TOWN OF VERMILION
FUNCTIONAL STORMWATER MANAGEMENT PLAN
DRAFT FINAL REPORT
3 JULY 2017

Prepared for:

Town of Vermilion
Vermilion, AB

Prepared by:

Northwest Hydraulic Consultants Ltd.
Edmonton, AB

3 July 2017

NHC Project No. 100119

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Principal

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1 INTRODUCTION

Northwest Hydraulic Consultants (NHC) was retained by the Town of Vermilion (Town) to provide consulting engineering services to develop a Functional Stormwater Management Plan (Functional Plan) for areas within the south-central limits of the Town. **Figure 1** presents the extent of the study area. The Functional Plan will address stormwater infrastructure improvements needed to service development within the area indicated on **Figure 1**. The existing drainage system includes a series of culverts, ditches, and natural sloughs which drain to an underground storm pipe that discharges into a small ravine which drains on into Vermilion Park Lake.

Flooding in the south-central part of the Town has occurred in recent years and future uncontrolled development will further exacerbate the risk of flooding in this area. The Functional Plan will help to inform decisions on stormwater improvements needed to service existing and future development of the lands within the study area. The key objectives under the functional plan are to provide:

- A better understanding of known flooding issues associated with the lack of capacity of the existing drainage system,
- Recommendations on the system improvements required to meet the stormwater servicing needs of future development, and
- Assurance that the adopted stormwater servicing objectives are consistent with the applicable standards and guidelines.

The work required to meet the project objectives was organized into the following tasks:

- Data collection and review,
- Drainage assessment, and
- Improvement options.

This report presents a summary of the study results and recommendations.

2 DATA COLLECTION AND REVIEW

NHC collected historical engineering studies and reports associated with the existing drainage system including design reports and drawings. Most of this information was provided by the Town. BAR Engineering provided design information relating to their work for the Town for the Yellowhead Industrial and Junction 16/Highway 41 developments including as-built drawings and survey information collected for those studies. Rainfall data was obtained from information published by Environment Canada. Lastly, NHC reviewed local planning documents to confirm that the recommended stormwater servicing improvements were consistent with the Town’s development planning objectives.

2.1 RAINFALL DATA

Historic rainfall data has been collected by Environment Canada at Vermilion intermittently since 1906. **Table 1** provides a summary of the three stations that have reported historic daily rainfall amounts for the period of record indicated.

Table 1. Environment Canada Historical Rainfall Gauge Data at Vermilion

Station ID	Station Name	Latitude (North)	Longitude (West)	Elevation (m)	100-year 24-hour Rainfall Amount (mm)*	Observation Record
3016790	VERMILION	53°22'	110°50’	618.4	98.8	1906-1940 (30 years: missing 6)
3016800	VERMILION	53°21'	110°50’	618.7	100.6	1945-1982 (37 years)
3016802	VERMILION AGDM	53°21'	110°55’	623	Not reported	2002-2014 (12 years)

*From Rainfall Intensity, Duration, Frequency Values prepared by the Hydrometeorology Division, Canadian Climate Centre, Atmospheric Environment Service

Rainfall amounts for durations less than 24 hours are not available for the rainfall data collected at Vermilion since the gauges only report daily values. Rainfall gauges in the region with historical rainfall data collected for shorter durations (e.g. 5-minute intervals) are listed in **Table 2**. **Figure 2** presents a plan showing the locations of the stations listed in **Table 2** relative to the study site. Short duration rainfall *Intensity-Duration-Frequency* (IDF) data is published by Environment Canada for these stations. The published IDF data facilitate the development of design storms of variable duration and return period. **Table 3** presents the 100-year rainfall amount, or depth, in millimeters for durations of 1, 2, 6, 12, and 24 hours. Published IDF values are available for a station at Camrose (ID 3011240), however, this station was excluded from the assessment since the observation record (11 years) was too short to provide reliable IDF values, as compared to the other regional stations.

Table 2. Environment Canada Rainfall Gauges with Short Duration Rainfall Data

Station ID	Station Name	Latitude (North)	Longitude (West)	Elevation (m)	Distance from Study Site (km)	Observation Record
3012205	EDMONTON INT'L A	53°19'	113°35’	723	181	1961-2006 (45 yrs)
3012208	EDMONTON CITY CENTRE A	53°34'	113°31’	670	179	1914-1993 (79 yrs)
3012210	EDMONTON NAMAO A	53°40'	113°28’	687	177	1965-1994 (29 yrs)
3011880	CORONATION A	52°04'	111°27’	791	148	1976-1993 (17 yrs)
3016761	VEGREVILLE CDA	53°29’	112°02’	635	79	1971-1994 (23 yrs)
3081680	COLD LAKE A	54°25’	110°17’	541	125	1966-2006 (40 yrs)
4065058	MEADOW LAKE A	54°08’	108°31’	480	177	1979-2006 (27 yrs)
4045600	NORTH BATTLEFORD A	52°46’	108°16’	548	186	1975-2004 (29 yrs)
4047240	SCOTT CDA	52°22’	108°50’	659	174	1961-1996 (35 yrs)

Table 3. 100-year Rainfall Amounts (mm) for Proximate IDF Gauge Sites

Station Name	100-Year Return Period Rainfall Amounts (mm) for Variable Rainfall Event Duration				
	1-hour	2-hour	6-hour	12-hour	24-hour
EDMONTON INT'L A	37	44	61	79	105
EDMONTON CITY CENTRE A	48	55	80	97	120
EDMONTON NAMAO A	38	46	65	89	119
CORONATION A	35	41	48	61	84
VEGREVILLE CDA	56	64	77	94	101
COLD LAKE A	49	54	63	82	96
MEADOW LAKE A	44	48	61	67	79
NORTH BATTLEFORD A	42	50	59	63	73
SCOTT CDA	40	44	56	64	74

IDF data published at Vegreville (Station 3016761) was the most representative set of data for developing short duration design rainfall events in Vermilion. The 24-hour Vegreville rainfall amount (101 mm) is comparable to the amounts reported for Vermilion (98.8 mm and 100.6 mm), Vegreville is the nearest regional station, and Vegreville and Vermilion are at similar elevations and latitudes. **Table 4** presents a summary of the IDF rainfall amounts for Vegreville. These amounts were used for design rainfall amounts for Vermilion.

Table 4. Return Period Rainfall Amounts for Vegreville CDA (Station 3016761)

Duration	Return Period Rainfall Amount (mm)*					
	2-year	5-year	10-year	25-year	50-year	100-year
1-hour	15.9	26.6	33.8	42.8	49.4	56.1
2-hour	20.0	31.7	39.4	49.2	56.5	63.7
4-hour	24.5	**36.8**	44.9	55.2	62.8	70.4
6-hour	28.9	41.8	50.4	61.2	69.2	**77.2**
12-hour	35.1	50.9	61.3	74.5	84.3	94.0
24-hour	42.1	57.8	68.2	81.4	91.1	**100.8**

*Bold values are adopted values for design storm rainfall amounts.

The 12 July 2010 Rainfall Event: A very large rainstorm event caused notable flooding in Vermilion on 12 July 2010. As reported by the Vermilion Standard, *"The rain, hail and thunderstorm on July 12 in Vermilion brought approximately 100 millimeters of precipitation in a three-hour time span…".* This convective storm brought intense rainfall over a relatively short period of time, however, it is not clear as to source for the estimated amount of rainfall (100 mm) in the newspaper. The rain gauge at Vermilion AGDM (Station 3016802) reported a total daily amount of 76.7 mm. It is plausible that spatial variability in the storm resulted in total rainfall amounts of 100 mm over concentrated areas. Based on the storm duration and the historical rainfall record, it is reasonable to characterize the 12 July 2010 event as having a return period of at least 100-years.

3 DRAINAGE ASSESSMENT

The Town provided NHC with aerial imagery and database information on the existing stormwater drainage network. This information, combined with the field survey and design data provided by BAR Engineering was used to delineate drainage areas and associated stormwater infrastructure servicing the study area. The data was used to develop an integrated rainfall runoff model to assess: rainfall runoff volumes and rates, pond volumes and levels, flow in ditches and culverts, and hydraulic grade lines in the conveyance network. The model was used to assess the performance of the existing stormwater collection system under a pre-development condition, the existing "interim-development" condition, and a post-development condition. The post-development condition is unknown at the time of this report and will be based on the Town's preferred alternatives for stormwater improvements described herein.

3.1 ASSESSMENT MODEL AND HYDROLOGIC ASSUMPTIONS

The PCSWMM 2016 (Version 6.3.2223) integrated rainfall-runoff model was selected as the assessment tool for this analysis. It is a generally accepted stormwater model that has wide use by industry and it is compatible with the freely distributed US EPA SWMM5 public domain model. Infiltration over pervious areas was simulated by Horton's infiltration model. The following Horton infiltration model parameters were adopted for this study:

Maximum infiltration rate: *50 mm/hr*

Minimum infiltration rate: *3 mm/hr*

Infiltration rate decay constant: *4.14 1/hr*

Time for fully saturated soil to completely dry: *7 days*

The portion of rainfall that is retained within small depressions (depression storage) was assumed to be 15 mm for impervious areas and 1.5 mm for impervious areas. It is assumed that 25% of impervious areas do not have any depression storage and rainfall on this portion is treated as direct runoff. The total percent impervious was based on land use according to the values listed in **Table 5**.

Table 5. Modelled Percent Impervious Area according to Land Use

Land Use	Modelled % Impervious	Remarks
Agricultural	3	Includes farm buildings, parking areas, roads, and drainage ways.
Ditches and Swales	25	Ponded water was expected to develop in the ditches soon after the rain event began and rainfall onto the ponded areas contributed to direct runoff. This effect was captured by assuming a portion of the ditch as impervious.
Residential	45	Residential buildings, garages, lawns, and vegetation with some trees.
Industrial	70	Industrial buildings, roads, parking, gravel yards, grassed and vegetative areas.

3.2 DESIGN RAINFALL EVENTS

Three design rainfall events were examined for this study: a moderately large and intense rainfall event with a 5-year recurrence interval (5-year 4-hour rainfall); a very large and relatively intense rainfall event (100-year 6-hour rainfall) and a very large long duration rainfall event with a 100-year recurrence interval (100-year 24-hour rainfall). The shorter duration storms (5-year 4-hour and 100-year 6-hour) are used to provide design guidance on the stormwater collection and conveyance system and the long duration (100-year 24-hour) storm is used to assess flooding and provide design guidance on stormwater management facilities (e.g. ponds). Rainfall amounts (depths in mm) were derived from IDF data for Vegreville (ID 3016761). The distribution of the shorter duration storm was based on the City of Edmonton's modified Chicago distribution, while the longer durations storms were based on the AES 70th percentile prairie storm distribution. **Table 6** presents a summary of the design storms used for this study.

Table 6. Design Storm Events

Design Storm	Total Rainfall (mm)	Remarks
5-year 4-hour	36.8	Recommended event for assessment of the minor drainage system.
100-year 6-hour	77.2	Consistent with daily rainfall amount of 76.7 mm reported at Vermilion ADGM (Station 3016802) for the 12 July 2010 rain event (although over shorter duration).
100-year 24-hour	100.8	Consistent with both Vegreville and Vermilion 24-hour rainfall amounts. Amount is consistent with the total rainfall reported in Vermilion Standard for the 12 July 2010 rain event (although over longer duration).

3.3 PRE-DEVELOPMENT CONDITIONS

An assessment of the pre-development condition was completed to evaluate the model performance with respect to the 12 July 2010 storm event and to provide a baseline for comparison to post-development conditions for the interim and future developments scenarios.

Figure 3 presents a schematic depicting the local drainage patterns through the functional plan area. It also identifies those lands draining from the south onto the functional plan area. The general drainage paths are depicted by arrows. The study area is divided by Highway 41 which runs north-south through the study area and by the east-west conveyance system (green line) that runs along the northern limits of the functional plan area. Runoff drains mostly northward into the east-west conveyance system and is then directed to the entrance of a storm pipe which takes runoff underground across the exhibition grounds and discharges into a gully on the north side of 50th Avenue between 59th and 60th Streets. The gully empties into Vermilion Lake just north of the Town.

The east-west conveyance system begins at the outlet of a natural depression (denoted herein as the *"SE Pond")* that collects runoff from areas to the south and east. Flows exiting the SE Pond enter the drainage ditch through a control box that is fitted onto the upstream end of a culvert. The control structure and ditch extending from the SE Pond to Highway 41 were completed as part of the "South Central Drainage Project" and were designed by EPEC Consulting Group in 1989. Copies of the design drawings for the ditch and pond outlet structure are provided in Appendix A.

Stormwater flows pass through a series of culverts near the Highway 41 crossing. The inset on **Figure 3** identifies six culvert crossings. The first set of culverts (crossing ①) were removed sometime after the 12 July 2010 storm event and were thus only included in the analysis of the pre-development condition.

3.4 INTERIM-DEVELOPMENT CONDITIONS

An assessment was conducted for the stage of development following the completion of the Yellowhead Industrial and Junction 16/Highway 41 developments. This condition was denoted as the *Interim-Development* condition and is representative of conditions at the time of this report. The functional plan offers stormwater management improvement options to enhance the level of service for the interim-development condition and to facilitate future development.

Figure 4 presents a schematic depicting the local drainage for the interim-development condition. The overall drainage pattern is very much like the pre-development condition except for the following:

- Land use changes due to new developments at Yellowhead Industrial and Junction 16/Highway 41 resulting in a slight increase in drainage area and an notable increase in impervious areas over the newly developed lands.
- Additional pond capacity at the Yellowhead Industrial development. The additional pond capacity is denoted on the figure as "*SE Pond Expansion*".
- Removal of culvert crossing in ditch north of Junction 16/Highway 41 development (denoted as crossing ①).

3.5 POST-DEVELOPMENT CONDITIONS

Figure 5 presents a schematic depicting the local drainage for the post-development condition. The post-development condition is based on initial concepts developed in consultation with Town. The post-development condition represents a developed scenario where development has occurred within the functional plan area. Catchment impervious areas and slopes were increased so as to represent the introduction of paved surfaces, and more efficient stormwater drainage. Under post-development conditions, storage will be provided upstream of the Exhibition Grounds stormwater inlet. Two options for storage ponds were considered.

Pond 01 Option: This option provides storage just upstream of the stormwater inlet passing under the Exhibition Grounds (*Ex. Grounds Inlet*). The runoff reporting to the Ex. Grounds Inlet exceeds the capacity available in the storm pipe passing under the grounds – the excess capacity is stored in Pond

01. Stormwater is detained in Pond 01 until sufficient capacity becomes available for it to pass through the stormwater system under the exhibition grounds.

Pond 02 Option: This option provides storage in the large depression area left from the borrow pit northwest of the junction at Highways 16 and 41. During large runoff events, stormwater is diverted to Pond 02 and then some time after the storm event, the water is pumped from the pond back into the ditch downstream of the high flow diversion. The runoff diverted into storage in Pond 02 is pumped back into the drainage system at a rate that is below the capacity of the stormwater system under the exhibition grounds. The high flow diversion is configured such that the runoff from more frequent, smaller storm events, drain directly to the Ex. Ground Inlet. During large runoff events (when the capacity of the Ex. Grounds Inlet is exceeded) the high flow diversion directs excess runoff to Pond 02.

3.6 MODEL ASSESSMENT

The 12 July 2010 event was used to assess the assumptions on model input parameters by comparing observations of the 12 July 2010 storm event to the results of the rainfall-runoff model simulations for the 6-hour and 24-hour 100-year design events. The results of this assessment indicate that the pre-development model provides a reasonable analogue of the hydrologic response of the actual drainage system to large rainfall events. The following information from the 12 July 2010 event was used to assess the model:

- Town staff recalled that the top of the culvert immediately east of the Highway 41 east access road crossing (denoted as crossing ② on **Figure 3**) was submerged by approximately 12 to 24 inches (0.3 – 0.6 m) during the peak flood conditions. The modelled peak flow depths above the culvert at this location was about 0.8 m for the 6-hour 100-year design event.
- Significant flooding occurred along 44 Avenue east of 51A Street. Based on town staff's recollection of the approximate extent of inundation and height of water along fences and mobile homes in the flooded area, an approximate high water elevation was estimated from elevation data surveyed by BAR Engineering near these observed locations. The flood elevation in this area was estimated to be as high as 618.50 m. The modelled peak water surface elevations in the ditch opposite the flooded area on 44 Avenue was just over 618 m for the 6-hour 100-year design event.
- On 20 July 2010, the Vermilion Standard reported comments from the Town Manager which suggested that the culverts under Highway 41 were running at capacity 24 hours after the storm. Computed model results indicate that the culverts under Highway 41 were surcharged above normal capacity for approximately 23 hours for the 6-hour 100-year event.

The magnitude of flooding predicted by the model is consistent with the description of observed events. Although the observations are somewhat anecdotal, they are relevant and meaningful since they provide information for a very large flood event with magnitude comparable to the 100-year design. It is worth noting that for studies of this type, there is often little to no historical information available to assess the quality of the rainfall runoff assessment model.

3.7 MODEL RESULTS

Model results are presented in **Tables 7** through **10** for the following respective design rainfall events: 5-year 4-hour (36.8 mm), 100-year 6-hour (77.2 mm), and 100-year 24-hour (100.8 mm). Results are provided for representative model node locations listed in the tables and indicated on **Figure 5**.

Table 7. Total Rainfall Runoff Amounts Summary

Development Scenario	Drainage Area (ha)	Total Runoff Depth (mm)			Total Runoff Volume (m^3)		
		5YR 4HR	100YR 6HR	100YR 24HR	5YR 4HR	100YR 6HR	100YR 24HR
PRE	330	5.6	25.1	22.5	1,844	939	1,347
INTERIM	334	8.6	34.0	32.2	2,883	1,498	1,986
POND_01	334	8.6	34.0	32.2	2,883	1,498	1,986
POND_02	334	8.6	34.0	32.2	2,883	1,498	1,986

NOTE: PRE & INTERIM denote the pre-development and interim-development scenarios. POND_01 & POND_02 denote the two post-development scenarios.

Table 8. Rainfall Runoff Model Results Summary for the 5-year 4-hour Design Rainfall Event

Location	Total Inflow Volume (1000 m^3)				Maximum Level (m)			
	PRE	INTERIM	POND_01	POND_02	PRE	INTERIM	POND_01	POND_02
SE_Pond	5.5	27.1	27.1	27.1	618.49	618.54	618.54	618.54
Node_18	9.6	19.8	19.8	19.8	617.04	617.25	617.25	617.25
OPTION_01_POND	n/a	n/a	43.5	n/a	n/a	n/a	613.82	n/a
OPTION_02_POND	2.5	2.5	2.5	22.5	613.32	613.32	613.32	614.07
EXPO_GNDS_INLET	14.1	24.4	31.3	4.4	614.38	615.01	613.97	614.10
Ravine Outlet	14.1	24.4	20.1	4.4	-	-	-	-

NOTE: PRE & INTERIM denote the pre-development and interim-development scenarios. POND_01 & POND_02 denote the two post-development scenarios.

Table 9. Rainfall Runoff Model Results Summary for the 100-year 6-hour Design Rainfall Event

Location	Total Inflow Volume (1000 m^3)				Maximum Level (m)			
	PRE	INTERIM	POND_01	POND_02	PRE	INTERIM	POND_01	POND_02
SE_Pond	32.3	65.6	65.6	65.6	619.11	619.09	619.09	619.09
Node_18	53.8	76.0	76.0	76.0	617.87	617.67	617.67	617.67
OPTION_01_POND	n/a	n/a	77.0	n/a	n/a	n/a	614.75	n/a
OPTION_02_POND	9.2	10.4	10.4	84.0	613.65	613.69	613.69	615.47
EXPO_GNDS_INLET	71.9	100.0	138.0	28.8	615.50	615.79	614.75	615.14
Ravine Outlet	71.9	100.0	93.2	28.7	-	-	-	-

NOTE: PRE & INTERIM denote the pre-development and interim-development scenarios. POND_01 & POND_02 denote the two post-development scenarios.

Table 10. Rainfall Runoff Model Results Summary for the 100-year 24-hour Design Rainfall Event

Location	Total Inflow Volume (1000 m^3)				Maximum Level (m)			
	PRE	INTERIM	POND_01	POND_02	PRE	INTERIM	POND_01	POND_02
SE_Pond	25.8	60.3	60.3	60.3	618.80	618.86	618.86	618.86
Node_18	45.7	72.0	72.0	72.0	617.19	617.10	617.10	617.10
OPTION_01_POND	n/a	n/a	66.7	n/a	n/a	n/a	614.47	n/a
OPTION_02_POND	9.0	9.6	9.6	84.2	613.64	613.66	613.66	615.49
EXPO_GNDS_INLET	63.2	93.0	118.0	19.9	614.71	615.36	614.47	614.02
Ravine Outlet	63.2	92.9	83.2	19.9	-	-	-	-

NOTE: PRE & INTERIM denote the pre-development and interim-development scenarios. POND_01 & POND_02 denote the two post-development scenarios.

The following provide some of the principal observations based on interpretation of the model results.

- There is an overall increase in runoff rates and volumes due to the increase in impervious area from the Yellowhead Industrial and Junction 16/Highway 41 Developments.
- In general, the 100-year 6-hour event produces the largest runoff volumes, peak flow rates, and water elevations.
- The additional storage at the Yellowhead Industrial development (SE Pond) serves to reduce the total runoff volume and peak runoff rates downstream of the SE Pond area for the interim development condition.
- Removal of culvert crossing ① (just north of the Junction 16/Highway 41 development) contributes to a localized reduction in peak flood levels upstream of the old crossing and a slight increase in flood levels downstream near the Hwy 41 crossing.
- Two major flow restrictions results in significant backwater effects: the storm pipe under the fairgrounds, and the culverts under Highway 41.

4 IMPROVEMENT OPTIONS

The following two storage options provide technically feasible stormwater servicing improvements to minimize flooding for very large (e.g. 100-year) rainfall events.

1. **Pond Option 01:** The first option is to construct an online storage pond near the existing outlet pipe under the fairgrounds. This would provide local storage and reduce the flooding level at the downstream location. This option operates by gravity and does not require pumping.
2. **Pond Option 02.** The second option is to create a diversion structure to redirect a portion of the flow towards the south into the existing borrow pit located northwest of the intersection of Highway 41 and Highway 16. The water in the pond is subsequently pumped back into the ditch downstream of the diversion point, after the event has passed and sufficient capacity becomes available.

Figures 6 through 7 provide the computed maximum *hydraulic grade line* (HGL) profiles along the main drainage course extending along the north side of the Junction 16/Highway 41 development down into the storm sewer passing under the Exhibition Grounds. In an open ditch or pipe/culvert, the HGL is representative of the elevation of the water surface; under pipe full or surcharged conditions, the HGL is representative of the level to which the water would rise in an open standpipe. The HGLs provide insight on the impacts of development and the relative effectiveness of the pond options. The following summarize initial findings through the inspection of the computed HGLs.

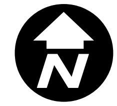
- The culvert crossings at Highway 41 are near capacity for the 5-year 4-hour and the 100-year 24-hour design events. The culverts become surcharged during peak flows associated with the 100-year 6-hour design event.
- The increased runoff rates from the Junction 16/Highway 41 Development are offset from the increased storage provided by the Yellowhead Industrial Development. Flow rates from areas upstream of the Yellowhead Industrial Development are attenuated by the ponds and thus providing additional capacity available in the ditch to accept the increased runoff from the Junction 16/Highway 41 Development. Further, the peak runoff from the Junction 16/Highway 41 Development arrives earlier than for the pre-development condition.
- Increased runoff from the Junction 16/Highway 41 and Yellowhead Industrial Developments increase peak water levels in the lower portion of the drainage network and at the inlet to the Exhibition Grounds sewer network. The sewer system does not have adequate capacity to accommodate large runoff events.
- Both Pond Options 01 and 02 reduce water levels in the lower portions of the drainage network and at the inlet to the Exhibition Grounds sewer network.
- The Pond Options 01 and 02 have little to no effect on computed water levels upstream of the series of culverts crossing and nearby Highway 41.

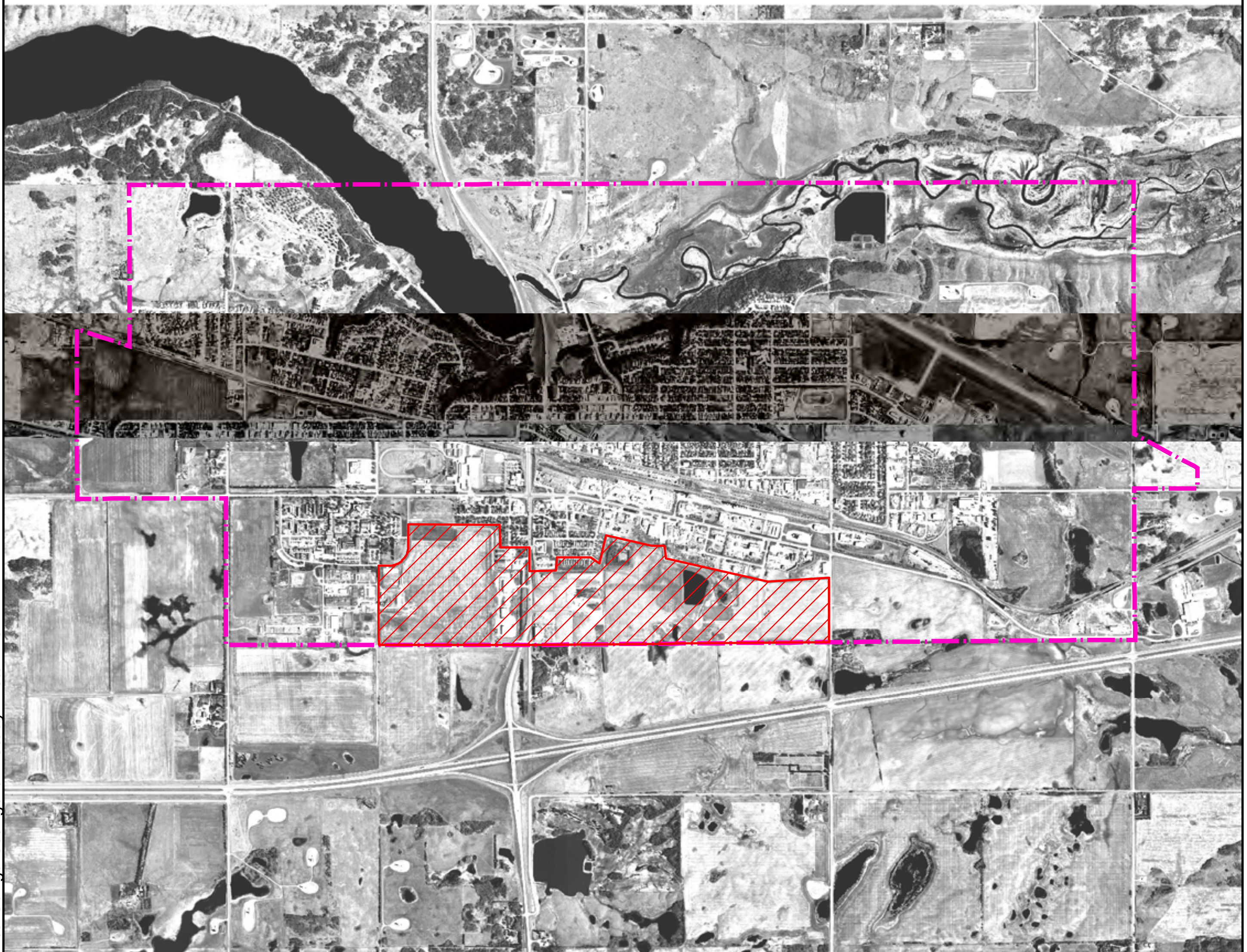
5 CONCLUSIONS AND RECOMMENDATIONS

The following lists the key conclusions and recommendations associated for this study.

- The additional storage provided at the Yellowhead Industrial Development offsets the increased runoff from the Junction 16/Highway 41 Development. The results of the analysis suggest there may be a slight reduction in the risk of flooding along the ditches north of the new Junction 16/Highway 41 Development. However, for practical planning purposes, it is advisable that the potential reduction in risk be considered negligible.
- The capacity of the existing culvert crossings will likely be exceeded during large runoff events and water will “back up” in the ditches, much like it has in the past. However, the culverts help to attenuate runoff rates reporting to downstream areas. It is advisable to implement downstream improvements prior to upgrading the capacity of the culvert crossings.
- The results of the study confirm that there are technically feasible alternatives to reduce the risk of flooding within downstream portions of the drainage system and near the inlet to the Exhibition Grounds. Two storage options have been offered for further consideration by the Town.

FIGURES





0 0.5 1 2 3 kms

Aerial imagery provided by Town of Vermilion (date unknown).

Legend/Notes:

Town Boundary

Functional Plan Area

TOWN OF VERMILION

TOWN OF VERMILIOIN FUNCTIONAL STORMWATER MANAGEMENT PLAN

STUDY AREA

DRAFT

100119	JULY 2017	**FIGURE 1**

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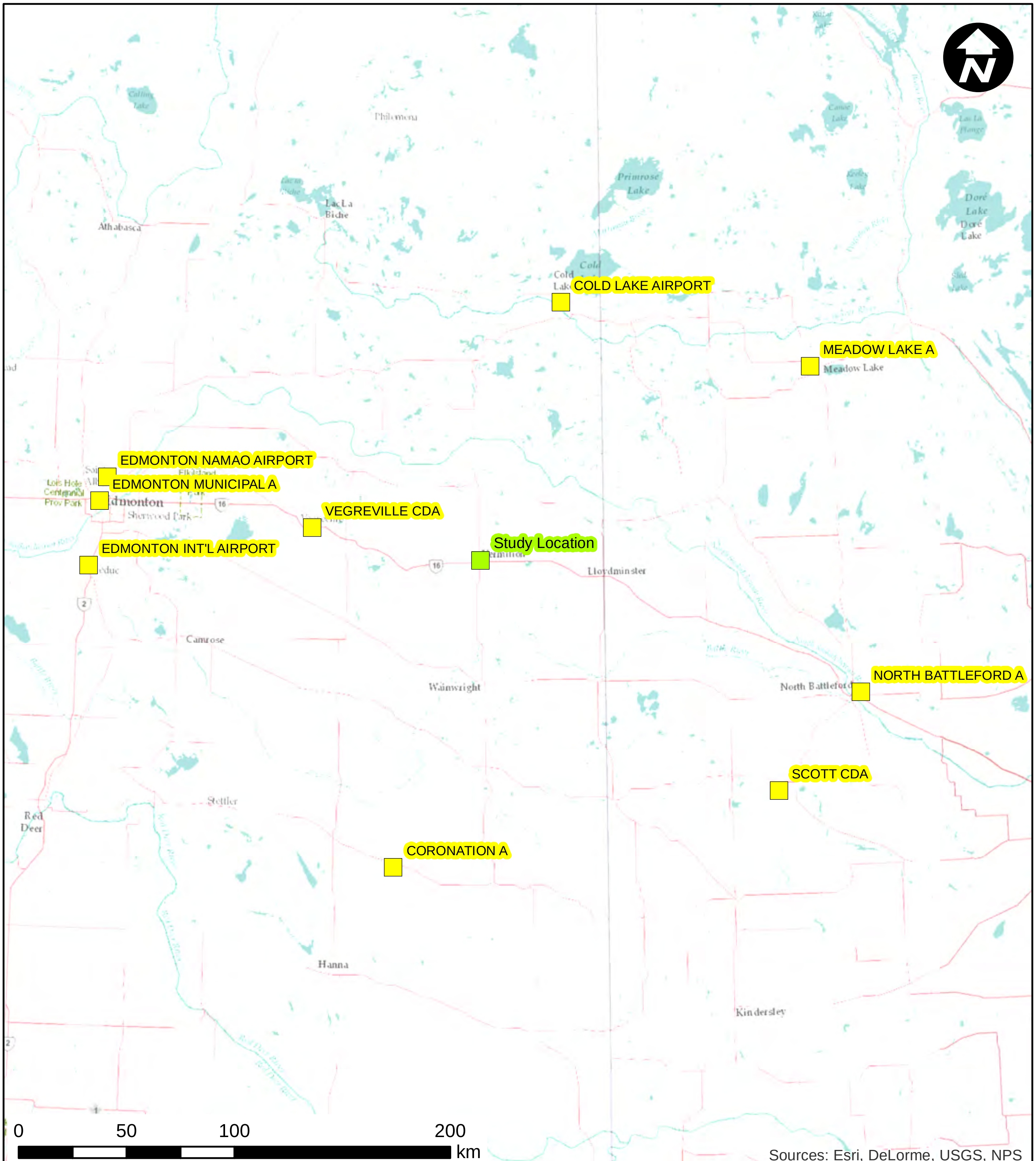

Legend/Notes:

Study Location

IDF Station Data

TOWN OF VERMILION ALBERTA

nhc northwest hydraulic consultants

TOWN OF VERMILION

TOWN OF VERMILIOIN FUNCTIONAL STORMWATER MANAGEMENT PLAN

IDF CLIMATE DATA STATION LOCATIONS

DRAFT

100119	JULY 2017	**FIGURE 2**

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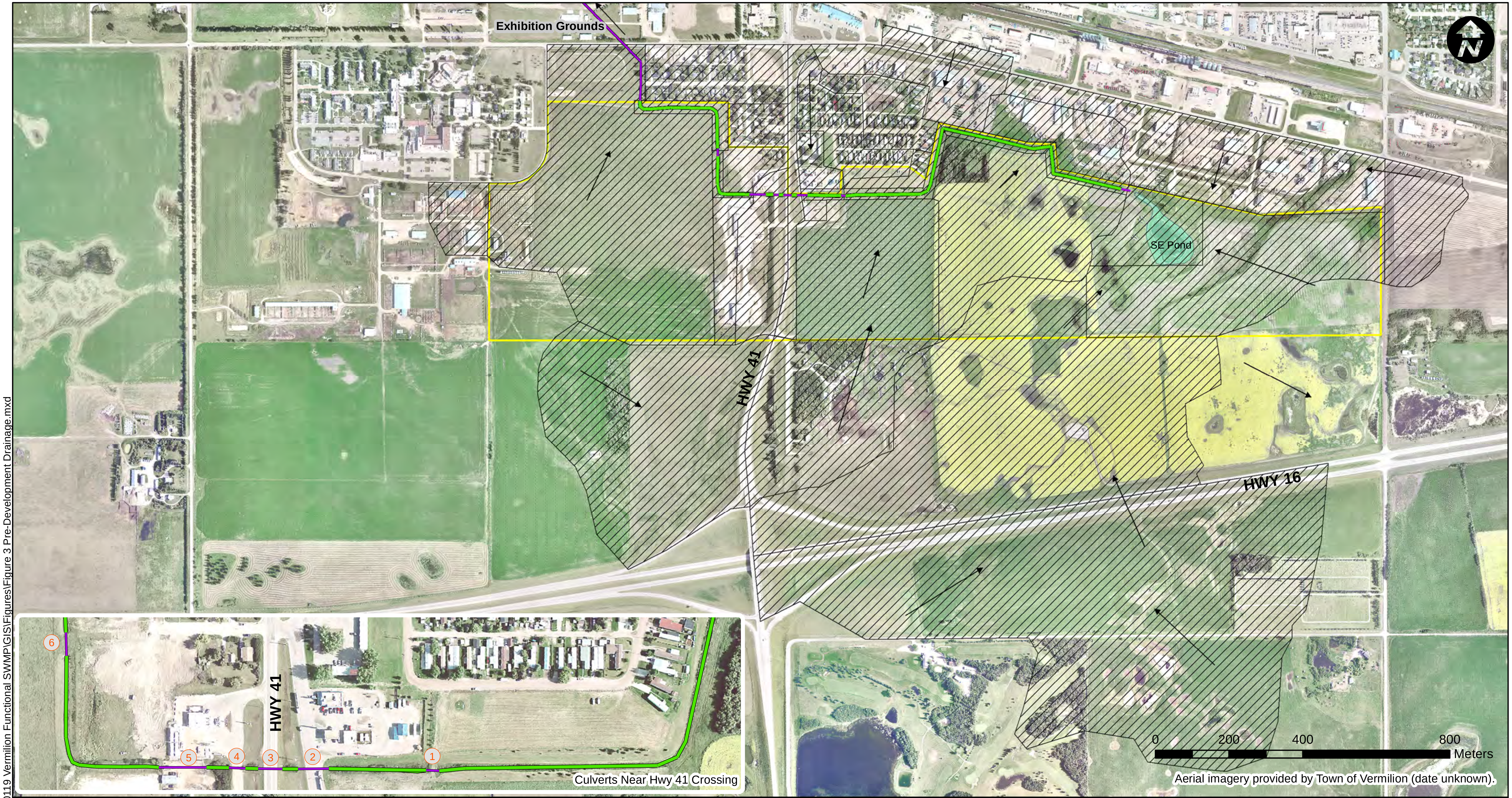


Path: P:\ Projects (Active)\100119 Vermilion Functional SWMP\GIS\Figures\Figure 3 Pre-Development Drainage.mxd

Legend/Notes:

- Functional Plan Area
- Sub Catchment
- Overland Drainage
- Pipe or Culvert
- Open Ditch

Culvert Descriptions

1. 3 x 600 mm diam, ~12m long, CSP [removed after July 2010 storm]
2. 1 x 900 mm diam, 29m long, CSP
3. 2 x 1200 mm diam, 23m long, CSP
4. 2 x 1200 mm diam, 15m long, CSP
5. 2 x 1050 mm diam, 45m long, CSP
6. 4 x 900 mm diam, 22m long, CSP

TOWN OF VERMILION ALBERTA

nhc northwest hydraulic consultants

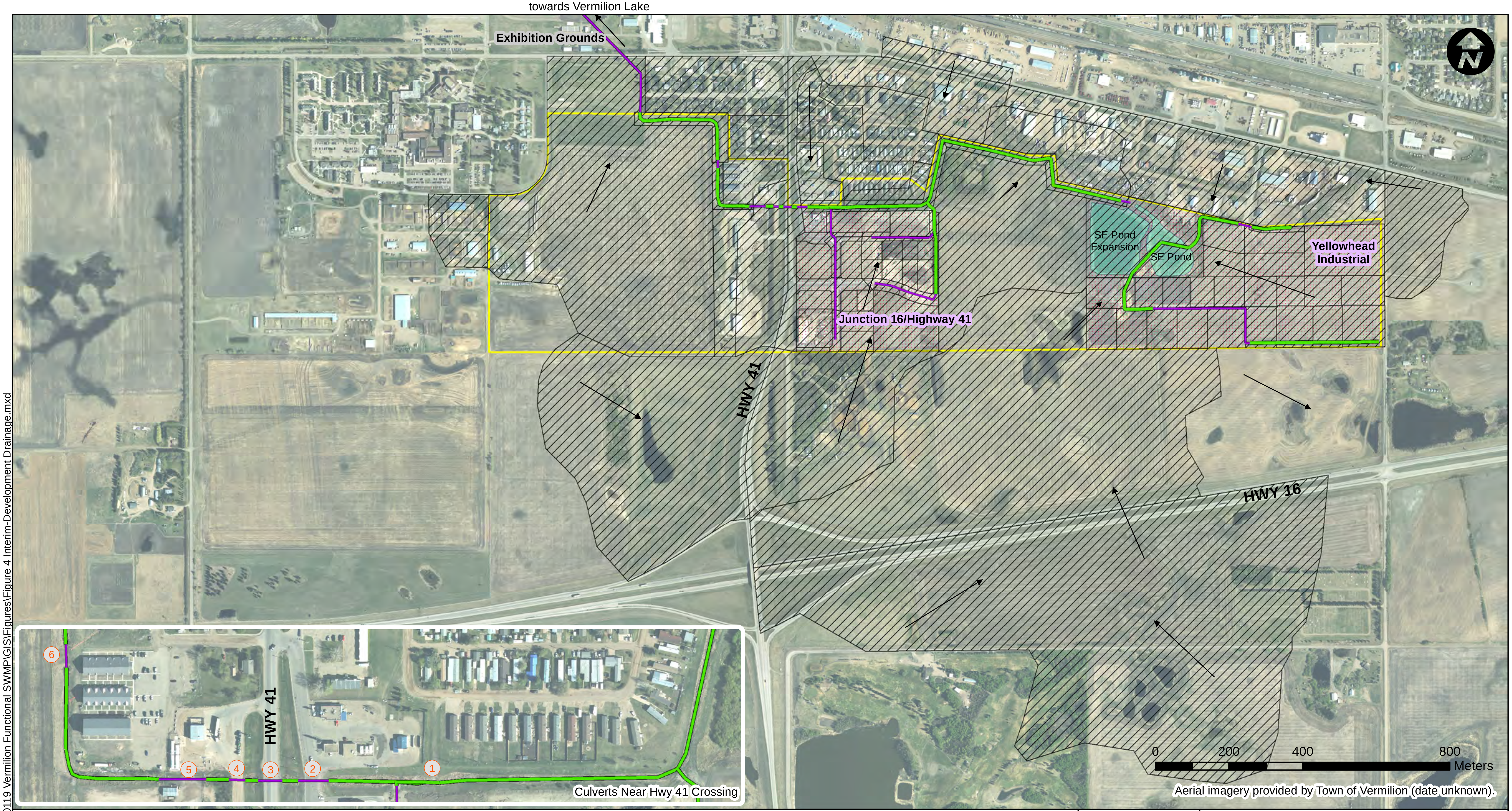
TOWN OF VERMILION

TOWN OF VERMILION FUNCTIONAL STORMWATER MANAGEMENT PLAN

PRE-DEVELOPMENT DRAINAGE

DRAFT

100119	JULY 2017	**FIGURE 3**



Legend/Notes:

- Functional Plan Area
- Subcatchment
- Overland Drainage
- SE Pond
- Recent_Development
- Pipe or Culvert
- Open Ditch

Culvert Descriptions

1. CULVERTS REMOVED
2. 1 x 900 mm diam, 29m long, CSP
3. 2 x 1200 mm diam, 23m long, CSP
4. 2 x 1200 mm diam, 15m long, CSP
5. 2 x 1050 mm diam, 45m long, CSP
6. 4 x 900 mm diam, 22m long, CSP

TOWN OF VERMILION ALBERTA

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TOWN OF VERMILION

TOWN OF VERMILION FUNCTIONAL STORMWATER MANAGEMENT PLAN

INTERIM-DEVELOPMENT DRAINAGE

DRAFT

100119	JULY 2017	**FIGURE 4**

Path: P:\ Projects (Active)\100119 Vermilion Functional SWMP\GIS\Figures\Figure 4 Interim-Development Drainage.mxd

Legend/Notes:

- Functional Plan Area
- Recent_Development
- Pond Options
- Subcatchment
- Pipe or Culvert
- Model Results Reporting Location
- Overland Drainage
- Open Ditch
- SE Pond

Culvert Descriptions

1. CULVERTS REMOVED
2. 1 x 900 mm diam, 29m long, CSP
3. 2 x 1200 mm diam, 23m long, CSP
4. 2 x 1200 mm diam, 15m long, CSP
5. 2 x 1050 mm diam, 45m long, CSP
6. 4 x 900 mm diam, 22m long, CSP

TOWN OF VERMILION ALBERTA

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TOWN OF VERMILION

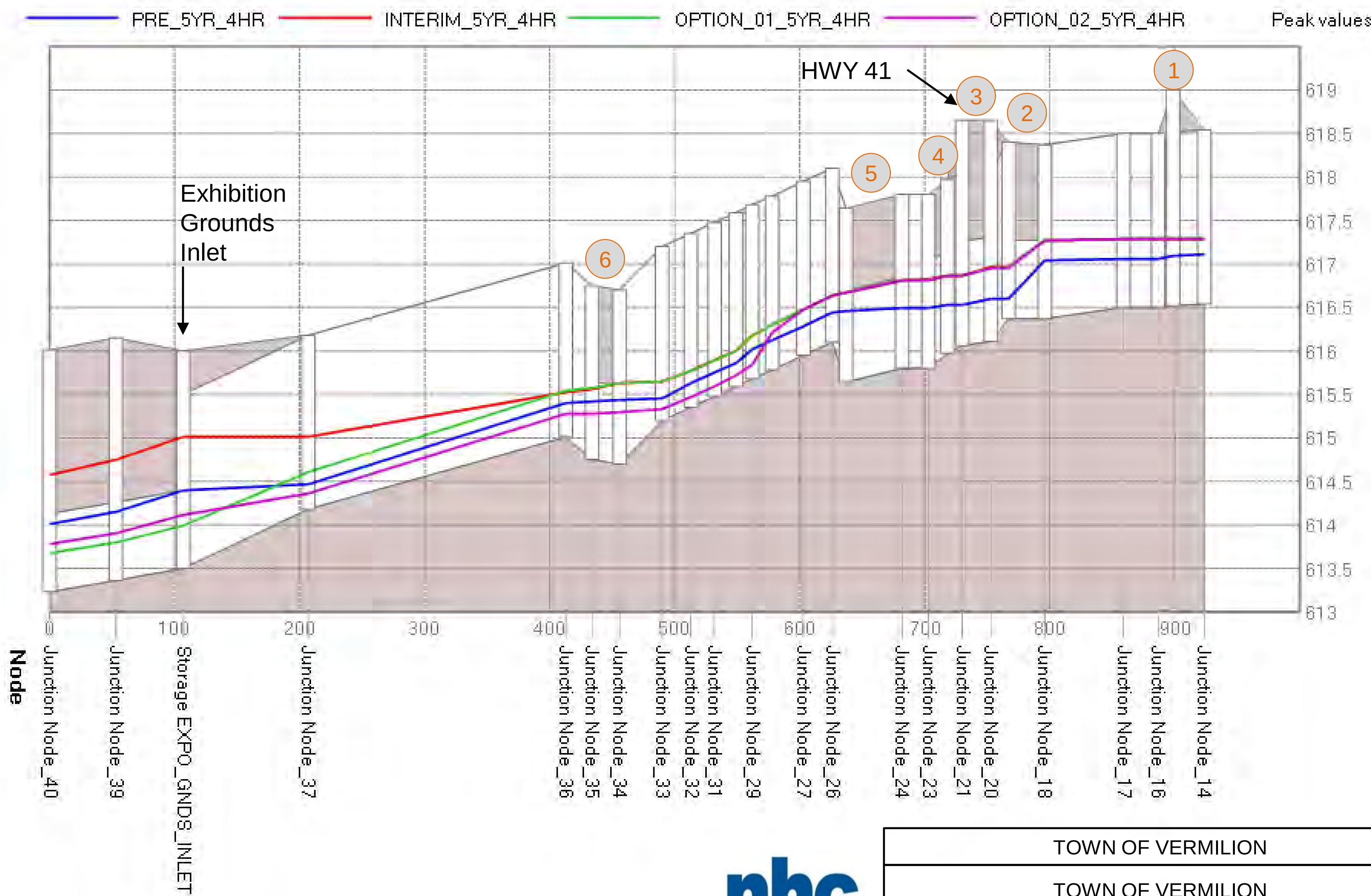
TOWN OF VERMILION FUNCTIONAL STORMWATER MANAGEMENT PLAN

POST-DEVELOPMENT DRAINAGE

DRAFT

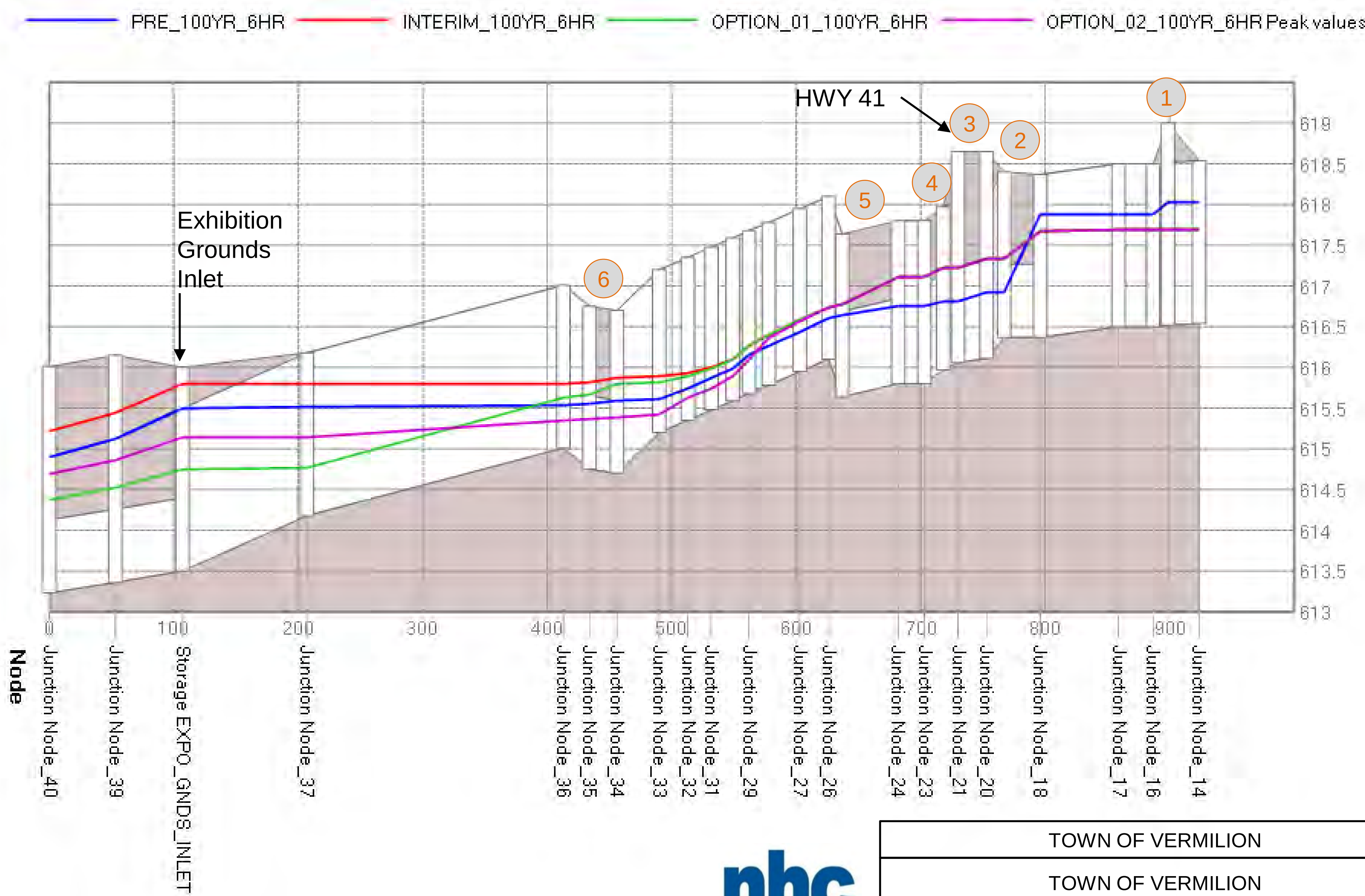
100119	JULY 2017	**FIGURE 5**

Path: P:\ Projects (Active)\100119 Vermilion Functional SWMP\GIS\Figures\Figure 5 Post-Development Drainage.mxd



(1) Culvert locations indicated on Figures 3 through 5

TOWN OF VERMILION		
TOWN OF VERMILION FUNCTIONAL STORMWATER MANAGEMENT PLAN **MAXIMUM HYDRAULIC GRADE LINE PROFILE** **GATEWAY TO EXHIBITION GROUNDS** **5-YEAR 4-HOUR DESIGN RAINFALL** DRAFT		
100119	JULY 2016	**FIGURE 6**



1 Culvert locations indicated on Figures 3 through 5

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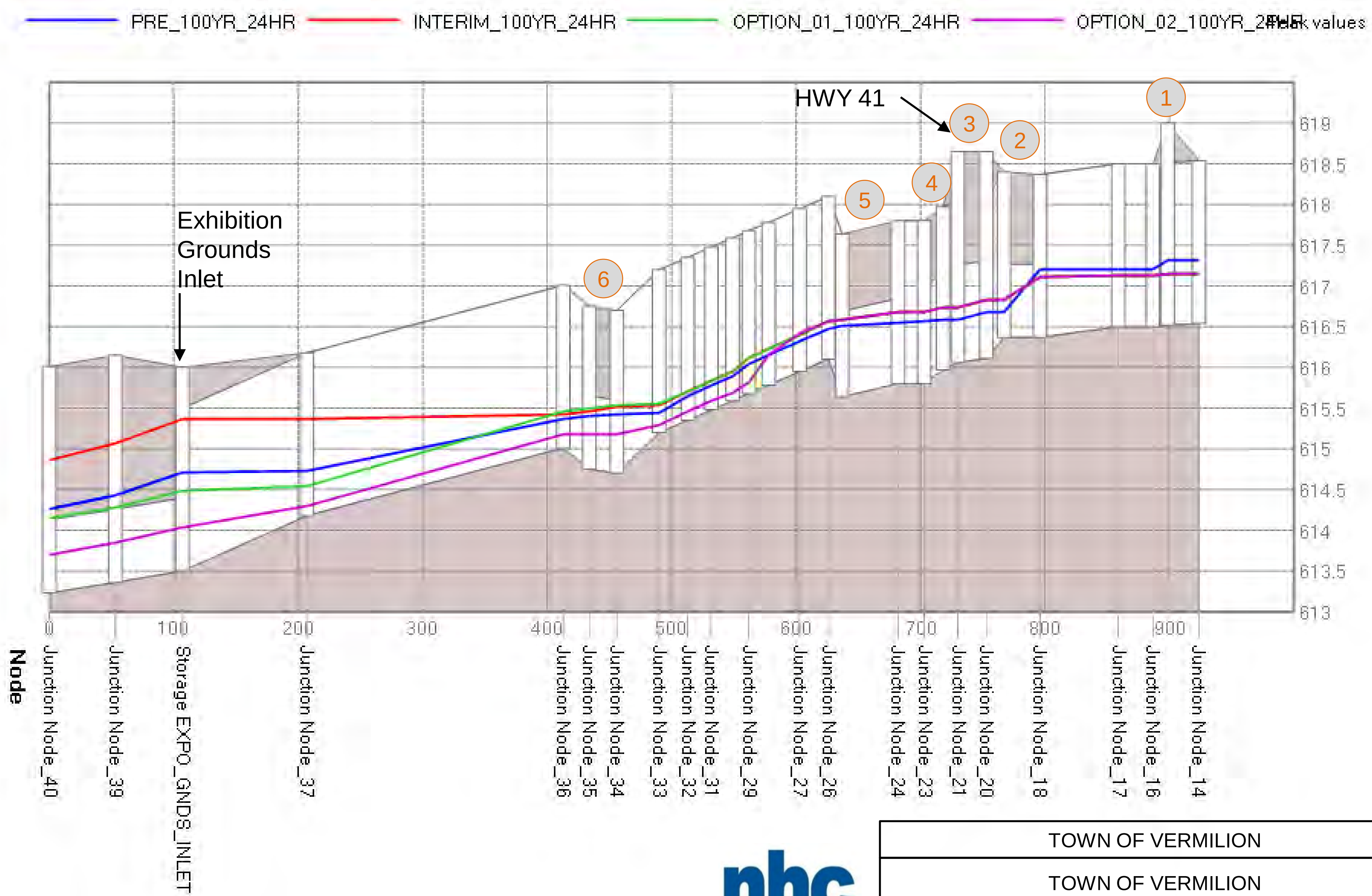
TOWN OF VERMILION		
TOWN OF VERMILION FUNCTIONAL STORMWATER MANAGEMENT PLAN **MAXIMUM HYDRAULIC GRADE LINE PROFILE** **GATEWAY TO EXHIBITION GROUNDS** **100-YEAR 6-HOUR DESIGN RAINFALL**		
100119	JULY 2016	**FIGURE 7**

DRAFT



(1) Culvert locations indicated on Figures 3 through 5

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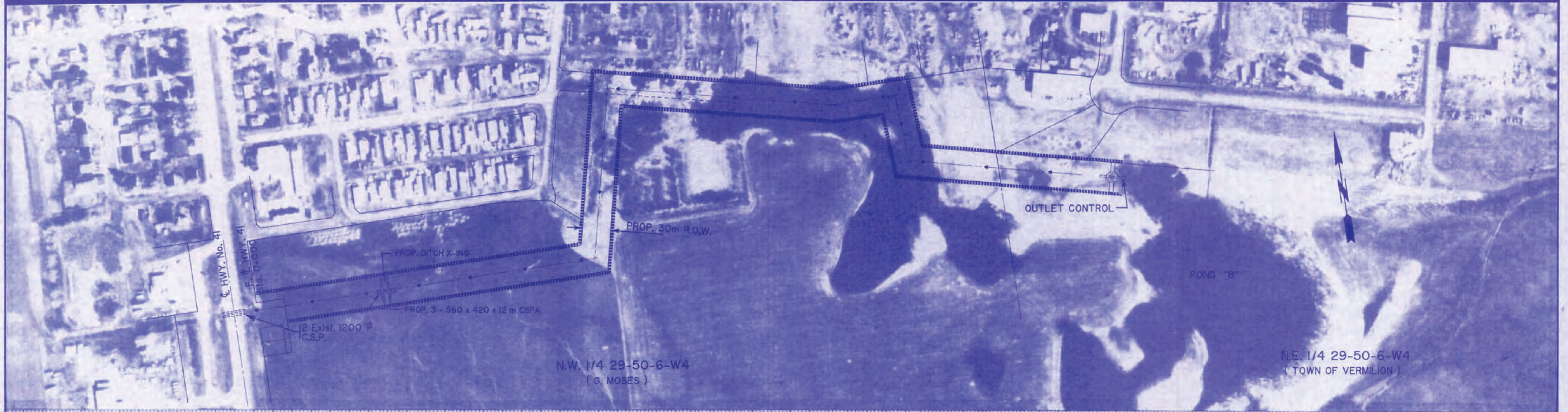
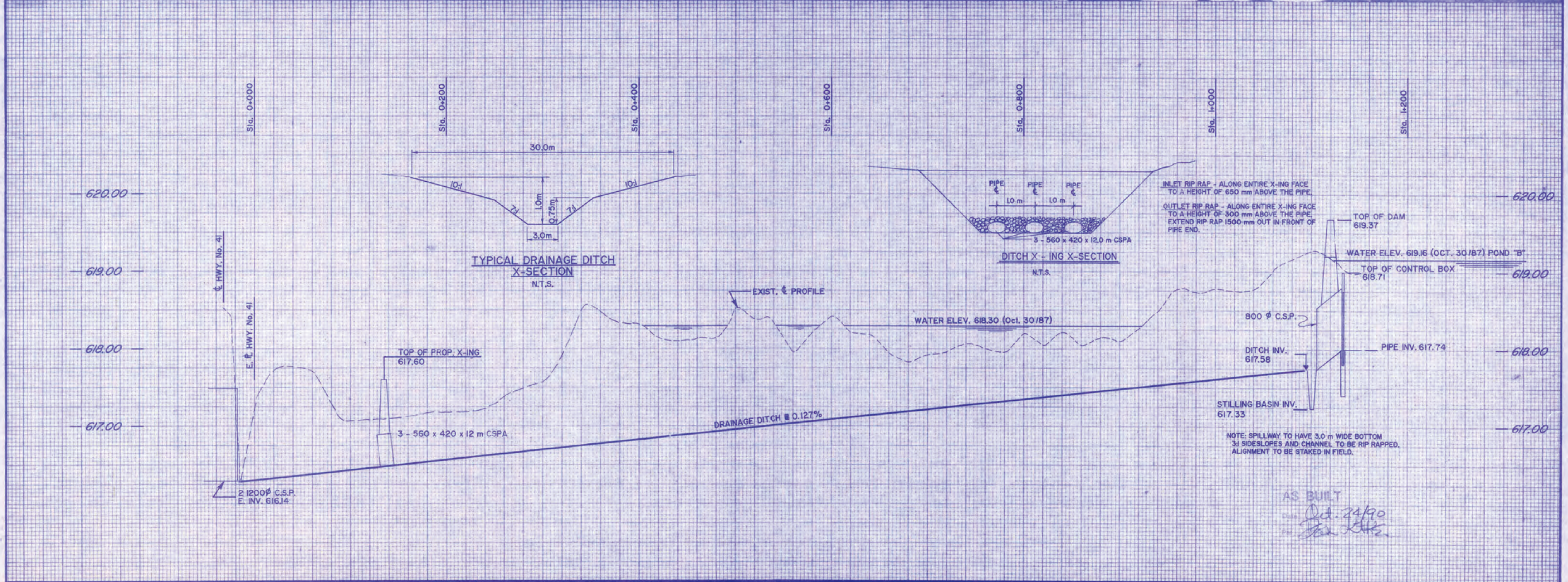
TOWN OF VERMILION		
TOWN OF VERMILION FUNCTIONAL STORMWATER MANAGEMENT PLAN **MAXIMUM HYDRAULIC GRADE LINE PROFILE** **GATEWAY TO EXHIBITION GROUNDS** **100-YEAR 24-HOUR DESIGN RAINFALL** DRAFT		
100119	JULY 2016	**FIGURE 8**

APPENDIX A





MARK	NATURE OF REVISION	DATE	ENG	DRWN

Note: The contractor shall be responsible for the location & protection of all existing utilities

PERMIT TO PRACTICE

Drawn By	G. LAFAUT
Design By	D. LITKE
Checked By	
Date	MAY, 1989
Job No.	7075-007
Scale — Horz	1:2000
Vert	1:25

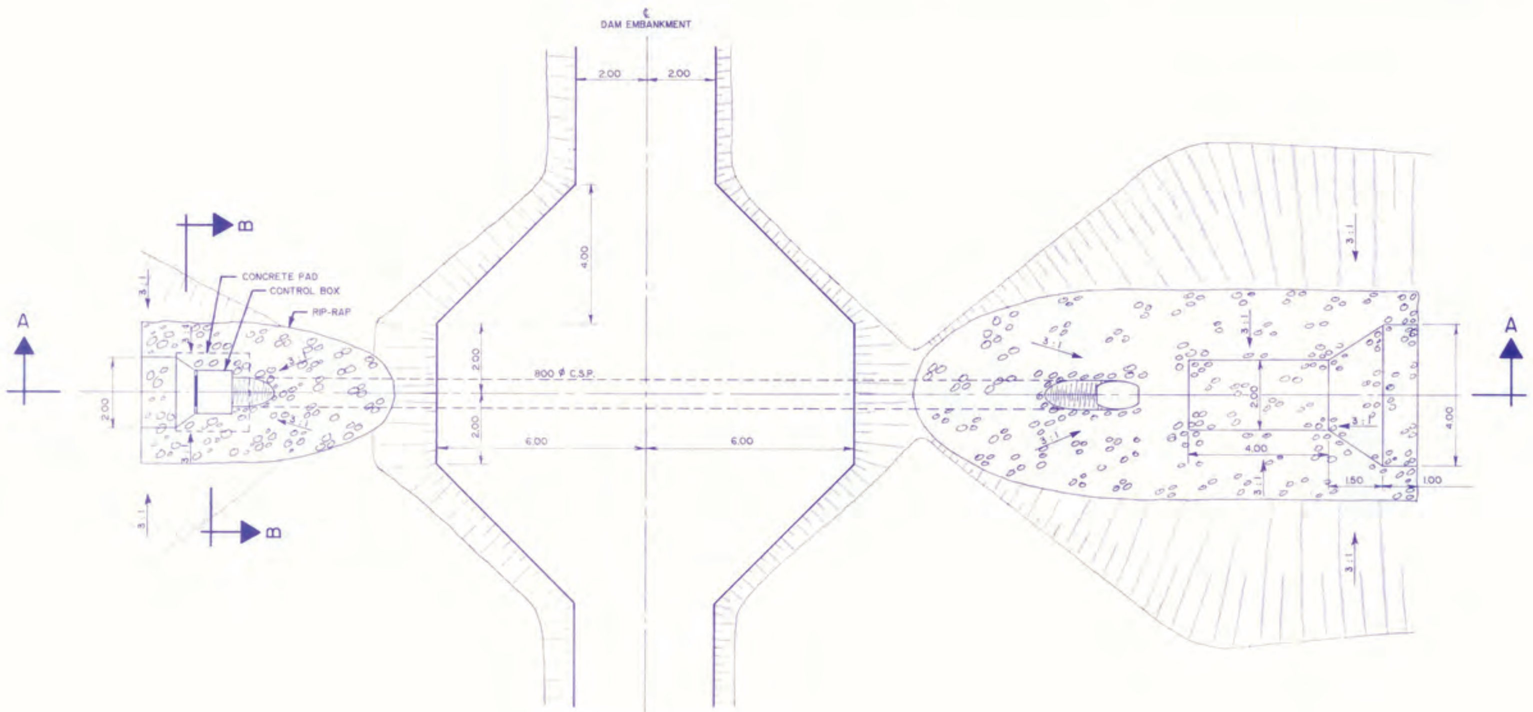
TOWN OF VERMILION

SOUTH CENTRAL DRAINAGE PROJECT

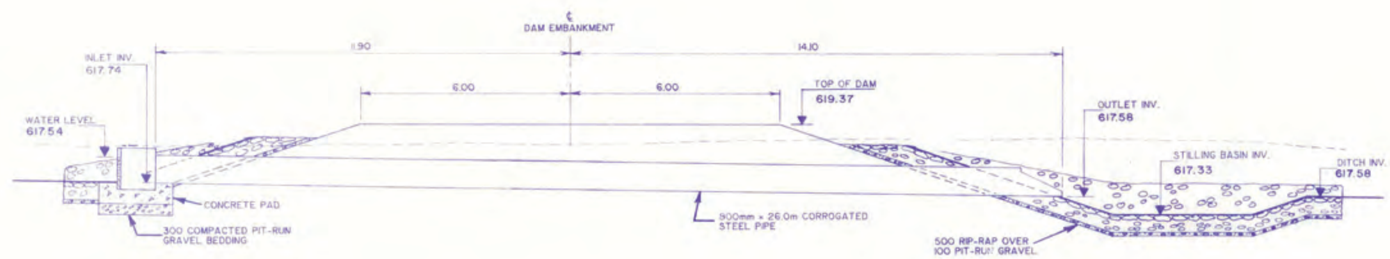
ALTERNATIVE "2"-STAGE 3

epec consulting group / Dean Litke Engineering Ltd.

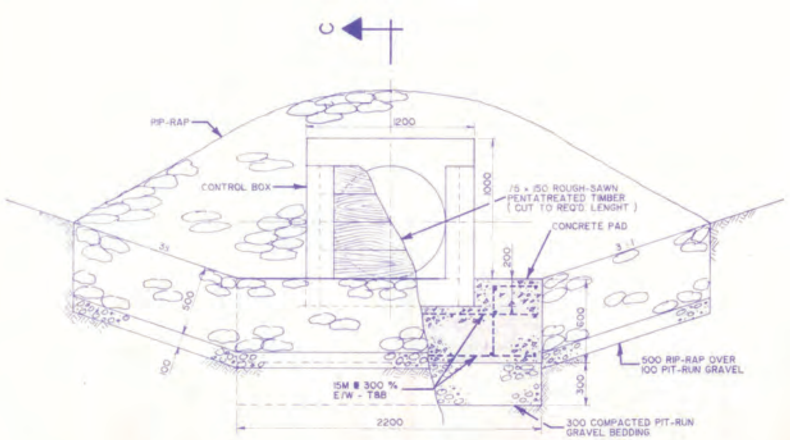
SHEET ONE OF TWO



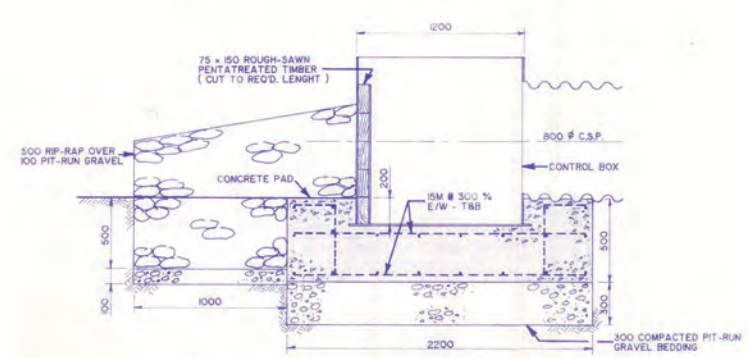
CONTROL SYSTEM
PLAN VIEW



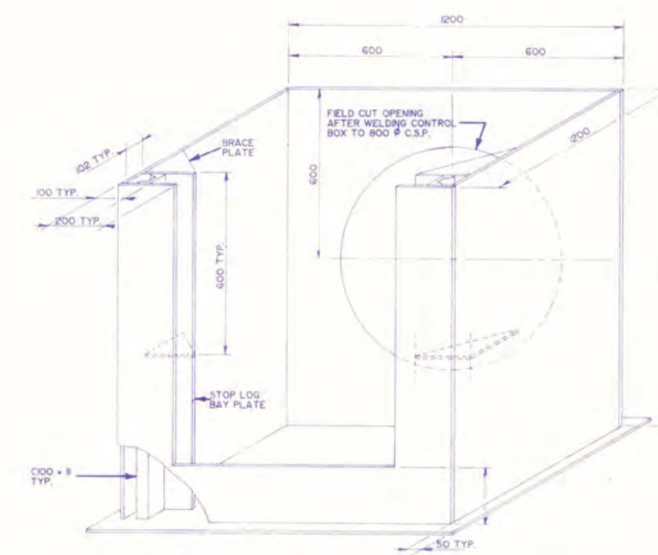
SECTION A-A



SECTION B-B



SECTION C-C



BOX TO BE FABRICATED USING 10 THK. PLATE
ALL JOINTS TO BE WELDED (5 mm FILLET) TO PROVIDE
WATER - TIGHT CORNERS

ALL METAL WORK TO BE CLEANED AND
PRIMED WITH RUST RESISTANT PAINT

CONTROL BOX
FABRICATION DETAIL

No.	NATURE OF REVISION	DATE

PROFESSIONAL ENGINEER DEAN J.C. LITKE ALBERTA

PERMIT TO PRACTICE
MAX SAHNSEN CONSULTING LTD.
OPERATING AS EPEC CONSULTING
Signature
Date July 23/89
PERMIT NUMBER: P 4046
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

Drawn By :	G. LAFAUT
Designed By :	D. LITKE
Checked By :	D. LITKE
Date :	JULY, 1989
Job No. :	7075-007
Scale :	N.T.S.

TOWN OF VERMILION
SOUTH CENTRAL DRAINAGE PROJECT
WATER LEVEL CONTROL

epec consulting group (lloyd) project management, procurement & construction

SHEET TWO OF TWO

The Epec Consulting Group (Lloyd) is a sole proprietorship of Max Sahnsen Developments Ltd.