4.0 SERVICING EVALUATION

Several municipal infrastructure options were considered to service the Kanata North Urban Expansion Area with a potable water supply, wastewater collection system, and storm water drainage.

Alternatives for municipal infrastructure were developed in a two stage process. The first stage was to review preliminary servicing options from an overall perspective. These alternatives are screened and a preferred preliminary alternative chosen. The second phase was to take the preferred preliminary servicing alternative and create more detailed servicing options which are then reviewed and analyzed in more detail to be able to recommend a preferred servicing alternative for the development.

4.1 Preliminary Servicing Alternatives

4.1.1 Storm Drainage Alternatives

Preliminary storm drainage alternatives for the Kanata North Urban Expansion Area include:

- Do Nothing
- Limit Growth
- Ditch & Culvert and/or Open Channel
- Piped Services or Expansion of Municipal Services

The *Do Nothing* and *Limit Growth* alternatives are not considered viable options as they do not meet the development objectives established for the study area.

The *Ditch & Culvert* or *Open Channel* alternatives permit opportunities for infiltration, reduced flow velocity, and pre-treatment of runoff. Ditches, culverts and open channels are generally used in rural areas. This type of drainage system is typically not supported in urban environments. This is not a viable option for the overall servicing.

Piped Services or Expansion of Municipal Services are considered the only viable option to achieve the development objectives for the KNUEA. This is consistent with the Provincial Policy Statement which recommends municipal water services as the preferred form of servicing for settlement areas.

Table 4.1 on the following page outlines the alternative storm drainage solutions.

Note: Discussions in this report pertain to storm drainage systems. Discussions with respect to stormwater management systems can be found in the Environmental Management Plan.

Table 4.1: Alternative Solutions - Storm Drainage

Alternative Solution	Drainage and Land Use	Social Environment	Natural Environment	Comment	Carried Forward
Do Nothing	×	×	×	Does not satisfy the drainage requirements Does not address the problem/opportunity Does not meet the intent of the planning or drainage/servicing policies	***No***
Limit Growth	×	~	~	Will satisfy a reduced drainage requirement Does not fully address the problem/opportunity Requires mitigation to lessen negative environmental impacts	***No***
Open Ditches & Culverts	✓	✓	✓	Provides opportunities for infiltration. Lower velocities than piped sewers. Provides pre-treatment of storm runoff (some removal of pollutants & suspended solids). Generally not utilized in urban areas.	***No***
Piped Services (sewers)	✓	✓	~	Lower land requirement than open ditches. More restrictions on minimum slopes, ground cover.	***Yes***

× Negative Impact ✓ Positive Impact ~ Neutral Impact (can be mitigated)

4.1.2 Wastewater Collection Alternatives

Preliminary wastewater collection alternatives for the Kanata North Urban Expansion Area include:

- Do Nothing
- Limit Growth
- Private Septic Systems
- Communal Collection and Treatment System
- Municipal Service Extension and Upgrades

The *Do Nothing* and *Limit Growth* alternatives are not considered viable options as they do not meet the development objectives established for the study area.

Private Septic Systems will satisfy a reduced sanitary demand. It would be difficult to address the intensive nitrate loadings into the groundwater system. This alternative would have negative environmental impacts. This is not a viable alternative for the required development objectives for the KNUEA. This alternative also is not consistent with the recommendations specified in the Provincial Policy Statement.

A *Communal Collection and Treatment System* could satisfy the demand and land use criteria. Social and environmental concerns associated with this type of system suggest there may be better alternatives. This alternative also is not consistent with the recommendations specified in the Provincial Policy Statement.

Municipal Service Extension and Upgrade is a more viable solution. This alternative produces only minimal social and environmental impacts, and is relatively cost effective by using spare capacity in the existing municipal infrastructure system. The Provincial Policy Statement recommends municipal sewage services as the preferred form of servicing for settlement areas.

Table 4.2 on the following page outlines the alternative wastewater collection solutions.

Table 4.2: Alternative Solutions - Wastewater Collection

Alternative Solution	Sanitary Demand and Land Use	Social Environment	Natural Environment	Comment	Carried Forward
Do Nothing	×	×	×	Does not satisfy the sanitary requirements Does not address the problem/opportunity Does not meet the intent of the planning or servicing policies	***No***
Limit Growth	×	~	~	Will satisfy a reduced sanitary demand Does not fully address the problem/opportunity Requires mitigation to lessen negative environmental impacts	***No***
Private Septic Systems	×	~	×	Will satisfy a reduced sanitary demand Does not fully address the problem/opportunity Difficult to address negative environmental impacts (nitrate loading of groundwater)	***No***
Communal Collection and Treatment System	✓	~	×	Satisfies the demand and land use criteria Mostly solves the problem/opportunity Intermittent odour concerns Nitrate impact on groundwater	***No***
Upgrade Municipal Services	✓	~	~	Requires mitigation to lessen negative environmental and social impacts	***Yes***
Extend Municipal Services	✓	~	~	Requires mitigation to lessen negative environmental and social impacts	***Yes***

× Negative Impact ✓ Positive Impact ~ Neutral Impact (can be mitigated)

4.1.3 Water Distribution Alternatives

Preliminary water distribution alternatives for the Kanata North Urban Expansion Area include:

- Do Nothing
- Limit Growth
- Private Water Well
- Communal Water Well
- Municipal Service Extension and Upgrades

The *Do Nothing* and *Limit Growth* alternatives are not considered viable options as they do not meet the development objectives established for the study area.

Private Water Well could satisfy a reduced water demand. This alternative is not consistent with the recommendations as specified in the Provincial Policy Statement for urban areas and could potentially reduce groundwater levels, negatively impacting the environment.

A *Communal Water Well* could satisfy the demand and land use criteria. However, this alternative is also not consistent with the recommendations specified in the Provincial Policy Statement for urban areas and could potentially reduce groundwater levels, negatively impacting the environment.

Municipal Service Extension and Upgrade is the most viable solution. This alternative produces only minimal social and environmental impacts, and is relatively cost effective by using spare capacity in the existing municipal infrastructure system. The Provincial Policy Statement recommends municipal water services as the preferred form of servicing for settlement areas.

Table 4.3 on the following page outlines the alternative water distribution solutions.

Table 4.3: Alternative Solutions - Water Distribution

Alternative Solution	Water Demand and Land Use	Social Environment	Natural Environment	Comment	Carried Forward
Do Nothing	×	×	×	Does not satisfy the demand requirements Does not address the problem/opportunity Does not meet the intent of the planning or servicing policies	***No***
Limit Growth	×	~	~	Will satisfy a reduced water demand requirement ï some infrastructure still required Does not fully address the problem/opportunity Requires mitigation to lessen negative environmental and social impacts	***No***
Private Wells	×	~	~	Will satisfy a reduced water demand Does not fully address the problem/opportunity Impact on groundwater system	***No***
Communal Wells	✓	~	~	Satisfies the demand and land use criteria Requires mitigation to lessen negative environmental impacts Does not conform to city infrastructure policy within the urban area	***No***
Extend and Upgrade Municipal Services	✓	✓	~	Satisfies the demand and land use criteria Requires mitigation to lessen negative environmental impacts	***Yes***

× Negative Impact ✓ Positive Impact ~ Neutral Impact (can be mitigated)

4.2 Preferred Servicing Alternative

An expansion and upgrade of the municipal infrastructure system was evaluated as the best servicing alternative to achieve the land use objectives, while minimizing negative impacts to both the social and natural environment.

4.2.1 Municipal Servicing: Criteria & Evaluation

The preferred servicing option of expanding the municipal infrastructure system was applied to four alternative Concept Plans (A through D, refer to **Figure 4.1**). These concepts were prepared based on feedback from the first public open house, the concept plans prepared at the public workshop in October 2013, and ongoing discussion with the CPT, TAC and PAC.

The municipal servicing solution, particularly for water supply and wastewater collection, was found to be relatively independent of the concept plans. In other words, irrespective of changes made to the Concept Plans, the design solutions were similar in nature. Based on the analysis, infrastructure was not a determining factor in selection of the final Concept Plan.

For comparative purposes, a criteria and indicator list was created to evaluate the relative benefits of each servicing solution. **Table 4.4** outlines the criteria and indicators, while **Tables 4.5, 4.6** and **4.7** evaluate the alternative Concept Plans. Rankings of worst, poor, okay and good are used in answer to the criteria and then an overall ranking is provided at the bottom of each table.

Table 4.4 - Servicing Criteria

Storm Drainage System	
Criteria	**Indicator**
1. Constraints	• Does the sewer design require significant rock excavation? • Is the sewer design excessively deep? • Does the sewer system disrupt natural habitat? • Does the sewer design disrupt the social environment?
2. Flood Protection	• Does the design minimize conveyance of 100-year overland flow across arterial and collector roadways?
3. Cost	• Is the design cost-effective? • Are the operation and maintenance costs reasonable?
Stormwater Management System The limit of the storm drainage system, for the purpose of this evaluation, is considered to be to the outlet of the storm sewer system or the inlet of the SWM facilities. Storm works beyond the outlet are considered part of the stormwater management system. Refer to the Environmental Management Plan for the criteria and evaluation of the stormwater management system.	
Wastewater Collection System	
Criteria	**Indicator**
1. Constraints	• Does the sewer design require significant rock excavation? • Is the sewer design excessively deep? • Does the sewer system disrupt natural habitat? • Does the sewer design disrupt the social environment?
2. Serviceability	• Does the design make efficient use of residual capacity? • Can development be readily phased?
3. Cost	• Is the design cost-effective? • Are the operation and maintenance costs reasonable?
Water Distribution System	
Criteria	**Indicator**
1. Serviceability	• Does the design make efficient use of residual capacity? • Can development be readily phased?
2. Cost	• Is the design cost-effective? • Are the operation and maintenance costs reasonable?

Table 4.5: Municipal Servicing Evaluation – Storm Drainage System

Criteria & Indicator	Concept Plan A	Concept Plan B	Concept Plan C	Concept Plan D
1. Constraints				
• Does the sewer design require significant rock excavation? • Is the sewer design excessively deep? • Does the sewer system disrupt natural habitat? • Does the sewer design disrupt the social environment? • Can development be readily phased?	• Okay ï Minor rock removal. • Okay ï Average depth, routing follows topography. • Okay ï The storm sewer system follows the road network. The road network has been established to minimize impact on natural environment areas. • Okay ï Watercourse crossings with the sewer are inevitable on this property given the tributaries to Shirleyôs Brook. Crossings have been minimized where possible. • Okay - Phasing is directly related to the downstream SWM facility construction. On-site servicing can be phased.	• Okay ï Minor rock removal. • Okay ï Average depth, routing follows topography. • Okay ï The storm sewer system follows the road network. The road network has been established to minimize impact on natural environment areas. • Okay ï Watercourse crossings with the sewer are inevitable on this property given the tributaries to Shirleyôs Brook. Crossings have been minimized where possible. • Okay - Phasing is directly related to the downstream SWM facility construction. On-site servicing can be phased.	• Okay ï Minor rock removal. • Okay ï Average depth, routing follows topography. • Okay ï The storm sewer system follows the road network. The road network has been established to minimize impact on natural environment areas. • Okay ï Watercourse crossings with the sewer are inevitable on this property given the tributaries to Shirleyôs Brook. Crossings have been minimized where possible. • Okay - Phasing is directly related to the downstream SWM facility construction. On-site servicing can be phased.	• Okay ï Minor rock removal. • Okay ï Average depth, routing follows topography. • Okay ï The storm sewer system follows the road network. The road network has been established to minimize impact on natural environment areas. • Okay ï Watercourse crossings with the sewer are inevitable on this property given the tributaries to Shirleyôs Brook. Crossings have been minimized where possible. • Okay - Phasing is directly related to the downstream SWM facility construction. On-site servicing can be phased.
2. Flood Protection				
• Does the design minimize conveyance of 100-year overland flow across arterial and collector roadways?	• Good ï No major overland flows across arteria/transitway.	• Good ï No major overland flows across arterial/transitway.	• Good - No major overland flows across arterial/transitway.	• Good ï No major overland flow across arterial/transitway.
3. Cost				
• Is the design cost-effective? • Are the operation and maintenance costs reasonable?	Okay - Capital and O&M costs are equivalent for all options.	Okay -Capital and O&M costs are equivalent for all options.	Okay -Capital and O&M costs are equivalent for all options.	Okay -Capital and O&M costs are equivalent for all options.
Rating: Storm	Okay	Okay	Okay	Okay

Table 4.6: Municipal Servicing Evaluation – Wastewater Collection System

Criteria & Indicator	Concept Plan A	Concept Plan B	Concept Plan C	Concept Plan D
1. Serviceability				
• Does the sewer design require significant rock excavation? Is the sewer design excessively deep?	• Poor ï Rock excavation is a dependent on the outlet location. The outlet is not within or at the perimeter of the site which puts the sewer at a deeper elevation. It is not a function of the concept.	• Poor ï Rock excavation is a dependent on the outlet location. The outlet is not within or at the perimeter of the site which puts the sewer at a deeper elevation. It is not a function of the concept.	• Poor ï Rock excavation is a dependent on the outlet location. The outlet is not within or at the perimeter of the site which puts the sewer at a deeper elevation. It is not a function of the concept.	• Poor ï Rock excavation is a dependent on the outlet location. The outlet is not within or at the perimeter of the site which puts the sewer at a deeper elevation. It is not a function of the concept.
• Does the sewer system disrupt natural habitat?	• Okay ï The sanitary sewer system follows the road network. The road network has been established to minimize impact on natural environment areas.	• Okay ï The sanitary sewer system follows the road network. The road network has been established to minimize impact on natural environment areas.	• Okay ï The sanitary sewer system follows the road network. The road network has been established to minimize impact on natural environment areas.	• Okay ï The sanitary sewer system follows the road network. The road network has been established to minimize impact on natural environment areas.
• Does the sewer design disrupt the social environment?	• Okay ï Watercourse crossings with the sewer are inevitable on this property given the tributaries to Shirleyôs Brook. Crossings have been minimized where possible.	• Okay ï Watercourse crossings with the sewer are inevitable on this property given the tributaries to Shirleyôs Brook. Crossings have been minimized where possible.	• Okay ï Watercourse crossings with the sewer are inevitable on this property given the tributaries to Shirleyôs Brook. Crossings have been minimized where possible.	• Okay ï Watercourse crossings with the sewer are inevitable on this property given the tributaries to Shirleyôs Brook. Crossings have been minimized where possible.

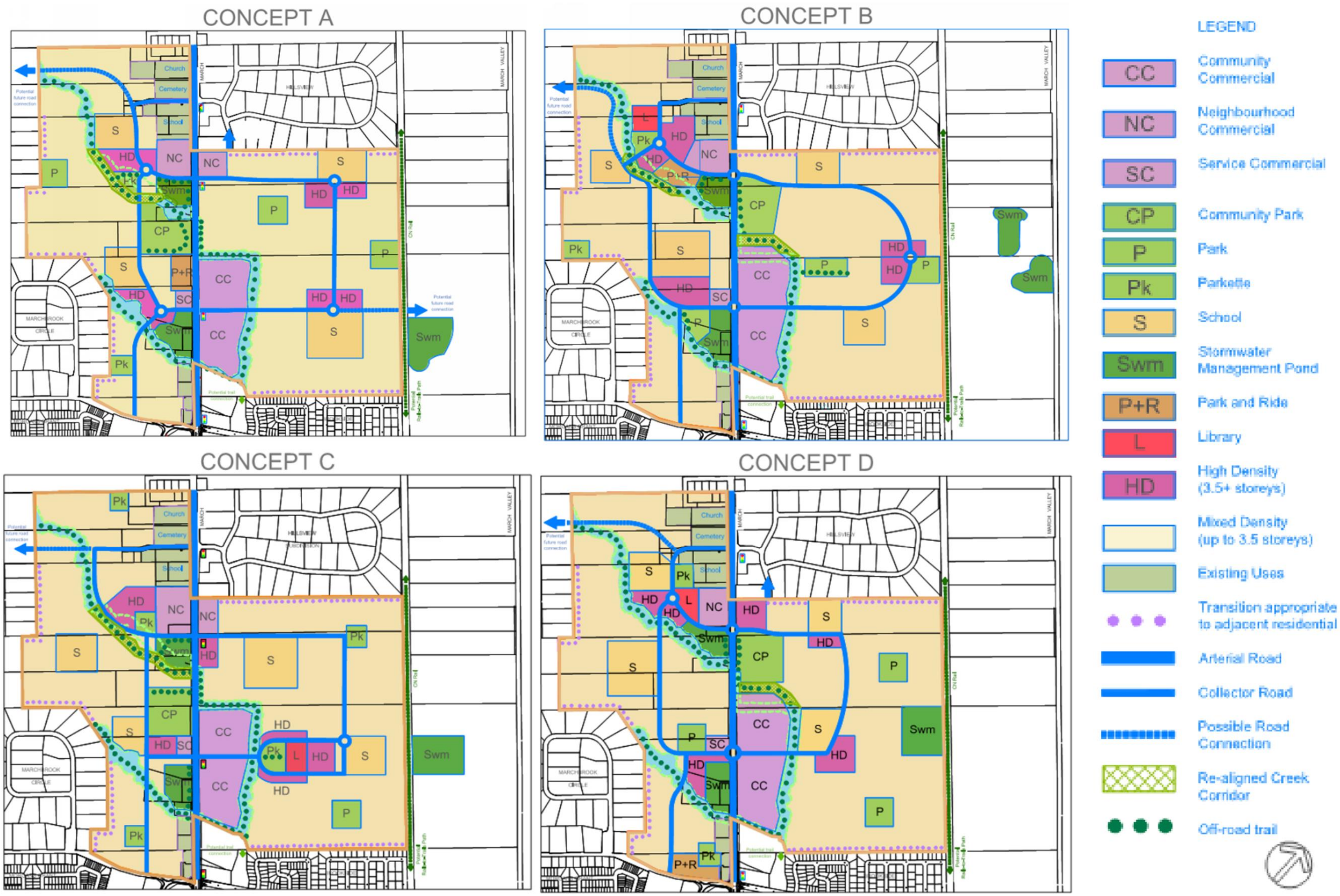
Table 4.6: Municipal Servicing Evaluation – Wastewater Collection System (continued)

Criteria & Indicator	Concept Plan A	Concept Plan B	Concept Plan C	Concept Plan D
2. Compatibility with Municipal Infrastructure				
• Does the design make efficient use of residual capacity? • Can development be readily phased?	• Okay ï The sewer system follows the road network and the outlet to the City system is the same for all concepts. Off-site servicing is evaluated independently. • Okay ï Phasing of the servicing is a function of the off-site servicing. On-site servicing can be phased.	• Okay ï The sewer system follows the road network and the outlet to the City system is the same for all concepts. Off-site servicing is evaluated independently. • Okay ï Phasing of the servicing is a function of the off-site servicing. On-site servicing can be phased.	• Okay ï The sewer system follows the road network and the outlet to the City system is the same for all concepts. Off-site servicing is evaluated independently. • Okay ï Phasing of the servicing is a function of the off-site servicing. On-site servicing can be phased.	• Okay ï The sewer system follows the road network and the outlet to the City system is the same for all concepts. Off-site servicing is evaluated independently. • Okay ï Phasing of the servicing is a function of the off-site servicing. On-site servicing can be phased.
3. Cost				
Is the design cost-effective? Are the operation and maintenance costs reasonable?	• Okay - Capital and O&M costs are equivalent for all options.	• Okay - Capital and O&M costs are equivalent for all options.	• Okay - Capital and O&M costs are equivalent for all options.	• Okay - Capital and O&M costs are equivalent for all options.
Rating: Wastewater	Okay	Okay	Okay	Okay

Table 4.7: Municipal Servicing Evaluation – Water Distribution System

Criteria & Indicator	Concept Plan A	Concept Plan B	Concept Plan C	Concept Plan D
1. Serviceability				
• Does the design make efficient use of residual capacity? • Can development be readily phased?	• Good - Lands readily serviced by water. • Good ï Phasing to move north from southern boundary.	• Good ï Lands readily serviced by water. • Good ï Phasing to move north from southern boundary.	• Good ï Lands readily serviced by water. • Good ï Phasing to move north from southern boundary.	• Good ï Lands readily serviced by water. • Good ï Phasing to move north from southern boundary.
2. Cost				
• Is the design cost-effective? Are the operation and maintenance costs reasonable?	• Okay - Capital costs and O&M expenses exhibit near equivalency between the options (based on roadway length and ease of connection to external supply).	• Okay - Capital costs and O&M expenses exhibit near equivalency between the options (based on roadway length and ease of connection to external supply).	• Okay - Capital costs and O&M expenses exhibit near equivalency between the options (based on roadway length and ease of connection to external supply).	• Okay - Capital costs and O&M expenses exhibit near equivalency between the options (based on roadway length and ease of connection to external supply).
Rating: Water	Good	Good	Good	Good
Total Rating	**Okay/Good**	**Okay/Good**	**Okay/Good**	**Okay/Good**

Figure 4.1: Alternative Concept Plans (presented at Second Open House on February 26, 2014).



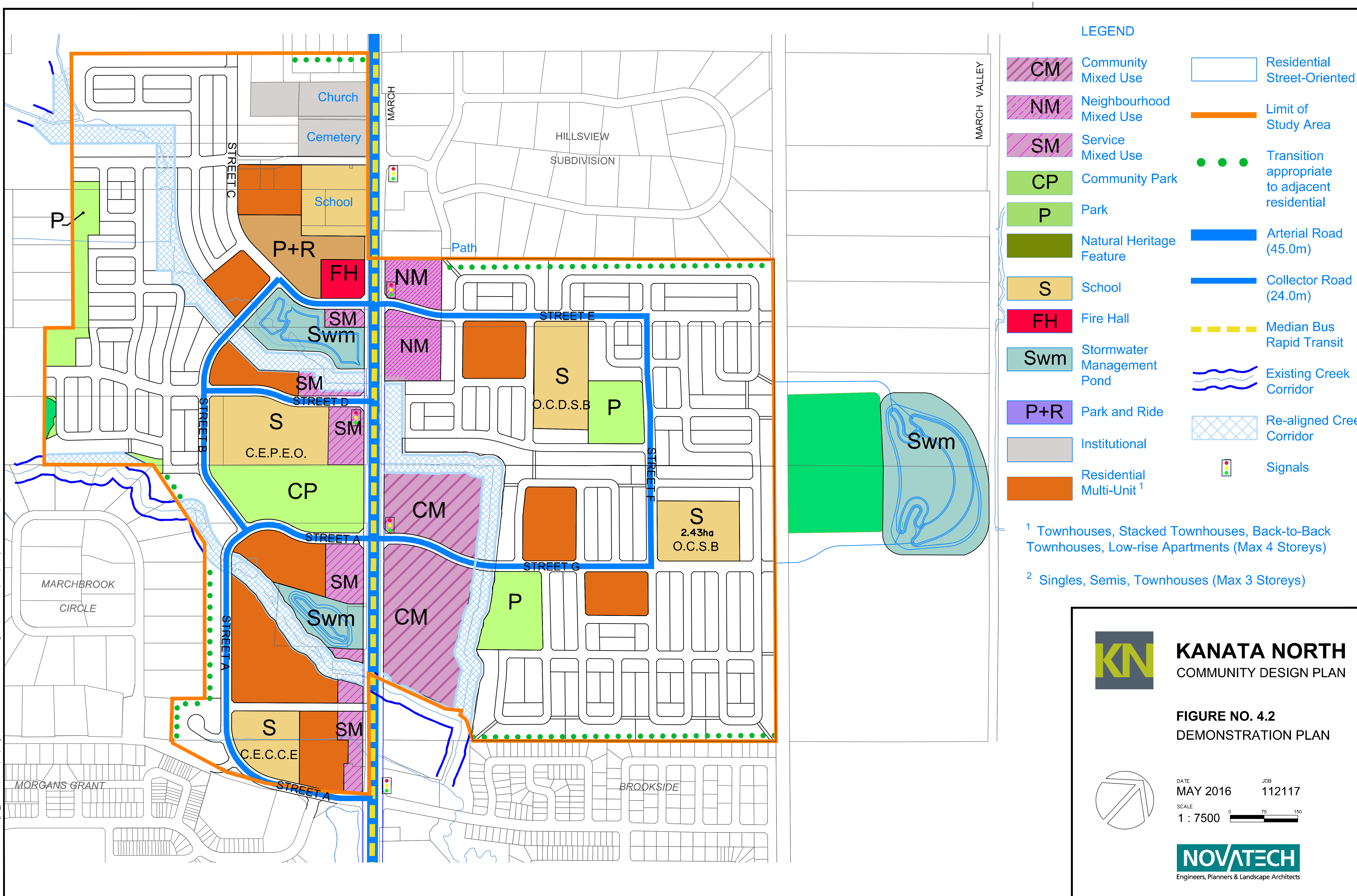
4.2.2 Municipal Servicing: Conclusion

The municipal infrastructure design for Concept Plans A through D was rated for the storm drainage, wastewater collection, and water distribution systems. Each category was assigned a qualitative rank as either Best, Good, Okay, Poor, or Worst. The cumulative criteria values were then used to rank the alternative Concept Plans.

In general, the Concept Plans all have fairly similar ratings from an infrastructure servicing perspective. This suggests that factors other than municipal servicing will dictate the layout of the Preferred Land Use Plan. Other factors were considered such as planning rationale, design of transportation corridors, public feedback, input from the Technical Advisory Committee, etc. to create a Preferred Land Use Plan.

The Preferred Land Use Plan establishes the land use designations, parks, pathways and natural heritage system and collector road network. Based on the Preferred Land Use Plan, a Demonstration Plan, **Figure 4.2**, has been prepared which adds an additional level of detail to illustrate one way in which the Land Use Plan could be implemented through development approvals.

The Demonstration Plan includes an example of a possible internal road network and lot pattern to provide an estimate of the total housing supply and population that could be accommodated within the community. The Demonstration Plan was used to establish the recommended flow rates, sewer capacity requirements and infrastructure routing which form the servicing plan for the KNUEA.



M:\2012\112117\CAD\Design_EMP\MEMO (CS)\Figure 9.1 Demonstration Plan.dwg, DEMO PLAN (MSS), May 26, 2016 - 3:56pm, tbrooks

5.0 STORM DRAINAGE & SERVICING

The Environmental Management Plan (EMP), prepared by Novatech, evaluates the stormwater management servicing options for the KNUEA. The EMP recommends servicing the proposed development with three stormwater management (SWM) ponds to provide water quality, erosion and peak flow control for the proposed development. The conceptual SWM facility design and analysis are provided in the EMP. The location of the SWM ponds and their associated contributing drainage areas are shown on **Figure 5.1**.

5.1 Stormwater Management Criteria

Stormwater management criteria have been established and are outlined in the EMP. The SWM criteria have been developed on the basis of aquatic habitat protection and the sensitivity of the downstream erosion regime. Quality control objectives have been developed based on the recommendations of the Shirley's Brook and Watts' Creek Subwatershed Study. Quantity control objectives have been developed to ensure there is no adverse impact on the downstream watercourses resulting from the proposed development. A summary of the stormwater management criteria presented in the EMP is provided below.

<u>Quantity Control</u>

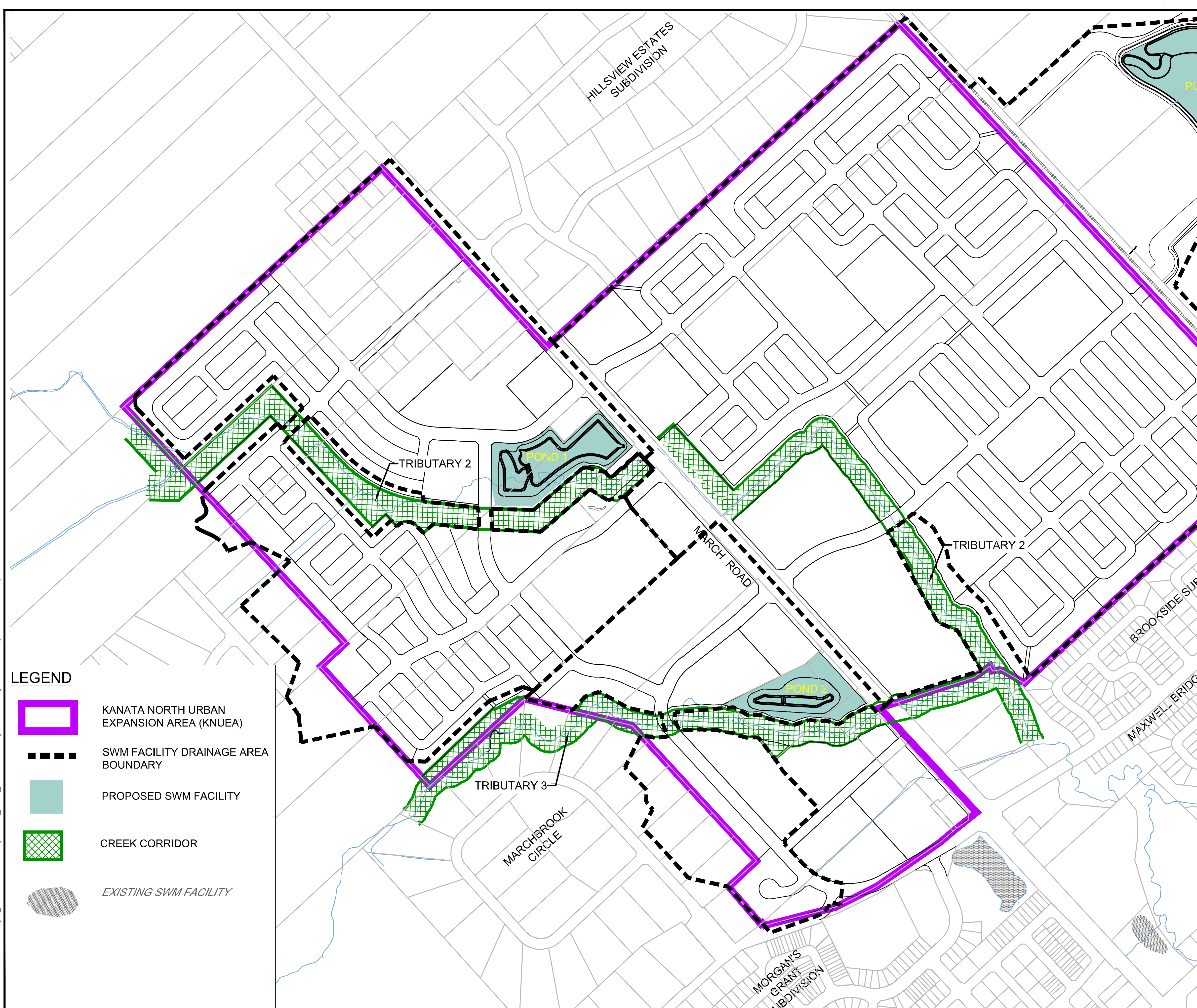
- West of March Road, quantity control storage is to be designed to ensure no increase in peak flow in the receiving watercourses (Tributaries 2 & 3) downstream of the KNUEA;
- East of March Road, post-development peak flows from the development area are to be controlled to pre-development rates for all storms up to and including the 100-year event.
- Ensure no adverse impacts on erosion in the watercourses resulting from future development within the KNUEA.

<u>Quality Control</u>

- An *Enhanced* level of water quality treatment (80% long-term TSS removal) is required for all development within the Shirley's Brook subwatershed.

<u>Storm Drainage</u>

- Storm drainage within the urban area will be provided using storm sewers sized to convey the uncontrolled 5-year post-development peak flow (10-year for March Road right-of-way).
- Major system flows are to be conveyed within the rights-of-way and/or along defined overland flow routes with no encroachment onto private property.
- Major system flows must not flow overland across arterial roads (March Road).



KANATA NORTH
COMMUNITY DESIGN PLAN

FIGURE NO. 5.1
SWM POND LOCATIONS

DATE MAY 2016
JOB 112117
SCALE N.T.S.

NOVATECH
Engineers, Planners & Landscape Architects

M:\2012\112117\CAD\Design_MSS\FIGURES\Figure 5.1_5.7.1_5.7.2. - Drainage Areas.dwg, FIG 5.1, May 18, 2016 - 1:07pm, mhrehoriak

<u>Watercourse Crossings (Culverts)</u>

- Watercourse crossings are to be sized to convey the 100-year peak flow without overtopping the roadways.
- Watercourse crossings should be designed in accordance with geomorphology principles.
- Watercourse crossings should be designed to ensure they meet any additional requirements for terrestrial and aquatic habitat.

<u>SWM Facilities</u>

- All proposed SWM facilities are to be designed in accordance with the following guidelines and manuals:
  - City of Ottawa Stormwater Management Facility Design Guidelines.
  - MOE SWM Planning and Design Manual.
- The normal water level (permanent pool) in wet ponds should ideally be above the 2-year water level in the receiving watercourse.
- Where possible, sanitary overflows are to be directed to SWM facilities. City design standards for overflows are currently in development. The following sanitary overflow criteria have been applied to the KNUEA:
  - Sanitary overflows are to operate by gravity and be directed to a SWM facility.
  - The sanitary overflow must be above the 100-year elevation in the SWM facility.
- SWM facilities should be integrated into the community through the use of pathways or other linkages.

<u>Geotechnical / Rock Elevation</u>

The proposed stormwater strategies are to be designed to minimize the extent of bedrock excavation as much as possible. The depth to bedrock is relatively shallow in some areas, and some bedrock excavation will be required.

<u>Low Impact Development / Green Stormwater Infrastructure</u>

Low impact development (LID) represents a design philosophy which attempts to minimize the impacts on the hydrologic cycle resulting from development. Green stormwater infrastructure represents the stormwater management technologies used to achieve this objective. The City of Ottawa has recently implemented several LID pilot projects to evaluate the performance and maintenance requirements of LID designs, with the expectation that LID designs will become more prevalent in the near future. The EMP provides general guidance for areas and opportunities where LID techniques could be considered at the plan of subdivision / site plan stage.

5.2 Storm Drainage Design

The MSS has built upon the recommendations of the EMP to develop a preliminary storm servicing design. The conceptual design of the SWM ponds included establishing contributing drainage areas for each SWM pond. These drainage areas were used to establish a conceptual layout of trunk sewers based on the road network shown on the Demonstration Plan (**Figure 4.2**). Factors such as optimizing routing to the outlet location (SWM ponds), minimizing creek crossings, and collection of runoff from upstream drainage areas have been considered as part of the conceptual storm drainage design.

In accordance with City of Ottawa Sewer Design Guidelines (October 2012) a dual drainage approach was applied to the design of the KNUEA storm drainage system, which includes:

- Storm sewers (minor system) will be used for conveyance of runoff up to the 5-year return period (10-year for March Road);
- An overland flow network (major system) consisting of the road network and other defined overland flow routes will be designed to provide safe conveyance of runoff from larger storm events when peak flows exceed the inlet capacity to the minor system.

5.3 Storm Drainage Design – Minor System

5.3.1 Minor System Criteria

The storm sewers servicing the KNUEA are to be designed based on the criteria outlined in the *City of Ottawa Sewer Design Guidelines*, as summarized below:

<u>Return Period</u>

- 5 year - Local and Collector Roads
- 10 year - Arterial Roads and Transitways

<u>Design Flows</u>

- Storm Sewer Design Sheets created using Rational Method
- IDF Rainfall Data as per *City of Ottawa Sewer Design Guidelines*
- Initial Time of Concentration T_c = 15 minutes (trunk sewers only)
- Runoff Coefficients
    - Mixed Use / Commercial C = 0.85
    - Arterial Roads / Transitway C = 0.65
    - Parks C = 0.40
    - Open Space C = 0.20
    - Schools / Church C = 0.65
    - Street Oriented Residential C = 0.65
    - Multi / Unit Residential C = 0.70
    - Park and Ride C = 0.85

<u>Inlet Control Devices</u>

Inlet control devices (ICD) are proposed within the roadways to ensure inflows to the storm sewer system are regulated to the 5-year peak flow (10-year peak flow for arterial roads and transitway). Inlet control devices in catchbasins are to be vertical sliding type for removal and cleaning. ICDs should be selected from the sizes/types listed in Section 13.1.19 of the *Ottawa Sewer Materials Specifications* (March 2014). Final specifications to be provided at detail design.

5.3.2 Trunk Sewer Sizing

The preliminary design of the trunk sewers is based on the road patterns shown on the Demonstration Plan and is intended to provide a preliminary design of the required storm drainage infrastructure. The proposed trunk storm sewer system is shown on **Figure 5.3.2** and drainage areas are shown on the Storm Drainage Area Plan ï Minor System Drainage (112117-STM1) in **Appendix B**. Storm sewer design sheets for the drainage areas tributary to each of the proposed SWM facilities are also provided in **Appendix B**. Prior to Draft Plan Approval the routing of sub-drainage areas tributary to Pond 1 will need to be confirmed once more information on the proposed development is available. Consideration will need to be given to elements including but not limited to grade raise restrictions, rock, any existing storm drainage plans and storm sewer crossings under existing Tributaries. The overall drainage area (sewershed) to Pond 1 will remain unchanged.

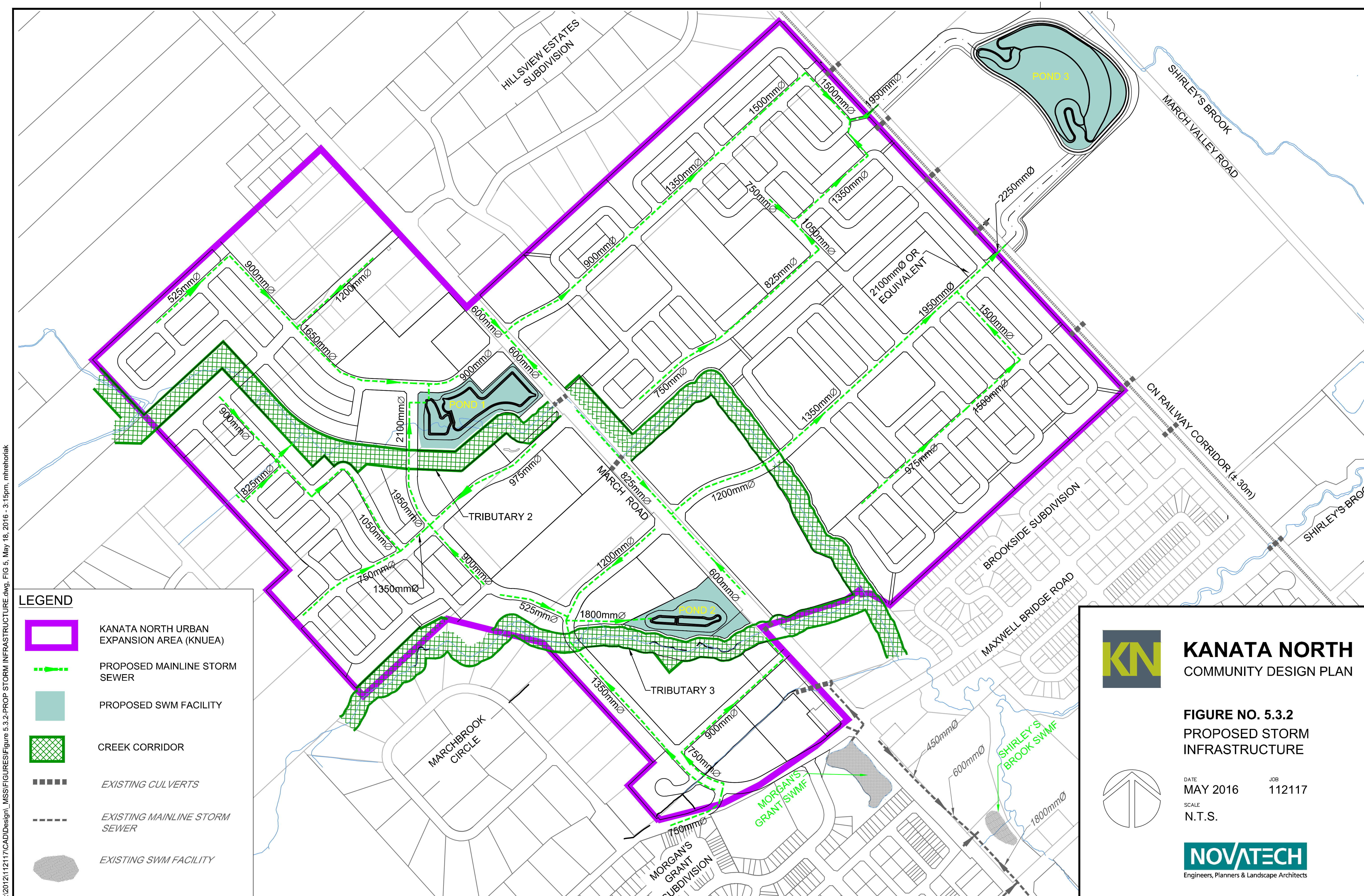
The storm sewer design prepared for the MSS is based on the Demonstration Plan and intended to demonstrate the feasibility of the overall storm servicing strategy. Refinements to the design and layout of the trunk storm sewer system will be made as plans of subdivision are developed. Development plans within the KNUEA should make an effort to maintain the drainage boundaries shown on the above noted drainage area plan since the SWM facility blocks have been sized to accommodate those areas.

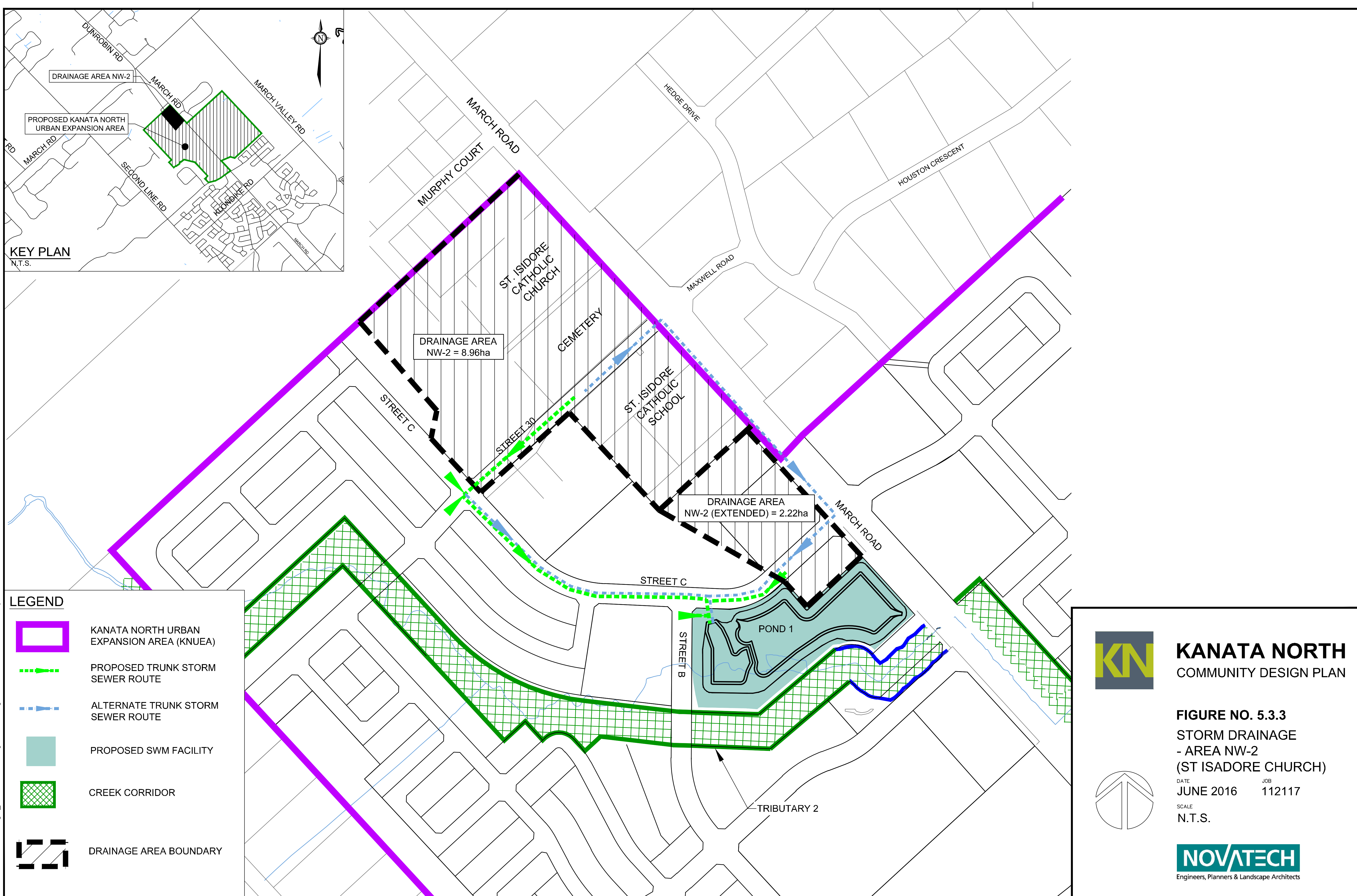
It is not anticipated that the grade raise restrictions, as indicated in the various geotechnical investigations, will be a constraining factor in the trunk storm sewer design. The geotechnical information is summarized on **Figure 3.3**.

The preliminary design of trunk sewers includes some rock removal. In particular, there is a portion of the trunk storm sewer in the northwest quadrant that requires some deep rock removal. Refer to the Preliminary Plan and Profiles (Drawings 112117-PP5 and 112117-PP11 in **Appendix E**). This section of sewer has been designed to collect drainage from a low area, through the KNUEA and outlet to Pond 1. **Figure 5.3.3** shows this area. Another option would be to drain this low area to a sewer along March Road which would still outlet to Pond 1. This option still requires rock removal and overall more storm sewer. When the type of housing and final road patterns are more defined, a cost benefit analysis could be completed to determine which option is preferable.

5.3.3 Hydraulic Grade Line Analysis - Trunk Storm Sewers

A preliminary hydraulic grade line (HGL) analysis of the trunk storm sewers was undertaken using the Autodesk Storm and Sanitary Analysis (SSA) model. This model is based on EPA SWMM 5.0 and can be exported to a generic SWMM5 file, which can then be used in PCSWMM or any other modelling software based on the EPA SWMM engine. The HGL generated as part of this study is preliminary in nature and was used only to confirm feasibility of the proposed storm sewer sizing. Prior to any draft plan approvals, the HGL


HILLSVIEW ESTATES SUBDIVISION
POND 3
SHIRLEY'S BROOK
MARCH VALLEY ROAD
CN RAILWAY CORRIDOR (± 30m)
SHIRLEY'S BROOK
BROOKSIDE SUBDIVISION
MAXWELL BRIDGE ROAD
MARCH ROAD
POND 1
POND 2
TRIBUTARY 2
TRIBUTARY 3
MARCHBROOK CIRCLE
MORGAN'S GRANT SUBDIVISION
MORGAN'S GRANT SWMF
SHIRLEY'S BROOK SWMF
2100mmØ OR EQUIVALENT
525mmØ
900mmØ
1200mmØ
1650mmØ
600mmØ
2100mmØ
825mmØ
1950mmØ
1050mmØ
750mmØ
1350mmØ
975mmØ
1800mmØ
1500mmØ
2250mmØ
450mmØ
LEGEND
KANATA NORTH URBAN EXPANSION AREA (KNUEA)
PROPOSED MAINLINE STORM SEWER
PROPOSED SWM FACILITY
CREEK CORRIDOR
EXISTING CULVERTS
EXISTING MAINLINE STORM SEWER
EXISTING SWM FACILITY
KN
KANATA NORTH
COMMUNITY DESIGN PLAN
FIGURE NO. 5.3.2
PROPOSED STORM INFRASTRUCTURE
DATE
MAY 2016
JOB
112117
SCALE
N.T.S.
NOVATECH
Engineers, Planners & Landscape Architects
M:\2012\112117\CADDesign_MSS\FIGURES\Figure 5.3.2-PROP STORM INFRASTRUCTURE.dwg, FIG 5, May 18, 2016 - 3:15pm, mhrehoriak



M:\2012\112117\CAD\Design_MSS\FIGURES\Figure 5.3.3.dwg, FIG 5.3, Jun 23, 2016 - 12:25pm, tbrooks analysis for the trunk sewers will need to be confirmed on a sewershed basis using a hydrodynamic model or some similar approach acceptable to the City.

<u>Methodology</u>

The HGL analysis uses steady-state flows to calculate the 100-year hydraulic grade line. The 100-year flow was estimated by modifying the storm sewer design sheets to use a fixed time of concentration of 15 minutes for the 5-year design storm. The resulting flows approximate the controlled 100-year peak flow, assuming the inlets are restricted to the 5-year peak flow using ICDs. During large storm events, ICDs will restrict inflows to a relatively constant and sustained flow, and the peak flows from each minor system inlet will converge in the minor system at roughly the same time. This approach is not dependant on the major system design, but has been demonstrated to produce results comparable to a dynamic dual-drainage model. The major system was evaluated using a different methodology ï refer to **Section 5.4.**

- The model uses hydrodynamic routing to calculate the HGL in the storm sewers.
- Peak flows have been calculated using City of Ottawa IDF data using a fixed 15-minute time of concentration - refer to design sheet in **Appendix B**.
- The steady-state peak flows are added at each node, corresponding to the upstream maintenance holes in the storm sewer design sheets.
- Downstream boundary conditions are based on the 2-year water levels in the SWM facilities. As this is a steady-state analysis, using the 100-year water level as the boundary condition was deemed to be too conservative. The 2-year elevation represents the approximate storage depth that will coincide with the 100-year peak inflow.
- The model was run until the HGL reaches an equilibrium based on the steady-state peak flows and downstream boundary conditions.
- Entrance and exit losses are applied at the inlet and outlet of each pipe section. The losses are documented in the model output provided in **Appendix B**.

Based on the HGL assessment, some pipes were upsized to ensure the 100-year HGL is no higher than 0.6m above the pipe obverts. This cap was applied to ensure that pipes maintain a sustainable HGL elevation. When HGL elevations are high, relatively small increases in flow result in much larger increases in HGL elevation throughout a storm sewer system under surcharge conditions. The greater the surcharge condition, the greater the potential variance as the pipe system struggles to pass the additional flow. A maximum HGL of 0.6m above the pipe obvert also helps to ensure a reasonable design of storm sewer networks which discharge to the trunk sewers.

This HGL analysis is conceptual and HGL elevations will need to be re-evaluated during detail design. The SSA modelling output is included in **Appendix B**.

5.4 Storm Drainage Design - Major System

A conceptual analysis of the major system was completed to evaluate the conveyance of overland flows exceeding the capacity of the minor system during the 100-year storm event.

5.4.1 Major System Criteria

Design of the major system will adhere to the design standards outlined in Section 5.5 of the *City of Ottawa Sewer Design Guidelines*. Criteria used in the major system design are summarized below:

<u>Major System Flow Outlets</u>
Major system flow must be directed to either:

- One of the proposed SWM facilities; or
- An outlet watercourse.

<u>Maximum Flow/Velocity on Streets</u>
For overland flow the product of the Velocity (m/s) x Depth (m) should not be greater than 0.6.

<u>Cross-Street Flow</u>
No cross-street flow is permitted for the minor (5-year) storm event, and there is to be only minimal ponding within the roadways. Major system flow from local streets can be conveyed to other local or collector roads, or to a SWM facility or watercourse.

<u>Major System Flow Depths</u>
For events exceeding the minor system design storm and up to the 100 year design storm, flow depth is permitted in the right of way up to the following maximum water depths:

- Local: 300mm at edge of pavement
- Collector: 250mm at edge of pavement
- Arterial: No barrier curbs overtopping. Flow spread must leave at least one lane free of water in each direction

It should also be noted that during detailed design, where possible, it is desirable to promote overland sheet drainage directly to the tributaries from primarily vegetated open spaces (i.e. School yards, parks, and low density residential rear yards). These mainly pervious areas will generally have ócleanô runoff, and as such do not require quality or quantity treatment. Allowing these vegetated areas to sheet drain will help distribute major system flows along the tributaries, which will reduce the flows directed along the proposed rights-of-way, and to the SWM ponds.

Where on-site storage is provided up to the 100-year event and if locations permit, major system flows in excess of the 100-year storm event may be allowed to flow overland directly to the tributaries.

Culverts

There are various culverts proposed to service the KNUEA. These culverts include:

- Existing culverts crossing March Road. These existing culverts have been evaluated in terms of condition and capacity in the EMP.
- Existing culverts crossing the abandoned rail corridor. These existing culverts have been evaluated in the MSS to confirm there is capacity to convey major flows from the proposed development.
- Proposed culverts for the road crossings proposed along Tributary 2 and 3. Supporting calculations for these proposed culverts are included in the EMP.

It should be noted that there will be services located at the tributary crossings including storm sewer, sanitary sewer and watermain. The proposed trenches for these crossings will be in rock and will require a clay cap to prevent surface water in the tributaries from migrating into the underlying trenches. Prior to Draft Plan Approval the details of the crossings will need to be confirmed to ensure City requirements have been met.

5.4.2 Major System Drainage Areas

A preliminary grading plan was developed using the Demonstration Plan. This Preliminary Grading Plan provides preliminary grades at key points such as intersections and defines the major system overland flow routes within the KNUEA. A major system drainage area plan was developed based on this preliminary macro-grading plan that subdivides the site into overland flow catchment areas. The macro-grading is shown on the Preliminary Grading Plan (112117-PGR) in **Appendix E**. Prior to Draft Plan Approval the routing of sub-drainage areas in the northwest quadrant tributary to Pond 1 and specifically the Park and Ride block will need to be confirmed once more information on the proposed development is available. Consideration will need to be given to elements including grade raise restrictions, shallow rock, overland flow routes and any existing storm drainage plans. The overall drainage area (sewershed) to Pond 1 will remain unchanged.

The northwest quadrant of the KNUEA, including portions of March Road will be graded to direct the major system drainage to Pond 1. The southwest quadrant will be graded, where possible, to direct the major system drainage to Pond 2. Some areas of the southwest quadrant are at a lower elevation and the major system flow will be directed either along March Road directly to Tributary 3, or to cross under March Road to Pond 3.

East of March Road, the major system drainage will be directed along collector roads, and cross through existing and proposed culverts (if required) along the abandoned rail corridor and outlet into the proposed drainage swales leading to Pond 3. The existing culverts have been evaluated and have capacity to convey the proposed flows. However, there may be more preferable locations for culverts to cross the abandoned rail corridor therefore, new culverts may be proposed during the detail design. It is also anticipated that the existing abandoned rail corridor drainage ditch will be used to provide rear yard drainage for lots adjacent to the rail corridor, as well as provide conveyance for the major system from the proposed subdivision to the various culverts crossing the abandoned rail corridor. The existing ditch has also been evaluated and has capacity to convey the major flows from the proposed development. A figure showing the ditch sections and culvert locations, and capacity calculations are included in **Appendix B.**

Prior to Draft Plan Approval, the assumptions and calculations made will need to be confirmed and the following requirements will need to be addressed:

- Grade raise restrictions;
- Property limits identified;
- Major system flow encroachment onto private property;
- Adequate maintenance access.

The major system drainage areas are shown on the Storm Drainage Area Plan ï Major System Drainage (112117-STM2) in **Appendix B**. The major and minor system drainage boundaries may differ due to site topography and should be confirmed during detail design.

5.4.3 Major System Design Flows

Conceptual major system design flows were determined based on land use and are summarized in **Table 5.4.3**. The anticipated flow rates shown in the table are cumulative for a given site.

- Example: During a 100-year event, a collector road is assumed to discharge 145 L/s/ha into the minor drainage system (storm sewers) and an additional 125 L/s/ha into the major drainage system (overland flow).

<u>Storage in Roadways</u>

Storage within road sags has not been included in the analysis of the major overland system given the general topography of the site. The conceptual grading design does not include any road sags on collector roads, except at the major system inlets to the SWM facilities.

Storage in roads is not precluded, and during the detailed design stage road sag storage could be implemented where appropriate.

<u>Low / Medium Density Residential Areas</u>

The KNUEA is comprised mainly of low and medium density residential development and the stormwater management methodology is different than for larger, single outlet sites (i.e. commercial/institutional). The routing of major system flows through local streets and rear yards of residential areas attenuates peak flows in the major system. The total flow will still increase as the upstream area increases, but the per hectare rate will gradually decrease. This concept is similar to the minor system design where a greater time of concentration for a given catchment area will reduce unit (per hectare) flows.

The attenuation of major system flows has been accounted for in the major system analysis by using SWMHYMO to simulate major and minor system runoff from generic residential drainage areas ranging in size from 5 hectares to 25 hectares ï refer to **Figure 5.4.3**.

- Example: During a 100-year event, a 10ha medium density residential area will generate 90L/s/ha of major system runoff. If this runoff is routed through another 10ha medium density residential area, the total major system flow from the combined 20ha area will have been attenuated to approximately 70 L/s/ha.

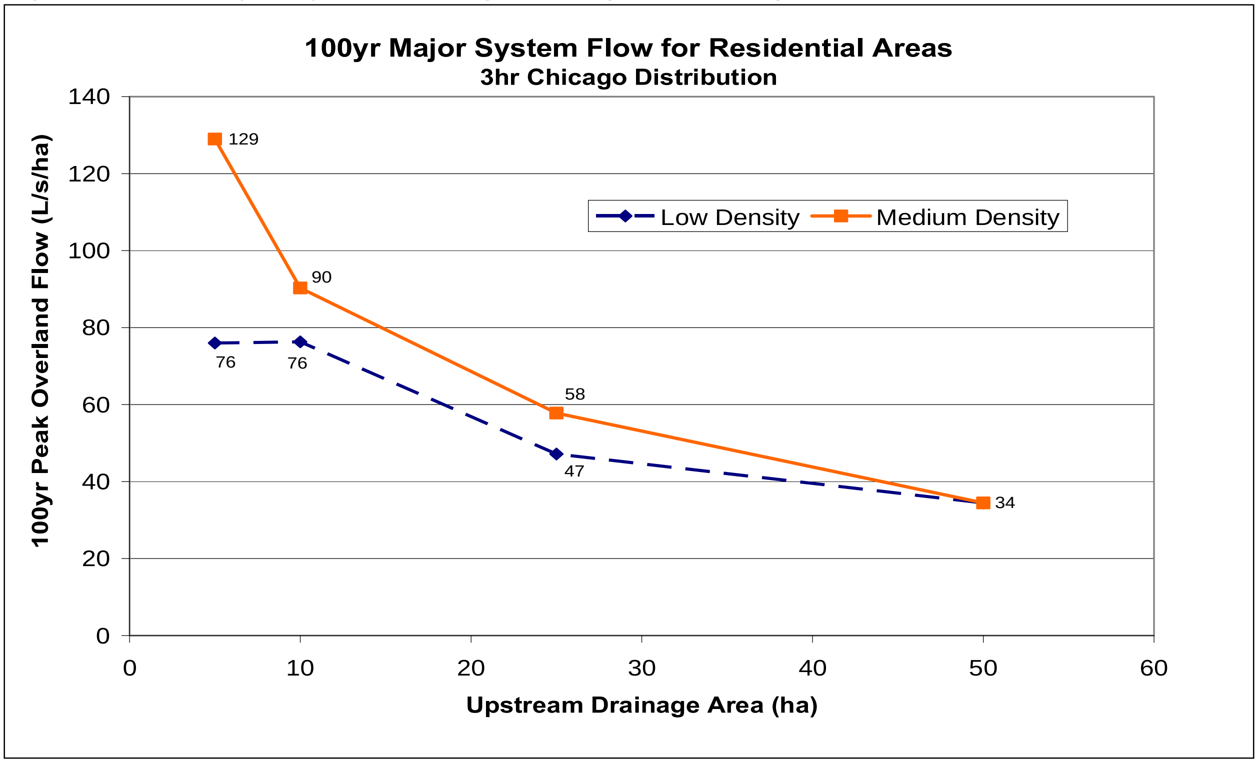
Commercial / Institutional / Multi-Unit Residential Areas

The major system analysis also assumes that on-site storage will be provided for commercial, institutional, and multi-unit residential areas for storms greater than the 5-year and up to the 100-year event, and that no major system flows will be generated for these areas. The overall site grading does provide major drainage outlets from these areas in the event that the available on-site storage is exceeded.

Table 5.4.3: Estimated Major System Peak Flows and Runoff Volumes

Land Use	'C'	% Imperv	Minor System Inlet Rate (L/s/ha)	Major System Discharge Rate (L/s/ha)
Arterial Roads / Transitway	0.65	64%	185	101
Collector Roads	0.70	71%	145	125
Mixed Use / Commercial	0.85	93%	150	0
Schools/Church	0.65	64%	115	130
Parks	0.40	29%	70	12
Open Space	0.20	0%	50	26
Street Oriented Residential	0.65	64%	100	Varies, see Figure 5.4.3
Multi Unit Residential	0.70	71%	115	Varies, see Figure 5.4.3
Park and Ride	0.85	93%	185	0

Figure 5.4.3: Major System Rating Curve (Peak Flows) for Residential Development



5.4.4 Major System Peak Flows

The conceptual major system peak flows have been evaluated to ensure that flow depths and velocities meet the City of Ottawa design criteria. The highest peak flows within each major system drainage area have been used in the evaluation. The evaluation has been completed using Manningõs equation based on the average slope of the drainage area. A summary of the analysis including design flows and depth of flow on the roadway is shown on the Storm Drainage Area Plan ï Major System Drainage (drawing 112117-STM2). Preliminary design calculations are provided in **Table B-2** within **Appendix B.**

The major system analysis will need to be re-evaluated at the detailed design stage to ensure the criteria outlined in Section 5.4.1 are met.

5.5 Storm Servicing Evaluation

As indicated previously, the storm servicing was determined based on factors such as optimum routing to the outlet (SWM ponds) and following the road network on the Demonstration Plan, minimizing creek crossings, avoiding crossing conflicts with other sewers/watermain, conveyance of upstream drainage areas and routing of the major system to the SWM ponds. The following criteria in **Table 5.5** below were used to evaluate the storm sewer system.

Table 5.5: Storm Servicing Evaluation

	Criteria	Indicators	Evaluation	
Design and Construction	Geotechnical issues and construction risks	Potential of poor soils/rock/elevated groundwater etc.	~	Some deep sewers
	Infrastructure requirements	Extent of new infrastructure required	✓	Works contained to KNUEA lands
	Operational Impacts	Amount of maintenance intensive infrastructure required	✓	Standard Storm sewers
	Construction Scheduling	Impact of construction on development timing	~	SWMFs required prior to Storm sewers
	System Reliability	Proximity of emergency overflow	✓	SWMF & Overflows adjacent to creek corridors
	Servicing Flexibility	Ease of accommodating potential changes in servicing plans.	✓	Sewers to follow future ROWs, residual capacity available
Land-Use	Property Acquisition	Ease of property acquisition	✓	Contained within existing and proposed corridors
	Phasing	Flexibility of design to allow multiple phasing options	~	SWMFs required prior to Storm sewers
	Impact on Future Lands/Development	Allowance of residual capacity for future growth	✓	Residual capacity available
Social	Displacement of Residents, Community/Recreation Facilities and Institutions	Affects areas of residence, institutions or businesses	✓	Works contained to KNUEA lands
	Disruption to Existing Community	Extent of works affecting existing residences and businesses and traffic disruption	✓	Works contained to KNUEA lands
Natural	Impact on Significant Natural Features	Loss of natural area due to installation of works	✓	Follows land-use plan
	Impact on Aquatic Systems	Potential impact on fish habitat due to installation of works	✓	3 Creek crossings
	Impact on Quality and Quantity of Surface Water and Groundwater	Minimize creek crossings and depth of excavation	✓	3 Creek crossings, some deep sewers
	Effects on Urban Greenspace, Open Space and Vegetation (i.e., Trees, shrubs, etc.)	Disruption to greenspace and trees	✓	Follows land-use plan
Economic	Potential to Use Combined Service Corridor	Use of existing corridors where possible	✓	Follows land-use plan
	Efficiency of Use of Existing Infrastructure	Use of excess capacity in existing infrastructure	✓	Maintains existing culvert crossings
	Capital Costs	Initial construction cost	✓	Standard sewer design, deep trunk sewers as required
	Operating Costs	Ongoing operations and maintenance requirements	✓	Standard Storm sewers

Good ✓ Okay ~ Poor X

5.6 Additional Storm System Capacity

The proposed storm sewer system, both major and minor, was designed to provide additional capacity in the event of minor changes to the proposed plan. The following measures were taken to create the additional capacity:

- The minor system storm sewer design limited pipe sizes to no more than 80% capacity during the minor system design storm;
- Runoff coefficient were determined based on a more conservative assumption for housing density;
- Major system overland flow routes were limited to no more than 80% capacity during the major system design storm; and
- SWM ponds were conceptually graded using the minimum permanent pool depth and 5:1 slopes, both of which increase the proposed footprint of the facility and could be modified to obtain greater pond storage volume.

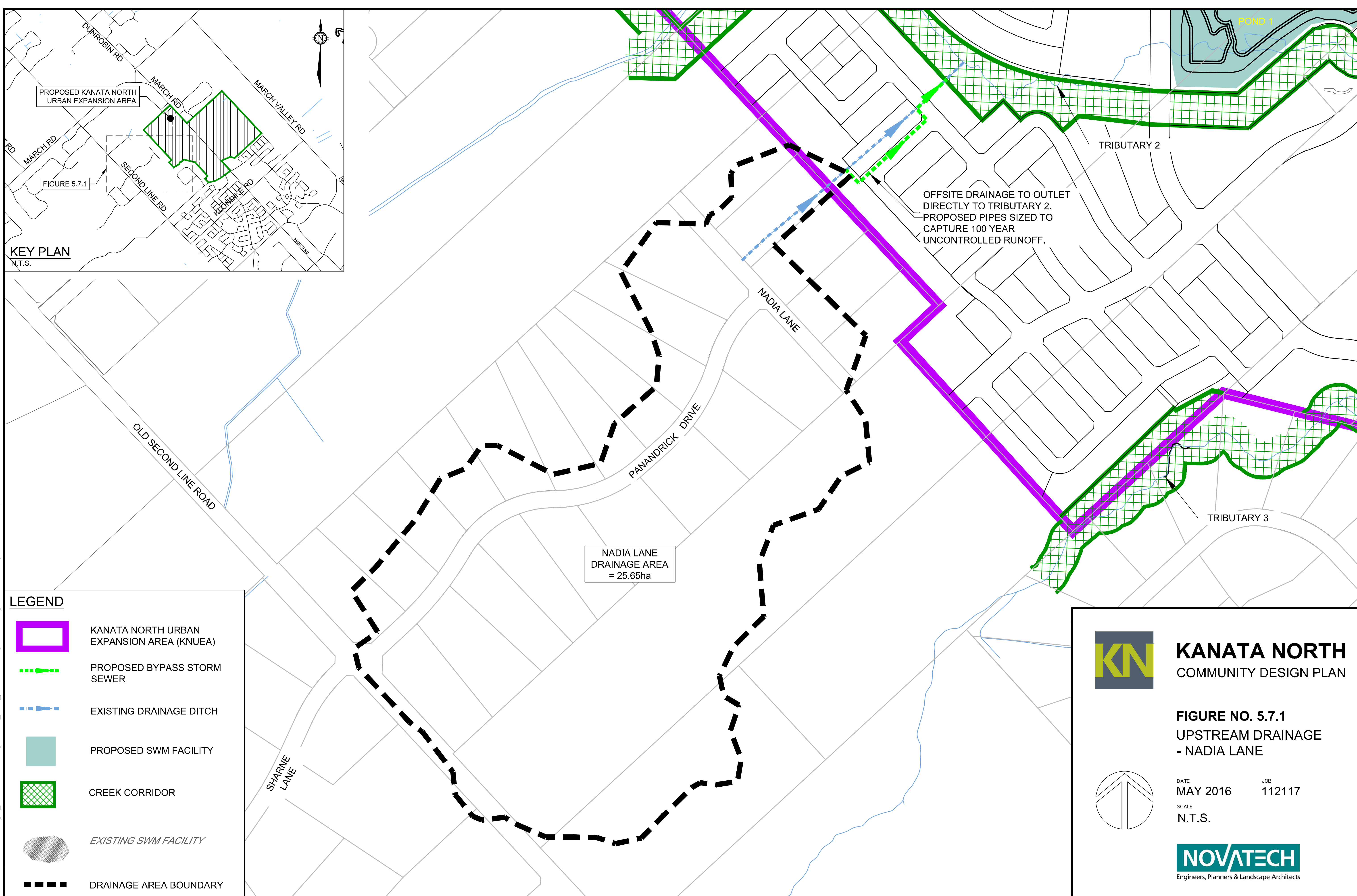
5.7 Off-Site Drainage Areas

There are two off-site, upstream drainage areas that drain onto the KNUEA. Storm drainage from these areas are re-routed and accounted for in the storm servicing design for the KNUEA. The areas and the drainage solution are as follows:

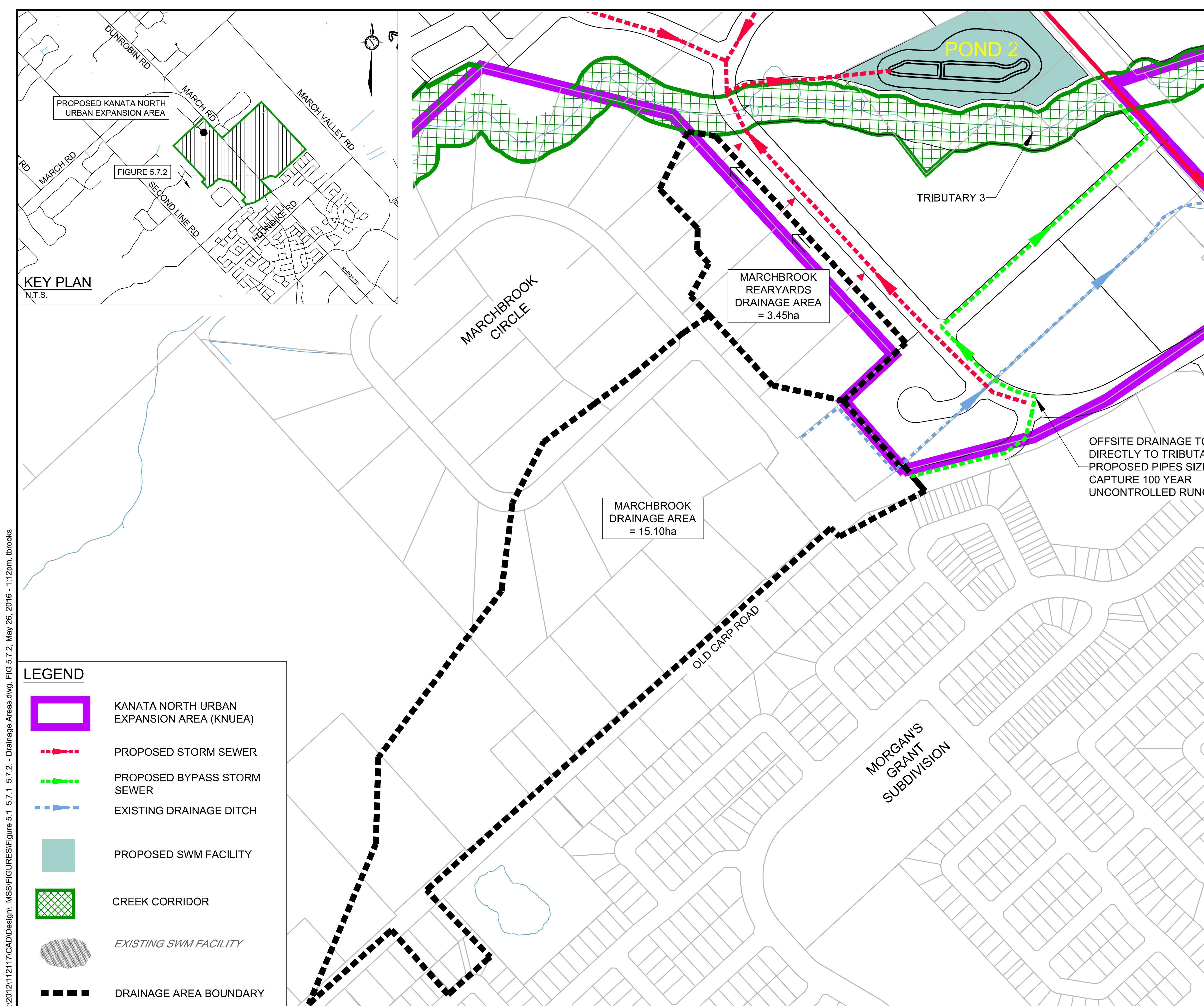
- Nadia Lane drainage ï A primarily rural residential area, approximately 26 hectares in size, northwest of the KNUEA. This area currently drains to an existing ditch in the northwest quadrant which outlets to Tributary 2 as shown on **Figure 5.7.1**. It is proposed to collect this drainage once it flows onto the KNUEA in a ditch inlet catchbasin within a proposed park area and provide a storm sewer to convey the drainage directly to Tributary 2 as per existing conditions.

- Marchbrook Circle drainage ï A primarily rural residential area, approximately 19 hectares in size, southwest of the KNUEA. This area currently drains to an existing ditch which outlets to Tributary 4 as shown on **Figure 5.7.2**. It is proposed to collect a portion this drainage area (15ha) in a storm sewer along Old Carp Road. The storm sewer will convey the major and minor system drainage though the southwest quadrant and outlet directly to Tributary 3. The remainder of the area (3.5ha) will have the minor system drain to Pond 2 through the Street A storm sewer and the major system directed overland through the proposed rear yards directly to Tributary 3. Prior to Draft Plan Approval this off-site drainage proposal will require confirmation including adequate maintenance access.

These drainage areas, the existing drainage patterns and proposed drainage solutions are shown on **Figures 5.7.1** and **5.7.2**. Supporting calculations for the sizing of the proposed storm sewers are provided in **Appendix B**.



KEY PLAN
N.T.S.
PROPOSED KANATA NORTH URBAN EXPANSION AREA
FIGURE 5.7.1
DUNROBIN RD
MARCH RD
MARCH VALLEY RD
SECOND LINE RD
KLONDIKE RD
POND 1
TRIBUTARY 2
TRIBUTARY 3
OFFSITE DRAINAGE TO OUTLET DIRECTLY TO TRIBUTARY 2. PROPOSED PIPES SIZED TO CAPTURE 100 YEAR UNCONTROLLED RUNOFF.
NADIA LANE
PANANDRICK DRIVE
OLD SECOND LINE ROAD
SHARNE LANE
NADIA LANE DRAINAGE AREA = 25.65ha
LEGEND
KANATA NORTH URBAN EXPANSION AREA (KNUEA)
PROPOSED BYPASS STORM SEWER
EXISTING DRAINAGE DITCH
PROPOSED SWM FACILITY
CREEK CORRIDOR
EXISTING SWM FACILITY
DRAINAGE AREA BOUNDARY
KN
KANATA NORTH
COMMUNITY DESIGN PLAN
FIGURE NO. 5.7.1
UPSTREAM DRAINAGE - NADIA LANE
DATE
MAY 2016
JOB
112117
SCALE
N.T.S.
NOVATECH
Engineers, Planners & Landscape Architects



KANATA NORTH
COMMUNITY DESIGN PLAN

FIGURE NO. 5.7.2
UPSTREAM DRAINAGE
- MARCHBROOK CIRCLE

DATE JUNE 2016
JOB 112117
SCALE N.T.S.

NOVATECH
Engineers, Planners & Landscape Architects

5.8 Storm Summary and Recommendations

Following is a summary of the storm sewer system findings for the Kanata North Urban Expansion Area Lands:

- The EMP evaluates the stormwater management servicing options for the KNUEA and recommends servicing the development using three stormwater management ponds. The EMP also outlines design criteria for the stormwater management system.
- The storm drainage design includes a dual-drainage approach and design criteria are provided which provides guidance for future draft plan and site plan applications.
- A preliminary trunk sewer network was designed based on the Demonstration Plan to confirm feasibility of servicing the KNUEA.
- The preliminary trunk sewer network was modelled and adjusted to ensure the HGL for the storm sewer system is no more than 0.6m above the obvert of the storm sewer at any given point.
- A preliminary grading plan was prepared and used to develop overland flow catchment areas.
- Allowable release rates were developed based on land use for the minor and major storm systems. These allowable release rates should be used in future detailed designs for the development.
- A storm sewer servicing evaluation was completed and is summarized to document the results using the criteria and indicators as shown in Section 5.5 on the preferred storm servicing solution.
- Additional capacity has been incorporated into the storm sewer system which permits design flexibility for a moderate degree of intensification within KNUEA and suggests the system can readily accommodate moderate change and minor adjustments to the land use plan are readily accommodated.
- Drainage solutions for two off-site, upstream drainage areas are provided and incorporated into the storm servicing design.
- The existing ditch and culverts within the abandoned rail corridor have the capacity to convey the major system flows from the proposed development to Pond 3.

6.0 WASTEWATER SERVICING

6.1 Introduction

As indicated previously, the subject development is within the City of Ottawa West Urban Community (former City of Kanata). This area is serviced by local gravity sewers and pump stations that discharge to a regional trunk system that carries flows to the Robert O. Pickard Environmental Centre for treatment of wastewater.

There are several trunk sanitary sewers and pump stations servicing the West Urban Community including the East March Trunk, Marchwood Trunk, Kanata Lakes Trunk, North Kanata Trunk, March Pump Station, and the Briar Ridge Pump Station. These all drain into the Watt’s Creek Relief Sewer that provides service to the entire West Urban Community and flows into the Acres Road Pump Station. An Existing Wastewater Collection System Schematic (Figure 2) from the 2013 Infrastructure Master Plan is included in **Appendix C-1** for reference.

The outlet for the Kanata North Urban Expansion Area is the existing March Pump Station. The City has indicated that the inlet to the March Pump Station is a reasonable limit for wastewater analysis.

Based on the proposed land use, a probable wastewater flow was calculated to be 182.2L/s. Further details on the calculations of this flow rate are discussed in Section 6.6.1.2.

6.2 Existing Wastewater Infrastructure

There are three trunk sewers that drain to the March Pump Station. These are the East March Trunk, Marchwood Trunk and the Kanata Lakes Trunk. These trunk sewers and their drainage boundaries are shown on **Figure 6.2.** The East March Trunk and Marchwood Trunk sewers are the two most viable options to service development of the KNUEA. The Kanata Lakes Trunk Sewer is located farther from the development area and is not a viable option for servicing the Kanata North Urban Expansion Area.

The following is a brief description of each trunk sewer along with capacity and probable flow rates. The flow generation and wastewater modelling, completed in 2013 on behalf of the City, is provided in the *2013 Infrastructure Master Plan Wastewater Collection System Assessment* (2013 IMP) prepared by Stantec, dated Sept 2013. This document provides the most current sanitary analysis of the entire City and establishes a basis upon which the KNUEA can be evaluated. Where information was not available in the 2013 IMP, namely for trunk sewers, information was obtained from the *West Urban Community – Wastewater Collection System Master Servicing Plan Study* (2012 WUC, RVA, July 2012).

The data obtained from the above noted Master Plans provides flow data for existing flows monitored as of 2010, and projected flows for 2031. The projected flow data in the 2031 IMP has accounted for the full development/buildout of the KNUEA. Therefore during the analysis of KNUEA on existing infrastructure, design KNUEA flows have only been added where 2013 IMP data was not available.