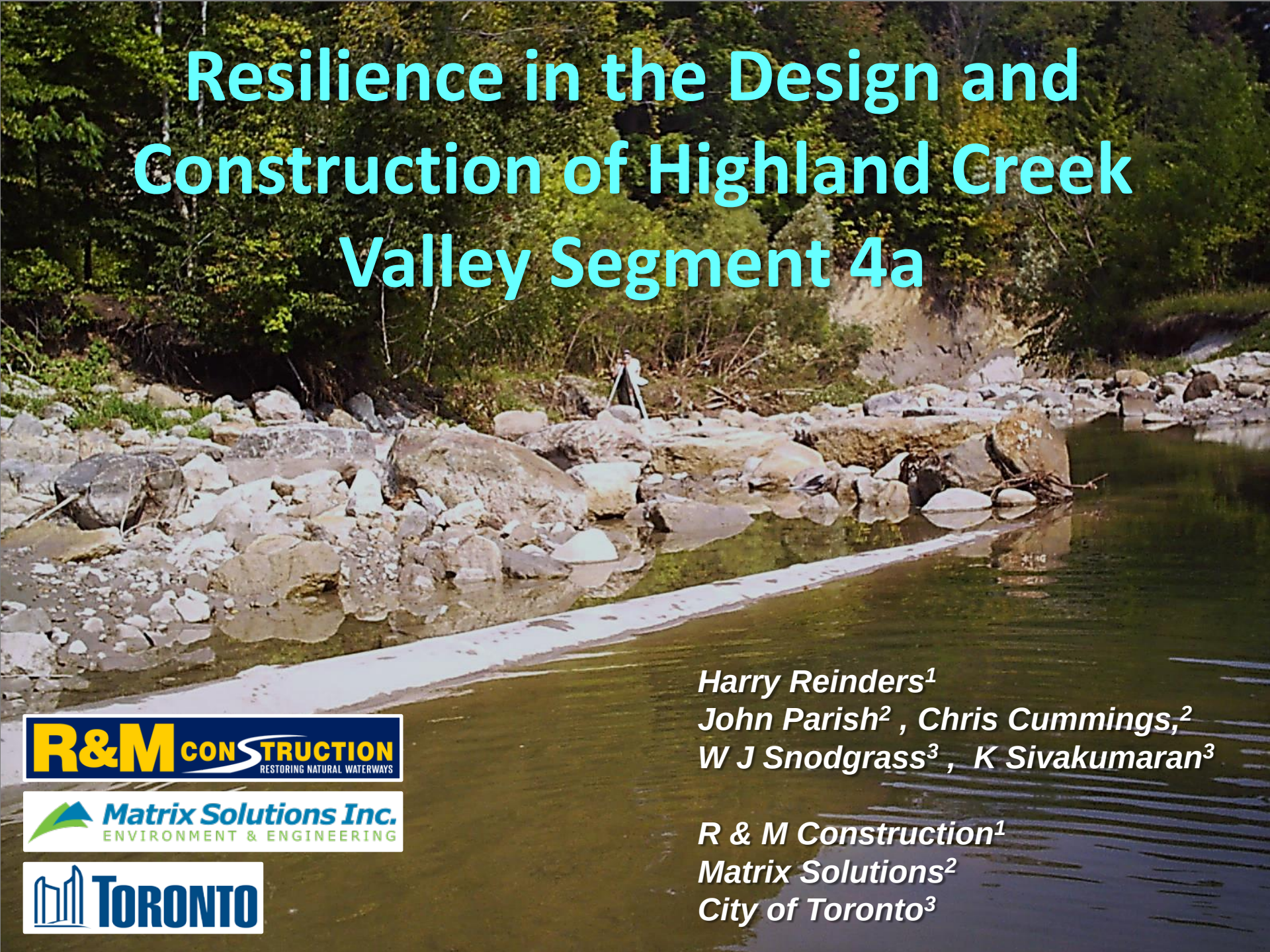
# Resilience in the Design and Construction of Highland Creek Valley Segment 4a

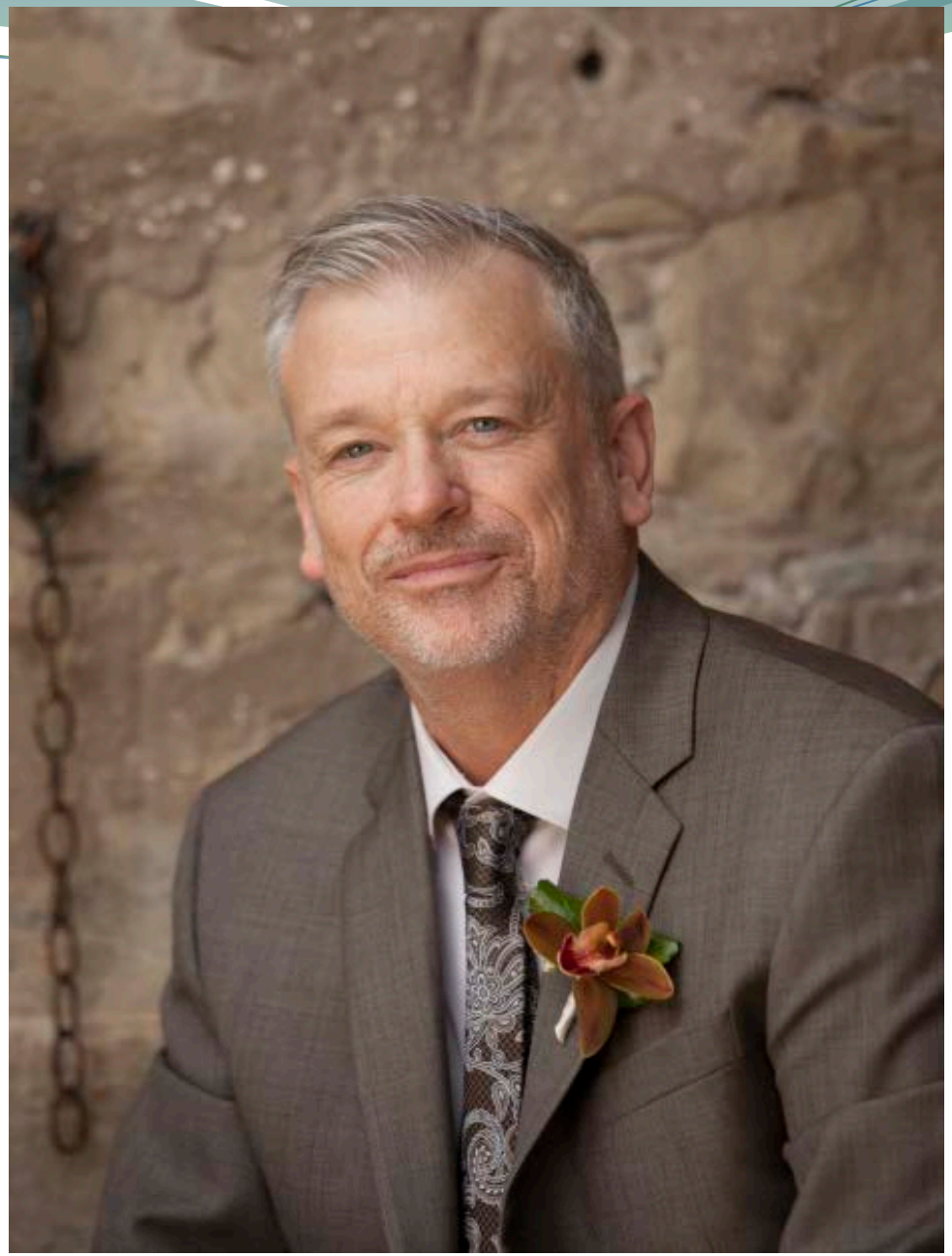



*Harry Reinders[1]*
*John Parish[2] , Chris Cummings,[2]*
*W J Snodgrass[3] , K Sivakumaran[3]*

*R & M Construction[1]*
*Matrix Solutions[2]*
*City of Toronto[3]*

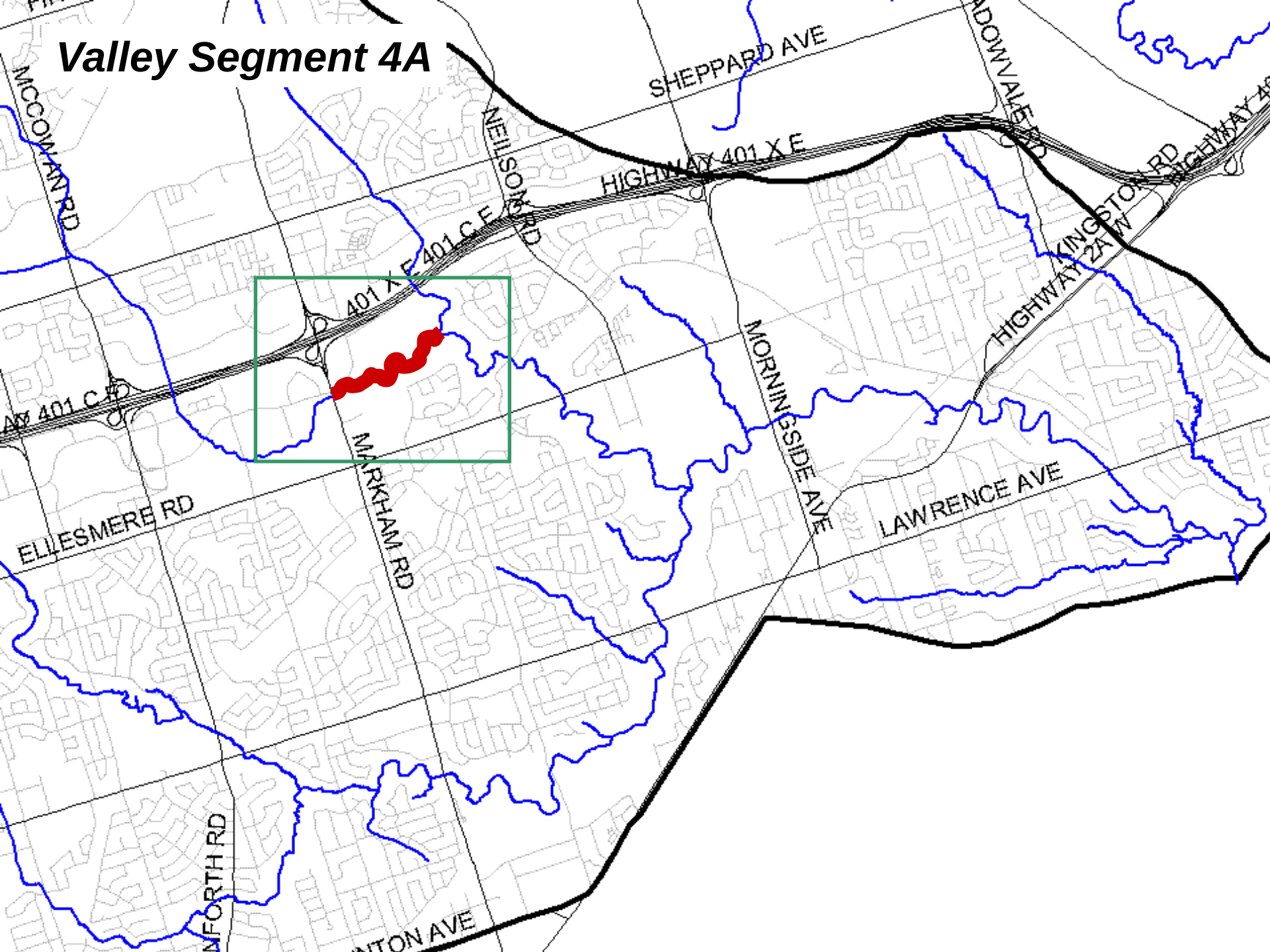
# Please join us in a reflective moment

**JP was the inspiration for this project**

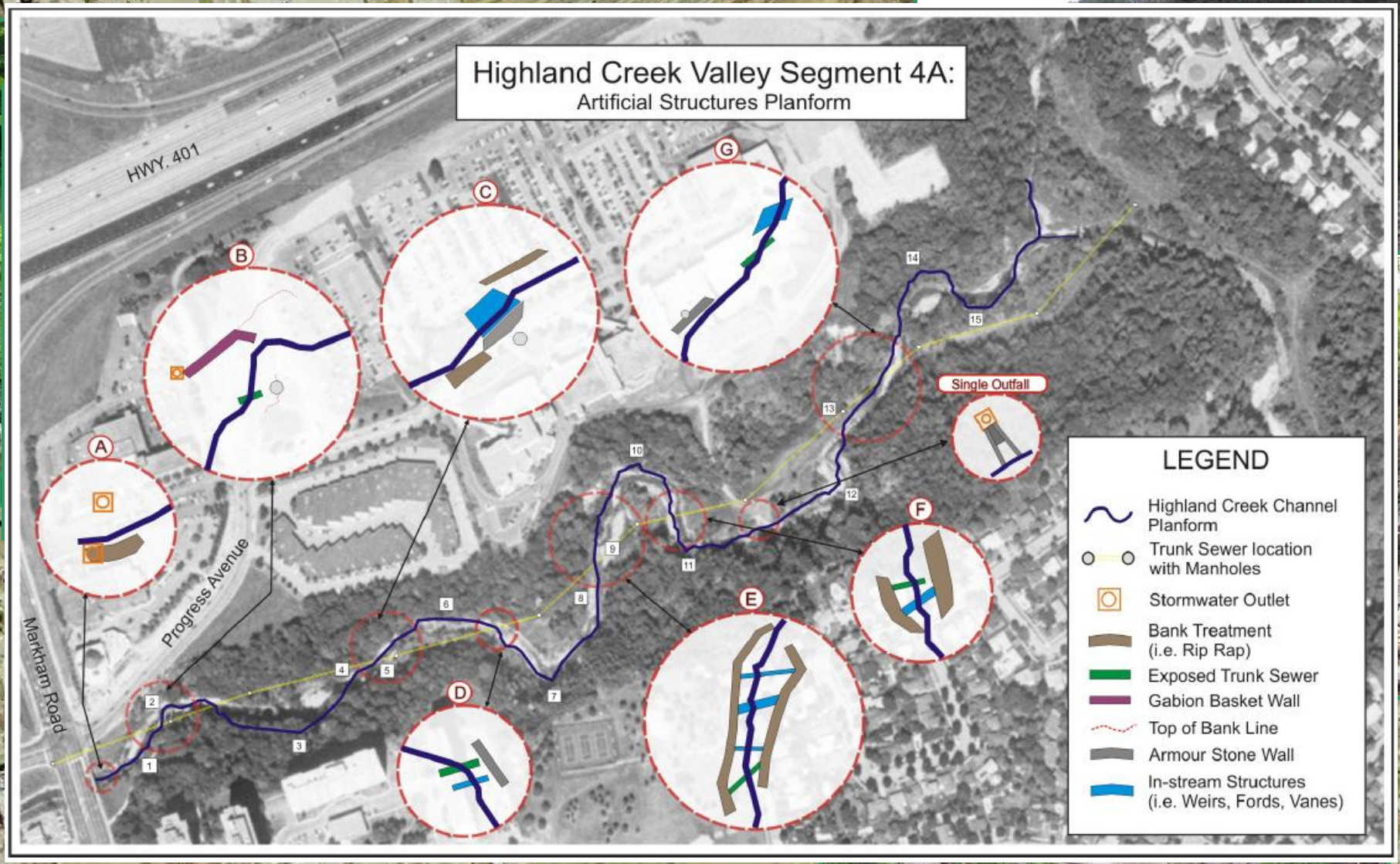



March, 2006
Sanitary Sewer Exposures


Valley Wall Erosion
May, 2006

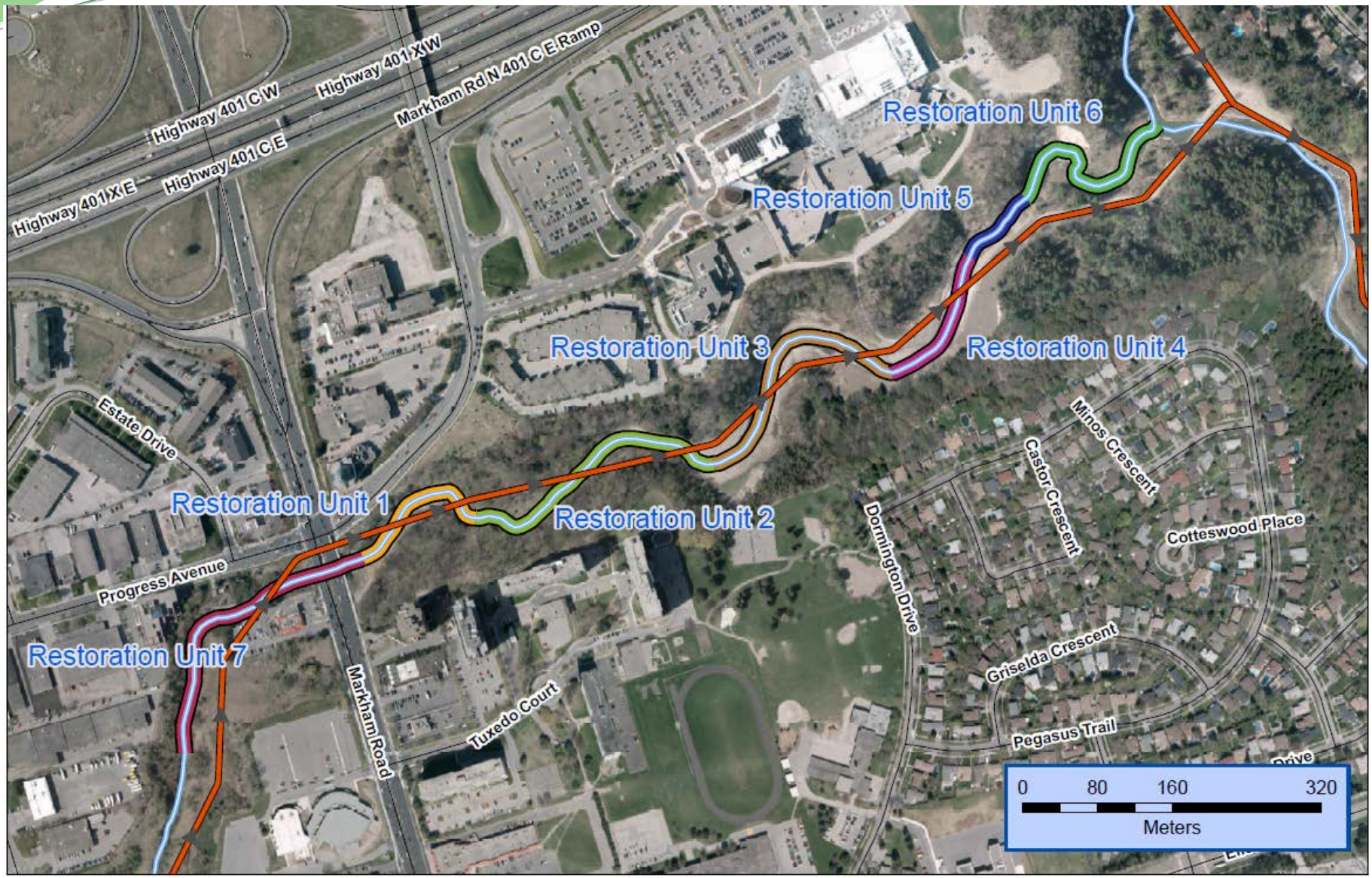

Valley Segment 4A
SHEPPARD AVE
MCCOWAN RD
NEILSON RD
HIGHWAY 401 X E
401 C F
401 X F
401 C F
MARKHAM RD
MORNINGSIDE AVE
HIGHWAY 2A W
LAWRENCE AVE
ELLESMERE RD

# Valley Segment 4A




## Segment 4A – Characterization Report

# East Highland Creek – Valley Segment 4/4A




Sanitary Trunk Sewer and stream crossings shown

# East Highland Creek – Valley Segment 4/4A

## Restoration Unit 7




# East Highland Creek – Valley Segment 4/4A
# Restoration Units 3 & 4

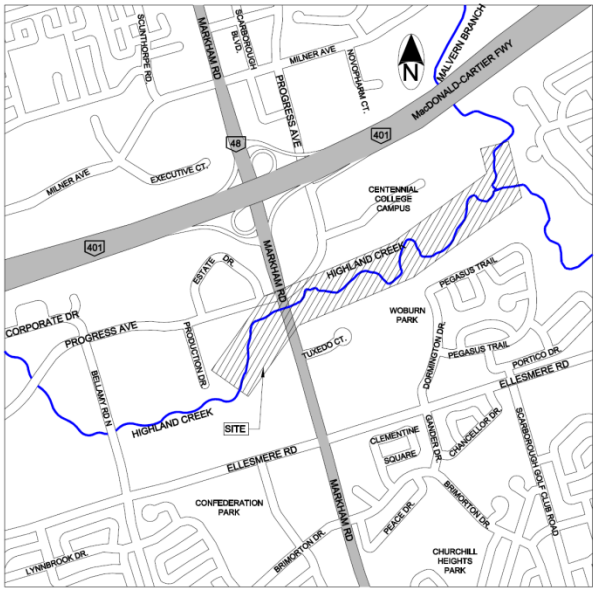



ENGINEERING SERVICES
WORKS FACILITIES and STRUCTURES SECTION
TECHNICAL SERVICES DIVISION

# HIGHLAND CREEK VALLEY

## REHABILITATION OF EROSION CONTROL STRUCTURES FOR MARKHAM BRANCH CREEK SEGMENT (PROGRESS AT MARKHAM ROAD)
## CONTRACT No. 1079-2008-59

| DWG. NO. | DESCRIPTION | FROM | TO |
|---|---|---|---|
| 1 | EXISTING PLAN | | |
| 2 | PROPOSED PLAN | | |
| 3 | PHASE 1A & 1B – CONSTRUCTION PHASING / SEDIMENT EROSION PLAN | STATION 0+580 | STATION 1+080 |
| 4 | PHASE 2 – CONSTRUCTION PHASING / SEDIMENT EROSION PLAN | STATION 1+080 | STATION 1+600 |
| 5 | PHASE 3 – CONSTRUCTION PHASING / SEDIMENT EROSION PLAN | STATION 1+600 | STATION 2+250 |
| 6 | EXISTING REMOVALS – PHASE 1A & 1B | STATION 0+580 | STATION 1+080 |
| 7 | EXISTING REMOVALS – PHASE 2 | STATION 1+080 | STATION 1+500 |
| 8 | EXISTING REMOVALS – PHASE 2 & 3 | STATION 1+500 | STATION 1+960 |
| 9 | EXISTING REMOVALS – PHASE 3 & MALVERN | STATION 1+960 | STATION 2+250 |
| 10 | PROPOSED PLAN AND PROFILE – PHASE 1 | STATION 0+580 | STATION 0+760 |
| 11 | PROPOSED PLAN AND PROFILE – PHASE 1 | STATION 0+760 | STATION 0+940 |
| 12 | PROPOSED PLAN AND PROFILE – PHASE 1 & 2 | STATION 0+940 | STATION 1+120 |
| 13 | PROPOSED PLAN AND PROFILE – PHASE 2 | STATION 1+120 | STATION 1+300 |
| 14 | PROPOSED PLAN AND PROFILE – PHASE 2 | STATION 1+300 | STATION 1+480 |
| 15 | PROPOSED PLAN AND PROFILE – PHASE 2 & 3 | STATION 1+480 | STATION 1+660 |
| 16 | PROPOSED PLAN AND PROFILE – PHASE 3 | STATION 1+660 | STATION 1+840 |
| 17 | PROPOSED PLAN AND PROFILE – PHASE 3 | STATION 1+840 | STATION 2+020 |
| 18 | PROPOSED PLAN AND PROFILE – PHASE 3 | STATION 2+020 | STATION 2+200 |
| 19 | PROPOSED PLAN AND PROFILE – PHASE 3 | STATION 2+200 | STATION 2+380 |
| 20 | PROPOSED PLAN AND PROFILE – PHASE 3 (MALVERN) | STATION 0+040 | STATION 0+240 |
| 21 | PROPOSED PLANTING PLAN – PHASE 1A & 1B | STATION 0+580 | STATION 1+080 |
| 22 | PROPOSED PLANTING PLAN – PHASE 2 | STATION 1+080 | STATION 1+500 |
| 23 | PROPOSED PLANTING PLAN – PHASE 2 & 3 | STATION 1+500 | STATION 1+960 |
| 24 | PROPOSED PLANTING PLAN – PHASE 3 & MALVERN | STATION 1+960 | STATION 2+250 |
| 25 | CREEK DETAILS | | |
| 26 | CREEK DETAILS | | |
| 27 | CREEK DETAILS | | |
| 28 | CREEK DETAILS | | |
| 29 | SECTIONS – PHASE 1 | STATION 0+580 | STATION 0+820 |
| 30 | SECTIONS – PHASE 1 | STATION 0+840 | STATION 1+080 |
| 31 | SECTIONS – PHASE 2 | STATION 1+100 | STATION 1+360 |
| 32 | SECTIONS – PHASE 2 | STATION 1+380 | STATION 1+600 |
| 33 | SECTIONS – PHASE 3 | STATION 1+620 | STATION 1+860 |
| 34 | SECTIONS – PHASE 3 | STATION 1+880 | STATION 2+100 |
| 35 | SECTIONS – PHASE 3 | STATION 2+120 | STATION 2+320 |
| 36 | SECTIONS – MALVERN | STATION 0+020 | STATION 0+240 |



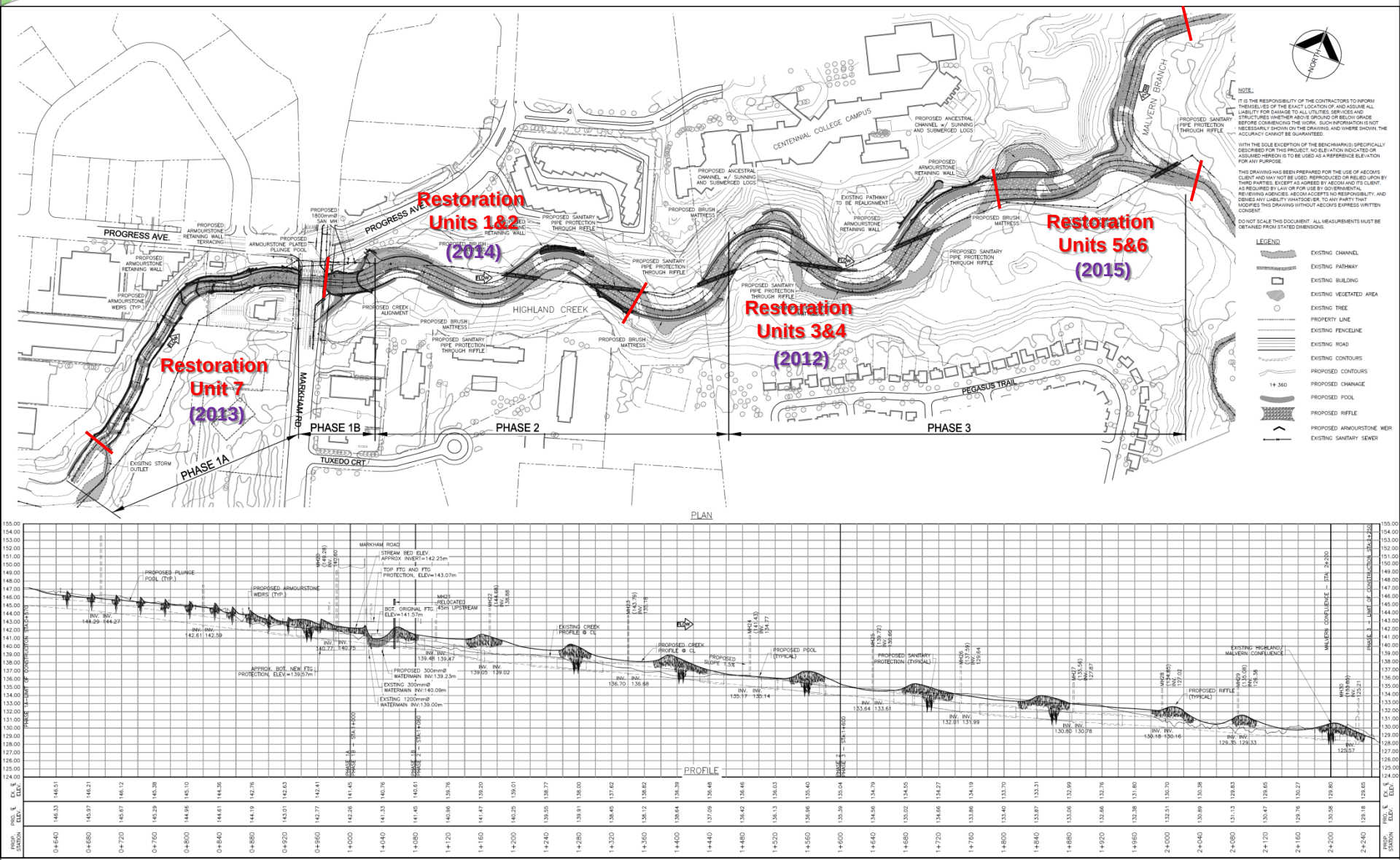

AECOM PARISH geomorphic

NOVEMBER 10, 2009

CITY DRAWING No.
COVER

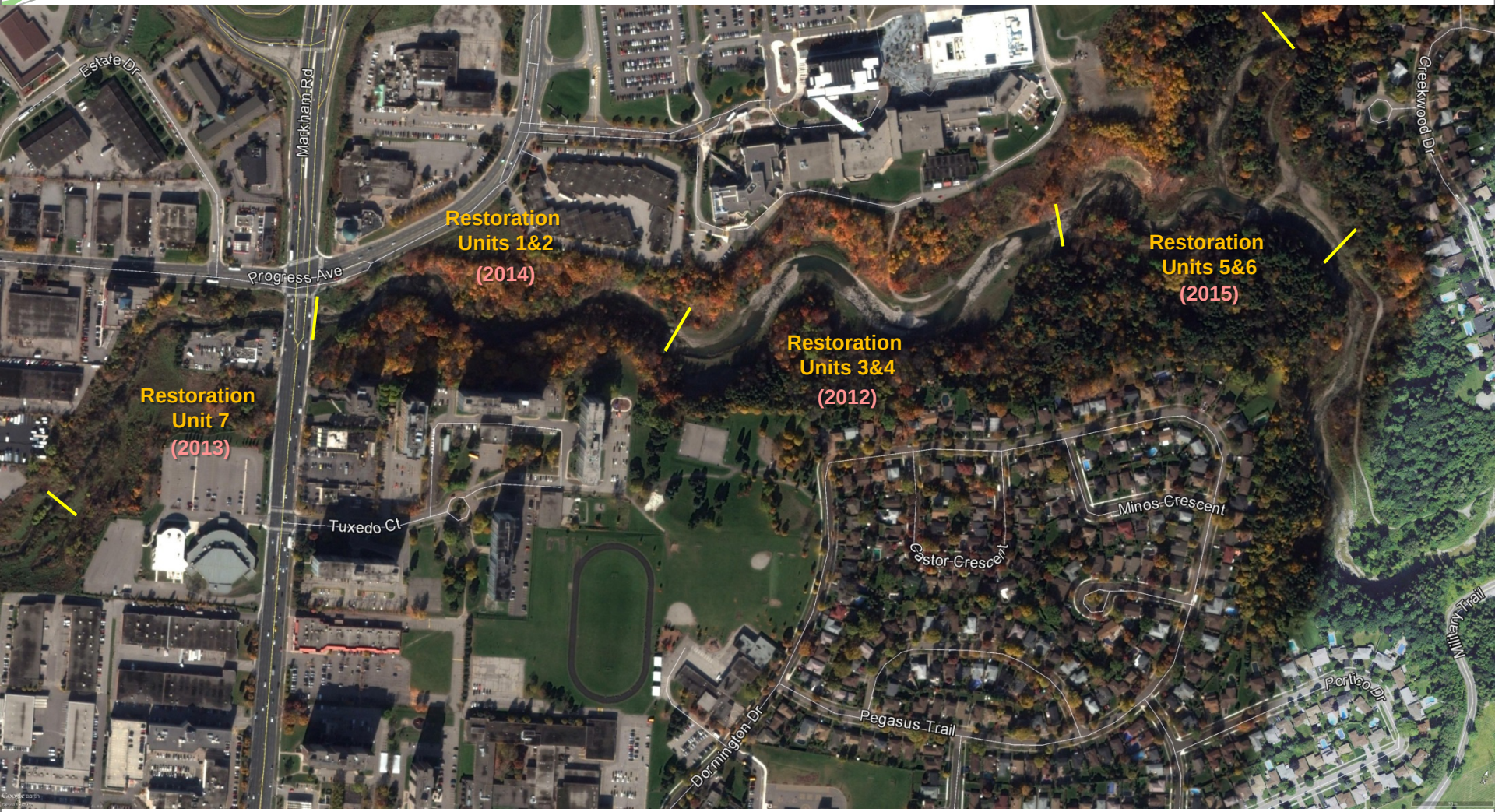
# Design Summary

- Approximately 1,650m total channel length
- 8 Sanitary Trunk Sewer Crossings, multiple stormwater outfalls & watermains, one bridge (Markham Road)
- Approximate 19m drop from Upstream tie-in to Downstream tie-in (1.15%)
- Calculated Design Discharge (Bankfull) = 32$m^3$/sec
- Based on principles of Natural Channel Design with Engineered features for infrastructure protection

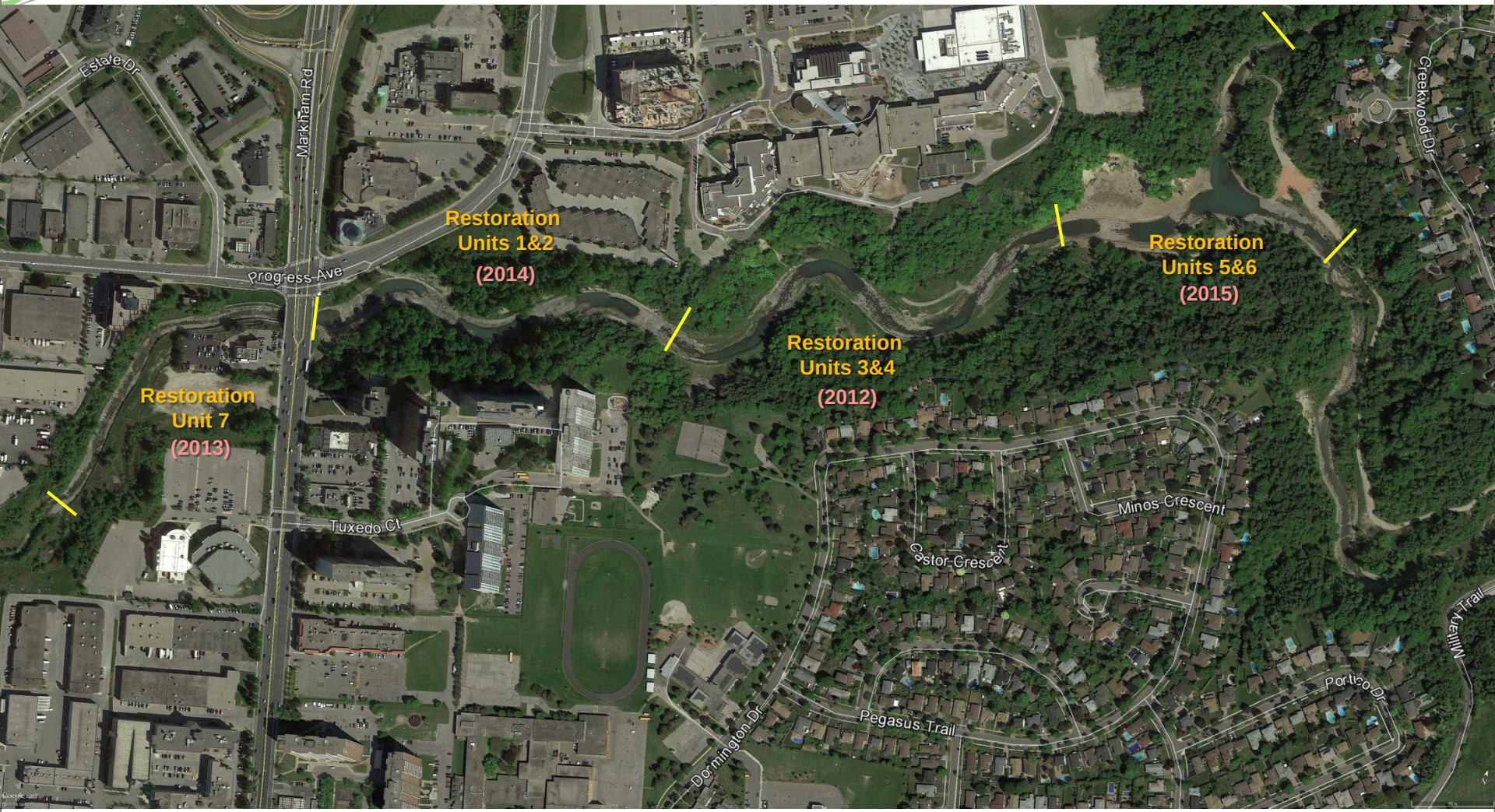

Restoration Units 1&2 (2014)
Restoration Unit 7 (2013)
Restoration Units 3&4 (2012)
Restoration Units 5&6 (2015)
PROGRESS AVE.
MARKHAM RD
HIGHLAND CREEK
CENTENNIAL COLLEGE CAMPUS
MALVERN BRANCH
PEGASUS TRAIL
TUXEDO CRT.
PHASE 1A
PHASE 1B
PHASE 2
PHASE 3
EXISTING STORM OUTLET
PROPOSED ARMOURSTONE RETAINING WALL TERRACING
PROPOSED ARMOURSTONE PLATED PLUNGE POOL
PROPOSED ARMOURSTONE WEIRS (TYP.)
PROPOSED ARMOURSTONE RETAINING WALL
PROPOSED SANITARY PIPE PROTECTION THROUGH RIFFLE
PROPOSED BRUSH MATTRESS
PROPOSED CREEK ALIGNMENT
PROPOSED ANCESTRAL CHANNEL w/ SUNNING AND SUBMERGED LOGS
EXISTING PATHWAY TO BE REALIGNMENT
NORTH
NOTE:
IT IS THE RESPONSIBILITY OF THE CONTRACTORS TO INFORM THEMSELVES OF THE EXACT LOCATION OF, AND ASSUME ALL LIABILITY FOR DAMAGE TO ALL UTILITIES, SERVICES AND STRUCTURES WHETHER ABOVE GROUND OR BELOW GRADE BEFORE COMMENCING THE WORK. SUCH INFORMATION IS NOT NECESSARILY SHOWN ON THE DRAWING, AND WHERE SHOWN, THE ACCURACY CANNOT BE GUARANTEED.
WITH THE SOLE EXCEPTION OF THE BENCHMARK(S) SPECIFICALLY DESCRIBED FOR THIS PROJECT, NO ELEVATION INDICATED OR ASSUMED HEREON IS IT TO BE USED AS A REFERENCE ELEVATION FOR ANY PURPOSE.
THIS DRAWING HAS BEEN PREPARED FOR THE USE OF AECOM'S CLIENT AND MAY NOT BE USED, REPRODUCED OR RELIED UPON BY THIRD PARTIES, EXCEPT AS AGREED BY AECOM AND ITS CLIENT, AS REQUIRED BY LAW OR FOR USE BY GOVERNMENTAL REVIEWING AGENCIES. AECOM ACCEPTS NO RESPONSIBILITY, AND DENIES ANY LIABILITY WHATSOEVER, TO ANY PARTY THAT MODIFIES THIS DRAWING WITHOUT AECOM'S EXPRESS WRITTEN CONSENT.
DO NOT SCALE THIS DOCUMENT. ALL MEASUREMENTS MUST BE OBTAINED FROM STATED DIMENSIONS.
LEGEND
EXISTING CHANNEL
EXISTING PATHWAY
EXISTING BUILDING
EXISTING VEGETATED AREA
EXISTING TREE
PROPERTY LINE
EXISTING FENCELINE
EXISTING ROAD
EXISTING CONTOURS
PROPOSED CONTOURS
PROPOSED CHAINAGE
PROPOSED POOL
PROPOSED RIFFLE
PROPOSED ARMOURSTONE WEIR
EXISTING SANITARY SEWER

PLAN


PROFILE
MARKHAM ROAD
PROPOSED PLUNGE POOL (TYP.)
PROPOSED ARMOURSTONE WEIRS (TYP.)
STREAM BED ELEV. APPROX INVERT=142.25m
TOP FTG AND FTG PROTECTION, ELEV=143.07m
BOT. ORIGINAL FTG. ELEV=141.57m
MH02 RELOCATED 45m UPSTREAM
APPROX. BOT. NEW FTG PROTECTION, ELEV=139.57m
PROPOSED 300mmØ WATERMAIN INV:139.23m
EXISTING 300mmØ WATERMAIN INV:140.09m
EXISTING 1200mmØ WATERMAIN INV:139.00m
EXISTING CREEK PROFILE @ CL
PROPOSED CREEK PROFILE @ CL
PROPOSED SLOPE 1.5%
PROPOSED POOL (TYPICAL)
PROPOSED SANITARY PROTECTION (TYPICAL)
PROPOSED RIFFLE (TYPICAL)
EXISTING HIGHLAND / MALVERN CONFLUENCE
MALVERN CONFLUENCE
PHASE 1A - LIMIT OF CONSTRUCTION STA 0+970
PHASE 1B - LIMIT OF CONSTRUCTION STA 1+000
PHASE 2 - LIMIT OF CONSTRUCTION STA 1+600
PHASE 3 - LIMIT OF CONSTRUCTION STA 2+250
EX. & PROP. ELEV.
PROP. STATION



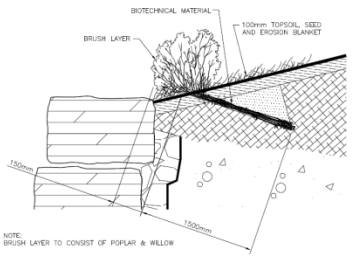

# October, 2012


Estate Dr
Markham Rd
Progress Ave
Restoration
Units 1&2
(2014)
Restoration
Units 5&6
(2015)
Creekwood Dr
Restoration
Unit 7
(2013)
Restoration
Units 3&4
(2012)
Tuxedo Ct
Minos Crescent
Castor Crescent
Millbank Trail
Portiso Dr
Pegasus Trail
Dormington Dr

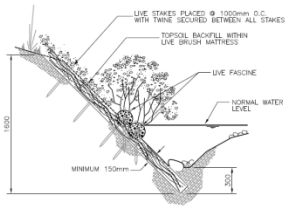
**May, 2015**

# Design Approach

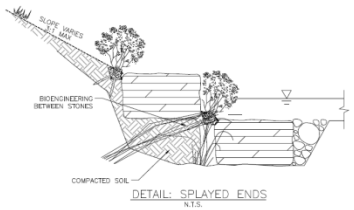
- Existing channel was highly dynamic and in a constant state of adjustment
- Channel was designed to accommodate ‘bankfull’ flows
  - Resulted in a significant increase in channel width (~12m increased to ~26m)
  - Connectivity to floodplain
- Infrastructure in the valley was lowered, shifted or concrete encased to protect from future adjustments
- Substrate size was increased significantly over existing materials



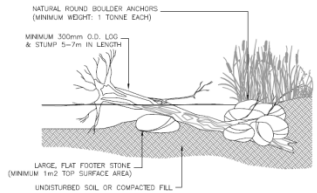

DETAIL: BRUSH LAYER
SCALE 1:25



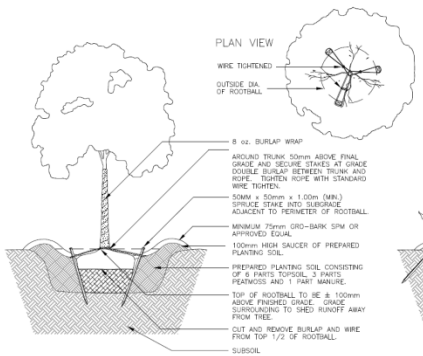

DETAIL: BRUSH MATTRESS
SCALE 1:25



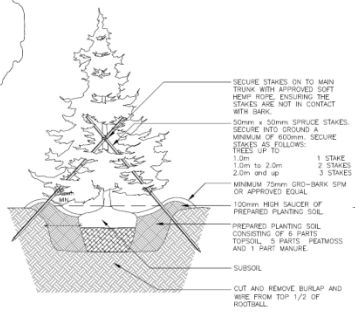

DETAIL: SPLAYED ENDS
N.T.S.



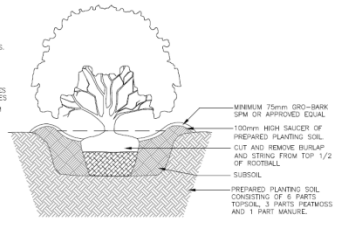

SUNNING LOG DETAIL
SCALE 1:50



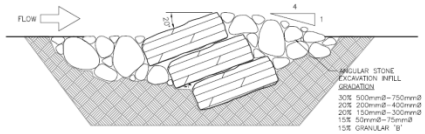

DETAIL: TYPICAL DECIDUOUS TREE
SCALE 1:100



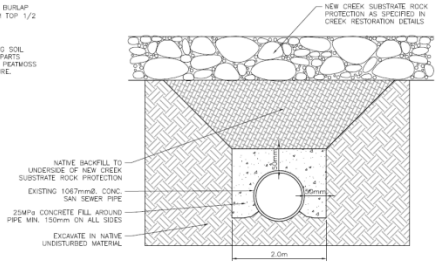

DETAIL: TYPICAL CONIFEROUS TREE
SCALE 1:100




DETAIL: TYPICAL SHRUB
SCALE 1:100

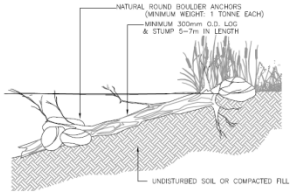



TYPICAL SECTION FOR WEIR
1 : 50

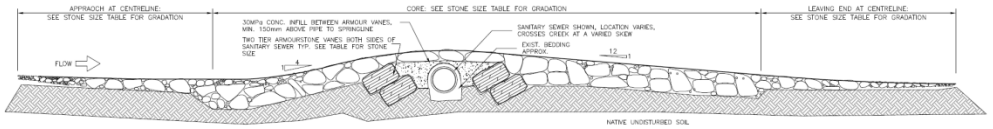



SANITARY DETAIL (APPLIES BELOW CREEK ONLY)
SCALE 1:50

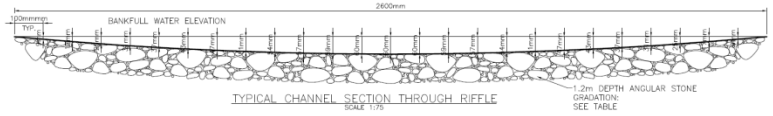
DETAIL APPLIES UNLESS OTHERWISE SHOWN AT RIFFLE/SANITARY CROSSING



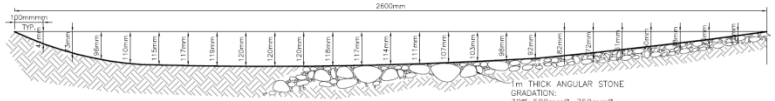

SUBMERGED LOG DETAIL
SCALE 1:50




PROFILE: SANITARY PIPE PROTECTION THROUGH CREEK
SCALE 1:100




TYPICAL CHANNEL SECTION THROUGH RIFFLE
SCALE 1:75




TYPICAL CHANNEL SECTION THROUGH POOL
SCALE 1:75

RIFFLE STONE SIZE GRADATION TABLE

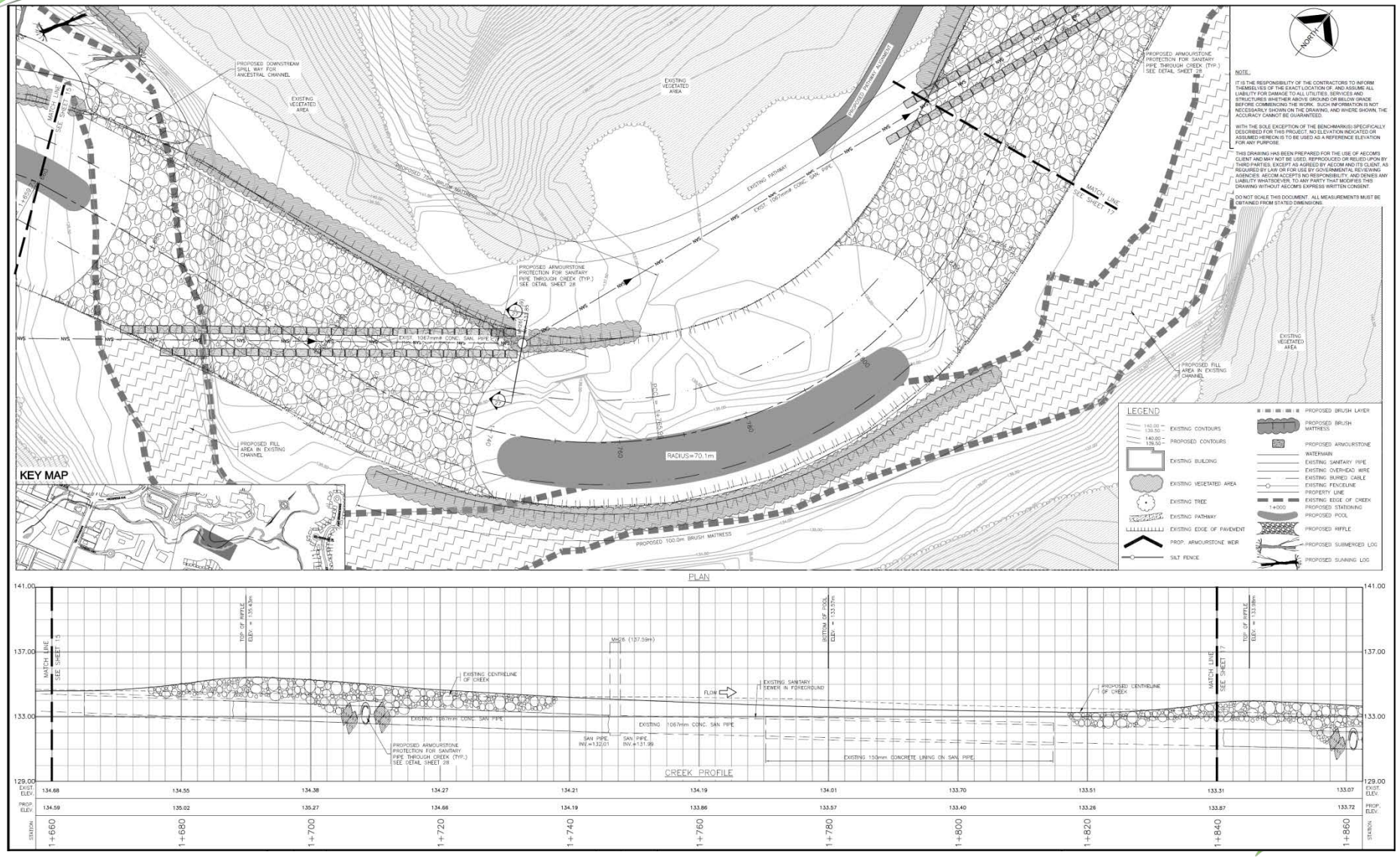
| RIFFLE LOCATION | APPROACH LENGTH AND GRADATION | LEAVING END LENGTH AND GRADATION | CORE LENGTH AND GRADATION | ARMOURSTONE SIZE AND WEIGHT/STONE |
|---|---|---|---|---|
| STATION 0+960 | 20m G1 | 20m G1 | 40m C1 | 1.5W x 2.75L x 0.8H 6 TONNE |
| STATION 1+160 | 15m G1 | 15m G1 | 40m C1 | 1.5W x 2.75L x 0.8H 6 TONNE |
| STATION 1+280 | 15m G1 | 15m G1 | 30m C1 | 1.5W x 2.75L x 0.8H 6 TONNE |
| STATION 1+410 | 15m G1 | 20m G1 | 40m C1 | 1.5W x 2.75L x 0.8H 6 TONNE |
| STATION 1+560 | 15m G1 | 15m G1 | 30m C1 | 1.5W x 2.75L x 0.8H 6 TONNE |
| STATION 1+700 | 15m G2 | 20m G2 | 40m C2 | 1.2W x 2.0L x 0.8H 4 TONNE |
| STATION 1+860 | 15m G2 | 20m G2 | 40m C2 | 1.2W x 2.0L x 0.8H 4 TONNE |
| STATION 2+010 | 15m G2 | 20m G2 | 30m C3 | N/A |
| STATION 2+090 | 15m G2 | 15m G2 | 20m C3 | N/A |
| STATION 2+090 | 15m G2 | 20m G2 | 25m C2 | N/A |

GRADATION (UNITS IN: mm DIAMETER)

| C1 | C2 | C3 | G1 | G2 |
|---|---|---|---|---|
| 40%, 800 TO 1200 | 40%, 600 TO 800 | 50%, 400 TO 600 | 50%, 400 TO 600 | 50%, 200 TO 400 |
| 20% 400 TO 600 | 30% 300 TO 400 | 30% 200 TO 300 | 30% 200 TO 300 | 30% 100 TO 150 |
| 20% 200 TO 300 | 20% 150 TO 200 | 20% 50 TO 100 | 20% 50 TO 100 | 20% 50 TO 75 |
| 20% 100 TO 150 | 10% 50 TO 100 | | | |

# Design Approach

- Channel bed was designed and constructed using two different bed forms:
  - Bed level weir structures for channel upstream of Markham Road
  - A riffle - pool bedform downstream of Markham Road
- Design emphasized the placement of riffles over sanitary sewer crossings for long-term protection
- Banks were a variety of treatments ranging from:
  - Vegetated Soils - Brush Mattress
  - Vegetated Rip-rap - Engineered Armourstone Walls


PROPOSED DOWNSTREAM SPILL WAY FOR ANCESTRAL CHANNEL
EXISTING VEGETATED AREA
EXISTING PATHWAY
EXIST. 1067mm# CONC. SAN. PIPE
PROPOSED ARMOURSTONE PROTECTION FOR SANITARY PIPE THROUGH CREEK (TYP.) SEE DETAIL SHEET 28
PROPOSED 100.0m BRUSH MATTRESS
PROPOSED FILL AREA IN EXISTING CHANNEL
RADIUS=70.1m
MATCH LINE SEE SHEET 17
KEY MAP
NORTH
NOTE:
IT IS THE RESPONSIBILITY OF THE CONTRACTORS TO INFORM THEMSELVES OF THE EXACT LOCATION OF, AND ASSUME ALL LIABILITY FOR DAMAGE TO ALL UTILITIES, SERVICES AND STRUCTURES WHETHER ABOVE GROUND OR BELOW GRADE BEFORE COMMENCING THE WORK. SUCH INFORMATION IS NOT NECESSARILY SHOWN ON THE DRAWING, AND WHERE SHOWN, THE ACCURACY CANNOT BE GUARANTEED.
WITH THE SOLE EXCEPTION OF THE BENCHMARK(S) SPECIFICALLY DESCRIBED FOR THIS PROJECT, NO ELEVATION INDICATED OR ASSUMED HEREON IS TO BE USED AS A REFERENCE ELEVATION FOR ANY PURPOSE
THIS DRAWING HAS BEEN PREPARED FOR THE USE OF AECOM'S CLIENT AND MAY NOT BE USED, REPRODUCED OR RELIED UPON BY THIRD PARTIES, EXCEPT AS AGREED BY AECOM AND ITS CLIENT, AS REQUIRED BY LAW OR FOR USE BY GOVERNMENTAL REVIEWING AGENCIES. AECOM ACCEPTS NO RESPONSIBILITY, AND DENIES ANY LIABILITY WHATSOEVER, TO ANY PARTY THAT MODIFIES THIS DRAWING WITHOUT AECOM'S EXPRESS WRITTEN CONSENT
DO NOT SCALE THIS DOCUMENT. ALL MEASUREMENTS MUST BE OBTAINED FROM STATED DIMENSIONS.
LEGEND
EXISTING CONTOURS
PROPOSED CONTOURS
EXISTING BUILDING
EXISTING VEGETATED AREA
EXISTING TREE
EXISTING PATHWAY
EXISTING EDGE OF PAVEMENT
PROP. ARMOURSTONE WEIR
SILT FENCE
PROPOSED BRUSH LAYER
PROPOSED BRUSH MATTRESS
PROPOSED ARMOURSTONE
WATERMAIN
EXISTING SANITARY PIPE
EXISTING OVERHEAD WIRE
EXISTING BURIED CABLE
EXISTING FENCELINE
PROPERTY LINE
EXISTING EDGE OF CREEK
PROPOSED STATIONING
PROPOSED POOL
PROPOSED RIFFLE
PROPOSED SUBMERGED LOG
PROPOSED SUNNING LOG
PLAN
CREEK PROFILE
TOP OF RIFFLE ELEV. = 135.43m
MH26 (137.59m)
BOTTOM OF POOL ELEV. = 133.57m
TOP OF RIFFLE ELEV. = 133.38m
EXISTING CENTRELINE OF CREEK
EXISTING 1067mm CONC. SAN PIPE
PROPOSED ARMOURSTONE PROTECTION FOR SANITARY PIPE THROUGH CREEK (TYP.) SEE DETAIL SHEET 28
SAN PIPE INV.=132.01
SAN PIPE INV.=131.99
FLOW
EXISTING SANITARY SEWER IN FOREGROUND
EXISTING 150mm CONCRETE LINING ON SAN. PIPE
PROPOSED CENTRELINE OF CREEK
141.00
137.00
133.00
129.00
EXIST. ELEV.
PROP. ELEV.
STATION
134.68 134.55 134.38 134.27 134.21 134.19 134.01 133.70 133.51 133.31 133.07
134.59 135.02 135.27 134.66 134.19 133.86 133.57 133.40 133.26 133.67 133.72
1+660 1+680 1+700 1+720 1+740 1+760 1+780 1+800 1+820 1+840 1+860

# Additional Design Features

- Creation of three off-channel wetland areas (former stream bends)
- Disconnection of active channel from valley slope contacts has allowed for the natural re-stabilization of the scarps and stabilization of habitat
- Embedded Woody Roughness in Floodplain
- Valley Restoration Planting Plan
- Access routes for sewer maintenance

# Channel Character

- The wider channel design resulted in a larger channel footprint, requiring a net loss of valley floor forest cover
- The channel is developing a ‘nested’ low flow channel within the greater ‘bankfull’ channel
- Bar features store sediment, likely to be partially flushed during significant storm events

# Construction Phase 2012-2015

MUST BE WORN

Head Protection

Foot Protection

BATTLEFIELD CAT Rental

1-800-RENT-CAT

## Highland Creek Channel Restoration Project
## Valley Segment 4A

A restoration project is currently underway in the Highland Creek Valley to address several urgent problems that were identified in a detailed Class Environmental Assessment (EA) completed by the City of Toronto in 2006. Several sanitary sewer crossings have been exposed and erosion of the valley slopes is threatening property and structures. This restoration project will protect infrastructure and the environment by creating a dynamically stable, natural channel system.

To achieve a stable creek in the Highland Valley, the channel will be enlarged to better handle stormwater flows and will be moved away from the eroding valley walls. These works will provide long term protection to both the sewer and the natural environment.


**For further enquiries about this project, please call 311 or visit our website at www.toronto.ca/improvements**

Toronto and Region Conservation for The Living City

TORONTO

To implement these works, a number of trees must be removed. The City of Toronto will compensate for the loss of these trees through vegetation restoration plans within the Highland Creek Valley and in other parts of the City, in accordance with the Toronto and Region Conservation Authority's Greening Strategy for the Highland Creek Watershed, and as required by the City's Ravine & Natural Feature Protection bylaw.

This project is working under approvals issued by Toronto and Region Conservation Authority, Fisheries and Oceans Canada, and the Ontario Ministry of Natural Resources. Through routine inspections by these agencies and on-site inspectors during construction, the protection of the valley's environmental features, and the infrastructure within the valley will be ensured.

Starting in January 2012, it will take about three months to construct Restoration Units 3 and 4.

# Construction Phasing

- The construction project was built in four successive winter construction periods (2012-2015), which:
  - Accommodated City budget constraints
  - Permitted monitoring, learning and design adaptation
  - Allowed for the use of dormant vegetation during construction

# Construction Challenges / Design Adaptation

- Infrastructure (i.e. sewers) did not always match original as-built plans
  - Required design revisions to address discrepancies.
- Weather, flow management and site access challenges
- Due to construction phasing and design modifications, two banks experienced scour after 2012 construction requiring repair of banks

# Construction Challenges / Design Adaptation

- Winnowing of fines from riffles after 2012 construction period created gravel bar formations which affected channel thalweg alignment

- Design modifications were implemented which included:
  - Use of a denser rock material in riffles
  - Rib structures in select riffles
  - Modification of fines in select riffles

# Restoration Units 1&2


# Restoration Units 3&4

February, 2012

# Restoration Units 3&4


February, 2012

# Restoration Units 3&4

February, 2012

# Restoration Units 3&4

February, 2012


Restoration Units 3&4
April, 2018
Matrix Solutions Inc.

# Restoration Unit 7

February, 2013


Restoration Unit 7
March, 2013

# Restoration Units 1&2

# Restoration Units 1&2

# Restoration Units 1&2

# Restoration Units 1&2

# Restoration Units 1&2

# Restoration Units 5&6

# Restoration Units 5&6

# Restoration Units 5&6

# Questions?