- WC1: The channel morphology site length was 56 m. This site was the furthest downstream site sampled and is located just south of where the creek flows into the culvert that runs under the RCMP complex. The creek banks at this site are forested with a thin section of riparian woodland. Exposed soils along the banks and erosion sites are evident throughout this reach.

Photographic logs of each assessment site (WC5- WC1) are included in Appendix D.

Eastern Creek

- EC5: The channel morphology site length was 73 m. This site is the most upstream site and was located north of the Rockcliffe Parkway culvert. EC5 is heavily forested with secondary growth deciduous forest. The flow regime can be characterized as having shallow water depth and low flow velocity at the time of the assessment (baseflow conditions) however the channel planform is highly straightened and the channel cross-section is in adjustment to the flows from the Rockcliffe Parkway culvert. Exposed soils and stream bank erosion is evident throughout this reach. Instream cover consisted of extensive woody debris.

- EC4: The channel morphology site length was 40 m. The site was heavily forested with a narrow channel cross-section. The flow regime can be characterized as having shallow water depth but with higher flow velocities than EC5 due to the reduced channel width. Stream banks have improved vegetative cover and overall erosion sites are reduced, however undercutting of the banks is evident.

- EC3: The channel morphology site length was 74 m. This site is a side tributary to the main channel (flowing from west of the main creek). The side tributary is heavily forested and was virtually dry during baseflow periods. The channel cross-section is wide and ill defined.

- EC2: The channel morphology site length was 44 m. This site was heavily forested with low banks. Overall EC2 does not demonstrate current signs of erosion or instability.

- EC1: The channel morphology site length was 40 m. This site is heavily forested. Connection to the Ottawa River at this location is blocked by the raised recreational trail. Ponded water was observed upstream of the raised recreational trail both during baseflow and peak flow conditions.

Photographic logs of each assessment site (EC5- EC1) are included in Appendix D.

General Findings

The following sections describe the general findings of the DST (2013) Aquatic Habitat Assessment Report Appendix D. Table 19 presents a summary of key findings and individual results.

Active Channel

Both the Eastern and Western creek had an active channel width ranging from 0.5 to 2.0 m with the Western Creek gradually increasing from upstream to downstream, while the Eastern creek channel width varied along its course. Maximum bank height ranged from approximately 450 mm to 700 mm in the Western creek and 350 mm to 750 mm in the Eastern creek.

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LEGEND:

- CREEK LOCATIONS
- OSAP SURVEY LOCATION
- SITE BOUNDARY

NOTE:

1. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH THE ASSOCIATED TECHNICAL REPORT.
2. SOURCE - GOOGLE EARTH

REV	DATE	ISSUE	APPROVAL
0	09/08/13	FINAL	A.M.

PROJECT TITLE

AQUATIC HABITAT ASSESSMENT: WESTERN AND EASTERN CREEKS, FORMER CFB ROCKCLIFFE

DRAWING TITLE

SITE PLAN

DESIGNED BY: A.M.	SCALE: N.T.S
DRAWN BY: R.P.	DATE: August 2013
PROJECT MANAGER: A.M.	PROJECT NO.: OE-OT-017184
FIGURE No.:	

Bank Angle

Overall, bank angles for both creeks range from 13° to 26°. The Western creek is characterized by higher bank angles (steeper banks) in the middle reaches as compared to the upstream and downstream extents, while the Eastern Creek displays shallower bank angles in the middle reaches and lower reaches.

Water Depth and Flow

The water depth during baseflow conditions in the Western creek ranged from 52 to 105 mm while the Eastern creek ranged from 0 to 46 mm. In both creeks the main channels were hydrated along their entire length suggesting that these creeks are primarily groundwater fed during baseflow conditions. This is supported by the hydrogeological studies (DST, June 2014). Overall, during baseflow conditions, both creeks can be characterized as having shallow flow depths and low flow velocities.

Bank Vegetation and Instream Cover

In general, Western creek had more bank vegetative cover on average than the Eastern creek. The Eastern creek was found to have low to moderate levels of bank vegetative cover throughout its length. Whereas, the Eastern Creek is characterized as having low to moderate levels of bank vegetation, it does display consistently high counts of instream cover (20 cover points/site), an important component of aquatic habitat for fish species. Cover is more varied in the Western creek with higher levels of instream cover observed at upstream locations as compared downstream.

Table 19: Aquatic Habitat Assessment Findings- Channel Characteristics

Site	Active Channel width (m)	Water Depth (mm)	L/R Channel Depth (mm)	Hydraulic Head (mm)	Max. Particle (mm)	Instream Cover Points	Channel Slope	L/R Bank Angles (Degrees)
WC5	0.55	52	458/466	0.59	28.32	33	0.27	16.88/16.47
WC4	1.31	88	648/691	0.36	13.14	14	0.45	22.64/24.15
WC3	1.02	105	693/572	1.36	49.09	34	0.38	24.56/20.71
WC2	1.54	61	703/686	2.05	98.50	51	0.46	24.89/24.30
WC1	1.77	76	485/531	1.14	114.75	30	0.34	17.54/19.21
EC5	1.84	30	732/756	0.17	72.00	21	0.49	25.74/26.40
EC4	0.52	26	465/524	0.45	106.40	20	0.35	17.05/18.97
EC3	1.82	0	447/474	0.0	19.26	24	0.29	16.53/17.42
EC2	0.98	25	357/353	0.16	2.09	18	0.22	13.26/13.09
EC1	1.95	46	525/575	0.05	55.56	19	0.38	18.99/20.85

Bank Undercuts

Bank undercutting indicates locations where active or historic bank erosion is or has occurred and is an indication of channel stability, state of adjustment, and overall flow regime.

In general, the Western Creek displayed few sever bank undercuts (Table 20), whereas the majority of the Eastern Creek displayed undercutting of the right bank. Other signs of erosion within the Eastern Creek including slumping banks were also noted. Overall, it appears that moderate levels of erosion are occurring along the majority of the channel length of the Eastern creek. Conversely, only a few areas of moderate erosion within the Western creek were identified.

Table 20: Total Bank Undercuts

Site	Left Bank (mm)	Right Bank (mm)
WC5	0	0
WC4	0	398
WC3	150	80
WC2	0	40
WC1	0	0
EC5	10	1320
EC4	150	480
EC3	0	270
EC2	0	200
EC1	0	0

Water Temperature

Maximum summer water temperature was assessed by DST on July 24, 2013.

Water temperature in the Western creek was highest at the upstream but was considerably cooler in the deeper mid-reach sections of the creek (Table 21). Lower mid-reach temperatures are likely influenced by a combination of factors including temperature moderation from subsurface stormwater discharges, water depth and heavy shade.

In general, water temperature in the Eastern Creek was highest at the downstream extent as compared to the upstream. Higher downstream water temperatures are likely a result of prolonged exposure to ambient air temperature due shallow gradients and the lack of an outlet to the Ottawa River at the raised pedestrian walkway.

Table 21: Water Temperature

Site	Water Temp. (°C)	Air Temp. (°C) *
WC5	17.5	19.6-20.7
WC3	12.5	
EC5	17.0	
EC1	21.8	

* http://climate.weather.gc.ca (accessed 7/14)

Macroinvertebrates

The 2013 assessment by DST also considered the stream-bottom macroinvertebrate community, as these animals are an important link in the aquatic food chain.

The community of macroinvertebrates was found to be moderately diverse, ranging from 9 to 15 taxa at each site, however key indicator species were mostly absent. The findings suggest that the overall habitat quality of the creeks varies from moderately good to moderately poor. Most of the taxa found during the 2013 surveys were relatively common taxa which are either very tolerant or moderately tolerant to poor water quality and contamination.

The limited number of macroinvertebrate indicator species suggests that the best quality sites are WC5 and WC4 on the Western Creek and EC4 and EC3 on the Eastern Creek.

Fish and Fish Habitat

Western Creek

Sites in the Western Creek appear to provide marginal fish habitat that could be suitable for some common fish species, however no fish were encountered during the fish surveys. While adequate instream cover exists in the Western Creek (particularly in its lower sections), most of the cover is woody debris, flat rocks, or detritus, while very little aquatic vegetation was observed. In its upper reaches the banks are well vegetated, while the downstream sites have relatively less bank vegetation but are well shaded by tree cover. While specific sites may be suitable to support a low diversity fish community, it appears that the lack of connectivity to the Ottawa River (as the final 550m of the creek runs subsurface) and extensive entombment of creek sections have prevented fish from reaching potentially suitable sites.

Eastern Creek

During baseflow conditions, the main creek had very little water depth and its side tributaries were found to be completely dry. However, the main body of the creek maintained some flow throughout its length, even during baseflow conditions. Water levels were low throughout the Eastern Creek during baseflow conditions and few deeper pools were present to support fish.

The Eastern Creek generally had low levels of in-stream cover, most of which was woody debris and virtually no aquatic vegetation throughout its length. The banks were moderately to sparsely vegetated, though the entire creek north of the Rockcliffe Parkway was well-shaded by forest cover.

The Eastern Creek could potentially provide habitat for species that are tolerant of low water levels (sticklebacks for example), though no fish were found during fish surveys. This is likely due to the fact that there was no downstream connection to the Ottawa River at the elevated recreational path and no upstream connection to other habitats.

It is likely that future connections to the Ottawa River will likely result in an increase in fish species using the Eastern Creek as habitat. Future efforts in this regard should evaluate species composition in the Ottawa River in the context of proposed connections and habitat creation activities.

Aquatic Species at Risk (SAR)

Per the Preliminary Terrestrial Habitat Assessment for the Proposed Stormwater Ponds at the Former CFB Rockcliffe (DST, 2013) included in Appendix E the Ontario Stream Assessment Protocol (OSAP) performed as part of the Aquatic Habitat Assessment – Western and Eastern Creeks (DST, 2013) has provided sufficient information on the quality and character of the aquatic habitat in these areas to rule out the possibility that any aquatic species at risk may be present in the survey area (DST, 2013). The OSAP assessment indicated that the creeks did not support fish at the time of the survey, nor do they support any rare or SAR varieties of invertebrates. Due to the poor quality of aquatic habitat and absence of significant open water, it is highly unlikely that any wetland associated SAR birds, reptiles, insects, or fish would be present within the survey area.

Stormwater Impacts on Aquatic Habitat

With respect to aquatic habitat, the primary concern that has been identified with the proposed development and the

associated stormwater management is the potential impacts related to changes in water temperature and increases in stream erosion. Erosion was discussed in Section 3.6, while temperature concerns are described below.

The DST Aquatic Habitat Assessment – Western and Eastern Creeks (2013) report concluded that the results of this aquatic habitat assessment indicate that there currently is little to no fish life in the creeks, nor are there many sensitive varieties of macroinvertebrates. The habitat can generally be considered low quality and there are only small isolated patched of aquatic vegetation present. Hence there are few biotic values present within the creeks themselves which would be sensitive to water temperature changes. Because neither creek has large flow volumes nor high flow velocity, any temperature changes resulting from the stormwater management plan will return to ambient conditions long before reaching the Ottawa River and hence no thermal impacts on the river are expected. Therefore, temperature mitigation measures should not be required for the outflows from the stormwater facilities.

3.8 TERRESTRIAL ECOLOGY

Companion existing conditions reports for the Rockcliffe lands provides a comprehensive summary of the existing vegetation communities including Provincially Designated Natural Areas and Urban Natural Areas, as well as list of Significant Vegetation and Wildlife Species. A detailed report entitled CFB Rockcliffe Vegetation Survey (Baker, January 2013) is included in Appendix G.

The following discussion is limited to the context of stormwater management as part of the landscape level system for the maximization of the function of vegetation, ensuring the protection of the natural hydrologic function and linkages between surface and groundwater sources and vegetation, wildlife and natural heritage features through groundwater recharge, temperature moderation strategies and the creation of wildlife habitat.

Vegetation

As part of this project, the inventory of trees and tree groupings on the site prepared in 2004 was reviewed and updated in 2013 to account for changes impacting the site. These include changes in legislation, changes to tree health, and changes to development on the site.

Vegetation on the Former CFB Rockcliffe CDP site is generally consistent with vegetation found in the greater Ottawa area, which is part of the Great Lakes/Saint Lawrence Forest region. This forest region is represented by a mixture of deciduous and coniferous trees.

On site native tree species identified include Sugar Maple, Basswood, Red Oak, White Pine, White Spruce, and White Cedar as well as Bitternut Hickory, Butternut, and Silver Maple.

Non-native tree species identified on site, including Black Locust, Norway Maple, Norway Spruce, Blue Spruce, and Weeping Willow.

In general, the trees recommended for retention on the site are native trees, as some non-native species tend to be invasive (i.e., Norway Maple). However, some non-native trees are recommended for retention on the site. Figure 21 provides a survey of existing trees and tree groupings on the site, and identifies their condition.

Provincially Designated Natural Areas

There are four provincially designated natural areas within one kilometer of the site; however the only area with the potential to be impacted by the redevelopment of the site is the Rockcliffe Airbase Woods. These woods are located northeast of the Rockcliffe Parkway and Airport-Marina Road and are characterized by a rolling landscape of deep marine clay that is lightly and irregularly covered by sand and silty sand and dominated by a young to submature upland deciduous forest. The underlayer of impervious clay has created complex moisture conditions across the site, resulting in equally complex variations in forest dominants. This site supports the largest clay-based upland area of relatively natural vegetation in Ottawa (NHIC, 2013).

Urban Natural Areas

The City of Ottawa prepares reports on Urban Natural Areas (UNAs) within the City, detailing the fauna and flora, and the general health of the area. Within the

vicinity of the former CFB Rockcliffe site, there are five UNAs (Figure 22):

1. the Airbase Woods,
2. the NRC Woods North,
3. the Montfort Hospital Woods,
4. the Carson Grove Woods, and
5. the Assaly Woods.

From an ecological standpoint, the two most valuable vegetated areas in the vicinity of the site are the Montfort Hospital Woods and the NRC Woods North. The Montfort Hospital woods are owned by the National Capital Commission. The City of Ottawa has confirmed that any development within 30 m of these features will require the completion of an Environmental Impact Statement (EIS).

Vegetation and Stormwater Management

It is recommended, that as part of a landscape level stormwater management system that all SWM techniques maintain and enhance the form and function of existing vegetation communities both within and off-site of the Former CFB Rockcliffe CDP site and that all SWM proposed controls be designed as passive stormwater management systems that maintain the hydrologic connection of both surface and groundwater to the identified communities. In this regard, special consideration should be given to:

- The maintenance of the existing hydrologic regime, specifically the enhancement of groundwater recharge, of the three (3) significant on-site vegetation communities (Figure 21):
    1. North of Dubhe Private at the headwaters of the Western Creek
    2. North of Hemlock Private on both sides of Hurley Crescent
    3. North of Arcturus Private, east of Burma Road.

The maintenance of the existing hydrologic regime, specifically the enhancement of groundwater recharge, as it relates to the adjacent (off-site) Urban Natural Areas (UNAs). Based on the identified shallow groundwater system (shall potentiometric contours) illustrated on Figure 10, stormwater practices, specifically infiltration based controls, on the Former CFB site will affect the hydrologic function of downstream UNAs, specifically (Figure 22):

1. the Airbase Woods,
2. the NRC Woods North,

It is unlikely that stormwater on-site controls will affect the hydrologic regime and groundwater systems contributing to the upstream UNAs, specifically:

1. the Montfort Hospital Woods,
2. the Carson Grove Woods, and
3. the Assaly Woods.

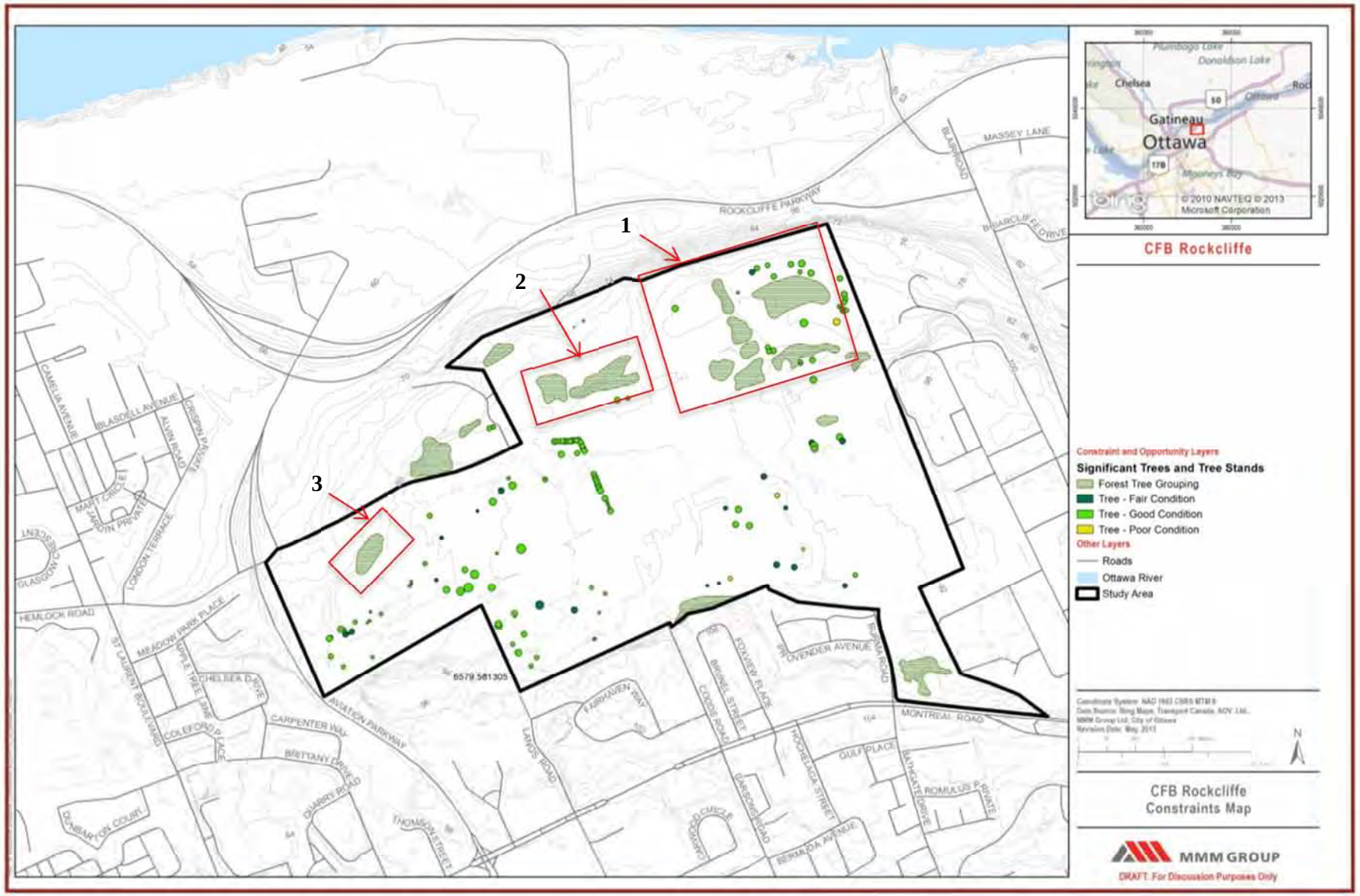

Figure 21: Inventory of Existing Trees and Tree Groupings in the Study Area

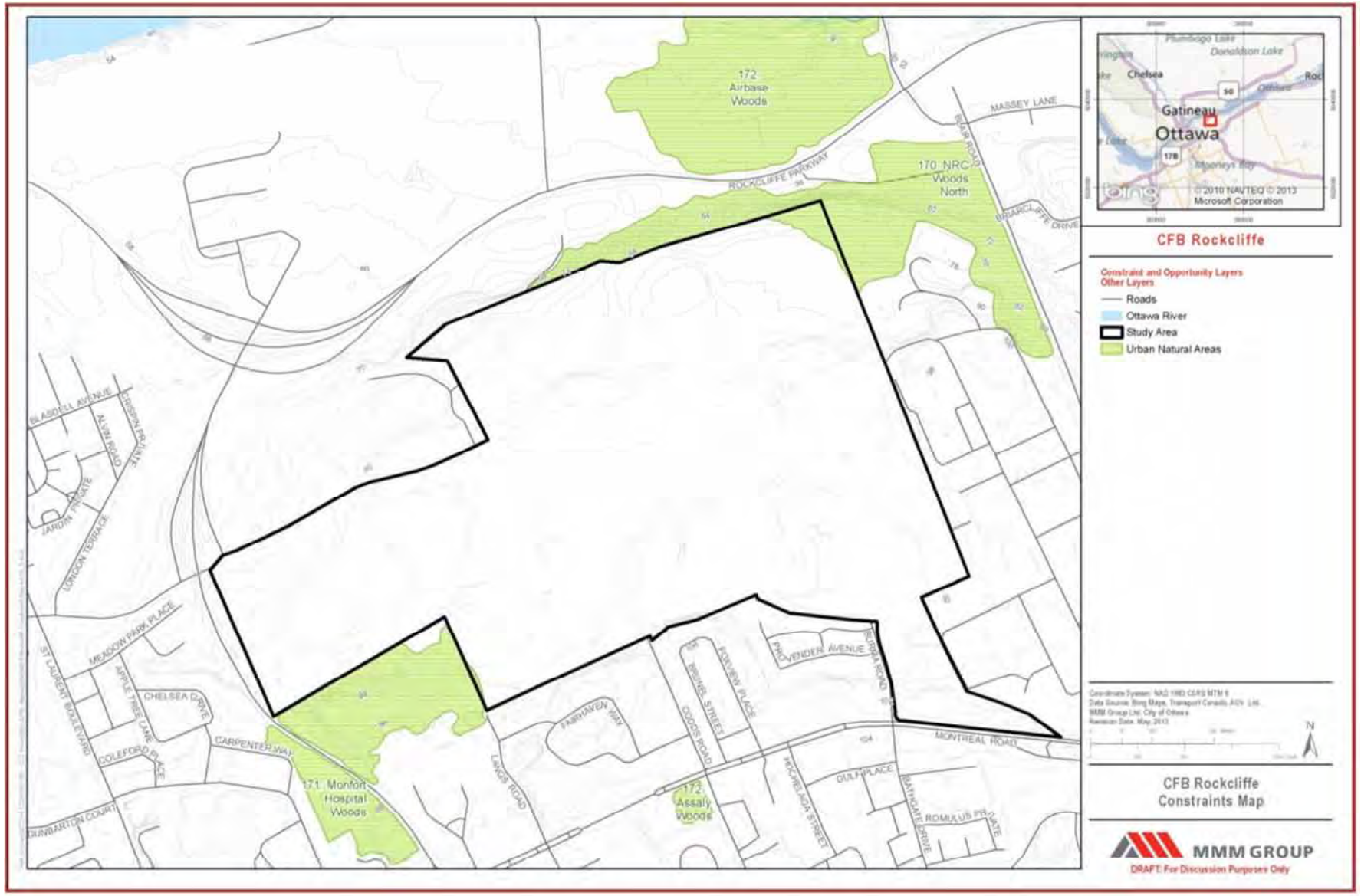

Figure 22: Urban Natural Areas

Terrestrial Habitat

A report entitled Preliminary Terrestrial Habitat Assessment for Proposed Stormwater Ponds at the Former CFB Rockcliffe was prepared by DST (August 2013) and is summarized below. Source materials and reports are included in Appendix E.

The purpose of the preliminary terrestrial habitat assessment was to briefly characterize the habitat that occurs on adjacent parcels of National Capital Commission (NCC) land north of the Former CFB Rockcliffe CDP site and to conduct a high level screening of the Ontario Ministry of Natural Resources (OMNR) online information on Species at Risk (SAR) to determine which SAR may be present on site, based on the presence of potentially suitable habitat. The surveyed area is illustrated on Figure 23. Note: at the time of the assessment, two stormwater management ponds were proposed in the vicinity of these areas. Currently only one (1) stormwater management pond is proposed within the subject area immediately upstream of the Eastern Creek on the south side of the

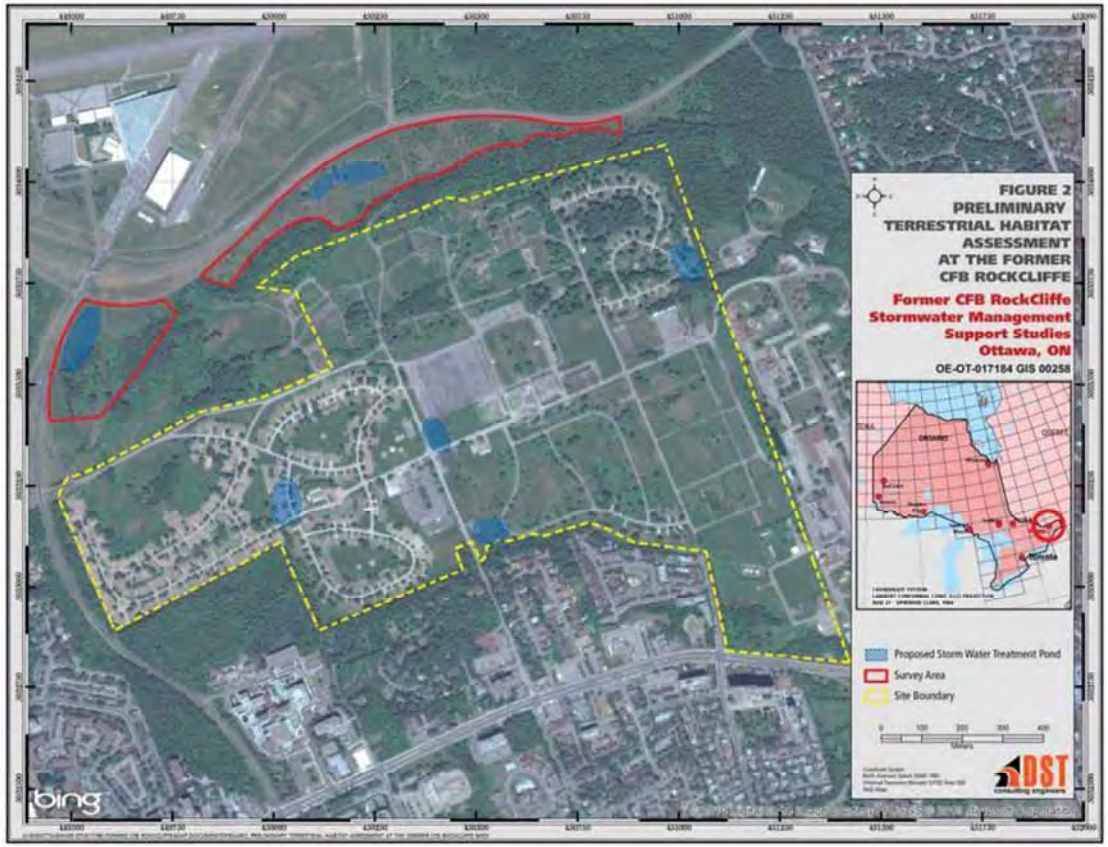

Figure 23: Preliminary Terrestrial Habitat Assessment – Study Area (DST, 2013)

Rockcliffe Parkway (the Eastern SWM Facility).

The terrestrial habitat in the area of the proposed location of the Eastern SWM Facility can be characterised as grassland immediately south of the Rockcliffe Parkway, with thick secondary growth deciduous forest growing around the base of the cliffs and cliff slope further to the south. The boundary between the NCC parcel south of the Rockcliffe Parkway and the former CFB Rockcliffe property is a cliff which varies between vertical rockface and sections of steep rocky slopes along the southern edge of the survey area.

Based on the habitat features noted, the proposed locations of the stormwater management pond has the potential to be

suitable habitat for SAR associated with grasslands, deciduous forest, and cliff environments.

Terrestrial Species at Risk (SAR)

Based on the presence of grassland, secondary growth deciduous forest, and cliff habitats, potentially suitable habitat exists in the survey area for the SAR listed below in Table 22. Aquatic associated SAR have been excluded from the list presented in Table 22 are discussed in Section 3.7 – Aquatic Species at Risk (SAR).

It should be noted that Butternut tree (Juglans cinerea) survey was completed by DST in July 2013 for the same study area (Figure 23) and is discussed separately in subsequent section. With the exception of Butternut trees, the actual presence/absence of SAR in the survey area has not yet been confirmed and there are currently no known occurrences of SAR in the survey area.

Table 22: Possible SAR Based on Presence of Potentially Suitable Habitat (Source: DST, 2013)

Species			Listings		
Common Name	Scientific Name	Taxon	COSEWIC	SARA	SARO/COSSARO
Barn Swallow	*Hirundo rustica*	Birds	Threatened	No Status	Threatened
Bobolink	*Dolichonyx oryzivorus*	Birds	Threatened	No Status	Threatened
Canada Warbler	*Wilsonia canadensis*	Birds	Threatened	Threatened	Special Concern
Cerulean Warbler	*Dendroica cerulea*	Birds	Endangered	Special Concern	Special Concern
Chimney Swift	*Chaetura pelagica*	Birds	Threatened	Threatened	Threatened
Common Nighthawk	*Chordeiles minor*	Birds	Threatened	Threatened	Special Concern
Eastern Meadowlark	*Sturnella magna*	Birds	Threatened	No Status	Threatened
Eastern Wood Pewee	*Contopus virens*	Birds	Special Concern	No Status	No Status
Henslow's Sparrow	*Ammodramus henslowii*	Birds	Endangered	Endangered	Endangered
Hooded Warbler	*Wilsonia citrina*	Birds	Not at Risk	Threatened	Not at Risk
Loggerhead Shrike	*Lanius ludovicianus*	Birds	Endangered	Endangered	Endangered
Peregrine Falcon	*Falco peregrinus*	Birds	Special Concern	Threatened	Special Concern
Rusty Blackbird	*Euphagus carolinus*	Birds	Special Concern	Special Concern	No Status
Short-eared Owl	*Asio flammeus*	Birds	Special Concern	Special Concern	Special Concern
Whip-poor-will	*Caprimulgus vociferus*	Birds	Threatened	Threatened	Threatened
Wood Thrush	*Hylocichla mustelina*	Birds	Threatened	No Status	No Status
Little Brown Myotis	*Myotis lucifugus*	Mammals	Endangered	No Status	Endangered
Northern Myotis	*Myotis septentrionalis*	Mammals	Endangered	No Status	Endangered
Tricolored Bat	*Perimyotis subflavus*	Mammals	Endangered	No Status	No Status
American Ginseng	*Panax quinquefolius*	Plants	Endangered	Endangered	Endangered
Butternut	*Juglans cinerea*	Plants	Endangered	Endangered	Endangered
Milksnake	*Lampropeltis triangulum*	Reptiles	Special Concern	Special Concern	Special Concern
Monarch	*Danaus plexippus*	Insects	Special Concern	Special Concern	Special Concern
Rusty Patched Bumble Bee	*Bombus affinis*	Insects	Endangered	No Status	Endangered

The Species at Risk Survey included consultation with the Ontario Ministry of Natural Resources; review of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and the Species at Risk Ontario (SARO) SAR status reports and range maps for the target species; review of the Natural Heritage Information Center (NHIC) mapping and historical records of SAR occurrences. In addition, the scope of work included identification of species-specific mitigation measures and discussion of anticipated SAR related permitting requirements. Mitigation and permitting information presented in this report should be reviewed and confirmed in the context of the more detailed impact assessments that will be undertaken as part of the forthcoming Environmental Impact Statement (EIS) and Environmental Effects Analysis (EEA) studies.

Based on the above-noted records review, DST compiled a list of 24 SAR which may potentially be present within the survey area. Survey results indicate the presence of six species, as follows:

- Butternut trees were identified at the CLC property, north of the property, as well as along the Eastern Creek. The Butternuts are classified as Category 1 (non-retainable, for example, terminally infected with Butternut Canker) or Category 2 (considered retainable). Most of these trees were clustered within the forest patch growing along the edge of the escarpment. Additional detail is provided in subsequent sections.

- The Monarch Butterflies were noted at three locations within fields containing Milkweed plants within the survey area. Due to the presence of Milkweed plants, it is presumed that Monarch Butterfly are both foraging and breeding within the survey area.

- Common Nighthawk were heard calling. It is presumed that Common Nighthawk may utilize the survey area for foraging purposes but no evidence of nesting behavior within the survey area was noted (calls were heard outside the survey area) and therefore, no significant habitat features were noted for this species.

- The Preliminary Terrestrial Habitat Assessment identified the potential that exposed rock crevices and rock cracks within the cliffs/exposed bedrock areas could serve as bat maternity roosting or hibernation habitats. The escarpment beyond the northern CLC property boundary is characterized by a steep drop in topography moving from south to north, with areas of exposed rock, rock crevices, and rock cracks creating unusual geologic conditions. Such features have the potential to serve as either summer roosting habitat and/or hibernation sites for some bat species. Three SAR bat species (Little Brown Myotis, Northern Myotis, and Tricolored Bat) were found to occur within the survey area. A comparatively small number of recordings were documented for each of these species, suggesting that while these species are present within the survey area, it is unlikely that a large colony exists for any of the SAR bats. The number of recordings observed for each species is similar to background levels of activity observed by DST for the SAR bats throughout

the Ottawa area, and suggests that these species are utilizing the survey area and adjacent grasslands, meadows, and forested areas adjacent to the Rockcliffe and Aviation Parkways for foraging purposes only. It is also possible that small numbers of the SAR bats utilize rock crevices and cracks within the Rockcliffe Escarpment as summer roosting sites. Because all three SAR bats typically hibernate communally in sites with constant temperature conditions (e.g. caves, abandoned mines, large tunnels, etc.) and no large openings or caves have been noted within the escarpment, it is unlikely that the SAR bats would overwinter within the escarpment. There was not an observed significant increase in the number of recordings for the SAR bat species over the course of the survey, and no evidence of swarming activity within the survey area for these species was observed. Migratory Silver Haired Bats (not an SAR) increased in abundance towards the end of August, suggesting that this species is migrating through the survey area at that time.

Due to the presence of potentially significant bat roosting habitat, which may serve as a summer roosting sites for small numbers of SAR bats and for larger numbers of Big Brown Bats, DST recommends that the future EIS/EEA should evaluate potential impacts to this feature. The Rockcliffe Escarpment is contained wholly within the NCC lands, and hence would be within federal jurisdiction. It should be noted that none of the SAR bats are currently listed under Schedule 1 of SARA, and hence do not require SARA-related permitting. Ontario Ministry of Natural Resources (OMNR) guidance dictates that bat hibernacula and roosting sites should be protected by a buffer of 120 m and that impacts to the habitat within 120 m of the feature should be considered as part of an EIS/EEA (OMNR 2011). Mitigation measures include pre-construction searches of any affected areas of the escarpment and a work timing window.

Several mitigation measures specific to the SAR identified have been outlined in the Species at Risk Survey report. The forthcoming EIS/EEA should elaborate on these mitigation measures to address other environmental impacts that are not specific to these species, as the list of mitigation measures outlined in the Species at Risk Survey report are not intended to address all potential environmental concerns. Ultimately, the EIS/EEA should include mitigation measures related to environmental impacts from the proposed undertaking.

Butternut Survey

A report entitled Butternut Survey for Proposed Stormwater Ponds at the Former CFB Rockcliffe was prepared by DST (August 2013) and is summarized below. Source materials and reports are included in Appendix F.

The Butternut was declared a nationally endangered species by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in November of 2003. This species is listed as endangered, both federally under the Species at Risk Act and provincially under the Ontario Endangered Species Act. Butternut is primarily at risk due to the effects of a fungal pathogen

(Sirococcus clavigignenti-juglandacearum) which causes wounds known as Butternut Cankers. Butternut Cankers are responsible for the loss of approximately one third of the eastern Ontario Butternut population. It is possible for a tree to live many years with the Canker, although most only live a few years after infection (OMNR 2013). In Canada, Butternut can be found in Quebec, New Brunswick, and areas in Ontario (southwestern to south of the Canadian Shield) (OMNR 2013). This species does well in moist, well-drained soils, preferring to grow in small clearings within a forest, or at the forest edge (OMNR 2013).

All living trees within the survey area were examined, the presence/absence of Butternut noted and identified to the genus, and any members of a genus which are superficially similar to Butternut were identified to species level.

Twenty eight (28) Butternut trees were found within the survey area, most of these trees were clustered within the forest patch growing along the edge of the cliff.

Management Options

Butternut trees identified at the CLC property, north of the property, as well as along the Eastern Creek are classified as

- Category 1 (non-retainable, for example, terminally infected with Butternut Canker) or
- Category 2 (considered retainable). Most of these trees were clustered within the forest patch growing along the edge of the escarpment. Additional detail is provided in subsequent sections. Category 2 Butternut trees are illustrated on Figure 24.

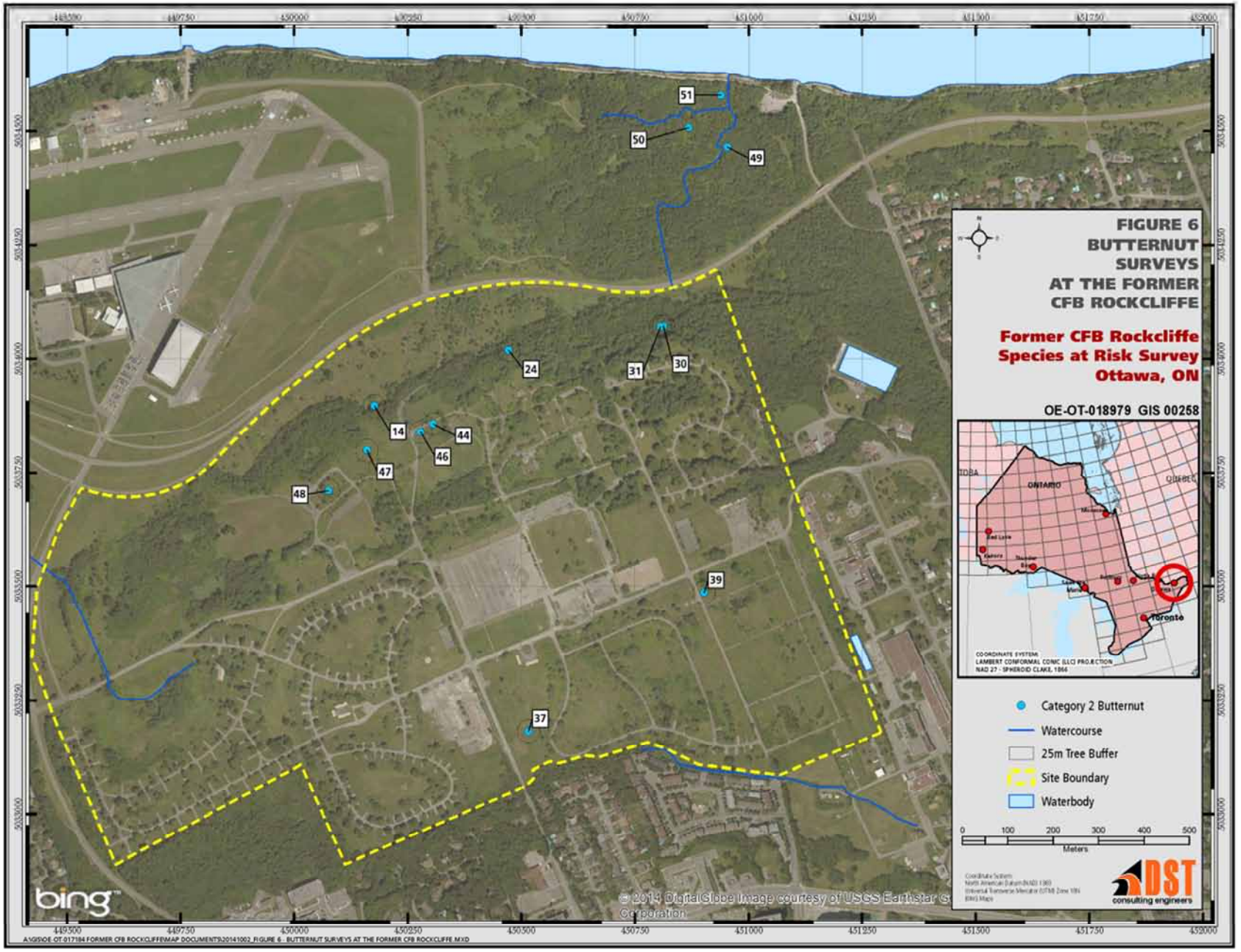

Figure 24: Butternut Location Plan (Source: DST, 2014)

3.9 SUMMARY OF EXISTING CONDITIONS

The following represents key findings concerning existing conditions within the Former CFB Rockcliffe CDP site (study area). The findings are discussed in light of the comprehensive review of recent background assessments and investigations discussed in detail earlier in the Chapter.

Geology and Hydrogeology

The study area includes two connected hydrogeological units in the area: the overburden unit and the shallow bedrock unit. There are variable thicknesses and types of overburden materials overlying the bedrock:

- Areas with shallow overburden soil (less than 2 m of overburden thickness overlying bedrock) covering approximately 17% of the study area; and
- Areas with overburden thickness ranging from greater than 2 m to about 10 m.

The native overburden comprises clay to silt marine deposits over the Southern half of the study area, silty to sandy till plain in parts of the Western and Northern portions, and sand/silt alluvial sediments forming parts of the Western portion of the study area.

In summary, the generalized stratigraphy for the east side of the site consists of asphalt surface treatment underlain by granular sand and gravel which is again underlain by silt or clay layer followed by bedrock. The generalized stratigraphy for the west side of the site consists of a thin layer of topsoil underlain by silty clay and sand and gravel layers followed by possible bedrock.

The elevation across the study area ranges from about 70 to 90 m above sea level (asl). The base of the escarpment descends to approximately 55 m asl at the Rockcliffe Parkway, and about 45 m asl at the Ottawa River.

Groundwater on site flows from north to northwest, approximately following the local topography descending towards the Ottawa River. In general, the overburden water table is slightly higher than the bedrock groundwater surface across most of the property, with the exception of the top of the escarpment located in the northwest corner of the site. From the 2014 data analyzed by Aquafor Beech for 14 monitoring wells, the range of water levels was between 0.18 and 2.09 m.

Data on hydraulic conductivity (from rising or falling head slug tests) show that:

- Sand and sandy gravel has K values between 10^{-6} and 10^{-7} (m/sec)
- Silty clay and clay till have K values between 10^{-6} and 10^{-8} (m/sec)
- Limestone bedrock has K values between 10^{-8} and 10^{-9} (m/sec)

In-situ hydraulic conductivity testing, found that the field saturated hydraulic conductivity varies across the site per the various soil types and that localized areas of high infiltration encountered (more than 490mm/hr) and generally correspond to localized areas of sandy soil. In addition, localized areas of low infiltration encountered (less than 1 mm/hr) and generally correspond to silty clay soils. Silty clay and clay till generally found to be lower in original estimates as compared to in-situ testing. Using all available data and

employing a sensitivity analysis, an average hydraulic conductivity was determined to be 9.5mm/hr and 5.2mm/hr for the Western and Eastern Creek Subwatersheds respectively.

Surface Water Features

There are three watercourses flowing within and around the Former CFB Rockcliffe site:

1. Western Creek
2. Eastern Creek
3. Northeastern Escarpment Tributary to the Eastern Creek

The Eastern and Western creeks have tributaries that originate within the Former CFB Rockcliffe CDP site, and both also merge with tributaries flowing from adjacent properties. The Northeastern Escarpment Tributary originates from an existing storm sewer outlet.

These creeks flow into the Ottawa River and have sections which flow through underground stormwater piping and culverts.

Existing Drainage

Drainage features within the study area include a major drainage system and a minor drainage system. The major drainage system includes two watercourses (creeks) that drain major storm events and outlet to the Ottawa River. The Western Creek bisects the site and originates at the southeast corner (on National Research Council lands), and discharges at the northwest edge of the site, crossing the Aviation Parkway via a culvert and outletting to the Ottawa River. The Eastern Creek provides drainage to the northeast quadrant of the site and drains runoff northward over the north escarpment, ultimately discharging to the Ottawa River.

In regard to the minor drainage system, a combined sewer system is present on the site, in addition to two storm sewer systems: one collects surface runoff from the central portion of the site (near Via Venue and Codd's Road) and the second carries runoff from the Thorncliffe Park residential development (immediately south of the site). Both systems eventually discharge into the Ottawa River through a series of culverts, roadside ditches, and/or natural watercourses.

Hydraulics

The flow discharge from the study area is currently conveyed to two existing culvert crossings at the Aviation and Rockcliffe Parkways.

The first crossing at the Aviation Parkway on the west edge of the Former CFB Rockcliffe CDP site (West Outlet) consists of a 0.91m diameter (36") CSP. The following information has been compiled from field survey work. The upstream and downstream inverts were surveyed at elevations 60.25m, and 60.16m, respectively. The culvert is approximately 137m in length with slope of 0.07%. Results indicate that the peak capacity of the existing culvert is approximately 0.85cms, with water surface elevation at 61.75m at the upstream end of the culvert.

Rockcliffe Parkway at the eastern edge of the Former CFB Rockcliffe CDP site (East Outlet) is comprised of a 1.24m diameter (48") CSP. The following information has been compiled from field survey work. The upstream and downstream inverts were surveyed at elevations 52.52m and

52.15m, respectively. The culvert is approximately 28m in length with slope of 1.3%. The results indicate that the peak capacity of the existing culvert is approximately 3.5cms, with water surface elevation of 54.80m at the upstream end of the culvert. As discussed in previous sections, no outlet to the Ottawa River currently exists for the Eastern Creek.

From the hydraulic analysis, the existing outlets from the system are constrained by capacity limitations at the Eastern outlet and Western outlet at the Rockcliffe and Aviation Parkways respectively. Therefore, assuming a suitable outlet for the Eastern Creek can be constructed at the Ottawa River, from a hydraulics perspective any future stormwater management system must either:

a) Control post-development flows to respect the capacity of the existing infrastructure

b) Provide sufficient capacity to convey post-development flows such that major flows can be safely conveyed to the Ottawa River (where flood control is not required).

Hydrology

In support of the proposed development within the Former CFB Rockcliffe CDP site, IBI Group has completed a preliminary hydrological analysis of the existing site conditions, and conceptual stormwater management for the proposed development.

The hydrologic analysis of the study area was conducted using SWMHYMO computer model. According to the IBI documentation, the modeling effort included the analyses of existing conditions, future conditions, and future conditions with two SWM facilities (i.e. Eastern SWMF and Western SWMF).

Existing Conditions

Design Storm	Peak Flow to Western Outlet (cms)	Peak Flow to Eastern Outlet (cms)
2 Year, 24 Hr, SCS Type II	3.91	2.97
5 Year, 24 Hr, SCS Type II	5.76	4.37
100 Year, 24 Hr, SCS Type II	11.56	8.83

Water Budget

Water Budget Analysis is required to understand the overall hydrology of the study area, and evaluate the relationship between precipitation and the response of the study area to precipitation events over a long timeframe. The overarching objective of understanding the water budget is so that one can analyze the existing conditions hydrology in order to establish baseline conditions, which will be used later to carry out an impact assessment of future development and develop stormwater management targets. There are many benefits that result from a water balance assessment. These benefits include:

- Identifying key elements in the Hydrological Cycle, including surface runoff, evapotranspiration, and infiltration;
- Defining streamflow regime and variability; and
- Providing baseline conditions to help develop stormwater management targets.

From the analysis, the existing conditions water budget was determined and is presented below.

Water Budget Analysis Results for the Study Area

Water Budget Component	Volume (mm/year)
Total Precipitation	887
Surface Runoff	120
Evapotranspiration	532
Infiltration	235

Fluvial Geomorphology

For the purpose of characterizing the fluvial geomorphology of the Eastern and Western Creek systems under existing conditions, the Fluvial Geomorphology Assessment Study prepared by DST (September, 2013) was reviewed.

The Western Creek was determined to be geomorphically stable, with most reaches lacking obvious signs of ongoing erosion. However, sub-reaches between Hemlock Road and the Aviation Parkway did show signs of instability, and a reach immediately downstream of a culvert north of the Aviation Parkway was deemed to be an eroding steep-walled gully with a very steep (5%) channel bed and incising into the consolidated clay base material. It is assumed that the channel was disturbed by flow from the existing culvert, leading to the destabilization of the downstream channel.

Unlike the Western Creek, the Eastern Creek has several sub-reaches that show signs of channel instability, including exposed roots on channel banks and over-sized channel dimensions. The most upstream reach appears to be the most destabilized, which is likely attributable to the culvert under the Rockcliffe Parkway and resultant potential augmentation and/or grade change.

In both creeks, it was observed that engineering works such as culverts have the potential to destabilize the channel.

The recommendations of the Fluvial Geomorphology Assessment Study included the following:

1. It is imperative that any future stormwater detention pond designs minimize perturbation of the channel.
   a. Western – Report authors suggest 800 l/s will have no significant impact to the creek stability as the flow velocity and bed shear stress will not be affected
   b. Eastern - estimated bankfull discharge is 1500 l/s.

2. Implemented stormwater pond design should not change the input discharge or sediment load to either creek.

In addition, it is noted that enhancement to the western Creek are required to remove debris between Havelock Rd and the Aviation Parkway (removal of silt build up in the creek at the outlet of the Aviation Parkway culvert), and remove the blockage in a culvert within the RCMP campus is required to restore a positive outlet.

Aquatic Ecology

An aquatic habitat assessment was undertaken for the Western Creek and Eastern Creek downstream from the Former CFB Rockcliffe CDP site in order to assess potential impacts on aquatic habitat resulting from the management of stormwater for the site.

The assessment was undertaken using the Ontario Stream Assessment Protocol (OSAP) (Stanfield 2010), and it included

examining five (5) reaches of both the Western Creek and Eastern Creek. Key findings included:

- Active Channel: Both the Eastern and Western creek had an active channel width ranging from 0.5 to 2.0 m. Maximum bank height ranged from approximately 450 mm to 700 mm in the Western creek and 350 mm to 750 mm in the Eastern creek.

- Bank Angle: Overall, bank angles for both creeks range from 13° to 26°.

- Water Depth and Flow: The water depth during baseflow conditions in the Western creek ranged from 52 to 105 mm while the eastern creek ranged from 0 to 46 mm. during baseflow conditions, both creeks can be characterized as having shallow flow depths and low flow velocities.

- Bank Vegetation and Instream Cover: The Eastern creek was found to have low to moderate levels of bank vegetative cover throughout its length. Whereas, the Eastern Creek is characterized as having low to moderate levels of bank vegetation, it does display consistently high counts of instream cover (20 cover points/site), an important component of aquatic habitat for fish species. Cover is more varied in the Western creek with higher levels of instream cover observed at upstream locations as compared downstream.

- Bank Undercuts: In general, the Western Creek displayed few sever bank undercuts, whereas the majority of the Eastern Creek displayed undercutting of the right bank. Other signs of erosion within the Eastern Creek including slumping banks were also noted.

- Water Temperature: Water temperature in the Western creek was highest at the upstream but was considerably cooler in the deeper mid-reach sections of the creek. In general, water temperature in the Eastern Creek was highest at the downstream extent as compared to the upstream. Higher downstream water temperatures are likely a result of prolonged exposure to ambient air temperature due to the lack of outlet to the Ottawa River at the raised pedestrian walkway.

- Macroinvertebrates: The community of macroinvertebrates was found to be moderately diverse, ranging from 9 to 15 taxa at each site, however key indicator species were mostly absent.

- Fish and Fish Habitat: Sites in the Western Creek appear to provide marginal fish habitat that could be suitable for some common fish species, however no fish were encountered during the fish surveys. It appears that the lack of connectivity to the Ottawa River (as the final 550m of the creek runs subsurface) and extensive entombment of creek sections have prevented fish from reaching potentially suitable sites. The Eastern Creek could potentially provide habitat for species that are tolerant of low water levels (sticklebacks for example), though no fish were found during fish surveys. This is likely due to the fact that there was no downstream connection to the

Ottawa River at the elevated recreational path and no upstream connection to other habitats.

Moreover, the OSAP assessment indicated that the creeks did not support any rare or SAR varieties of invertebrates. Due to the poor quality of aquatic habitat and absence of significant open water, the report noted that it is highly unlikely that any wetland associated SAR birds, reptiles, insects, or fish would be present within the survey area.

The DST Aquatic Habitat Assessment report indicated that temperature mitigation measures should not be required for the outflows from the stormwater facilities proposed for stormwater control within proposed areas.

Terrestrial Ecology

Background documents revealed the following information:

Vegetation: it was noted that on site native tree species identified include Sugar Maple, Basswood, Red Oak, White Pine, White Spruce, and White Cedar as well as Bitternut Hickory, Butternut, and Silver Maple.

Non-native tree species identified on site, including Black Locust, Norway Maple, Norway Spruce, Blue Spruce, and Weeping Willow.

In general, the trees recommended for retention on the site are native trees, as some non-native species tend to be invasive (i.e., Norway Maple). However, some non-native trees are recommended for retention on the site.

There are four provincially designated natural areas within one kilometer of the site; however the only area with the potential to be impacted by the redevelopment of the site is the Rockcliffe Airbase Woods.

Within the vicinity of the former CFB Rockcliffe site, there are five (5) Urban Natural Areas (UNAs); the Airbase Woods, the NRC Woods North, the Montfort Hospital Woods, the Carson Grove Woods, and the Assaly Woods. From an ecological standpoint, the two most valuable vegetated areas in the vicinity of the site are the Montfort Hospital Woods and the NRC Woods North.

It is recommended, that as part of a landscape level stormwater management system that all SWM techniques maintain and enhance the form and function of existing vegetation communities both within and off-site of the Former CFB Rockcliffe CDP site including three (3) significant on-site vegetation communities: 1) North of Dubhe Private at the headwaters of the Western Creek; 2) North of Hemlock Private on both sides of Hurley Crescent; and 3) North of Arcturus Private, east of Burma Road and two (2) UNAs downstream of shallow groundwater system including: 1) the Airbase Woods; and 2) the NRC Woods North.

Terrestrial Habitat: The terrestrial habitat in the area of the proposed location of the Eastern SWM Facility can be characterised as grassland immediately south of the Rockcliffe Parkway, with thick secondary growth deciduous forest growing around the base of the cliffs and cliff slope further to the south. The boundary between the NCC parcel south of the Rockcliffe Parkway and the former CFB Rockcliffe property is a cliff which varies between vertical rockface and sections of steep rocky

slopes along the southern edge of the survey area.

Terrestrial Species at Risk: The Species at Risk Survey included consultation with the Ontario Ministry of Natural Resources; review of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and the Species at Risk Ontario (SARO) SAR status reports and range maps for the target species; review of the Natural Heritage Information Center (NHIC) mapping and historical records of SAR occurrences. In addition, the scope of work included identification of species-specific mitigation measures and discussion of anticipated SAR related permitting requirements. Based on the above-noted records review, DST compiled a list of 24 SAR which may potentially be present within the survey area. Survey results indicate the presence of six species, as follows: Butternut; Monarch Butterfly, Common Nighthawk and three (3) bat species - Little Brown Myotis, Northern Myotis, and Tricolored Bat.

MSS STORMWATER STRATEGY

4.1 INTRODUCTION

As detailed in the Master Servicing Study (MSS) completed by IBI (2015), an integrated environmental assessment and planning process has been completed and is detailed in Chapter 3 of the MSS. The Municipal Class Environmental Assessment (EA) process recognizes the benefits of integrating approvals under the Environmental Assessment Act and the Planning Act.

From the perspective of the MSS, the problem presented by this proposed redevelopment of the Former CFB Rockcliffe site and the associated increase in density is the provision of municipal services to adequately service the preferred concept plan, and to incorporate these services into the existing surrounding municipal infrastructure while meeting the design criteria and level of service requirements of the City of Ottawa and other regulatory agencies.

To assist in developing a preferred servicing solution for the redevelopment of Former CFB Rockcliffe, a two stage evaluation process was utilized.

The evaluation was carried out in conjunction with the CDP process, out of which a preferred development concept plan and preferred municipal servicing plan are identified. The evaluation was completed in sufficient detail to satisfy Phases 1 and 2 of the MEA Municipal Class EA process and, as part of the CDP process, included consultation with review agencies, stakeholders, and the public

Finally, with the identification of a preferred concept plan and preferred municipal servicing plan, design parameters are developed for water, wastewater and stormwater to facilitate more detailed design work for each municipal service.

Stage I – Identification and Evaluation of Stormwater Solutions

Based on the Stage 1 evaluation of servicing solutions, the expansion of the existing municipal infrastructure system was determined to be the best servicing technique to advance. The technique will service the former CFB Rockcliffe site while minimizing negative impacts to the social and natural environment.

In regards to stormwater management, the Stage 1 evaluation identified a separate storm sewer system, complete with end-of-pipe SWM facility(ies) as preferred. The storm sewer system will be designed to current City of Ottawa and MOE design guidelines and in parallel with the LID Pilot/ Demonstration project.

Stage II – Identification and Evaluation of Stormwater Alternatives

In support of the preferred servicing technique established in the Stage I evaluation, three (3) municipal servicing alternatives have been developed for each municipal service (water, wastewater and stormwater).

In regards to stormwater management, the, Alternative III was identified as the preferred alternative for stormwater. This alternative includes two end-of-pipe SWM facilities to balance stormwater discharge between the existing outlets recognizing the constraints and opportunities associated with these outlets, minimize storm pipe sizes and depth, and to facilitate construction phasing.

The details of the preferred alternative from the MSS (IBI, 2015) for stormwater management (Alternative III) are summarized in regards to the evaluation criteria of Serviceability, Social, Natural Environment and Cost.

Serviceability

To service the Former CFB Rockcliffe site, two major SWM facilities have been proposed to direct runoff from the site to both Western and Eastern Creeks. These two facility systems, and the existing topography, offers the opportunity to balance the post-development flow between the two creeks, mitigating the constraints associated with each creek. Majority of the trunk storm sewers are in proposed rights-of-way, servicing associated frontage, resulting in an efficient design from an overall sewer length perspective. Size and depth of the trunk storm sewers is also minimized, relative to the single SWM facility options, and also maximizes phasing potential.

Location of the main collector road on the preferred concept plan is such that there are numerous locations where the green space abuts the collector road, offering good opportunity to control major flow along the corridor, if necessary. The proximity of the collector road to the proposed trunk storm servicing corridor also provides the opportunity to increase discharge to the storm trunk system with minimal impact to the local storm system, if necessary. Due to the sewers primarily in proposed rights-of-way, and off-site SWM facilities that are significantly downgradient of the development, the design is expected to have minimal impact on the aesthetics or functionality of the development.

This parallel study which is evaluating the potential to add LID technique to the storm system may result in further enhancement of the development's aesthetics and the functionality of the storm system.

Social

Construction of two SWM facilities, together with the site topography, offers the opportunity to balance post-development flow. This would assist in minimizing the required upgrades to the Western Creek, thereby lessening impact to the adjacent community.

The construction of the Eastern SWM Facility may require upgrades to the existing outlet channel and/or the construction of a new storm sewer outlet from the SWM facility to the Ottawa River due to the restricted space available at this location and potential design constraints imposed by the NCC.

Natural Environment

Existing combined sewer system to be eliminated and replaced by separate sanitary and storm sewers. Baseflow that had previously been diverted to the combined system is now conveyed to the natural environment. Since a SWM facility is proposed at the headwaters of both creeks, baseflow to both creeks will be enhanced, and there is the potential to improve aquatic habitat of both creeks.

Existing topography of the site also provides opportunity to balance the post-development flow between the two outlets, minimizing impact on both creeks. However, physical constraints associated with the western outlet suggest a limited ability to convey post-development flow, compared to the eastern outlet. Any upgrades required to mitigate constraints

in the Eastern Creek will require tree removal and/or the construction of a storm sewer directly to the Ottawa River.

Potential use of natural channel design techniques and a reforestation program can be implemented to minimize long term impact to natural environment. Any work in the Eastern Creek has the added benefit of creating an outlet to the Ottawa River at the recreational pathway, which provides an opportunity to enhance the creek's aquatic habitat. It will also provide opportunity to stabilize the creek slopes and terminate the active erosion which is currently occurring.

Cost

Requires construction of two SWM facilities; however, the overall sewer system is relatively cost effective due to the reduced sewer sizes and sewer depths as a result of multiple outlets.

Additional costs associated with constructing two SWM facilities would be significantly offset by the savings in sewer costs throughout the development.

Since most of the storm sewers are located in proposed roads with useable frontage, the system is considered to be relatively cost effective from a capital and long term operating and maintenance cost perspective.

Figure 3.4 of the MSS (IBI, 2015), illustrates the preferred servicing solution for water, wastewater and stormwater management. Figure 26 and Figure 27 illustrate the final preferred servicing solution which evolved through agency and municipal consultation and engineering design activities.

Preferred SWM Alternative Regulatory Requirements

A summary of the regulatory requirements of the preferred stormwater alternative from the MSS (IBI, 2015) are detailed below in regards to Water Quantity, Water Quality, Erosion Control, Temperature, Water Budget, and Level of Service (LOS)

Water Quantity

As previously discussed, the preferred SWM alternative is comprised of two end-of-pipe SWM facilities with outlets to the Ottawa River:

1. Eastern SWM Facility
2. Western SWM Facility

Construction of the Eastern SWM Facility, adjacent to the Rockcliffe Parkway, will include a new pipe conveying outflow from the facility to the Ottawa River. Due to the direct connection to the Ottawa River, it is not required the Eastern SWM Facility provide water quantity control. Additional field work and consultation with the NCC and RVCA will be required as part of detailed design.

The Western SWM Facility is tributary to the Aviation Parkway culvert crossing. Enhancement to remove debris from the Aviation Parkway culvert, remove silt build up in the creek at the outlet of the Aviation Parkway culvert, and remove the blockage in a culvert within the RCMP campus is required to restore a positive outlet.

Water Quality

The two (2) SWM facilities servicing the site will provide an Enhanced Level of Protection, which corresponds to 80% TSS removal as per the Stormwater

Management Planning and Design Manual (Ontario Ministry of the Environment, March 2003).

Erosion Control

Pre the MSS, it is recommended that the future SWM facility designs minimize perturbation of the creek channels. The Eastern Creek is characterized by eroding, incising reaches separated by depositional wet grassy areas. The estimated bankfull discharge is between 0.5 cms and 2.5 cms.

The Western Creek is generally stable except upstream of the Aviation Parkway (which is going to be modified by development). The estimated bankfull discharge is between 0.7 cms and 1.4 cms downstream of the Aviation Parkway and upstream of the confluence with the western tributary.

Temperature

With respect to temperature, the Aquatic Habitat Assessment indicates that temperature mitigation measures should not be required for the outflows from future SWM facilities.

Water Budget

The existing conditions water budget analysis as detailed in Section 3.2 of this report was included within the MSS in order to provide baseline conditions from which targets could be developed.

Level of Service (LOS)

The level of service for future development is to be based on the latest City of Ottawa guidelines. The key recommendations of Technical Bulletin 2012-4 are summarized as follows:

- An inlet time of 10 minutes is to be used for all land uses and lot grading configurations. For the sizing of sewer segments (leads) connecting back yard catchbasins to the street sewer the inlet time is 15 minutes.
- In the absence of detail lot configuration and building size and position, the total imperviousness of external future urban areas is to be used for detailed design of infrastructure for the subject phase of development. The imperviousness ratio must be consistent with the runoff coefficient.
- Designs of sewer systems in Greenfield developments are not to be completed on the basis of unit ICD flow rates. ICD flow rates are to be calculated for each drainage area to ensure that the stormwater management (SWM) objectives are satisfied.
- The maximum flow depth on streets under either static or dynamic conditions shall be 300 mm. Flow depth of runoff on street rights-of-way is not to extend onto private property.
- In addition to the use of Historical storms, drainage systems be stress tested using design storms calculated on the basis of a 20% increase of the City's IDF curves rainfall values. Modifications to the drainage system would be required if severe flooding of properties is identified.

4.2 CONVENTIONAL SWM SYSTEM CONCEPT

Per the MSS (IBI, 2015) the proposed redevelopment of former CFB Rockcliffe will be comprised of low, medium and high density residential, commercial, institutional and park space. As part of the development, the existing combined sewer and storm sewer systems will be eliminated, with installation of new independent storm and sanitary services. The proposed storm system will be designed to provide capacity for the existing external flows that are currently conveyed through former CFB Rockcliffe, including outflows from the northeastern portion of the Montfort Hospital, the Burma Road SWM Facility, and surface flows from the external lands south and east of the site.

The conceptual stormwater management system incorporates standard urban drainage design and stormwater management features that can be summarized:

- As a dual drainage concept incorporating both a minor system and major system;
- Two end-of-pipe stormwater management facilities.
- Rehabilitation of the existing Burma Road SWM facility (originally constructed in the early 1990's)
- Three (3) Dry Ponds for water quantity control

The MSS also recognizes that LID techniques are being considered for the site that the SWM system concept as presented in the MSS is designed with the flexibility to incorporate LID techniques.

Dual Drainage Concept

Dual drainage design features a combination of on-site detention (surface ponding) with inlet control devices (ICDs) and direct conveyance with no ponding. It accommodates both minor (pipe) and major (surface) stormwater runoff. Figure 25 and Figure 26 illustrate the proposed minor and major system per the MSS.

End-of-Pipe SWM Facilities

To address the water quantity and quality requirements of the redeveloped former CFB Rockcliffe site, the MSS (IBI, 2015) proposes that two end-of-pipe SWM facilities be provided.

1. Eastern SWM Facility
2. Western SWM Facility

The locations of the facilities are illustrated on Figure 25 and Figure 26. Figures 27 and Figures 28 illustrates the proposed end-of-pipe SWM facility layout, grading and facility attributes.

Both facilities have been designed to provide an Enhanced Level of Protection. According to the MOE Stormwater Management Planning and Design Manual (March 2003).

It should be noted that in addition to the Rockcliffe development, the Eastern SWM Facility provides water quality treatment for the lands tributary to the Burma Road SWM Facility (a water quantity facility only) and for the future museum site. The Western SWM Facility provides water quality treatment for the portion of the Montfort Hospital site tributary to the Montfort SWM Facility (a water quantity facility only).

Additional detail with respect to the end-of-pipe facilities as described in the MSS (IBI, 2015) is provided in the subsequent sections.

Eastern SWM Facility

As indicated on Figure 26, the trunk storm sewer servicing the eastern portion of the study area extends north from the development towards the escarpment bordering the study area. It is proposed in the MSS (IBI, 2015) that the 3000 mm x 3600 mm trunk storm sewer will terminate at the top of the escarpment and the runoff will cascade to the SWM facility below via a waterfall.

The Eastern SWM Facility (Figure 28) is designed as a wet pond, is comprised of a stilling basin, and a wet cell, with an outlet structure to a new storm sewer to the Ottawa River. The proposed design creates a series of smaller open water surfaces, considered less desirable to birds, augmented by floating islands.

As discussed previously, the estimated bankfull flows in the Eastern Creek could range between 0.50cms and 2.5cms (DST, September 2013). From a fluvial geomorphology perspective the flow generated by the contributing drainage areas during the 25mm storm event is 0.56cms, which is at the lower end of the bankfull estimates.

It is proposed that the Eastern SWM Facility provide baseflow augmentation to the Eastern Creek by means of a small diameter pipe. Based on a volumetric calculation, 51,081cu-m/year is to be conveyed from the pond to the creek. The MSS recommends that this be confirmed at the detailed design stage, supported by continuous modeling.

It is important to notes that the increase in flow resulting from development will be directed to the Ottawa River, away from the two creeks, via a 2400 mm diameter storm sewer.

Western SWM Facility

The Western SWM Facility is located at the northwestern corner of the development, abutting Hemlock Road to the south.

Runoff will flow from the two inlets to sediment forebays, from which flow is conveyed to the main cell of the facility. Downstream of the southern sediment forebay, the Southwest Channel will tie into the main cell of the facility. Similar to the Eastern SWM Facility, the proposed design creates a series of smaller open water surfaces, considered less desirable to birds, possibly augmented with floating islands to further discourage waterfowl.

Outflow from the facility is conveyed downstream via the Hemlock Road culvert, where it will flow overland towards the existing Aviation Parkway culvert. Downstream, flow will discharge to the Western Creek via the Aviation Parkway culvert during frequent storm events. During infrequent storm events, flow in excess of the Aviation Parkway culvert capacity will be conveyed east via the proposed channel-pipe configuration (Figure 29).

As discussed previously, the estimated bankfull flows in the downstream Western Creek could range between 0.70cms and 1.4cms (DST, September 2013). The MSS notes, that from a fluvial geomorphology perspective, outflow through the Aviation Parkway culvert during the 25mm storm event is 0.37cms, a rate that corresponds to less than bankfull estimates.

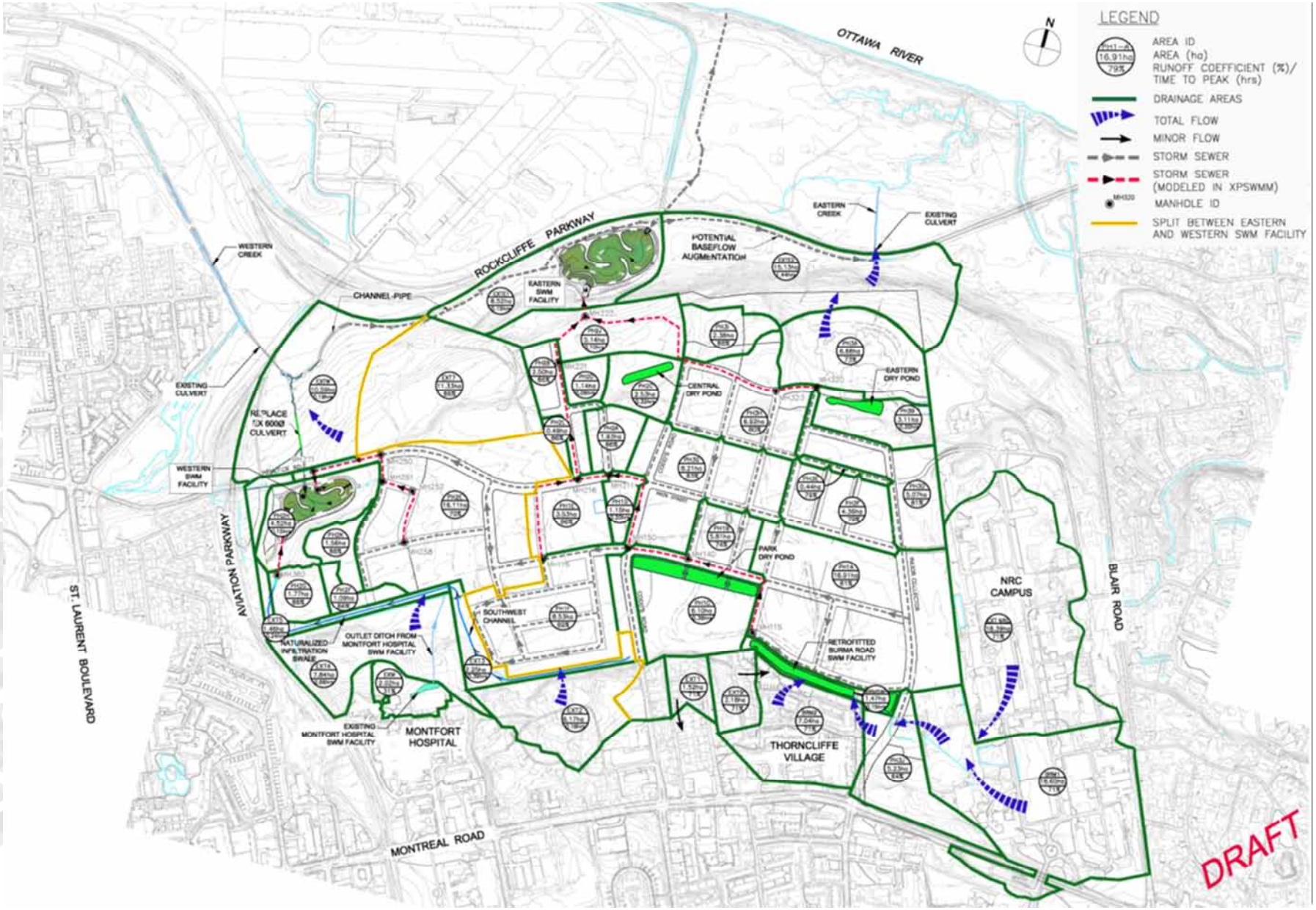

Figure 25: Post Development Conditions Drainage Area Plan – Minor System Connectivity

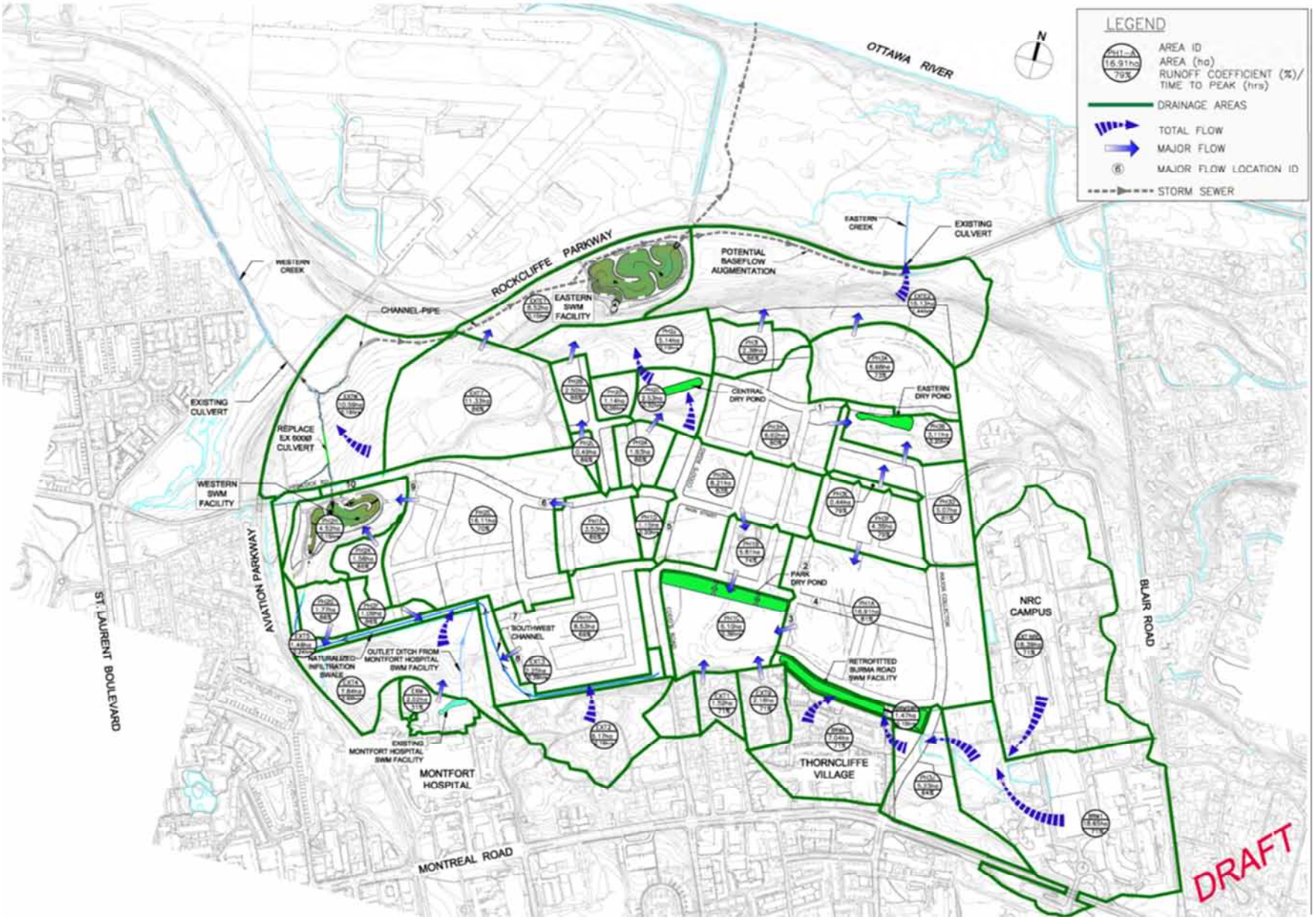

Figure 26: Post Development Conditions Drainage Area Plan – Major System Connectivity

Figure 27: Eastern SWM Facility – Layout, Grading and Facility Attributes

Figure 28: Western SWM Facility – Layout, Grading and Facility Attributes

Special Design Area

Stormwater runoff from the Special Design Area (Block 44, refer to Figure 2.0) is to be provided with its own stormwater management system, which proposes the use of a storm sewer for conveyance outletting to the Eastern Creek and an OGS system for water quality control. The specific details of the stormwater management for this Special Design Area will be determined at the detailed design stage.

While the MSS provides a conventional SWM serving approach, it is envisioned that the Special Design Area will be developed (Phase 3 - starting in the year 2024) as a full LID development without the need for conventional stormwater management to service the minor systems (concrete piping networks) or major system flows (SWM ponds).

Types of LID controls proposed as part of the demonstration project are described in Section 5.13 – Specific Projects.

Dry Ponds

Three (3) dry ponds are proposed across the site for the purpose of surface storage and flow routing (Figure 26 and Figure 27):

1. Park Dry Pond
2. Eastern Dry Pond
3. Central Dry Pond

In addition, in Block 22 (area PH1D), a park, will provide 230 m^3 of storage during the 100 year event. Major flow from portions of the study area will be directed to the three (3) dry ponds for attenuation prior to release, specifically 16.2, 2.5 and 0.5 m^3/s for the 100 year event for the Park, Eastern and Central dry ponds respectively.

The infiltration potential of these ponds are discussed in Section 5.0 of this report, however, the storage volume designated for the ponds is for major system storage. The MSS (IBI, 2015) acknowledges that the functional design for the major system storage provides flexibility in terms of the potential future use for LID techniques.

Additional detail with respect to each dry pond facility as described in the MSS (IBI, 2015) is provided in the subsequent sections.

Park Dry Pond

The Park Dry Pond is proposed to be located in the park block identified as Block 38 (Figure 2.0). Total flow from Foxview, major flow from a portion of Thorncliffe Village, and major flow from the southeast of the study area will be conveyed overland to the park dry pond for attenuation, prior to being released to the minor system. The areas contributing major flow to the park dry pond are indicated on Figure 26.

The conceptual plan and cross-section of the park dry pond are presented on Figures 29. The facility is divided into three cells, separated by berms provided by culverts. The berms have been incorporated into the design to allow for pedestrian access to the rest of the park south of the dry pond. The three cells are designed with flat bottoms, ranging from 88.5m at the upstream, 87.7m at the intermediate cell, and 87.5m at the downstream cell.

The MSS (IBI, 2015) notes that the proposed design provides flexibility at the detailed design stage, should the dry pond also be used for infiltration purposes. Otherwise, a longitudinal slope can be introduced across each of the cells.

On the north, the side slopes of the facility are proposed at 3H:1V. On the south, a 0.7m armour stone wall is proposed. The outlet control structure, located at the western-most point of the facility, will convey flow to the storm sewer located in the adjacent street. The elevation of the outlet control structure corresponds to the invert of the facility (87.5m), resulting in there being no permanent pool in the facility. Outflow from the facility is restricted to 160 l/s. During the 100 year storm event, it is anticipated the average depth of ponding will be 0.6 m. The total volume utilized is 3,000m^3. Figure 29 illustrates the Park Dry Pond plan view and cross-section.

Eastern Dry Pond

The eastern dry pond is located in the northeast of the site. The bottom of the pond is flat, with an invert of 85.5m. The side slopes of the pond are proposed at 3H:1V. The outlet control structure, located at the western-most point of the pond, will convey flow to the storm sewer located in the adjacent street. The elevation of the outlet control structure is set at 85.3m, slightly below the invert of the pond, resulting in there being no permanent pool in the pond. Outflow from the facility is restricted to 147 l/s. During the 100 year storm event, it is estimated the water level will reach 86.1m, corresponding to an average depth of 0.6m. The total volume utilized is 1610m^3. The conceptual plan and cross-section of the pond are presented on Figure 30.

Central Dry Pond

The central dry pond is located in the north-central of the site. The bottom of the pond is flat, with an invert of 82.3m. The side slopes of the pond are proposed at 3H:1V. Outflow from the pond will be conveyed from the western-most point of the pond by either pipe or swale. The outflow will be conveyed to the Eastern SWM Facility. The elevation of the outlet corresponds to the invert of the pond (82.3m), resulting in there being no permanent pool in the pond. Outflow from the pond is restricted to 98 l/s. During the 100 year storm event, it is estimated the water level will reach 82.5m, corresponding to an average depth of 0.3m. The total volume utilized is 560m^3. The conceptual plan and cross-section of the dry pond are presented on Figure 31.

Southwest Conveyance Channel

A conveyance channel is proposed around the south and west of the study area, henceforth referred to as the Southwest Channel. It extends west from Codd's Road, between the redevelopment and the Montfort Hospital Woods, from where it will extend north prior to releasing to the Western SWM Facility (Figure 25 and Figure 26). Major flow runoff from a portion of the study area will be directed to the channel, as will runoff from Fairhaven, the Montfort Hospital Woods, outflow from the Montfort Hospital SWM Facility, and major flow from the northeastern portion of the hospital site.

The channel consists of a trapezoidal cross-section with a bottom ranging in width from 1-3m, and 3H:1V side slopes that tie into existing grades to the south and west and the proposed development to the north and east. The proposed

longitudinal slope of the channel ranges from between 0.5 and 1.7%. At its downstream end, the total flow to be conveyed to the channel is 2.9cms. The estimated depth of flow in the channel during the 100 year event is 0.6m. The conceptual cross-section is indicated on Figure 32.

The MSS (IBI, 2015) notes that the proposed design provides flexibility at the detailed design stage, should the Southwest channel also be used for infiltration purposes.

All analysis, modelling in regards to the dual drainage concept, end-of-pipe SWM facilities, Special Design Areas, dry ponds and channel characteristics are detailed in Section 6.0 of the MSS (IBI, 2015).

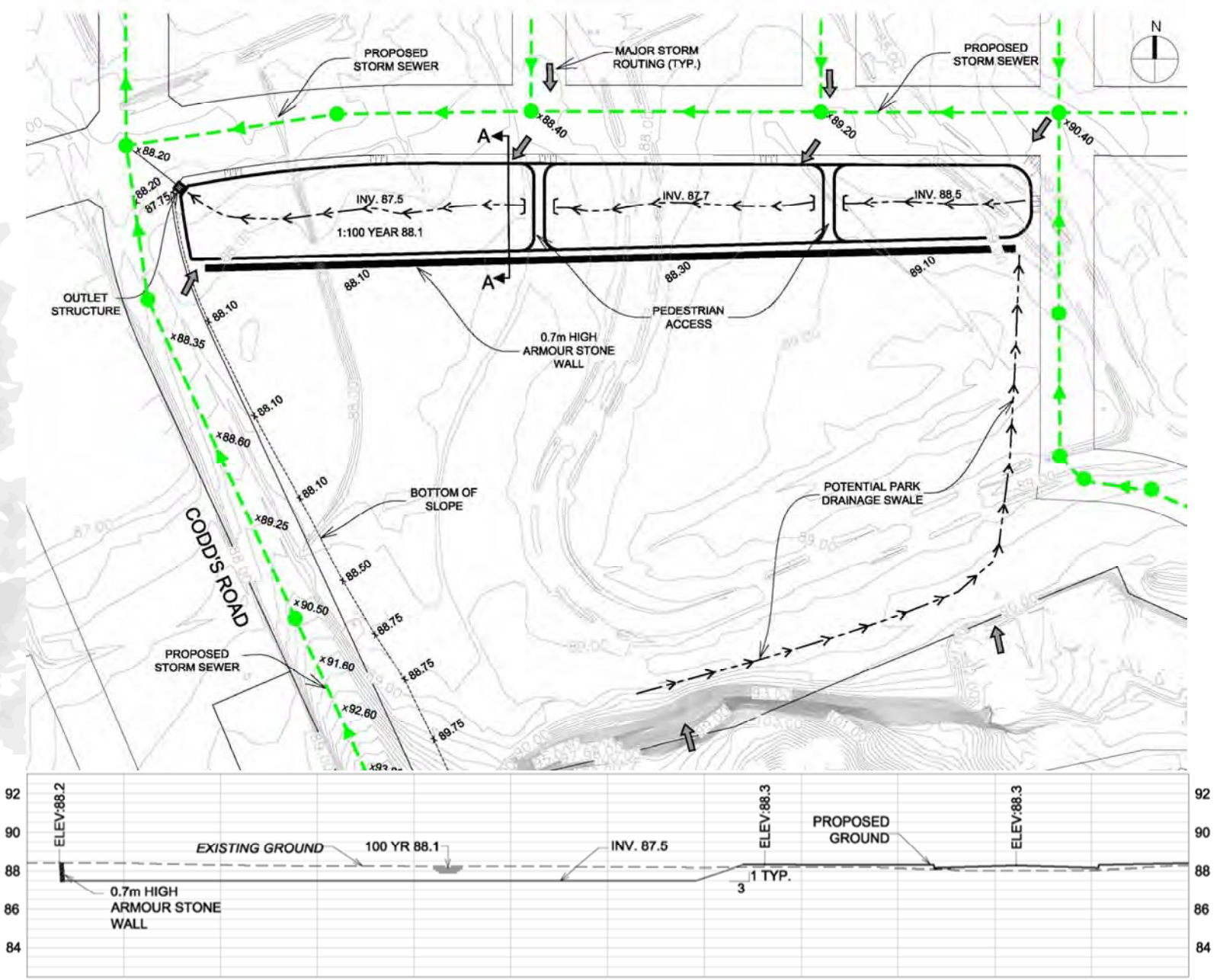

Figure 29: Park Dry Pond - Plan View and Cross Section A-A

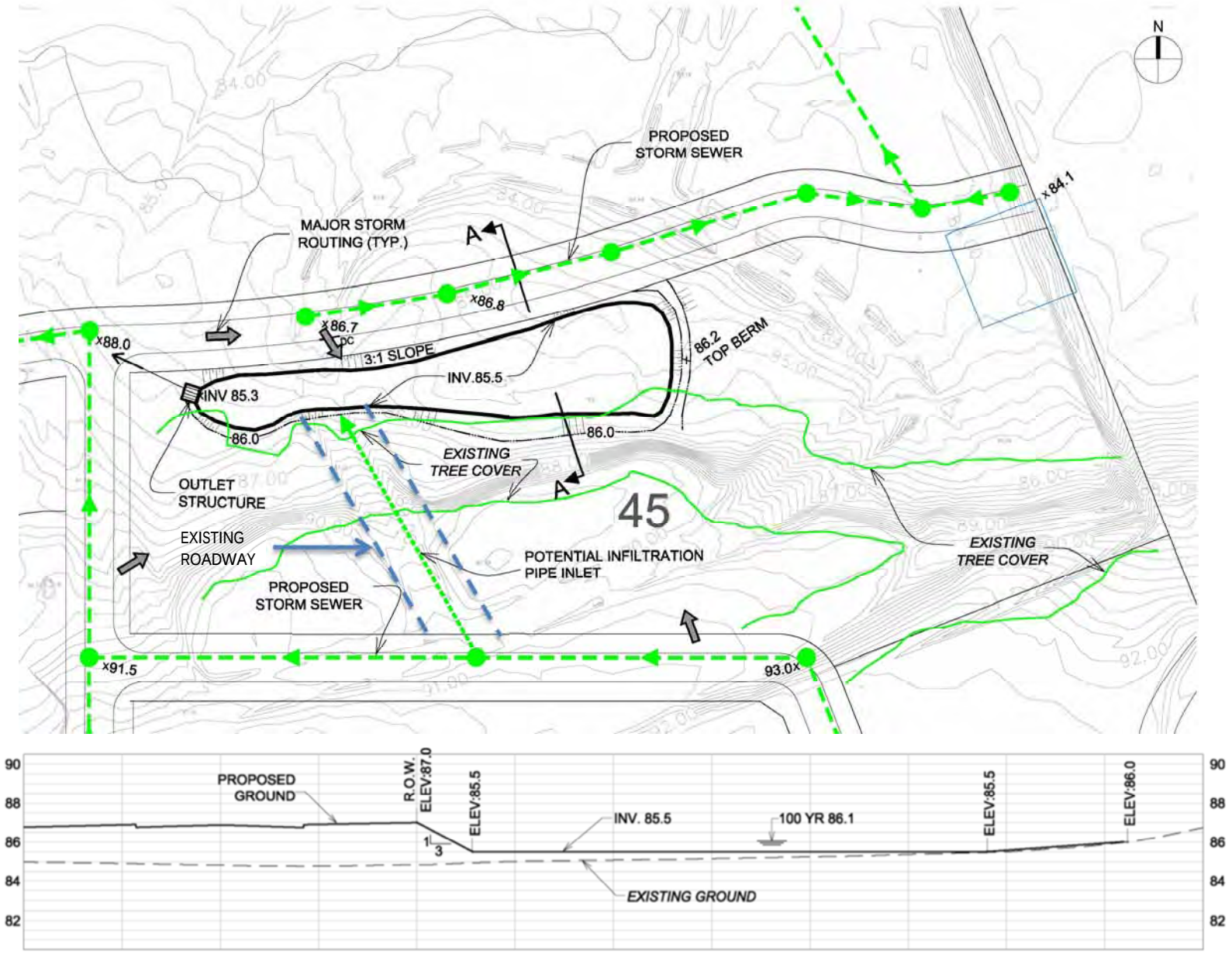

Figure 30: Eastern Dry Pond - Plan View and Cross Section A-A

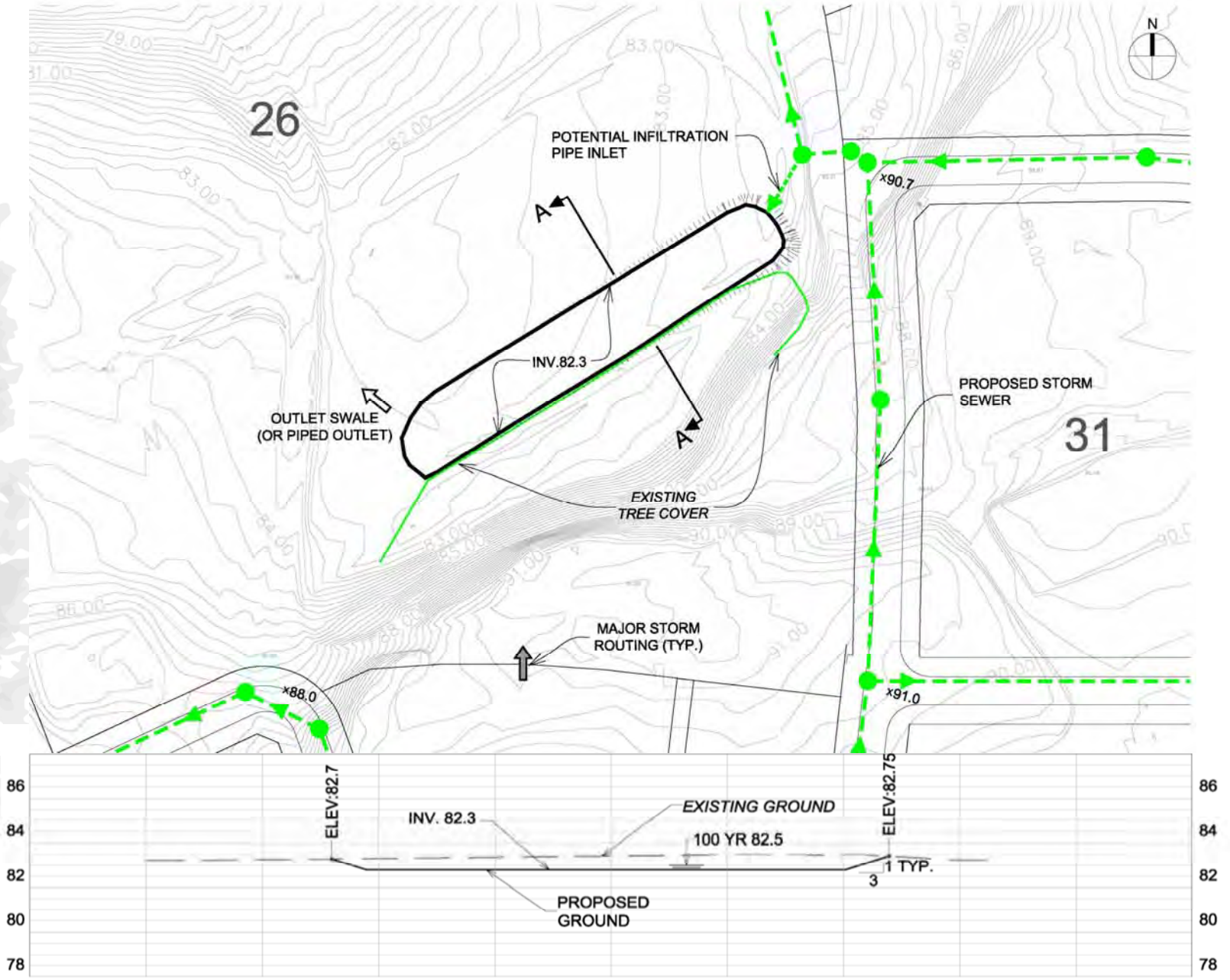

Figure 31: Central Dry Pond - Plan View and Cross Section A-A

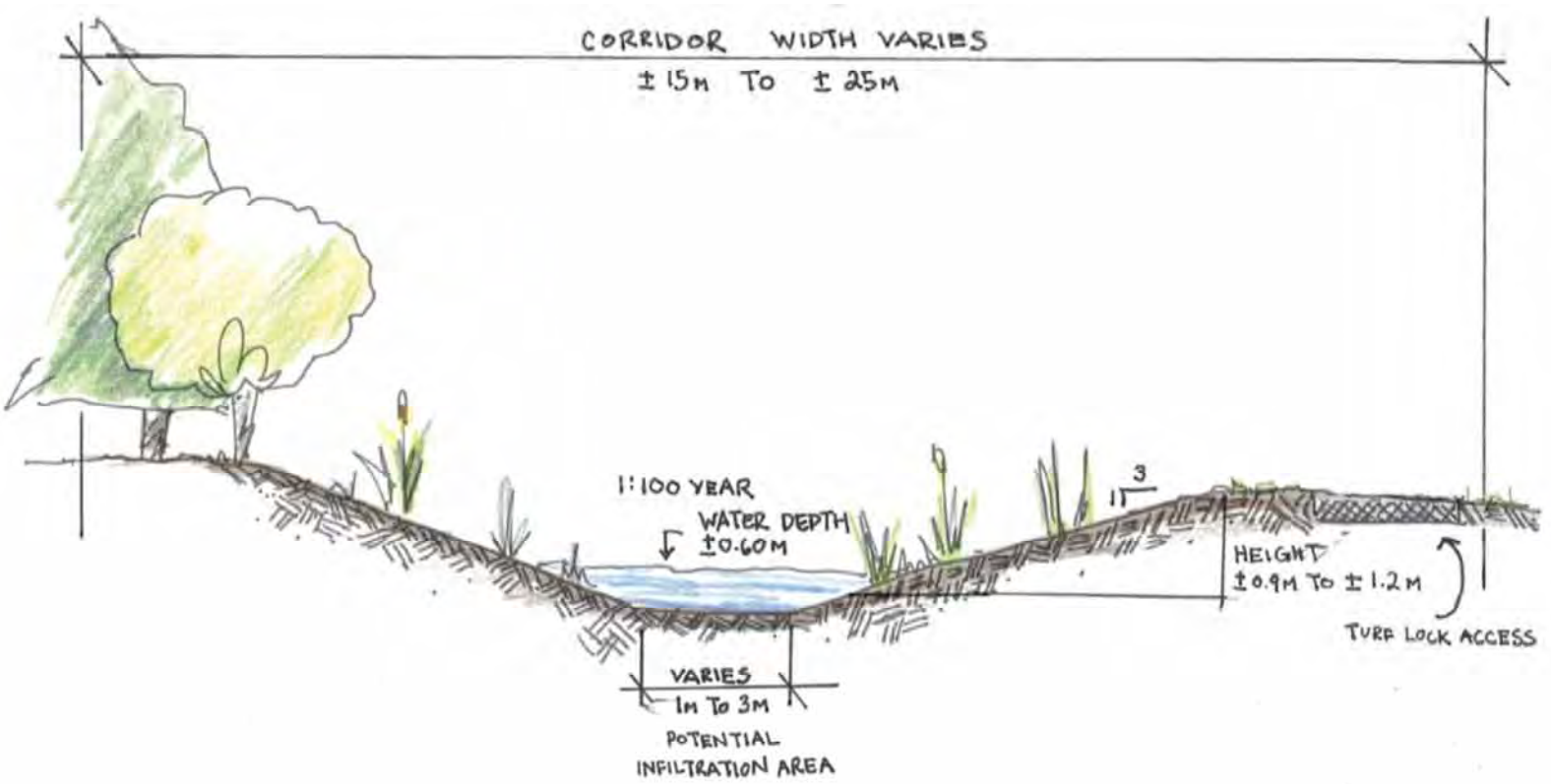

Figure 32: Southwest Channel – Typical Channel Section

4.3 CONVENTIONAL SWM SYSTEM PHASING

The development of the former CFB Rockcliffe site will occur in a phased sequence spread over a number of years as demonstrated in Figure 33. Additionally, Phase 1 will be divided into two: Phase 1A and Phase 1B. Phase 1A will include Codd's Road to the City Centre area and the lower density residential areas immediately west of Codd's road.

Phase IA Stormwater Infrastructure

Local minor storm sewers will be needed to properly service Phase 1A. All stormwater runoff from this phase will be routed to the new Eastern SWM Facility, which will need to be constructed as part of Phase 1A. Also, the western cell of the proposed Park Dry Pond will need to be constructed as part of Phase 1A in order to accept major storm runoff from Codd's Road.

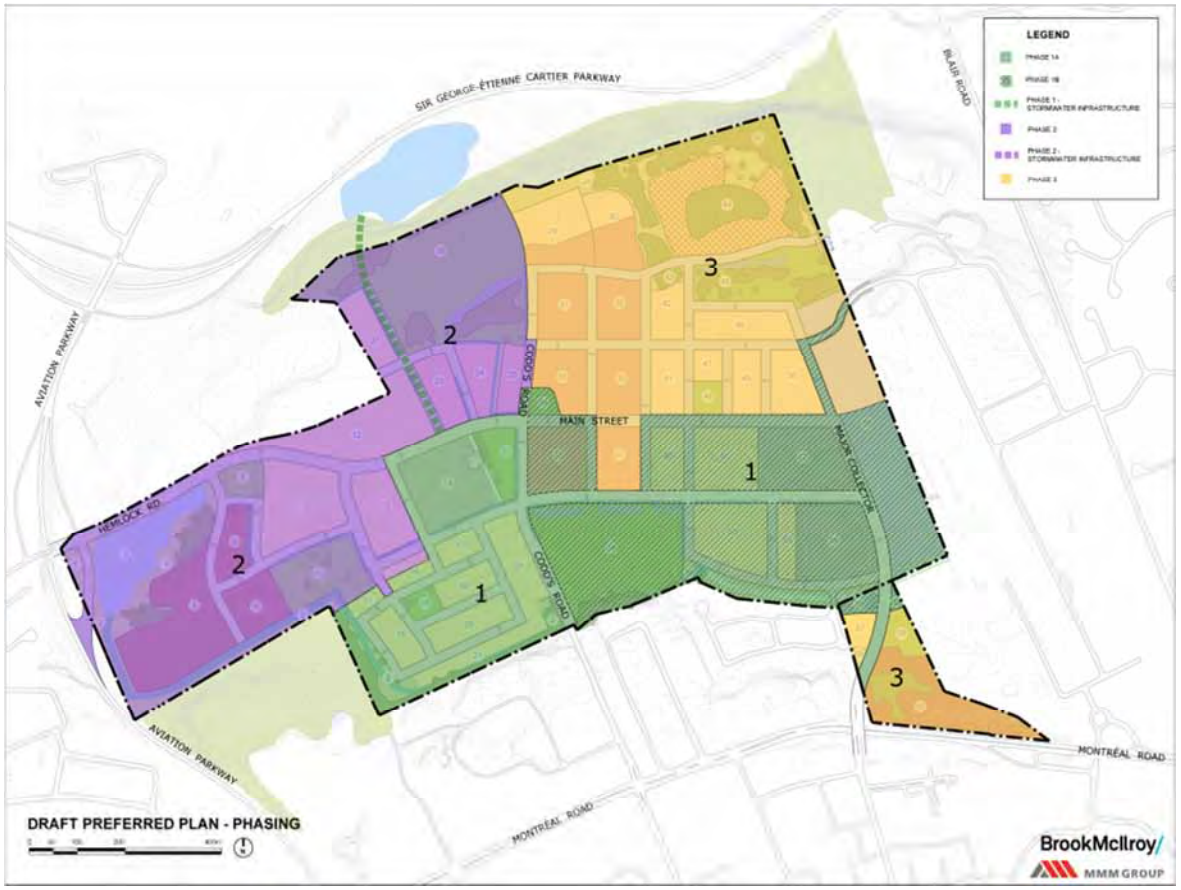

Figure 33: Development Phasing Plan