m	400	$ **74,000.00**
Supply and install 900mm pipe	495	m	500	$ **247,500.00**
Supply and install 1200mm manhole - std.	6	EA	10000	$ **60,000.00**
Supply and install 1800mm manhole - std.	5	EA	15000	$ **75,000.00**
Supply and Install oversized structure for 92 Ave / 92 St Intersection	By Others		-	-
900 mm catch basin - std. (to be coordinated with road upgrades)	22	EA	5000	$ **110,000.00**
300 mm catch basin connections	110	m	140	$ **15,400.00**
Surface removal	2234	m^2	50	$ **111,700.00**
Subgrade excavation	6537	m^3	20	$ **130,740.00**
Trenching and backfill	1148	l. m	120	$ **137,760.00**

SUBTOTAL		$	1,041,800.00
CONTINGENCY	15%	$	156,270.00
ENGINEERING	10%	$	104,180.00
TAX	5%	$	65,112.50
TOTAL AMOUNT		$	1,367,362.50

Preliminary Design Cost Estimate -Railtown Ditch Improvements

Project Name: Smith Storm Basin Study
Location: Grainde Prairie, AB
Estimate By: Karen Hofbauer
Reviewed By: Manas Shome

Project No.: 21908
Date: April 26, 2016

BID QUANTITIES			Preliminary Estimate	
Description	Qty.	UNIT	UNIT AMOUNT	BID
Channel Excavation	2100	m^3	16	**$ 33,600.00**
Soil covering (medium flow)	5400	m^2	3	**$ 16,200.00**
Broadcast Seeding	0.54	ha	2050	**$ 1,107.00**

SUBTOTAL		$	50,907.00
CONTINGENCY	30%	$	15,272.10
ENGINEERING	20%	$	13,235.82
TAX	5%	$	3,970.75
TOTAL AMOUNT		$	83,385.67