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SEWRPC Staff Memorandum

BURLINGTON STORMWATER MANAGEMENT EVALUATION

April 5, 2019

INTRODUCTION AND SCOPE

In a meeting with the Southeastern Wisconsin Regional Planning Commission (SEWRPC) staff on September 7, 2017, the Burlington City Administrator requested that SEWRPC staff prepare a stormwater management analysis for a portion of the City's storm sewer system (Map A.1 in Appendix A). The area of interest, referred to herein as the study site area, is an industrial area on the southwest side of the City that includes the Lavelle Industries, KW Precast, Ardagh Group, WE Energies, Asphalt Contractors, and Cretex Materials properties. The low-lying areas on these properties along the west side of McHenry Street (CTH P), south of the Canadian National Railroad and north of the STH 11 Burlington Bypass, are subject to flooding resulting from high-intensity rainfall events. While the extreme rainfall events of July 2017 created widespread flooding for the study site area and the City, the Lavelle and Ardagh properties have experienced long-standing flooding issues on a frequent basis over the years.

The main objective of this planning-level evaluation is to create a reasonable representation of the existing storm sewer system serving the study site area (herein referred to as the storm sewer study route), and evaluate up to five alternatives to reduce surface flooding for the properties identified above. Major project tasks completed for this evaluation include:

- Compile existing conditions data for the storm sewer network and contributing drainage areas
- Conduct site visits to confirm subbasin divides for the contributing drainage areas and the drainage system configuration within the study site area
- Develop an existing conditions hydrologic and hydraulic model for the storm sewer study route and contributing drainage areas
- Starting from the existing conditions model, evaluate viable alternatives to reduce flooding for the study site area
- Develop planning-level cost estimates for the viable alternatives

DESCRIPTION OF STUDY AREA

This evaluation is focused on the areas served by the storm sewer study route and flooding in the study site area, which has repeatedly affected the properties located along the west side of McHenry Street south of Market Street. The storm sewer study route and the subbasins delineated for this evaluation are highlighted on Map A.1. The total drainage area considered to contribute runoff to the storm sewer study route is approximately 550 acres. Subbasin areas were determined based on topographic data and the City's storm sewer pipe networks. The delineation performed for the storm sewer study route included 28 subbasins

served by City storm sewers, and 12 subbasins within the study site area. For this evaluation, the City's portion of the storm sewer study route will be referred to as the municipal storm sewer.

Maps A.2 and A.3 in Appendix A presents the study site area and the 12 associated subbasins in detail. The total study site area is approximately 300 acres with nearly half of the area on the west side comprised of numerous low-lying depressional areas without outlets that do not contribute runoff to the storm sewer study route. Table 1 provides a summary of the subbasins that comprise the study site area, including drainage area and outlet information.

Table 1
Study Site Area Subbasin Summary

Subbasin	Drainage Area (acres)	Description	Outlet/Downstream Subbasin
A1	50.1	Ardagh (south)	Municipal Storm Sewer
A2	16.9	Ardagh (north)	Municipal Storm Sewer
A3	14.2	Lavelle (site) & WE Energies	Lavelle Pond to Lavelle Storm Sewer to Municipal Storm Sewer
A4	2.7	Lavelle (roof drainage)	Lavelle Storm Sewer to Municipal Storm Sewer
A5	2.0	WE Energies (former owner)	Railroad Culvert to Lavelle (A3)
A6	11.0	Asphalt Contractors, Inc.	Railroad Culvert to Lavelle (A3)
A7	12.5	KW Precast (southeast)	KW Precast Pond to Railroad Culvert to Lavelle (A3)
A8	35.4	KW Precast (northeast)	KW Precast Pond to Railroad Culvert to Lavelle (A3)
A9	5.3	Cretex Materials (entrance)	Railroad Culvert to Lavelle (A3)
A10	10.2	KW Precast (north)	Cretex Materials (A11 – no outlet)
A11	113.1	Cretex Materials (west)	Closed Basin (no outlet)
A12	26.7	KW Precast (northwest)	Closed Basin (no outlet)

Source: SEWRPC

The Canadian National (CN) Railroad splits the study site area into two distinct areas that are connected by a 36-inch diameter concrete culvert running underneath the railroad tracks. The lower area, south of the railroad tracks, includes the Lavelle property that has frequently experienced flooding. The upper area, north of the railroad tracks, includes the properties of KW Precast, Cretex Materials, WE Energies, and Asphalt Contractors. Under existing conditions excess rainfall from the upper area becomes stormwater runoff and flows to the Lavelle property through the 36-inch culvert under the railroad tracks. Once on the Lavelle property, runoff enters the onsite storm sewer system from which it discharges into the municipal storm sewer, and flows generally east to the outlet at the Fox River.

The remaining subbasins within the study site area include the Ardagh property, which is just north of the STH 11 Burlington Bypass and west of McHenry Street. Runoff from the Ardagh property drains into the municipal storm sewer at two separate locations near the upstream extent of the storm sewer study route along McHenry Street. The Ardagh property experiences flooding and frequently has standing water in the parking lot on the east side of the site. Anecdotal evidence indicates that flooding issues have gotten worse for the Ardagh property since the construction of the STH 11 Burlington Bypass. The Ardagh property subbasins are self-contained and not hydraulically connected to the Lavelle property; the railroad spur between the two properties is high enough to prevent cross-flow, and did so even during the extreme flooding of July 2017.

INPUT DATA SOURCES

The following data sources were used to develop the hydrologic/hydraulic model for the storm sewer study route. All elevations defined in this document are referenced to National Geodetic Vertical Datum of 1929 (NGVD29), and any vertical datum conversions or assumptions are stated in the following text.

Land Data

- 2010 Racine County topographic contour data with 2-foot contours, referenced to NGVD29
- 2015 Racine County digital orthophotography

- 2010 SEWRPC land use inventory

- 2016 Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO) hydrologic soil group data

Infrastructure Data

The following information was provided by Kapur & Associates:

- City of Burlington municipal storm sewer system data was provided in a GIS file. The GIS file was used in conjunction with supplemental large-scale system maps to determine pipe lengths, pipe diameters, invert elevations, manhole locations and depths for the storm sewer study route. Elevation data for the municipal storm sewer system are referenced to NGVD29.

- 2007 Stormwater Pollution Prevention Plan (SWPPP) for the KW Precast site (formerly JW Peters) provided data for hydraulic features including site ponds and storage features, pipes, and culverts. Elevation data utilized for the 2007 SWPPP are referenced to an undefined local vertical datum. The following datum relationship was developed based on the topographic data, field measurements and engineering judgement to convert SWPPP elevations to NGVD29.

    - NGVD29 Elevation = SWPPP Elevation + 698 feet

    - This elevation conversion assumption applies to the elevations of the KW Precast drainage features, the area near the railroad tracks at the outlet of the KW Precast pond, and the 36-inch diameter culvert running under the railroad tracks.

- Plan drawings from previous Lavelle expansion projects provided information related to the on-site storm sewer system, the existing stormwater pond, and local grade elevations. All elevation data obtained from the following reference materials are assumed to be referenced to NGVD29:

    - 2009 parking lot plan by Kapur & Associates

    - 2011 parking lot surfacing plan by Reesman's Excavating & Grading

    - 2014 site survey performed by Baxter & Woodman

    - 2015 parking lot expansion plan by Lynch & Associates

    - 2017 site improvement plans by Lynch & Associates

    - 2018 conceptual design expansion plans by Peter Scherrer Group

- STH 11 Burlington Bypass and McHenry Street (CTH P) Interchange drawings developed by Kapur & Associates in 2008 provided data related to the Wisconsin Department of Transportation (WisDOT) stormwater pond located near the northeast ramp access for McHenry Street, drainage culverts, and modifications to the municipal storm sewer system under McHenry Street. The vertical datum for this plan set is NGVD29.

- McHenry Street (CTH P) utility improvement plans developed by Kapur & Associates in 2009 provided data related to municipal storm sewer modifications. All elevation data are assumed to be referenced to NGVD29.

Rainfall Data

- National Oceanic and Atmospheric Administration (NOAA) Atlas 14, Volume 8, Version 2.0

- 2006 SEWRPC rainfall distribution

Fox River Water Level Data

- National Weather Service (NWS) Advanced Hydrologic Prediction Service (AHPS) River Stage Gauging Station: Fox River at Burlington (BRGW3). The datum conversion for river stage height provided on the NWS website is assumed to be equivalent to NGVD29.

- Federal Emergency Management Agency (FEMA) Racine County Flood Insurance Study (FIS) Volume 2, effective date: May 2, 2012

MODEL DEVELOPMENT

The Environmental Protection Agency (EPA) Storm Water Management Model (SWMM) model is a dynamic rainfall-runoff-routing model and was used to represent hydrologic and hydraulic features serving the study site area. EPA SWMM is public domain software, and the model version used for this evaluation is 5.1.012. EPA SWMM simulates rainfall over subbasins and generates runoff hydrographs, which are routed through various hydraulic features including ponds, culverts and pipes. The model was run using single storm event simulation with dynamic wave flow routing, which allows for the evaluation of pressure flow, reverse flow, and other complicated hydraulics that are not accommodated by other more simplified routing approach methods. The model results include runoff timing, volumes, flow rates, flow depths, and ponded depths for each model component throughout the duration of the simulation.

Hydrologic Features – Subbasin Characterization

Following subbasin delineation, the hydrologic parameters affecting stormwater runoff generation were developed for each subbasin shown on Map A.1. Physical subbasin parameters were measured and the longest flow path for each subbasin was identified and used to derive the average slope and the characteristic subbasin width. Parameters representing depression storage and surface roughness for overland flow were established for pervious and impervious surfaces based on standard values provided in the SWMM Hydrology Reference Manual. The NRCS curve number method was utilized to model infiltration, and a composite curve number was developed for each subbasin by overlaying the land use data on soil data. The percent impervious cover was estimated based on the types of land use within each subbasin. The one exception is Subbasin A4, which encompasses the Lavelle building and front loading dock footprint and represents the roof drain system that discharges directly into Lavelle's storm sewer pipe that runs under the building. Subbasin A4 is considered to be 100 percent impervious and is assigned a curve number of 98, consistent with directly connected impervious surfaces. The model routes runoff hydrographs from each subbasin directly to either a stormwater storage feature or to a manhole located on the storm sewer study route.

Hydraulic Features

The existing hydraulic features included in the SWMM model drainage network are discussed in the following text, starting at the downstream end of the drainage network and moving upstream through the system. Figure 1 illustrates the existing conditions model schematic for the hydraulic features in the study site area.

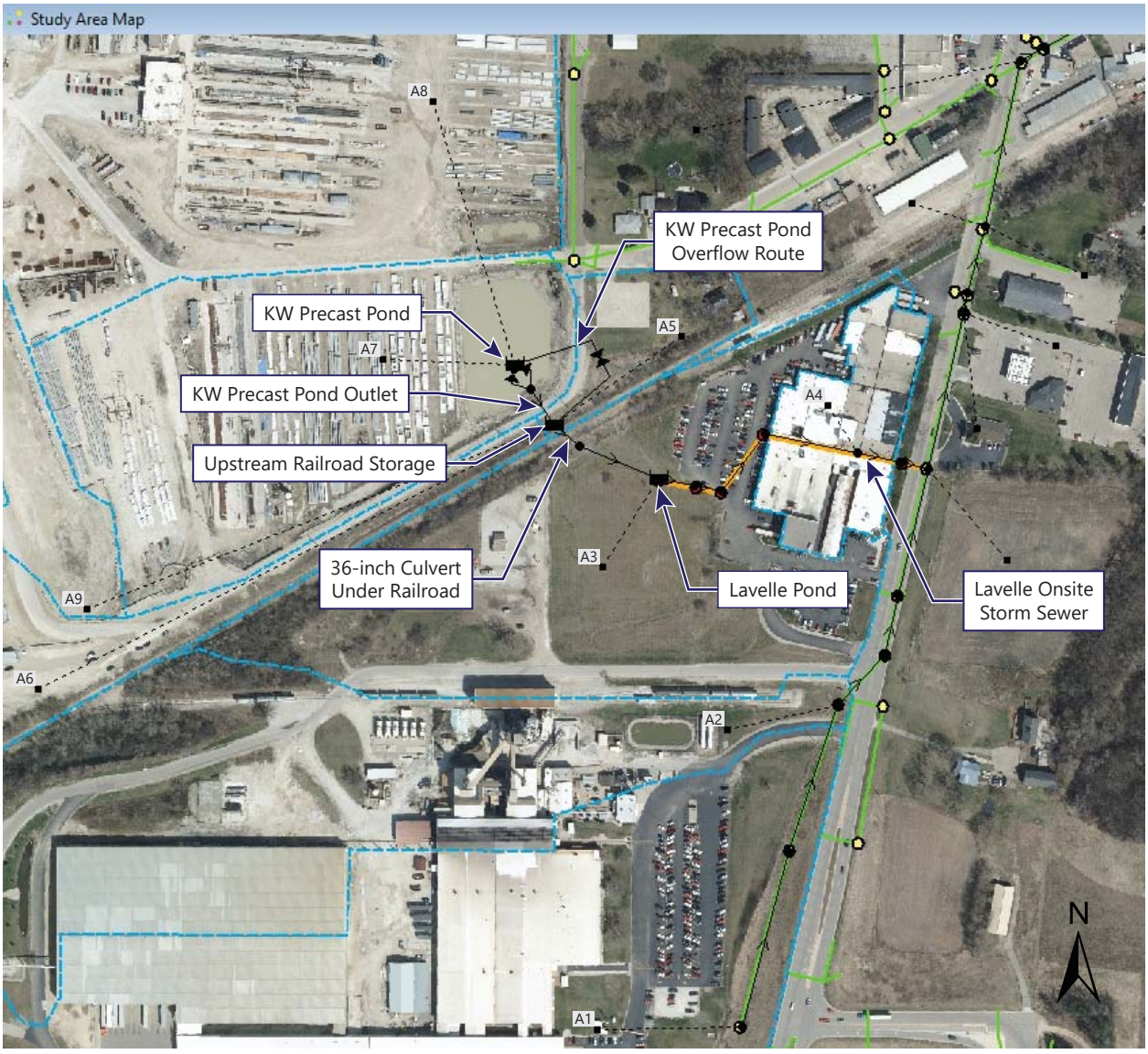
Municipal Storm Sewer Study Route

The municipal portion of the storm sewer study route was modeled using pipe and manhole data provided by Kapur & Associates. The study route consists of one 36-inch diameter circular concrete pipe along McHenry Street, transitioning into one 48-inch diameter circular concrete pipe along Market Street, and continuing downstream to the outlet at the Fox River.

When storm sewer pipes receive more runoff than they are designed to carry, the SWMM model stores this excess water until it can be reintroduced into the system as capacity allows. The dynamic wave routing method allows the modeler to define a surface area over which the ponding would occur above a manhole or pipe junction. Four such ponded areas are provided in the model along the municipal portion of the storm sewer study route to account for sag storage on roadways or low-lying areas adjacent to McHenry Street or Market Street. The ponded areas included in the SWMM model were estimated using topographic contour data at the four discrete locations.

The municipal storm sewer pipe network branches shown on Map A.1 feeding into the storm sewer study route were not explicitly represented in the SWMM model for this evaluation; however, the subbasins

Figure 1
Existing Conditions Model Schematic – Study Site Area Hydraulic Features



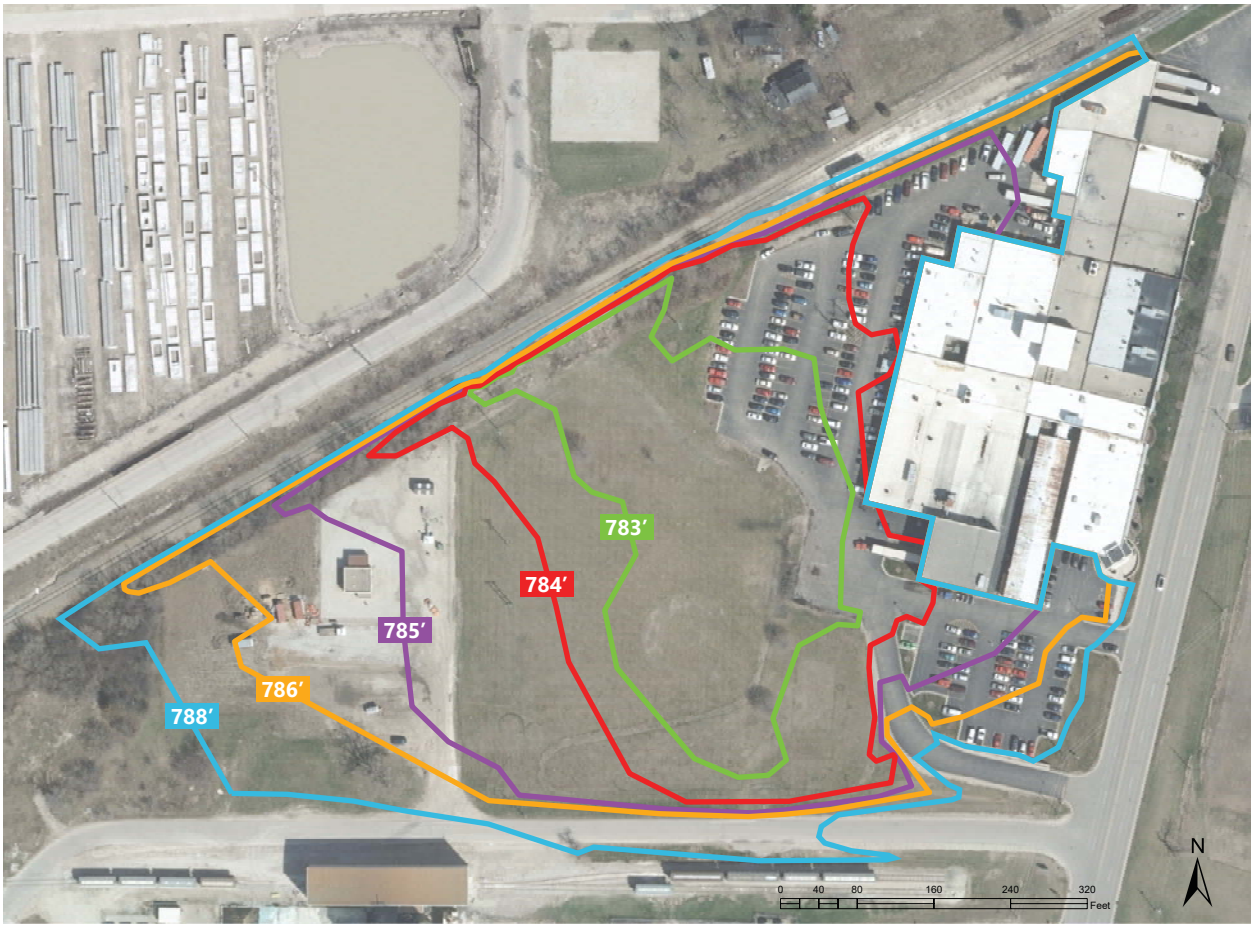
Source: SEWRPC

served by these storm sewer branches are included in the model, and the runoff hydrographs from these subbasins are routed directly into the storm sewer study route. The subbasin delineations for the municipal storm sewers were based on the data received and engineering judgment, employing assumptions for flow split locations at local high points in the storm sewer pipe network. Map A.1 also includes several subbasins identified as non-contributing to the storm sewer study route, based on the data received and engineering judgement.

Lavelle Storm Sewer Network and Existing Pond

Stormwater runoff on the Lavelle property enters the municipal storm sewer through a 15-inch diameter concrete storm sewer pipe that runs under their building. Data for the Lavelle storm sewer network was obtained from plan drawings and field measurements/observations. Plan drawings were used define the invert elevations at the upstream and downstream ends of the system, and intermediate invert elevations are assigned assuming a constant slope between known elevations. The Lavelle roof drain system enters the 15-inch pipe under the building, and as there were no details available for the layout of the roof drain system, runoff from the roof drains was modeled to discharge into the 15-inch pipe at one central location under the building. The Lavelle storm sewer network also collects runoff from the parking lot and local

Figure 2
Approximate Contours used to Model Stormwater Ponding (above 782 feet) Within Subbasin A3



Source: Lavelle Industries Grading Plan (Lynch & Associates, 04/23/2015) and SEWRPC

area around the Lavelle building and provides an outlet for the existing pond on the property. A backflow prevention valve was installed in September 2017 on the 15-inch diameter Lavelle storm sewer pipe just upstream of the municipal connection. This valve is included in the SWMM model as a flap gate to prevent flow from the municipal storm sewer system from entering the Lavelle storm sewer pipes and pond.

The existing pond just west of the parking lot at Lavelle collects runoff and drains directly into the Lavelle storm sewer network through a 12-inch diameter pipe with a flared end section. The existing pond has an approximate bottom elevation of 779 feet NGVD29 and a top elevation of 782 feet NGVD29, and provides approximately 0.3 acre-feet of stormwater storage. For modeling purposes, the storage curve for the Lavelle pond was extended above the top of the pond up to an elevation of 788 feet NGVD29 using both the 2010 contour data and the 2015 design drawings in order to represent the available flood storage within Subbasin A3 beyond the existing pond and estimate the maximum water level at Lavelle during modeled flood events. Figure 2 presents the approximate contours above the top of pond elevation of 782 feet NGVD used to develop the storage curve for the Lavelle pond. Localized flooding in the Lavelle parking lot occurs when water levels rise above the catch basin rim elevations, and site flooding becomes more widespread as water levels rise above the existing top of pond elevation of approximately 782 feet NGVD.

Culvert under Railroad and Upstream Storage Area

Runoff from subbasins upstream of the CN Railroad drain onto the Lavelle site through a 36-inch diameter circular concrete culvert that runs under the railroad tracks. The culvert empties into a low-lying area on the south side of the railroad tracks and from there runoff flows overland to the existing Lavelle pond. The invert elevations of the railroad culvert were approximated using data from the KW Precast SWPPP along with

data from the 2014 Baxter & Woodman survey. The SWPPP includes a small storage area at the upstream end of the 36-inch culvert, which receives discharge from the upstream KW Precast pond and collects runoff that drains to the low-lying areas along the north side of the CN railroad. The railroad stormwater storage area is located between the CN railroad and the Cretex Materials access road, and is modeled in SWMM using the same storage curve utilized for the KW Precast SWPPP.

Existing KW Precast Pond

The existing KW Precast pond was constructed for water quality control purposes. As a flow-through pond, with the inlet and outlet pipes installed at the same elevation, it does not offer significant stormwater storage capacity. The pond and related hydraulic features were included in the SWMM model based on data provided within the KW Precast SWPPP. The pond storage curve presented in the SWPPP indicates there is approximately 6.5 acre-feet of stormwater storage available between the lowest pond outlet feature and the lowest elevation along the top of the existing pond (approximately 785.4 feet NGVD). For modeling purposes, the existing pond storage curve from the SWPPP was extended to elevation 787 feet NGVD29 using 2010 contour data. The existing KW pond outlet is multi-level with a low-level orifice and an overflow weir that both discharge into the 54-inch diameter concrete outlet pipe running under the Cretex Materials access road to the 36-inch concrete culvert under the CN railroad. An overflow route for this pond is included in the SWMM model to provide a relief route for runoff exceeding the modeled pond storage capacity. The overflow route is based on emergency spillway data from the KW Precast SWPPP and available topography. The overflow route allows excess runoff to flow over the road on the east side of the pond, and is routed to the storage feature described above at the upstream end of the CN railroad culvert.

Design Storm Events

NOAA Atlas 14 was used to obtain rainfall depth and duration data for the study site area in the City of Burlington. The rainfall depth-duration data was used in conjunction with the SEWRPC storm distribution to develop the design storm input. Several design storm events were modeled in SWMM, ranging from the 50-percent-annual-probability (2-year recurrence interval) to the 1-percent-annual-probability (100-year recurrence interval). All events reflect a 24-hour storm duration. Table 2 presents the design storm rainfall data used in this evaluation.

Table 2
Design Storm Rainfall Data for Study Site Area

Design Storm Event	Recurrence Interval (years)	24-hour Rainfall Depth (inches)
50-percent-annual-probability	2	2.72
20-percent-annual-probability	5	3.33
10-percent-annual-probability	10	3.88
4-percent-annual-probability	25	4.68
2-percent-annual-probability	50	5.35
1-percent-annual-probability	100	6.05

Source: NOAA Atlas 14, Volume 8, Version 2.0 (Coordinates: 42.6651, -88.2863)

Fox River Water Level

While Fox River flooding presents a serious risk to the City of Burlington, the scope of this analysis is focused on flooding in the study site area on the southwestern side of the City, which results from excess stormwater runoff due to high-intensity rainfall events. While it is recognized that high water levels on the Fox River can inhibit flow from the municipal storm sewer system and create flooding issues for low-lying areas near the river, the Fox River is not the primary source of flooding issues for the study site area. Additionally, the Fox River drainage area above Burlington is approximately 744 square miles and takes several days to reach peak flood levels in the City, while the single storm events considered in this analysis would peak significantly earlier. Therefore, relatively normal river water levels were used for this evaluation and are discussed in the following text.

The water level in the Fox River serves as the downstream boundary condition for the modeled storm sewer study route. The downstream boundary condition was developed based on water level data recorded at the

NWS river stage gauge station for the Fox River at Burlington, which is located nearly one mile upstream of the storm sewer study route outlet. Based on NWS gauge data, minor flood stage occurs at 11 feet with the flood action stage established at 9 feet. For this evaluation a river stage of 8 feet at the NWS gauge was used, which is one foot below the flood action stage and corresponds to an approximate elevation of 751.7 feet NGVD29. The water level at the storm sewer study route outlet nearly one mile downstream is estimated to be approximately one foot below the water level at the NWS gauge station, based on the water surface gradient for the Fox River flood profiles presented in the Racine County FIS. Hence, a water surface elevation of 750.7 feet NGVD29 in the Fox River was utilized as the downstream boundary condition for the SWMM model. This elevation corresponds to approximately 2 feet of water above the invert elevation of the municipal storm sewer outlet pipe.

EXISTING CONDITIONS MODEL RESULTS

The existing conditions model developed for this evaluation was run for various design storm events. For each storm event, the model generates stormwater runoff hydrographs and routes runoff through the stormwater ponds and storm sewer study route. The total volume of runoff generated during the 1-percent-annual-probability (100-year recurrence interval) storm event for each subbasin in the study site area is presented in Table 3.

Table 3
Study Site Area Subbasin Runoff Volumes for the 100-year Recurrence Interval Storm Event

Subbasin	Description	Total Runoff Volume (acre-feet)
A1	Ardagh (south)	19.8
A2	Ardagh (north)	7.1
A3	Lavelle (site) & WE Energies	5.8
A4	Lavelle (roof drainage)	1.3
A5	WE Energies (former owner)	0.7
A6	Asphalt Contractors, Inc.	4.4
A7	KW Precast (southeast)	5.7
A8	KW Precast (northeast)	15.7
A9	Cretex Materials (entrance)	2.1

Note: Total runoff volumes are obtained from the existing conditions SWMM model, and represent the total amount of runoff generated for each subbasin.

Source: SEWRPC

Table 4 presents the SWMM model results for the maximum water level in the existing stormwater ponds at Lavelle and KW Precast for each storm event. The existing conditions model results indicate that the existing stormwater pond at Lavelle is not sufficient to handle the 50-percent-annual-probability (2-year recurrence interval) storm event without flooding, with a maximum water level at the site of nearly 1.5 feet above the top of the pond during this storm event. The existing KW Precast pond has the capacity to store up to the 4-percent-annual-probability (25-year recurrence interval) storm event, but the pond is overtopped (i.e., water levels exceed the top of pond elevation) for larger storm events.

Based on the City's stormwater management ordinance, the municipal storm sewer system should be designed to convey the 10-percent-annual-probability (10-year recurrence interval) storm event with a 24-hour duration. Figure 3 shows the maximum water surface profile along the municipal storm sewer system during the 5-year recurrence interval storm event. The SWMM model indicates that while some pipe capacities are exceeded, the system can convey the 5-year recurrence interval storm event without street flooding along the municipal storm sewer study route. The maximum water surface profile along the municipal storm sewer line during the 10-year recurrence interval storm event, presented in Figure 4, shows minor ponding on Market Street just west of the intersection with Pine Street and further upstream near the intersection with Emerson Street. The current level of service of the municipal storm sewer study route is estimated to be just below the 10-year recurrence interval storm event. Model runs indicate that conveyance improvements to the storm sewer study route, as required to meet the 10-year recurrence interval level of service, would not alleviate flooding in the study site area and would have a negligible impact on water levels at Lavelle.

Table 4
Existing Conditions Model Results for Design Storm Events

Design Storm Recurrence Interval	Existing Lavelle Pond[a]		Existing KW Precast Pond[b]		Duration of Zero Outflow from Study Site Area[c] (hours)
	Maximum Water Surface Elevation (feet NGVD29)	Maximum Volume (acre-feet)	Maximum Water Surface Elevation (feet NGVD29)	Maximum Volume (acre-feet)	
100-year	[786.3]	21.1	[786.3]	9.5	10.6
50-year	[785.8]	17.2	[785.8]	7.7	8.3
25-year	[785.3]	13.4	785.4	6.4	5.9
10-year	[784.6]	8.5	784.6	5.1	2.1
5-year	[784.0]	5.2	784.2	4.5	0
2-year	[783.3]	2.7	784.0	4.1	0

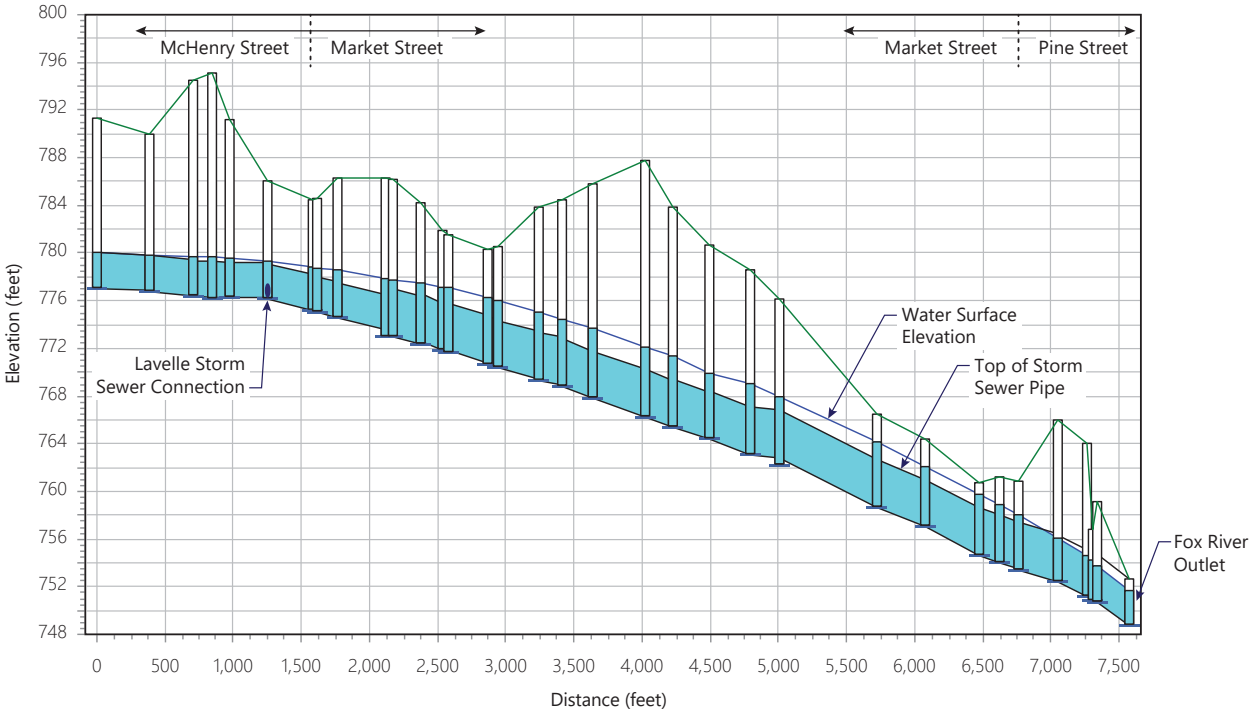
[a] *The existing Lavelle top of pond elevation is approximately 782 feet NGVD29; water surface elevations within brackets indicate pond overtopping*

[b] *The existing KW Precast lowest top of pond elevation is approximately 785.4 feet NGVD29; water surface elevations within brackets indicate pond overtopping*

[c] *The duration of zero outflow from the study site area represents the duration over which the municipal storm sewer is surcharged and unable to accept additional flow*

Source: SEWRPC

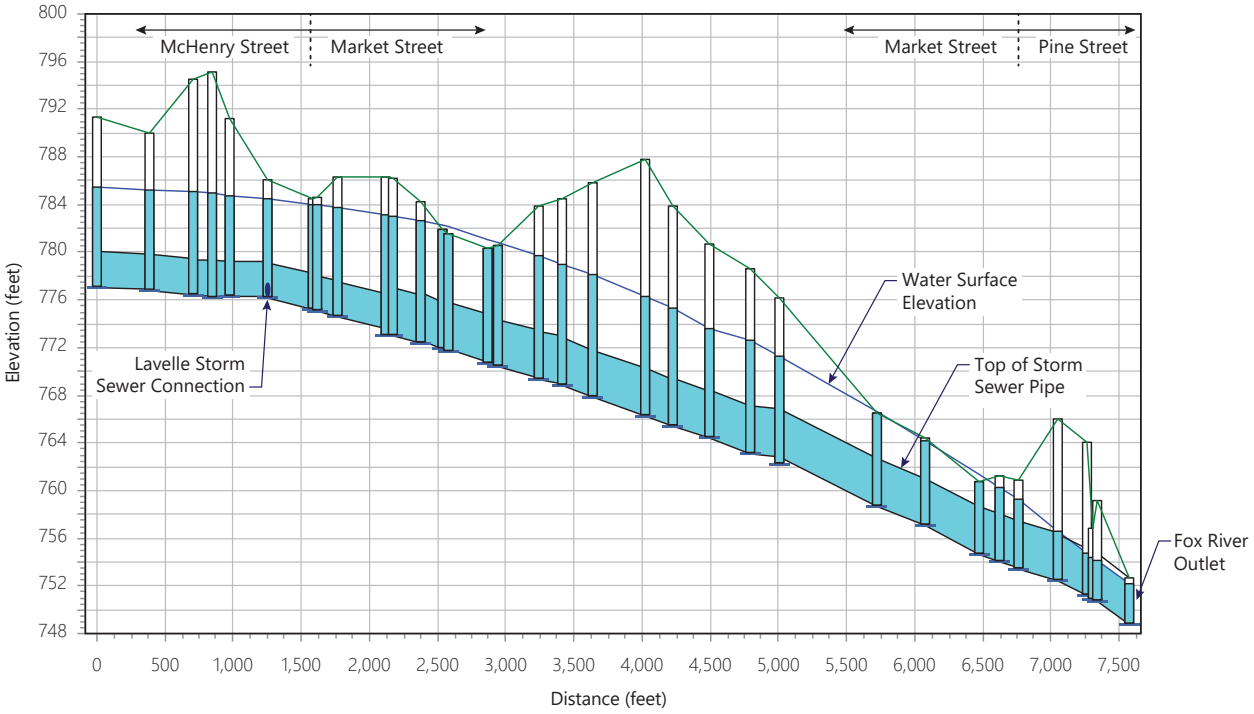
Figure 3
Existing Conditions Model Results 5-year Recurrence Interval Design Storm: Municipal Storm Sewer Study Route Maximum Water Surface Elevation Profile



Source: SEWRPC

For storm events with a 10-year recurrence interval and larger, the municipal storm sewer operates under surcharge conditions. This means that modeled water depths create flooding above the top of manholes in the street at several locations along the storm sewer study route. In addition, portions of the study site area where stormwater runoff collects are significantly lower in elevation than the flood elevations in the municipal storm sewer system. Due to this elevation differential, drainage from the study site area is inhibited as outflow to the municipal storm sewer is temporarily reduced to zero. Hence the stormwater generated over the study site area must be stored until adequate capacity is available in the downstream

Figure 4
Existing Conditions Model Results 10-year Recurrence Interval Design Storm: Municipal Storm Sewer Study Route Maximum Water Surface Elevation Profile



Source: SEWRPC

municipal storm sewer. The backflow prevention valve on the Lavelle storm sewer line prevents reverse flow onto the site from the municipal storm sewer system. The duration over which stormwater from the study site area cannot discharge into the municipal storm sewer under existing conditions is also presented in Table 4.

EVALUATION OF STORMWATER MANAGEMENT ALTERNATIVES

There are two types of issues that contribute to flooding at the study site area on the southwest side of the City of Burlington. The first is the lack of storage available to detain the volume of stormwater runoff generated during rainfall events, and the second issue is the inability to convey stormwater away from the study site area while the municipal storm sewer is surcharged. This analysis considers stormwater management alternatives that address both stormwater storage and conveyance capacity improvements, and evaluates the relative effectiveness of the alternatives at reducing flooding in the study site area. Increasing the stormwater storage capacity in the study site area is necessary to detain and control stormwater. The City stormwater management ordinance requires stormwater storage facilities accommodate up to the 1-percent-annual-probability (100-year recurrence interval) storm event with 24-hour duration. The proposed stormwater storage facilities discussed herein are all designed to be drained by gravity, and are intended to drain completely following a rainfall event. In order for the ponds to be dry in between storm events, it is assumed that the study site area groundwater levels are lower than the bottom of the proposed ponds.

Stormwater management alternatives to alleviate flooding in the study site area include both storage alternatives and conveyance improvement alternatives. For this evaluation, the flood protection criteria is established as the top of pond elevation and the level of flood protection is considered to be the storm event that is contained within the proposed pond(s) without overtopping. Various combinations of stormwater management alternatives are evaluated in the following sections.

Alternative 1A: Lavelle Stormwater Storage Pond – Existing Site Layout

The existing conditions SWMM model indicates that the stormwater storage currently available in the study site area is inadequate to contain the 2-year recurrence interval storm event without causing flooding at the Lavelle property. The proposed Lavelle stormwater storage pond represents an expansion of the existing pond and maximizes use of the open space west of the Lavelle building and parking lot. Map 1 shows the proposed 3.1-acre footprint of the Lavelle stormwater pond and the new outlet. The proposed pond will be excavated to a bottom elevation of 777 feet NGVD29, which is two feet deeper than the existing Lavelle pond. The proposed pond will have a top elevation of 783 feet NGVD29 with 3H:1V side slopes, and the storage capacity below elevation 783 feet NGVD29 is approximately 16.3 acre-feet. An emergency spillway for stormwater runoff exceeding the pond storage capacity is not considered for the proposed new pond at Lavelle, as the pond is located in the lowest-lying area on the property and as such there is no overland relief route available when the pond is overtopped. For the SWMM model, the storage curve was extended above the top of the pond to an elevation of 788 feet NGVD29 using the 2010 topographic contours to characterize the total available storage above grade. The proposed top of pond elevation is established approximately one foot below the personnel entrance to Lavelle from the parking lot on the west side of the building. Even with the flood protection provided by the proposed pond under conditions during which the pond is not overtopped, there would be minor flooding in low-lying areas of the Lavelle parking lot any time water levels in the pond are higher than the catch basin rim elevations in that lot, which could affect vehicles parked in these areas.

A new 18-inch diameter concrete outlet pipe is proposed at the southeast corner of the pond, with a new end section and an invert elevation of 777 feet NGVD29. The new pond outlet pipe will connect to the municipal storm sewer under McHenry Street at the manhole located across from the southern-most driveway access to Lavelle, as shown on Map 1. Upstream of the 18-inch pipe connection with the municipal storm sewer manhole, a structure containing a backflow prevention valve is proposed. The existing Lavelle pond outlet pipe and stormwater system serving the parking lot and building roof drain system will remain unchanged and will be connected to the new pond. This connection is necessary because the existing Lavelle pond also receives runoff from the Lavelle building roof drain system. When the municipal storm sewer is surcharged and cannot accept flow from Lavelle, runoff from the building roof is routed into the 15-inch pipe running beneath the building and is forced to flow in reverse, upstream to the stormwater pond.

Model Runs and Results for Alternative 1A

Several model runs were developed to evaluate the proposed stormwater pond at Lavelle under Alternative 1A. The model runs are described below, and the model results are presented in Table 5.

- The first model run considered only the proposed stormwater pond and outlet at Lavelle, without any other changes to the study site area, and this condition was evaluated for the 1-percent-annual-probability (100-year recurrence interval) storm event. Model results indicate the flooding depth at Lavelle is reduced approximately 1.5 feet compared to existing conditions model results, but the maximum water level is still approximately 2.5 feet above the top of the proposed Alternative 1A pond.

- The second model run was performed for the same 100-year recurrence interval storm event to evaluate the benefit of restricting the KW Precast pond outlet from the existing 54-inch diameter pipe to a 12-inch diameter concrete pipe. Compared to the first model run, restricting the outlet of the existing KW Precast pond produced slightly lower flood levels at Lavelle, with higher water levels in the existing KW Precast pond such that the pond and the adjacent road to the east of the pond are overtopped.

- The proposed Lavelle Alternative 1A stormwater pond alone does not prevent flooding on the Lavelle site during the 100-year recurrence interval storm event. Storm events of smaller magnitudes were evaluated using the SWMM model to determine the maximum level of flood protection for Alternative 1A. Based on the model results, the proposed Alternative 1A pond at Lavelle, when combined with restricting the existing KW Precast pond outlet to the 12-inch diameter pipe, can store the 4-percent-annual-probability (25-year recurrence interval) storm event without overtopping.

Map 1
Alternative 1A: Lavelle Stormwater Pond – Existing Site Layout

Table 5
Model Results for Alternative 1A

Model Run Description	Design Storm Recurrence Interval	Proposed Lavelle Pond[a]		Existing KW Precast Pond[b]		Duration of Zero Outflow from Study Site Area[c] (hours)
		Maximum Water Surface Elevation (feet NGVD29)	Maximum Volume (acre-feet)	Maximum Water Surface Elevation (feet NGVD29)	Maximum Volume (acre-feet)	
Alternative 1A with Existing KWP Pond Outlet	100-year	[785.1]	26.3	785.1	5.9	11.5
Alternative 1A with KWP Pond Outlet Restricted	100-year	[785.0]	25.8	[785.5]	6.9	11.4
Alternative 1A with KWP Pond Outlet Restricted	25-year	782.5	14.7	[785.5]	6.7	6.7

[a] *The proposed Lavelle top of pond elevation is approximately 783 feet NGVD29; water surface elevations within brackets indicate pond overtopping*

[b] *The existing KW Precast lowest top of pond elevation is approximately 785.4 feet NGVD29; water surface elevations within brackets indicate pond overtopping*

[c] *The duration of zero outflow from the study site area represents the duration over which the municipal storm sewer is surcharged and unable to accept additional flow*

Source: SEWRPC

Alternative 1B: Lavelle Stormwater Storage Pond – Proposed Site Expansion

Lavelle Industries has announced their intention to expand operations at their Burlington location. The proposed expansion includes building additions extending into the existing parking lot. Additionally, the parking lot footprint will be increased under the proposed site expansion. As with the proposed Lavelle pond evaluated under Alternative 1A, the open space behind Lavelle industries is utilized for a new stormwater storage pond; however, the proposed site expansion reduces the area available for stormwater management. Maximizing the available space under the planned site expansion yields a proposed Alternative 1B stormwater pond with a footprint of approximately 2.0 acres, as illustrated on Map 2. The proposed stormwater pond was modeled with a bottom elevation of 777 feet NGVD29, a top elevation of 783 feet NGVD29, and 3H:1V side slopes. The pond storage capacity below elevation 783 feet NGVD29 is approximately 9.8 acre-feet for Alternative 1B. As previously explained under Alternative 1A, the pond storage curve was extended to elevation 788 feet NGVD for modeling purposes, and the Lavelle parking lot may experience minor flooding even with the proposed stormwater pond.

Similar to Alternative 1A, a new 18-inch diameter concrete outlet pipe was proposed at the southeast corner of the pond, with a new end section and an invert elevation of 777 feet NGVD29. The new pond outlet pipe follows the same route and is proposed to have the same connection and backflow prevention valve described under Alternative 1A. With the proposed parking lot expansion, the existing 12-inch diameter Lavelle pond outlet pipe will be extended west into the proposed Alternative 1B stormwater pond. A new manhole structure will be provided at the connection with the existing outlet pipe, and a new end section will be provided within the proposed Alternative 1B pond at the pipe inlet.

Model Runs and Results for Alternative 1B

Several model runs were developed to evaluate the proposed stormwater pond at Lavelle under Alternative 1B. The model runs are described below, and the model results are presented in Table 6.

- The 1-percent-annual-probability (100-year recurrence interval) storm event model run considered the proposed Alternative 1B stormwater pond and outlet at Lavelle with the proposed site expansion, in conjunction with the existing KW Precast pond outlet restricted to a 12-inch diameter pipe. The stormwater pond at Lavelle for Alternative 1B is not able to contain the 100-year recurrence interval storm event, and the maximum water surface elevation at Lavelle is nearly one foot higher than the same conditions modeled for Alternative 1A.

- Storm events of smaller magnitudes were evaluated to determine the maximum level of flood protection for the Alternative 1B stormwater pond, with the existing KW Precast pond outlet restricted. Based on the model results provided in Table 6, the proposed Alternative 1B pond at Lavelle under site expansion conditions would be expected to contain the 10-percent-annual-probability (10-year recurrence interval) storm event without overtopping.

Alternative 2: KW Precast Stormwater Storage Pond

Alternative 2 proposes a new stormwater storage pond for the KW Precast site in order to detain runoff generated on that site. The proposed location for the new storage facility is north of the existing KW Precast pond, and is connected to the existing pond through four existing culverts that run beneath the KW Precast entrance road. This configuration allows runoff to be captured from Subbasins A7 and A8 (Map A.2) without major modifications to site grading and continues to take advantage of the available stormwater storage in the existing KW Precast pond. Additionally, the existing KW Precast pond discharge will be redirected to the proposed Alternative 2 pond, and will discharge to the municipal storm sewer system through the proposed pond outlet. Map 3 presents the proposed KW Precast stormwater pond with the new pond outlet and an approximate footprint area of 2.8 acres.

The proposed Alternative 2 stormwater pond for KW Precast was modeled with an excavated bottom elevation of 779 feet NGVD29 and a top elevation of 786 feet NGVD29 with 3H:1V side slopes. The storage capacity below elevation 786 feet NGVD29 is approximately 16.8 acre-feet for the proposed Alternative 2 pond only. A new concrete outlet structure is proposed at the southeast corner of the pond, with a low-level orifice and a weir at the top of the concrete structure (similar to the existing pond outlet) and a 24-inch diameter concrete outlet pipe. The proposed outlet pipe will connect to the municipal storm sewer system

Map 2
Alternative 1B: Lavelle Stormwater Pond – Proposed Site Expansion

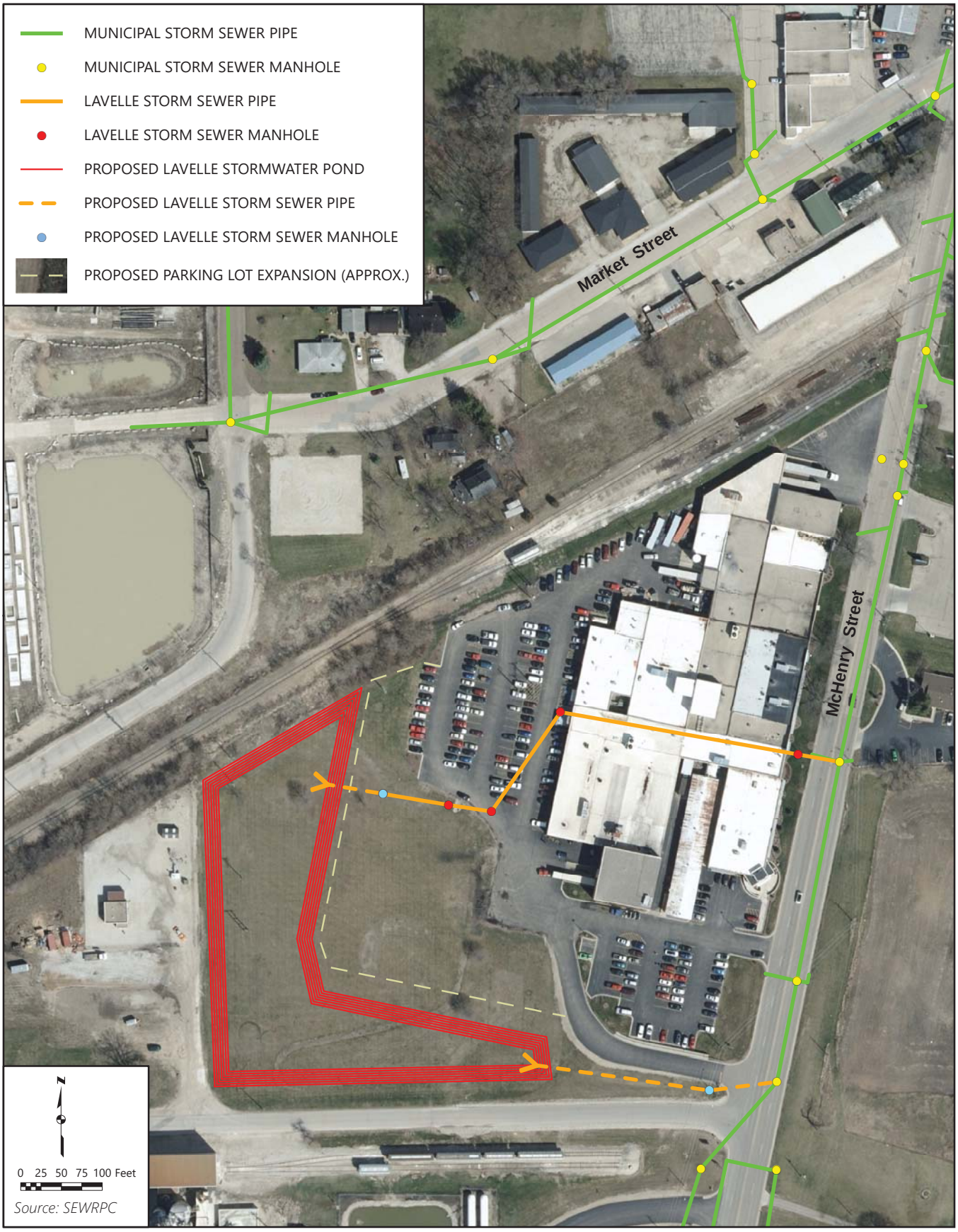


Table 6
Model Results for Alternative 1B

Model Run Description	Design Storm Recurrence Interval	Proposed Lavelle Pond[a]		Existing KW Precast Pond[b]		Duration of Zero Outflow from Study Site Area[c] (hours)
		Maximum Water Surface Elevation (feet NGVD29)	Maximum Volume (acre-feet)	Maximum Water Surface Elevation (feet NGVD29)	Maximum Volume (acre-feet)	
Alternative 1B with KWP Pond Outlet Restricted	100-year	[785.8]	24.5	[785.8]	7.5	11.0
Alternative 1B with KWP Pond Outlet Restricted	10-year	782.0	7.8	785.3	6.4	3.2

[a] *The proposed Lavelle top of pond elevation is approximately 783 feet NGVD29; water surface elevations within brackets indicate pond overtopping*

[b] *The existing KW Precast lowest top of pond elevation is approximately 785.4 feet NGVD29; water surface elevations within brackets indicate pond overtopping*

[c] *The duration of zero outflow from the study site area represents the duration over which the municipal storm sewer is surcharged and unable to accept additional flow*

Source: SEWRPC

Map 3
Alternative 2: KW Precast (KWP) Stormwater Pond

at the intersection of Market Street and Sheldon Street. In order to model the Alternative 2 configuration, the storm sewer study route was expanded within SWMM to include the pipe reach along Market Street, extending west from McHenry Street to Sheldon Street. Upstream of the connection with the municipal storm sewer, a manhole structure containing a backflow prevention valve is also proposed. With the proposed installation of a separate Alternative 2 pond outlet to the municipal storm sewer system, the existing 54-inch diameter KW Precast pond outlet was blocked to prevent discharge from the KW Precast pond from being routed through the Lavelle property.

The new Alternative 2 stormwater storage feature on the KW Precast property is modeled as an open pond; however, the cost estimate also includes an option for underground storage. The volume of underground storage required is estimated based on the volume of the proposed Alternative 2 stormwater pond of 16.8 acre-feet, which is equivalent to the maximum volume of storage available for the proposed above ground KW Precast pond. It is important to note that Alternative 2 addresses the KW Precast site stormwater management from a water quantity perspective, but the proposed design does not consider water quality requirements nor does it address modifications to the intended function of the existing KW Precast pond.

Model Runs and Results for Alternative 2

Several model runs were developed to evaluate the proposed Alternative 2 stormwater pond at KW Precast, in conjunction with the proposed Lavelle stormwater ponds highlighted under Alternatives 1A and 1B. The model runs are described below, and model results for Alternative 2 are summarized in Table 7.

- The 1-percent-annual-probability (100-year recurrence interval) storm event was run for the new stormwater pond and outlet at KW Precast along with the proposed stormwater pond Alternative 1A at Lavelle (existing site layout). With the existing KW Precast pond outlet blocked, the combination of storage Alternatives 1A and 2 is sufficient to handle runoff from the 100-year recurrence interval storm event without flooding or overtopping the pond at either site.

- The next set of model runs consider the performance of Alternative 2 in conjunction with the Alternative 1B proposed stormwater pond at Lavelle under site expansion conditions. Results from the 100-year recurrence interval storm event indicate flooding at Lavelle (approximately 1-foot above the top of proposed pond) even with the KW Precast existing pond outlet blocked.

- Storm events of smaller magnitudes were evaluated using the SWMM model to determine the maximum level of flood protection for the Alternative 2 stormwater pond at KW Precast in conjunction with the Alternative 1B proposed stormwater pond at Lavelle under site expansion conditions. Based on the model results provided in Table 7, the combination of storage Alternatives 1B and 2 is sufficient to handle runoff from the 4-percent-annual-probability (25-year recurrence interval) storm event without flooding or overtopping the pond at either site.

Alternative 3: Municipal Storm Sewer Conveyance Improvements

Alternative 3 considers conveyance capacity improvements for portions of the municipal storm sewer in order to reduce the duration of surcharge when the storm sewer pipe capacity is exceeded following large rainfall events. Alternative 3 was developed for scenarios in which the storage alternatives alone were not sufficient to reduce flooding at the study site area, specifically for the scenarios that include site expansion at Lavelle (e.g., Alternative 1B). The Alternative 3 conveyance improvements do not preclude the need for increased storage capacity in the study site area, rather Alternative 3 is intended to be employed in conjunction with the storage alternatives previously discussed. Additionally, Alternative 3 is not offered as an upgrade of the existing municipal storm sewer system to meet the required 10-year level of service, which would require significantly less extensive modifications than those included in Alternative 3. Municipal storm sewer systems are not typically designed to convey the 100-year recurrence interval storm event, nor does this memorandum recommend meeting a 100-year level of service. Alternative 3 demonstrates the potential benefits of conveyance improvements, however it is recommended that any modification to the municipal storm sewer be evaluated using an expanded model that includes all components of the storm sewer system, rather than the isolated storm sewer study route modeled for this analysis.

For stormwater management Alternative 3, additional storm sewer pipes would be installed under Market Street, running parallel to the existing storm sewer study route. Specifically, a new 48-inch diameter concrete

Table 7
Model Results for Alternative 2

Model Run Description	Design Storm Recurrence Interval	Proposed Lavelle Pond[a]		KW Precast Ponds[b]			Duration of Zero Outflow from Study Site Area[c] (hours)
		Maximum Water Surface Elevation (feet NGVD29)	Maximum Volume (acre-feet)	Maximum Water Surface Elevation (feet NGVD29)	Existing Pond Maximum Volume (acre-feet)	Proposed Pond Maximum Volume (acre-feet)	
Alternatives 1A and 2	100-year	781.9	12.8	784.8	5.4	13.5	12.1
Alternatives 1B and 2	100-year	[784.0]	12.8	784.8	5.4	13.5	12.1
Alternatives 1B and 2	25-year	782.1	8.1	783.3	3.2	9.9	6.7

[a] *The proposed Lavelle top of pond elevation is approximately 783 feet NGVD29; water surface elevations within brackets indicate pond overtopping*

[b] *The proposed KW Precast top of pond elevation is approximately 786 feet NGVD29 and the existing KW Precast lowest top of pond elevation is approximately 785.4 feet NGVD29; water surface elevations within brackets indicate pond overtopping*

[c] *The duration of zero outflow from the study site area represents the duration over which the municipal storm sewer is surcharged and unable to accept additional flow*

Source: SEWRPC

pipe is proposed to extend from the intersection of Market Street and McHenry Street downstream to the CN railroad tracks that run between Pine Street and the Fox River, as highlighted on Map 4. The proposed 48-inch storm sewer pipes were modeled to match the invert elevations of the existing storm sewer, and manhole structures would be provided with cross connections to the existing municipal manholes. The SWMM model for Alternative 3 represents the two parallel 48-inch diameter concrete pipes as a single, equivalent-flow-area, 4-foot by 6-foot reinforced concrete box culvert. This model simplification is deemed acceptable for the purposes of demonstrating the effects of increasing the conveyance capacity of the municipal storm sewer. The upstream and downstream extents of the new sewer would terminate at underground concrete junction boxes, allowing for the dispersal of stormwater between the two parallel pipes. For Alternative 3 the existing downstream end of the storm sewer study route from the railroad to the Fox River would not be modified.

Model Runs and Results for Alternative 3

The 1-percent-annual-probability (100-year recurrence interval) storm event was run for the Alternative 3 storm sewer conveyance improvements, along with the proposed stormwater pond at KW Precast (Alternative 2) and the proposed stormwater pond at Lavelle considering site expansion (Alternative 1B). The conveyance improvements offered by Alternative 3 significantly reduce the duration over which the municipal storm sewer is surcharged and unable to accept flow from the study site area. Based on the model results summarized in Table 8, the combination of Alternative 1B, Alternative 2, and Alternative 3 has the capacity to handle runoff from the 100-year recurrence interval storm event without flooding or overtopping the pond at either site.

To understand the isolated effect of the conveyance improvement alternative, a model run was completed for Alternative 3 in conjunction with the existing stormwater facilities in the study site area for the 1-percent-annual-probability (100-year recurrence interval) storm event. This model run indicated that Alternative 3 conveyance improvements alone do not alleviate flooding problems in the study site area (Table 9). While Alternative 3 employed alone considerably reduces the duration of surcharge in the municipal system, the study site area experiences significant flooding. Compared to the existing conditions model results for the 1-percent-annual-probability (100-year recurrence interval) storm event presented in Table 4, Alternative 3 employed alone reduces water levels in the study site area by 0.4 feet, with a maximum water surface elevation that is still almost 4 feet above the existing top of pond elevation. Based on these model results, it is clear that conveyance improvements to the municipal storm sewer system alone offer limited benefit with respect to flood level reduction within the study site area.

Additional Stormwater Management Considerations

Ardagh Site

The recommendations for stormwater management improvements on the Ardagh property are qualitative as the existing available data was not sufficient to develop meaningful SWMM model simulations for that site. Updated topographic data, expected to be available in 2019, will be useful for characterizing the existing site conditions, rainfall-runoff response, and to identify areas vulnerable to flooding on the property. Additionally, a survey of the existing stormwater drainage network pipes and facilities would allow for expansion of the model hydraulic features onto the Ardagh site, similar to the model representation for Lavelle. The following considerations are recommended for the Ardagh site:

- Backflow prevention valves are recommended for the two subsurface pipe connections to the municipal storm sewer at the Ardagh site. This would prevent stormwater in the municipal storm sewer from backing up into the Ardagh stormwater drainage system under surcharge conditions. When choosing the appropriate backflow prevention valve, the following should be considered:
    - The headloss introduced by the valve and the water surface/head differential required to allow flow from the Ardagh drainage system to the municipal storm sewer should be investigated such that the valve would not excessively hinder normal site drainage. Pipes with very flat slopes may have trouble draining entirely.
    - The backflow prevention valve should be rated to withstand the worst-case backpressure on the downstream municipal side of the valve.

Map 4
Alternative 3: Municipal Storm Sewer Conveyance Improvements

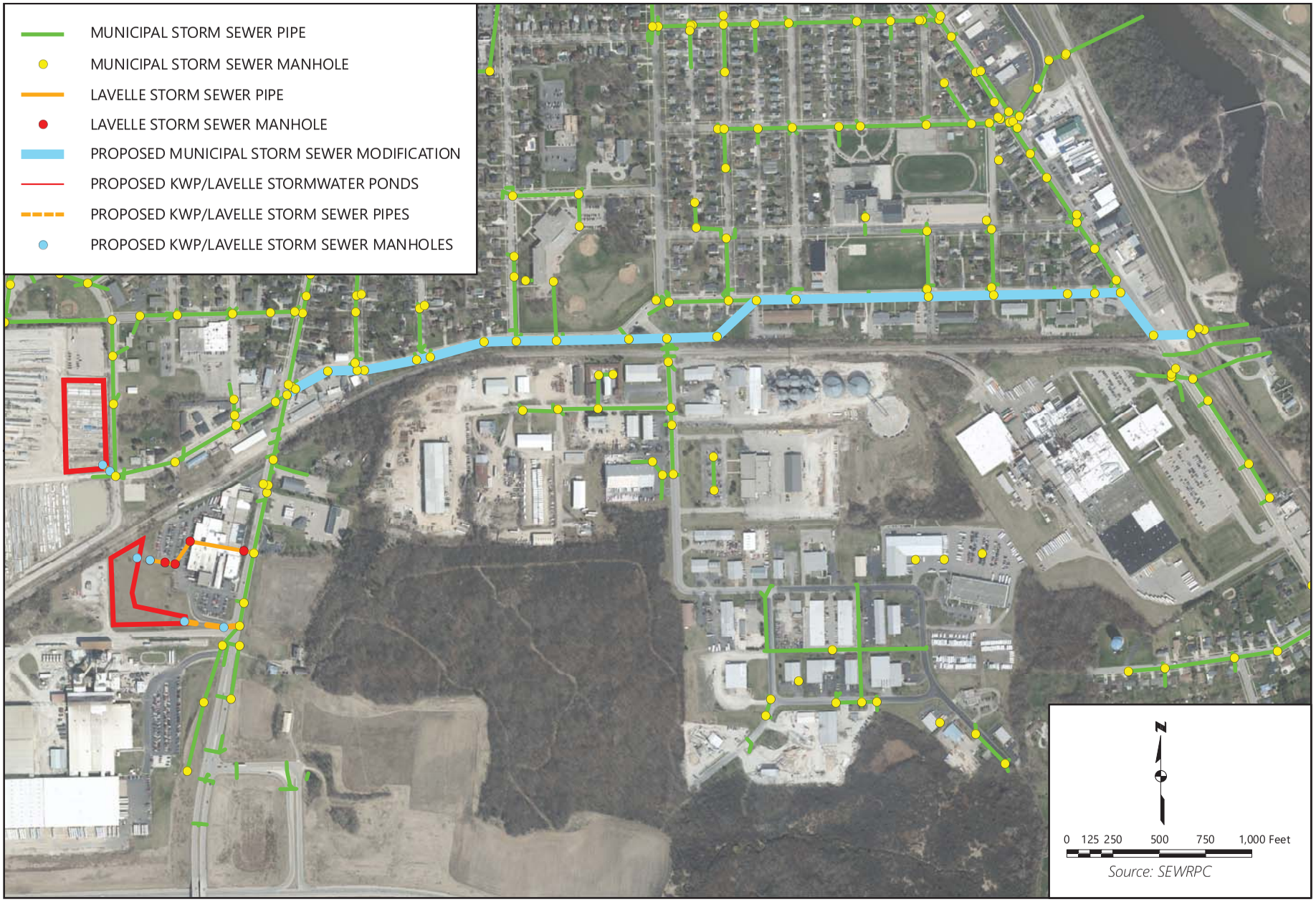


Table 8
Model Results for Alternative 3

Model Run Description	Design Storm Recurrence Interval	Proposed Lavelle Pond[a]		KW Precast Ponds[b]			Duration of Zero Outflow from Study Site Area[c] (hours)
		Maximum Water Surface Elevation (feet NGVD29)	Maximum Volume (acre-feet)	Maximum Water Surface Elevation (feet NGVD29)	Existing Pond Maximum Volume (acre-feet)	Proposed Pond Maximum Volume (acre-feet)	
Alternative 3 with Alternatives 1B and 2	100-year	782.4	8.6	784.0	4.2	11.6	2.5

[a] *The proposed Lavelle top of pond elevation is approximately 783 feet NGVD29; water surface elevations within brackets indicate pond overtopping*

[b] *The proposed KW Precast top of pond elevation is approximately 786 feet NGVD29 and the existing KW Precast lowest top of pond elevation is approximately 785.4 feet NGVD29; water surface elevations within brackets indicate pond overtopping*

[c] *The duration of zero outflow from the study site area represents the duration over which the municipal storm sewer is surcharged and unable to accept additional flow*

Source: SEWRPC

Table 9
Model Results for Alternative 3 with Existing Ponds

Model Run Description	Design Storm Recurrence Interval	Existing Lavelle Pond[a]		Existing KW Precast Pond[b]		Duration of Zero Outflow from Study Site Area[c] (hours)
		Maximum Water Surface Elevation (feet NGVD29)	Maximum Volume (acre-feet)	Maximum Water Surface Elevation (feet NGVD29)	Maximum Volume (acre-feet)	
Alternative 3[d]	100-year	[785.9]	17.6	[785.9]	7.9	2.3

[a] *The existing Lavelle top of pond elevation is approximately 782 feet NGVD29; water surface elevations within brackets indicate pond overtopping*

[b] *The existing KW Precast lowest top of pond elevation is approximately 785.4 feet NGVD29; water surface elevations within brackets indicate pond overtopping*

[c] *The duration of zero outflow from the study site area represents the duration over which the municipal storm sewer is surcharged and unable to accept additional flow*

[d] *This model run considers isolated effects of Alternative 3 conveyance improvements with the existing stormwater storage ponds at Lavelle and KW Precast; refer to Table 4 for comparison with existing conditions*

Source: SEWRPC

- Consider increasing stormwater storage capacity at multiple locations across the Ardagh site. The SWMM model results indicates that the volume of runoff generated on the Ardagh subbasins (A1 and A2, Map A.2) is approximately 27 acre-feet for the 1-percent-annual-probability (100-year recurrence interval) storm event. Consider the feasibility of excavating to clean out the existing stormwater pond on the southwest side of the site, which has an approximate 1.2 acre footprint area but has lost storage capacity over the years due to sediment deposition and overgrown vegetation. Also consider constructing additional stormwater storage ponds in open areas along the southeast side of the site and under-utilized areas on the north side of the property.

- Consider modification of the culvert that runs from the Ardagh site into the WisDOT pond located just east of Ardagh, across McHenry Street, discussed in detail below. The culvert invert elevation on the Ardagh property is perched a few feet above the surrounding grade, such that significant ponding on the Ardagh site would be required before the culvert could provide drainage from the site to the WisDOT pond. Instead, the culvert may contribute to excess stormwater to the Ardagh site by allowing stormwater to flow from the WisDOT pond west when pond water levels are elevated. Consider engaging WisDOT to understand whether this culvert pipe may be fit with a backflow prevention device or otherwise blocked without adversely impacting the WisDOT pond function, in order to prevent stormwater from flowing through the culvert onto the Ardagh site.

- If increasing the stormwater storage capacity on the site is not sufficient to prevent flooding at Ardagh, a stormwater lift station could help remove excess stormwater by pumping into the WisDOT pond on the east side of McHenry Street. The lift station could be located along the eastern side of the Ardagh site, and the discharge piping from the pumps could be routed to the WisDOT pond through the existing culvert with modifications to prevent stormwater from flowing back onto the Ardagh site.

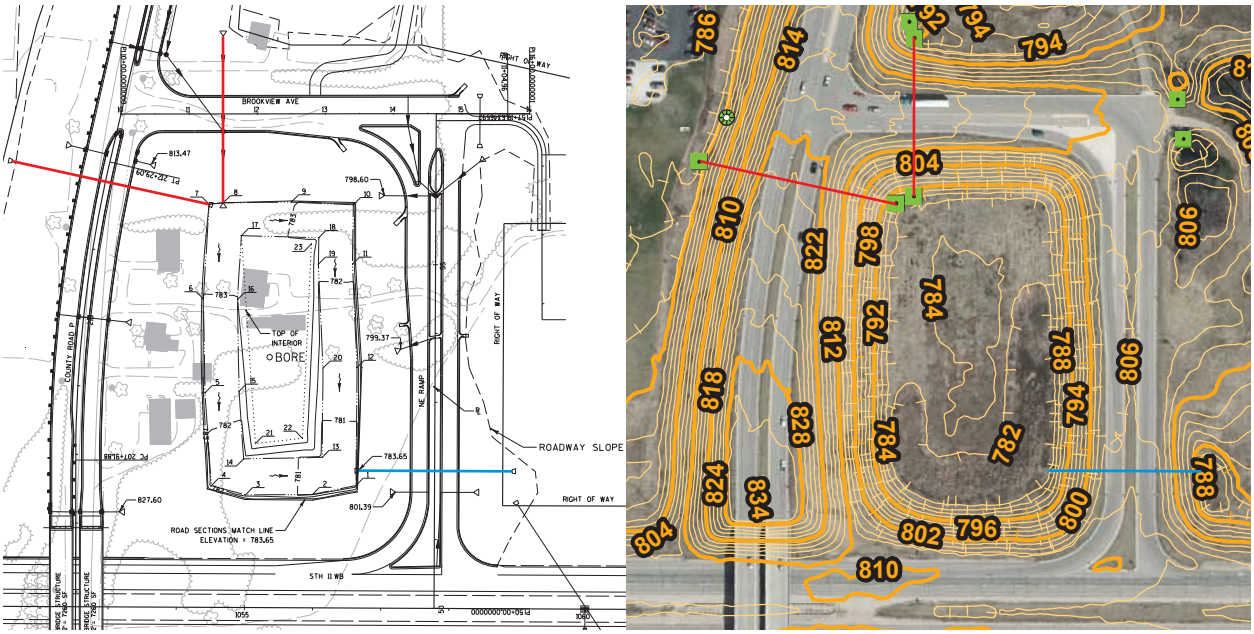
WisDOT Pond Utilization

The WisDOT stormwater pond was developed during the construction of the STH 11 Burlington Bypass and is encircled by the bypass, McHenry Street, and the northeast ramp access to McHenry Street as shown in Figure 5. The WisDOT pond collects runoff from the surrounding roadways and the property north of the pond. The pond is over 20 feet deep, and offers a potential storage capacity of approximately 64 acre-feet between elevations 784 feet NGVD29 and 804 feet NGVD29 based on 2010 topographic contour data; however, the effective stormwater storage capacity of the WisDOT pond is significantly less due to low-level culvert pipes that allow water to flow out of the pond onto adjacent properties. The existing WisDOT pond outlet pipe is located in the southeast corner. Additional information is needed for the hydraulic features downstream of the pond outlet; however, it appears that stormwater discharged from the WisDOT pond would flow through a culvert running southeast under the bypass and eventually discharge into Spring Brook, which flows to the Fox River.

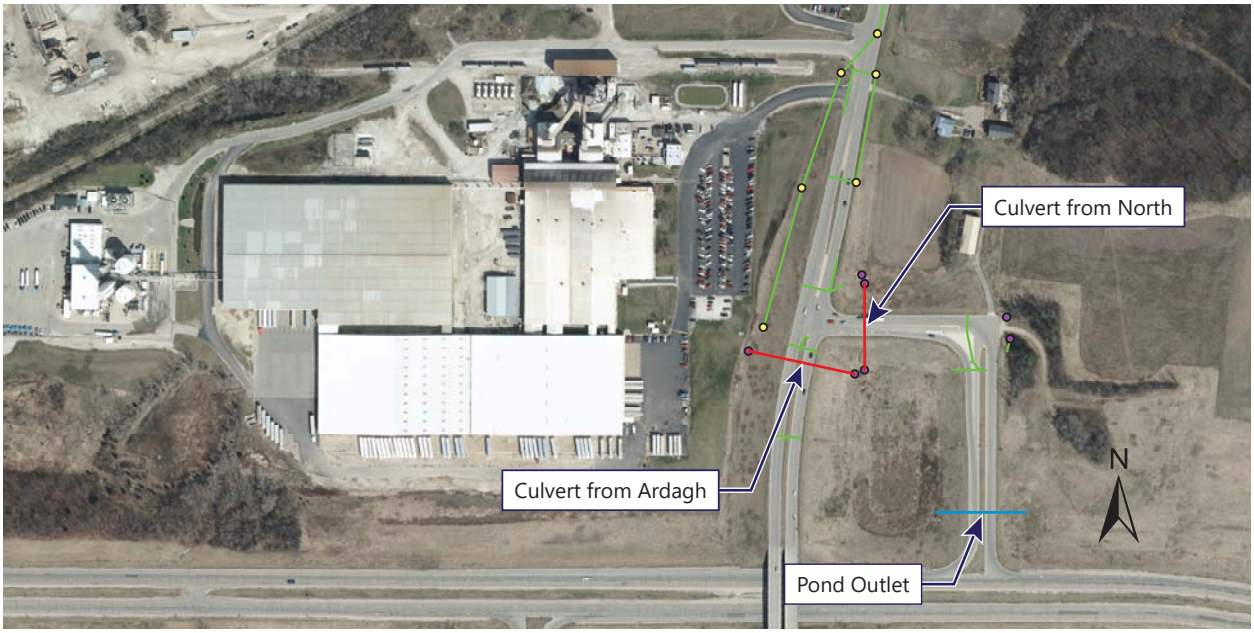
The bottom elevation of the WisDOT pond is too high to offer flood relief for the low-lying areas subject to flooding at the Lavelle and Ardagh sites, and excavating the pond deeper would not allow the pond to drain. SWMM model runs were performed to investigate the benefit of installing a pipe from the upstream-most manhole on the municipal storm sewer study route into the WisDOT pond to provide relief under surcharge conditions. While the WisDOT pond bottom elevation is too high to prevent relief of flooding on the Lavelle property, the model indicates minimal pressure relief on the municipal system and a slight reduction of street ponding in the upstream portion of the municipal storm sewer study route. Additionally, connecting the WisDOT pond to the storm sewer study route would force the pond to outlet to the storm sewer, ultimately increasing the drainage area contributing runoff to the municipal storm sewer system and potentially exacerbating storm sewer capacity issues.

Based on these considerations, it is recommended to continue to utilize the WisDOT stormwater pond for emergency pumping operations, and block the culvert connecting the pond to the Ardagh site as described in the preceding section. Another culvert connects the WisDOT pond with the property directly to the north; however, this culvert has a greater pipe slope and higher invert elevation compared to the Ardagh culvert. The upstream invert elevation of the northern culvert is approximately 790 feet NGVD, and the storage capacity in the pond below 790 feet NGVD is approximately 18 acre-feet. Hence it may be possible to keep the northern culvert operational and achieve stormwater storage relief using the WisDOT pond without

Figure 5
Wisconsin Department of Transportation Stormwater Pond



Source: Kapur & Associates



Source: SEWRPC

negatively impacting water levels and drainage on the property north of the pond. The benefit of pumping into the WisDOT pond under emergency operations is that it is not connected to the municipal storm sewer system, so it would not be contributing to surcharge issues in the system.

Cretex Materials Excavated Storage Feature

In 2017 a pond was excavated on the Cretex Materials property near their entrance in the southeast corner of the site (Subbasin A9, Map A.2). At the time of this study, there was no information available to develop a pond storage curve for inclusion in the SWMM model. There is no constructed pond outlet and the storage capacity is limited by the lowest elevation along the perimeter of the pond; as the pond fills to capacity, stormwater spills over the south side of the excavation onto the access road, where it can either flow along

the north side of the access road into the KW Precast pond or flow toward the south along the CN railroad tracks to the 36-inch diameter culvert under the tracks and onto the Lavelle property. A site visit conducted by SEWRPC staff in May 2018 provided insight into recommendations for improvement to this facility, as highlighted below.

- Consider providing additional locations for stormwater to enter the excavated pond on the uphill (north and west) side. At the time of the staff site visit, excavated material from the pond was bermed several feet above existing ground around the perimeter of the pond on the uphill side, preventing runoff from draining directly into the pond. Runoff is directed toward the south along the edge of the excavated material, and is funneled into the pond through erosion-induced pathways near the southern edge of pond.

- Consider providing a defined outlet for this pond toward the east, draining to the existing KW Precast pond. A discharge pipe into the low-lying area east of the pond and north of the access road would allow stormwater from this pond to be routed through the existing KW Precast culvert and drainage swale along the north side of the access road into the KW Precast pond. Note that redirecting flow from Cretex Materials Subbasin A9 to the existing KW Precast pond may slightly impact the SWMM model results for the alternatives discussed herein.

- Consider deploying erosion control to stabilize the area around the perimeter of the pond and at locations of concentrated flow to prevent the erosion observed at locations where runoff flows into or out of the pond.

PLANNING-LEVEL COST ESTIMATES FOR STORMWATER MANAGEMENT ALTERNATIVES

Planning-level cost estimates were developed for the viable stormwater management alternatives modeled for this study. Cost information was compiled from a variety of sources. The Engineering News-Record Construction Cost Index (CCI) was used to convert historical cost data to 2018 dollar values. The cost estimates include major items such as excavation, pipe material, installation and restoration costs, as well as a 35 percent contingency. The 35 percent contingency represents costs such as geotechnical investigation, engineering and detailed design, permitting, and minor construction items.

The estimated construction costs do not include annual operation and maintenance costs for the alternatives as well as the following potential items, which may significantly alter the final construction costs if they are encountered during final design:

- Underground utility conflicts
- Contaminated soils
- Temporary shoring or bracing for pipe trenching
- Land acquisition or easement costs
- Pond lining (to address high groundwater elevations)
- Dewatering during construction
- Security fencing and safety barriers for stormwater ponds

The cost estimates for each evaluated stormwater management alternative are presented in Table 10.

Table 10
Cost Estimate Summary for each Stormwater Management Alternative

Alternative	Description	Total 2018 Construction Cost[a] ($ in millions)
Alternative 1A	Proposed Lavelle Pond – Existing Site Layout	1.25
Alternative 1B	Proposed Lavelle Pond – Proposed Site Expansion	0.83
Alternative 2	Proposed KW Precast Pond	1.24
Alternative 2 (UG)	Proposed KW Precast Underground Storage Option	7.50
Alternative 3	Municipal Storm Sewer Conveyance Improvements	4.62

[a] *Includes 35 percent contingency*

Source: SEWRPC

Table 11
Estimated Cost and Level of Protection Summary for Combined Stormwater Management Alternatives

Alternative(s)	Description	Total Combined Cost ($ in millions)	Level of Flood Protection at Lavelle (storm event recurrence interval)
1A	Proposed Lavelle Pond (Existing Site Layout) with KW Precast Existing Pond Outlet Restricted	1.25	25-year
1B	Proposed Lavelle Pond (Site Expansion) with KW Precast Existing Pond Outlet Restricted	0.83	10-year
1A and 2	Proposed KW Precast Pond with Alternative 1A	2.50	100-year
1B and 2	Proposed KW Precast Pond with Alternative 1B	2.10	25-year
1B and 2 and 3	Proposed Municipal Storm Sewer Conveyance Improvements with Alternatives 1B and 2	6.70	100-year

Note: The level of flood protection for the existing KW Precast pond is estimated at the 25-year recurrence interval storm event, and the proposed Alternative 2 stormwater pond for KW Precast provides flood protection up to the 100-year recurrence interval storm event.

Source: SEWRPC

SUMMARY

EPA SWMM model simulations have indicated that no single stormwater management alternative considered for this study would prevent flooding at the study site area on its own. Various combinations of the proposed stormwater management alternatives offer different levels of flood protection, as summarized below and in Table 11. Maps 1 through 4 present each stormwater management alternative.

The new stormwater pond proposed for the existing Lavelle site layout (Alternative 1A) alone provides flood protection for storm events up to the 4-percent-annual-probability (25-year recurrence interval) with an estimated cost of $1.25 million. Alternative 1A employed in combination with the Alternative 2 stormwater pond proposed for KW Precast provides flood protection for the 1-percent-annual-probability (100-year recurrence interval) storm event with an estimated combined cost of $2.5 million.

Considering the proposed site expansion at Lavelle, the new stormwater pond proposed under Alternative 1B alone provides flood protection up to the 10-percent-annual-probability (10-year recurrence interval) storm event with an estimated cost of $830,000. Alternative 1B employed in combination with the Alternative 2 stormwater pond proposed for KW Precast provides flood protection for the 4-percent-annual-probability (25-year recurrence interval) storm event with an estimated combined cost of $2.1 million. The model indicates that flood protection for the study site area during the 1-percent-annual-probability (100-year recurrence interval) storm event can be achieved with the Alternative 1B stormwater pond at Lavelle when employed in conjunction with the Alternative 2 stormwater pond proposed for KW Precast and the municipal storm sewer conveyance improvement proposed under Alternative 3. The estimated combined cost for these three alternatives is approximately $6.7 million.

FUTURE WORK

This memorandum summarizes the effort completed by SEWRPC staff to model the existing storm sewer system serving the industrial study site area located on the southwest side of the City of Burlington, and to evaluate potential stormwater management alternatives to reduce surface flooding for that area. Planning-level cost estimates were developed for the viable stormwater management alternatives considered for the Lavelle and KW Precast properties as well as the municipal storm sewer system. Final selection of the preferred alternative will depend on multiple factors including the desired level of service or level of flood protection, individual site constraints, detailed design, and cost.

Due to limitations in the source information available, the planning-level analysis set forth in this memorandum required a number of assumptions to be made regarding the current stormwater drainage conditions. Future studies and detailed engineering design should include additional investigations to validate these assumptions. These additional investigations are set forth below:

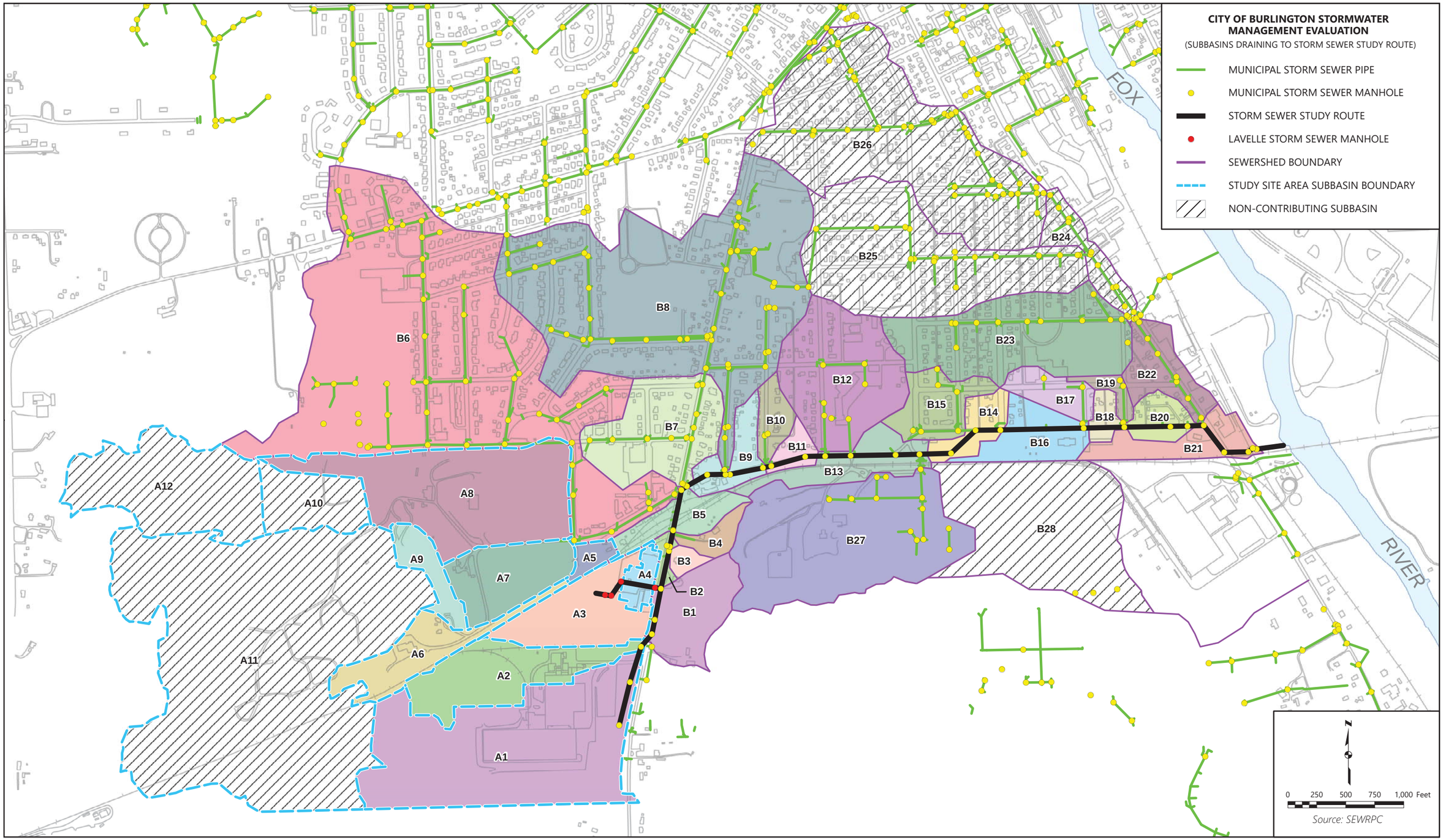
- SWMM model assumptions to be confirmed/verified:
    - Perform a field survey for the hydraulic features of the KW Precast pond and 36-inch pipe under the CN railroad to confirm elevations referenced to either NGVD29 or another established vertical datum.
    - Updated topographic data for Racine County is anticipated to become available in 2019, which could be used to refine or validate subbasin delineations and flow paths, and to identify additional storage opportunities.
    - Obtain additional storm sewer network survey data to confirm assumptions regarding non-contributing drainage areas and subbasin divides based on the City storm sewer system.
- For storage Alternatives 1A, 1B, and 2 – perform a geotechnical evaluation to establish groundwater elevations and determine whether groundwater could impact the proposed ponds, either by limiting proposed pond depth or requiring pond lining.
- For the conveyance Alternative 3 – expand the SWMM model developed for this planning-level evaluation to incorporate all of the contributing municipal storm sewers to the storm sewer study route along McHenry and Market Streets. Detailed design of proposed modifications to the municipal storm sewer based upon an expanded model will provide a more accurate representation of system hydraulics and routing, runoff timing, and storage opportunities throughout the system and contributing drainage areas.
- As discussed previously, additional survey and topographic information is needed to define the stormwater storage and hydraulic features on the Ardagh site for incorporation into the model.
- Where site constraints present challenges for required stormwater management, consider procurement of nearby properties for development of stormwater management facilities (e.g., the property east of Lavelle across McHenry Street, properties near KW Precast on the east side of Sheldon Street, WE Energies properties in the study site area).
- Perform additional investigation for the WisDOT pond features as it relates to options for emergency flood operations, and engage in discussions with WisDOT regarding potential modifications.

Additionally, the City may consider development of a Stormwater Master Plan in order to provide an integrated evaluation of the overall stormwater management features and storm sewer network for the entire city.

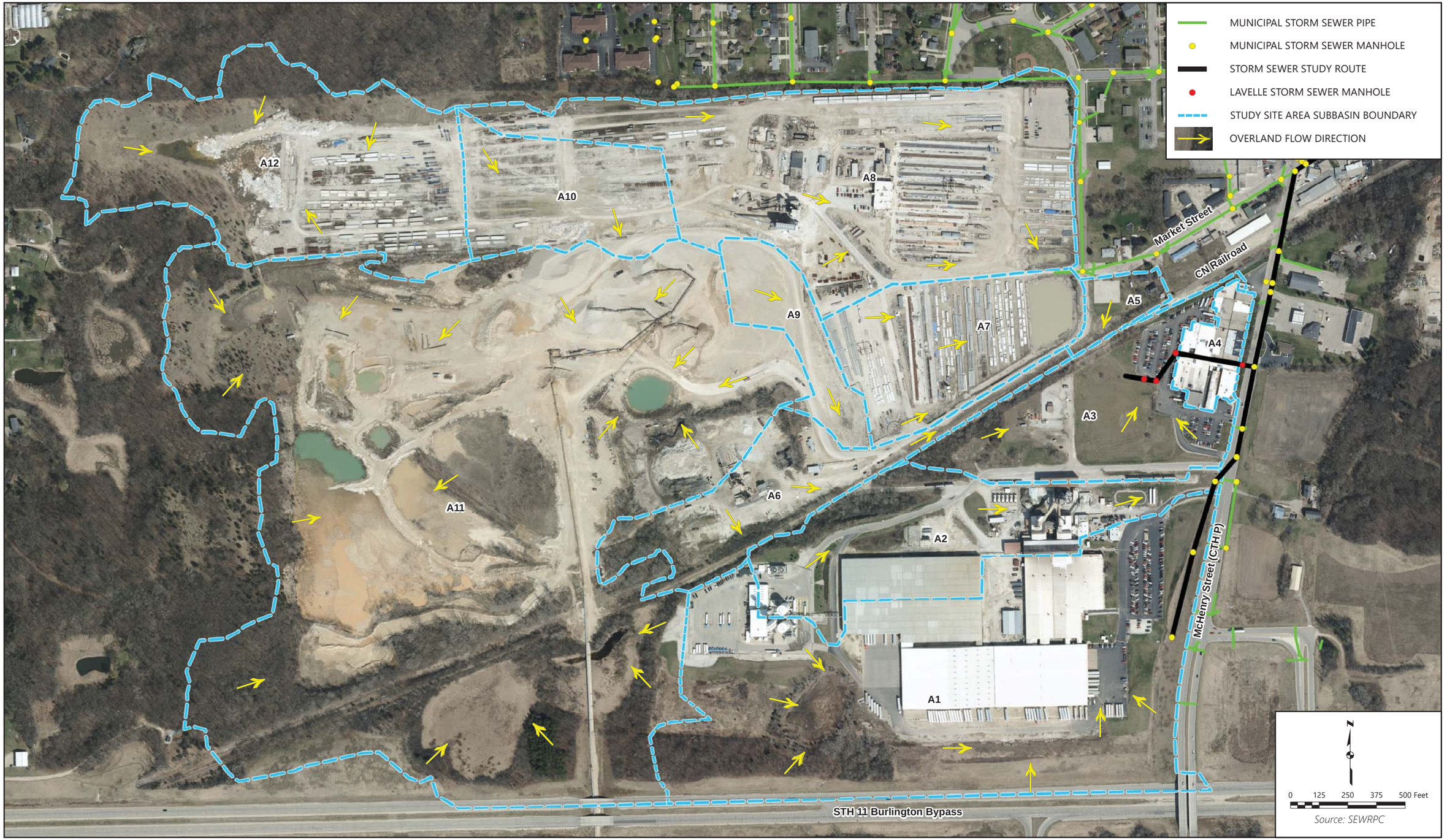
APPENDIX A

PROJECT AREA MAPS

Map A.1
Burlington Stormwater Management Evaluation – Overall Subbasin Map and Storm Sewer Study Route



Map A.2
Burlington Stormwater Management Evaluation – Study Site Area Subbasins



Map A.3
Burlington Stormwater Management Evaluation – Study Site Area Subbasins with Property Ownership