Appendix A

Background Information

HAGER-RAMBO FLOOD CONTROL WORKS
OPERATIONS AND MAINTENANCE MANUAL

CITY OF BURLINGTON
HALTON REGION CONSERVATION AUTHORITY

December 1997

Philips Planning and Engineering Limited
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APPENDICES

HAGER-RAMBO FLOOD CONTROL WORKS

Operations and Maintenance Manual
City of Burlington
Halton Region Conservation Authority

1. Introduction

The Hager-Rambo flood control system has been constructed as part of a multi-proponent initiative involving the City of Burlington, Halton Region Conservation Authority and Ministry of Transportation. The first works towards this system, the East Rambo Creek channelization were constructed in 1986/87. Two key components, as of the time of writing, have not yet been constructed, namely the East Rambo Flood Control facility and the Highway 407 diversion system. All other components are in-place and described in detail in this document.

The intent of this manual is to provide City staff, who now have the responsibility of operations and maintenance of the flood control system, with a reference tool for the work's design principles and features. The manual describes the operation and maintenance considerations associated with each flood control element.

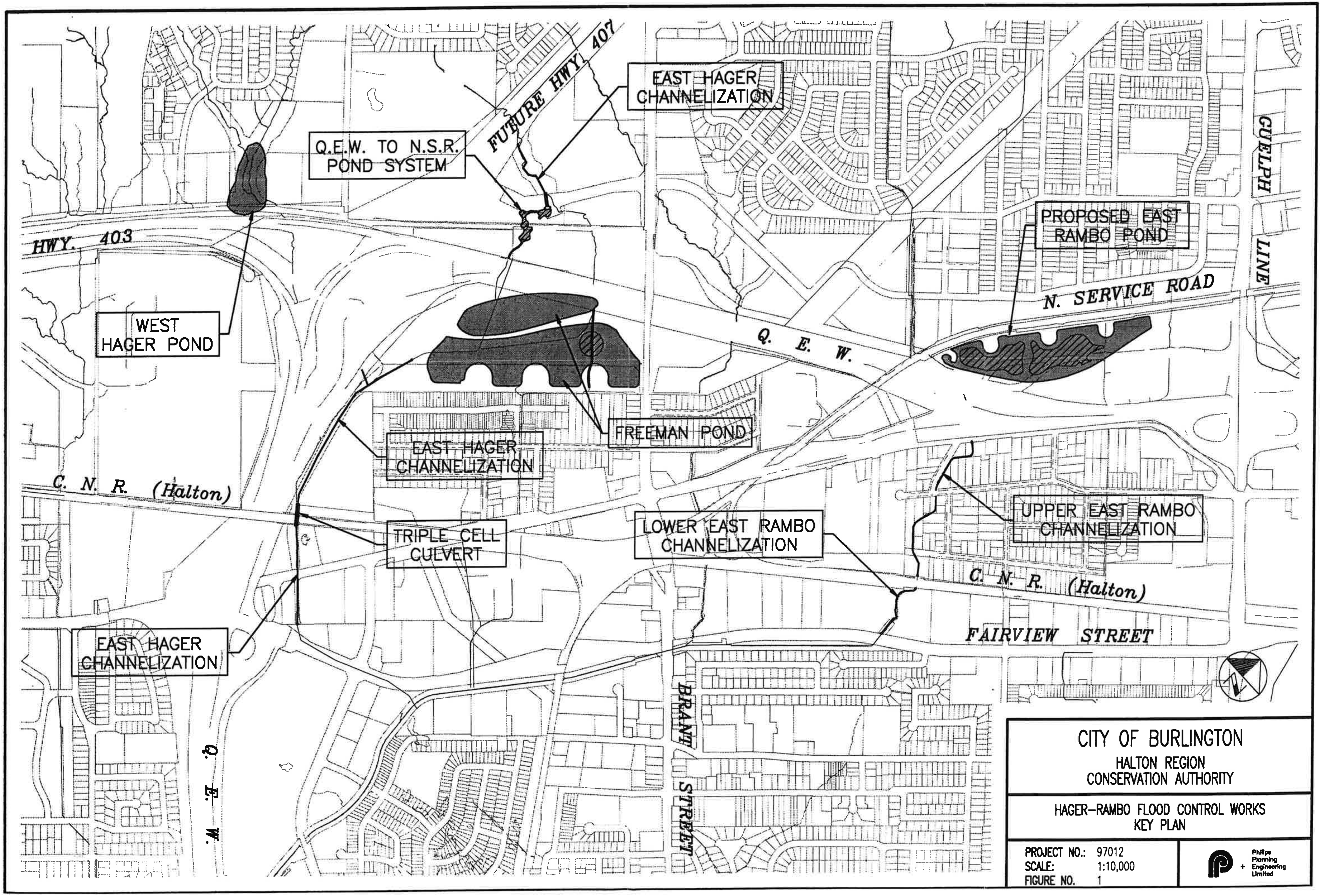
The works include:

1) East Rambo Creek Channelization (Queensway Drive to CNR – Oakville)
2) Lower East Rambo Creek Channelization (CNR – Oakville to Fairview Street)
3) East Hager Creek Channelization (CNR to Fairview Street)
4) East Hager Creek (CNR Crossing)
5) East Hager Creek Channelization (CNR to Freeman Pond)
6) Freeman Detention Facility
7) East Hager Creek Realignment and Pond System (Q.E.W. to North Service Road)
8) East Hager Creek Reconstruction (North Service Road to Future 407 (West))
9) West Hager Detention Facility

Figure 1 depicts the location of the respective works within the Hager-Rambo system in the City of Burlington.

Aerial photographs were taken in 1998, to supplement the ground level photographs taken in 1997 (ref. Appendix D)

Appendix B provides a standard inspection form along with Operation and Maintenance Schedule. As has been generally recommended in this manual, the works should be inspected either once or twice a year. This inspection can take the form of a quick "walk through", examining the works for "obvious" problems. Every five years a more detailed inspection should be undertaken whereby each component element of the works is inspected to ensure its safe and continued operation. A detailed photographic log should be taken at 5 year intervals and added to this manual.



CITY OF BURLINGTON

HALTON REGION
CONSERVATION AUTHORITY

HAGER-RAMBO FLOOD CONTROL WORKS
KEY PLAN

PROJECT NO.:	97012
SCALE:	1:10,000
FIGURE NO.	1

Philips Planning + Engineering Limited

2. East Rambo Creek Channelization (Queensway Drive to CNR-Oakville)

2.1 Project Description and Year of Construction

East Rambo Creek Channelization
- Queensway Drive to CNR - Oakville

Constructed from September 1986 to June 1987.

This project involved the realignment and lining of the East Rambo Creek. A 650 metre long concrete lined invert with two courses of gabion baskets approximately 3.2 m +/- top width, a precast culvert replacement at Glenwood School Drive, and the lowering and re-lining of the CNR-Oakville culvert crossing, were all components of this project undertaking.

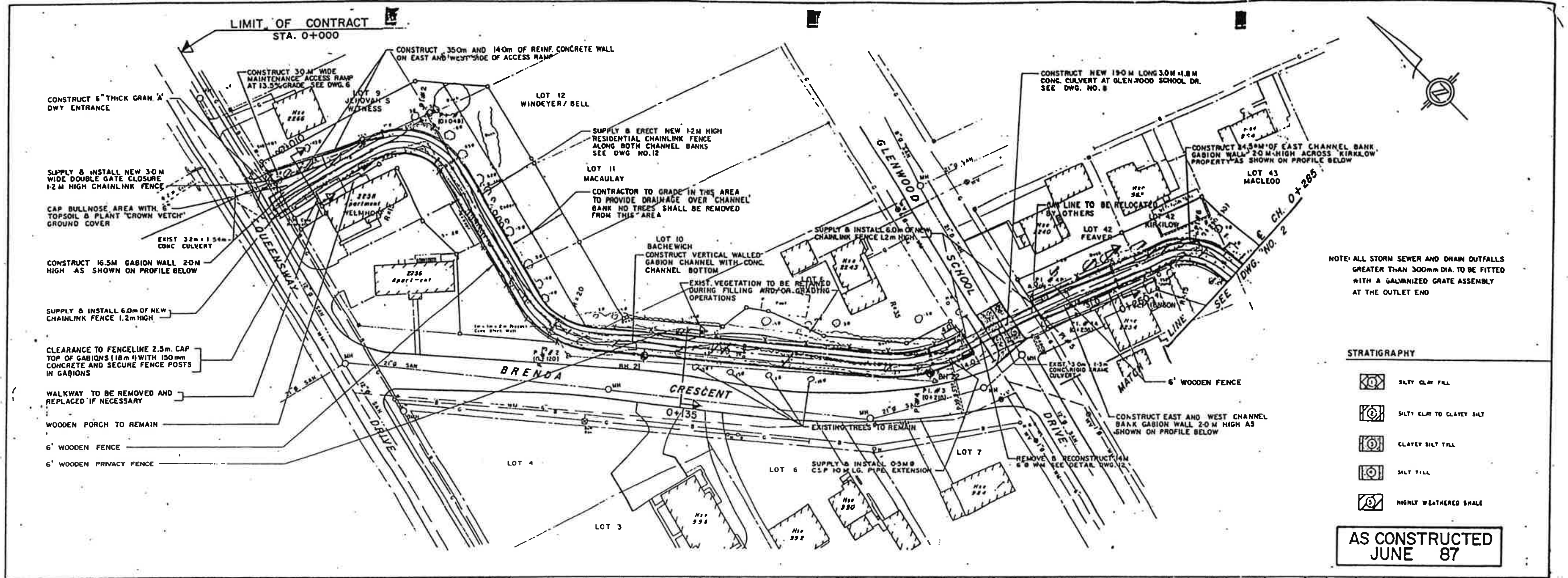
2.2 Project Location

The project site is located halfway between Guelph Line and Brant Street, with the upstream limits beginning at Queensway Drive extending through the residential community of Queensway to downstream of the CNR – Oakville crossing, approximately 120 m north of Fairview Street.

2.3 Design Objectives and Criteria

The channel works were designed to the "controlled" 100 year future land use peak flow to be regulated by the proposed East Rambo Detention facility to 15.0 m^3/s +/- at Queensway Drive. Design levels during a 100 year event average 1.3 metres, with a 0.3 metre freeboard.

Note: While considered at the time of design, protection to the Regulatory standard (Hurricane Hazel) was not attainable due to insufficient land and storage, within the East Rambo Creek watershed.

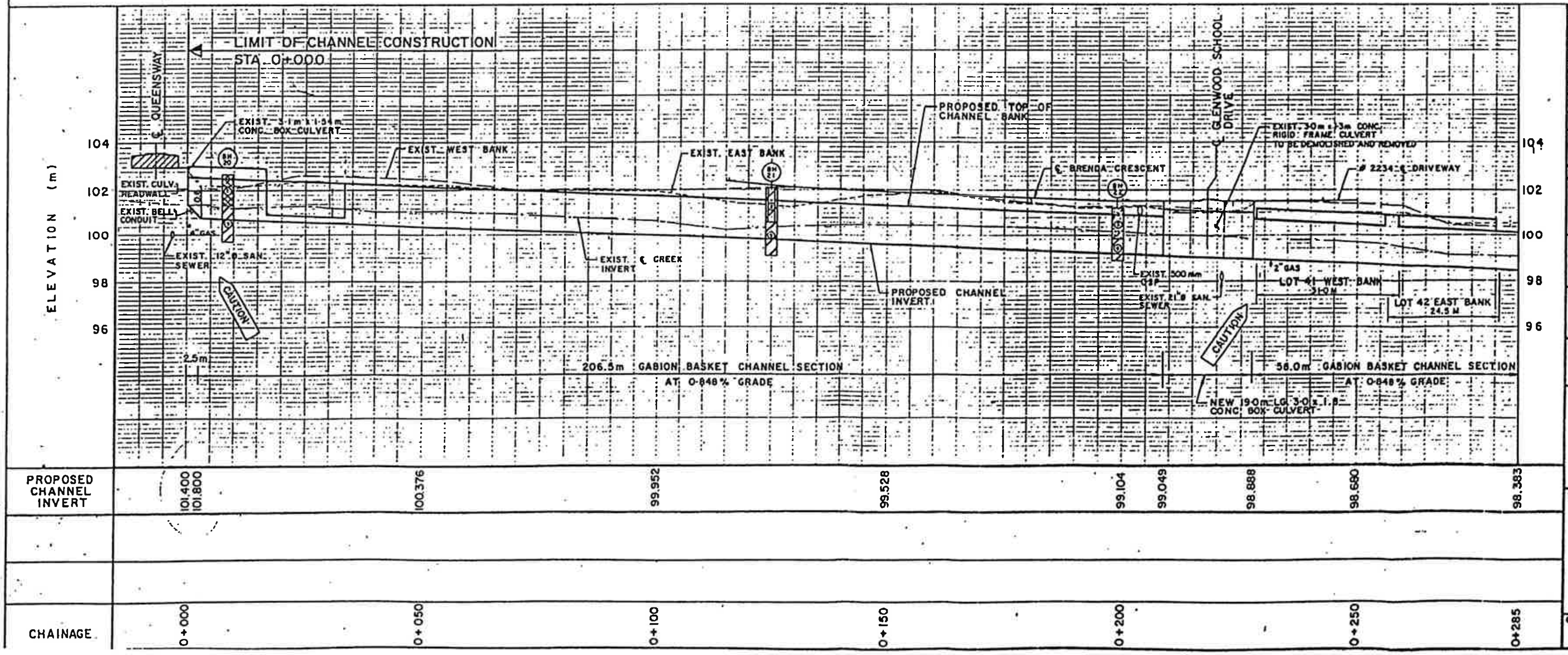


NOTE: ALL STORM SEWER AND DRAIN OUTFALLS GREATER THAN 300mm DIA. TO BE FITTED WITH A GALVANIZED GRATE ASSEMBLY AT THE OUTLET END

STRATIGRAPHY

①	SILTY CLAY FILL
②	SILTY CLAY TO CLAYEY SILT
③	CLAYEY SILT TILL
④	SILT TILL
⑤	HIGHLY WEATHERED SHALE

AS CONSTRUCTED
JUNE 87



Nº	Date	By	REVISIONS

Design	R B S	Checker	F K D	Date JUNE 1985
Drawn	M.B.K.	Checked	K R.D.	

Scale HORIZONTAL 1:500
VERTICAL 1:100

REFERENCES · L.B. 1506

APPROVALS

FIELD NOTES

CLIENT

CONTRACTOR

STAMP

REGISTERED PROFESSIONAL ENGINEER
K. R. De POOCHIA
PROVINCE OF ONTARIO

STAMP

CONSULTANT
Phillips Planning + Engineering Limited

CLIENT

Halton Region Conservation Authority

TITLE

RAMBO CREEK FLOOD CONTROL

EAST BRANCH

PLAN AND PROFILE
STA. 0+000 TO STA. 0+285

CONTRACT Nº 84071-A

SHEET 1 OF 12

METRIC

NOTE : ALL STORM SEWER AND DRAIN OUTFALLS GREATER THAN 300mm DIA. TO BE FITTED WITH A GALVANIZED GRATE ASSEMBLY AT THE OUTLET END.

STRATIGRAPHY

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②	SILTY CLAY TO CLAYEY SILT
③	CLAYEY SILT TILL
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⑤	HIGHLY WEATHERED SHALE

AS CONSTRUCTED
JUNE 87

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Drawn	M.B.K.	Checked	K.R.D.	
Scale	HORIZONTAL 1:500 VERTICAL 1:100			REFERENCES L.B. 1506

APPROVALS

FIELD NOTES

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STAMP

K. R. DE POOLSTA
PROVINCE of ONTARIO

CONTRACTOR

STAMP

CONSULTANT

Philips
Planning
Engineering
Limited

CLIENT

Halton Region
Conservation Authority

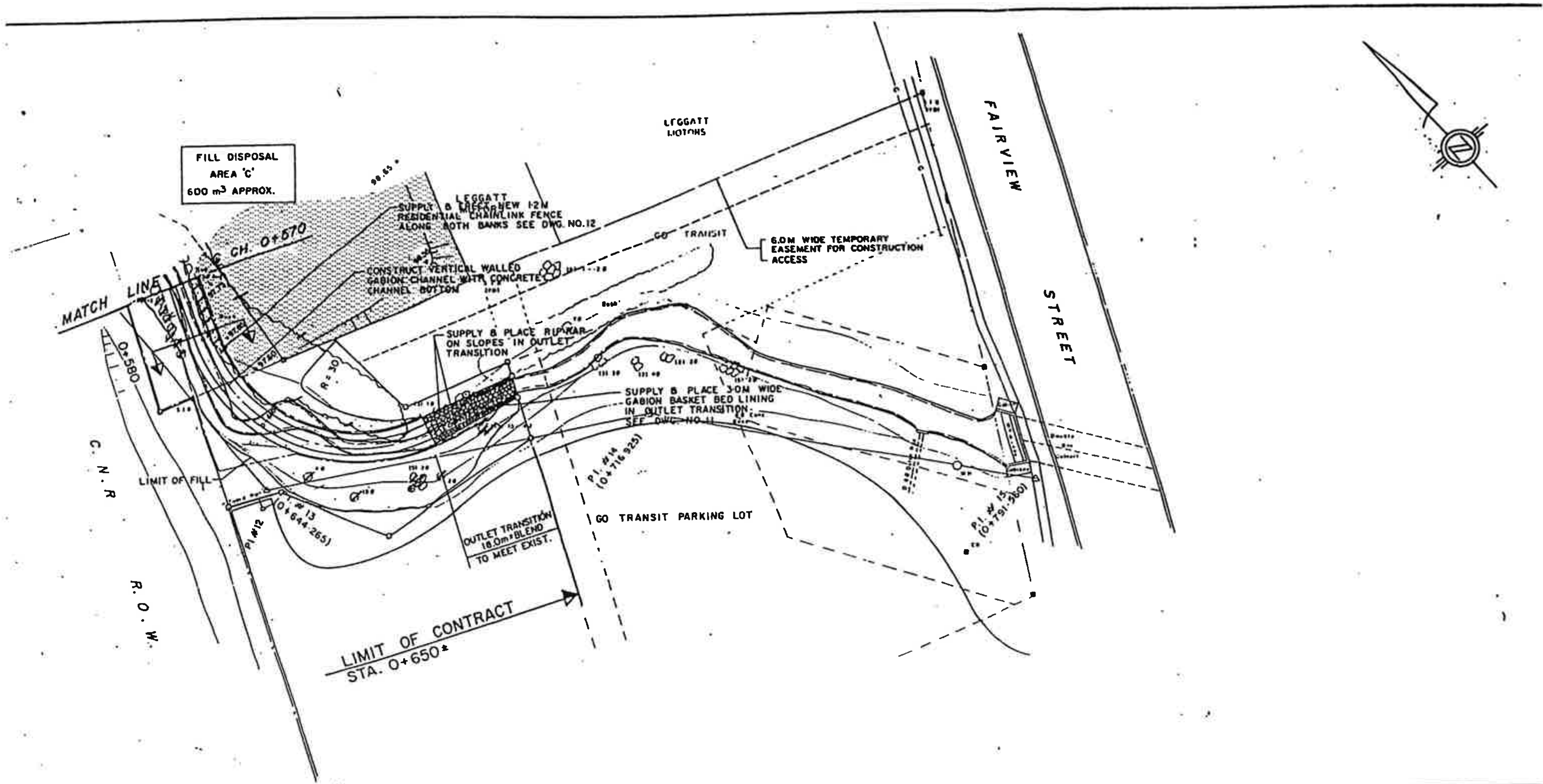
TITLE

RAMBO CREEK
FLOOD CONTROL
EAST BRANCH
PLAN AND PROFILE
STA. 0+285 TO STA. 0+570

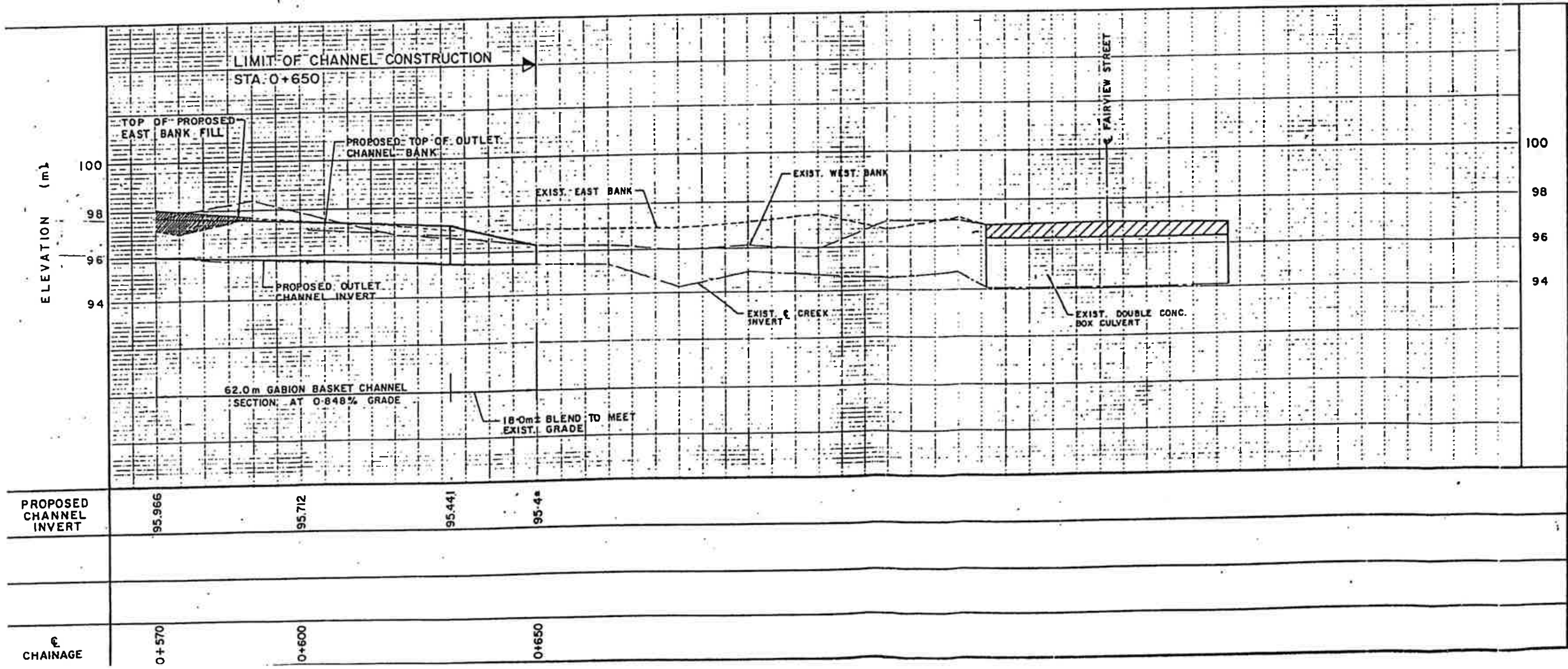
CONTRACT Nº 84071-A

SHEET 2 OF 12

METRIC



AS CONSTRUCTED
JUNE 87



Nº	Date	By	REVISIONS

Design R.B.S. Checked K.R.D.
Drawn M.B.K. Checked K.R.D.
Date JUNE 1985
Scale HORIZONTAL 1:500
VERTICAL 1:100
REFERENCES L.B. 1506
APPROVALS
FIELD NOTES
CLIENT
STAMP
K. R. De POORTER
STAMP
CONTRACTOR
CONSULTANT
Philips Planning + Engineering Limited
CLIENT

Halton Region Conservation Authority

TITLE

RAMBO CREEK FLOOD CONTROL

EAST BRANCH

PLAN AND PROFILE
STA. 0+570 TO STA. 0+650

CONTRACT NO 84071-A
SHEET 3 OF 12

2.5 Photographic Reconnaissance

Photo 2.1 - Downstream view of the Queensway Drive culvert, at the upstream limits of the study area. Note the heavy vegetation blocking the access ramp on the right, and growth through the cracks in the channel.

Photo 2.2 – Looking upstream at East Rambo Creek from Brenda Crescent at approximately Station 0+100

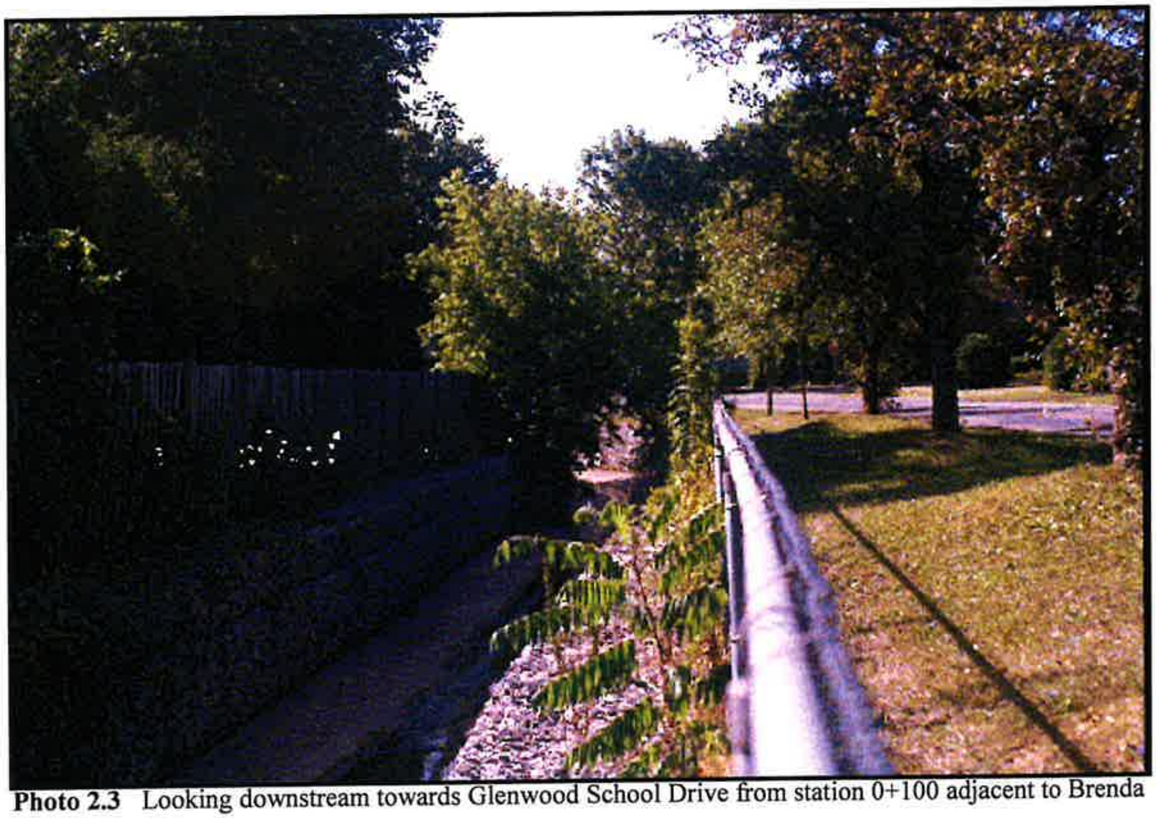


Photo 2.3 Looking downstream towards Glenwood School Drive from station 0+100 adjacent to Brenda Crescent.

Photo 2.4 - Looking upstream towards the Glenview School Drive culvert.

Photo 2.5 - Looking upstream from station 0+420, just north of the Fassel Avenue access gates.

Photo 2.6 – View of the maintenance access gates and ramps from Fassel Avenue. The vegetation within this area should be kept clear at all times to provide unconstrained access.

Photo 2.7 - Looking downstream at the CNR crossing from station 0+510. Note the damage to the chainlink fencing, and the vegetation growth through the channel base and gabions

2.6 Operations and Maintenance

2.6.1 Ownership Status

The rights to an 8.0 m wide strip of land, centered about the channel centreline, was secured through permanent easement at the time of construction, by the Halton Region Conservation Authority (Reference Appendix A).

2.6.2 Project Ingress and Egress

The channel invert is accessible between Queensway Drive and Glenwood School Drive, from a ramp located off Queensway Drive. Downstream of Queensway Drive, the channel up to the CNR is accessible through a bi-directional ramp located at Fassel Avenue. Downstream of the CNR, access is facilitated by a ramp structure off Fairview Street in the GO parking lot constructed as part of a separate contract (ref. Section 3). Key No. 18 facilitates gated access to each of the foregoing, available through the Halton Region Conservation Authority (905-336-1158).

2.6.3 Project Element Maintenance

Reference Appendix B for a summary table of project elements and deficiencies, along with the frequency of inspection and the methods of remedial works.

Site Reconnaissance

In order to ensure the normal operation of the channel under the range of expected flow conditions, a "walk through" of the works should be carried out at least once a year. A detailed inspection of the works recording the location and types of any deficiencies, along with photographs should be carried out every five years. Information thusly collected should be catalogued and added to this manual.

Gabion Baskets

The channelization of the East Rambo at this location is unique from the other sites of the Hager-Rambo Flood Control Works, since the entire channel is lined with a two-stage gabion basket retaining wall system. This element should be inspected for any settlement or displacement of the baskets, the degradation of the wire or stone, and large vegetation (tree roots) that may cause damage to the walls. Typically, the most damaging impact is from vandalism, particularly in residential areas.

Concrete Channel Invert and Structures

The concrete invert of the channel and the culvert structures should be inspected annually. The concrete should be checked for any cracking or spalling, which may be repaired by sealing or grouting. Any major areas of cracking (> 3mm), displacement, or heaving (> 5 mm), along with the separation of slab or wall joints (expansion / control), requires a thorough investigation by a qualified Structural Engineer, to determine the cause and recommend remedial works. The underdrain system should also be inspected for any blockage of sediment or vegetation by monitoring the system's effectiveness and by probing the pipe. Throughout these works the site is covered with graffiti which may be removed by sandblasting or painted over for aesthetic reasons.

General/Ingress/Egress

Vegetation that may be obstructing the culverts, drainage or outlet pipes, or growing through the channel should be removed. The low flow channel should be monitored for sediment accumulation, and cleaned every five years (HRCA recommendation from Halton Channel Study). However, with the present state of the Hager-Rambo system this component does not seem to be a factor with the operation or function of the channels. Therefore, due to the channel design features and minimal sediment being transported into the system, this procedure is not recommended unless a serious blockage of the channel or culvert structures is imminent. Locations for access to the channel should remain clear of any obstructions (tall/thick vegetation). The locks and gates should be checked twice a year to ensure easy access under normal or emergency conditions.

3. Lower East Rambo Creek Channelization (CNR – Oakville to Fairview Street)

3.1 Project Description and Year of Construction

Lower East Rambo Creek Channelization

- Fairview Street to downstream of CNR Oakville

Construction completed in July 1996.

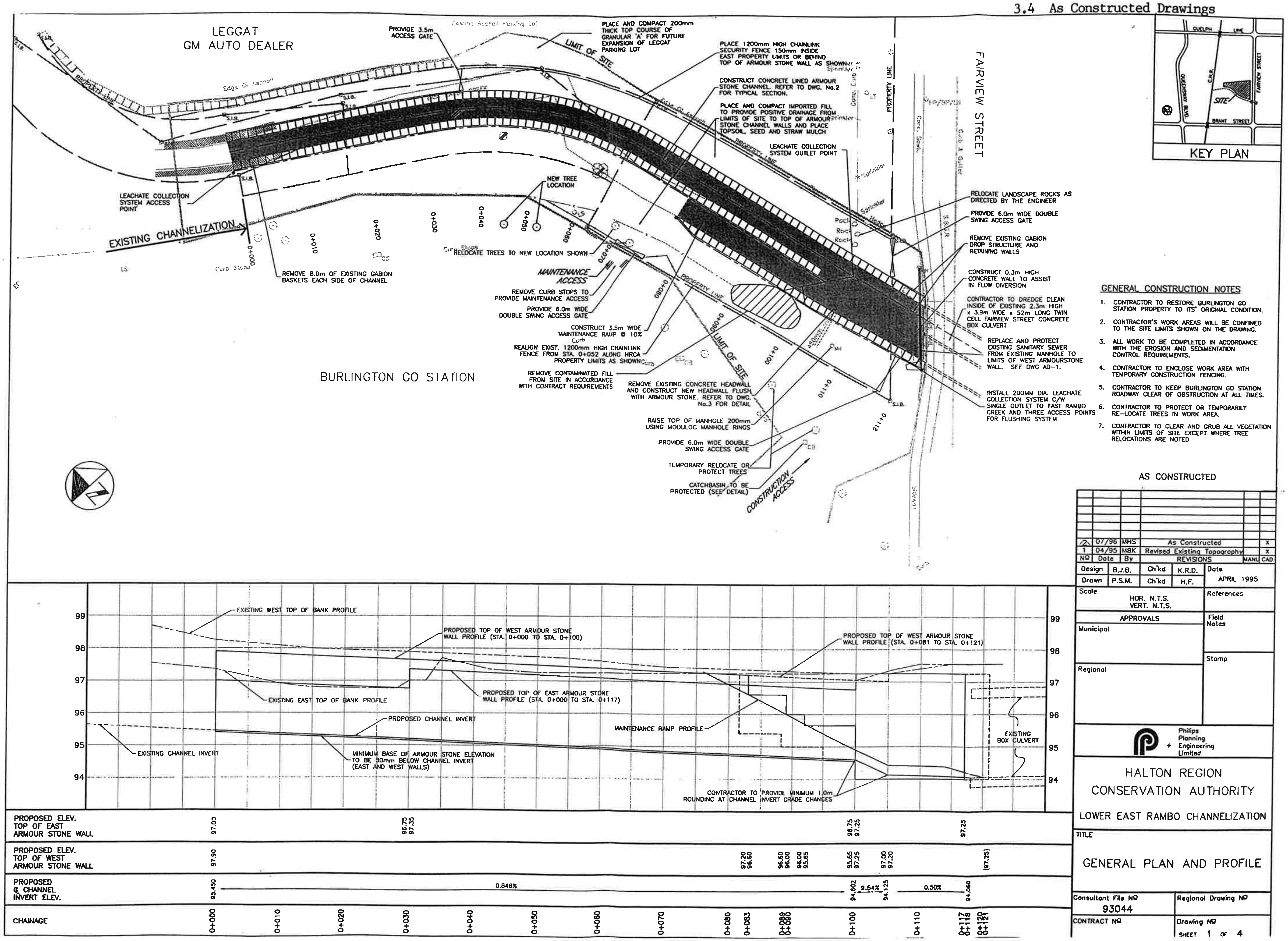
This project involved the construction of 120 metres of concrete lined invert with varying multiple courses of armour stone ranging from 3.2 metres wide to 3.9 metres to match into the existing double cell culvert at Fairview Street. A maintenance ramp was built to provide access to the channel invert between the CNR and Fairview Street.

3.2 Project Location

The project site is located between Brant Street and Guelph Line, extending from downstream of the CNR Oakville Subdivision crossing to Fairview Street. Adjacent to the site is the Burlington GO Station to the west, and Leggat GM Auto Dealership to the east.

3.3 Design Objectives and Criteria

The channelization of East Rambo Creek was designed to accommodate the regulated 100 year flow of 15.0 m^3/s, having a headwater elevation of 96.4 metres at the Fairview Street culvert, with a 0.3 metre freeboard. The main purpose of the works was to provide flood and erosion protection to the last remaining unlined creek component in this area.



GENERAL CONSTRUCTION NOTES

1. CONTRACTOR TO RESTORE BURLINGTON GO STATION PROPERTY TO ITS' ORIGINAL CONDITION.
2. CONTRACTOR'S WORK AREAS WILL BE CONFINED TO THE SITE LIMITS SHOWN ON THE DRAWING.
3. ALL WORK TO BE COMPLETED IN ACCORDANCE WITH THE EROSION AND SEDIMENTATION CONTROL REQUIREMENTS.
4. CONTRACTOR TO ENCLOSE WORK AREA WITH TEMPORARY CONSTRUCTION FENCING.
5. CONTRACTOR TO KEEP BURLINGTON GO STATION ROADWAY CLEAR OF OBSTRUCTION AT ALL TIMES.
6. CONTRACTOR TO PROTECT OR TEMPORARILY RE-LOCATE TREES IN WORK AREA.
7. CONTRACTOR TO CLEAR AND GRUB ALL VEGETATION WITHIN LIMITS OF SITE EXCEPT WHERE TREE RELOCATIONS ARE NOTED

3.5 Photographic Reconnaissance

Photo 3.1 Looking upstream at the transition from the vertical gabion walled channel to the armour stone lined channel from station 0+020.

Photo 3.2 View of the Fairview Street culvert looking downstream from station 0+070 along the alignment of the access ramps.

Photo 3.3 Looking upstream from atop the Fairview Street culvert.

3.6 Operations and Maintenance

3.6.1 Ownership Status

This section of the Lower East Rambo Creek is owned by the Halton Region Conservation Authority (Parts 1 & 2, Plan 20R-11811), averaging approximately 12 metres in width. (Reference Appendix A)

3.6.2 Project Ingress and Egress

The channel invert is accessible by one of three 6 m double swing access gates, located on either side of the channel off Fairview Street, and from the Burlington GO Station parking lot. Gated access to each of the foregoing is facilitated by Key No. 18, available through the Halton Region Conservation Authority (905-336-1158).

3.6.3 Project Element Maintenance

Reference Appendix B for a summary table of standard component elements of the project, along with the frequency of inspection and the methods of remediation.

Site Reconnaissance

In order to ensure the normal operation of the channel under the range of expected flow conditions, a "walk through" of the works should be carried out at least once a year. A detailed inspection of the works recording the location and types of any deficiencies, along with photographs should be carried out every five years. Information thusly collected should be catalogued and added to this manual.

Armour Stone

During the annual inspection, the stone should be checked for any degradation or displacement. Specific items to check for include intrusive vegetation and washout of backfill material. If distress is occurring, a thorough investigation is required by a qualified Engineer to determine the cause and recommend remedial works.

Concrete Channel Invert

The concrete invert of the channel and the culvert structures should be inspected annually. The concrete should be checked for any cracking or spalling, which may be repaired by sealing or grouting. Any major areas of cracking (> 3mm), displacement, or heaving (> 5 mm), along with the separation of slab or wall joints (expansion / control), requires a thorough investigation by a qualified Structural Engineer, to determine the cause and recommend remedial works. The underdrain system should also be inspected for any blockage of sediment or vegetation by monitoring the system's effectiveness and by probing the pipe.

General/Ingress/Egress

Vegetation that may be obstructing the culverts, drainage or outlet pipes, or growing through the channel should be removed. The low flow channel should be monitored for sediment accumulation, and cleaned every five years (HRCA recommendation from Halton Channel Study). However, with the present state of the Hager-Rambo system, this component does not seem to be a factor with the operation or function of the channels. Therefore, due to the channel design features and minimal sediment being transported into the system, this procedure is not recommended unless a serious blockage of the channel or culvert structures is imminent. Locations for access to the channel should remain clear of any obstructions (tall/thick vegetation). The locks and gates should be checked twice a year to ensure easy access under normal or emergency conditions.

4. East Hager Creek Channelization (Fairview Street to CNR – Halton)

4.1 Project Description and Year of Construction

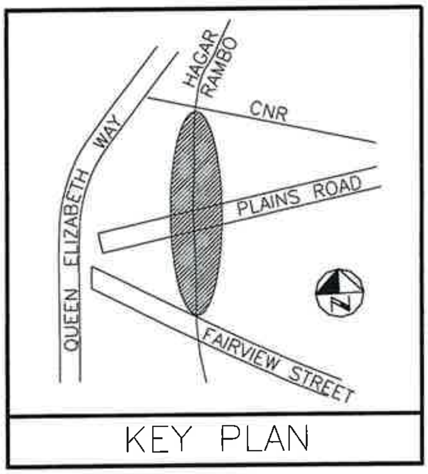
East Hager Creek Channelization
- Fairview Street to CNR Halton

Construction completed in October 1991

From Fairview Street to the CNR Halton crossing, 268 metres of concrete lined trapezoidal invert with a low flow channel was constructed, connecting to the existing structures at the upstream and downstream limits of this site. The concrete channel walls extend vertically to a maximum height of 4.2 metres above the centerline invert of the channel, having an approximate top width of 6.4 metres. This project also included the replacement of the Plains Road structure with a 2.6 x 2.6 x 27.0 metre, twin concrete box culvert.

4.2 Project Location

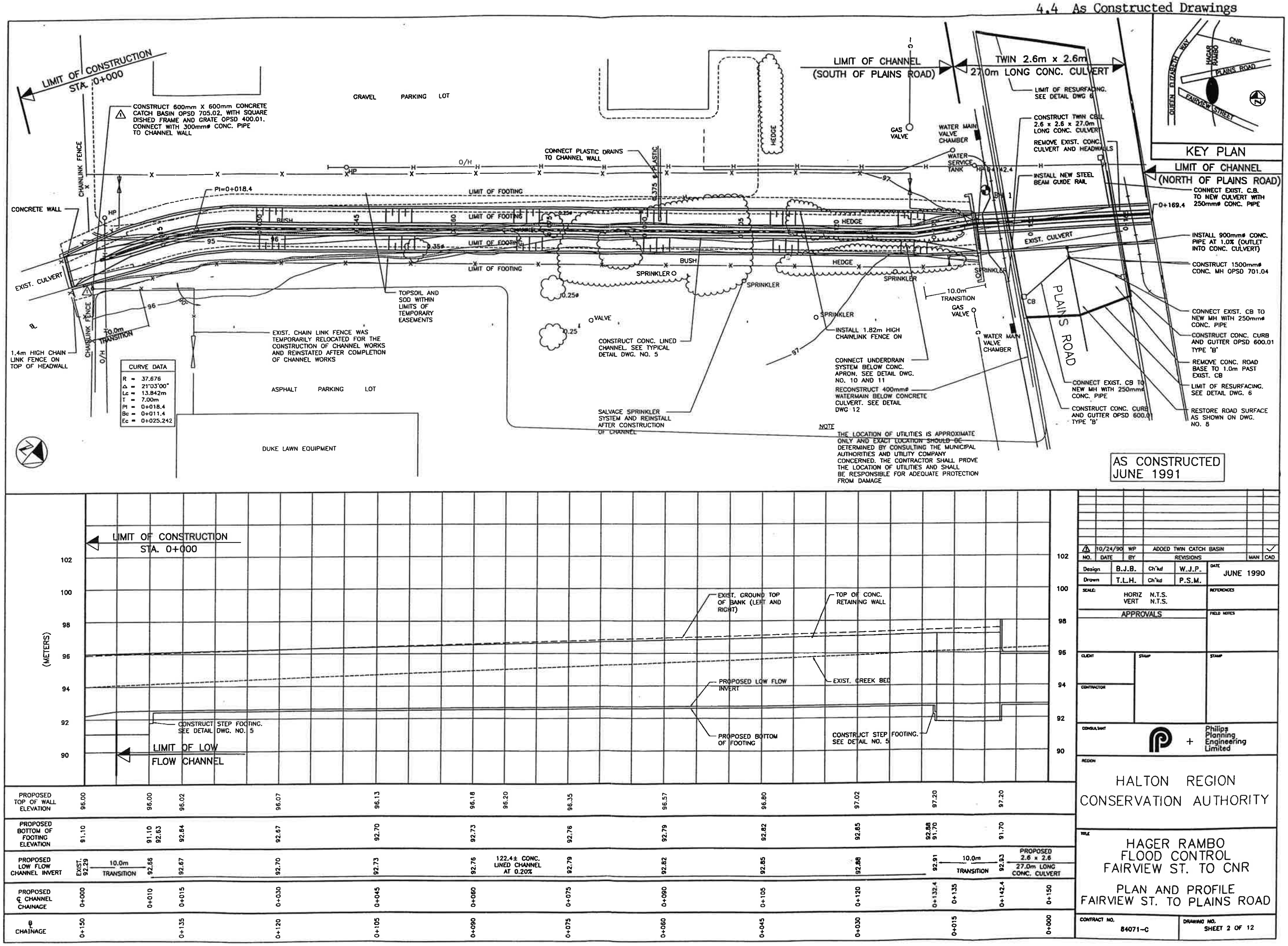
This section of the East Hager Creek reconstruction is located between Fairview Street and the CNR Halton crossing, just east of the QEW.



4.3 Design Objectives and Criteria

The channelization works were designed to the Regional event (Hurricane Hazel), future land use peak flow of 48 m^3/s, regulated by the existing Freeman Detention Facility (Reference Section 7.3) based on the capacity of the existing Fairview Street culvert.

4.4 As Constructed Drawings



NOTE

THE LOCATION OF UTILITIES IS APPROXIMATE ONLY AND EXACT LOCATION SHOULD BE DETERMINED BY CONSULTING THE MUNICIPAL AUTHORITIES AND UTILITY COMPANY CONCERNED. THE CONTRACTOR SHALL PROVE THE LOCATION OF UTILITIES AND SHALL BE RESPONSIBLE FOR ADEQUATE PROTECTION FROM DAMAGE

PROPOSED TOP OF WALL ELEVATION	96.00		96.00	96.02	96.07	96.13	96.18	96.20	96.35	96.57	96.80	97.02	97.20		97.20		
PROPOSED BOTTOM OF FOOTING ELEVATION	91.10		91.10 92.63	92.84	92.67	92.70	92.73		92.76	92.79	92.82	92.85	92.88 91.70		91.70		
PROPOSED LOW FLOW CHANNEL INVERT	EXIST. 92.29	10.0m TRANSITION	92.66	92.67	92.70	92.73	92.76	122.4± CONC. LINED CHANNEL AT 0.20%	92.79	92.82	92.85	92.88	92.91	10.0m TRANSITION	92.93	PROPOSED 2.6 x 2.6 27.0m LONG CONC. CULVERT	
PROPOSED ℄ CHANNEL CHAINAGE	0+000		0+010	0+015	0+030	0+045	0+060		0+075	0+090	0+105	0+120	0+132.4	0+135	0+142.4		0+150
B℄ CHAINAGE	0+150			0+135	0+120	0+105	0+090		0+075	0+060	0+045	0+030		0+015			0+000

NO.	DATE	BY	REVISIONS	MAN	CAD
1	10/24/90	WP	ADDED TWIN CATCH BASIN		✓

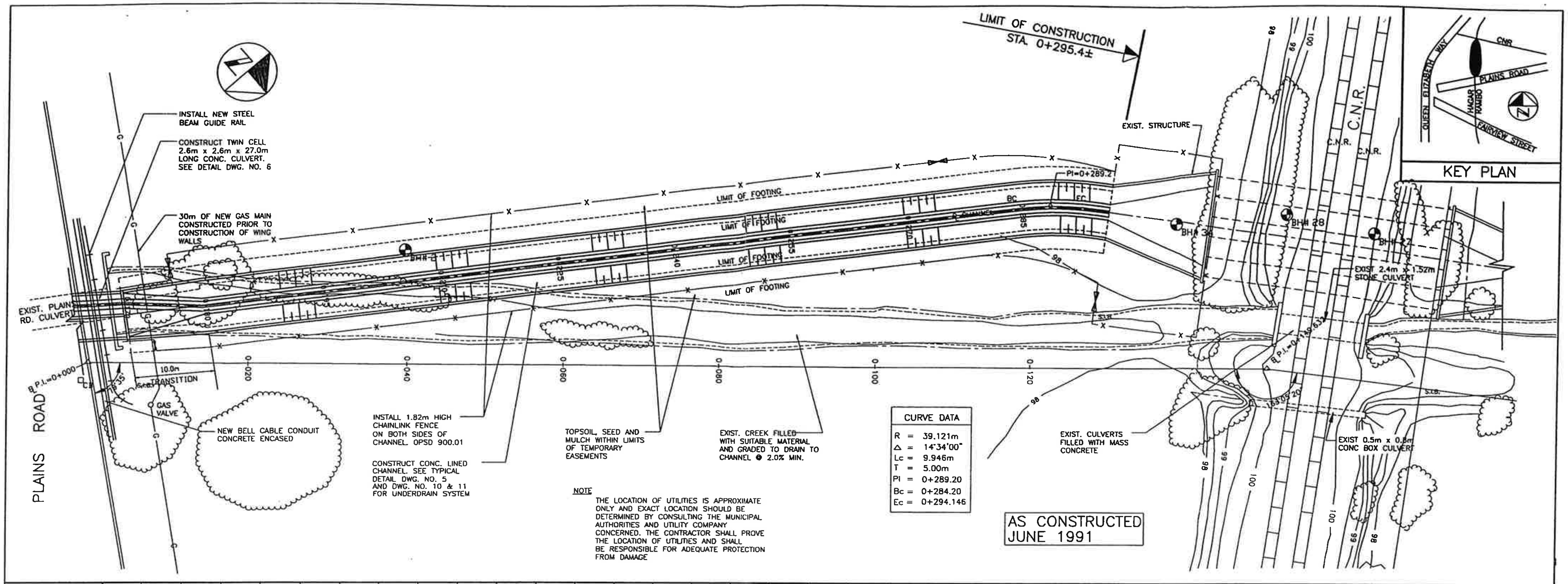
Design B.J.B. Ch'kd W.J.P.
Drawn T.L.H. Ch'kd P.S.M.
DATE JUNE 1990
SCALE: HORIZ N.T.S. VERT N.T.S.
REFERENCES
APPROVALS
FIELD NOTES
CLIENT
STAMP
STAMP
CONTRACTOR
CONSULTANT + Philips Planning Engineering Limited

REGION
HALTON REGION
CONSERVATION AUTHORITY

TITLE
HAGER RAMBO
FLOOD CONTROL
FAIRVIEW ST. TO CNR

PLAN AND PROFILE
FAIRVIEW ST. TO PLAINS ROAD

CONTRACT NO. 84071-C
DRAWING NO. SHEET 2 OF 12



KEY PLAN

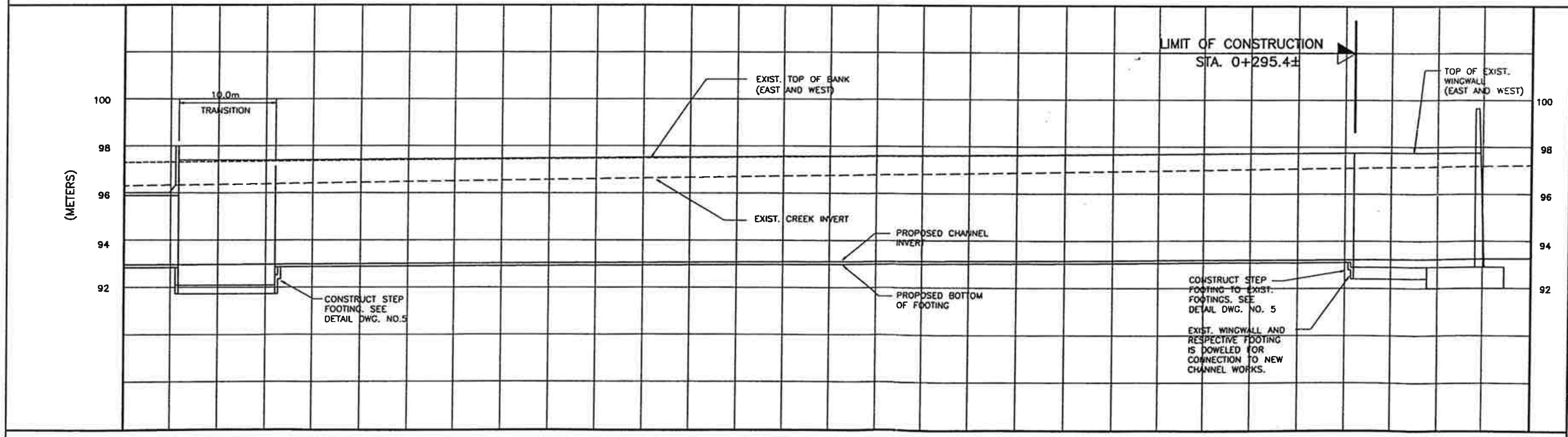
NOTE

THE LOCATION OF UTILITIES IS APPROXIMATE ONLY AND EXACT LOCATION SHOULD BE DETERMINED BY CONSULTING THE MUNICIPAL AUTHORITIES AND UTILITY COMPANY CONCERNED. THE CONTRACTOR SHALL PROVE THE LOCATION OF UTILITIES AND SHALL BE RESPONSIBLE FOR ADEQUATE PROTECTION FROM DAMAGE

CURVE DATA

R = 39.121m
Δ = 14°34'00"
Lc = 9.946m
T = 5.00m
PI = 0+289.20
Bc = 0+284.20
Ec = 0+294.146

AS CONSTRUCTED
JUNE 1991



PROPOSED TOP OF WALL ELEVATION		97.30	97.30	97.36	97.43	97.49	97.56	97.62	97.69	97.75	97.80		
PROPOSED BOTTOM OF FOOTING ELEVATION		91.80	91.80 92.98	93.01	93.04	93.07	93.10	93.13	93.16	93.19	93.22		
PROPOSED LOW FLOW CHANNEL INVERT		93.00	93.02	93.04	93.07	93.10 PROPOSED CONC. LINED CHANNEL 116.0m± AT 0.2%	93.13	93.16	93.19	93.22	93.25	EXISTING	
PROPOSED ℄ CHANNEL CHAINAGE	0+150	0+169.4 10.0 TRANSITION	0+179.4	0+195	0+210	0+225	0+240	0+255	0+270	0+285	0+295.4	EXIST. CHANNEL GRADE 0.38%	
℄ CHAINAGE	0+000		0+015	0+030	0+045	0+060	0+075	0+090	0+105	0+120	0+130	0+135	0+150

NO.	DATE	BY	REVISIONS	MAN	CAD

Design	B.J.B.	Ch'kd	W.J.P.	DATE JUNE 1990
Drawn	T.L.H.	Ch'kd	P.S.M.	

SCALE: HORIZ N.T.S.
VERT N.T.S.

REFERENCES

APPROVALS

FIELD NOTES

CLIENT

STAMP

STAMP

CONTRACTOR

CONSULTANT

Philips Planning Engineering Limited

REGION

HALTON REGION
CONSERVATION AUTHORITY

TITLE

HAGER RAMBO
FLOOD CONTROL
FAIRVIEW ST. TO CNR

PLAN AND PROFILE
PLAINS RD. TO CNR

CONTRACT NO. 84071-C

DRAWING NO. SHEET 2 OF 12

4.5 Photographic Reconnaissance

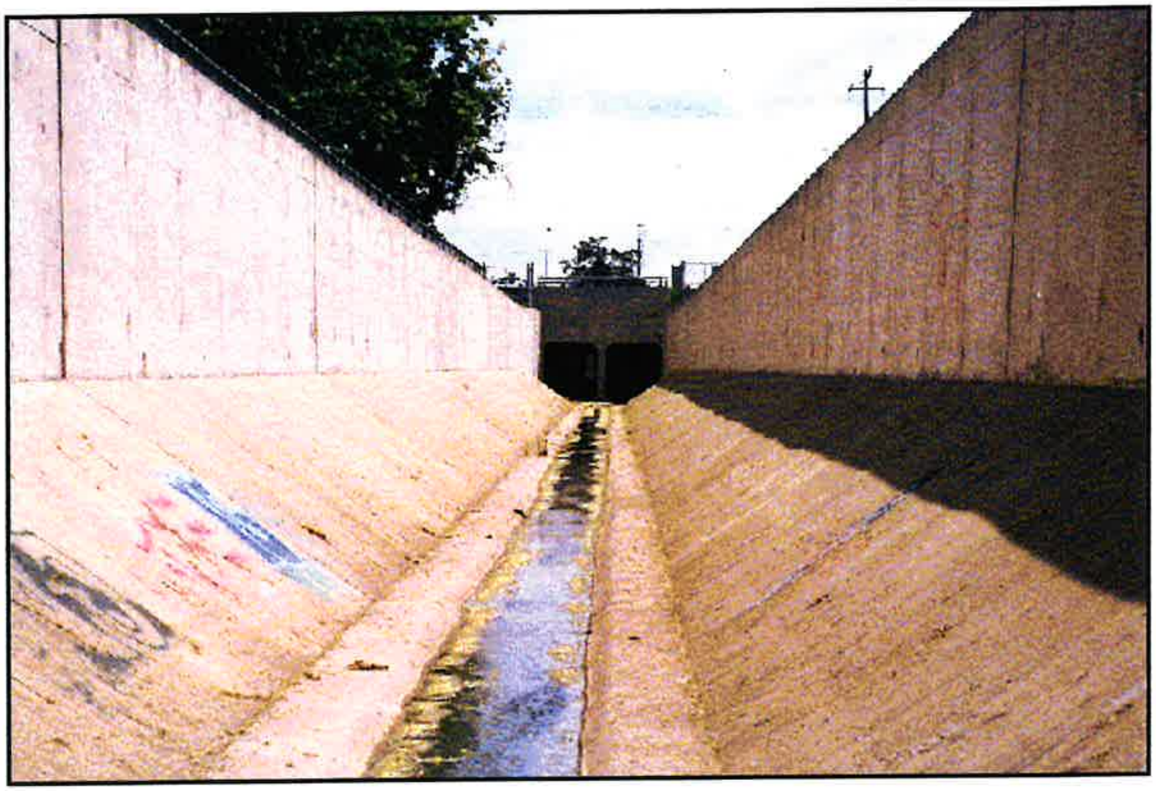


Photo 4.1 - View of the channelization works from station 0+270 looking downstream towards the Plains Road culvert.

Photo 4.2 - Looking downstream from atop the Plains Road culvert towards Fairview Street.

4.6 Operations and Maintenance

4.6.1 Ownership Status

The Halton Region Conservation Authority has ownership title to a 13 metre wide strip of land between Fairview Street and Plains Road, as referenced to the centreline of the channel (Parts 2, 3, and 4, Plan 20R-9601). The Conservation Authority also has ownership title to a 13 metre wide strip of land between Plains Road and the CNR Crossing (Part 2, Plan 20R-9602), and a 7 metre wide permanent easement for maintenance along the east side of the channel (Part 1, Plan 20R-9602). (Reference Appendix A)

4.6.2 Project Ingress and Egress

The channel between Fairview Street and Plains Road is accessible by gated access on the west side of the channel at the Fairview Street culvert and the south side of Plains Road. The channel section between Plains Road and the CNR is accessible by gated access on both the east and west sides of the Plains Road culvert on the north side. In both cases the access is along the top of the west side of the channel and direct access to the channel invert is not possible.

Key No. 18 facilitates gated access to each of the foregoing, available through the Halton Region Conservation Authority (905-336-1158).

4.6.3 Project Element Maintenance

Reference Appendix B for a summary table of standard component elements of the project, along with the frequency of inspection and the methods of remediation.

Site Reconnaissance

In order to ensure the normal operation of the channel under the range of expected flow conditions, a "walk through" of the works should be carried out at least once a year. A detailed inspection of the works recording the location and types of any deficiencies, along with photographs should be carried out every five years. Information thusly collected should be catalogued and added to this manual.

Concrete Retaining Walls and Channel Invert

The concrete invert, walls, and culvert structures should be inspected annually. The concrete should be checked for any cracking or spalling, which may be repaired by sealing or grouting. Any major areas of cracking (> 3mm), displacement, or heaving (> 5 mm), along with the separation of slab or wall joints (expansion / control), requires a thorough investigation by a qualified Structural Engineer, to determine the cause and recommend remedial works. The underdrain system should also be inspected for any blockage of sediment or vegetation by monitoring the system's effectiveness and by probing the pipe. Throughout these works the walls are covered with graffiti and which may be removed by sandblasting or painted over for aesthetic reasons.

General/Ingress/Egress

Vegetation or debris that may be obstructing the Fairview Street or Plains Road culvert, drainage or outlet pipes, or growing through the channel invert should be removed. Locations for access to the channel from Plains Road and Fairview Street should remain clear of any obstructions (tall/thick vegetation). The locks and gates should be checked twice a year to ensure easy access under normal or emergency conditions.

5. East Hager Creek (CNR Halton Culvert Crossing)

5.1 Project Description and Year of Construction

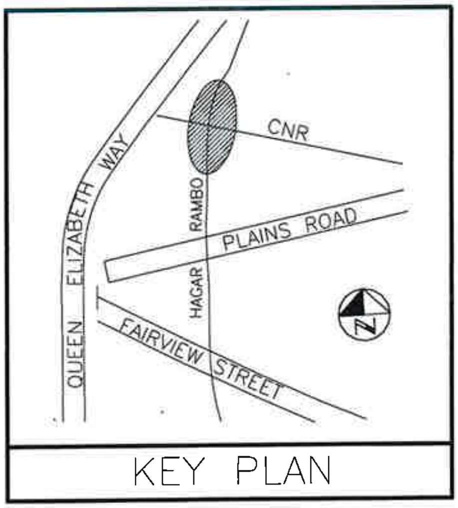
East Hager Creek
- CNR Halton Culvert Crossing

Construction completed in 1990.

This project involved the pipe-jacking of three 2100 mm diameter reinforced concrete pipes, each 26 metres in length, through the CNR crossing. In addition, both upstream and downstream headwalls, wing-walls, and retaining walls were constructed.

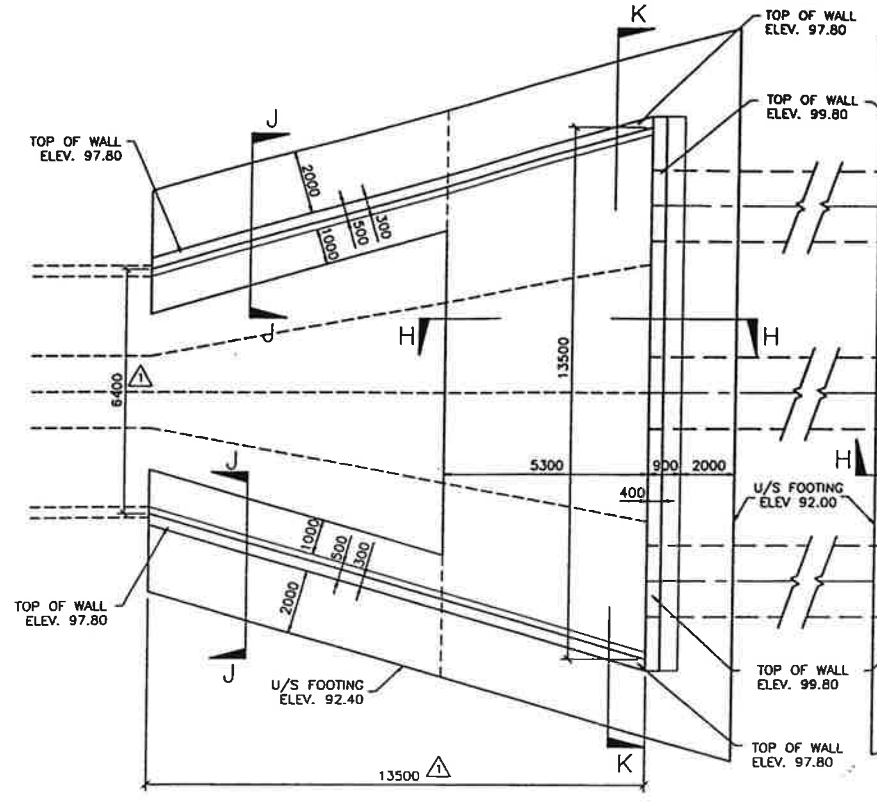
5.2 Project Location

The CNR Halton crossing is located approximately 120 metres north of Plains Road, east of the QEW.

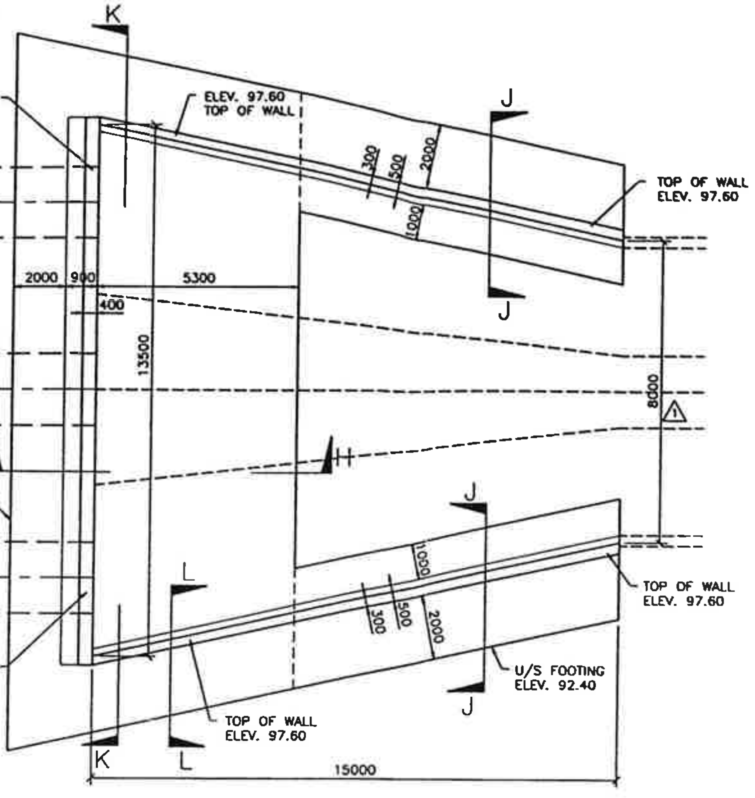


5.3 Design Objectives and Criteria

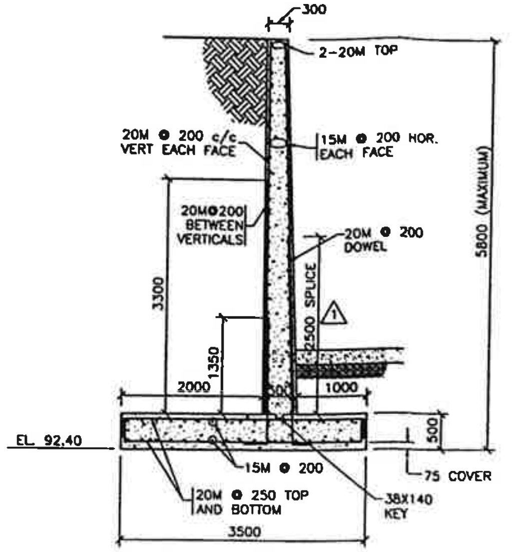
Culvert crossing works were designed to the controlled Regional event (Hurricane Hazel) future land use peak flow of 48 m^3/s, regulated by the Freeman Detention Facility and the capacity of the Fairview Street culvert. This design flow promotes an upstream water surface elevation of 97.5 m at the culvert, allowing for a 0.3 m freeboard to the top of headwall elevation of 97.8 m.



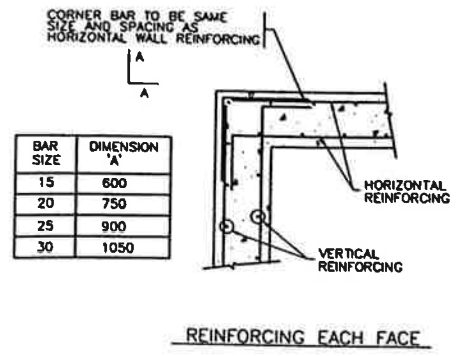
PLAN
DOWN STREAM HEADWALL
AND RETAINING WALL



PLAN
UPSTREAM HEADWALL
AND RETAINING WALL



WING WALL SECTION J-J



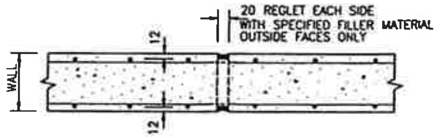
BAR SIZE	DIMENSION 'A'
15	600
20	750
25	900
30	1050

REINFORCING EACH FACE

TYPICAL CORNER PLAN DETAIL

NOTES

1. ALL CONSTRUCTION SHALL BE CARRIED OUT IN ACCORDANCE WITH THE REQUIREMENTS OF THE ONTARIO BUILDING CODE, 1986 EDITION, AND WITH GOOD CONSTRUCTION PRACTICE.
2. MINIMUM CONCRETE STRENGTH AT 28 DAYS SHALL BE 25MPa.
3. REINFORCING STEEL SHALL BE DEFORMED BARS CONFORMING TO CSA STANDARD G30.12-M77, GRADE 400.
4. CONCRETE COVER TO REINFORCING STEEL SHALL BE:
   75mm – FOR CONCRETE PLACED AGAINST EARTH
   50mm – FOR CONCRETE EXPOSED TO EARTH AND WEATHER.
5. ALL FOOTINGS SHALL BEAR ON NATIVE UNDISTURBED SOIL CAPABLE OF SUPPORTING 200 kN/m².
6. PROVIDE A MINIMUM 1200mm EARTH COVER TO THE UNDERSIDE OF CONCRETE WALLS AND FOOTINGS FOR FROST PROTECTION. PROTECT SOIL FROM FREEZING TO AND BELOW ALL FOOTINGS.
7. U/S DENOTES UNDERSIDE
   U/N DENOTES UNLESS NOTED
   E.W. DENOTES EACH WAY

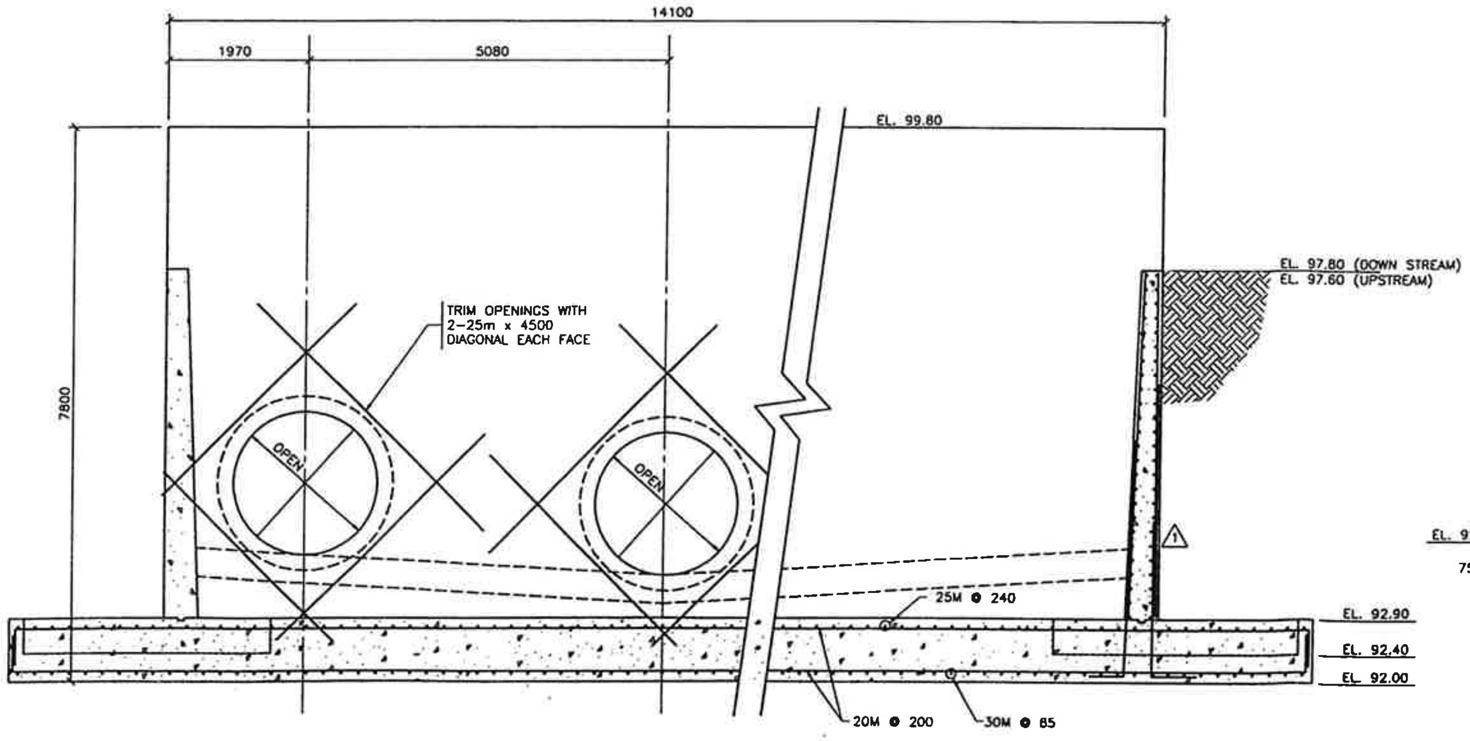


WHERE TOP OF WALL IS EXPOSED PROVIDE REGLET ACROSS TOP OF THE WALL

CUT HALF OF ALL HORIZONTAL BARS EXCEPT HEAVY TOP AND BOTTOM BARS

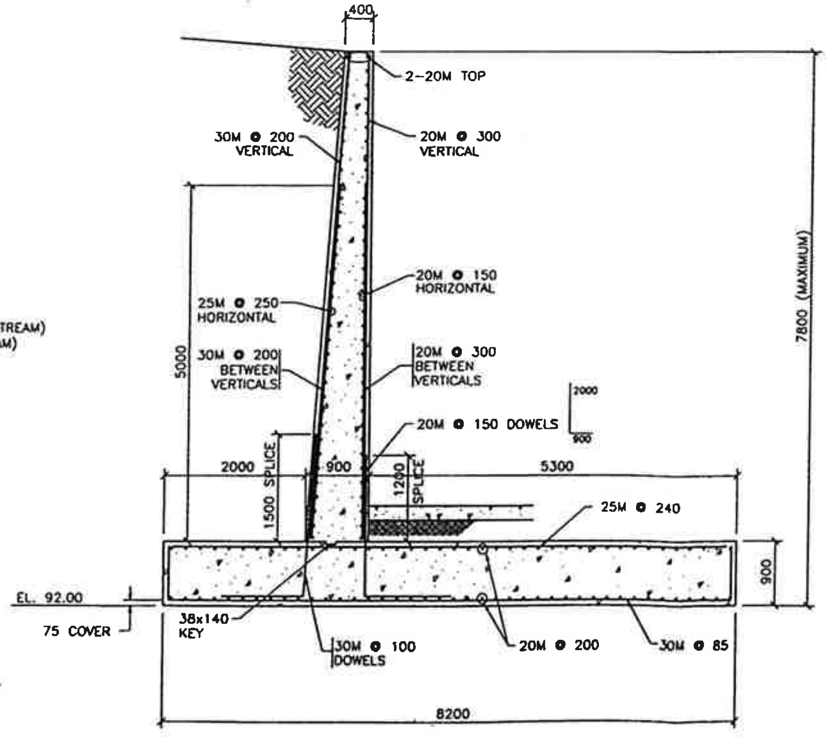
(TO BE PROVIDED IN ALL WALLS @ 5m c/c MAX. UNLESS SPECIFICALLY LOCATED OTHERWISE ON THE DRAWINGS)

TYPICAL VERTICAL CONTROL
JOINT IN CONCRETE WALL



HEADWALL ELEVATION K-K

HEADWALL ELEVATION L-L



HEADWALL SECTION H-H

Nº	Date	By	REVISIONS
1	05/10/90	H.A.P.H.	GENERAL REVISIONS

Design	H.A.P.H.	Checked	R.B.L.F.	Date SEPT. 1989
Drawn	J.O.	Checked	H.A.P.H.	

Scale
N.T.S.

REFERENCES

APPROVALS

FIELD NOTES

CLIENT

STAMP

STAMP

CONTRACTOR

CONSULTANT

Philips
Planning
+ Engineering
Limited

CLIENT

HALTON REGION
CONSERVATION AUTHORITY

TITLE

HAGER-RAMBO
FLOOD CONTROL
DIVERSION CROSSING AT C.N. RAILWAY
MILEAGE 32.57
RAILWAY RETAINING WALL
DETAILS

CONTRACT Nº
84071

SHEET 5 OF 6

5.5 Photographic Reconnaissance

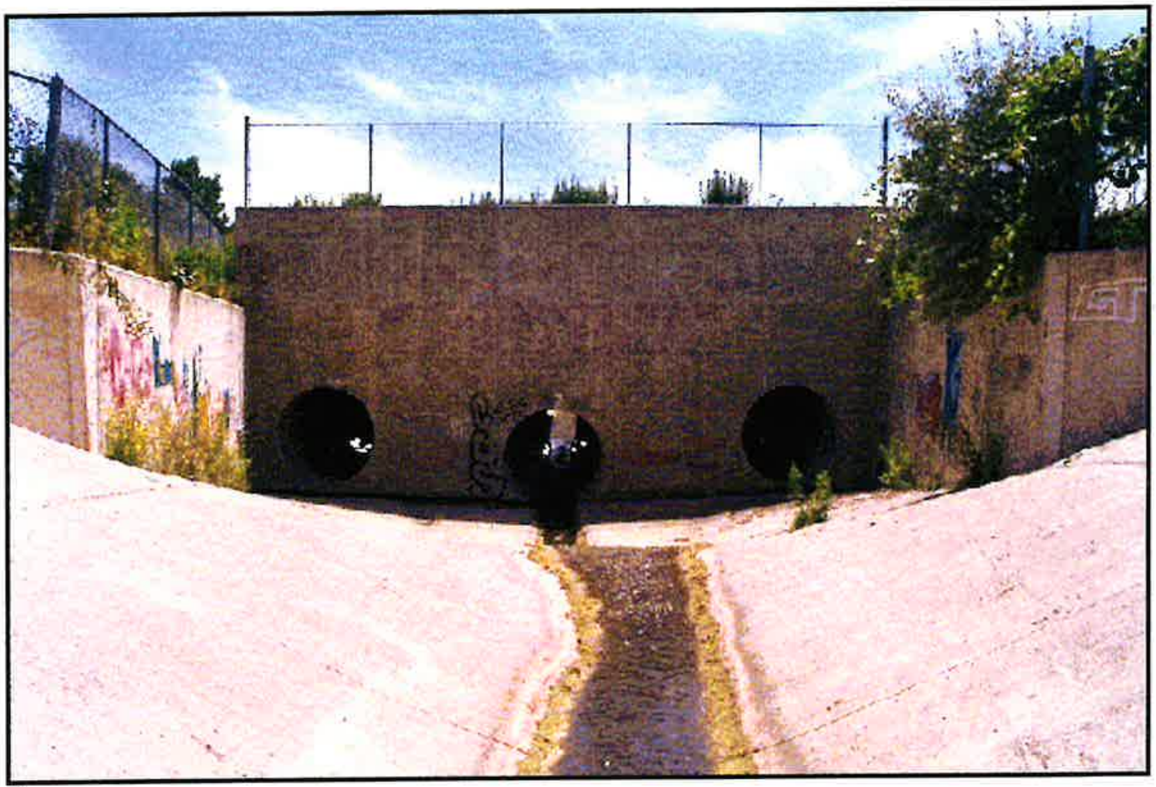


Photo 5.1 - View of the upstream side of the CNR crossing with the triple 2100 mm concrete pipe culverts. Note the vegetation growth out of the concrete.

Photo 5.2 - Looking upstream towards the CNR crossing with low flow levels confined to the centre pipe.

5.6 Operations and Maintenance

5.6.1 Ownership Status

The works are located on a 27.5 metre strip of land owned by the Canadian National Railway, with a maintenance easement granted to the Halton Region Conservation Authority. (Reference Appendix A)

5.6.2 Project Ingress and Egress

The site is accessible from the top only (i.e. no invert access) from the north side of Plains Road, from the end of Coric Avenue through Leighland Park, or through the Freeman Pond entrance off of Brant Street. Gated access to the Plains Road and Brant Street location is facilitated by Key No. 18, for access to the CNR location, available through the Halton Region Conservation Authority (905-336-1158).

5.6.3 Project Element Maintenance

Reference Appendix B for a summary table of standard component elements of the project, along with the frequency of inspection and the methods of remediation.

Site Reconnaissance

In order to ensure the normal operation of the culverts under the range of expected flow conditions, a "walk through" of the works should be carried out at least once a year. A detailed inspection of the works recording the location and types of any deficiencies, along with photographs should be carried out every five years. Information thusly collected should be catalogued and added to this manual.

Concrete Pipe and Walls

The concrete culverts, headwalls, and wingwalls should be inspected annually. The concrete should be checked for any cracking or spalling, which may be repaired by sealing or grouting. Any major areas of cracking (> 3mm), displacement, or heaving (> 5 mm), along with the separation of slab or wall joints (expansion / control) and movement of backfill material, requires a thorough investigation by a qualified Structural Engineer, to determine the cause and recommend remedial works.

The culverts should also be checked for sediment accumulation and cleaned as necessary (Reference Section 2.6.4). Throughout these works the walls are covered with graffiti and which may be removed by sandblasting or painted over for aesthetic reasons.

General/Ingress/Egress

Vegetation or debris that may be obstructing the triple cell culvert at the CNR Halton crossing should be removed manually. Locations for access to the channel should remain clear of any obstructions (tall/thick vegetation).

6. East Hager Creek Channelization

6.1 Project Description and Year of Construction

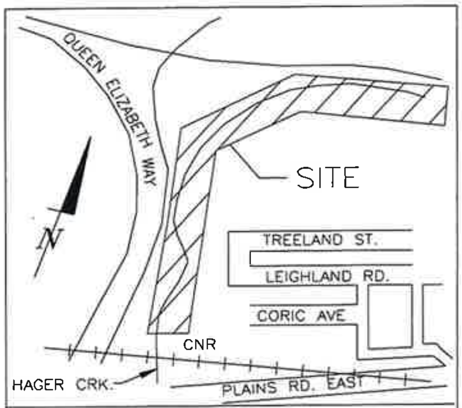
East Hager Creek Channelization
- CNR Halton to Freeman Detention Facility

Construction completed in October 1995

Approximately 480 metres of channel was constructed between the CNR Halton crossing and the Freeman Detention Facility outlet. This predominately interlocking concrete block (Terrafix ^{TM}) lined channel has a top width of 14 m with a depth of 2.7 metres.

6.2 Project Location

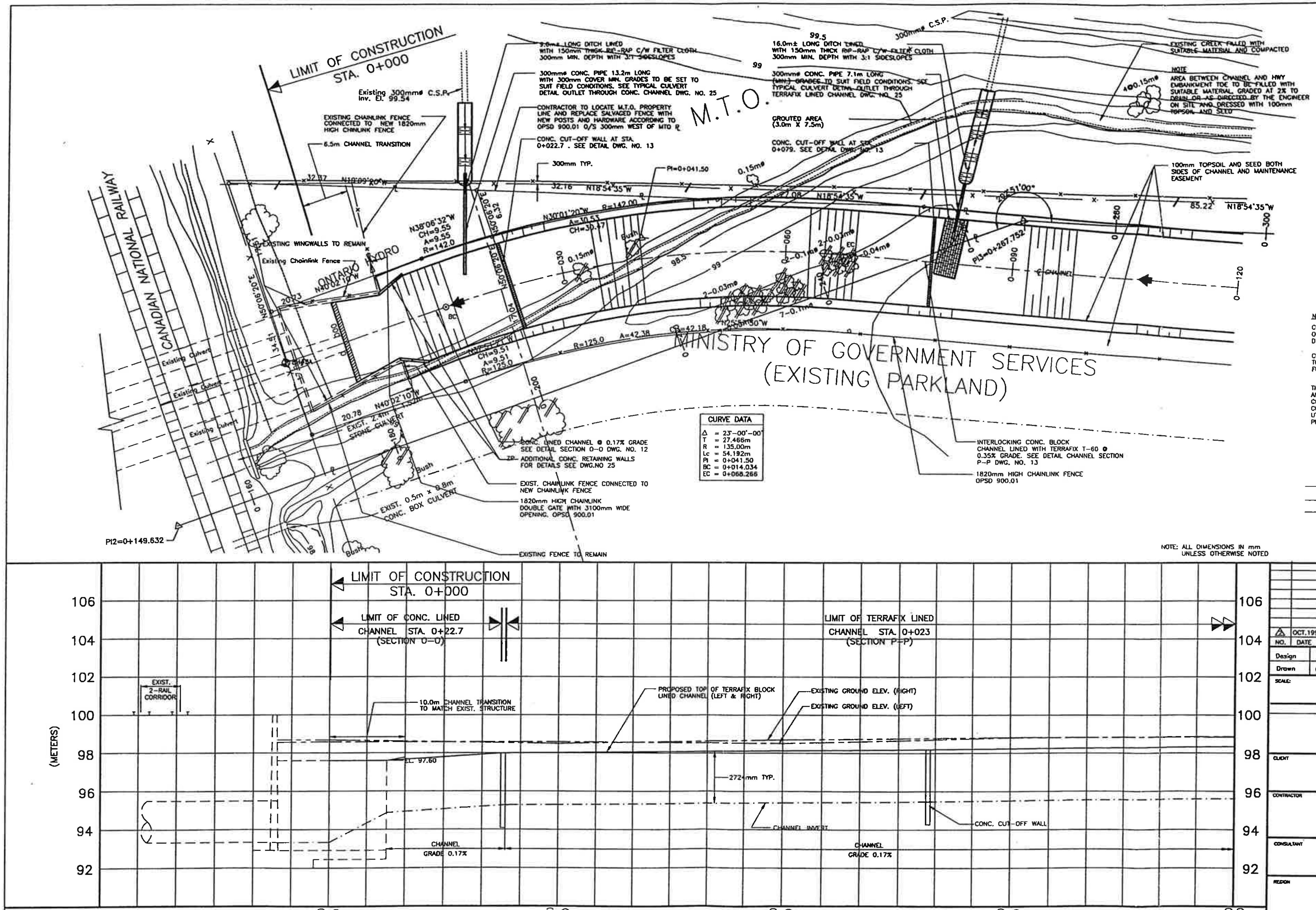
The site is situated between the QEW Toronto-bound lanes and Leighland Park, extending north from the CNR Halton crossing to the Freeman Detention Facility outlet.

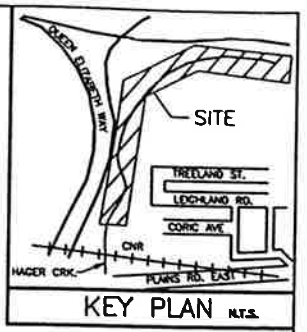


KEY PLAN N.T.S.

6.3 Design Objectives and Criteria

Channel works were designed to the controlled Regional event, future land use peak flow of 48 m^3/s, regulated by the existing Freeman Detention Facility (reference Section 7) based on the capacity of the existing Fairview Street culvert.





EXISTING GROUND ELEVATIONS AT 7.0m EACH SIDE OF CENTERLINE	RIGHT LEFT	98.68(RT.) 98.58(LT.)			98.50(RT.) 98.59(LT.)	98.70(RT.) 98.51(LT.)		98.82(RT.) 98.80(LT.)	98.84(RT.) 98.84(LT.)
PROPOSED TOP OF CONC. OR TERRAFIX BLOCK LINED CHANNEL (LEFT & RIGHT)		97.75 (RT.& LT.)	97.600 (RT.& LT.)	97.998 (RT.& LT.)	98.024 (RT.& LT.)	98.129 (RT.& LT.)	98.195 (RT.& LT.)	98.234 (RT.& LT.)	98.339 (RT.& LT.)
PROPOSED CHANNEL INVERT		93.450	95.251	95.274	95.300	95.405	95.471	95.510	95.615
PROPOSED ℄ CHANNEL CHAINAGE		0+000	0+007.5	0+022.7	0+030	0+060	0+079	0+090	0+120
℄ CHAINAGE	0+148	0+178			0+208	0+238		0+268	0+298

NOTE

CONSTRUCTION ACCESS WILL BE FROM EAST SIDE OF CHANNEL ONLY. WEST OF CHANNEL TO BE DISTURBED FOR GRADING ONLY

CONTRACTOR TO PLACE 1 STRIP OF SOD ALONG TOP OF TERRAFIX AND CONCRETE CHANNEL FOR FULL LENGTH, BOTH SIDES.

THE LOCATION OF UTILITES IS APPROXIMATE ONLY AND EXACT LOCATION SHOULD BE DETERMINED BY CONSULTING UTILITY COMPANY CONCERNED. THE CONTRACTOR SHOULD PROVE THE LOCATION OF THE UTILITIES AND BE RESPONSIBLE FOR ADEQUATE PROTECTION FROM DAMAGE DURING CONSTRUCTION.

LEGEND

- — - — — GROUND ELEV. LEFT
- — - - — GROUND ELEV. RIGHT
- — - —— GROUND ELEV. LEFT & RIGHT
- // REMOVAL
- ◀ DIRECTION OF FLOW

NO.	DATE	BY	REVISIONS	MAN	CAD
△	OCT.1992	K.R.K.	AS CONSTRUCTED		✓

Design	B.J.B.	Ch'kd	K.R.D.	DATE APR. 1991
Drawn	C.D.A.	Ch'kd	P.S.M.	

SCALE: HORIZ N.T.S.
VERT N.T.S.

REFERENCES

APPROVALS

FIELD NOTES L.B. 1512

CLIENT

STAMP

STAMP

CONTRACTOR

CONSULTANT Philips Planning + Engineering Limited

REGION

HALTON REGION CONSERVATION AUTHORITY

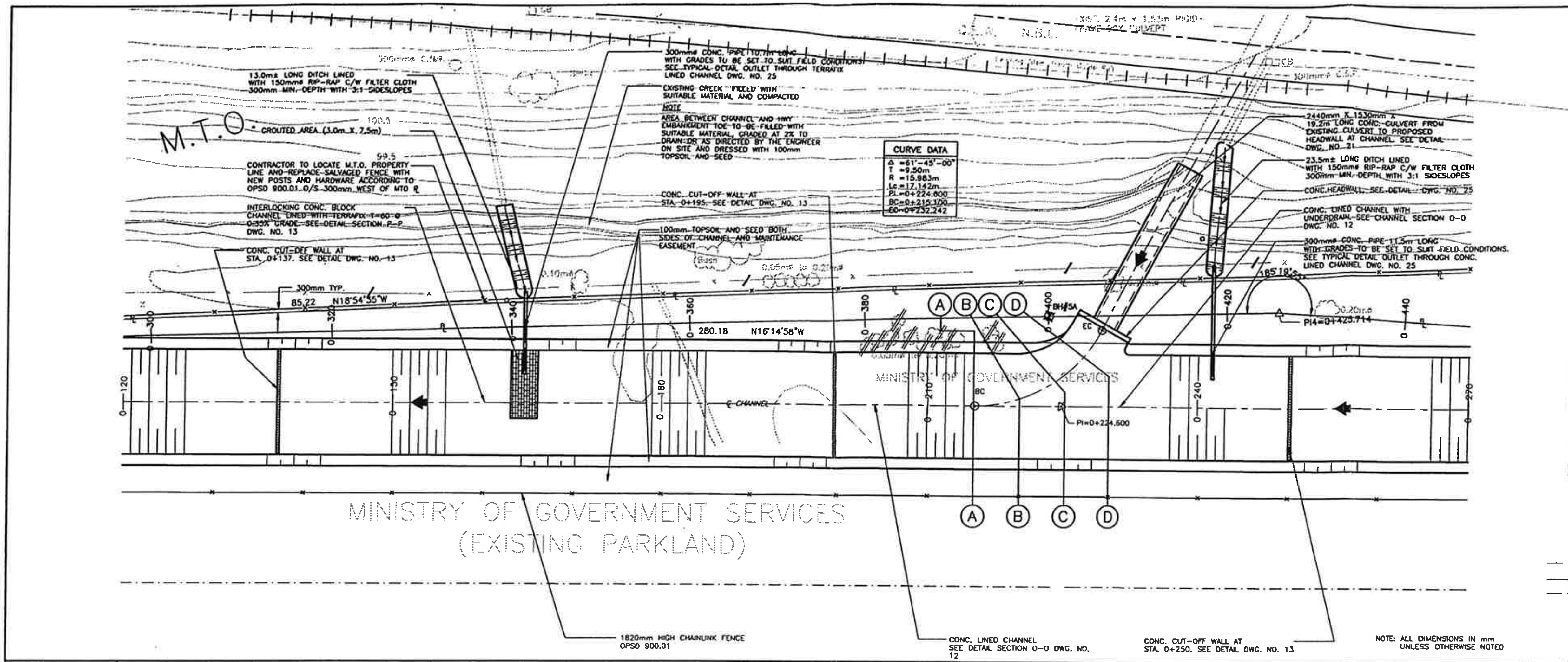
TITLE

HAGER RAMBO
FLOOD CONTROL
CNR TO FREEMAN POND

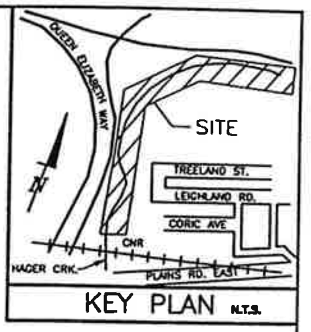
PLAN AND PROFILE
0+000 TO 0+120

CONTRACT NO 84071-0

SHEET 2 OF 28



NOTE: ALL DIMENSIONS IN mm UNLESS OTHERWISE NOTED



KEY PLAN N.T.S.

NOTE

CONSTRUCTION ACCESS WILL BE FROM EAST SIDE OF CHANNEL ONLY. WEST OF CHANNEL TO BE DISTURBED FOR GRADING ONLY

CONTRACTOR TO PLACE 1 STRIP OF SOD ALONG TOP OF TERRAFIX AND CONCRETE CHANNEL FOR FULL LENGTH, BOTH SIDES.

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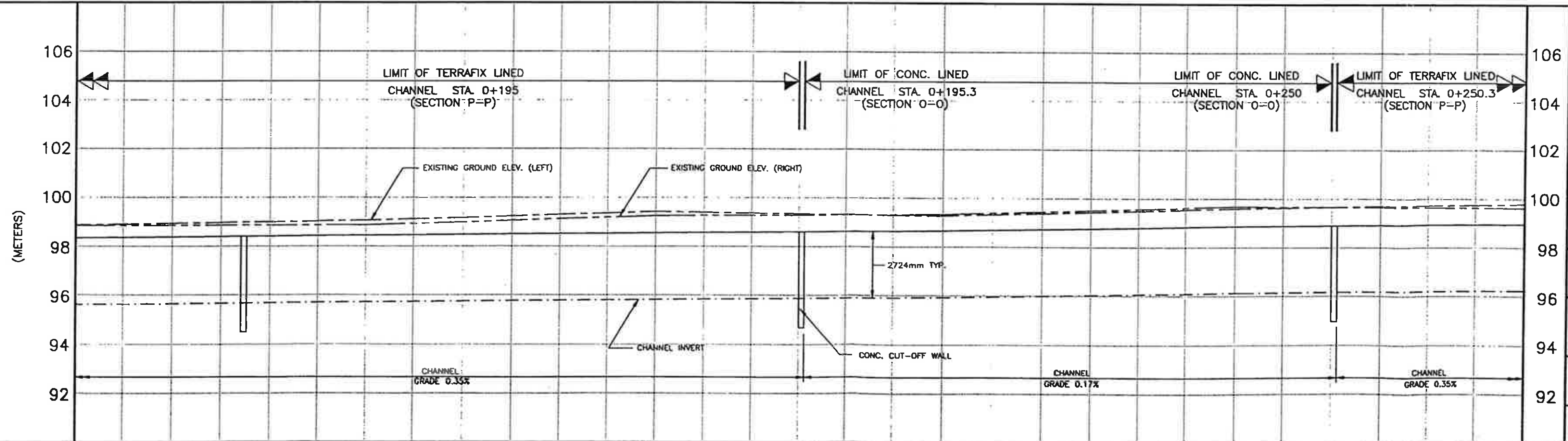
LEGEND

— - —— - —	GROUND ELEV. LEFT
—— - - ——	GROUND ELEV. RIGHT
— - ———	GROUND ELEV. LEFT & RIGHT
//	REMOVAL
◀	DIRECTION OF FLOW



EXISTING GROUND ELEVATIONS AT 7.0m EACH SIDE OF CENTERLINE	98.84(RT.) 98.87(LT.)	98.87(RT.) 99.06(LT.)	99.25(RT.) 99.42(LT.)	99.33(RT.) 99.27(LT.)	99.67(RT.) 99.59(LT.)	99.63(RT.) 99.79(LT.)
PROPOSED TOP OF CONC. OR TERRAFIX BLOCK LINED CHANNEL (LEFT & RIGHT)	98.339 (LT.& RT.)	98.444 (LT.& RT.)	98.549 (LT.& RT.)	98.654 (LT.& RT.)	98.859 (LT.& RT.)	98.964 (LT.& RT.)
PROPOSED CHANNEL INVERT	95.615	95.720	95.825	95.900 ← SEE DWG. NO. 6 FOR DETAIL PROFILE	→ 96.154	96.240
PROPOSED ℄ CHANNEL CHAINAGE	0+120	0+150	0+180	0+210	0+240	0+270
℞ CHAINAGE	0+298	0+328	0+358	0+388	0+418	0+448

NO.	DATE	BY	REVISIONS	MAN	CAD
△	OCT.1992		AS CONSTRUCTED		✓
△	20-06-91	B.J.B.	INV.& SIZE OF CULVERT REVISED	✓	

Design	B.J.B.	Ch'kd	K.R.D.	DATE APR. 1991
Drawn	C.D.A.	Ch'kd	P.S.M.	

SCALE: HORIZ N.T.S. VERT N.T.S.

REFERENCES

APPROVALS

FIELD NOTES L.B. 1512

CLIENT

STAMP

STAMP

CONTRACTOR

CONSULTANT

+ Philips Planning Engineering Limited

REGION

HALTON REGION CONSERVATION AUTHORITY

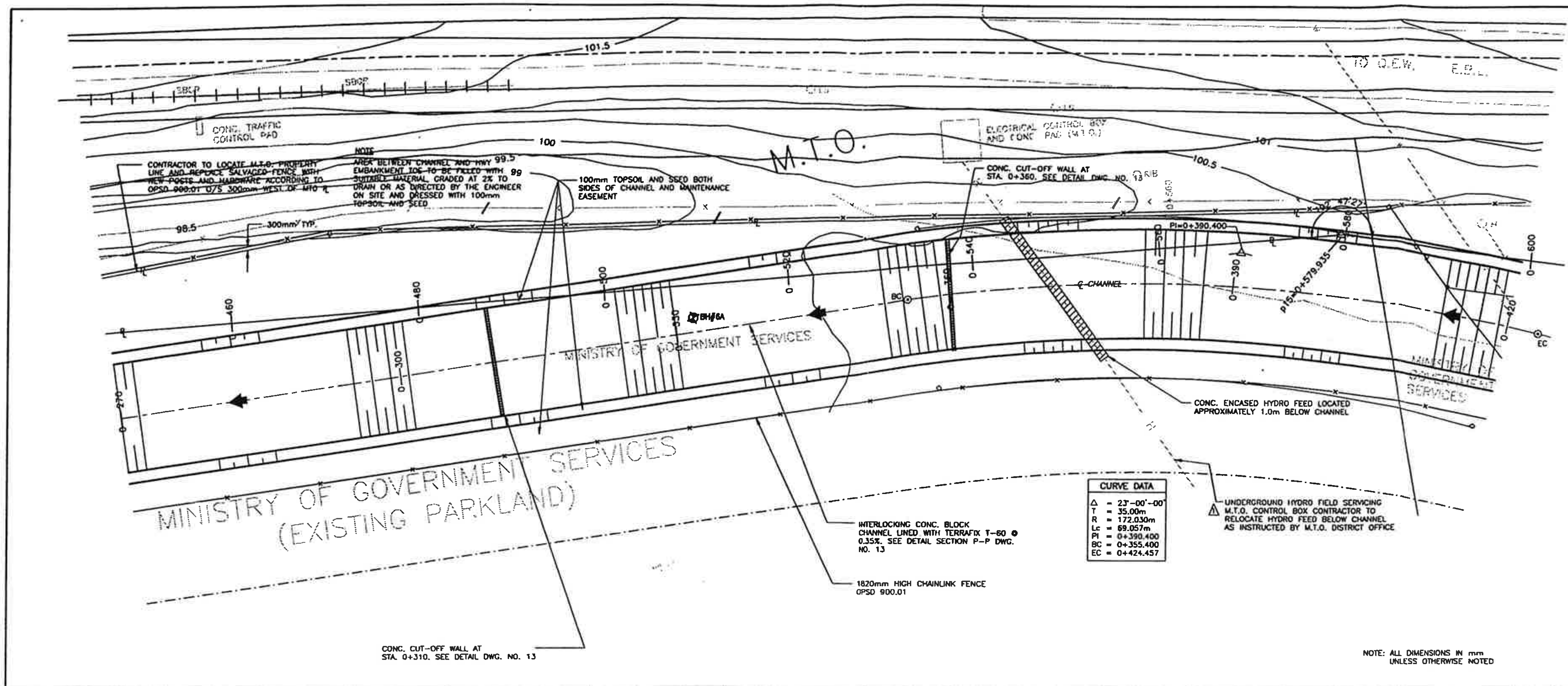
TITLE

HAGER RAMBO
FLOOD CONTROL
CNR TO FREEMAN POND

PLAN AND PROFILE
0+120 TO 0+270

CONTRACT NO 84071-D

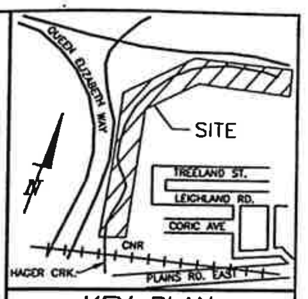
SHEET 3 OF 28



CURVE DATA

Δ = 23°-00'-00"
T = 35.00m
R = 172.030m
Lc = 69.057m
PI = 0+390.400
BC = 0+355.400
EC = 0+424.457

NOTE: ALL DIMENSIONS IN mm UNLESS OTHERWISE NOTED



KEY PLAN N.T.S.

NOTE

CONSTRUCTION ACCESS WILL BE FROM EAST SIDE OF CHANNEL ONLY. WEST OF CHANNEL TO BE DISTURBED FOR GRADING ONLY

CONTRACTOR TO PLACE 1 STRIP OF SOD ALONG TOP OF TERRAFIX AND CONCRETE CHANNEL FOR FULL LENGTH, BOTH SIDES.

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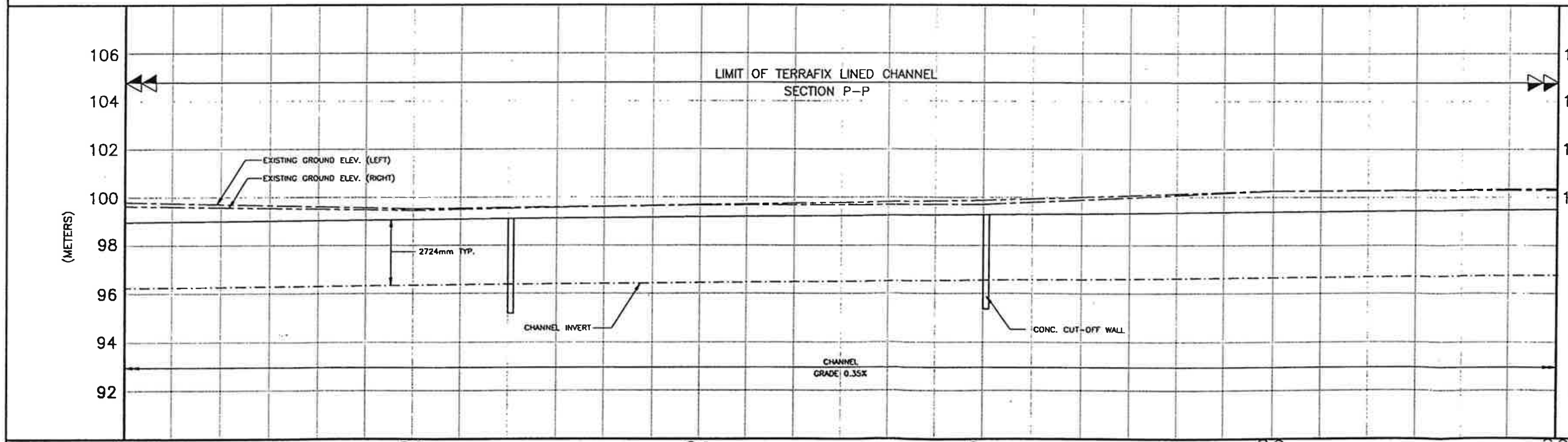
LEGEND

—·—·—	GROUND ELEV. LEFT
—--—--—	GROUND ELEV. RIGHT
—-—-—-	GROUND ELEV. LEFT & RIGHT
//	REMOVAL
◀	DIRECTION OF FLOW



EXISTING GROUND ELEVATIONS AT 7.0m EACH SIDE OF CENTERLINE	99.63(RT.) 99.79(LT.)	99.45(RT.) 99.52(LT.)	99.68(RT.) 99.66(LT.)	99.87(RT.) 99.70(LT.)	100.26(RT.) 100.26(LT.)	100.29(RT.) 100.35(LT.)
PROPOSED TOP OF CONC. OR TERRAFIX BLOCK LINED CHANNEL (LEFT & RIGHT)	98.964 (RT.& LT.)	99.069 (RT.& LT.)	99.174 (RT.& LT.)	99.279 (RT.& LT.)	99.384 (RT.& LT.)	99.489 (RT.& LT.)
PROPOSED CHANNEL INVERT	96.240	96.345	96.450	96.555	96.660	96.765
PROPOSED ℄ CHANNEL CHAINAGE	0+270	0+300	0+330	0+360	0+390	0+420
℄ CHAINAGE	0+448	0+478	0+508	0+538	0+568	0+598

NO.	DATE	BY	REVISIONS	MAN	CAD
2	OCT.1992	K.R.K.	AS CONSTRUCTED		✓
1	20-06-91	B.J.B.	NOTE TO RELOCATE HYDRO FEED	✓	

Design	B.J.B.	Ch'kd	K.R.D.
Drawn	C.D.A.	Ch'kd	P.S.M.

DATE
APR. 1991

SCALE:
HORIZ N.T.S.
VERT N.T.S.

REFERENCES

APPROVALS

FIELD NOTES
L.B. 1512

CLIENT

STAMP

CONTRACTOR

STAMP

CONSULTANT
+ Philips Planning Engineering Limited

REGION

HALTON REGION
CONSERVATION AUTHORITY

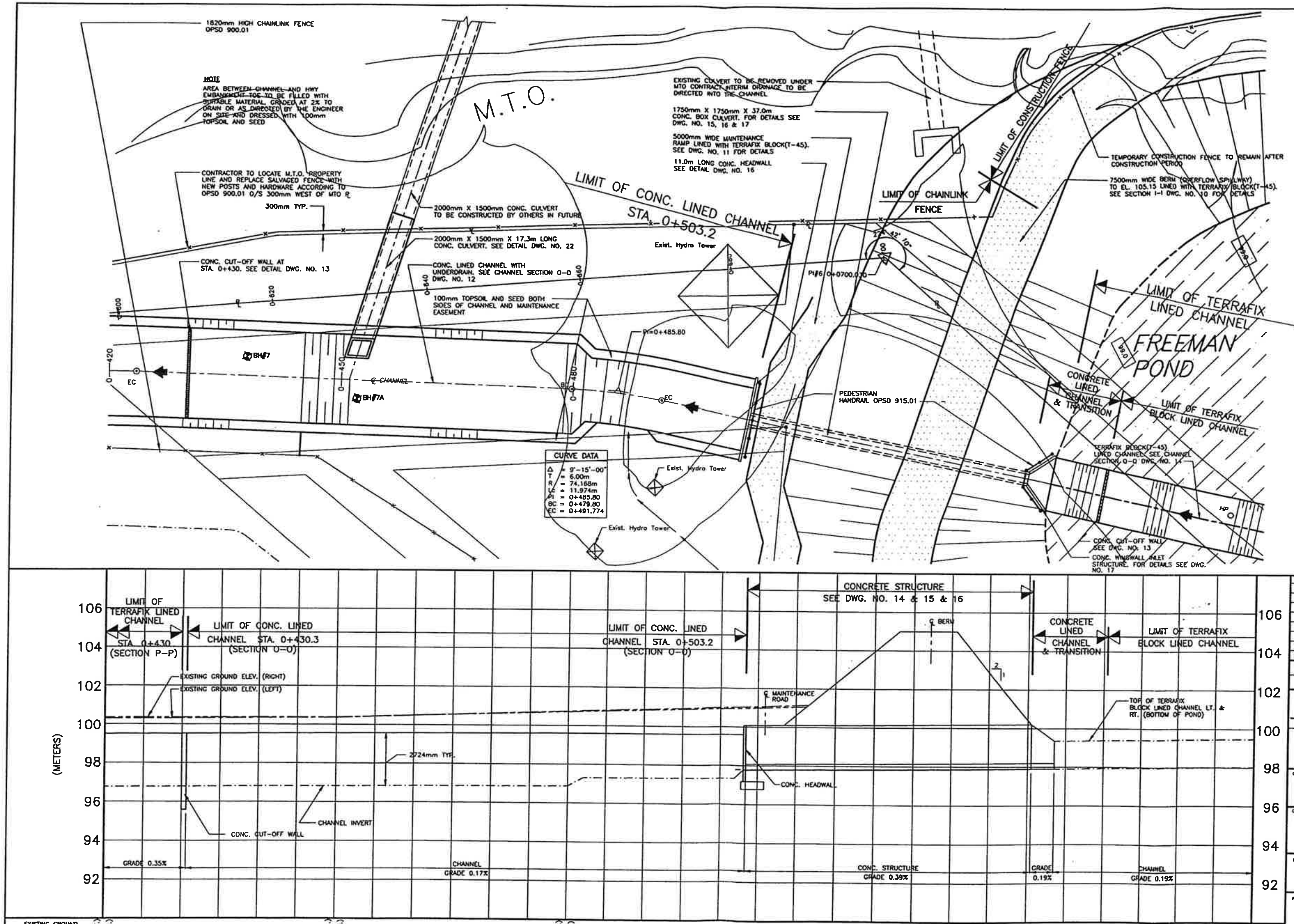
TITLE

HAGER RAMBO
FLOOD CONTROL
CNR TO FREEMAN POND

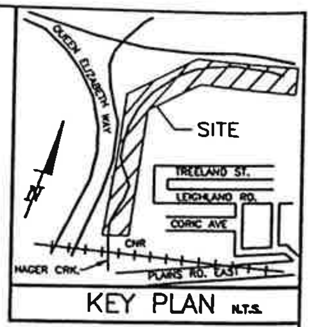
PLAN AND PROFILE
0+270 TO 0+420

CONTRACT NO
84071-0

SHEET 4 OF 28



EXISTING GROUND ELEVATIONS AT 7.0m EACH SIDE OF CENTERLINE	100.29(RT.) 100.35(LT.)	100.22(RT.) 100.32(LT.)	100.60(RT.) 100.65(LT.)				
PROPOSED TOP OF CONC. OR TERRAFIX BLOCK LINED CHANNEL (LEFT & RIGHT)	99.489 (RT.& LT.)	99.554 (RT.& LT.)	99.599 (RT.& LT.) 99.800 (RT.& LT.)		1750mm X 1750mm X 37.0m LONG CONC. BOX CULVERT	CONC. WINGWALLS INLET STRUCTURE	
PROPOSED CHANNEL INVERT	96.765	98.830	98.875 97.305	97.335 97.750		97.896 97.905	97.855
PROPOSED ℄ CHANNEL CHAINAGE	0+420	0+450	0+480 0+482	0+502 0+503.30	0+510	0+540.50 0+543.50	0+570
℞ CHAINAGE	0+598	0+628	0+658		0+688	0+718	0+748



KEY PLAN N.T.S.

NOTE

CONSTRUCTION ACCESS WILL BE FROM EAST SIDE OF CHANNEL ONLY. WEST OF CHANNEL TO BE DISTURBED FOR GRADING ONLY

CONTRACTOR TO PLACE 1 STRIP OF SOD ALONG TOP OF TERRAFIX AND CONCRETE CHANNEL FOR FULL LENGTH, BOTH SIDES.

THE LOCATION OF UTILITES IS APPROXIMATE ONLY AND EXACT LOCATION SHOULD BE DETERMINED BY CONSULTING UTILITY COMPANY CONCERNED. THE CONTRACTOR SHOULD PROVE THE LOCATION OF THE UTILITIES AND BE RESPONSIBLE FOR ADEQUATE PROTECTION FROM DAMAGE DURING CONSTRUCTION.

NOTE: ALL DIMENSIONS IN mm
UNLESS OTHERWISE NOTED

LEGEND

—— - —— - ——	GROUND ELEV. LEFT
— — —— — — —	GROUND ELEV. RIGHT
—— — —— — — —	GROUND ELEV. LEFT & RIGHT
//	REMOVAL
◀	DIRECTION OF FLOW
99.0	BOTTOM OF POND SPOT ELEV.

NO.	DATE	BY	REVISIONS	MAN	CAD
△	OCT.1992	K.R.K.	AS CONSTRUCTED		✓

Design B.J.B. Ch'kd K.R.D.
Drawn C.D.A. Ch'kd P.S.M.
DATE APR. 1991
SCALE: HORIZ N.T.S.
VERT N.T.S.
REFERENCES
APPROVALS
FIELD NOTES L.B. 1512
CLIENT
STAMP
STAMP
CONTRACTOR
CONSULTANT
+ Philips Planning Engineering Limited
REGION

HALTON REGION
CONSERVATION AUTHORITY

TITLE

HAGER RAMBO
FLOOD CONTROL
CNR TO FREEMAN POND

PLAN AND PROFILE
0+420 TO 0+510

CONTRACT NO 84071-D
SHEET 5 OF 28

6.5 Photographic Reconnaissance

Photo 6.1 - Looking downstream from station 0+300 towards the CNR Halton crossing.

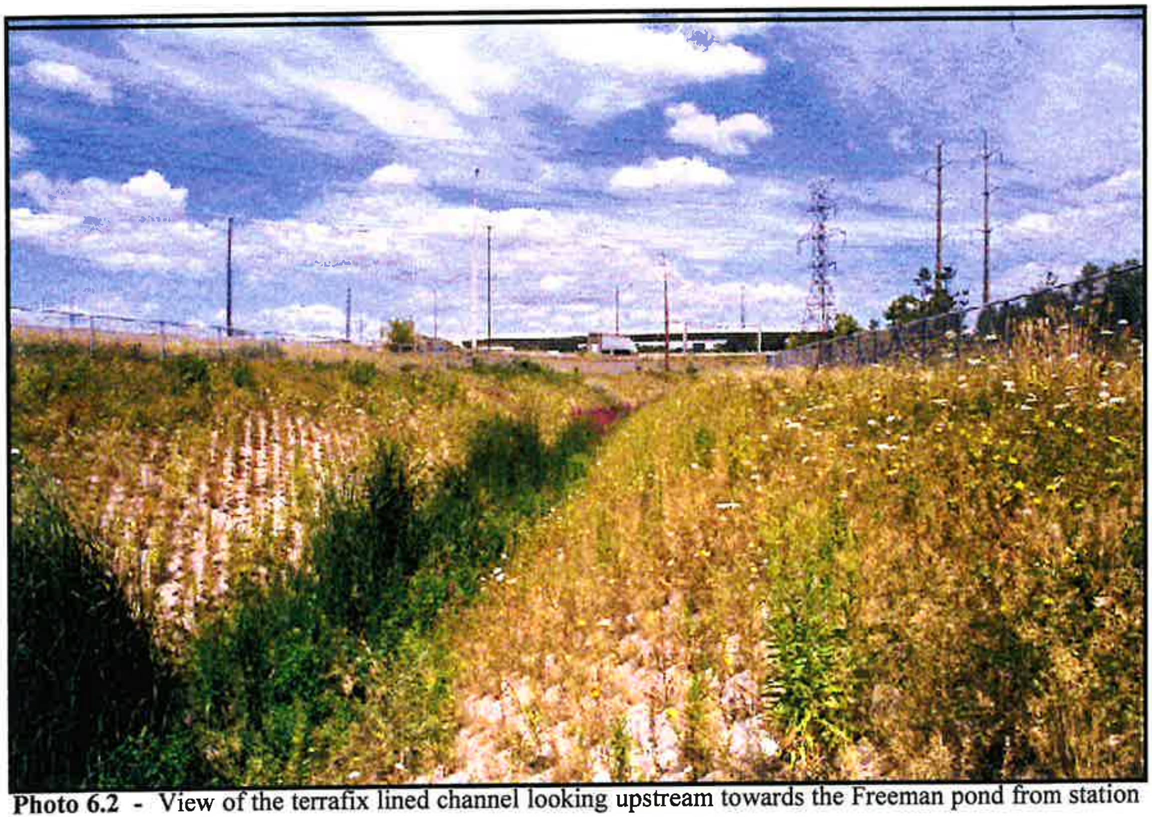


Photo 6.2 - View of the terrafix lined channel looking upstream towards the Freeman pond from station 0+300. This vegetation growth through the terrafix block is typical throughout.

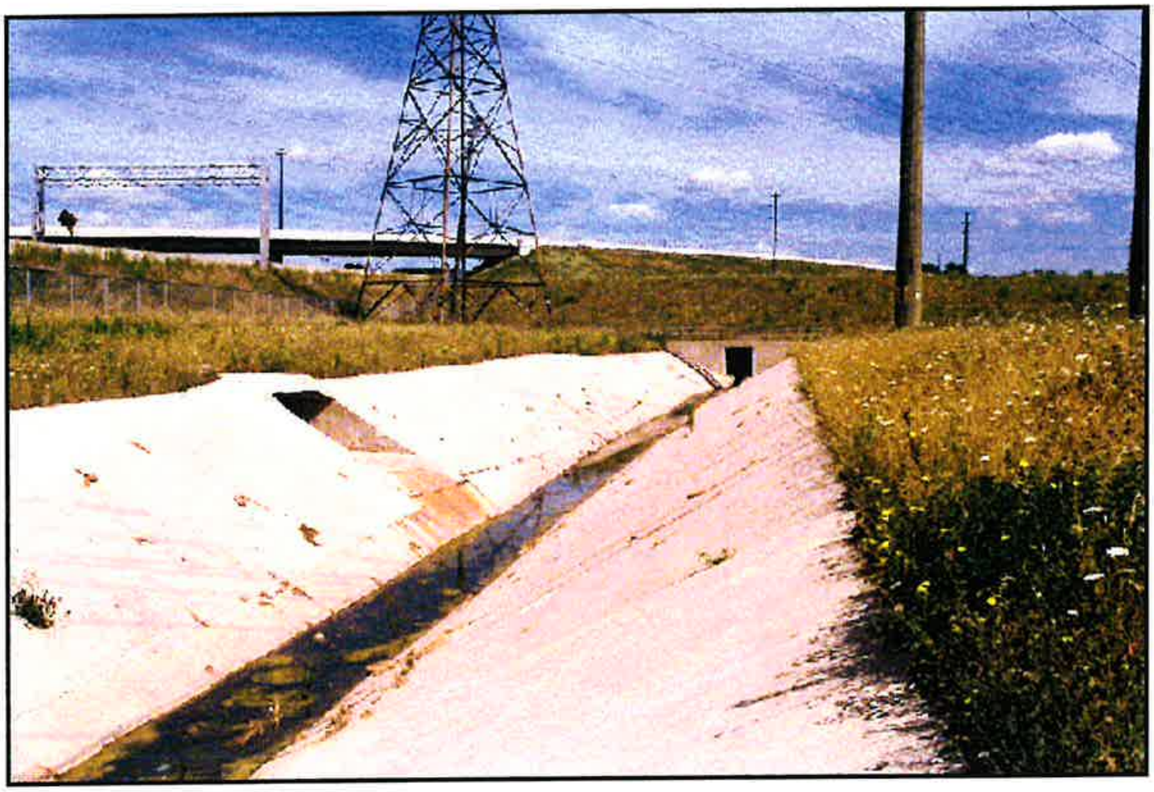


Photo 6.3 - Looking upstream at the concrete channel section and outlet culvert. Note the vegetation growing out of the drainage pipes.

Photo 6.4 - Looking downstream at the concrete to terrafix block channel transition from the top of berm above the outlet culvert.

6.6 Operations and Maintenance

6.6.1 Ownership Status

The Halton Region Conservation Authority has title to the portion of the channel from the CNR crossing to the northerly limit of Leighland Park. This land is approximately 20 metres wide from the centreline of the channel and 480 metres in length. (Reference Appendix A)

6.6.2 Project Ingress and Egress

The site is accessible through the double gated entrance to the Freeman Pond, located on the west side of Brant Street just south of the QEW. An access road through the Ontario Hydro right-of-way on the south side of the berm leading to the outlet culvert, with a 3 metre wide access road running along the east side of the channel to the CNR Halton crossing. (There is no direct access ramp to the invert, but it is possible to reach from the access road) The site is enclosed by a 1.8 metre chainlink fence with gated access facilitated by Key No. 18, available through the Halton Region Conservation Authority (905-336-1158).

6.6.3 Project Element Maintenance

Reference Appendix B for a summary table of standard component elements of the project, along with the frequency of inspection and the methods of remediation.

Site Reconnaissance

In order to ensure the normal operation of the channel under the range of expected flow conditions, a "walk through" of the works should be carried out at least once a year. A detailed inspection of the works recording the location and types of any deficiencies, along with photographs should be carried out every five years. Information thusly collected should be catalogued and added to this manual.

Interlocking Concrete Block Channel

During the annual inspection, the interlocking concrete block (Terrafix ^{TM}) should be checked for any displacement, bulging, or heaving. The blocks should be checked to ensure that they are embedded or covered with native material (soil) and that vegetation is growing through the spaces to allow for additional stability. Any sections that may be damaged or missing blocks, should be replaced and the channel should be kept clear of any debris that may inhibit the function of the channel. The underdrain system should also be inspected for any blockage of sediment or vegetation by continually monitoring the systems effectiveness and by probing the pipe.

General/Ingress/Egress

Vegetation or debris that may be obstructing the concrete channel invert, drainage or outlet pipes, or growing through the channel invert should be removed. Invasive species such as Purple Loosestrife that are present in the channel should be removed prior to pollination by manually digging or pulling the plants and roots, or by biological or chemical control. Locations for access to the channel should remain clear of any obstructions (tall/thick vegetation). The locks and gates should be checked twice a year to ensure easy access under normal or emergency conditions.

7. Freeman Detention Facility and East Hager Creek Channelization

7.1 Project Title and Year of Construction

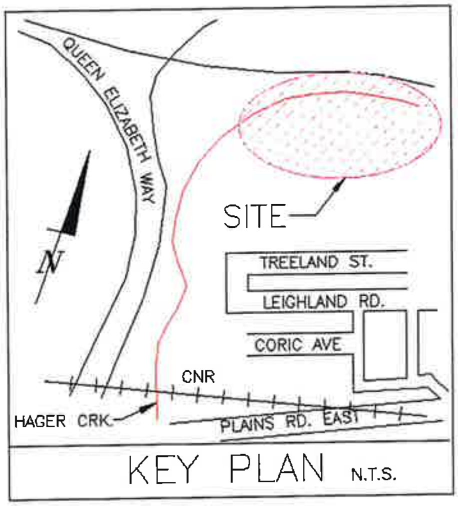
East Hager Creek Channelization
- Freeman Detention Facility

Construction completed in October 1995

The pond construction involved earth excavation of a 45,000 m^3 and earth borrow of 105,000 m^3 to build the berm and highway embankments. This project also required the placement of a culvert for the Freeman Facility outlet, and accompanying concrete transition sections. Through the Freeman Detention Facility, a 244 metre long interlocking concrete block (Terrafix ^{TM}) lined low flow channel, and a 32 metre long concrete low flow transition channel, both 7 metres wide were constructed. A 5.05 x 5.05 metre culvert and channel through from the Upper Freeman Pond (volumc storage of 5.06 ha-m) were constructed to convey flows from the North Service Road Pond System.

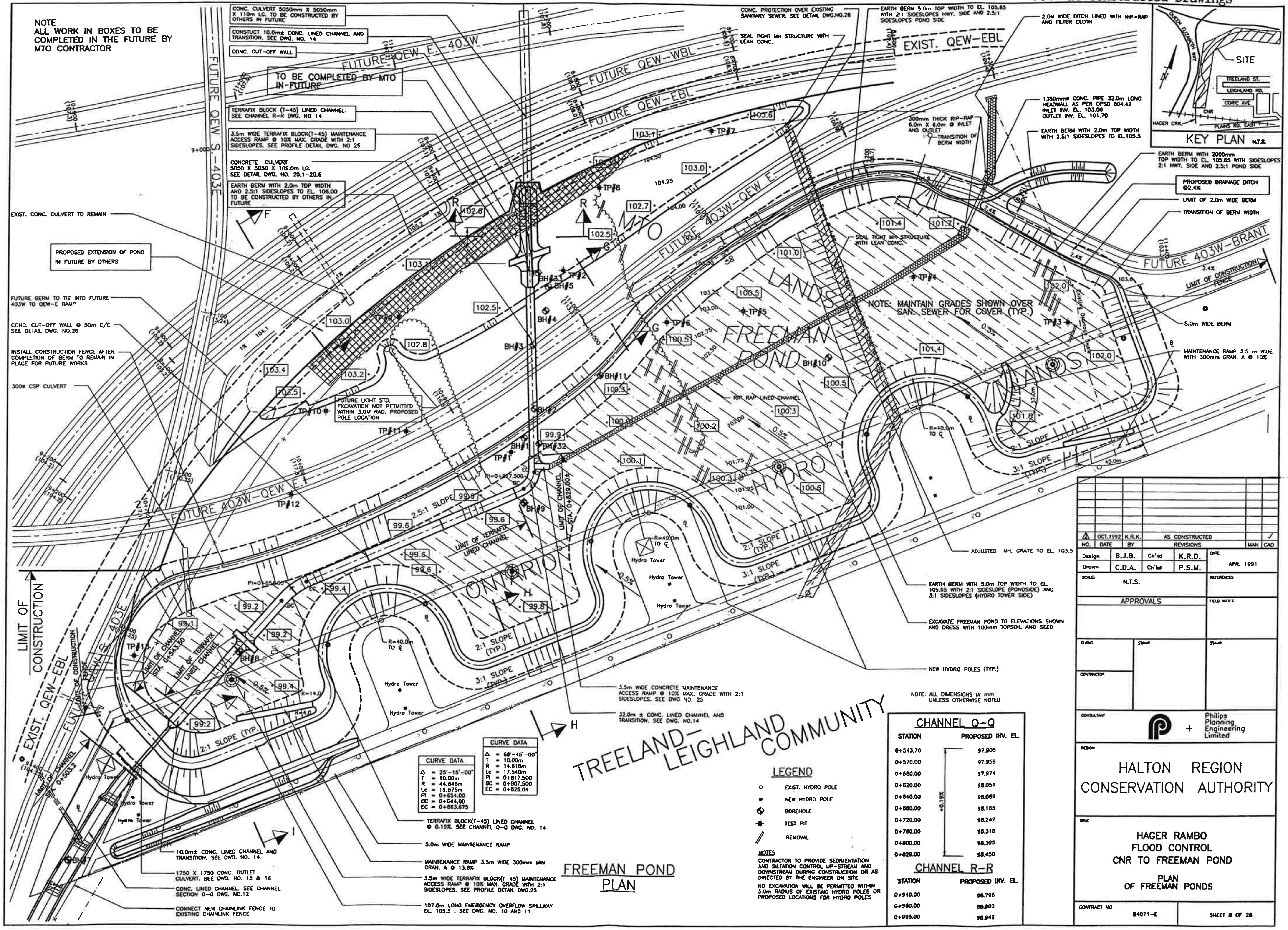
7.2 Project Location

The Freeman Detention Facility is located west of Brant Street, enclosed by the QEW/403 Interchange embankment to the north and west, and the Treeland-Leighland community to the south.



7.3 Design Objectives and Criteria

The Freeman Storage Facility was designed as a “dry facility” with a low flow channel to provide flood storage of 27 ha-m for the Regional event to an elevation of 105.4 metres, allowing a 0.3 metre freeboard to the top of the berm. This design has been implemented to control the downstream channel flow to 48.0 m^3/s based on the capacity of the Fairview Street culvert.



CURVE DATA
Δ = 25°-15'-00"
T = 10.00m
R = 44.646m
Lc = 19.675m
PI = 0+654.00
BC = 0+644.00
EC = 0+663.675

CURVE DATA
Δ = 68°-45'-00"
T = 10.00m
R = 14.618m
Lc = 17.540m
PI = 0+817.500
BC = 0+807.500
EC = 0+825.04

FREEMAN POND PLAN

NOTE: ALL DIMENSIONS IN mm UNLESS OTHERWISE NOTED

LEGEND

○	EXIST. HYDRO POLE
●	NEW HYDRO POLE
⊕	BOREHOLE
✦	TEST PIT
//	REMOVAL

NOTES

CONTRACTOR TO PROVIDE SEDIMENTATION AND SILTATION CONTROL UP-STREAM AND DOWNSTREAM DURING CONSTRUCTION OR AS DIRECTED BY THE ENGINEER ON SITE

NO EXCAVATION WILL BE PERMITTED WITHIN 3.0m RADIUS OF EXISTING HYDRO POLES OR PROPOSED LOCATIONS FOR HYDRO POLES

CHANNEL Q–Q

STATION		PROPOSED INV. EL.
0+543.70	+0.19%	97.905
0+570.00		97.955
0+580.00		97.974
0+620.00		98.051
0+640.00		98.089
0+680.00		98.165
0+720.00		98.242
0+760.00		98.318
0+800.00		98.395
0+829.00		98.450

CHANNEL R–R

STATION	PROPOSED INV. EL.
0+940.00	98.796
0+980.00	98.902
0+995.00	98.942

NO.	DATE	BY	REVISIONS	MAN	CAD
△	OCT.1992	K.R.K.	AS CONSTRUCTED		✓

Design	B.J.B.	Ch'kd	K.R.D.	DATE APR. 1991
Drawn	C.D.A.	Ch'kd	P.S.M.	

SCALE: N.T.S.

REFERENCES

APPROVALS

FIELD NOTES

CLIENT

STAMP

STAMP

CONTRACTOR

CONSULTANT
+ Philips Planning Engineering Limited

REGION
HALTON REGION
CONSERVATION AUTHORITY

TITLE
HAGER RAMBO
FLOOD CONTROL
CNR TO FREEMAN POND

PLAN
OF FREEMAN PONDS

CONTRACT NO 84071-E

SHEET 8 OF 28

7.5 Photographic Reconnaissance

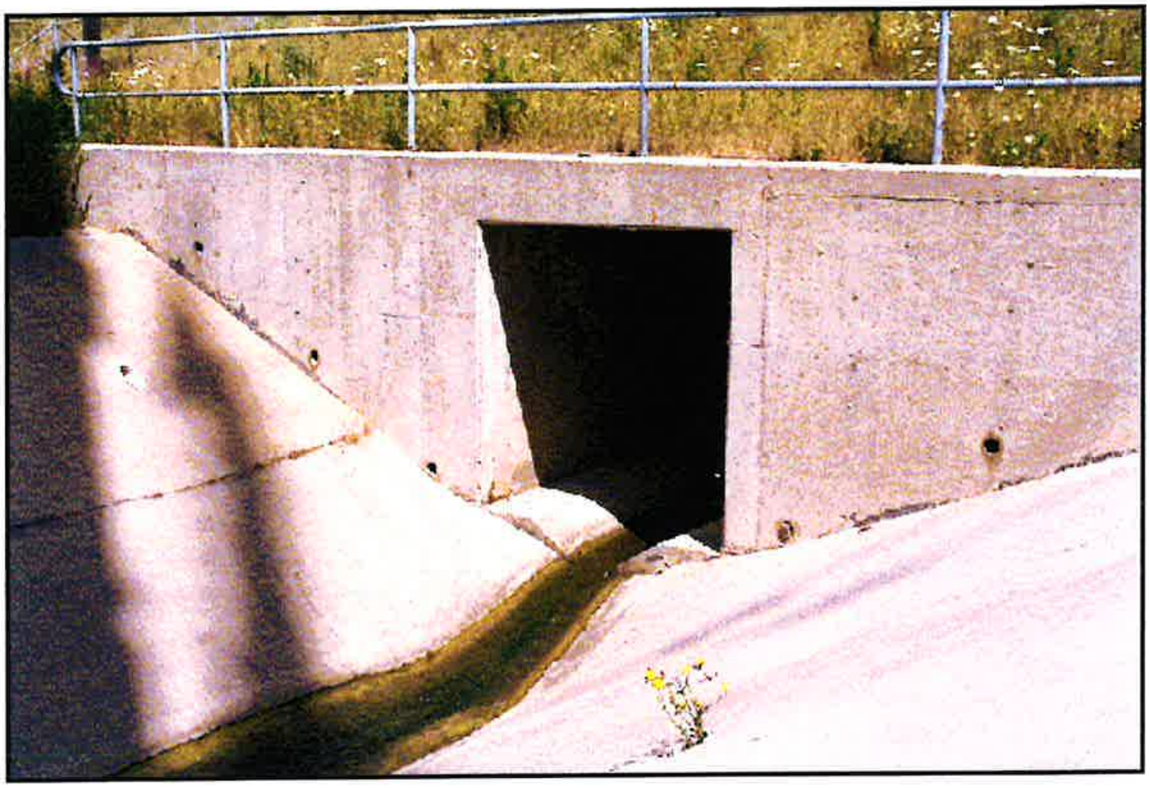


Photo 7.1 - View of the downstream face and transition of the Freeman Pond outlet culvert.

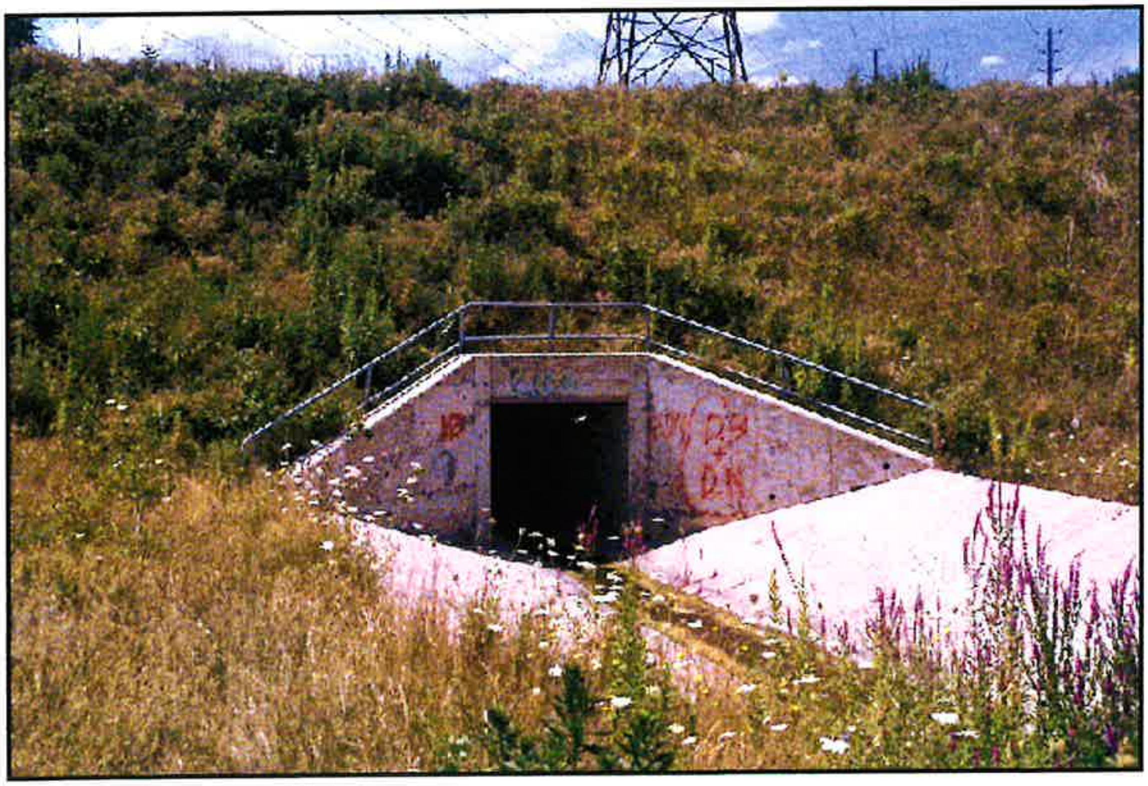


Photo 7.2 - View of the upstream side of the outlet culvert and concrete transition.

Photo 7.3 - Looking upstream at the Freeman Pond System from the berm at the outlet.

Photo 7.4 - Looking downstream from the berm on the south side of the Freeman Pond.

Photo 7.5 - Looking upstream at the pond from from the previous location atop the berm, with the 5.05 x 5.05 metre culvert on the left and the 1350 mm culvert in the centre.

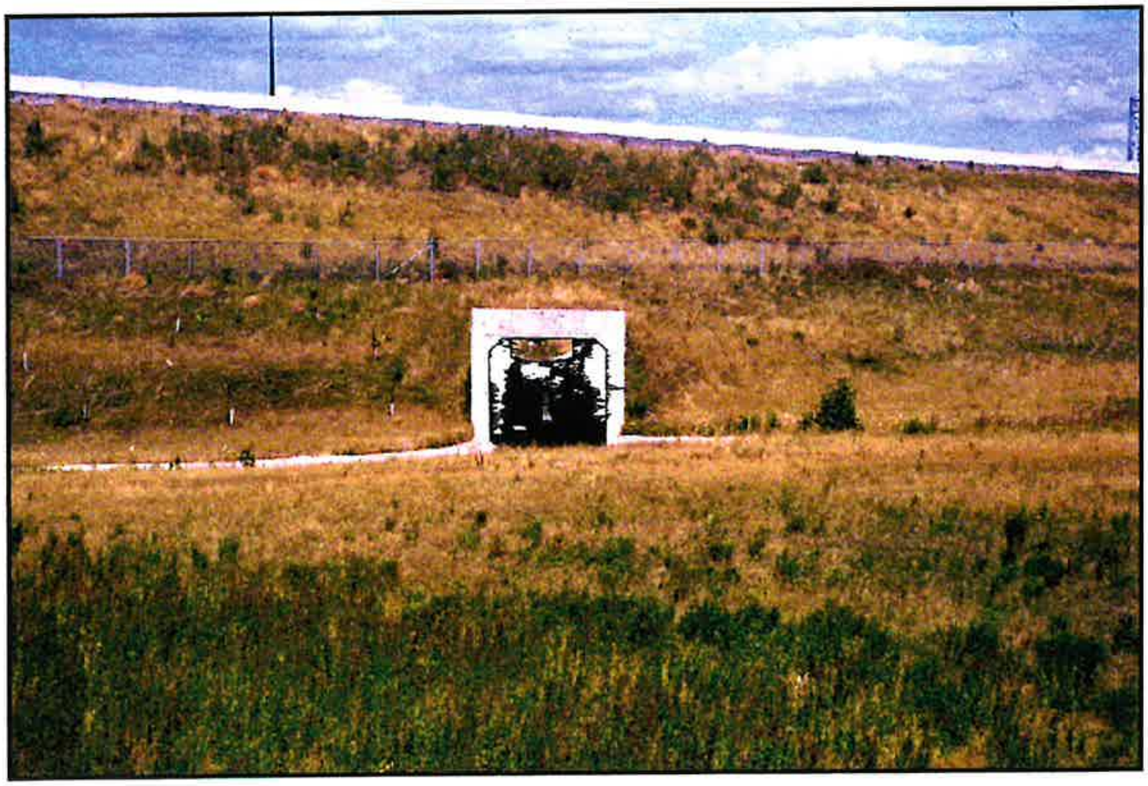


Photo 7.6 - View of the downstream face of the culvert from the Upper Freeman Pond

Photo 7.7 - Downstream face of the 1350 mm concrete pipe extending for 32 metres under the 403 west to Brant Street north/south ramp, at the northeast corner of the site.

Photo 7.8 - Looking downstream at the Freeman Pond from the headwall of the culvert. Note how the Purple Loostrife clearly defines the channel

7.6 Operations and Maintenance

7.6.1 Ownership Status

The Freeman Pond Site is owned by the Ministry of Transportation Ontario, with exception of a 70 metre wide strip of land along the south limit of the site, which is owned by Ontario Hydro, with an easement granted to Burlington Hydro. The Halton Region Conservation Authority also has been granted a License of Occupation for maintenance purposes. (Reference Appendix A)

7.6.2 Project Ingress and Egress

The Freeman Pond System is accessible through a double gated entrance located on the west side of Brant Street just south of the QEW. Access roads along the top and south side of the berm through the Hydro right-of-way and through the pond can be used to reach the channel and culverts. A 1.8 metre chainlink security fence encloses the site with gated access facilitated by Key No. 18, available through the Halton Region Conservation Authority (905-336-1158).

7.6.3 Project Element Maintenance

Reference Appendix B for a summary table of standard component elements of the project, along with the frequency of inspection and the methods of remediation.

Site Reconnaissance

In order to ensure the normal operation of the "dry" storm water management pond under the range of expected flow conditions, a "walk through" inspection of the works should be carried out at least once a year. A detailed inspection of the works recording the location and types of any deficiencies, along with photographs should be carried out every five years. Information thusly collected should be catalogued and added to this manual.

Interlocking Concrete Block Channel

During the annual inspection, the interlocking concrete block should be checked for any displacement, bulging, or heaving. The blocks should be checked to ensure that they are embedded or covered with native material (soil) and that vegetation is growing through the spaces to allow for additional stability. Any sections that may be damaged or missing blocks should be replaced and the channel should be kept clear of any debris that may inhibit that function of the channel. The underdrain system should also be inspected for any blockage of sediment or vegetation by continually monitoring the systems effectiveness and by probing the pipe.

Concrete Structures

The concrete inlet and outlet structures within the site should be inspected annually and checked for any minor cracking that may be repaired by sealing or grouting. Any major areas of cracking (> 3mm), displacement, or heaving (> 5 mm), along with the separation of slabs at the expansion, control, or walls joints, requires a thorough investigation by a qualified Structural Engineer, to determine the cause and recommend remedial works.

General/Ingress/Egress

As a storm water management facility, the condition of the berms is an integral part of the system to function properly. The slopes should be checked for stability and any signs of failure. In addition, the outlet control structure should be clear of vegetation and debris. As in the downstream channel, Purple Loosestrife is the dominant species within the channel and should be removed. (Reference Section 6.6.4 General/Ingress/Egress). Vegetation or debris that may be obstructing the culverts, channel invert, drainage or outlet pipes, should be removed. Locations for access to the channel should remain clear of any obstructions (tall/thick vegetation). The locks and gates should be checked twice a year to ensure easy access under normal or emergency conditions.

8. East Hager Creek Realignment and Pond System

8.1 Project Description and Year of Construction

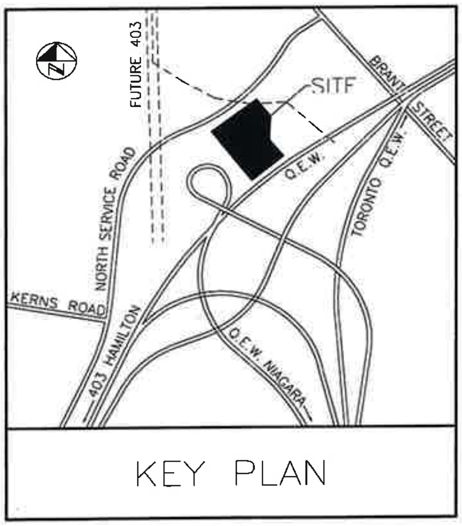
East Hager Creek Realignment and Pond System
- QEW to North Service Road

Construction completed in 1994

The East Hager Creek was realigned through a series of three storm water detention ponds from the North Service Road to the QEW/403 outlet culvert, having a centerline chainage of 225 m. This design allowed for the channel to be lowered by 11 metres over a relatively short distance of 110 metres, while enhancing the efficiency of the system to control downstream flows entering the Freeman Detention Facility.

8.2 Project Location

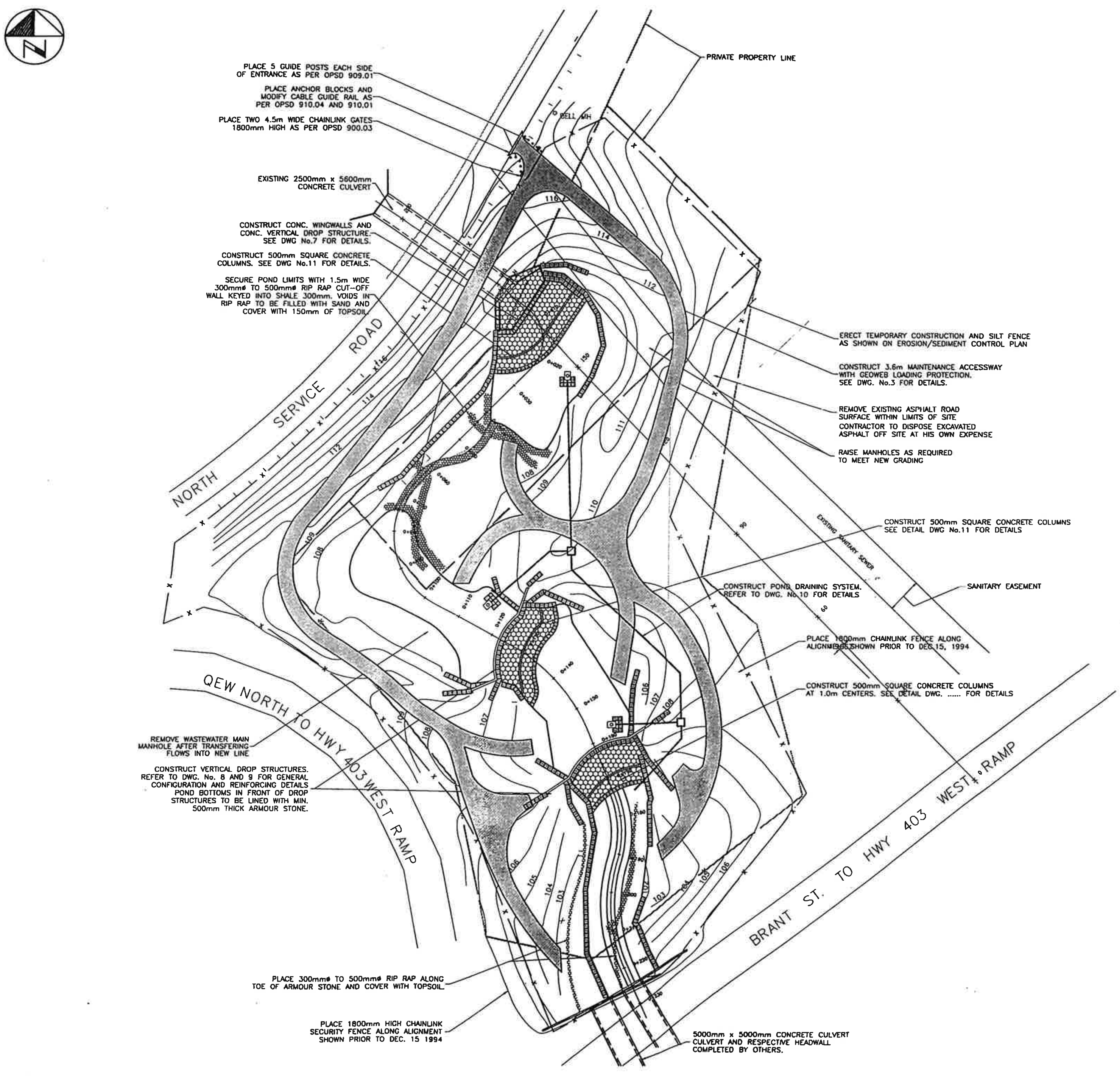
The project site is located between the North Service Road and the QEW Niagara lanes, east of the QEW northbound ramp to the 403 westbound lanes, approximately 300 metres west of Brant Street.



8.3 Design Objectives and Criteria

The channel and pond system was designed to accommodate the 100 year future land use event of 72 m^3/s. The invert elevation of the North Service Road culvert is 111.2 metres, and is lowered to 100.3 metres at the QEW/403 outlet culvert of the system. While allowing for hydraulic conveyance, the ponds also provide a sediment removal and water quality enhancement function.

8.4 As Constructed Drawings



PLACE 5 GUIDE POSTS EACH SIDE OF ENTRANCE AS PER OPSD 909.01

PLACE ANCHOR BLOCKS AND MODIFY CABLE GUIDE RAIL AS PER OPSD 910.04 AND 910.01

PLACE TWO 4.5m WIDE CHAINLINK GATES 1800mm HIGH AS PER OPSD 900.03

EXISTING 2500mm x 5600mm CONCRETE CULVERT

CONSTRUCT CONC. WINGWALLS AND CONC. VERTICAL DROP STRUCTURE. SEE DWG No.7 FOR DETAILS.

CONSTRUCT 500mm SQUARE CONCRETE COLUMNS. SEE DWG No.11 FOR DETAILS.

SECURE POND LIMITS WITH 1.5m WIDE 300mmø TO 500mmø RIP RAP CUT-OFF WALL KEYED INTO SHALE 300mm. VOIDS IN RIP RAP TO BE FILLED WITH SAND AND COVER WITH 150mm OF TOPSOIL.

ERECT TEMPORARY CONSTRUCTION AND SILT FENCE AS SHOWN ON EROSION/SEDIMENT CONTROL PLAN

CONSTRUCT 3.6m MAINTENANCE ACCESSWAY WITH GEOWEB LOADING PROTECTION. SEE DWG. No.3 FOR DETAILS.

REMOVE EXISTING ASPHALT ROAD SURFACE WITHIN LIMITS OF SITE
CONTRACTOR TO DISPOSE EXCAVATED ASPHALT OFF SITE AT HIS OWN EXPENSE

RAISE MANHOLES AS REQUIRED TO MEET NEW GRADING

CONSTRUCT 500mm SQUARE CONCRETE COLUMNS SEE DETAIL DWG No.11 FOR DETAILS

CONSTRUCT POND DRAINING SYSTEM. REFER TO DWG. No.10 FOR DETAILS

SANITARY EASEMENT

PLACE 1800mm CHAINLINK FENCE ALONG ALIGNMENT AS SHOWN PRIOR TO DEC.15, 1994

CONSTRUCT 500mm SQUARE CONCRETE COLUMNS AT 1.0m CENTERS. SEE DETAIL DWG. ...... FOR DETAILS

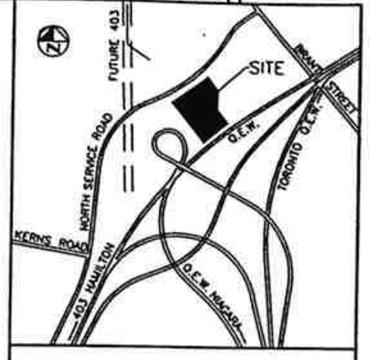
REMOVE WASTEWATER MAIN MANHOLE AFTER TRANSFERING FLOWS INTO NEW LINE

CONSTRUCT VERTICAL DROP STRUCTURES. REFER TO DWG. No. 8 AND 9 FOR GENERAL CONFIGURATION AND REINFORCING DETAILS POND BOTTOMS IN FRONT OF DROP STRUCTURES TO BE LINED WITH MIN. 500mm THICK ARMOUR STONE.

PLACE 300mmø TO 500mmø RIP RAP ALONG TOE OF ARMOUR STONE AND COVER WITH TOPSOIL.

PLACE 1800mm HIGH CHAINLINK SECURITY FENCE ALONG ALIGNMENT SHOWN PRIOR TO DEC. 15 1994

5000mm x 5000mm CONCRETE CULVERT CULVERT AND RESPECTIVE HEADWALL COMPLETED BY OTHERS.



KEY PLAN

GENERAL CONSTRUCTION NOTES

1. ALL TOPSOIL BETWEEN LIMITS OF EXCAVATION OF FILL TO BE STRIPPED AND STOCKPILED.
2. EXCAVATION AND EARTH PLACEMENT TO BE COMPLETED TO MATCH CONTOURING AND GRADES SHOWN ON GRADING PLAN. EXCESS MATERIAL TO BE REMOVED FROM SITE AND DISPOSED OF AT CONTRACTORS EXPENSE.
3. ARMOUR STONE TO BE PLACED TO ELEVATIONS AND SPECIFICATIONS NOTED ON GRADING AND CROSS-SECTION PLANS.
4. SITE TO BE RESTORED WITH 150mm TOPSOIL SEED AND MULCH. EXCEPT WHERE OTHERWISE NOTED
5. FINAL REVEGETATION TO BE COMPLETED AS PER REVEGETATION PLAN.
6. CONSTRUCTION OPERATIONS TO BE IN COMPLIANCE WITH STAGING AND EROSION/SEDIMENT CONTROL PLAN.
7 NO BLASTING WILL BE PERMITTED FOR EXCAVATION OF SHALE

NO	Date	By	REVISIONS	MANU	CAD
1	Feb 96	MBK	AS CONSTRUCTED		X

Design	B.J.B.	Ch'kd	K.R.D.	Date MAY 1994
Drawn	J.P.E.	Ch'kd	H.F.	

Scale N.T.S.

References

APPROVALS

Municipal

Field Notes

Regional

Stamp

Philips Planning + Engineering Limited

HAGER AND RAMBO CREEKS
FLOOD CONTROL PROGRAM
HALTON REGION
CONSERVATION AUTHORITY

TITLE
QEW TO NORTH SERVICE RD
EAST HAGER CREEK REALIGNMENT
GENERAL PLAN

Consultant File NO 84071-I

Regional Drawing NO

CONTRACT NO

Drawing NO
SHEET 1 OF 15

8.5 Photographic Reconnaissance

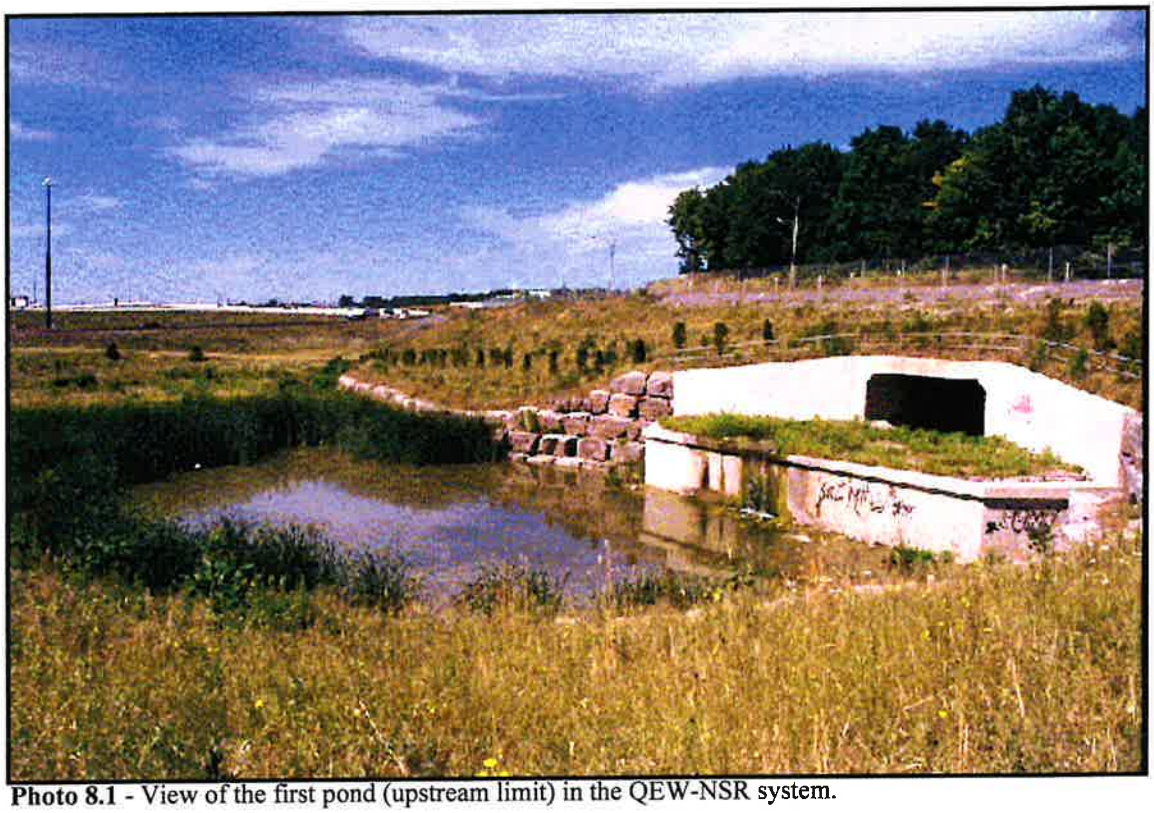


Photo 8.1 - View of the first pond (upstream limit) in the QEW-NSR system.

Photo 8.2 - Looking downstream from the North Service Road at the second and third ponds with the QEW in the background.

Photo 8.3 - Looking upstream at the ponds and drop structures from the Brant Street ramp to 403 west

Photo 8.4 – Looking downstream at the outlet culvert of the system that conveys flows under the QEW to the Upper Freeman Pond

8.6 Operations and Maintenance

8.6.1 Ownership Status

The Ministry of Transportation owns the area of the site below the abandoned North Service Road ROW, however; the Ministry has granted an Encroachment Permit to the Halton Region Conservation Authority for this area and a License of Occupation for the lands north of the abandoned North Service Road. This does not include the North Service Road culvert, which is owned by the City of Burlington. (Reference Appendix A)

8.6.2 Project Ingress and Egress

The site is accessible from the North Service Road approximately 300 m west of Brant Street across from the Burlington Power Center. The site is enclosed by a 1.8 metre chainlink fence with gated access facilitated by Key No. 18, available through the Halton Region Conservation Authority (905-336-1158).

8.6.3 Project Element Maintenance

Reference Appendix B for a summary table of standard component elements of the project, along with the frequency of inspection and the methods of remediation.

Site Reconnaissance

In order to ensure the normal operation of the channel under the range of expected flow conditions, a "walk through" of the works should be carried out at least once a year. A detailed inspection of the works recording the location and types of any deficiencies, along with photographs should be carried out every five years. Information thusly collected should be catalogued and added to this manual.

Stormwater Energy Dissipation Ponds

The ponds should be inspected with regard to sediment build up and should be dredged every 10 years as necessary. These ponds contain overflow valves that are operated by sluice gates, and should be turned opened and closed at least twice a year to ensure proper operation.

Concrete Structures

The concrete drop structures and dams should be inspected annually and checked for any minor cracking that may be repaired by sealing or grouting. Any major areas of cracking (> 3mm), displacement, or heaving (> 5 mm), along with the separation of slabs at the expansion, control, or walls joints, requires a thorough investigation by a qualified Structural Engineer, to determine the cause and recommend remedial works. In each pond a row of 500mm x 500mm dissipation blocks were constructed and should be checked for any deficiencies when the ponds are empty.

Armour Stone

During the annual inspection, the stone should be checked for any degradation or displacement. Specific items to check for include intrusive vegctation and washout of backfill material. If distress is occurring, a thorough investigation is required by a qualified Engineer to determine the cause and recommend remedial works.

General/Ingress/Egress

Vegetation or debris that may be obstructing the drop structures, overflow valves, and the outlet channel invert, should be inspected at least twice a year. Locations for access to the channel should remain clear of any obstructions. The locks and gates should be checked twice a year to ensure easy access under normal or emergency conditions.

9. East Hager Creek Reconstruction (North Service Road to Future Highway 407)

9.1 Project Description and Year of Construction

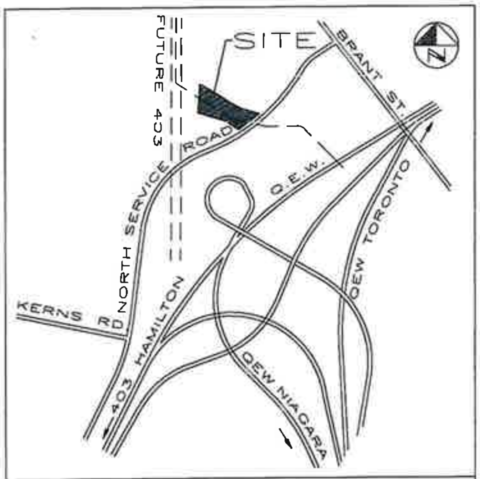
East Hager Creek Reconstruction
- North Service Road to Future Highway 407

Construction completed in 1992

This project involved 200 m of channelization to provide a "naturally" lined, meandering watercourse, with bank stabilization to protect against erosion potential for flood flows having a frequency up to five years. A concrete cut off wall and adjoining culvert were constructed at the upstream limit to stabilize the existing creek and lower it to the future invert grade. In addition, a concrete headwall and wingwalls were added to the existing North Service Road culvert.

9.2 Project Location

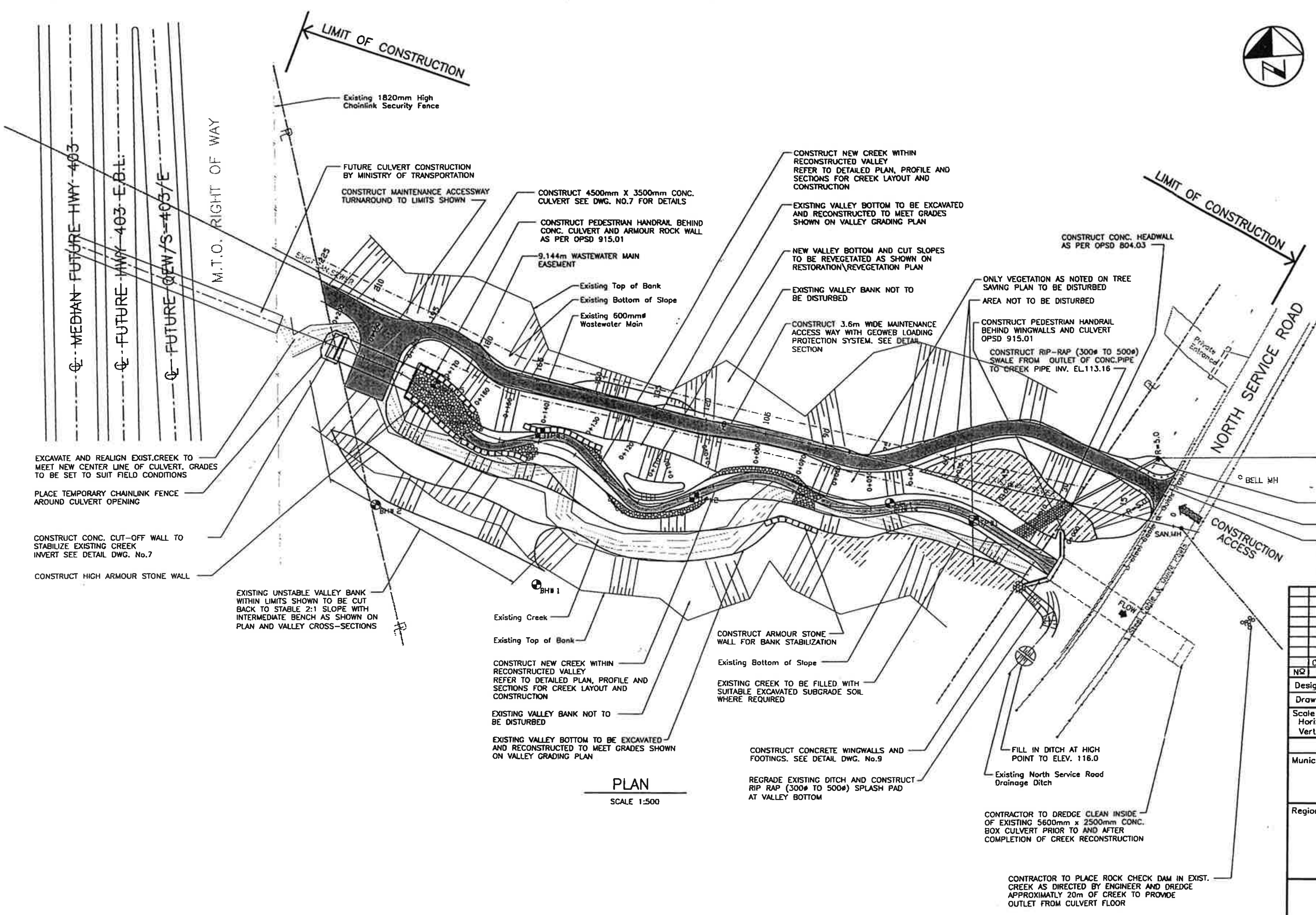
The channel works are located between the North Service Road and the Future Highway 403 right-of-way, appoximately 300 metres west of Brant Street, adjacent to the Burlington Power Center.



KEY PLAN

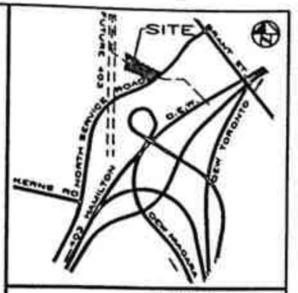
9.3 Design Objectives and Criteria

This channel was designed to convey the 100 year future land use flow of 72 m^3/s from Highway 403 through the existing North Service Road culvert to the downstream systems having an overbank elevation of 117.0 metres at the North Service Road.



PLAN

SCALE 1:500



KEY PLAN

NOTES

1. TEMPORARY CREEK REALIGNMENT, INCLUDING ALL UNWATERING AND SILT/SEDIMENT CONTROLS SHALL BE IN COMPLIANCE WITH CONSTRUCTION STAGING AND SILT/ SEDIMENT CONTROL PLAN.
2. CONTRACTORS APPROACH TO CONSTRUCTION OF THIS PROJECT MUST BE IN FULL ACCORDANCE WITH GUIDLINES STIPULATED ON CONSTRUCTION STAGING DWG.
3. VALLEY BOTTOM TO BE TOPSOILED, SEEDED AND MULCHED, AND REVEGETATED AS SHOWN ON RESTORATION/REVEGETATION PLAN.
4. CONSTRUCTION FENCE TO BE ERECTED AROUND ENTIRE SITE AS SHOWN ON DWG.2
5. CONTRACTOR TO STRIP AND STOCKPILE TOPSOIL WITHIN LIMITS OF EXCAVATION OR FILL

NO	Date	By	REVISIONS	MANU	CAD
1	OCT.93	P.S.M.	AS CONSTRUCTED		X

Design	B.J.B.	Ch'kd	K.R.D.	Date APRIL 1993
Drawn	P.S.M.	Ch'kd	B.J.B.	

Scale
Horiz. 1:500
Vert. 1:100

References

APPROVALS

Municipal

Regional

Field Notes

Stamp

Philips Planning + Engineering Limited

HALTON REGION
CONSERVATION AUTHORITY
HAGER RAMBO
FLOOD CONTROL WORKS

TITLE
NORTH SERVICE ROAD TO HWY 403
E.HAGER CREEK DIVERSION
GENERAL OVERALL PLAN

Consultant File NO 84071-F

Regional Drawing NO

CONTRACT NO

Drawing NO
SHEET 1 OF 16

9.5 Photographic Reconnaissance

Photo 9.1 – Looking upstream at the channel from the North Service Road.

Photo 9.2 - Looking downstream at the North Service Road culvert.

Photo 9.3 - Looking upstream towards the culvert and cut-off wall structure

Photo 9.4 - Looking downstream from atop the culvert 4.5 x 3.5 metre culvert. Note the broken handrail and high concentration of Purple Loosestrife.

Photo 9.5 - Looking down into the cut-off wall structure at the upstream limit of the works

Photo 9.6 - Looking downstream from the future Highway 403 right-of-way.

9.6 Operations and Maintenance

9.6.1 Ownership Status

The site of the East Hager Creek Channel Reconstruction is owned by the Halton Region Conservation Authority (Parts 1-4, Plan 20R-11144, (Reference Appendix A). In addition, a 9.1 metre wide wastewater main easement (Part 2) extending the length of the site to the north of the channel, has been assumed by the Regional Municipality of Halton.

9.6.2 Project Ingress and Egress

The site is accessible from the North Service Road on the north side of the creek, through a single 4 metre wide gate. The maintenance accessway extends along the north side of the channel, to the limit of construction with a turnaround area over the culvert. A chainlink security fence does not enclose the site, although the gate off of the North Service Road is facilitated by Key No. 18, available through the Halton Region Conservation Authority (905-336-1158).

9.6.3 Project Element Maintenance

Reference Appendix B for a summary table of standard component elements of the project, along with the frequency of inspection and the methods of remediation.

Site Reconnaissance

In order to ensure the normal operation of the channel under the range of expected flow conditions, a "walk through" of the works should be carried out at least once a year. A detailed inspection of the works recording the location and types of any deficiencies, along with photographs should be carried out every five years. Information thusly collected should be catalogued and added to this manual.

Concrete Structures

The concrete vertical drop structure should be inspected annually and checked for any minor cracking or spalling that may be repaired by sealing or grouting. Any major areas of cracking (> 3mm) or displacement along expansion, control, or walls joints, requires a thorough investigation by a qualified Structural Engineer, to determine the cause and recommend remedial works.

Armour Stone

During the annual inspection, the stone should be checked for any degradation or displacement. Specific items to check for include intrusive vegetation and washout of backfill material. If distress is occurring, a thorough investigation is required by a qualified Engineer to determine the cause and recommend remedial works.

General/Ingress/Egress

The channelization of East Hager Creek at this location utilizes the function of a "natural" channel system. As in the downstream sites, Purple Loosestrife is the dominant invasive species within the channel and should be removed in order to ensure maximum efficiency of the ecosystem. Larger debris (fallen trees, etc.) that may be obstructing the culverts or channel should be removed.

Rip-rap has been used for erosion protection on the outside banks. This component should be checked for any signs of degradation, displacement, erosion of backfill material, or the exposure of the geotextile material. Locations for access to the channel should remain clear of any obstructions. The gate and lock should be checked twice a year to ensure easy access under normal or emergency conditions.

10. West Hager Detention Facility

10.1 Project Description and Year of Construction

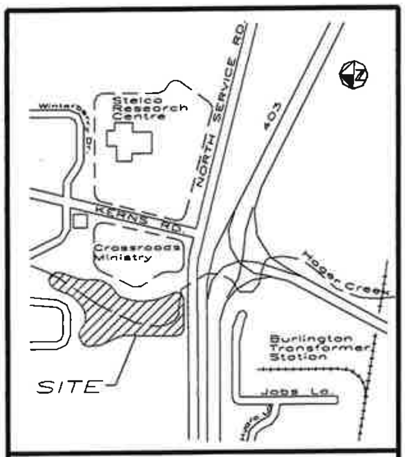
West Hager Creek Realignment and Detention Facility

Construction completed in 1993

The project required the excavation of 9,500 m^3 of earth from the existing valley floor and the construction of a structural earth berm. In addition, approximately 347 metres of the existing creek was realigned to provide a 2.3 metre wide low flow rip-rap lined channel. The outlet works included the installation of a 1.44 x 1.44 x 42 m concrete box culvert and erosion control to the channel leading from the outlet to the existing North Service Road culvert

10.2 Project Location

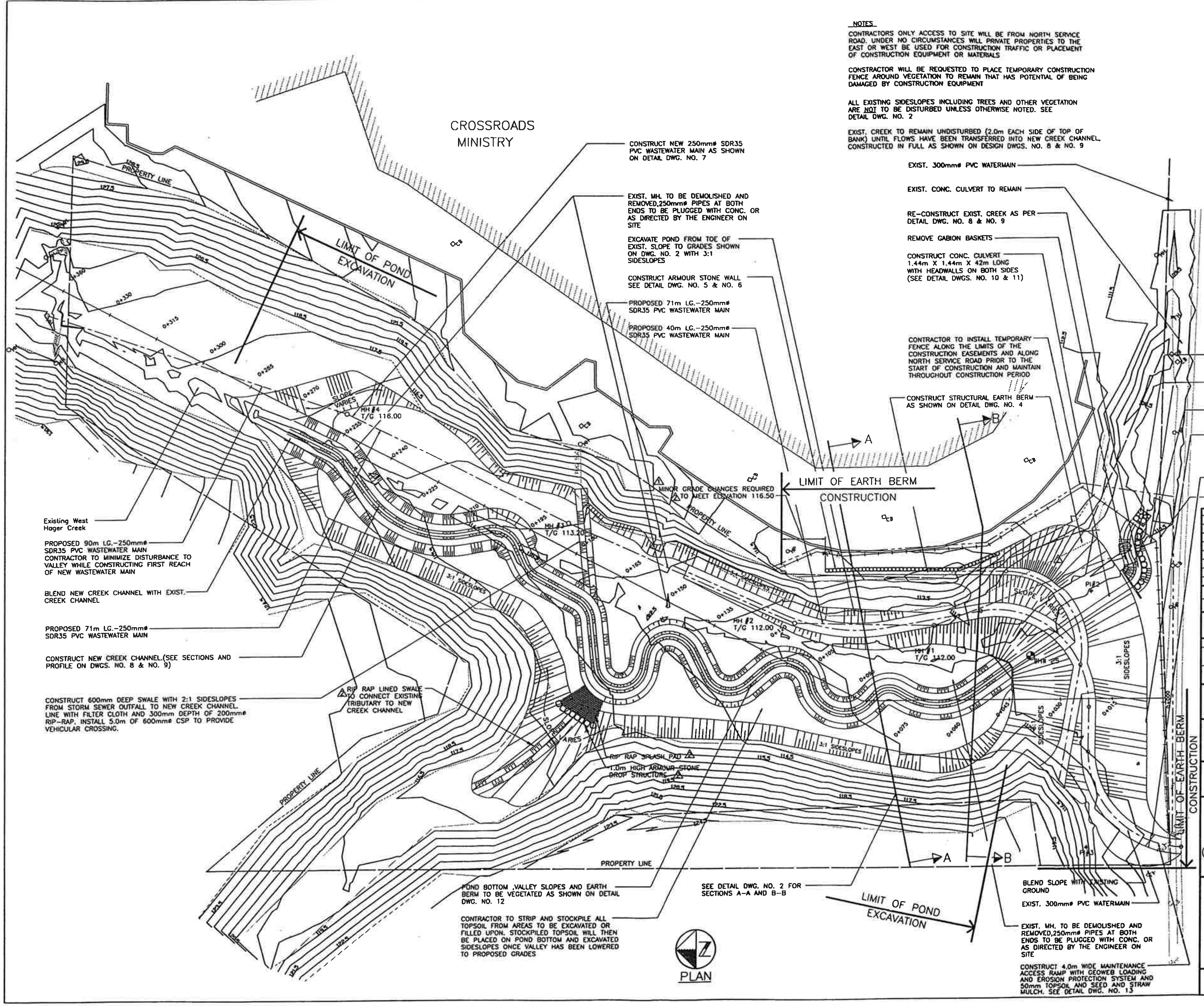
The site is located on the north side of the North Service Road, west of Kerns Road, adjacent to the Crossroads Ministry lands.



KEY PLAN

10.3 Design Objectives and Criteria

This system was designed to store the Regional event to an elevation of 116.2 m allowing a 0.3 m freeboard, and regulates the outlet flow from the system to 15.6 m^3/s to control downstream flows to the Fairview Street culvert capacity.



NOTES

CONTRACTORS ONLY ACCESS TO SITE WILL BE FROM NORTH SERVICE ROAD. UNDER NO CIRCUMSTANCES WILL PRIVATE PROPERTIES TO THE EAST OR WEST BE USED FOR CONSTRUCTION TRAFFIC OR PLACEMENT OF CONSTRUCTION EQUIPMENT OR MATERIALS

CONSTRACTOR WILL BE REQUESTED TO PLACE TEMPORARY CONSTRUCTION FENCE AROUND VEGETATION TO REMAIN THAT HAS POTENTIAL OF BEING DAMAGED BY CONSTRUCTION EQUIPMENT

ALL EXISTING SIDESLOPES INCLUDING TREES AND OTHER VEGETATION ARE NOT TO BE DISTURBED UNLESS OTHERWISE NOTED. SEE DETAIL DWG. NO. 2

EXIST. CREEK TO REMAIN UNDISTURBED (2.0m EACH SIDE OF TOP OF BANK) UNTIL FLOWS HAVE BEEN TRANSFERRED INTO NEW CREEK CHANNEL, CONSTRUCTED IN FULL AS SHOWN ON DESIGN DWGS. NO. 8 & NO. 9

CONSTRUCT NEW 250mmø SDR35 PVC WASTEWATER MAIN AS SHOWN ON DETAIL DWG. NO. 7

EXIST. MH. TO BE DEMOLISHED AND REMOVED,250mmø PIPES AT BOTH ENDS TO BE PLUGGED WITH CONC. OR AS DIRECTED BY THE ENGINEER ON SITE

EXCAVATE POND FROM TOE OF EXIST. SLOPE TO GRADES SHOWN ON DWG. NO. 2 WITH 3:1 SIDESLOPES

CONSTRUCT ARMOUR STONE WALL SEE DETAIL DWG. NO. 5 & NO. 6

PROPOSED 71m LG.–250mmø SDR35 PVC WASTEWATER MAIN

PROPOSED 40m LG.–250mmø SDR35 PVC WASTEWATER MAIN

EXIST. 300mmø PVC WATERMAIN

EXIST. CONC. CULVERT TO REMAIN

RE–CONSTRUCT EXIST. CREEK AS PER DETAIL DWG. NO. 8 & NO. 9

REMOVE GABION BASKETS

CONSTRUCT CONC. CULVERT 1.44m X 1.44m X 42m LONG WITH HEADWALLS ON BOTH SIDES (SEE DETAIL DWGS. NO. 10 & 11)

CONTRACTOR TO INSTALL TEMPORARY FENCE ALONG THE LIMITS OF THE CONSTRUCTION EASEMENTS AND ALONG NORTH SERVICE ROAD PRIOR TO THE START OF CONSTRUCTION AND MAINTAIN THROUGHOUT CONSTRUCTION PERIOD

CONSTRUCT STRUCTURAL EARTH BERM AS SHOWN ON DETAIL DWG. NO. 4

Existing West Hager Creek

PROPOSED 90m LG.–250mmø SDR35 PVC WASTEWATER MAIN CONTRACTOR TO MINIMIZE DISTURBANCE TO VALLEY WHILE CONSTRUCTING FIRST REACH OF NEW WASTEWATER MAIN

BLEND NEW CREEK CHANNEL WITH EXIST. CREEK CHANNEL

PROPOSED 71m LG.–250mmø SDR35 PVC WASTEWATER MAIN

CONSTRUCT NEW CREEK CHANNEL.(SEE SECTIONS AND PROFILE ON DWGS. NO. 8 & NO. 9)

CONSTRUCT 600mm DEEP SWALE WITH 2:1 SIDESLOPES FROM STORM SEWER OUTFALL TO NEW CREEK CHANNEL. LINE WITH FILTER CLOTH AND 300mm DEPTH OF 200mmø RIP–RAP. INSTALL 5.0m OF 600mmø CSP TO PROVIDE VEHICULAR CROSSING.

△2 RIP RAP LINED SWALE TO CONNECT EXISTING TRIBUTARY TO NEW CREEK CHANNEL

POND BOTTOM ,VALLEY SLOPES AND EARTH BERM TO BE VEGETATED AS SHOWN ON DETAIL DWG. NO. 12

CONTRACTOR TO STRIP AND STOCKPILE ALL TOPSOIL FROM AREAS TO BE EXCAVATED OR FILLED UPON. STOCKPILED TOPSOIL WILL THEN BE PLACED ON POND BOTTOM AND EXCAVATED SIDESLOPES ONCE VALLEY HAS BEEN LOWERED TO PROPOSED GRADES

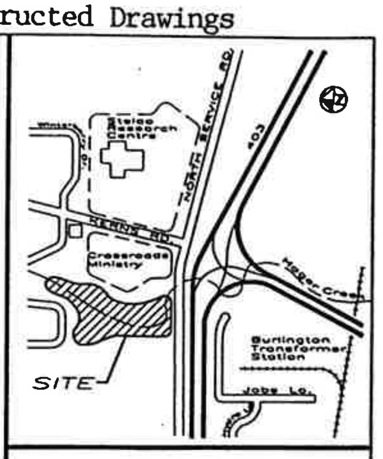
SEE DETAIL DWG. NO. 2 FOR SECTIONS A–A AND B–B

BLEND SLOPE WITH EXISTING GROUND

EXIST. 300mmø PVC WATERMAIN

EXIST. MH. TO BE DEMOLISHED AND REMOVED,250mmø PIPES AT BOTH ENDS TO BE PLUGGED WITH CONC. OR AS DIRECTED BY THE ENGINEER ON SITE

CONSTRUCT 4.0m WIDE MAINTENANCE ACCESS RAMP WITH GEOWEB LOADING AND EROSION PROTECTION SYSTEM AND 50mm TOPSOIL AND SEED AND STRAW MULCH. SEE DETAIL DWG. NO. 13



KEY PLAN N.T.S.

CURVE DATA FOR RAMP	CURVE DATA FOR RAMP
PI#2	PI#3
STA. 0+020.972	STA. 0+022.309
OFFSET 30.757	OFFSET 42.014m
RIGHT	LEFT
Δ=97°–00'–00"	Δ=89°–00'–00"
T=33.11m	T=27.00m
R=27.50m	R=27.50m
L=46.55m	L=42.71m

CONSTRUCT ROCK CHECK DAM PRIOR TO ANY EARTH WORKS ON SITE AND MAINTAIN THROUGHOUT CONSTRUCTION PERIOD. SEE DETAIL DWG. NO. 13

ERECT SILT FENCE PRIOR TO ANY EARTH WORKS AND MAINTAIN THROUGHOUT CONSTRUCTION PERIOD SEE DETAIL DWG. NO. 13

PROPOSED 69.5m LG.–250mmø SDR35 PVC WASTEWATER MAIN

TOP AND FRONT FACE OF BERM TO HAVE 3:1 SLOPE WITH GEOWEB EROSION PROTECTION AND 125mm TOPSOIL AND SEED AND STRAW MULCH. SEE DETAIL DWG. NO. 13

CONTRACTOR TO SUPPLY AND INSTALL 4.0m WIDE STEEL GATE AS SHOWN ON DWG. NO. 13

LOCATE EXISTING WASTE WATER MAIN AND CONSTRUCT NEW M.H. NO. 1A. SEE DWG. NO. 7 FOR DETAILS

NO.	DATE	BY	REVISIONS	MAN	CAD
△2	OCT./92	RKA	AS CONSTRUCTED		CAD
1	MAY./92	BB	ADDED MH–1A	MAN	

Design	B.J.B.	Ch'kd	K.R.D.	DATE APR. 1992
Drawn	C.D.A.	Ch'kd	P.S.M.	

SCALE: N.T.S.

REFERENCES

REGIONAL APPROVALS

COMMISSIONER OF PUBLIC WORKS

DIR. OF DESIGN AND CONSTRUCTION

FIELD NOTES

CLIENT

STAMP

STAMP

CONTRACTOR

CONSULTANT

Philips Planning Engineering Limited

REGION

HALTON REGION
CONSERVATION AUTHORITY

TITLE

HAGER RAMBO
FLOOD CONTROL
WEST HAGER DETENTION
FACILITY
GENERAL OVERALL PLAN

CONTRACT NO. 84071–G

DRAWING NO. SHEET 1 OF 14

10.5 Photographic Reconnaissance

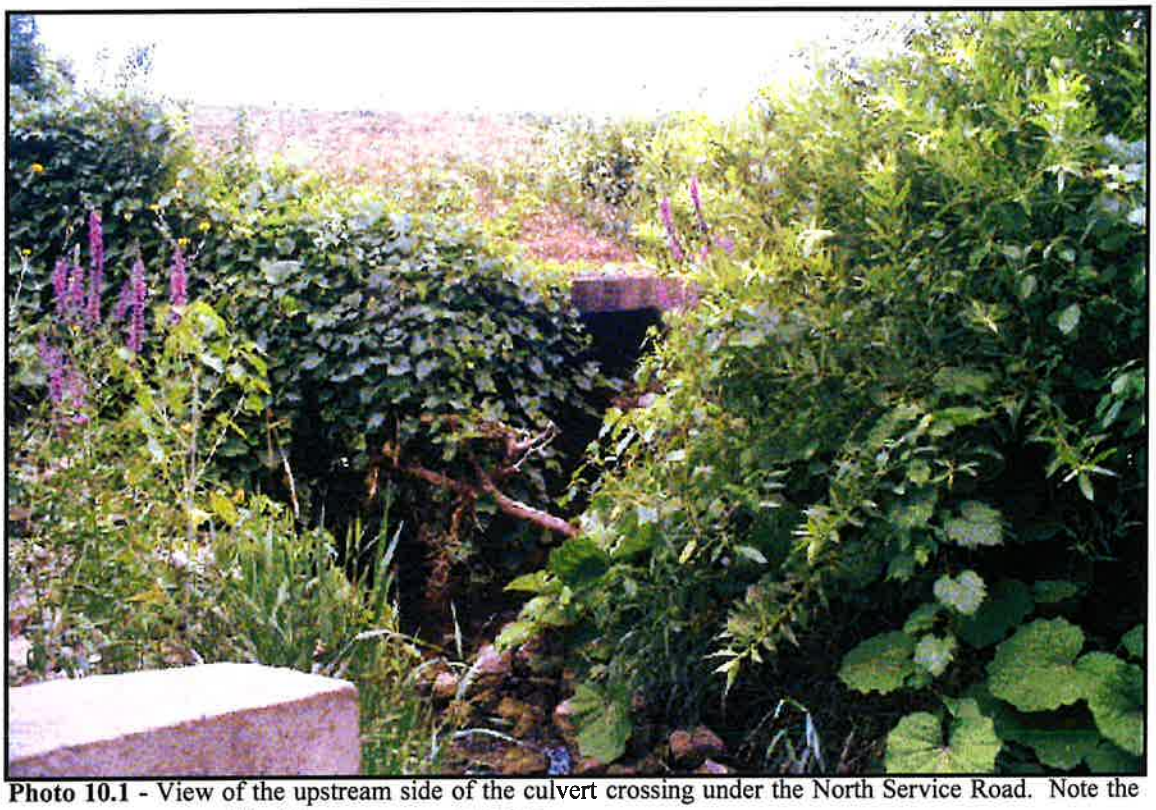


Photo 10.1 - View of the upstream side of the culvert crossing under the North Service Road. Note the debris blocking the culvert opening.

Photo 10.2 - View of the detention facilities outlet culvert from the downstream side, taken from the North Service Road.

Photo 10.3 - Upstream view of the facility from atop the berm.

Photo 10.4 - Looking upstream towards the limit of the site from the maintenance accessway at station 0+180.

10.6 Operations and Maintenance

10.6.1 Ownership Status

The West Hager Creek Detention Facility is owned by The City of Burlington, with the Halton Region Conservation Authority having an easement agreement with the city for maintenance purposes. (Reference Appendix A).

10.6.2 Project Ingress and Egress

The site is accessible from the North Service Road approximately 300 metres west of Kerns Road next to the Crossroads Ministry property. An access road was constructed across the top of the berm and running parallel to the creek along the east side. Safety fencing does not enclose the facility, therefore keys for gated access are not required.

10.6.3 Project Element Maintenance

Reference Appendix B for a summary table of standard component elements of the project, along with the frequency of inspection and the methods of remediation.

Site Reconnaissance

In order to ensure the normal operation of the stormwater management facility under the range of expected flow conditions, a "walk through" of the works should be carried out at least once a year. A detailed inspection of the works recording the location and types of any deficiencies, along with photographs should be carried out every five years. Information thusly collected should be catalogued and added to this manual.

Concrete Structures

The North Service Road and outlet culvert should be inspected annually and checked for any minor cracking or spalling that may be repaired by sealing or grouting. Any major areas of cracking (> 3mm) or displacement along expansion, control, or walls joints, requires a thorough investigation by a qualified Structural Engineer, to determine the cause and recommend remedial works.

Armour Stone and Rip-Rap

During the annual inspection, the armour stone should be checked for any degradation or displacement. Specific items to check for include intrusive vegetation and washout of backfill material. Rip-rap has been used for the channel lining and should be checked for any signs of degradation, displacement, erosion of backfill material, or the exposure of the geotextile materials.

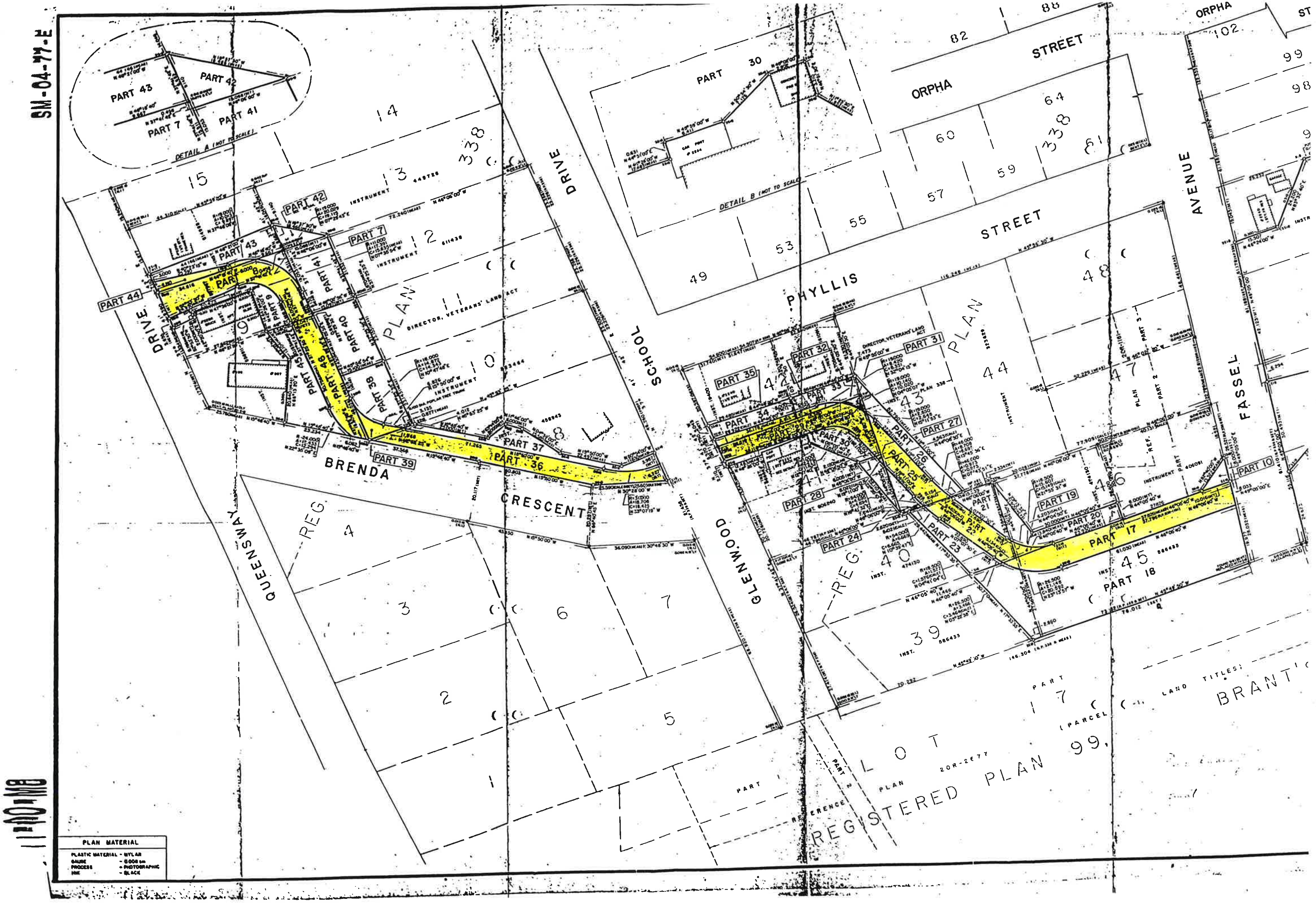
General/Ingress/Egress

As a storm water management facility, the condition of the berm and valley walls is an important feature of the system to function effectively. The slopes should be checked for stability and any signs of failure. The channelization of West Hager Creek at this location utilizes the function of a "natural" channel system as well.

As in the downstream sites, Purple Loosestrife is the dominant species within the channel and should be removed in order to ensure the efficiency Of the natural ecosystem. (Reference Section 6.6.4). Larger debris (fallen trees, etc.) that may be obstructing the culverts or channel should be removed.

APPENDIX 'A'

PROPERTY PLANS


SM-04-77-E
DETAIL A (NOT TO SCALE)
PART 43
PART 42
PART 41
PART 7
DETAIL B (NOT TO SCALE)
PART 30
CAR PORT
ORPHA STREET
ORPHA
PHYLLIS STREET
DRIVE
SCHOOL DRIVE
QUEENSWAY DRIVE
BRENDA CRESCENT
GLENWOOD
AVENUE
FASSEL
PLAN 338
PLAN
INSTRUMENT
DIRECTOR, VETERANS' LAND ACT
PART 44
PART 45
PART 46
PART 8
PART 9
PART 40
PART 38
PART 39
PART 37
PART 36
PART 35
PART 34
PART 33
PART 32
PART 31
PART 29
PART 28
PART 27
PART 26
PART 25
PART 24
PART 23
PART 22
PART 21
PART 20
PART 19
PART 18
PART 17
PART 10
PART 1
PART 2
PART 3
REF. PLAN
REG.
14
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102
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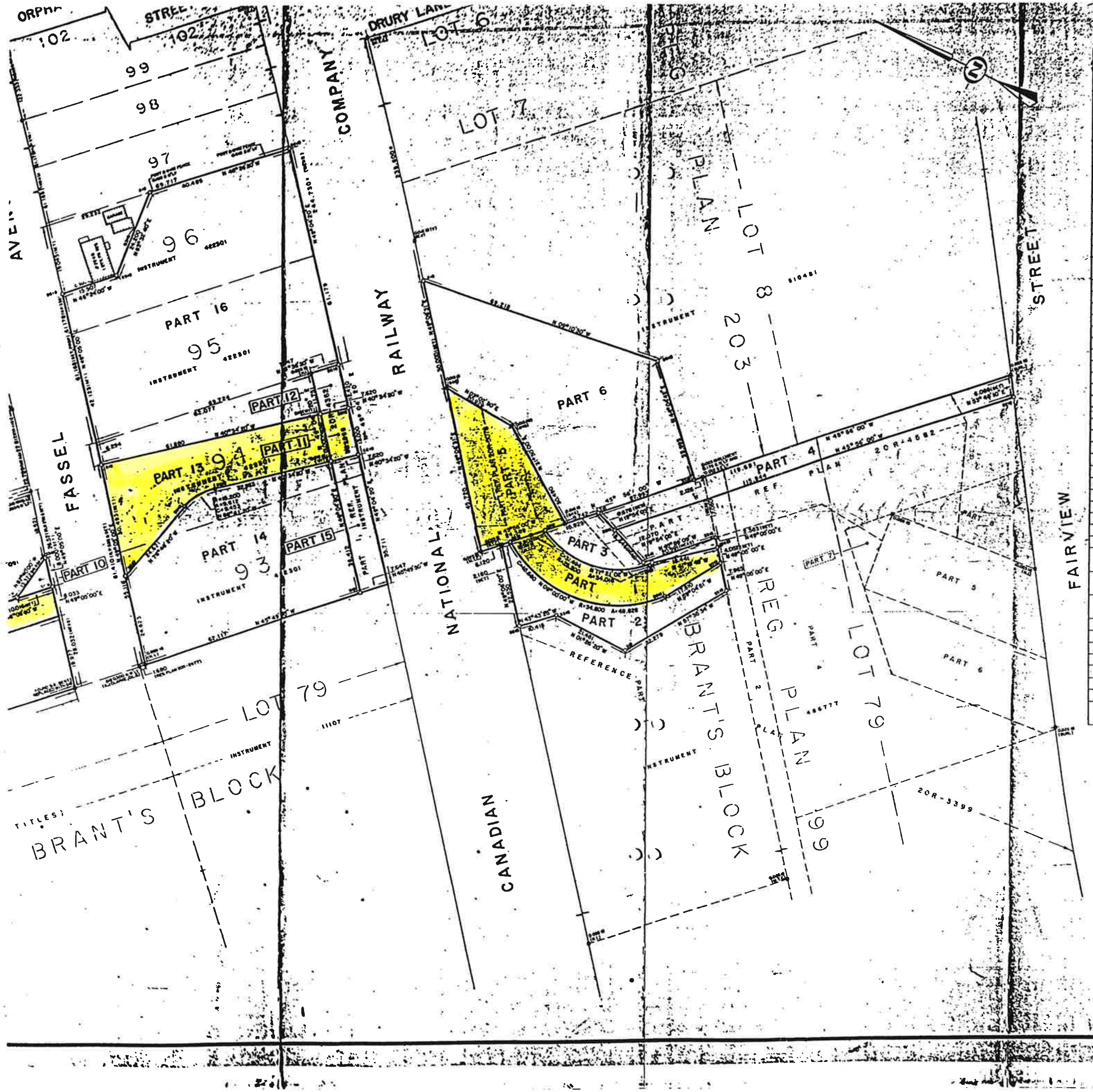
44
43
42
41
40
39
LOT 17
PART 1
PART 2
PLAN 20R-2677
REFERENCE
(PARCEL LAND TITLES)
REGISTERED PLAN 99, BRANT
PLAN MATERIAL
PLASTIC MATERIAL - MYLAR
GAUGE - 0.008 cm
PROCESS - PHOTOGRAPHIC
INK - BLACK
11-10-MB



		S C H E D U L E				
PART	LOCATION	OWNER	INSTRUMENT	AREA IN SQ. METRES PERM. EASEMENT	AREA IN SQ. METRES TEMP. EASEMENT	GRANT
1	PART OF LOT 79, REGISTERED PLAN 99, BRANT'S BLOCK	TORONTO AREA TRANSIT OPERATING AUTHORITY	466777	227.48		
2					148.09	
3					87.83	
4					708.89	
5	PART OF LOT 6, REGISTERED PLAN 203	DOUGLAS ROY LEGGAT	510481 SUBJECT TO EASEMENT (547819)	707.48		
6			510481		257.87	
11	PART OF LOT 94 REG. PLAN 338	CANADIAN NATIONAL RAILWAY COMPANY	522958	96.81		
12					92.83	
13	PART OF LOT 93 & 94, REG. PLAN 338	JAMES EDWARD JEFFERIES	422301	1014.72		
14					2217.44	
15		CANADIAN NATIONAL RAILWAY COMPANY	522958		274.76	
16	ALL OF LOT 95 AND PART OF LOTS 94 AND 96, REG. PLAN 338	JAMES EDWARD JEFFERIES	422301		4387.79	
17	PART OF LOTS 39 AND 45, REG. PLAN 338	DUARTE M. SOUSA AND CHERYL ANN SOUSA	566433	538.24		
18					17[illegible].40	
19	PART OF LOT 46, REG. PLAN 338	BENJAMIN LEWIS AND JEAN B. LEWIS	474130 (FIRSTLY)	59.48		
20					246.16	
21	PART OF LOT 40, REG. PLAN 338		474130 (SECONDLY)		154.81	
22				246.89		
23					207.98	
24	PART OF LOT 43, REG. PLAN 338	DIRECTOR VETERANS' LAND ACT	PLAN 338			89.81
25				226.76		
26					248.35	
27	PART OF LOT 41, REG. PLAN 338	SANDRA MARIE TURNER	606240	4.84		
28					76.85	
29		JAMES L. STEPHENSON	568662	363.72		
30					188.50	
31						20.46
32	PART OF LOT 42, REG. PLAN 338	ALEXANDER KIRILOW AND WANDA KIRILOW	161091	25.80		
33					132.44	
34		HAROLD LORNE FEAVER AND IRIS GWENDOLINE FEAVER	194000		145.99	
35				70.23		
36	PART OF LOT 8, REG. PLAN 338	JOHN GEORGE WHALE AND CHRISTINA ELIZABETH WHALE	458943	585.10		
37					277.88	
38	PART OF LOT 10, REG. PLAN 338	HARRY BACHEWICH AND HELEN DORTHY BACHEWICH	283468		293.23	
39				63.85		
40	PART OF LOT 11, REG. PLAN 338	DIRECTOR VETERANS' LAND ACT	PLAN 338		347.14	
41	PART OF LOT 12, REG. PLAN 338	DAVID RICHARD WINDEYER AND SYDNA GAIL BELL	611438		347.91	
42	PART OF LOT 13, REG. PLAN 338	THOMAS GEORGE STEWART AND EVA MAE STEWART	449726		68.55	
43	PART OF LOT 9, REG. PLAN 338	FLOYD HOLLENBECK, CHESTER MURRAY AND HAROLD ALFRED BANKS (TRUSTEES FOR JEHOVAH'S WITNESSES)	514988		266.99	
44				80.75		
7		JOHN WEEMHOFF	557967	41.23		
8				443.97		
9					202.73	
45		JUDY LEW	558911		366.07	
46				335.68		
10	PART OF LOT 46, REG. PLAN 338	JOHN MAGYAR	406091		39.90	

THE REGISTRY ACT
DATE FEBRUARY 5th, 1986

Allan G. Hall
ALLAN G. HALL
ONTARIO LAND SURVEYOR
FOR THE CORPORATION OF
THE CITY OF BURLINGTON

CAUTION: THIS PLAN IS NOT A PLA
THE MEANING OF THE PL

File copy

PLAN
OF SURVEY OF
PART LOTS 8, 9, 10, 11, 12, 13
39, 40, 41, 42, 43, 46 AND 9
AND
ALL OF LOTS 45, 93, 94 AND
REGISTERED PLAN 338
AND
PART OF LOT 8,
REGISTERED PLAN 203
AND
PART OF LOT 79,
REGISTERED PLAN 99
BRANT'S BLOCK
FORMERLY IN THE
GEOGRAPHIC TOWNSHIP OF NELSON
NOW IN THE
CITY OF BURLINGTON
REGIONAL MUNICIPALITY OF HALTON

SCALE-1:500
0 5 10 15
ALLAN G. HALL, O.L.S.
1986

METRIC
DISTANCES SHOWN ON THIS PLAN ARE IN METRES AND CAN BE CONVERTED TO FEET BY DIVIDING BY 0.3048

BEARING NOTE
BEARINGS HEREON ARE GRID BEARINGS, DERIVED FROM HORIZONTAL CONTROL M
001653078, 001653079, 043780073 AND 043780074 AND ARE REFERRED TO THE
CENTRAL MERIDIAN 81° 00' 00" WEST LONGITUDE OF ZONE 17 AND ARE BASED O
1974 ADJUSTMENT.

LEGEND
● - DENOTES FOUND
□ - DENOTES PLANTED
SIB - DENOTES STANDARD IRON BAR
SSIB - DENOTES SHORT STANDARD IRON BAR
RIP - DENOTES ROUND IRON PIPE
RIB - DENOTES ROUND IRON BAR
IB - DENOTES IRON BAR
646 - DENOTES R. G. SEWEL
655 - DENOTES MACKAY, MA
BURL - DENOTES CITY OF B
M.T.C. - DENOTES MINISTRY O COMMUNICA
N.I. - DENOTES NON-IDENTI

SURVEYOR'S CERTIFICATE
I HEREBY CERTIFY THAT:
1. THIS SURVEY AND PLAN ARE CORRECT AND IN ACCORDANCE WITH THE SURVEYS AC AND THE REGISTRY ACT AND THE REGULATIONS MADE THEREUNDER.
2. THE SURVEY WAS COMPLETED ON THE 29th DAY OF JANUARY, 1985.

FEBRUARY 5th, 1986

Allan
ALL
ONTARIO

CITY OF BURLINGTON
DEPARTMENT OF PUBLIC WORKS - SURVEY
426 BRANT STREET

SURVEY BY: F.Y. & J.E.	FIELD BOOK:	COMPUTED BY: D. KUMAR
DRAWN BY: G. GENERAL		DATE:

RAMBO CREEK - EAST BRANCH FROM FAIRVIEW STREET TO QUEENSWAY DRIVE

PLAN
SM-

RECEIVED
FEB 12 1985

AUG 4 1995

PLAN OF SURVEY OF
PART OF LOT 79
REGISTERED PLAN 99, BRANT'S BLOCK
FORMERLY TOWN OF BURLINGTON,
GEOGRAPHIC TOWNSHIP OF NELSON
CITY OF BURLINGTON
REGIONAL MUNICIPALITY OF HALTON
SCALE 1:250

MARSHALL MACKLIN MONAGHAN
ONTARIO LIMITED
ONTARIO LAND SURVEYORS

1995

METRIC
Distances shown on this plan are in metres and can be converted to feet by dividing by 0.3048

SCHEDULE

PART	LOT	REG'D PLAN	INSTRUMENT	NAME	SUBJECT TO	AREA in m²
1	79	99 BRANT'S BLOCK	486777	TORONTO AREA TRANSIT AUTHORITY	INST. 671754	1130.5
2			799613	DOUGLAS LEGGAT		191.8

I REQUIRE THIS PLAN TO BE DEPOSITED UNDER THE REGISTRY ACT.

DATE AUGUST 4, 1995

Bruce McMurchy
BRUCE I. McMURCHY O.L.S.

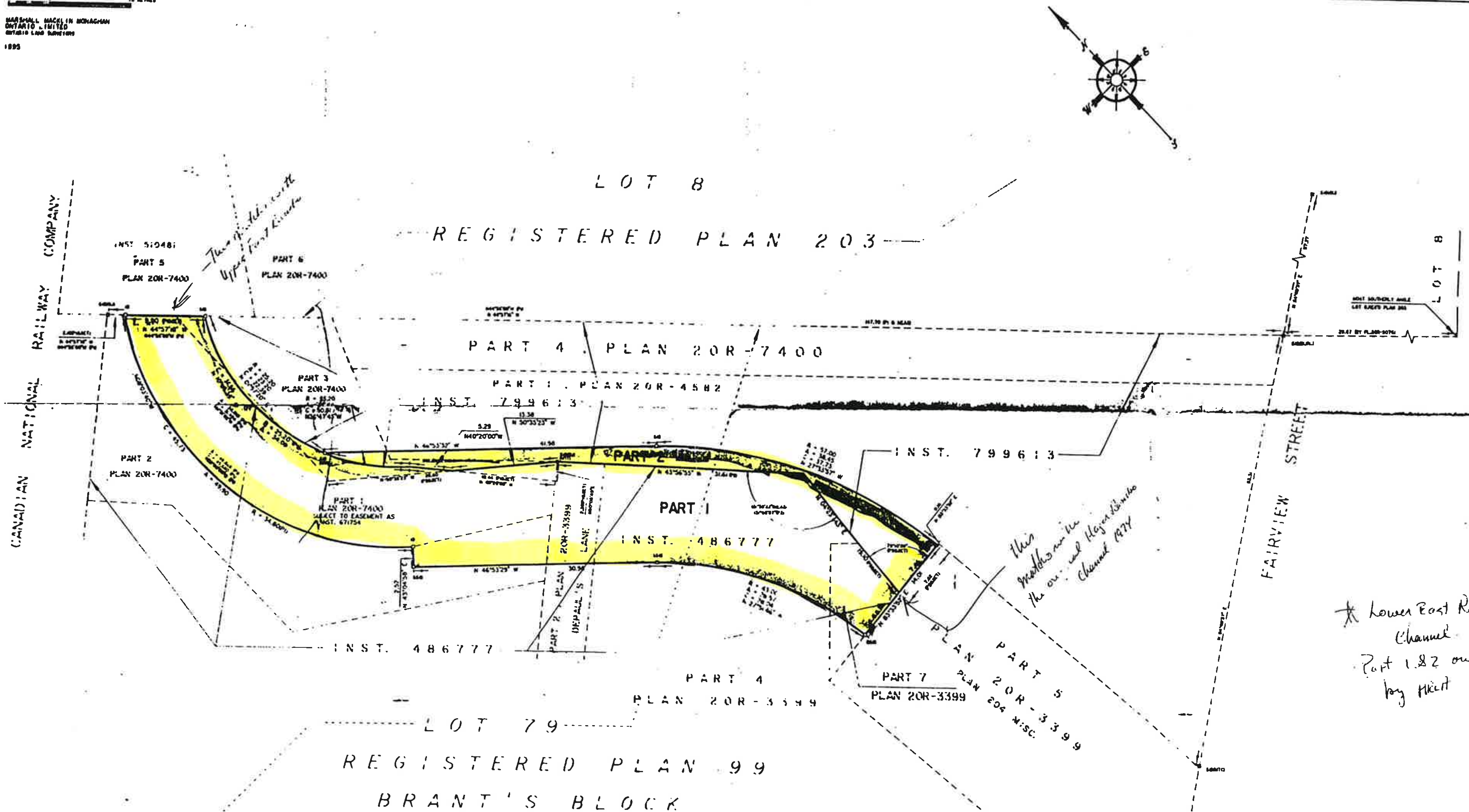
PLAN 20R-11811

RECEIVED AND DEPOSITED

DATE 04 AUG. 1995

Sheila Bell
A.D. LAND REGISTRAR FOR THE REGISTRY DIVISION OF HALTON (NO. 20)

CAUTION
THIS PLAN IS NOT A PLAN OF SUBDIVISION WITHIN THE MEANING OF THE PLANNING ACT



These match with Upper East Rambo

this matches with the original Hager Rambo Channel 1974

* Lower East Rambo Channel
Part 1 & 2 owned
by HRCA

LEGEND:
- ■ DENOTES MONUMENT FOUND
- □ DENOTES MONUMENT PLANTED
- SIB DENOTES STANDARD IRON BAR
- IB DENOTES IRON BAR
- OU DENOTES ORIGIN UNKNOWN
- BUR. DENOTES CITY OF BURLINGTON
- MTC DENOTES MINISTRY OF TRANSPORTATION AND COMMUNICATIONS
- P1 DENOTES PLAN 20R-7400
- P2 DENOTES PLAN 20R-4582
- SSIB DENOTES SHORT STANDARD IRON BAR
- WIT DENOTES WITNESS

NOTE:
BEARINGS SHOWN HEREON ARE ASTRONOMIC AND ARE REFERRED TO THE NORTHERLY LIMIT OF FAIRVIEW STREET HAVING A BEARING OF N64°48'37"E AS SHOWN ON PLAN 20R-4582.

SURVEYOR'S CERTIFICATE

I CERTIFY THAT

1. THIS SURVEY AND PLAN ARE CORRECT AND IN ACCORDANCE WITH THE SURVEYS ACT AND THE REGISTRY ACT AND THE REGULATIONS MADE THEREUNDER.
2. THE SURVEY WAS COMPLETED ON THE 6TH DAY OF JUNE 1995.

JUNE 22, 1995
DATE

LOUIS SCHOOLKATE
Ontario Land Surveyor

drawn T.R.	scale 1:250		
checked L.S.	plan no. 1-1	20-95-1867-01-000	

MARSHALL MACKLIN MONAGHAN
ONTARIO LIMITED
4200 SOUTH SERVICE ROAD, SUITE 101
BURLINGTON, ONT., L7L 4X5, 634-4044
Ontario Land Surveyors

METRIC
Distances shown on this plan are in meters and can be converted to feet by dividing by 0.3048.

SCHEDULE				
PART	LOT	PLAN	INSTRUMENT NO.	AREA
1	14	BRANT'S BLOCK REG'D PLAN 99	245394 (REMAINDER)	407.2 m²
2				41.33 m²
3			283103 (REMAINDER)	1302 m²
4				437.5 m²
5				671.8 m²

I REQUIRE THIS PLAN TO BE DEPOSITED UNDER THE REGISTRY ACT.

DATE OCT. 23, 1989

Bruce I. McMurchy
BRUCE I. McMURCHY O.L.S.

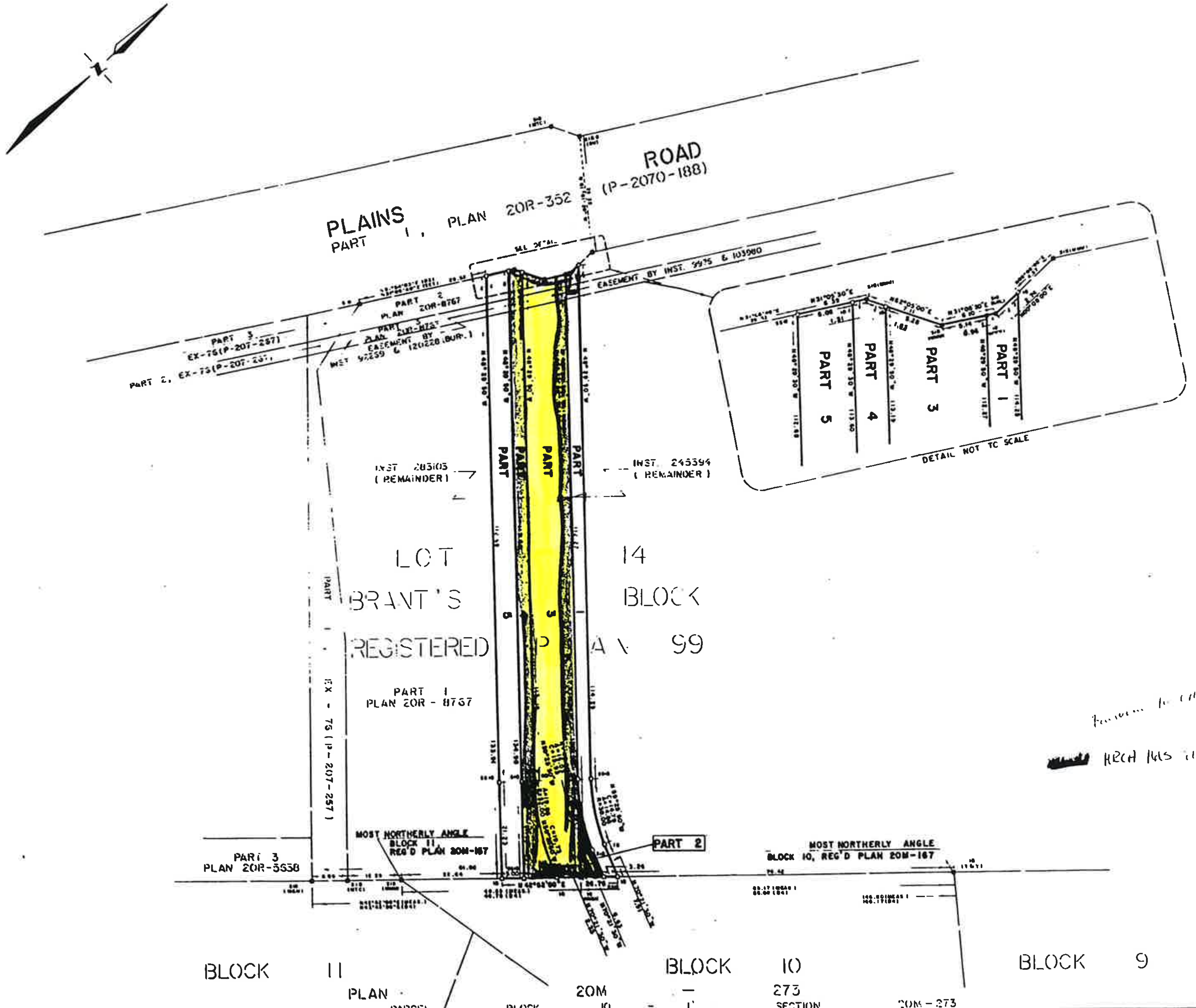
PLAN 20R-9601

RECEIVED AND DEPOSITED

DATE 31 OCT 1989

Sheila Bell
A.-D. LAND REGISTRAR
FOR THE REGISTRY DIVISION OF HALTON No 20.

CAUTION
THIS PLAN IS NOT A PLAN OF SUBDIVISION WITHIN THE MEANING OF THE PLANNING ACT



PLAN OF SURVEY OF
PART OF LOT 14
BRANT'S BLOCK
REGISTERED PLAN 99
FORMERLY IN THE VILLAGE OF BURLINGTON
COUNTY OF HALTON
CITY OF BURLINGTON
REGIONAL MUNICIPALITY OF HALTON

0 5 10 20 30 40 50 metres
SCALE 1:500

MARSHALL MACKLIN MONAGHAN
ONTARIO LIMITED
ONTARIO LAND SURVEYORS

1989

Boundary to [illegible]

[redacted] REGN HAS TITLE

NOTE

BEARINGS SHOWN HEREON ARE GRID AND DERIVED FROM CONTROL MONUMENTS 043820117 AND 043820118 AND ARE REFERRED TO THE 6° U.T.M. GRID SYSTEM ZONE 17, CENTRAL MERIDIAN 81°00'00" WEST.

LEGEND

■	DENOTES	FOUND
□	DENOTES	PLANTED
SIB	DENOTES	STANDARD IRON BAR
SSIB	DENOTES	SHORT STANDARD IRON BAR
D1	DENOTES	INST. No. 245394
D2	DENOTES	INST. No. 283103
D3	DENOTES	PLAN 20R-352
D4	DENOTES	PLAN 20M-273
OU	DENOTES	ORIGIN UNKNOWN
MTC	DENOTES	MINISTRY OF TRANSPORTATION AND COMMUNICATION
Y&Y	DENOTES	YATES AND YATES, O.L.S.
M&M	DENOTES	MARSHALL, MACKLIN, MONAGHAN, O.L.S.
IB	DENOTES	IRON BAR

SURVEYOR'S CERTIFICATE

I CERTIFY THAT

1. THIS SURVEY AND PLAN ARE CORRECT AND IN ACCORDANCE WITH THE SURVEYS ACT AND THE REGISTRY ACT AND THE REGULATIONS MADE THEREUNDER.
2. THE SURVEY WAS COMPLETED ON THE 12th DAY OF OCTOBER, 1989.

OCT. 23, 1989
DATE

Bruce I. McMurchy
BRUCE I. McMURCHY Ontario Land Surveyor

drawn b c MH	scale 1:500	job no. 21-89-585-000-1
checked B.M.	plan size K	

MARSHALL MACKLIN MONAGHAN ONTARIO LIMITED
4000 SOUTH SERVICE ROAD, SUITE 101
BURLINGTON, ONT., L7L 4X5, 634-4664
Ontario Land Surveyors

TABLE OF CONTROL MONUMENTS		
NO.	NORTHING	EASTING
043820117	4,798,281.419	594,030.099
043820118	4,797,910.366	595,008.619

METRIC
Distances shown on this plan are in meters and can be converted to feet by dividing by 0.3048.

SCHEDULE

PART	LOT	PLAN	INSTRUMENT NO.	AREA
1	14	BRANT'S BLOCK REG'D PLAN 99	394970 (REMAINDER)	951.4 m²
2				1924 m²
3				1187 m²

I REQUIRE THIS PLAN TO BE DEPOSITED UNDER THE REGISTRY ACT.

DATE OCT. 23, 1989

Bruce I. McMurchy
BRUCE I. McMURCHY O.L.S.

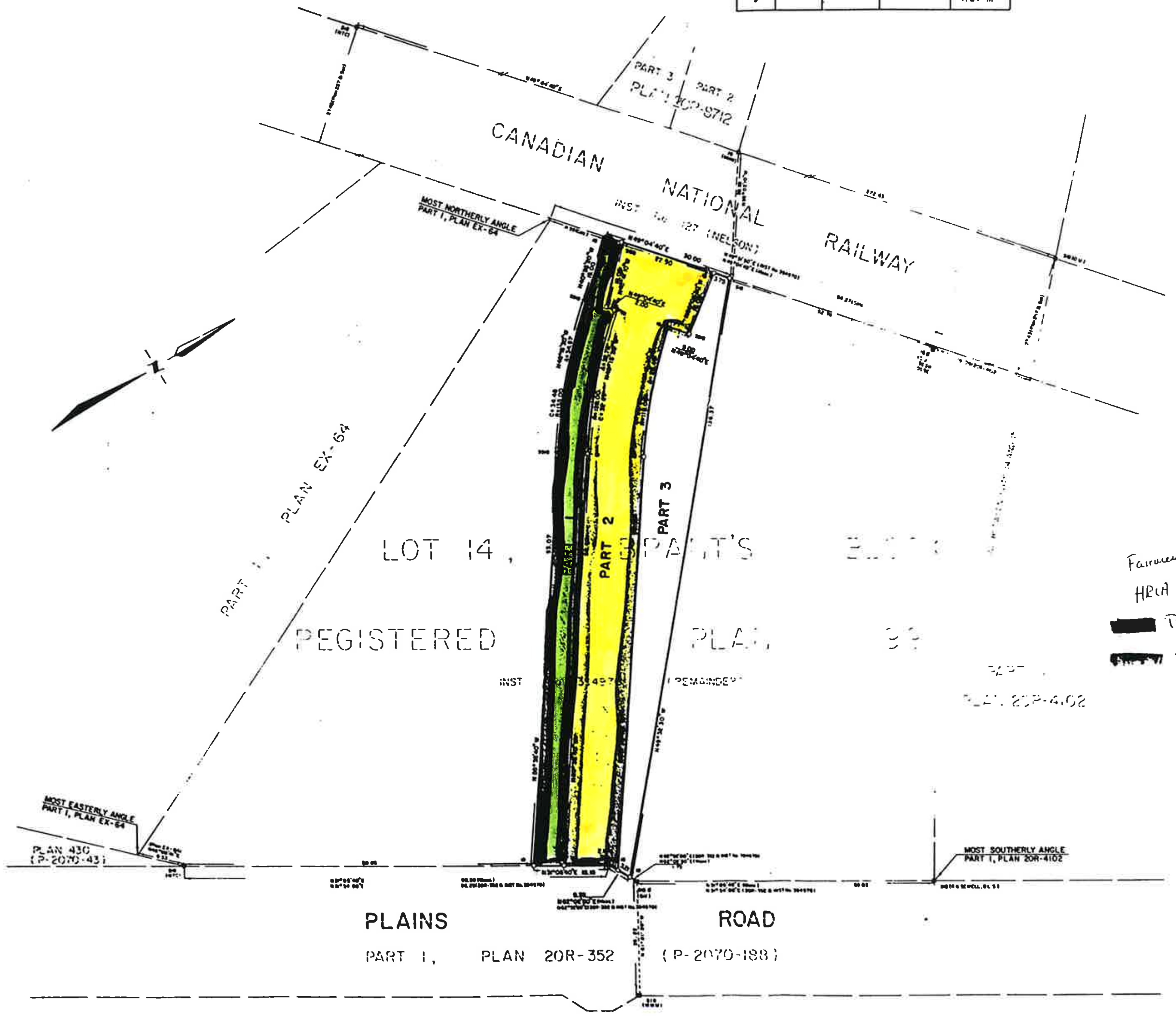
PLAN 20R-9602

RECEIVED AND DEPOSITED

DATE 31 OCT. 1989

Sheila Bell
A. D. LAND REGISTRAR
FOR THE REGISTRY DIVISION OF HALTON No 20

CAUTION
THIS PLAN IS NOT A PLAN OF SUBDIVISION WITHIN THE MEANING OF THE PLANNING ACT



Fairview to CNR.
HRCA ~~[illegible]~~ has
■ Perm. Easement
■ Title.

PLAN OF SURVEY OF
PART OF LOT 14
BRANT'S BLOCK
REGISTERED PLAN 99
FORMERLY IN THE VILLAGE OF BURLINGTON
COUNTY OF HALTON
CITY OF BURLINGTON
REGIONAL MUNICIPALITY OF HALTON

0 10 20 30 40m
SCALE 1:500

MARSHALL MACKLIN MONAGHAN
ONTARIO LIMITED
ONTARIO LAND SURVEYORS

1989

NOTE

BEARINGS SHOWN HEREON ARE GRID AND DERIVED FROM CONTROL MONUMENTS 043820117 AND 043820118 AND ARE REFERRED TO THE 6° U.T.M. GRID SYSTEM ZONE 17, CENTRAL MERIDIAN 81°00'00" WEST

LEGEND

■	DENOTES	FOUND
□	DENOTES	PLANTED
SIB	DENOTES	STANDARD IRON BAR
SSIB	DENOTES	SHORT STANDARD IRON BAR
MTC	DENOTES	MINISTRY OF TRANSPORTATION AND COMMUNICATION
●	DENOTES	ROUND
O.U.	DENOTES	ORIGIN UNKNOWN
IB	DENOTES	IRON BAR
MMM	DENOTES	MARSHALL MACKLIN MONAGHAN ONTARIO LIMITED, O.L.S.

TABLE OF CONTROL MONUMENTS

NO.	NORTHING	EASTING
043820117	4,796,281.419	596,030.099
043820118	4,797,910.566	595,808.819

SURVEYOR'S CERTIFICATE

I CERTIFY THAT

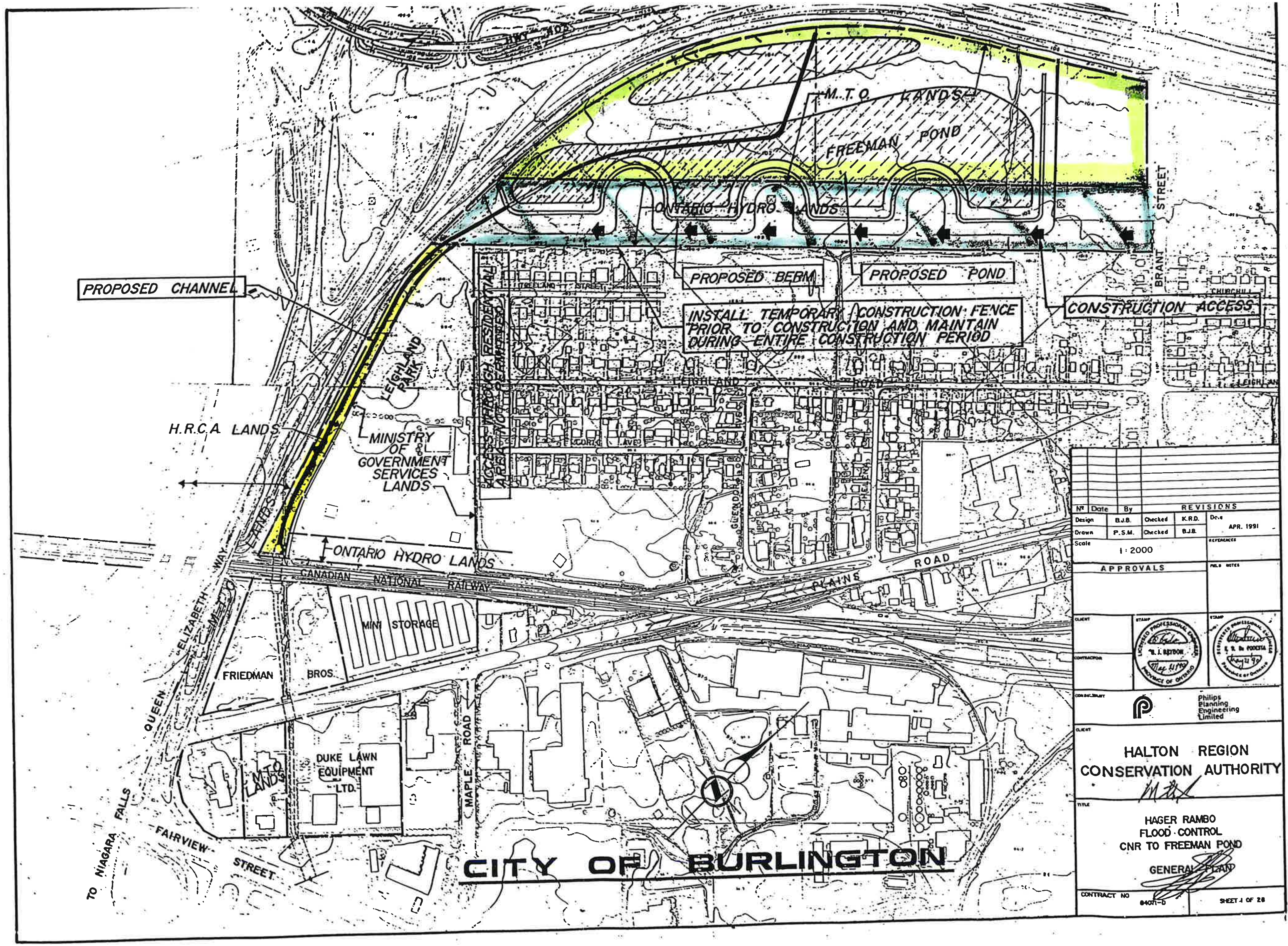
1. THIS SURVEY AND PLAN ARE CORRECT AND IN ACCORDANCE WITH THE SURVEYS ACT AND THE REGISTRY ACT AND THE REGULATIONS MADE THEREUNDER.
2. THE SURVEY WAS COMPLETED ON THE 18th DAY OF OCTOBER, 1989.

OCT. 23, 1989
DATE

Bruce I. McMurchy
BRUCE I. McMURCHY Ontario Land Surveyor

drawn E.P. Somak C.E.T.	scale 1:500	job no. 21-89-980-000-2
checked B.M.	plan size K	

MARSHALL MACKLIN MONAGHAN
ONTARIO LIMITED
4200 SOUTH SERVICE ROAD, SUITE 101
BURLINGTON, ONT., L7L 4X5. 639-4004
Ontario Land Surveyors



Nº	Date	By	REVISIONS

Design	B.J.B.	Checked	K.R.D.	Date APR. 1991
Drawn	P.S.M.	Checked	B.J.B.	

Scale 1 : 2000

REFERENCES

APPROVALS

FIELD NOTES

CLIENT

CONTRACTOR

STAMP B. J. BRYDON May 21/90

STAMP E. R. De POOCSTA May 21 90

CONSULTANT Philips Planning Engineering Limited

CLIENT

HALTON REGION CONSERVATION AUTHORITY

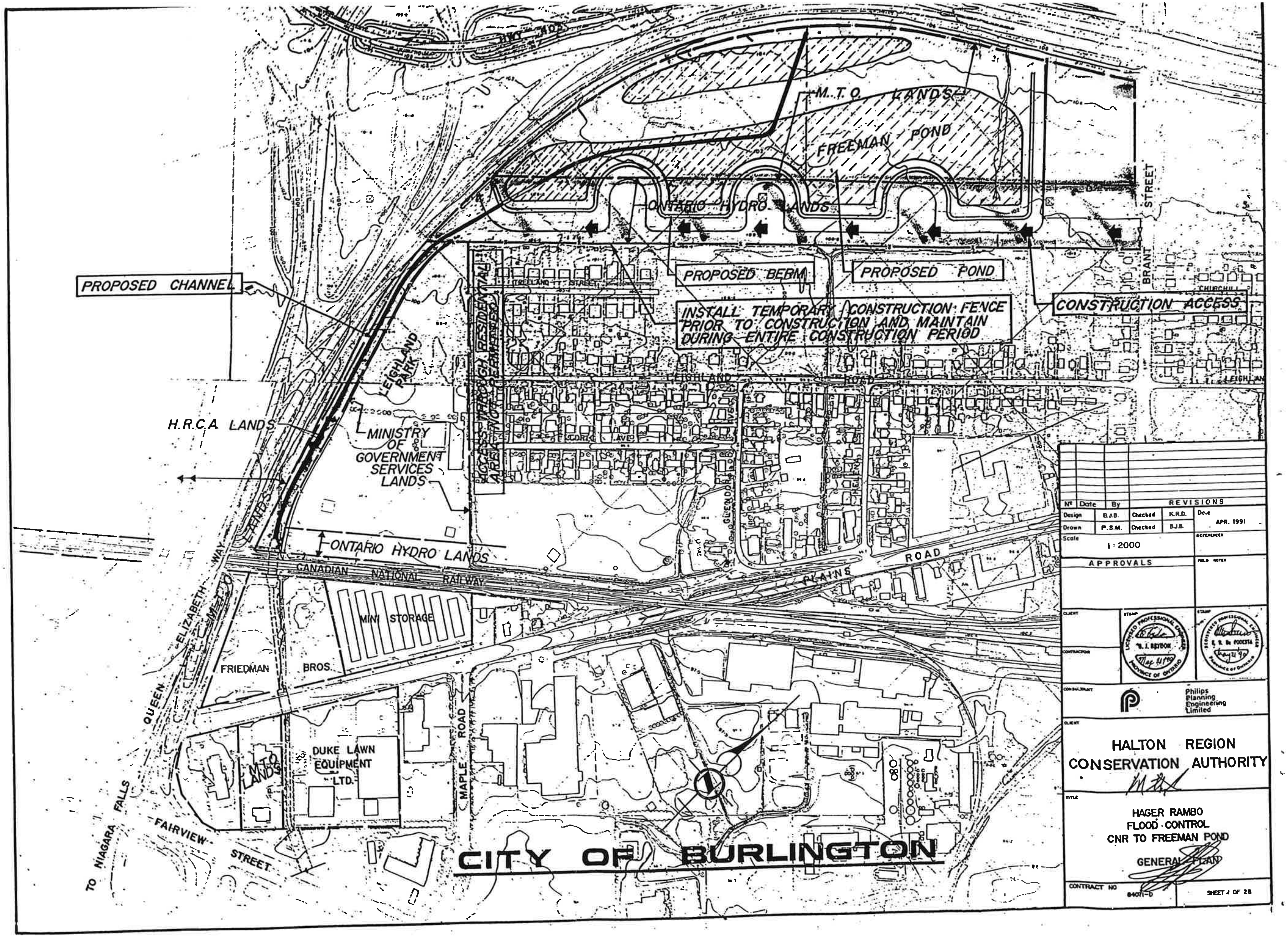
TITLE

HAGER RAMBO
FLOOD CONTROL
CNR TO FREEMAN POND

GENERAL PLAN

CONTRACT NO 84071-D

SHEET 1 OF 28



Nº	Date	By	REVISIONS

Design	B.J.B.	Checked	K.R.D.	Date APR. 1991
Drawn	P.S.M.	Checked	B.J.B.	

Scale 1 : 2000

APPROVALS

CONSULTANT Philips Planning Engineering Limited

CLIENT

HALTON REGION CONSERVATION AUTHORITY

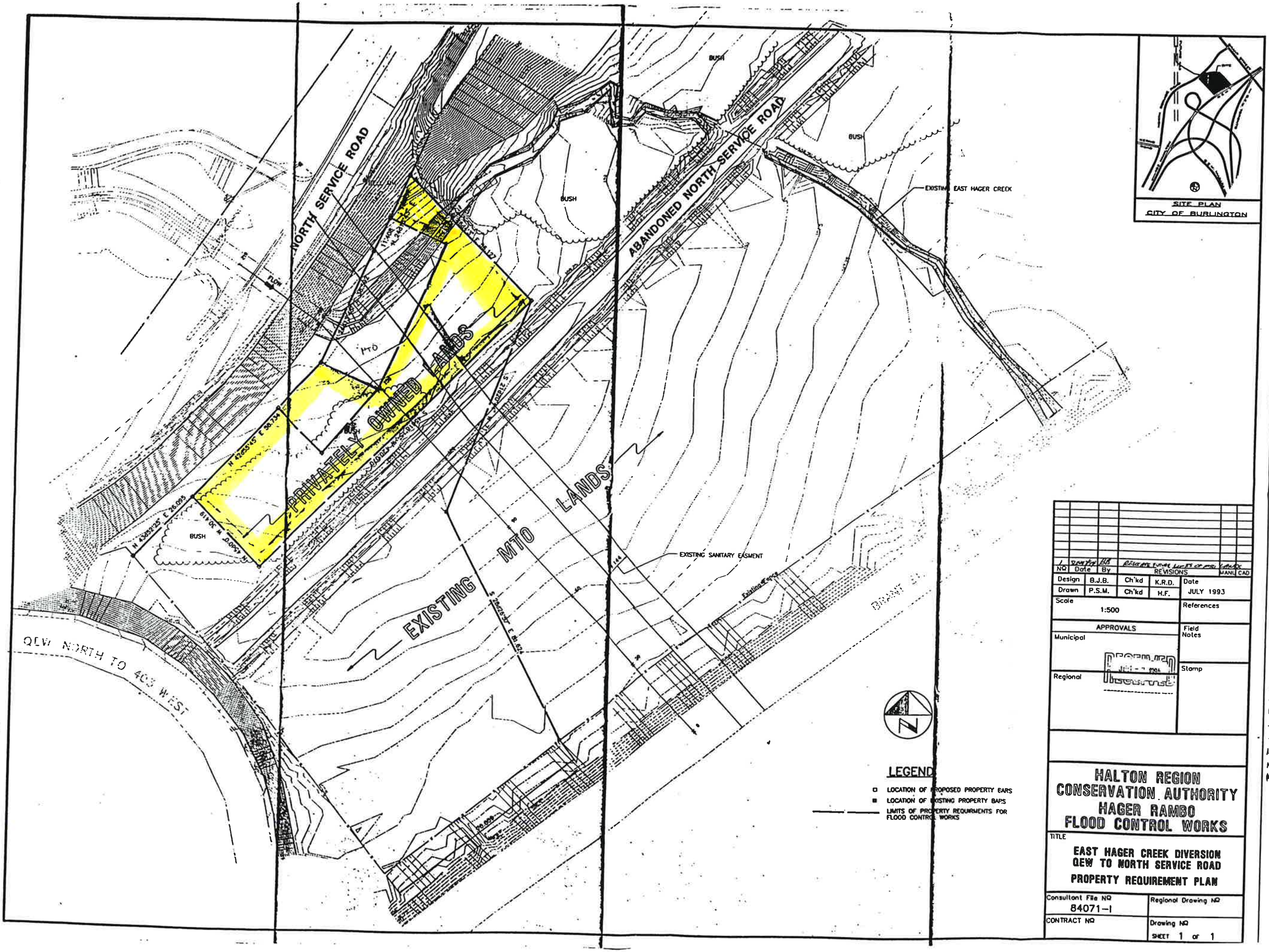
TITLE

HAGER RAMBO
FLOOD CONTROL
CNR TO FREEMAN POND

GENERAL PLAN

CONTRACT NO 84071-D

SHEET 1 OF 28



NO	Date	By	REVISIONS	MANU	CAD
1	[illegible]	BB	[illegible]		

Design	B.J.B.	Ch'kd	K.R.D.	Date JULY 1993
Drawn	P.S.M.	Ch'kd	H.F.	

Scale 1:500

References

APPROVALS

Municipal

Regional

Field Notes

Stamp

RECEIVED JUN - 7 1994

HALTON REGION
CONSERVATION AUTHORITY
HAGER RAMBO
FLOOD CONTROL WORKS

TITLE

EAST HAGER CREEK DIVERSION
QEW TO NORTH SERVICE ROAD
PROPERTY REQUIREMENT PLAN

Consultant File NO 84071-1

Regional Drawing NO

CONTRACT NO

Drawing NO SHEET 1 OF 1

GEL - [illegible]

[illegible]
land above Abandoned NSR owned [illegible]

Site Owner: The City of Burlington; the HRCA. has an easement agreement

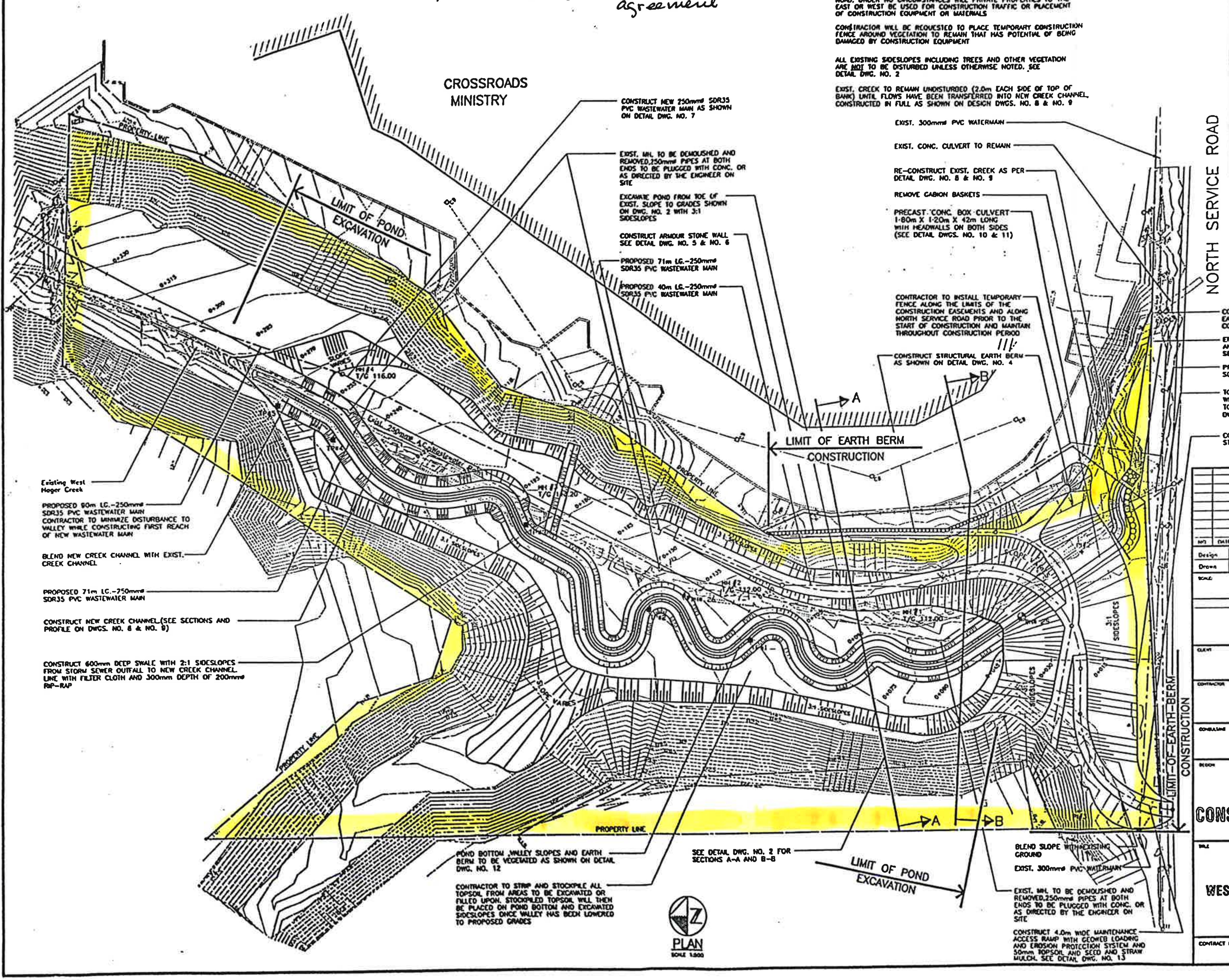
NOTES

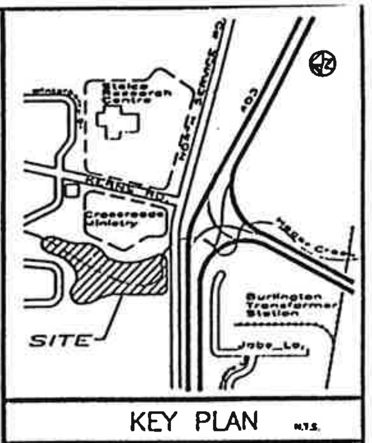
CONTRACTORS ONLY ACCESS TO SITE WILL BE FROM NORTH SERVICE ROAD, UNDER NO CIRCUMSTANCES WILL PRIVATE PROPERTIES TO THE EAST OR WEST BE USED FOR CONSTRUCTION TRAFFIC OR PLACEMENT OF CONSTRUCTION EQUIPMENT OR MATERIALS

CONTRACTOR WILL BE REQUESTED TO PLACE TEMPORARY CONSTRUCTION FENCE AROUND VEGETATION TO REMAIN THAT HAS POTENTIAL OF BEING DAMAGED BY CONSTRUCTION EQUIPMENT

ALL EXISTING SIDESLOPES INCLUDING TREES AND OTHER VEGETATION ARE <u>NOT</u> TO BE DISTURBED UNLESS OTHERWISE NOTED. SEE DETAIL DWG. NO. 2

EXIST. CREEK TO REMAIN UNDISTURBED (2.0m EACH SIDE OF TOP OF BANK) UNTIL FLOWS HAVE BEEN TRANSFERRED INTO NEW CREEK CHANNEL, CONSTRUCTED IN FULL AS SHOWN ON DESIGN DWGS. NO. 8 & NO. 9





KEY PLAN N.T.S.

CURVE DATA FOR RAMP	CURVE DATA FOR RAMP
PI#2 STA. 0+020.972 OFFSET 30.757 RIGHT ∠=97°–00'–00" T=33.11m R=27.50m L=46.55m	PI#3 STA. 0+022.309 OFFSET 42.014m LEFT ∠=89°–00'–00" T=27.00m R=27.50m L=42.71m

NO	DATE	BY	REVISIONS		

Design	B.J.B.	Ch'kd	K.R.D.	DATE APR. 1992
Drawn	C.D.A.	Ch'kd	P.S.M.	

SCALE 1:500

REFERENCES

APPROVALS

FIELD NOTES

CLIENT

CONTRACTOR

STAMP K. R. De POCESTA

STAMP B. L. BRYDON

CONSULTANT Philips Planning + Engineering Limited

REGION

HALTON REGION CONSERVATION AUTHORITY

TITLE

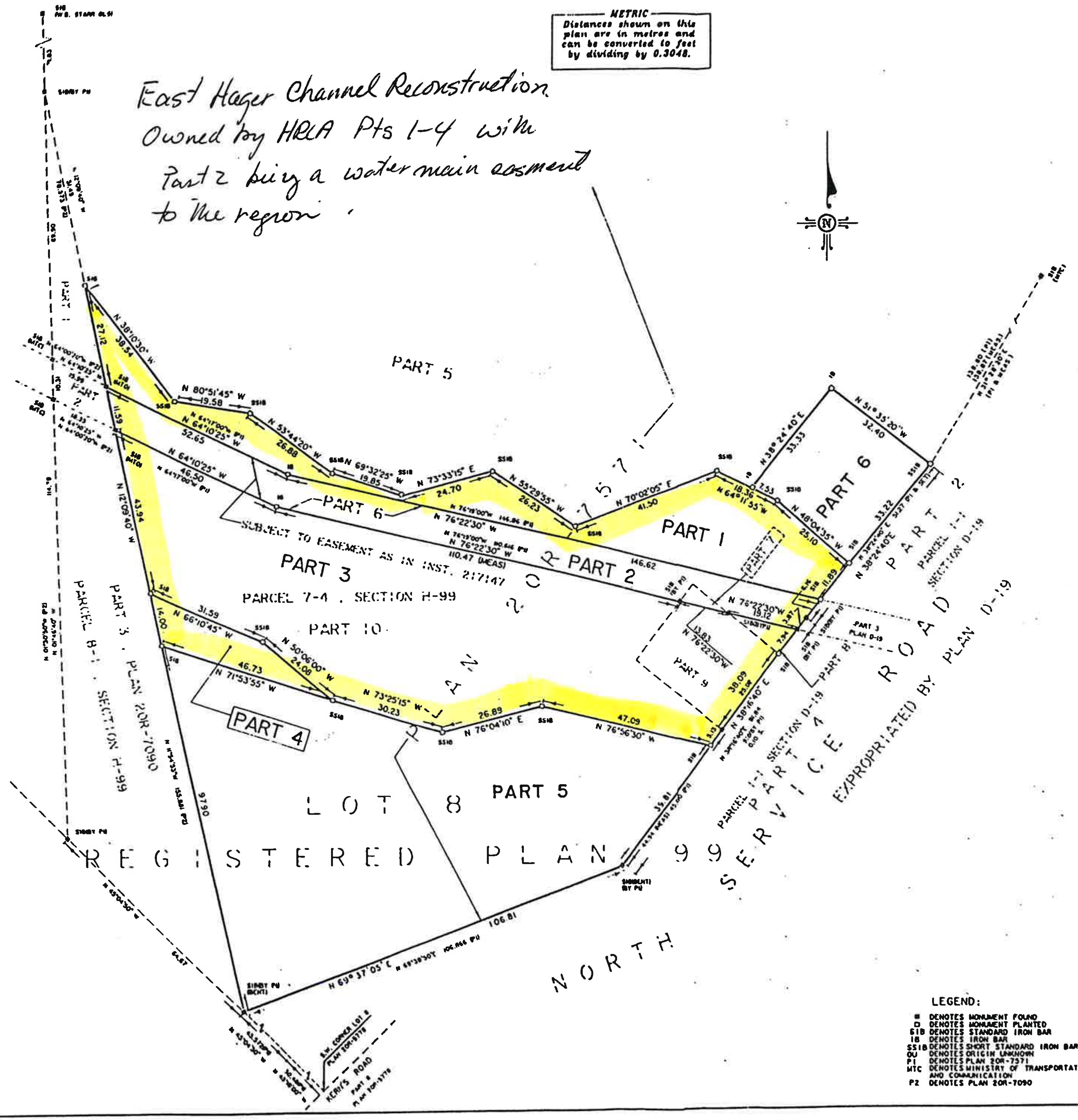
HAGER RAMBO FLOOD CONTROL WEST HAGER DETENTION FACILITY

GENERAL OVERALL PLAN

CONTRACT NO. 84071–C

DRAWING NO. SHEET 1 OF 14

APR. 13/1992



METRIC
Distances shown on this plan are in metres and can be converted to feet by dividing by 0.3048.

East Hager Channel Reconstruction
Owned by HRCA Pts 1-4 with
Part 2 being a watermain easment
to the region.

I REQUIRE THIS PLAN TO BE DEPOSITED UNDER THE LAND TITLES ACT.	PLAN 20R-11144
	RECEIVED AND DEPOSITED
DATE MAY 5, 1993	DATE Nov. 3.
Bruce I McMurchy BRUCE I. McMURCHY O.L.S	LAND REGISTRAR FOR THE LAND TITLES DIVISION OF HALTON NO.20

CAUTION
THIS PLAN IS NOT A PLAN OF SUBDIVISION WITHIN THE MEANING OF THE PLANNING ACT

PARTS 1 TO 6 INCLUSIVE
PART OF PARCEL 7-4 ,SECTION H-99
PART 2 - SUBJECT TO EASEMENT AS IN INST. 217147

PLAN OF SURVEY OF
PART OF LOT 8, BRANT'S BLOCK
REGISTERED PLAN 99
VILLAGE OF BURLINGTON
CITY OF BURLINGTON
REGIONAL MUNICIPALITY OF HALTON
SCALE 1: 750
10 5 0 10 25 METRES

MARSHALL MACKLIN MONAGHAN
ONTARIO LIMITED
ONTARIO LAND SURVEYORS

1993

NOTE:
BEARINGS SHOWN HEREON ARE ASTRONOMIC AND ARE REFERRED TO THE WESTERLY LIMIT OF PART 10 HAVING A BEARING OF N 12°09'40"W AS SHOWN ON PLAN 20R-7571.

SURVEYOR'S CERTIFICATE
I CERTIFY THAT
1. THIS SURVEY AND PLAN ARE CORRECT AND IN ACCORDANCE WITH THE SURVEYS ACT AND THE LAND TITLES ACT AND THE REGULATIONS MADE THEREUNDER.
2. THE SURVEY WAS COMPLETED ON THE 4th DAY OF MAY 1993.

MAY 5, 1993
DATE

Bruce I McMurchy
BRUCE I. McMURCHY Ontario Land Surveyor

LEGEND:

■	DENOTES MONUMENT FOUND
□	DENOTES MONUMENT PLANTED
SIB	DENOTES STANDARD IRON BAR
IB	DENOTES IRON BAR
SSIB	DENOTES SHORT STANDARD IRON BAR
OU	DENOTES ORIGIN UNKNOWN
P1	DENOTES PLAN 20R-7571
MTC	DENOTES MINISTRY OF TRANSPORTATION AND COMMUNICATION
P2	DENOTES PLAN 20R-7090

drawn T.R.	scale 1:750	job no. 20-93657-01-000
checked B.M.	plan size J	

MARSHALL MACKLIN MONAGHAN
ONTARIO LIMITED
4200 SOUTH SERVICE ROAD, SUITE 101
BURLINGTON, ONT., L7L 4X5. 639-4064

Ontario
Land
Surveyors

APPENDIX 'B'

STANDARD INSPECTION FORM

HAGER-RAMBO SITE INSPECTION FORM

Name of Inspector: ______________________________

Site: ______________ Date: ______________ Time: __________

Purpose for Inspection: Date of Last Rainfall: ______________

Complaint ☐

Annual ☐ Photographs Taken?: Y/N ______

Semi-Annual ☐

Other ☐ ______________________________

Comments on:

Ingress/Egress:
- Locks functioning?: Y/N ______
- Is site accessible?: Y/N ______
- Any remediation?: ______________________________

____

Excessive Sedimentation or Vegetation?: Y/N ______

If Yes: Describe location: ______________________________

____

Recommended Action: ______________________________

____

Any Structural Problems?

Gabion Basket or Armour Stone Settlement or Failure Including Mesh? Y/N ______

If Yes: Where?: ______________________________

____

Concrete Works Displacement Spalling or Cracking? Y/N ______

If Yes: Where and How Much (mm)? ______________________________

____

Subdrain Blockage? Y/N ______

If Yes: Where?: ______________________________

____

Recommendation: ______________________________

____

Fence Problems: Y/N ______

If Yes: Where?: ______________________________

____

Recommendation: ______________________________

____

Aesthetic Concerns? Y/N ______

If Yes: What?: ______________________________

____

Where?: ______________________________

____

Other Observations: ______________________________

____

____

Hager-Rambo Flood Control Works

Operation and Maintenance Deficiency Check List

Project Element	Type	Deficiency	Method to Address
Concrete	Channel Invert Culverts Vertical Drop Structures Headwall Wingwall Retaining Dissipation Blocks	Deterioration Diagonal Cracking Displacement/Distress Heaving Infiltration/Exfiltration Longitudinal Cracking Offsets Seepage Surface Defects Transverse Cracking Vandalism Vegetation Growth	Sealing Grouting Replacement Removal of Vegetation
Channel/Erosion Protection	Armour Stone	Degradation Displacement Vegetation	Replacement Removal of Vegetation
	Rip-Rap	Degradation Displacement Erosion Beneath Geotextiles Exposed	Replacement
	Gabions	Rock Degradation Settling Displacement Spaces Vegetation Growth Wire Degradation	Replacement Removal of Vegetation Repair Basket Wire
	Interlocking Concrete Block	Displacement Heaving Spaces	Replacement
Detention Facility	Berms	Slope Failure	Slope Stabilization
	Overlow Valves Sluice Gates	Defective Damaged	Replacement Repair
	Retention Ponds	Sediment/Siltation	Dredging
Obstructions	Channel Low Flow Channel Culverts Sub-drains Outlets	Aquatic Vegetation Dams Debris Fallen Rocks Sediment/Siltation Shrubs Slope Failure Tall Weeds Trees	Removal
Site Access & Protection	Access Ramps Security Fencing Pedestrian Handrails Gates Locks Hinges Signs	Obstructions Damaged Defective Visibilty	Replacement Repair Removal of Obstructions

APPENDIX 'C'

1997 FIELD RECONNAISSANCE

APPENDIX 'C'

1997 FIELD RECONNAISSANCE

East Rambo Creek Channelization (Queensway Drive to CNR–Oakville)

On June 20, 1997, the works were inspected by Philips Planning and Engineering Limited personnel. The concrete lined invert is in good shape, with only the expected shrinkage cracks. At one location (station 0+110) a slight (20 mm) settlement has occurred at the shrinkage crack. Gabion baskets are in excellent condition, with no evidence of settlement or potential failure.

The gate at Fassel Drive (east side) is damaged and in need of repair. As well, the Fassel Drive and Queensway Drive maintenance access locations are in need of clean up due to a high amount of vegetative growth, which may inhibit routine or emergency access to the channel invert.

Lower East Rambo Creek Channelization (CNR–Oakville to Fairview Street

Based on the June 1997 inspection, the concrete works for this project including the channel lining and the Fairview Street culvert appear to be in excellent condition. There are no signs of major cracking of the channel invert; however, vegetation is growing between the channel lining and the base of the armour stone retaining walls in a few locations. The low flow channel has a high amount of algae and sediment within it. The armour stone shows no sign of displacement or deterioration, and the fencing and gated access is in good condition and working order.

East Hager Creek Channelization (Fairview Street to CNR – Halton)

On August 6, 1997, the works were inspected by Philips Planning and Engineering Personnel. At the time of the site visit, the water level was contained to the low flow channel, with a high level of algae growth and sediment. The channel walls and the Plains Road Culvert were found to be in good condition. However; the channel lining has vegetation growing up through the control and/or expansion joints in a few areas.

East Hager Creek (CNR Halton Culvert Crossing)

The channel and culvert appear to be in good condition, however; vegetation growth is present in some areas of the control and expansion joints. The protective fencing around the perimeter of the site is in good condition. The walls of the CNR structure both upstream and downstream have been defaced by graffiti.

East Hager Creek Channelization

During the site visit on August 6, 1997, by Philips Planning and Engineering personnel, it was observed that this section of channel works is in very good condition. The interlocking concrete block lined channel shows no signs of failure in the form of displacement or buckling, and vegetation has grown very well throughout. The channel invert is well vegetated with Purple Loosestrife being the dominant species. Slight sediment build up has occurred in the low flow channel of the concrete sections, and the sub-drains are blocked with vegetation. (Reference Section 6.5)

Freeman Detention Facility and East Hager Creek Channelization

On August 6, 1997, a site visit was undertaken by Philips Planning and Engineering personnel. The three concrete culverts and the concrete channel transitions appear to be in good condition with no signs of distress or displacement; however, the upstream side of the outlet culvert has been defaced by vandalism. The interlocking concrete block channel is in good condition and heavily vegetated throughout, although Purple Loosestrife is the dominant species and clearly defines the channel as seen in the photographs (reference Section 7.5).

The vegetation throughout the remainder of the site seems to have taken well considering the minimal amount of topsoil. The chainlink security fence enclosing the facility is also in good condition with exception of a 0.4 metre opening at the northeast corner of the park where the chainlink fence ends adjacent to private property.

East Hager Creek Realignment and Pond System

At the time of the photographic reconnaissance on August 6, 1997, the watercourse was in a low flow state. The amount of vegetation growth immediately around the pond system has developed well, most notably at the first pond (furthest upstream) where a high concentration of cat-tails has evolved. However, the vegetation throughout the remainder of the overbank areas is very sparse.

The drop structures and retaining walls of each of the ponds appear to be in good condition, as well as the dissipation blocks at the base of the third pond (furthest downstream) and the upstream face of the Highway 403 culvert. There is an accumulation of algae on the face of each of the retaining walls, and evidence of vandalism is shown by the graffiti on the inlet structure and the damage to the access gate.

An additional site visit was made in November 1997, by Halton Region Conservation Authority and Philips Planning and Engineering personnel to determine the cause of the low permanent level of the ponds. It has been determined that each of the three sluice gates have been damaged and that slight leaking is occurring. Consultation with the manufacturer (Armtec^{TM}) has taken place and minor repairs have been made and water levels are back to where they have been designed. In December 1998, leaking was observed on the west side of the control structure for the downstream facility. As of the time of writing, the source of the leak was not yet identified; resolution of this issue is anticipated in the spring.

East Hager Creek Reconstruction (North Service Rd. to Future Hwy. 407)

At the time of the site visit on August 6, 1997, by Philips Planning and Engineering staff, the vegetation within the site appears to have grown very well (reference Section 9.5). Purple Loosestrife is the dominant species with the channel, as seen in Photos 1-4. The North Service Road culvert and the culvert and cut-off wall at the upstream limit of the site appear to be in good condition, however the handrails and fencing around the culvert and cut-off wall are damaged and in need of repair. The armour stone is in good condition and shows no sign of degradation or displacement. As seen in Photo 9.6, slight bank erosion is occurring just upstream of the cut-off wall.

West Hager Detention Facility

On August 6,1997, the works were inspected by Philips Planning and Engineering personnel. The valley has vegetated very well, including the infestation of Purple Loosestrife that follows the channel. The outlet culvert appears to be in good condition; however, vegetation and debris block both the outlet culvert and the existing culvert that conveys flow under the North Service Road.

APPENDIX 'D'

1998 AERIAL PHOTOGRAPHS

Freeman Pond – Inter Ramp Storage Area
(looking north, northeast)

Freeman Pond and West Hager Outlet Channel
(looking west)

West Hager Pond (looking south)

East Hager Stormwater Energy Dissipation Ponds
North Service Road to QEW (looking northwest)

East Rambo Creek Channelization
Glenwood School Drive to Queensway (looking east)

East Rambo Creek Channelization
CNR to Upstream of Fassel Drive (looking east)

Lower East Rambo Creek Channelization Fairview Street to CNR (looking east)

West Hager Creek Outlet Channel (Concrete Block), CNR Triple Cell Culvert crossing, West Hager Creek Channelization (Concrete) CNR to Fairview Street (looking south)

Memo

To: Heather Dearlove and Jannette Brenner, Conservation Halton

From: Ron Scheckenberger and Matt Senior, Wood

Date: August 9, 2019 (Revised December 18, 2019)

File: TPB178008

cc: Leah Smith, Cary Clark, and Umar Malik, City of Burlington

Re: **Downtown and Burlington GO Mobility Hubs**
Flood Hazard and Scoped SWM Assessment
East Rambo Flood Control Facility – Retrofit Feasibility Assessment
City of Burlington

A. Introduction and Background

Further to Wood's submission of the updated "Flood Hazard and Scoped Stormwater Management Assessment, Burlington GO and Downtown Mobility Hubs" Report (February 25, 2019), and the receipt of comments from Conservation Halton (ref. e-mail Dearlove-Enns, June 27, 2019 and written comments ref. Dearlove-Bustamante, July 25, 2019), as well as the meeting of July 9, 2019, we hereby provide a summary outlining Wood's professional opinion on the potential feasibility of a retrofit of the East Rambo Flood Control Facility, to prevent the spill condition to the West Rambo Creek. The text herein also reflects comments provided by Conservation Halton (CH) in its correspondence of September 25, 2019 (Dearlove-Malik).

As you are aware, the results of the previously noted assessment have indicated that under sufficiently high flows (approximately the 1 in 10-year storm event) the East Rambo Flood Control Facility (FCF) would generate uncontrolled spills via the CNR crossing under the QEW, which would direct flows to the West Rambo Creek system, south of the QEW (rather than the controlled discharge from the East Rambo FCF, which is directed to the East Rambo Creek at Plains Road/Brenda Crescent). This condition results in flows from the East Rambo FCF being split between the East and West Rambo Creek systems, contrary to the previously understood design performance (with all flows being directed to the East Rambo Creek system).

Based on the preceding, CH has previously requested that two (2) modelling scenarios be assessed: with the division of flows as estimated based on actual existing conditions (Scenario 1) and with all flows being directed to East Rambo Creek, as originally intended (Scenario 2). Peak flows for both scenarios were generated and included in the previously noted report, as well as estimated floodplain mapping for both scenarios.

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a Division of Wood Canada Limited
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Registered in Canada No. 773289-9; GST: 899879050 RT0008; DUNS: 25-362-6642

P:\2017\Projects\TPB178008S - Mobility Hub Planning Consulting Services\04_COR\04_MEMO\19-12-18 CH HDearlove.docx

In its comments of July 5, 2019 ref. (e-mail Dearlove-Enns), CH has noted that while Scenario 1 is more representative of existing conditions, it does not represent the worst case scenario for East Rambo Creek and the eventual receiver of East Rambo Creek flows, namely the Hager-Rambo Diversion Channel. Further, CH has suggested that Scenario 1 does not meet Provincial Guidelines, which recommend that reduced flows (i.e. to East Rambo Creek) should only be used after a review of alternatives proves that the spill cannot reasonably be prevented. CH has therefore recommended that Scenario 2 be used to delineate the flood hazard for the East Rambo Creek, as well as the Hager-Rambo Diversion Channel. Under Scenario 2, the generated floodplain mapping (refer to Drawing 5B from the previously noted report) indicates the potential for spill flows from East Rambo Creek in the vicinity of Fairview Street and Argon Court, as well as from the Hager-Rambo Diversion Channel itself, along Fairview Street, between the East and West Rambo Creeks. CH has suggested that these spill flows require additional assessment to better understand the impacts of these flows to the Burlington GO Mobility Hub, as well as the impact of routed flows to the downstream receivers (i.e. Lower Rambo Creek) within the Downtown Mobility Hub.

As discussed at the meeting of July 9, 2019 (and in Comment 11c of its July 25, 2019 comments), CH staff has indicated they may be in a position to support the application of the current condition and more representative flows associated with Scenario 1 (which would then eliminate the need for further hydraulic modelling and floodplain mapping for Scenario 2), if a sufficiently robust alternative/feasibility assessment is undertaken to demonstrate that it is not considered reasonably feasible or likely that the East Rambo FCF could ever be retrofitted or altered to address the previously noted spill. This memorandum is intended to document this assessment.

B. Potential Retrofitting East Rambo FCF – Review of Considerations

Wood is of the professional opinion that a retrofit of the East Rambo FCF to re-direct flood flows towards the East Rambo Creek is both undesirable (given the potential impacts) and also infeasible (given the technical and financial burdens associated with such works). This would apply both to a complete or partial re-direction of flows, given that similar challenges would occur in both instances. A summary of the rationale for this opinion is outlined herein.

1. ***Flood Impacts to Residential Properties.*** As evident from previously prepared floodplain mapping for Scenarios 1 (as per existing conditions) and 2 (all flows from the East Rambo FCF re-directed to East Rambo Creek), Scenario 2 results in a much more extensive floodplain for the East Rambo Creek between the QEW and Fairview Street (ref. Drawings 5A and 5B from the previously noted report). Based on a preliminary estimate, approximately 40 +\- additional detached residential homes between Plains Road and the CNR tracks would be placed within the Regulatory Floodplain under Scenario 2 as compared to Scenario 1, which would notably increase flood risk and damage potential. Further, a large number of additional residential homes would be placed at risk south of Fairview Street due to spill flows from East Rambo Creek and the Hager-Rambo Diversion

Channel under Scenario 2 as compared to Scenario 1. Based on a high-level review with staff from the City of Burlington, it is understood that there are no other critical infrastructure installations that should be considered in either spill area (i.e. electrical substations, telecommunications hub, waste management sites, etcetera). It is further understood that there are no critical vulnerable populations in either area (nursing homes, retirement homes, hospitals, etcetera). Thus, the primary differentiator between the flood risks in the two (2) areas relates to the presence (or absence) of residential units.

Under Scenario 1, spill flows to West Rambo Creek via the CNR would primarily impact industrial/commercial properties only, which would be expected to have a correspondingly lower risk to public life and public property as noted previously. The exception would be high surface flows along Plains Road and the Brant Street underpass, which would be expected to flood due to spill flows and would correspondingly pose a safety risk to drivers.

These flood risks could potentially be practically mitigated through additional measures however, such as increased culvert capacity of West Rambo Creek at Plains Road, grading modifications, and storage. This could also potentially include channel improvements to increase capacity.

With respect to Scenario 1, based on a review of property limits and grading, opportunities are generally considered limited along West Rambo Creek, downstream of Plains Road (subject to acquiring private property) and would also necessitate co-ordination to upgrade three (3) hydraulic structures (two (2) railway lines and one (1) private crossing).

With respect to Scenario 2, channel improvements would be further constrained by the larger number of private properties crossed by East Rambo Creek, and the greater complexities associated with acquiring private residential properties (as opposed to commercial/industrial properties). Although opportunities along both watercourses are considered limited/constrained, improvements to West Rambo Creek would generally be more feasible.

Overall, it is considered that the flood impacts and risks under Scenario 2 are greater than under Scenario 1, given the direct impact to residential properties and residents which involve overnight uses. Channel improvements along East Rambo Creek (which would receive more of the flow under Scenario 2) would also be more complex.

The preceding suggests that a retrofit of the East Rambo FCF to re-direct spill flows to East Rambo Creek (either partially or wholly) would be counter-productive in terms of risk management, and ultimately counter to the overall goals of both the City of Burlington and Conservation Halton.

2. ***Feasibility of Preventing Spill via CNR Crossing.*** As noted previously, based on the hydrologic modelling conducted for the Mobility Hub Study, the East Rambo FCF would be expected to spill to the West Rambo Creek system via the CNR crossing at approximately the 1 in 10-year storm event. The spill elevation of the railway tracks in this location has been estimated as 105.5 m, as compared to the base facility elevation of 103.3 m (active depth of 2.2 m at spill point). By contrast, the maximum simulated water level within the facility for the Regional Storm Event (Scenario 1) is estimated as 106.43 m (or some 0.93 m higher), or just above the secondary North Service Road spill elevation of 106.40 m.

   Given the grade constraints associated with railway tracks, it is considered unlikely that the railway tracks could be practically raised to address the spill; further this would have impacts on the vertical clearance within the CNR enclosure itself, which would suggest that the structure would need to be altered and replaced to meet CNR clearance requirements. Even a partial adjustment of rail geometry would be complex and costly, and ultimately only partially effective.

   A stand-alone automated active flood barrier could potentially be implemented on the CNR QEW crossing (to be enabled once flood levels within the pond reached a certain critical level), however this would require active ongoing monitoring of pond levels and associated automated controls for the barrier. It is unclear who would be responsible for the long-term capital, and operation and maintenance costs for such a system. It is also unclear whether or not both CNR and MTO would agree to the implementation of such a system within their jurisdiction. Such a flood barrier would also likely not be fully watertight, given the nature of railway tracks (i.e. irregular granular bedding and elevated tracks), although it would likely reduce flood spills, if it could be feasibly implemented.

   A passive flood barrier (i.e. a berm or wall) could also potentially be considered to prevent spill from entering the CNR QEW crossing. Notwithstanding, the barrier would need to be completed on both sides of the CNR tracks, given the potential for backwater and flooding on the upstream side of the CNR tracks via East Rambo Creek and the associated culvert crossing of the CNR. This would also require re-alignment of East Rambo Creek on the downstream side of the FCF and would also reduce the available flood storage volume within the FCF due to the barrier (notably there would be a reduced impact associated with a wall as compared to a sloped berm however). A barrier on the upstream side of the CNR would be constrained by available space and the numerous landowner interests in this area. Alternatively, a backwater prevention system could potentially be implemented and fitted to the East Rambo Creek culvert, however further detailed hydraulic modelling would need to be completed to confirm to assess effectiveness and feasibility at this scale.

With respect to both active and passive flood barriers to prevent spill via the CNR crossing, the local impacts of implementing such a flood barrier have also not been assessed. Increased operating levels in the FCF have the potential to result in additional flooding of the surrounding area unless additional flow relief was implemented in combination with the flood barrier. In particular, flood encroachment on the properties at 2220, 2250 and 2260 Industrial Street is estimated to occur at an elevation of approximately 106.0 m; this could potentially be worsened by berming off relief flow via the CNR QEW crossing and increasing operating levels within the facility.

Re-grading/expansion of the pond to reduce operating levels is also considered infeasible given surrounding infrastructure (roadways and railways). It is understood that available storage in the facility was maximized at the time of design and also further extended as part of the Area 8 Roseland Creek Diversion, hence potential for additional storage is not considered available. If the North Service Road were theoretically to be shifted closer to the QEW, there would be the potential to increase the facility footprint area, however this would be subject to the acquisition of additional land and agreement with the MTO, both of which may not be forthcoming given active uses in the area. In addition, such an expansion in storage in and of itself would likely not be effective; this storage expansion would likely need to be combined with additional relief flow, necessitating additional infrastructure upgrades (assessed further as part of the subsequent review point).

Based on the preceding, the direct elimination of spill flows through physical works via raising of the CNR tracks, implementation of a flood barrier, or re-grading/expansion of the existing FCF are all considered unlikely or infeasible. Spill flows via the CNR QEW crossing could also potentially be reduced/prevented if additional relief flow could be incorporated to re-direct flows towards East Rambo Creek; this is considered further as part of the subsequent review point.

3. ***Feasibility of Re-Directing Flows to East Rambo Creek.*** As a final consideration, the feasibility of re-directing overflows from the East Rambo FCF to East Rambo Creek has also been reviewed. Based on the currently estimated facility operating curve (stage-storage-discharge), the existing low flow outlet (3.0 m wide x 1.5 m high box culvert) has a limited capacity, which restricts discharge and ultimately results in spill via the first relief point (i.e. the CNR QEW crossing). As such, in order to re-direct flows to the East Rambo Creek, the FCF outlet would either need to be upgraded/upsized, or potentially twinned with a secondary relief crossing of the QEW to the East Rambo Creek. Such an undertaking would be expected to be extremely complex and costly. The crossing would need to cross not only the North Service Road but the QEW, with a combined 12 lanes of active traffic. Construction would therefore need to utilize trenchless methods, such as microtunnelling or jack and bore to avoid disruption to the roadways, and clearly require agreement with the MTO. The cost of the construction (including implementation of large diameter piping)

would be expected to be high. Additional reconstruction on Plains Road and Brenda Crescent/Queensway Drive would also be required to re-direct the additional storm flows to East Rambo Creek.

Further, the estimated Regional Storm inflow to the East Rambo FCF is 62.0 m^3/s. As per the simulated results for Scenario 2, the existing box culvert has been estimated to convey some 18.5 m^3/s, leaving a residual peak flow to be conveyed of some 43.5 m^3/s. Assuming a concrete box culvert structure at a 0.5% grade, and a similar rise to the existing structure (1.5 m), an additional width of some 7.5 m would be required. This large geometry would further increase construction costs, potentially necessitating two (2) separate relief lines.

A less costly alternative could potentially be to re-direct spill flow from the CNR at the downstream side of the QEW, via the existing grassed area in the QEW right-of-way between the CNR and Plains Road/Brenda Crescent. The feasibility of completely blocking and re-directing uncontrolled spill flows at this magnitude is considered low however; the potential for practically constructing a flow bypass in the noted area is unknown without further detailed assessment. Such a system would further require agreement with MTO (and could potentially limit its use of the corridor including any potential future widening), and would also need to assess any potential impacts to the existing industrial properties fronting on Plains Road in this area.

All of the preceding measures also assume no additional flow restrictor controls within the East Rambo FCF. Ultimately, the FCF was originally approved to provide flow controls up to and including the 100-year storm event. Any potential retrofit would need to consider what, if any, potential measures could be incorporated into the design to achieve a greater degree of flow control to ensure compatibility with the originally approved intent and mitigate downstream impacts associated with legacy works. The feasibility of this approach would require further consideration and assessment.

Overall, the re-direction of spill flows from West Rambo Creek to East Rambo Creek would be a highly complex and costly undertaking, and would necessarily involve partnership and agreement with the MTO given the works in proximity to the QEW.

C. Summary

Based on the preceding, Wood is of the professional opinion that a retrofit of the East Rambo Flood Control Facility to re-direct predicted spill flows towards East Rambo Creek is neither desirable (given the associated increase in flood damages and risk to residential properties and residents themselves) nor technically feasible (given the technical complexities and associated costs in preventing and re-directing the aforementioned spill flows).

Wood further notes that the City of Burlington is also of the same opinion with respect to the preceding; City staff will provide separate written confirmation of same.

It is recommended that the findings of the preceding be reviewed with CN rail staff, given the potential implications to CN rail infrastructure, and its potential interest in reducing the spill frequency associated with its infrastructure. It is recommended that the City of Burlington share this memorandum and associated reporting information with CN rail staff, and document any associated correspondence accordingly.

We trust the preceding to be satisfactory; please do not hesitate to contact Wood should you wish to discuss the matter further.

LEGEND

- WATERCOURSE
- CONTOUR (1m)
- PARCEL FABRIC
- STORM SEWER SYSTEM
- FLOOD CONTROL FACILITY SPILL

SCALE VALID ONLY FOR 24"x36" VERSION

MOBILITY HUB
PLANNING STUDY

CITY OF BURLINGTON

EAST RAMBO
FLOOD CONTROL FACILITY
OVERVIEW

wood.

Scale 1:1750
0 20 40 60

Consultant File No.
TPB178008

Drawing No.

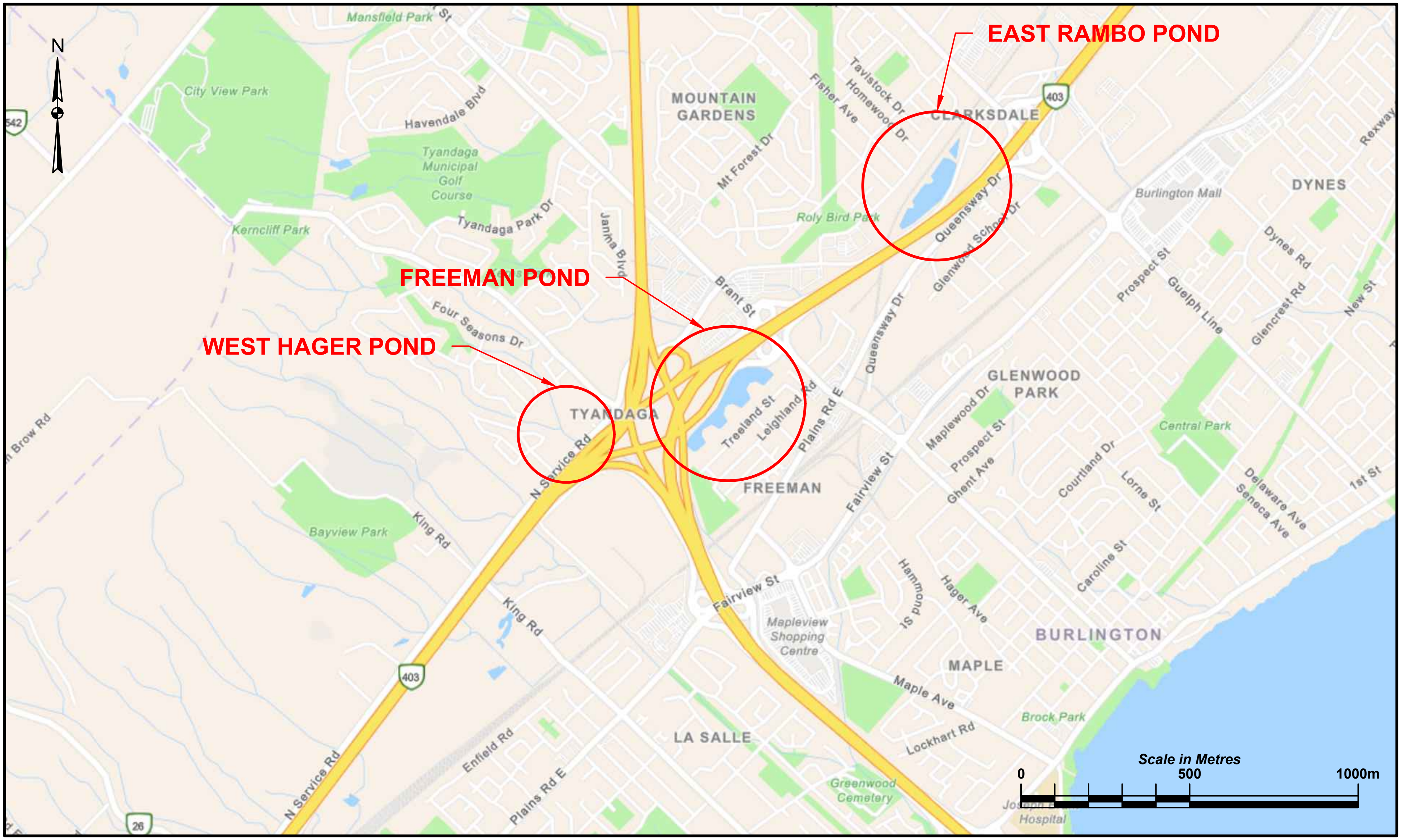
Path: P:\2017\Projects\TPB178008S – Mobility Hub Planning Consulting Services\06_DES-ENG\01_CAD\02_DWGS\05_WR\01_PROJ\2019-08 (EastRambo)\Dwg ER-Overview.dwg

Plotted By: richard.bartolo
Last Saved By: richard.bartolo

Plotted: 2019-08-12
Last Saved: 2019-08-12

Appendix B

Geotechnical Investigation



REFERENCE: Base plan provided by CITY OF BURLINGTON MAPS, https://navburl-burlington.opendata.arcgis.com/pages/maps

FOR ILLUSTRATION PURPOSES ONLY, ALL LOCATIONS APPROXIMATE.

CLIENT:

City of Burlington

Burlington

Wood Environment &
Infrastructure Solutions
3300 Merrittville Hwy, Unit 5
Thorold, Ontario

wood.

LEGEND:

○ Site Locations

DWN BY: DN

CHK'D BY: TR

DATUM: NAD83

PROJECTION: UTM Zone 17

SCALE: As Shown

PROJECT:

GEOTECHNICAL INVESTIGATION
MOBILITY HUBS FLOOD HAZARD ASSESSMENT
STORMWATER PONDS
CITY OF BURLINGTON, ONTARIO

TITLE:

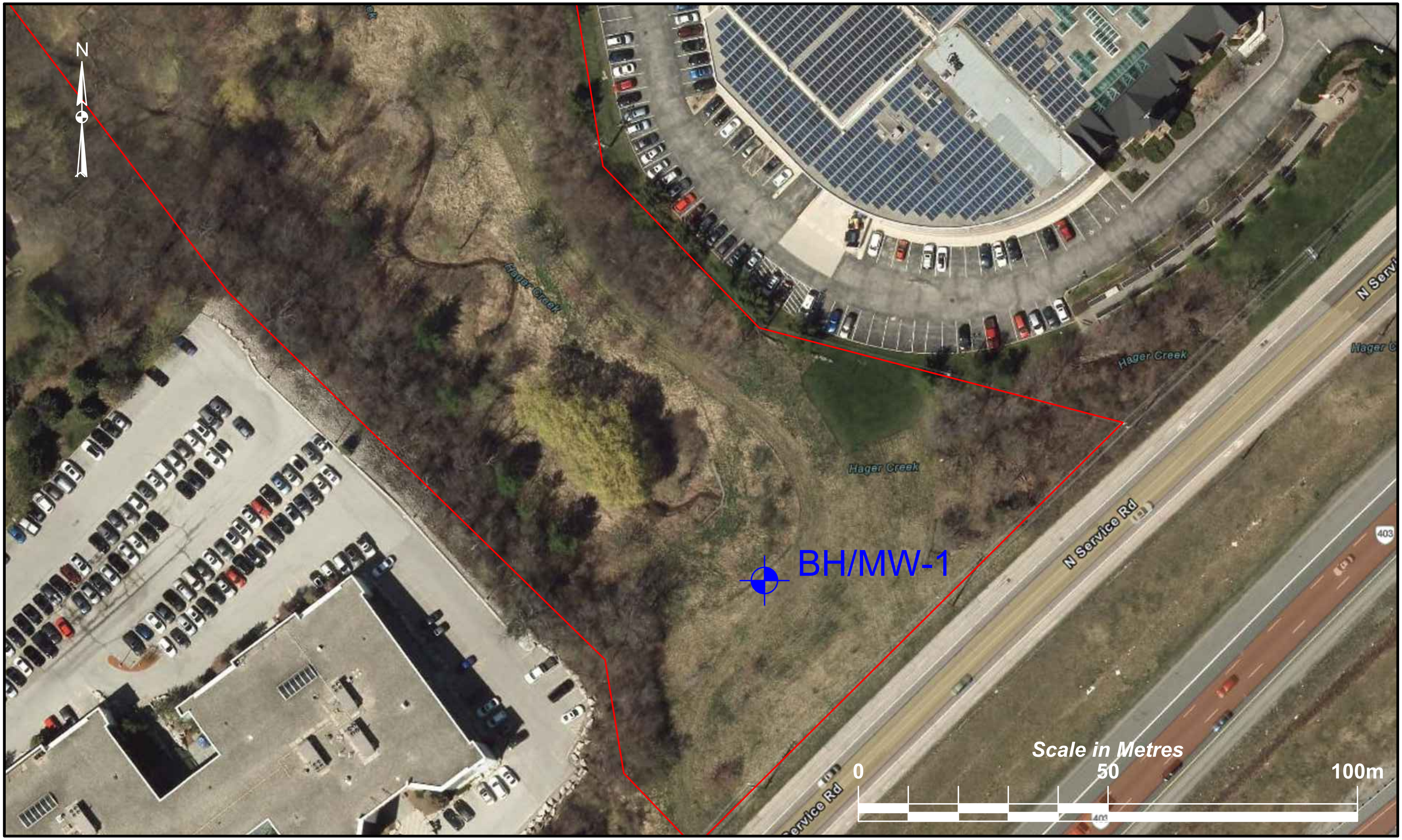
SITE LOCATION PLAN

REV. NO.: A

DATE: MARCH 2020

PROJECT NO.: TPB198130

NO.: FIGURE 1



REFERENCE: Base plan provided by NIAGARA NAVIGATOR, https://maps-beta.niagararegion.ca/Navigator/

FOR ILLUSTRATION PURPOSES ONLY, ALL LOCATIONS APPROXIMATE.

CLIENT:

City of Burlington

Wood Environment &
Infrastructure Solutions
3300 Merrittville Hwy, Unit 5
Thorold, Ontario

LEGEND:

⌖ BH/MW-1	Monitoring Well Location
🟥	Site Boundary

DWN BY:	DN
CHK'D BY:	TR
DATUM:	NAD83
PROJECTION:	UTM Zone 17
SCALE:	As Shown

PROJECT:

GEOTECHNICAL INVESTIGATION
MOBILITY HUBS FLOOD HAZARD ASSESSMENT
STORMWATER PONDS
CITY OF BURLINGTON, ONTARIO

TITLE:

BOREHOLE and MONITORING WELL LOCATION PLAN WEST HAGER POND

REV. NO.:	A
DATE:	MARCH 2020
PROJECT NO.:	TPB198130
NO.:	FIGURE 2A

REFERENCE: Base plan provided by NIAGARA NAVIGATOR, https://maps-beta.niagararegion.ca/Navigator/

FOR ILLUSTRATION PURPOSES ONLY, ALL LOCATIONS APPROXIMATE.

CLIENT:

City of Burlington

Wood Environment &
Infrastructure Solutions
3300 Merrittville Hwy, Unit 5
Thorold, Ontario

LEGEND:

BH-4	Borehole Location
BH/MW-2	Monitoring Well Location
▭	Site Boundary

DWN BY:	DN
CHK'D BY:	TR
DATUM:	NAD83
PROJECTION:	UTM Zone 17
SCALE:	As Shown

PROJECT:

GEOTECHNICAL INVESTIGATION
MOBILITY HUBS FLOOD HAZARD ASSESSMENT
STORMWATER PONDS
CITY OF BURLINGTON, ONTARIO

TITLE:

BOREHOLE and MONITORING WELL LOCATION PLAN FREEMAN POND

REV. NO.:	A
DATE:	MARCH 2020
PROJECT NO.:	TPB198130
NO.:	FIGURE 2B

REFERENCE: Base plan provided by NIAGARA NAVIGATOR, https://maps-beta.niagararegion.ca/Navigator/

FOR ILLUSTRATION PURPOSES ONLY, ALL LOCATIONS APPROXIMATE.

CLIENT:

City of Burlington

Wood Environment &
Infrastructure Solutions
3300 Merrittville Hwy, Unit 5
Thorold, Ontario

LEGEND:

BH-5	Borehole Location
BH/MW-6	Monitoring Well Location
🟥	Site Boundary

DWN BY: DN

CHK'D BY: TR

DATUM: NAD83

PROJECTION: UTM Zone 17

SCALE: As Shown

PROJECT:
GEOTECHNICAL INVESTIGATION
MOBILITY HUBS FLOOD HAZARD ASSESSMENT
STORMWATER PONDS
CITY OF BURLINGTON, ONTARIO

TITLE: BOREHOLE and MONITORING WELL
LOCATION PLAN
EAST RAMBO POND

REV. NO.: A

DATE: MARCH 2020

PROJECT NO.: TPB198130

NO.: FIGURE 2C

EXPLANATION OF BOREHOLE LOG

This form describes some of the information provided on the borehole logs, which is based primarily on examination of the recovered samples, and the results of the field and laboratory tests. Additional description of the soil/rock encountered is given in the accompanying geotechnical report.

GENERAL INFORMATION

Project details, borehole number, location coordinates and type of drilling equipment used are given at the top of the borehole log.

SOIL LITHOLOGY

Elevation and Depth

This column gives the elevation and depth of inferred geologic layers. The elevation is referred to the datum shown in the Description column.

Lithology Plot

This column presents a graphic depiction of the soil and rock stratigraphy encountered within the borehole.

Description

This column gives a description of the soil stratums, based on visual and tactile examination of the samples augmented with field and laboratory test results. Each stratum is described according to the *Modified Unified Soil Classification System* (modified slightly so that an inorganic clay of "medium plasticity" is recognized).

The compactness condition of cohesionless soils based on standard penetration testing (SPT) and the consistency of cohesive soils (undrained shear strength) are defined as follows *(Ref. Canadian Foundation Engineering Manual, 4th Edition, 2006)*:

Compactness of Cohesionless Soils	SPT N-Value
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	> 50

Consistency of Cohesive Soils	Unconfined Compressive Strength	
	kPa	psf
Very Soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1000
Stiff	50 to 100	1000 to 2000
Very Stiff	100 to 200	2000 to 4000
Hard	> 200	> 4000

SOIL SAMPLING

Sample types are abbreviated as follows:

SS	Split Spoon	TW	Thin Walled Open (Pushed)	RC	Rock Core	GS	Grab Sample
AS	Auger Sample	TP	Thin Walled Piston (Pushed)	WS	Washed Sample	AR	Air Return Sample

Additional information provided in this section includes sample numbering, sample recovery (%) and numerical testing results (SPT).

FIELD AND LABORATORY SAMPLING

Results of field testing (e.g., SPT, pocket penetrometer, and vane testing) and laboratory testing (e.g., natural moisture content, and limits) executed on the recovered samples are plotted in this section.

Definitions of Penetration Resistance

Standard penetration resistance 'N' – The number of blows required to advance a standard split spoon sampler 30 cm into the subsoil, driven by means of a 63.5 kg hammer falling freely a distance of 76 cm.

Dynamic penetration resistance – The number of blows required to advance a 50 mm, 60 degree cone, fitted to the end of drill rods, 30 cm into the subsoil, the driving energy being 474.5 Joules per blow.

INSTRUMENTATION INSTALLATION

Instrumentation installations (monitoring wells, piezometers, inclinometers, etc.) are plotted in this section.

WATER LEVEL

Water levels, if measured during fieldwork, are plotted in the depth/elevation column. These water levels may or may not be representative of the static groundwater level depending on the nature of soil stratum where the piezometer tips are located, the time elapsed from installation to reading and other applicable factors. Other information includes the depth of borehole cave-in, if any. This information is also included in the borehole log footer.

COMMENTS

This column is used to describe non-standard situations or notes of interest.

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EXPLANATION OF BOREHOLE LOG

GENERAL REPORT NOTE The soil conditions, profiles, comments, conclusions and recommendations found in this report are based upon the samples recovered during the fieldwork. Soils are heterogeneous materials and, consequently, variations (possibly extreme) may be encountered at site locations away from boreholes. During construction, competent, qualified inspection personnel should verify that no significant variations exist from the conditions described in this report.

Rev Date: January 7, 2019

MODIFIED* UNIFIED SOIL CLASSIFICATION SYSTEM

*The soil of each stratum is described using the Unified Soil Classification System (Technical Memorandum 36-357 prepared by Waterways Experiment Station, Vicksburg, Mississippi, Corps of Engineers, U.S Army. Vol. 1, March 1953) modified slightly so that an inorganic clay of "medium plasticity" is recognized.

MAJOR DIVISION			GROUP SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA
COARSE GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 75µm)	GRAVELS MORE THAN HALF THE COARSE FRACTION LARGER THAN 4.75mm	CLEAN GRAVELS (TRACE OR NO FINES)	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}} > 4$; $C_C = \frac{(D_{30})^2}{D_{10} X D_{60}} = 1$ to 3
			GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS
		DIRTY GRAVELS (WITH SOME OR MORE FINES)	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	ATTERBERG LIMITS BELOW "A" LINE OR I_P LESS THAN 4
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES	ATTERBERG LIMITS ABOVE "A" LINE OR I_P MORE THAN 7
	SANDS MORE THAN HALF THE COARSE FRACTION SMALLER THAN 4.75mm	CLEAN SANDS (TRACE OR NO FINES)	SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}} > 6$; $C_C = \frac{(D_{30})^2}{D_{10} X D_{60}} = 1$ to 3
			SP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS
		DIRTY SANDS (WITH SOME OR MORE FINES)	SM	SILTY SANDS, SAND-SILT MIXTURES	ATTERBERG LIMITS BELOW "A" LINE OR I_P LESS THAN 4
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES	ATTERBERG LIMITS ABOVE "A" LINE OR I_P MORE THAN 7
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT SMALLER THAN 75µm)	SILTS BELOW "A" LINE NEGLIGIBLE ORGANIC CONTENT	W_L < 50%	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (SEE BELOW)
		W_L > 50%	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS	
	CLAYS ABOVE "A" LINE NEGLIGIBLE ORGANIC CONTENT	W_L < 30%	CL	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY OR SILTY CLAYS, LEAN CLAYS	
		30% < W_L < 50%	CI	INORGANIC CLAYS OF MEDIUM PLASTICITY, SILTY CLAYS	
		W_L > 50%	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	
	ORGANIC SILTS & CLAYS BELOW "A" LINE	W_L < 50%	OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	WHENEVER THE NATURE OF THE FINES CONTENT HAS NOT BEEN DETERMINED, IT IS DESIGNATED BY THE LETTER "F", e.g. SF IS A MIXTURE OF SAND WITH SILT OR CLAY
		W_L > 50%	OH	ORGANIC CLAYS OF HIGH PLASTICITY	
HIGH ORGANIC SOILS			Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOUR OR ODOUR, AND OFTEN FIBROUS TEXTURE

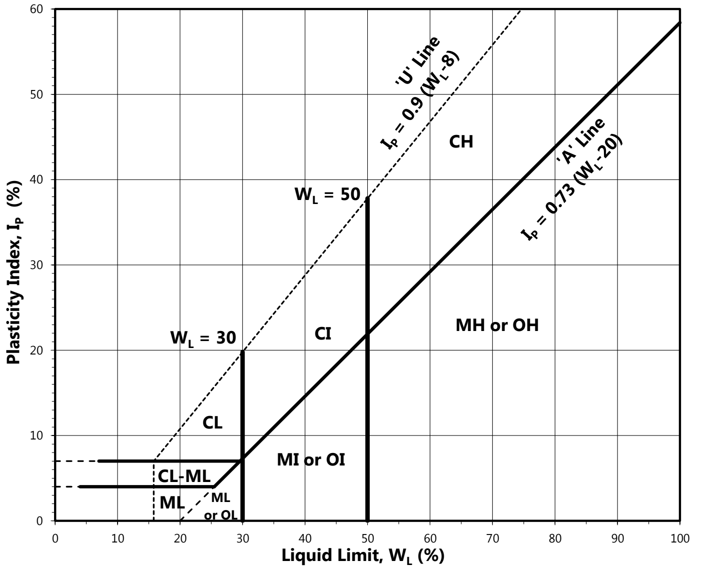
SOIL COMPONENTS

FRACTION	U.S STANDARD SIEVE SIZE			DEFINING RANGES OF PERCENTAGE BY WEIGHT OF MINOR COMPONENTS	
		PASSING	RETAINED	PERCENT	DESCRIPTOR
GRAVEL	COARSE	75 mm	19 mm	35 - 50	AND
	FINE	19 mm	4.75 mm	20 - 35	Y/EY
SAND	COARSE	4.75 mm	2.00 mm	10 - 20	SOME
	MEDIUM	2.00 mm	425 µm	1 - 10	TRACE
	FINE	425 µm	75 µm		
FINES (SILT AND CLAY BASED ON PLASTICITY)		75 µm			

OVERSIZED MATERIAL

ROUNDED OR SUBROUNDED: COBBLES 75 mm to 300 mm BOULDERS > 300 mm	NOT ROUNDED: ROCK FRAGMENTS > 75 mm ROCKS > 0.76 CUBIC METRE IN VOLUME

Plasticity Chart for Soil Passing 425 µm Sieve



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MODIFIED USCS

Note 1: Soils are classified and described according to their engineering properties and behaviour.

Note 2: The modifying adjectives used to define the actual or estimated percentage range by weight of minor components are consistent with the Canadian Foundation Engineering Manual (4th Edition, Canadian Geotechnical Society, 2006.)

Rev Date: January 7, 2019

RECORD OF BOREHOLE No. BH/MW-1

Project Number:	TPB198130	Drilling Location:	N: 4798767 E: 594356
Project Client:	City of Burlington	Drilling Method:	150 mm Solid Stem Augers
Project Name:	Burlington Stormwater Flood Remidiation	Drilling Machine:	Track Mounted Drill
Project Location:	Burlington, ON	Date Started:	Feb 10, 20 Date Completed: Feb 10, 20

Logged by: PG Compiled by: PG Reviewed by: TR Revision No.: 2, 3/28/20

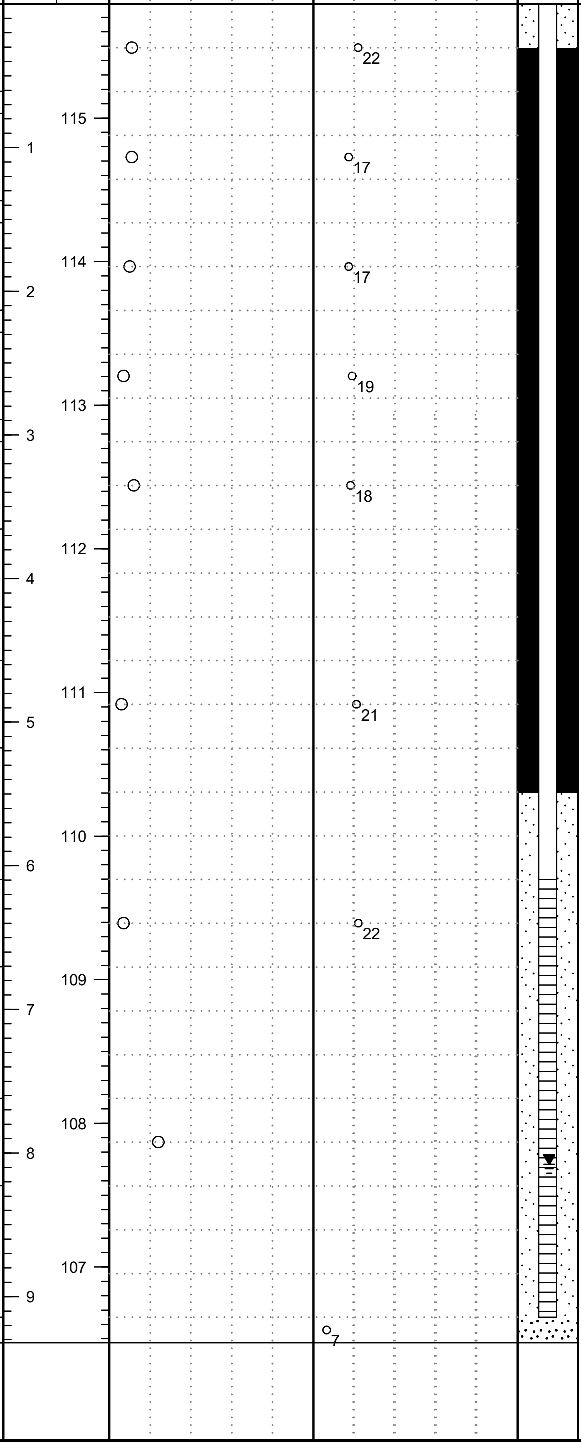
LITHOLOGY PROFILE

Local Ground Surface Elevation: 115.8 m

Lithology Plot	DESCRIPTION	Elevation (m)	Depth (m)
	Topsoil 50 mm	115.7	0.0
	Red Silty Clay / Clayey Silt **FILL** trace to some sand and gravel firm to stiff moist to damp		
	Red **Silt Till** compact moist	108.8	7.0
	Red **Weathered Shale**	106.6	9.2
	Borehole Terminated at Refusal on Inferred Bedrock	106.5	9.3

SOIL SAMPLING / LAB TESTING

Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	W
SS	1	42	11	22
SS	2	67	11	17
SS	3	100	10	17
SS	4	75	7	19
SS	5	83	12	18
SS	6	71	6	21
SS	7	67	7	22
SS	8	0	24	
SS	9	100	50 / 25 mm	7



COMMENTS & GRAIN SIZE DISTRIBUTION (%)

GR SA SI CL

Upon completion borehole remained open and dry.
Well installation: 5 cm diameter schedule 40 PVC pipe with 3.1 m length #10 mil slotted screen, No. 2 sand, stickup monument casing.

Wood
Environment & Infrastructure Solutions

3450 Harvester Road
Burlington, Ontario, L7N 3W5
Canada
Tel. No.: 1 (905) 335-2353
www.woodplc.com

∇ No freestanding groundwater observed in open borehole upon completion of drilling.

▼ Groundwater depth observed on 3/13/2020 at a depth of: 8.1 m.

Scale: 1 : 53

RECORD OF BOREHOLE No. BH/MW-2

Project Number: **TPB198130**
Project Client: **City of Burlington**
Project Name: **Burlington Stormwater Flood Remidiation**
Project Location: **Burlington, ON**
Drilling Location: **N: 4798729 E: 595067**
Drilling Method: **150 mm Solid Stem Augers**
Drilling Machine: **Track Mounted Drill**
Date Started: **Feb 11, 20** Date Completed: **Feb 11, 20**

wood.

Logged by: **PG** Compiled by: **PG** Reviewed by: **TR** Revision No.: **2, 3/28/20**

LITHOLOGY PROFILE

Local Ground Surface Elevation: 104.7 m

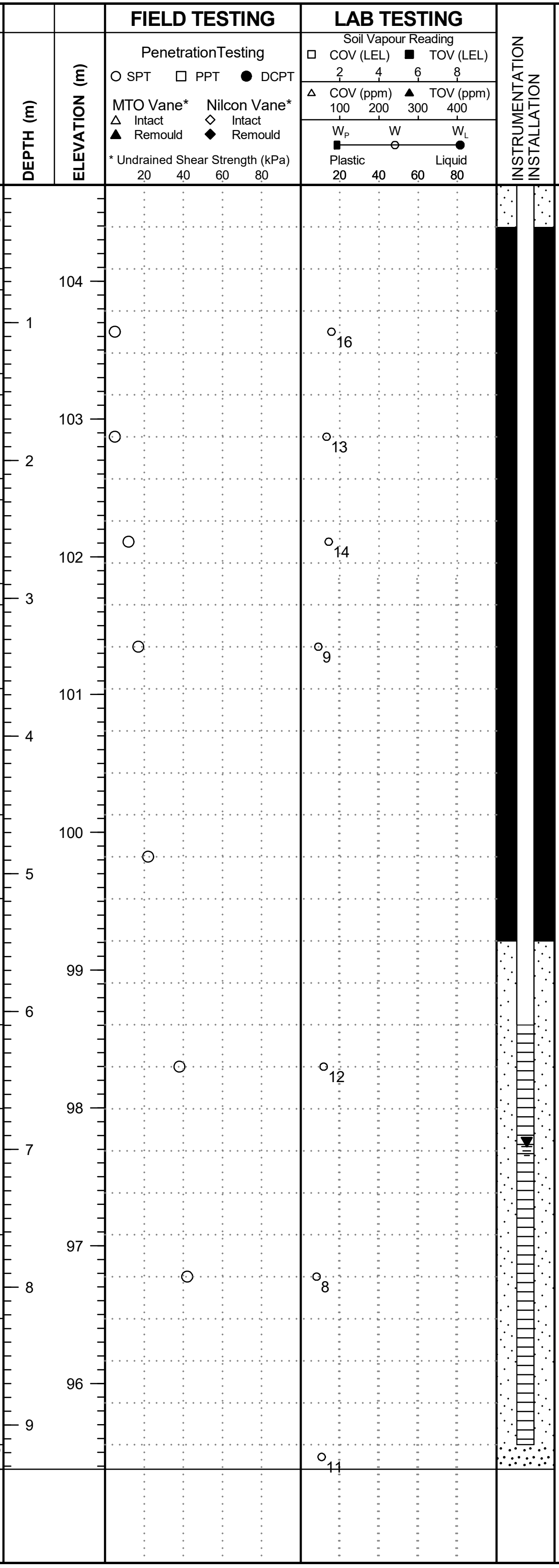
DESCRIPTION	Elevation / Depth (m)
Paving Stones 150 mm **Geotextile Layer at 150 mm**	104.5 0.2
Red Silty Clay / Clayey Silt **FILL** trace to some sand and gravel firm to very stiff moist	100.1 4.6
Brown **Silt Till** **Geotextile at 4.5 m** dense moist	95.4 9.3
Borehole Terminated at Refusal on Inferred Bedrock	

SOIL SAMPLING

Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)
SS	1	0	50 / 25 mm
SS	2	21	5
SS	3	58	5
SS	4	25	12
SS	5	75	17
SS	6	38	22
SS	7	100	38
SS	8	67	42
SS	9	0	50 / 25 mm

FIELD TESTING

LAB TESTING



COMMENTS & GRAIN SIZE DISTRIBUTION (%)

GR SA SI CL

Upon completion borehole remained open and dry.
Well installation: 5 cm diameter schedule 40 PVC pipe with 3.1 m length #10 mil slotted screen, No. 2 sand, stickup monument casing.

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Burlington, Ontario, L7N 3W5
Canada
Tel. No.: 1 (905) 335-2353
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▽ No freestanding groundwater observed in open borehole upon completion of drilling.

▼ Groundwater depth observed on 3/13/2020 at a depth of: 7.0 m.

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

Scale: 1 : 53

RECORD OF BOREHOLE No. BH/MW-3

Project Number: **TPB198130**
Project Client: **City of Burlington**
Project Name: **Burlington Stormwater Flood Remidiation**
Project Location: **Burlington, ON**

Drilling Location: **N: 4798976 E: 595233**
Drilling Method: **150 mm Solid Stem Augers**
Drilling Machine: **Track Mounted Drill**
Date Started: **Feb 11, 20** Date Completed: **Feb 11, 20**

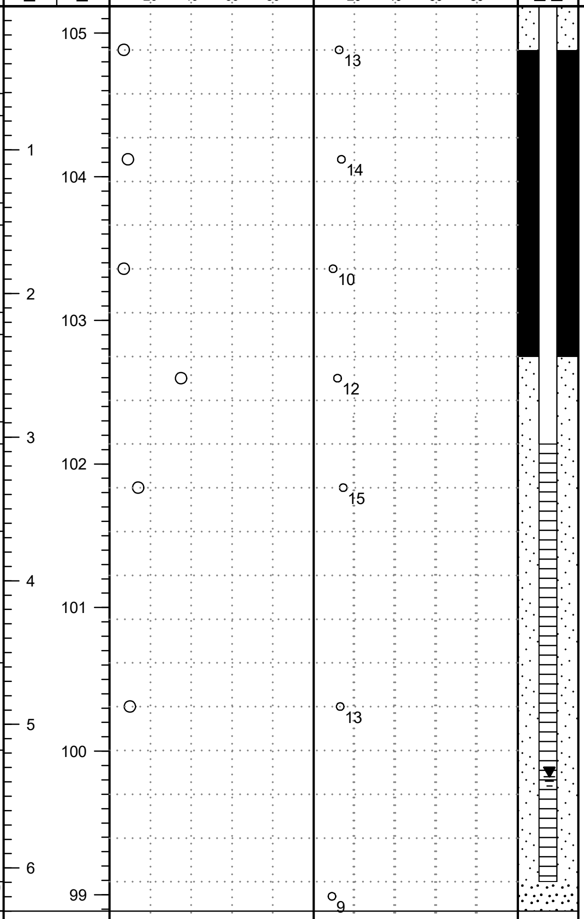
wood.

Logged by: **PG** Compiled by: **PG** Reviewed by: **TR** Revision No.: **2, 3/28/20**

Local Ground Surface Elevation: 105.2 m

Elevation (m) / Depth (m)	DESCRIPTION
105.0 / 0.2	**Topsoil** 150 mm
101.1 / 4.1	Red Silty Clay / Clayey Silt **FILL** trace to some sand and gravel firm to very stiff moist
99.1 / 6.1	Red **Silt** some sand, trace clay and gravel **Cobbles between 2.3 - 3.1 m** compact to dense moist
98.9 / 6.3	Red **Weathered Shale**
	Borehole Terminated at Refusal on Inferred Bedrock

Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	W (%)
SS	1	42	7	13
SS	2	29	9	14
SS	3	25	7	10
SS	4	92	35	12
SS	5	100	14	15
SS	6	67	10	13
SS	7	150	50 / 50 mm	9



COMMENTS & GRAIN SIZE DISTRIBUTION (%)

GR SA SI CL

Upon completion borehole remained open and dry.
Well installation: 5 cm diameter schedule 40 PVC pipe with 3.1 m length #10 mil slotted screen, No. 2 sand, stickup monument casing.

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Environment & Infrastructure Solutions
3450 Harvester Road
Burlington, Ontario, L7N 3W5
Canada
Tel. No.: 1 (905) 335-2353
www.woodplc.com

▽ No freestanding groundwater observed in open borehole upon completion of drilling.

▼ Groundwater depth observed on 3/13/2020 at a depth of: 5.4 m.

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

Scale: 1 : 53

RECORD OF BOREHOLE No. BH-4

Project Number:	**TPB198130**	Drilling Location:	**N: 4799128 E: 595375**
Project Client:	**City of Burlington**	Drilling Method:	**150 mm Solid Stem Augers**
Project Name:	**Burlington Stormwater Flood Remidiation**	Drilling Machine:	**Track Mounted Drill**
Project Location:	**Burlington, ON**	Date Started:	**Feb 11, 20** Date Completed: **Feb 11, 20**

wood.

Logged by: **PG** Compiled by: **PG** Reviewed by: **TR** Revision No.: **2, 3/28/20**

LITHOLOGY PROFILE | **SOIL SAMPLING** | **FIELD TESTING** | **LAB TESTING**

Local Ground Surface Elevation: 105.2 m

Penetration Testing: ○ SPT ☐ PPT ● DCPT

MTO Vane*: △ Intact ▲ Remould; Nilcon Vane*: ◇ Intact ◆ Remould

* Undrained Shear Strength (kPa) 20 40 60 80

Soil Vapour Reading: ☐ COV (LEL) ■ TOV (LEL) 2 4 6 8; △ COV (ppm) ▲ TOV (ppm) 100 200 300 400

W_P W W_L Plastic Liquid 20 40 60 80

INSTRUMENTATION INSTALLATION

COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

DESCRIPTION	Elevation / Depth	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	W (%)
Topsoil 100 mm	105.1 0.1					
Red Silty Clay / Clayey Silt **FILL** trace to some sand, trace gravel firm to very stiff moist to damp		SS	1	29	10	15
		SS	2	75	9	18
		SS	3	71	14	18
		SS	4	46	12	13
		SS	5	100	21	14
		SS	6	58	27	15
	99.1	SS	7	100	50 / 76 mm	9
Red **Shale**	99.0 6.1 6.2					
Borehole Terminated at Refusal on Inferred Bedrock						

DEPTH (m): 1, 2, 3, 4, 5, 6

ELEVATION (m): 105, 104, 103, 102, 101, 100

Wood
Environment & Infrastructure Solutions

3450 Harvester Road
Burlington, Ontario, L7N 3W5
Canada
Tel. No.: 1 (905) 335-2353
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▽ No freestanding groundwater observed in open borehole upon completion of drilling.

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

Scale: 1 : 53

RECORD OF BOREHOLE No. BH/MW-6

Project Number: **TPB198130**
Project Client: **City of Burlington**
Project Name: **Burlington Stormwater Flood Remidiation**
Project Location: **Burlington, ON**
Drilling Location: **N: 4800335 E: 596400**
Drilling Method: **150 mm Solid Stem Augers**
Drilling Machine: **Track Mounted Drill**
Date Started: **Feb 10, 20** Date Completed: **Feb 10, 20**

wood.

Logged by: **PG** Compiled by: **PG** Reviewed by: **TR** Revision No.: **2, 3/28/20**

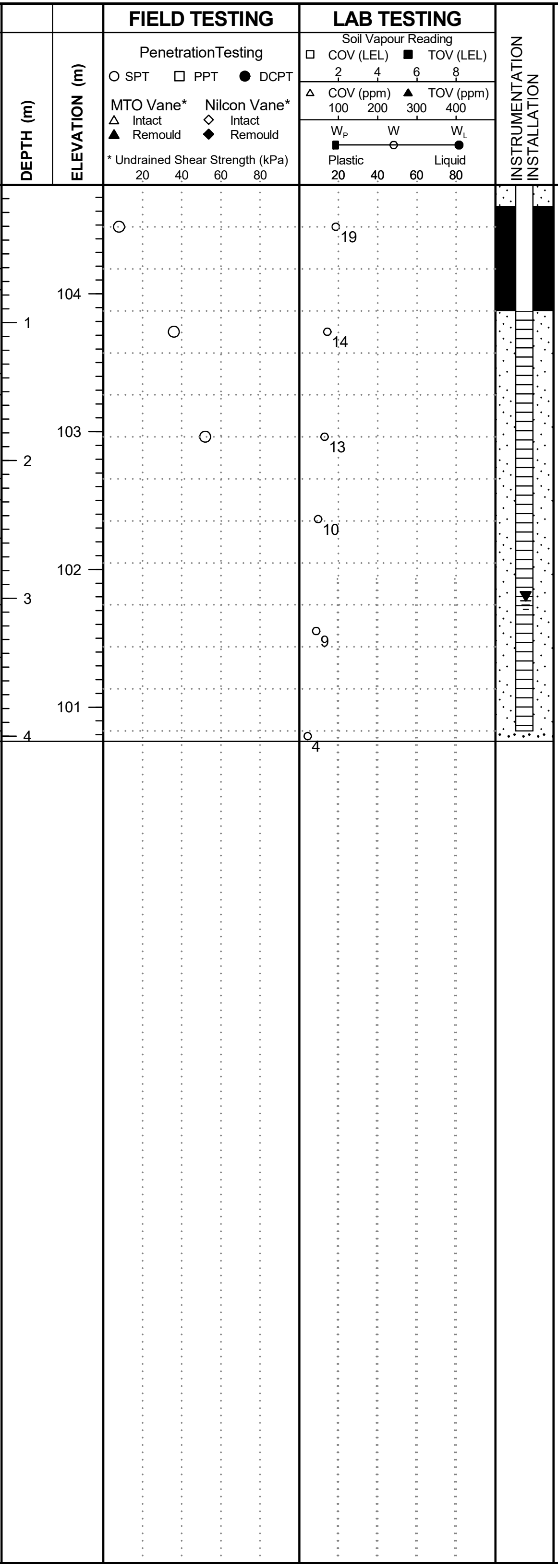
LITHOLOGY PROFILE

Local Ground Surface Elevation: 104.8 m

DESCRIPTION	Elevation (m) / Depth (m)
Red/Brown **Clayey Silt** some gravel soft damp	104.2 0.6
Red **Silt** some gravel and cobbles compact moist	102.7 2.1
Red **Silt Till** layers of weathered shale throughout very dense moist	100.8 4.0
Red **Weathered Shale**	100.8 4.0
Borehole Terminated on Inferred Bedrock	

SOIL SAMPLING

Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)
SS	1	100	8
S	2	75	36
SS	3	92	52
SS	4	91	50 / 127 mm
SS	5	87	50 / 76 mm
SS	6	0	50 / 76 mm



COMMENTS & GRAIN SIZE DISTRIBUTION (%)

GR SA SI CL

Upon completion borehole remained open and dry.
Well installation: 5 cm diameter schedule 40 PVC pipe with 3.1 m length #10 mil slotted screen, No. 2 sand, stickup monument casing.

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Environment & Infrastructure Solutions
3450 Harvester Road
Burlington, Ontario, L7N 3W5
Canada
Tel. No.: 1 (905) 335-2353
www.woodplc.com

▽ No freestanding groundwater observed in open borehole upon completion of drilling.
▼ Groundwater depth observed on 3/13/2020 at a depth of: 3.0 m.

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

Scale: 1 : 53

RECORD OF BOREHOLE No. BH-7

Project Number: **TPB198130**
Project Client: **City of Burlington**
Project Name: **Burlington Stormwater Flood Remidiation**
Project Location: **Burlington, ON**
Drilling Location: **N: 4800425 E: 596548**
Drilling Method: **150 mm Solid Stem Augers**
Drilling Machine: **Track Mounted Drill**
Date Started: **Feb 10, 20** Date Completed: **Feb 10, 20**

Logged by: **PG** Compiled by: **PG** Reviewed by: **TR** Revision No.: **2, 3/28/20**

wood.

Local Ground Surface Elevation: 105.9 m

LITHOLOGY PROFILE DESCRIPTION	Elevation (m) / Depth (m)	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	LAB TESTING W (%)
Topsoil 250 mm	105.6 0.2					
Red **Silt** some gravel and cobbles compact to very dense moist		SS	1	63	10	14
		SS	2	57	50 / 140 mm	5
	104.5 1.4					
Red **Silt Till** layers of weathered shale throughout very dense dry to moist		SS	3	100	48	10
		SS	4	83	83	10
	102.8 3.0					
Red **Weathered Shale**	102.7 3.2	SS	5	86	50 / 25 mm	8
Borehole Terminated at Refusal						

DEPTH (m): 1, 2, 3 — ELEVATION (m): 105, 104, 103

FIELD TESTING: PenetrationTesting ○ SPT ☐ PPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; * Undrained Shear Strength (kPa) 20 40 60 80

LAB TESTING: Soil Vapour Reading ☐ COV (LEL) ■ TOV (LEL) 2 4 6 8; △ COV (ppm) ▲ TOV (ppm) 100 200 300 400; W_P W W_L Plastic Liquid 20 40 60 80

INSTRUMENTATION INSTALLATION

COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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Canada
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www.woodplc.com

∇ No freestanding groundwater observed in open borehole upon completion of drilling.

Scale: 1 : 53

Photo 1: Hager Creek - BH/MW-01 (March 2020)

Photo 2: Hager Creek - east bank of Upper Hager Creek at 1767 Heather Hills Drive (June 2019)

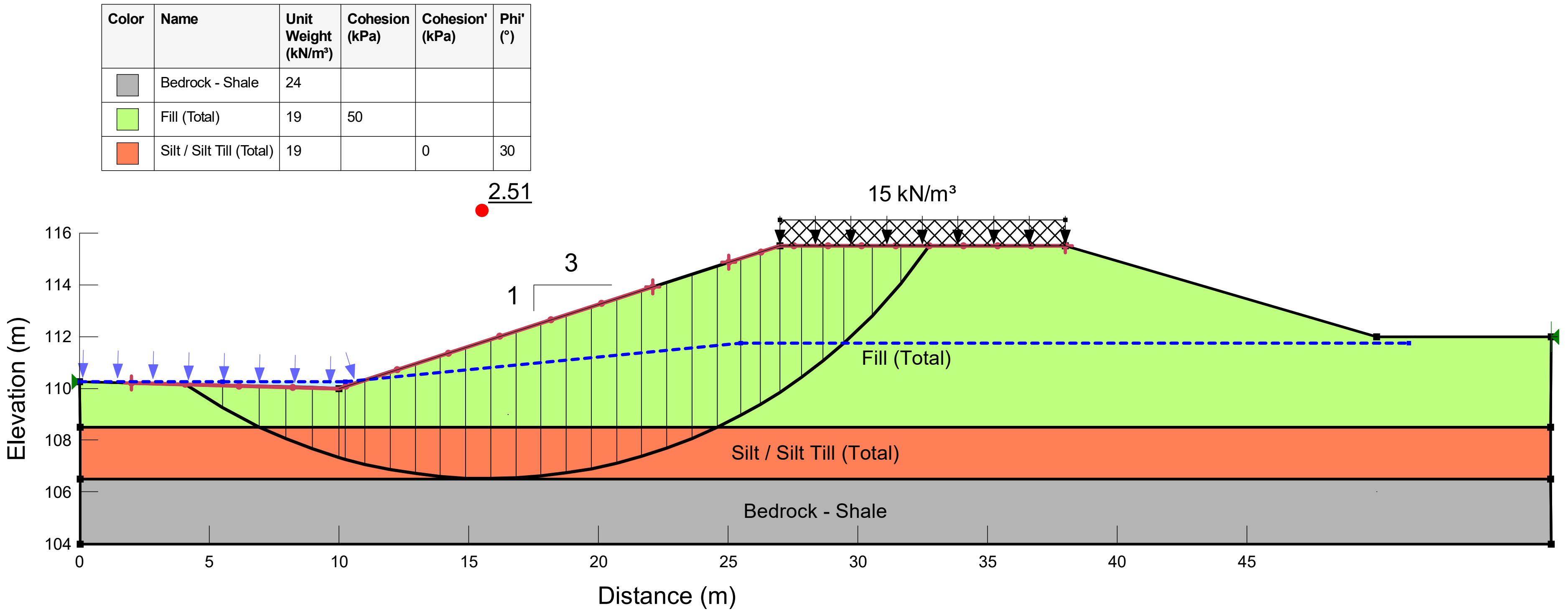
Photo 3: Hager Creek - slope toe at 1767 Heather Hills Drive (June 2019)

Photo 4: Freeman – BH-4, looking east (March 2020)

Photo 5: Freeman – near BH4 looking west (March 2020)

Photo 6: Rambo – from BH6 looking west (March 2020)

Photo 7: Rambo – culvert north to rail (June 2019)



Color	Name	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)
▨	Bedrock - Shale	24			
🟩	Fill (Total)	19	50		
🟧	Silt / Silt Till (Total)	19		0	30

TPB198130 Burlington Ponds

Figure 1: West Hager Berm (short term)

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TPB198130 - West Hager Berm 13MAY2020.gsz

1:244

Color	Name	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)
◼	Bedrock - Shale	24			
🟩	Fill (Total)	19	50		
🟧	Silt / Silt Till (Total)	19		0	30

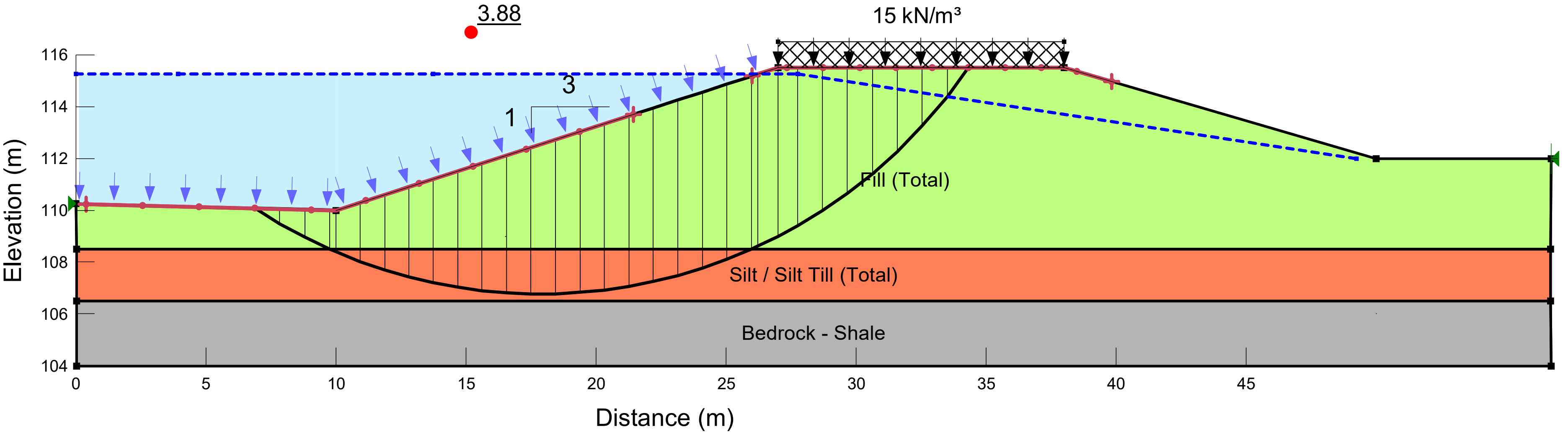

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Figure 2: West Hager Berm High Water (short term)

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1:244

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
⬜	Bedrock - Shale	24		
🟫	Fill (Effective)	19	5	26
🟧	Silt / Silt Till (Effective)	19	0	30

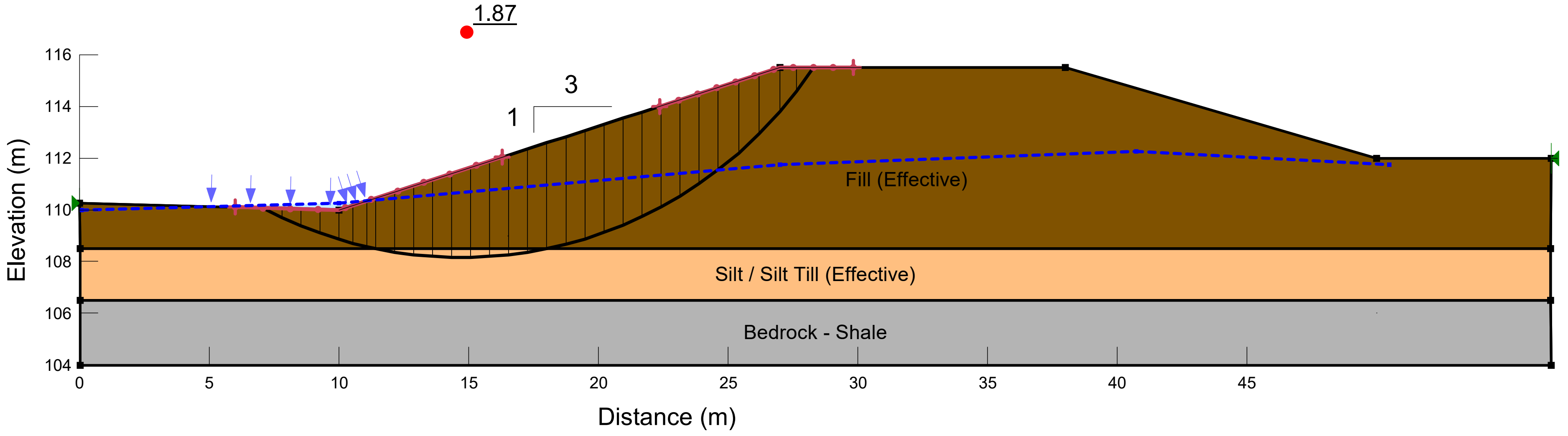

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Figure 3: West Hager Berm (long term)

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1:244

Color	Name	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)
⬛	Bedrock - Shale	24			
🟩	Fill (Total)	19	50		
🟧	Silt / Silt Till (Total)	19		0	30

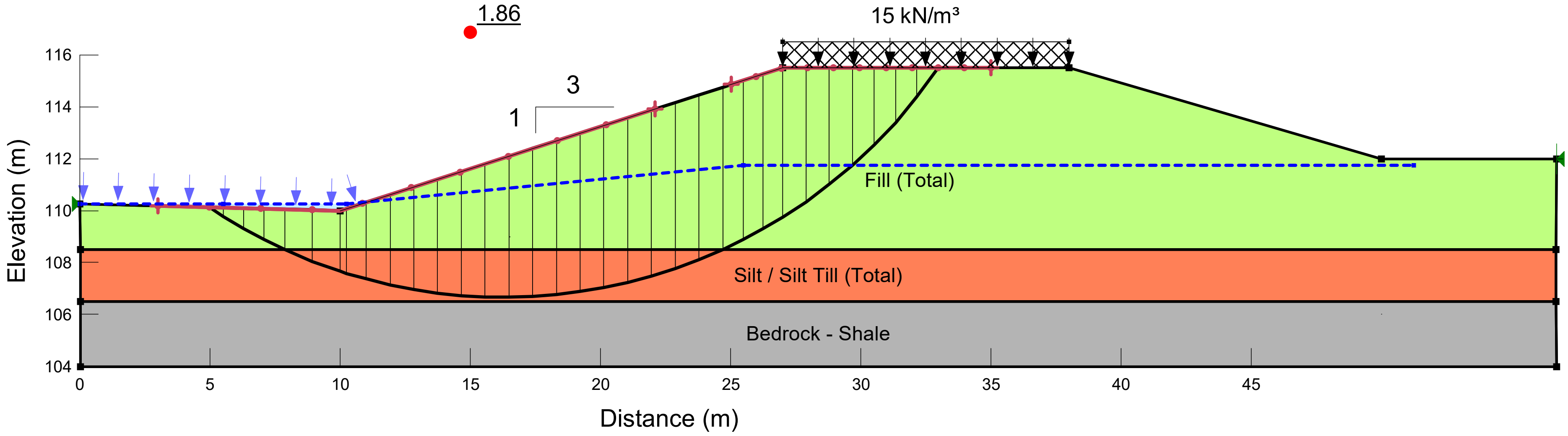

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Figure 4: West Hager Berm Psuedo Static (short term)

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1:244

Color	Name	Unit Weight (kN/m³)	Piezometric Line After Drawdown	Cohesion' (kPa)	Phi' (°)	Cohesion R (kPa)	Phi R (°)
⬜	Bedrock - Shale	24	2				
🟫	Fill (Effective)	19	2	5	26	50	0
🟧	Silt / Silt Till (Effective)	19	2	0	30	0	30

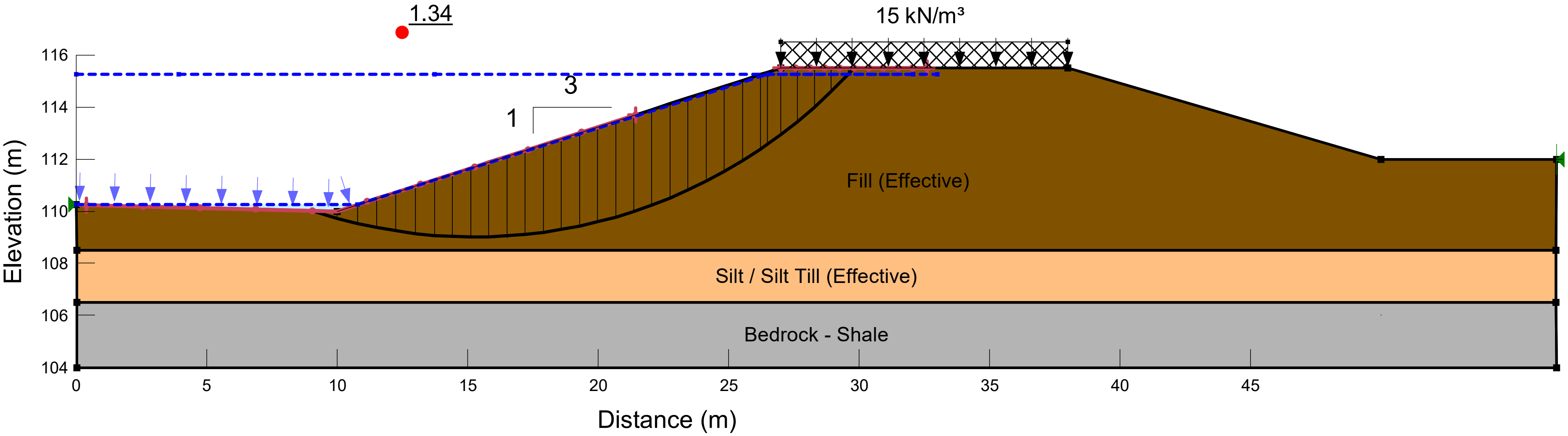

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Figure 5: West Hager Berm Rapid Drawdown

wood.

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1:244

Color	Name	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)
▩	Bedrock - Shale	24			
🟩	Fill (Total)	19	50		
🟧	Silt / Silt Till (Total)	21		0	32

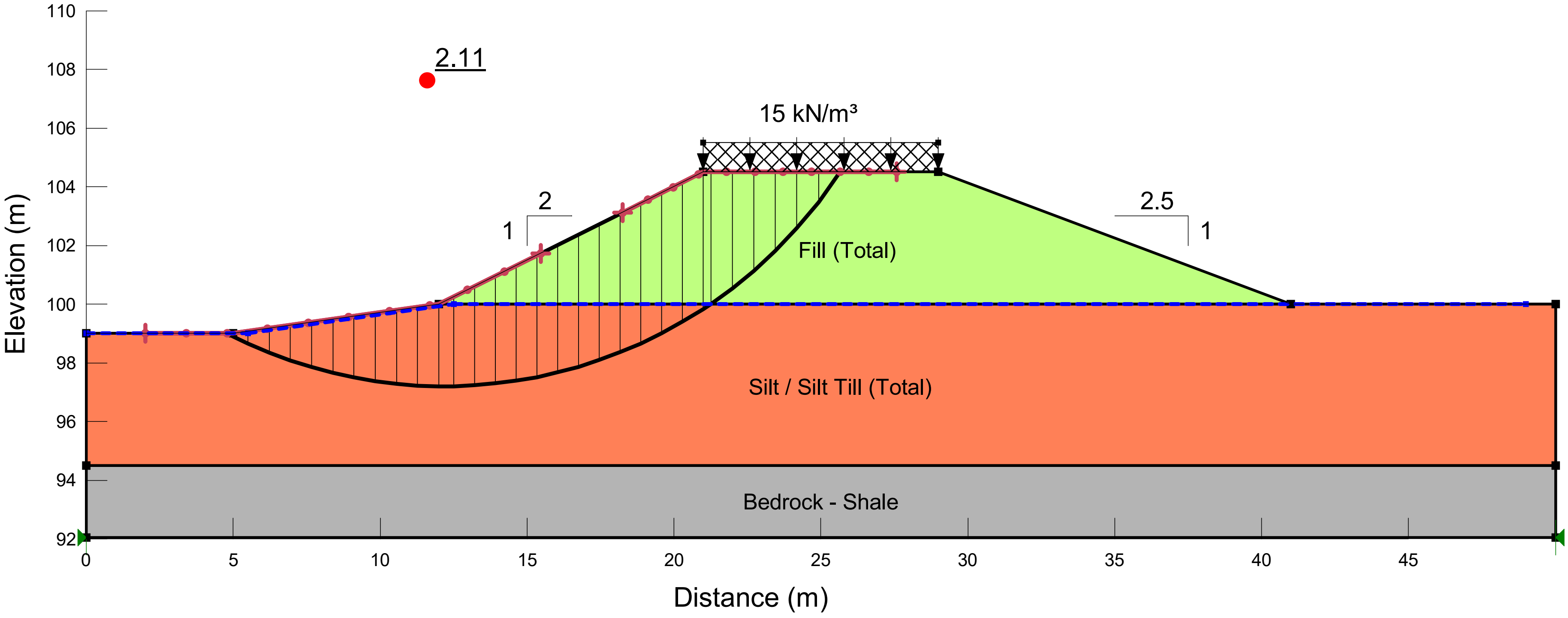

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Figure 6: Freeman Berm (short term)

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TPB198130 - Freeman 11MAY2020.gsz

1:221

Color	Name	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)
⬜	Bedrock - Shale	24			
🟩	Fill (Total)	19	50		
🟥	Silt / Silt Till (Total)	21		0	32

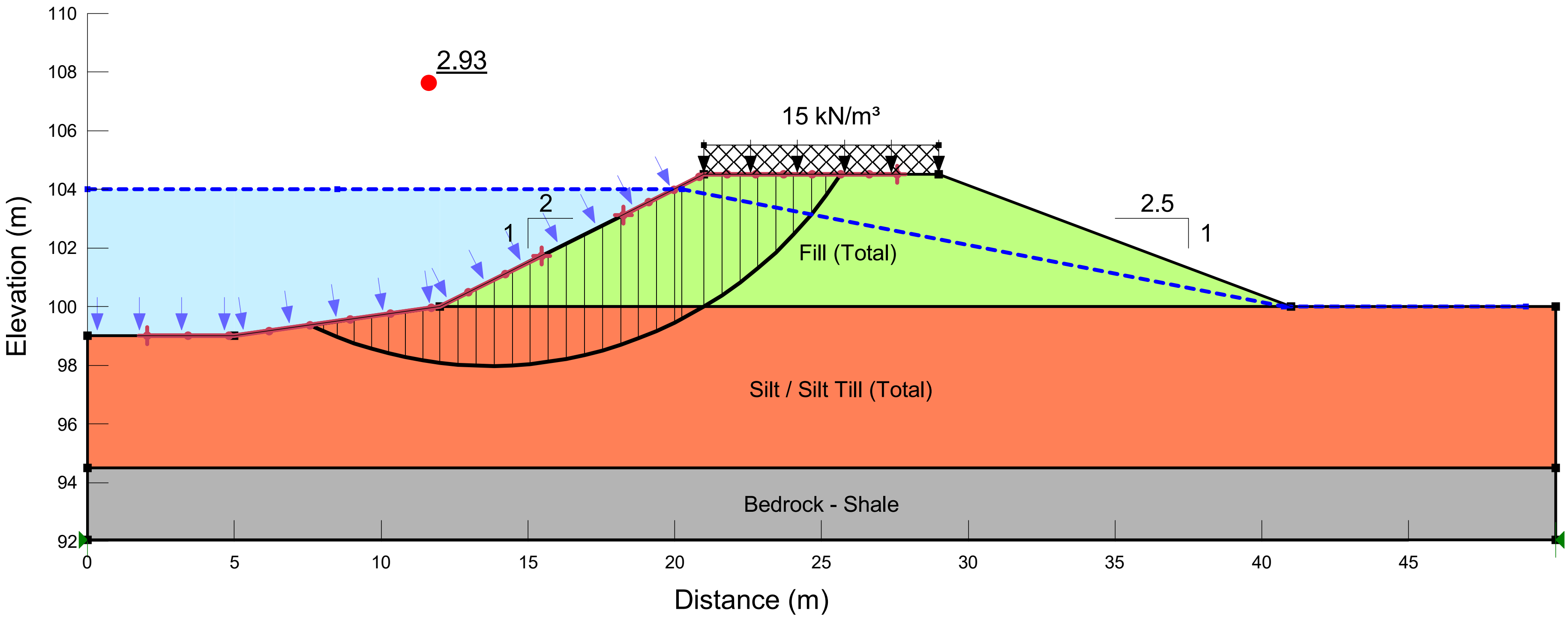

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Figure 7: Freeman Berm High Water Inside (short term)

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1:221

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
▨	Bedrock - Shale	24		
🟫	Fill (Effective)	19	5	26
🟧	Silt / Silt Till (Effective)	21	0	30

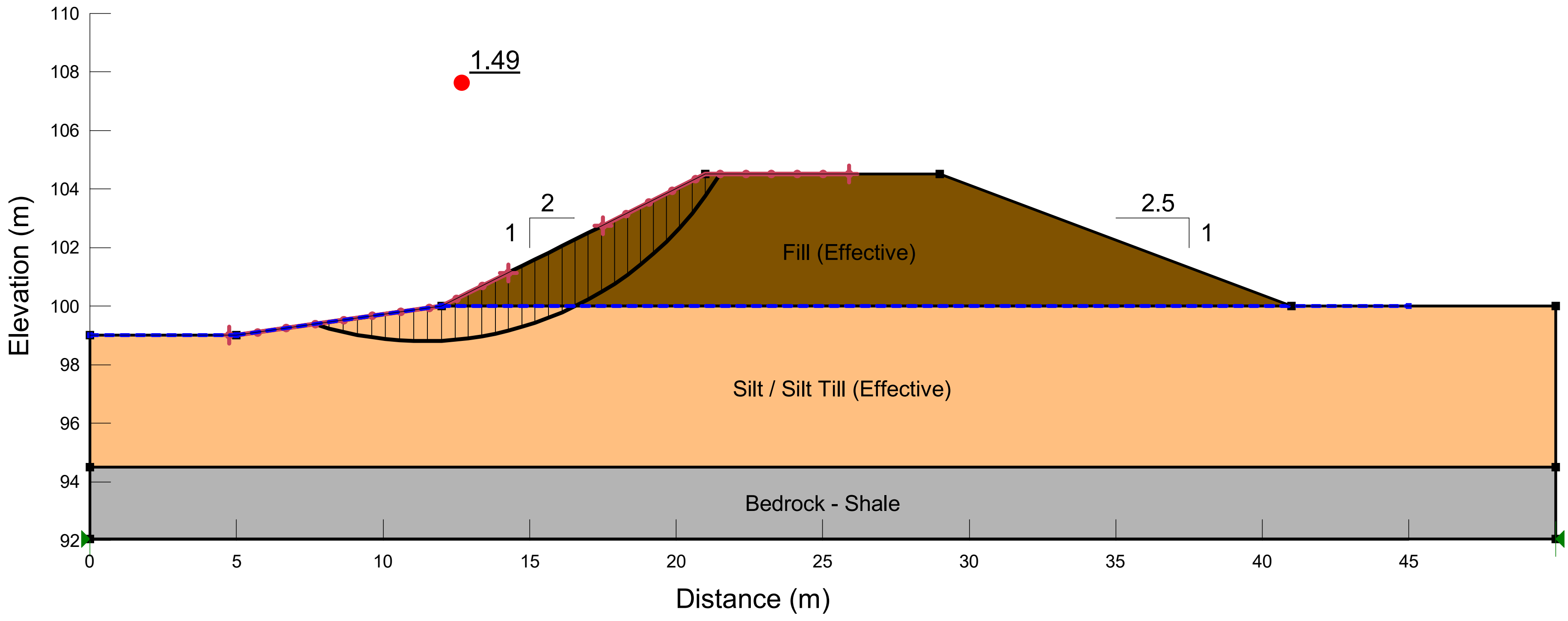

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Figure 8: Freeman Berm (long term)

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1:221

Color	Name	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)
◼	Bedrock - Shale	24			
🟩	Fill (Total)	19	50		
🟧	Silt / Silt Till (Total)	21		0	32

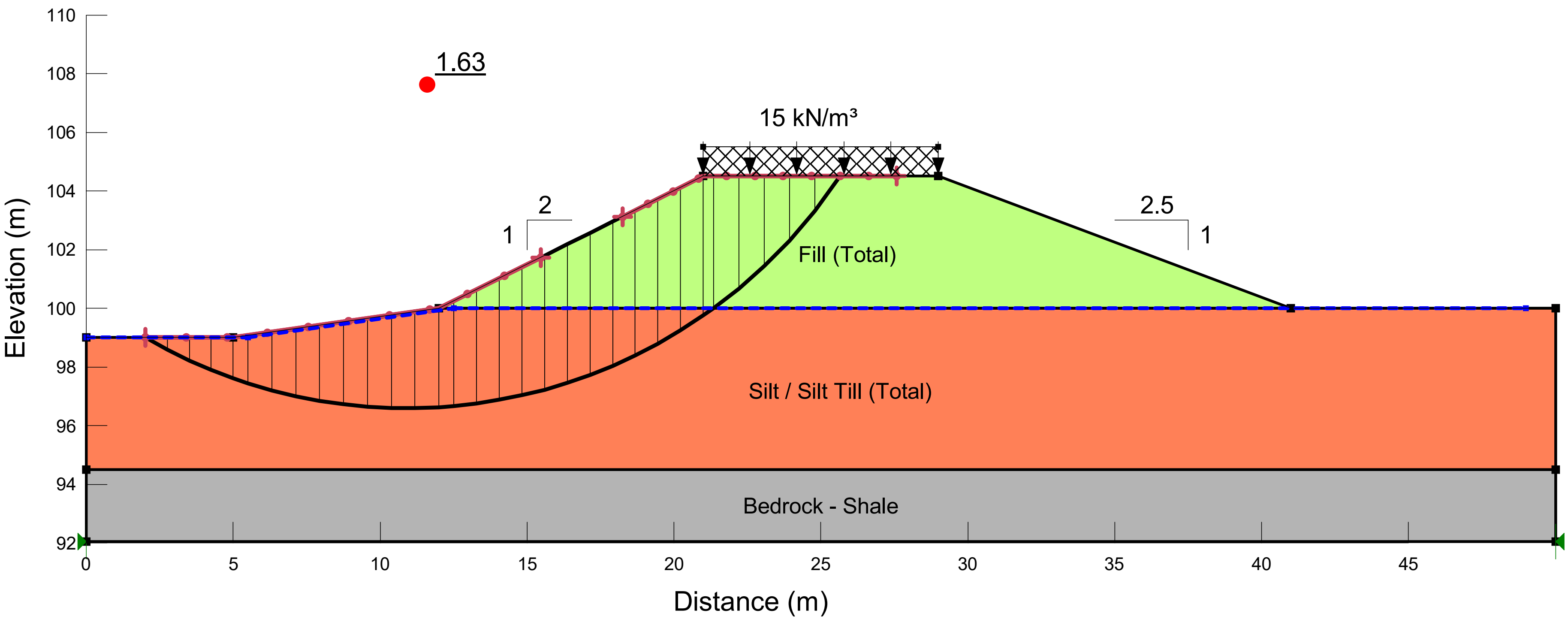

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Figure 9: Freeman Berm Pseudo Static (short term)

wood.

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1:221

Color	Name	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)
⬜	Bedrock - Shale	24			
🟩	Fill (Total)	19	50		
🟧	Silt / Silt Till (Total)	21		0	32

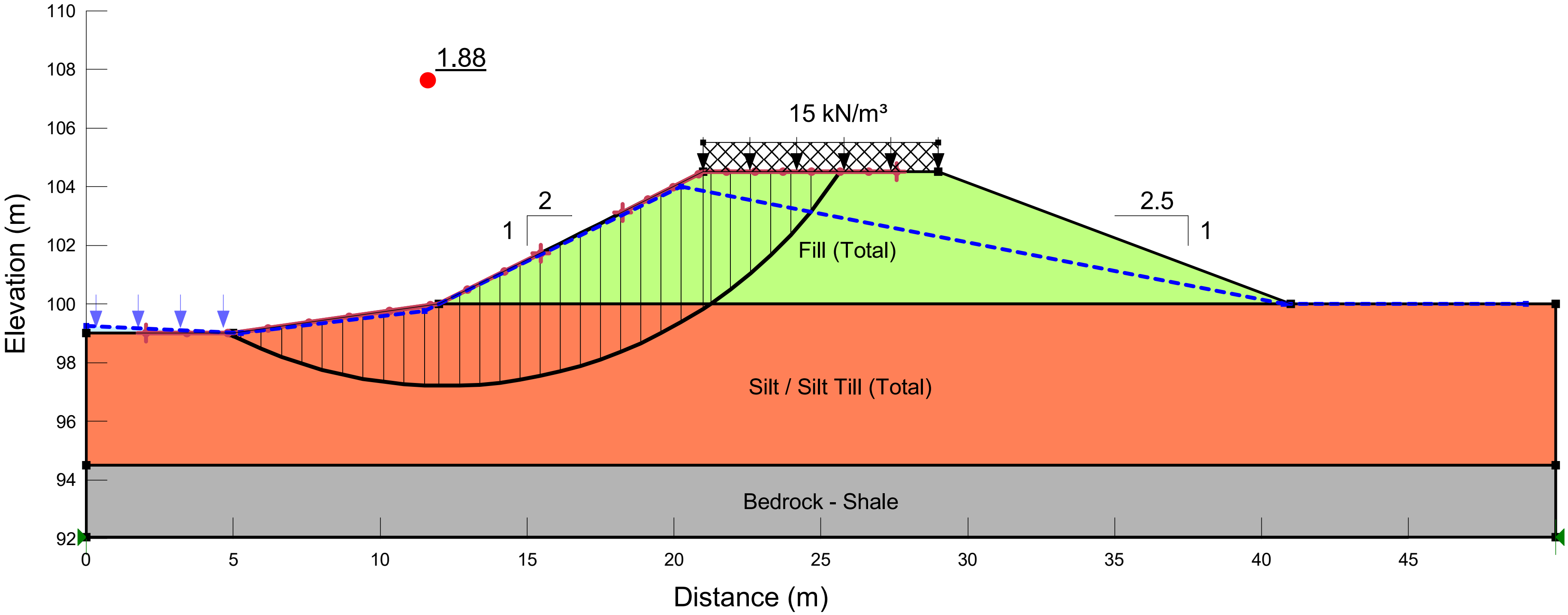

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Figure 10: Freeman Berm Rapid Drawdown (short term)

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1:221

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
⬜	Bedrock - Shale	24		
🟧	Silt / Silt Till (Total)	21	0	32

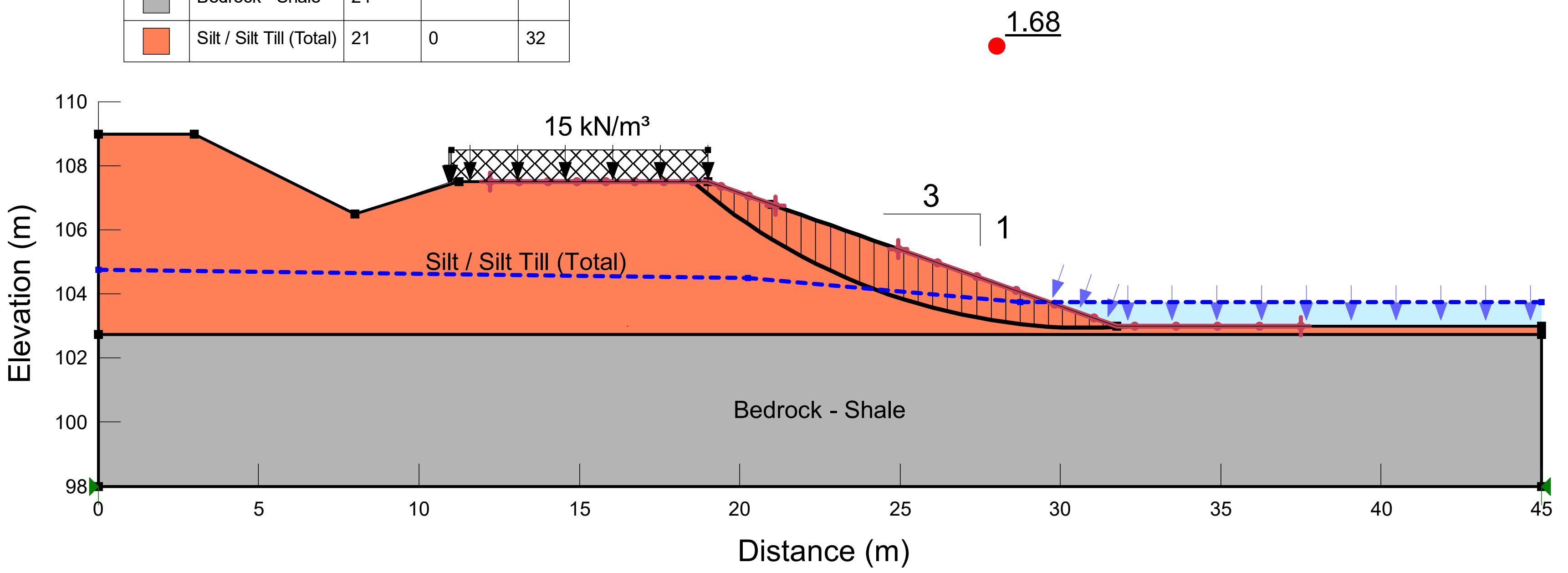

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Figure 11: East Rambo Berm (short term)

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1:215

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
▨	Bedrock - Shale	24		
🟧	Silt / Silt Till (Total)	21	0	32

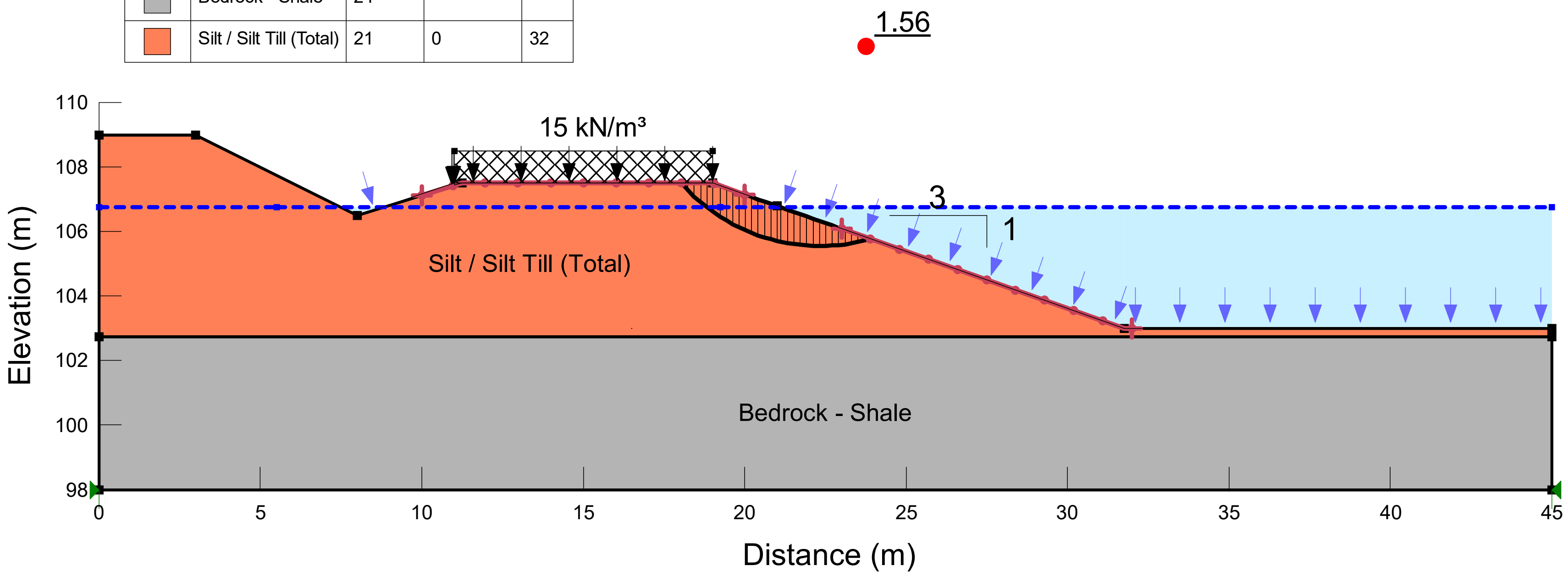

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Figure 12: East Rambo Berm High Water (short term)

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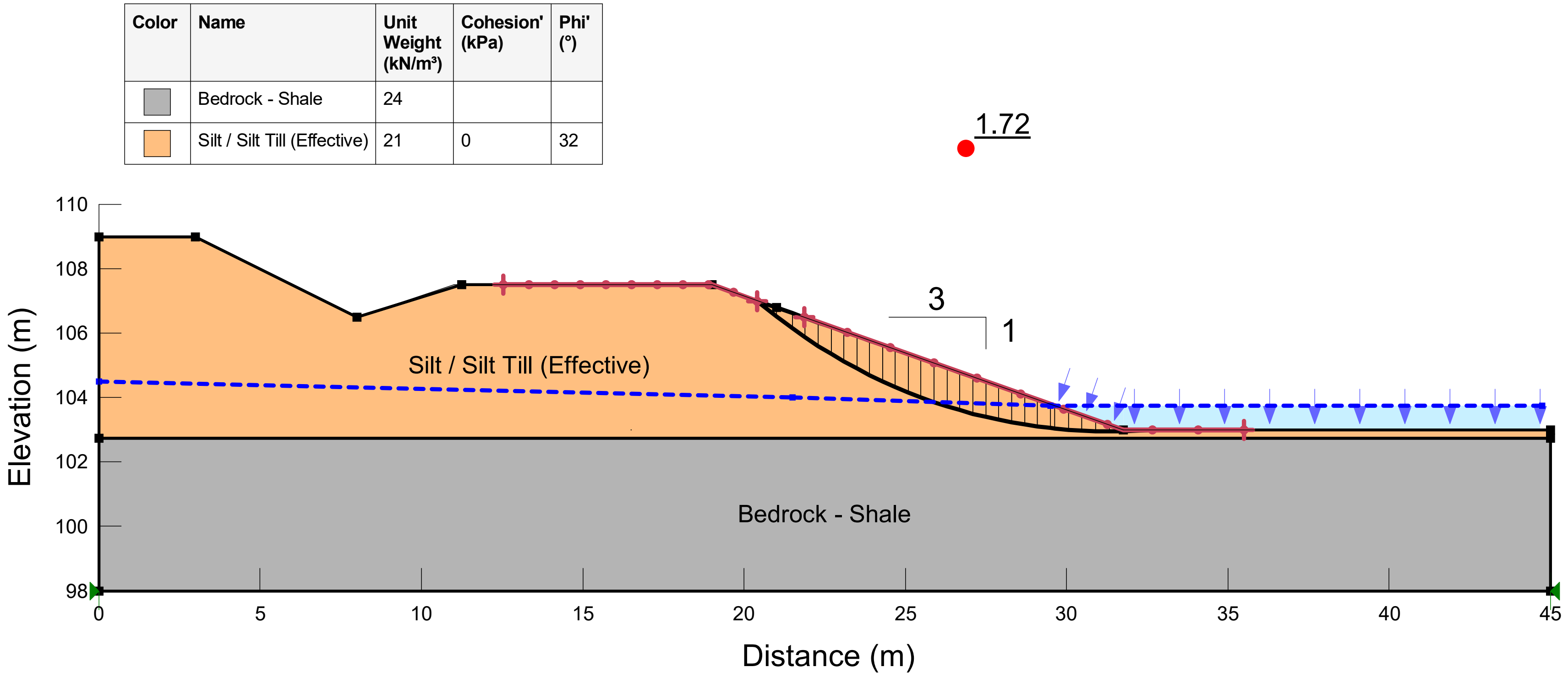
1:215



Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
⬜	Bedrock - Shale	24		
🟧	Silt / Silt Till (Effective)	21	0	32

TPB198130 Burlington Ponds

Figure 13: East Rambo Berm (long term)

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1:215

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
■	Bedrock - Shale	24		
🟧	Silt / Silt Till (Total)	21	0	32

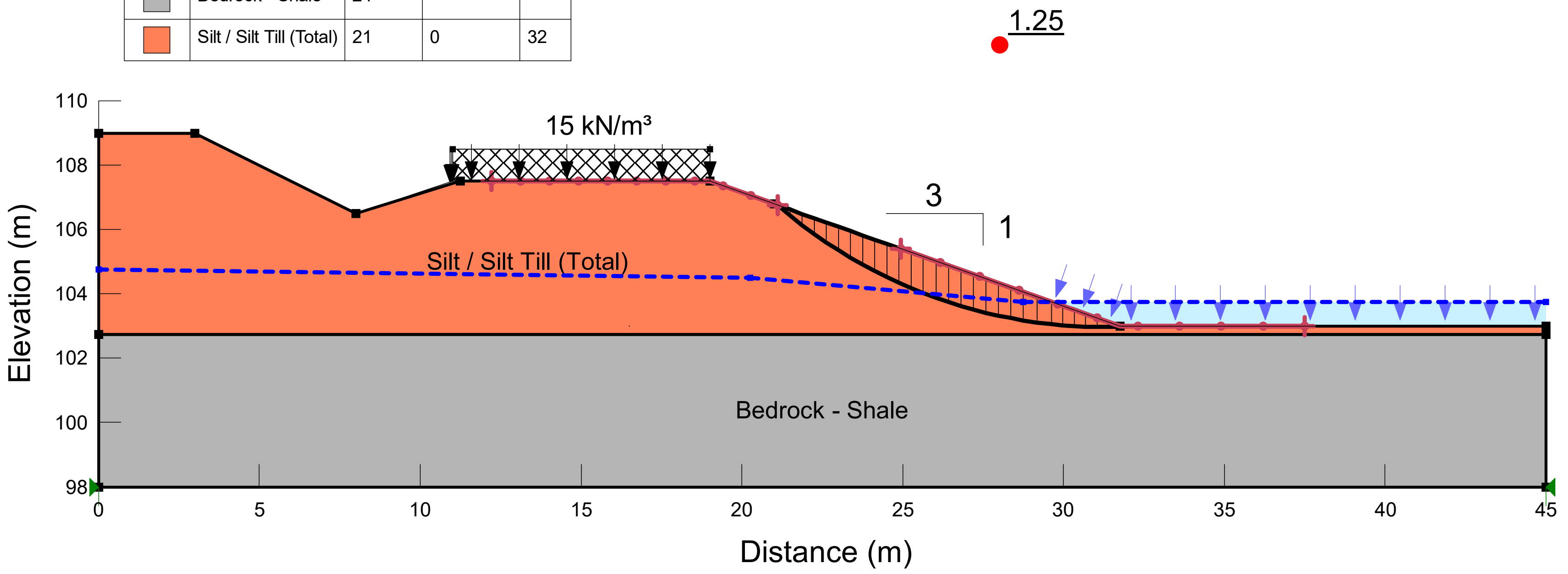

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Figure 14: East Rambo Berm Psuedo Static (short term)

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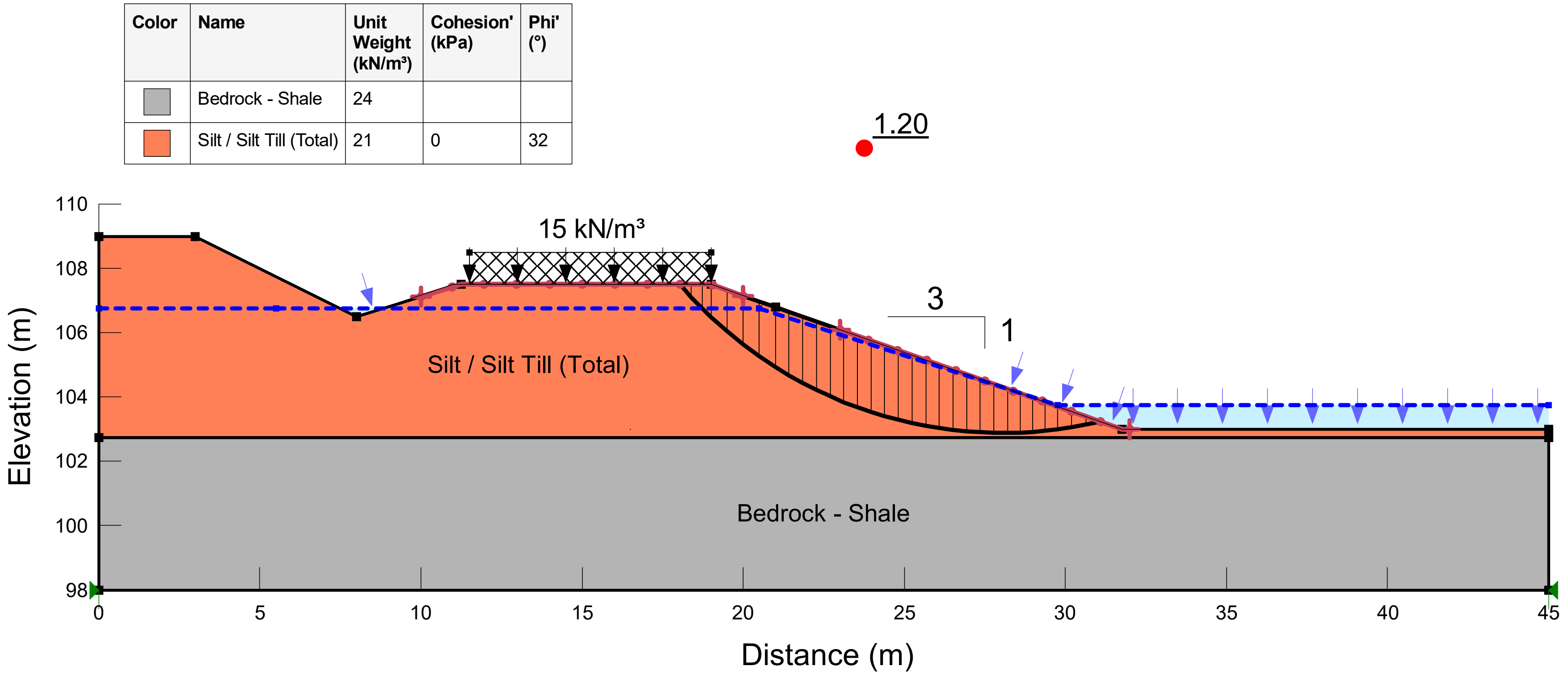
1:215



Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
⬜	Bedrock - Shale	24		
🟧	Silt / Silt Till (Total)	21	0	32

TPB198130 Burlington Ponds

Figure 15: East Rambo Berm Rapid Drawdown (short term)

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a Division of Wood Canada Limited

TPB198130 - East Rambo 11MAY2020.gsz

1:215

Appendix C

Hydrologic Modelling

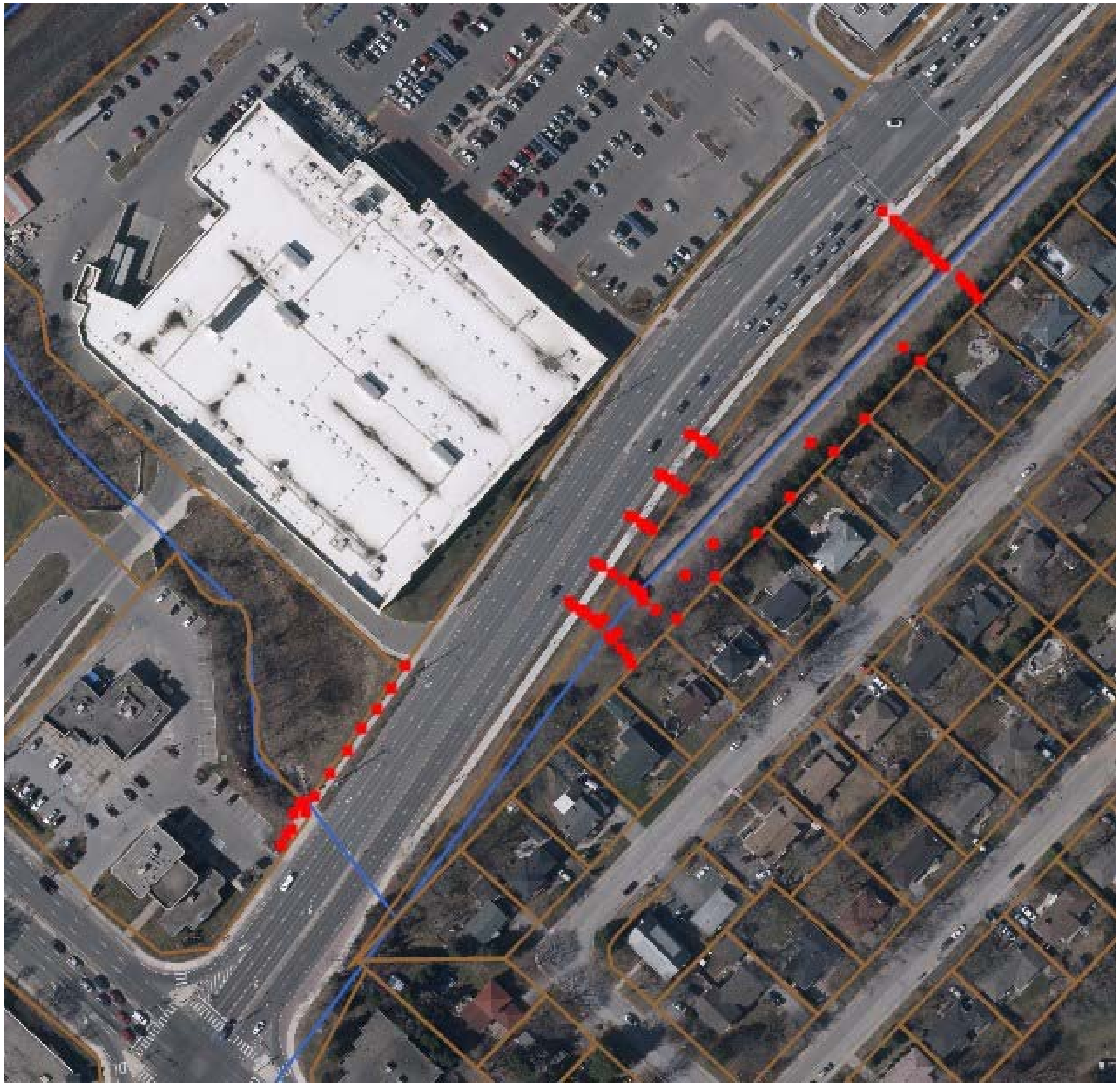

Figure C1: Topographic Survey Verification for Hager-Rambo Diversion Channel

Figure C2: Topographic Survey Verification for East Rambo Pond

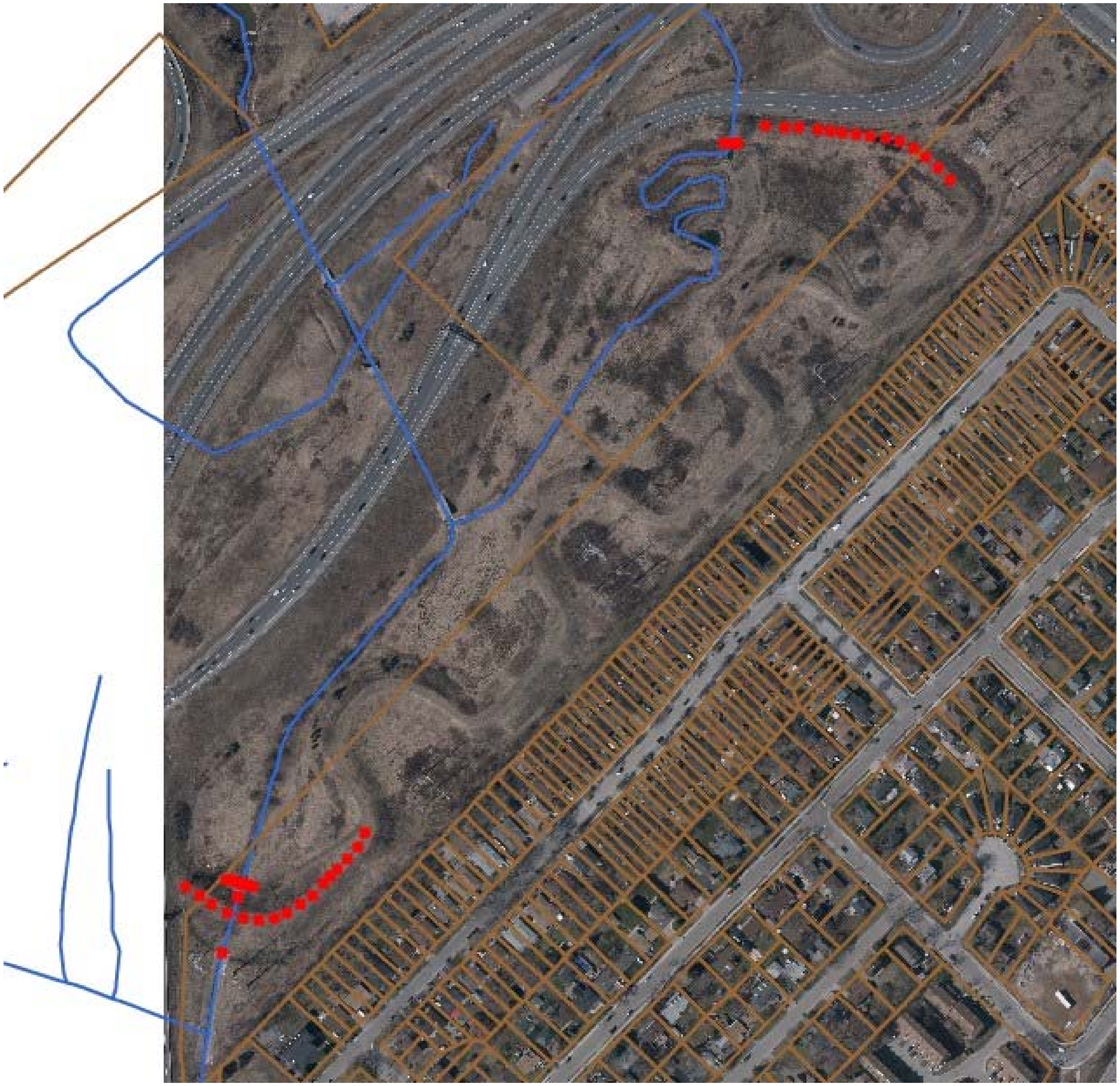

Figure C3: Topographic Survey Verification for Freeman Pond

PHILIPS
ENGINEERING

Memorandum

December 10, 2004
104138-26

TO: *Philip Kelly, P. Eng.*

FROM: *Aaron Brouwers / Ron Scheckenberger*

RE: *City of Burlington IDF Relationships and Design Storms*

As per our December 1, 2004 work plan, we have updated the IDF curves and the associated IDF parameters as well as regenerated the associated design storms based on the most current information.

SCS Design Storms

The 1994 Storm Drainage Design Manual (PPEL) developed the IDF relationships based on 27 years of rainfall intensity data (1964–1990) from the Royal Botanical Gardens gauge provided by the Atmospheric Environment Service (AES). The current assessment updates the previous and includes 35 years of data (1962–1996); most notably it includes the large events recorded in 1995. Table 1 compares AES 6 and 12 hour duration rainfall depths used in the 1994 and 2004 assessments; the depths have been used to develop the SCS Type II 6 and 12 hour design storms for the current assessment (ref. Tables 5 & 6, attached).

TABLE 1
COMPARISON OF AES RAINFALL DEPTHS (mm)

Duration (hours)	Frequency (Years)	1994	2004
6	100	85.9	92.4
6	5	48.7	51.3
12	100	92.1	103.6
12	5	55.2	58.9

The depths for the 100 year event show an 8 % and 12 % increase for the 6 and 12 hour durations, respectively. The 5 year event experiences lower relative increases of 5 % and 7 % for the 6 and 12 hour durations, respectively. The increases can largely be attributed to events experienced in 1995, which are the largest within the period of record. As would be expected, these large events have more influence on predicted rainfall depths for the less frequent events (i.e. 100 year).

IDF Parameters/Curve & Chicago Design Storms

Table 2 summarizes the AES IDF values for the subject gauge. Performing a three-parameter regression, using the SWMHYMO Chicago Storm function, provides initial A, B and C parameters, which define the IDF curve fit. These parameters have been refined through manual regression analysis and are presented in Table 3. The equation for the IDF curves is as follows:

$$i = \frac{A}{(t+B)^C}$$

where:
i = rainfall intensity (mm/hr)
t = storm duration (minutes)
A, B, C = defined in Table 2

The regression provides only a ‘best fit’ for the AES data, and when applying the IDF parameters provided, rainfall depths for a given frequency storm and duration will vary from actual statistically derived depths from

AES (ref. IDF curves attached). This is consistent with 1994 assessment and is necessary in order provide the standard set of three parameters (i.e. A, B &C). The ratio of the time to peak to the total storm duration, *r*, (used for calculating the Chicago distributions) has been set at 0.48, which is the recommended value for Ontario (Marsalek, 1978). This is consistent with the 1977 and 1994 assessments, which used a value of 0.46 for *r*. Table 4 presents a comparison of the current and previous IDF assessments; the 3 and 4 hour Chicago design storms are attached (ref. Table 7 & 8).

TABLE 2
INTENSITY-DURATION-FREQUENCY VALUES
ROYAL BOTANICAL GARDENS

Duration (min)	Rainfall Intensity (mm/hr)					
	2	5	10	25	50	100
5	94.6	122.2	140.6	163.7	180.9	198.0
10	68.3	89.2	103.2	120.8	133.8	146.7
15	55.7	74.3	86.7	102.2	113.8	125.2
30	36.2	47.2	54.5	63.7	70.5	77.3
60	22.1	27.6	31.2	35.7	39.1	42.5
120	14.3	18.6	21.4	25.0	27.7	30.4
360	6.0	8.5	10.2	12.3	13.9	15.4
720	3.5	4.9	5.8	7.0	7.8	8.6
1440	2.1	2.8	3.3	3.8	4.3	4.7

TABLE 3
IDF PARAMETERS – ROYAL BOTANICAL GARDENS

Parameter	2	5	10	25	50	100
A	595.5	688.2	748.0	867.0	947.3	1036.1
B	6.0	5.0	4.5	4.5	4.5	4.5
C	0.778	0.753	0.740	0.737	0.733	0.733

TABLE 4
COMPARISON OF IDF ASSESSMENTS

Item		1977	1994	2004
Source of Rainfall Data		Royal Botanical Gardens	Royal Botanical Gardens	Royal Botanical Gardens
Duration of Rainfall Record		12 Years	27 Years (1964-1990)	35 Years (1962-1996)
IDF Parameters				
5 Year	A	1111	697.4	688.2
	B	7	5	5.0
	C	0.857	0.764	0.753
100 Year	A	2377	1114.1	1036.1
	B	9	5	4.5
	C	0.886	0.761	0.733
Predicted Depth (mm)				
100 Year - 3 Hour Duration Depth		68.5	62.9	67.9
5 Year - 3 Hour Duration Depth		37.6	38.7	40.5
100 Year - 4 Hour Duration Depth		71.6	67.7	73.6
5 Year - 4 Hour Duration Depth		39.6	41.7	43.7

The results for the 100 year event show a 5 % and 6 % increase in rainfall depths for the 3 and 4 hour durations, respectively, when comparing the 2004 and 1994 assessments. The 5 year event experiences similar relative increases of 5 % for both the 3 and 4 hour durations, respectively.

We trust this satisfies your current requirements, should you require anything further please do not hesitate to contact our office. Once you have reviewed this information and are in agreement with its content, we will forward you digital copies of this memo and its attachments.

AB/RS/ab

Attach.

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2.0 Overview

Most studies that incorporate climate change rely on model-generated projections. These projections are most often computed with the use of global climate models (GCMs), which are dynamic system-based models that represent complex interactions between physical processes in the atmosphere, ocean, cryosphere and land surface. These are currently the most advanced tools to estimate how the climate system may respond to the natural and human driven stresses (e.g., increasing in greenhouse gas emissions, population, and other behaviours).

There are various climate organizations that conduct climate change modelling research and share their projections to the Coupled Model Inter-comparison Project Phase 5 (CMIP5). CMIP5 is the official body of science used by the Intergovernmental Panel on Climate Change (IPCC), which is a United Nations body founded with the purpose of evaluating climate change science. There are currently twenty (20) different climate modelling organizations that lead the evolution of climate models, resulting in a large repository of models available for various applications.

It is important to note that because each GCM provides a slightly different conceptualization of the earth-atmosphere system, the IPCC recommends using an ensemble approach. An ensemble is a grouping of climate projections. Together, the models in an ensemble provide a better characterization of the future and its uncertainty than a single model used in isolation.

2.1 Greenhouse Gas Emissions Scenarios

Future greenhouse gas (GHG) emissions are not known. Therefore, the IPCC developed four (4) Representative Concentration Pathways (RCPs) as part of a new initiative for the Fifth Assessment Reports (Taylor et al. 2012). These RCP scenarios move away from the Special Report on Emissions Scenarios[1] (SRES) (i.e. prescriptive GHG emissions scenarios) based on assumptions of socioeconomic scenarios (e.g., population growth, mitigation policy, and other prescriptive assumptions) and focus on representing the forcing which may be realized through a much broader set of socioeconomic scenarios while also incorporating carbon emission controls, which the previous iteration of scenarios (e.g., double CO_2, and SRES scenarios) were criticized for not including in a more integrated manner. These RCPs were created with Integrated Assessment Models (IAM) which include climate, economic, land use, demographic, and energy-usage effects. The outputs of these IAMs, which estimate GHG concentrations, were then converted to an emission trajectory using carbon cycle models. The RCP scenarios 2.6, 4.5, 6.0 and 8.5 reflect various levels of climate change mitigation efforts (i.e. RCP 2.6, resulting in an increase of 2.6 W/m^2 in radiative forcing to the global climate system) and business-as-usual GHG emissions continuing (i.e. RCP 8.5, an increase of 8.5 W/m^2).

For the purposes of this assessment, it is suggested that the Town of Oakville focus on projections for RCP 4.5 (a *moderate* emissions scenario that would require substantial reductions from current emission levels) and RCP 8.5 (business-as-usual). RCP 6.0 is not suggested for inclusion as it has been found to be very similar to RCP 4.5, which is deemed sufficient to represent the "medium" GHG scenario. Table 2-1 provides a description of each RCP scenario while Figure 2-1 illustrates the projected global warming associated with the four scenarios.

---

[1] See Appendix G

Table 2-1 RCP Scenario Descriptions

Scenario	Description
RCP 2.6	Lowest projected GHG concentrations, resulting from dramatic climate change mitigation measures implemented globally. It represents an increase of 2.6 W/m^2 in radiative forcing to the climate system.
RCP 4.5	Moderate projected GHG concentrations, resulting from substantial climate change mitigation measures. It represents an increase of 4.5 W/m^2 in radiative forcing to the climate system.
RCP 6.0	Moderate projected GHG concentrations, resulting from some climate change mitigation measures. It represents an increase of 6.0 W/m^2 in radiative forcing to the climate system.
RCP 8.5	Highest projected GHG concentrations, resulting from business-as-usual emissions. It represents an increase of 8.5 W/m^2 in radiative forcing to the climate system.

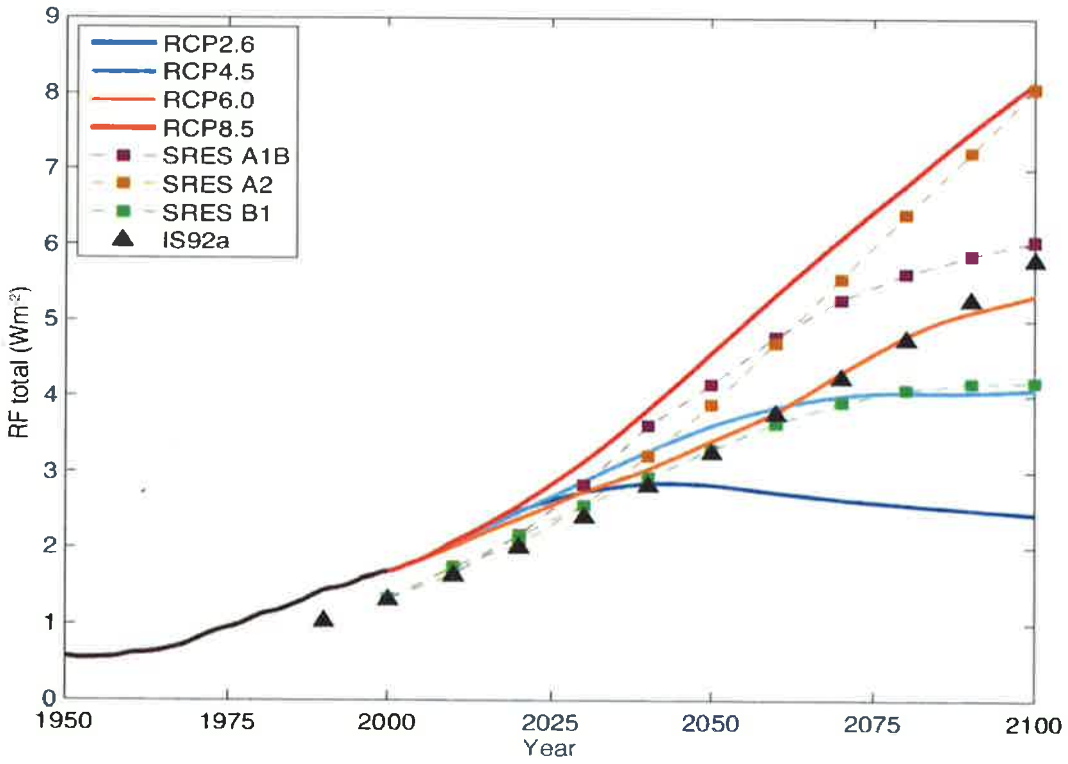

Figure 2-1 RCPs Used for Climate Modeling and Research

(Notes: Historical and projected total anthropogenic radiative forcing (W/m^2) relative to preindustrial (about 1765) between 1950 and 2100. Previous IPCC assessments (SAR IS92a, TAR/ AR4 SRES A1B, A2 and B1) are compared with RCP scenarios.

(source: Cubasch et al (2013); Figure 1.15)

Table 4-7 All Scenarios Summary – 5 Year and 100 Year 24 Hour Duration Events

All Scenarios 5 Year and 100 Year 24 Hour Duration Events Comparison – Rainfall Depth								
Rainfall Scenario / Representative Time Frame			Return Period		Comparison with Oakville Design Event (#1)			
			5 year	100 year	5 year		100 year	
			(mm)	(mm)	(mm)	%	(mm)	%
Town of Oakville								
1	IDF from Table 3.1 in the Design Guidelines	2018	60.0	98.4	0.0	0	0.0	0
2	IDF as computed from Chicago Storm parameters defined in Table 3.1 in the Design Guidelines	2018	60.9	98.1	0.9	1.5%	-0.3	-0.3%
3	#1 plus 15%	2050	69.0	113.2	9.0	15.0%	14.8	15.0%
4	#1 plus 20%	2050	72.0	118.1	12.0	20.0%	19.7	20.0%
5	#2 plus 15%	2080	70.0	112.8	10.0	16.7%	14.4	14.6%
6	#2 plus 20%	2080	73.1	117.7	13.1	21.8%	19.3	19.6%
Environment and Climate Change Canada								
7	Toronto City IDF v1.0 and v2.0 (Gumbel)	2007/2010	59.5	95.5	-0.5	-0.8%	-2.9	-2.9%
8	#7 - 95th percentile upper bound (converted from intensity)	2007/2010	60.2	96.6	0.2	0.3%	-1.8	-1.8%
9	#7 - 95th percentile lower bound (converted from intensity)	2007/2010	59.8	95.4	-0.2	-0.3%	-3.0	-3.0%
10	Toronto City IDF v2.3 (Gumbel)	2014	59.0	94.7	-1.0	-1.7%	-3.7	-3.8%
11	#10 - 95th percentile upper bound (converted from intensity)	2014	60.2	94.2	0.2	0.3%	-4.2	-4.3%
12	#10 - 95th percentile lower bound (converted from intensity)	2014	59.8	93.0	-0.2	-0.3%	-5.4	-5.5%
University of Western Ontario IDFCC Tool V2								
13	Oakville Ensemble projection (Gumbel-RCP 2.6)	2050	64.8	103.2	4.8	8.0%	4.8	4.9%
14	Oakville Ensemble projection (Gumbel-RCP 4.5)	2050	64.8	103.2	4.8	8.0%	4.8	4.9%
15	Oakville Ensemble projection (Gumbel-RCP 8.5)	2050	62.4	100.8	2.4	4.0%	2.4	2.4%
16	Oakville Ensemble projection (Gumbel-RCP 2.6)	2080	65.8	104.2	5.8	9.7%	5.8	5.9%
17	Oakville Ensemble projection (Gumbel-RCP 4.5)	2080	67.2	109.9	7.2	12.0%	11.5	11.7%
18	Oakville Ensemble projection (Gumbel-RCP 8.5)	2080	70.6	113.5	10.6	17.7%	15.1	15.3%
University of Western Ontario IDFCC Tool V3								
19	Toronto City - Base GEV	2010	58.3	101.8	-1.7	-2.8%	3.4	3.5%
20	Toronto City Ensemble projection (GEV-RCP 2.6)	2050	74.6	134.9	14.6	24.4%	36.5	37.1%
21	#20 - 25th percentile upper bound (GEV-RCP 2.6)	2050	67.5	125.1	7.5	12.5%	26.7	27.1%
22	#20 - 75th percentile lower bound (GEV-RCP 2.6)	2050	77.7	163.6	17.7	29.6%	65.2	66.3%
23	Toronto City Ensemble projection (GEV-RCP 2.6)	2080	71.2	134.5	11.2	18.6%	36.1	36.7%
24	#23 - 25th percentile upper bound (GEV-RCP 2.6)	2080	69.6	125.6	9.6	16.0%	27.2	27.7%
25	#23 - 75th percentile lower bound (GEV-RCP 2.6)	2080	78.6	149.1	18.6	31.0%	50.7	51.6%
26	Toronto City Ensemble projection (GEV-RCP 4.5)	2050	67.4	130.8	7.4	12.4%	32.4	32.9%
27	#26 - 25th percentile upper bound (GEV-RCP 4.5)	2050	63.8	119.8	3.8	6.4%	21.4	21.8%
28	#26 - 75th percentile lower bound (GEV-RCP 4.5)	2050	78.3	154.5	18.3	30.5%	56.1	57.0%
29	Toronto City Ensemble projection (GEV-RCP 4.5)	2080	78.2	149.0	18.2	30.3%	50.6	51.4%
30	#29 - 25th percentile upper bound (GEV-RCP 4.5)	2080	66.0	118.9	6.0	10.0%	20.5	20.9%
31	#29 - 75th percentile lower bound (GEV-RCP 4.5)	2080	82.5	179.3	22.5	37.5%	80.9	82.2%
32	Toronto City Ensemble projection (GEV-RCP 8.5)	2050	71.3	139.2	11.3	18.9%	40.8	41.5%
33	#33 - 25th percentile upper bound (GEV-RCP 8.5)	2050	68.5	128.0	8.5	14.2%	29.6	30.1%
34	#33 - 75th percentile lower bound (GEV-RCP 8.5)	2050	76.6	159.3	16.6	27.7%	60.9	61.9%
35	Toronto City Ensemble projection (GEV-RCP 8.5)	2080	80.0	145.0	20.0	33.3%	46.6	47.4%

All Scenarios 5 Year and 100 Year 24 Hour Duration Events Comparison – Rainfall Depth

Rainfall Scenario / Representative Time Frame			Return Period		Comparison with Oakville Design Event (#1)			
			5 year	100 year	5 year		100 year	
			(mm)	(mm)	(mm)	%	(mm)	%
36	#35 - 25th percentile upper bound (GEV-RCP 8.5)	2080	75.2	140.6	15.2	25.3%	42.2	42.9%
37	#35 - 75th percentile lower bound (GEV-RCP 8.5)	2080	85.9	173.9	25.9	43.1%	75.5	76.7%
38	Oakville Ensemble projection (GEV-RCP 2.6)	2050	88.5	244.8	28.5	47.5%	146.4	148.8%
39	#38 - 25th percentile upper bound (GEV-RCP 2.6)	2050	83.2	191.0	23.2	38.7%	92.6	94.1%
40	#38 - 75th percentile lower bound (GEV-RCP 2.6)	2050	95.3	277.5	35.3	58.9%	179.1	182.0%
41	Oakville Ensemble projection (GEV-RCP 2.6)	2080	86.6	221.3	26.6	44.4%	122.9	124.9%
42	#41 - 25th percentile upper bound (GEV-RCP 2.6)	2080	81.8	195.7	21.8	36.4%	97.3	98.8%
43	#41 - 75th percentile lower bound (GEV-RCP 2.6)	2080	94.9	244.8	34.9	58.1%	146.4	148.8%
44	Oakville Ensemble projection (GEV-RCP 4.5)	2050	78.5	213.4	18.5	30.8%	115.0	116.9%
45	#44 - 25th percentile upper bound (GEV-RCP 4.5)	2050	74.5	200.4	14.5	24.2%	102.0	103.7%
46	#44 - 75th percentile lower bound (GEV-RCP 4.5)	2050	96.1	233.3	36.1	60.1%	134.9	137.1%
47	Oakville Ensemble projection (GEV-RCP 4.5)	2080	95.1	246.8	35.1	58.5%	148.4	150.8%
48	#47 - 25th percentile upper bound (GEV-RCP 4.5)	2080	78.7	208.0	18.7	31.1%	109.6	111.4%
49	#47 - 75th percentile lower bound (GEV-RCP 4.5)	2080	100.9	276.3	40.9	68.2%	177.9	180.8%
50	Oakville Ensemble projection (GEV-RCP 8.5)	2050	87.1	214.1	27.1	45.2%	115.7	117.5%
51	#50 - 25th percentile upper bound (GEV-RCP 8.5)	2050	80.6	205.3	20.6	34.3%	106.9	108.6%
52	#50 - 75th percentile lower bound (GEV-RCP 8.5)	2050	93.7	235.9	33.7	56.2%	137.5	139.7%
53	Oakville Ensemble projection (GEV-RCP 8.5)	2080	96.0	254.6	36.0	59.9%	156.2	158.8%
54	#53 - 25th percentile upper bound (GEV-RCP 8.5)	2080	90.1	232.8	30.1	50.2%	134.4	136.6%
55	#53 - 75th percentile lower bound (GEV-RCP 8.5)	2080	107.6	270.6	47.6	79.3%	172.2	175.0%
Ontario Climate Change Data Portal								
56	Toronto City grid SRES A1B / Gumbel (Mean)	2050	100.8	177.6	40.8	68.0%	79.2	80.5%
57	#56 - 30th percentile	2050	86.4	136.8	26.4	44.0%	38.4	39.0%
58	#56 - 70th percentile	2050	100.8	182.4	40.8	68.0%	84.0	85.4%
59	#56 - 90th percentile	2050	110.4	204.0	50.4	84.0%	105.6	107.3%
60	Toronto City grid SRES A1B / Gumbel (Mean)	2080	110.4	192.0	50.4	84.0%	93.6	95.1%
61	#60 - 30th percentile	2080	100.8	175.2	40.8	68.0%	76.8	78.0%
62	#60 - 70th percentile	2080	117.6	216.0	57.6	96.0%	117.6	119.5%
63	#60 - 90th percentile	2080	127.2	235.2	67.2	112.0%	136.8	139.0%
64	Oakville grid SRES A1B / Gumbel (Mean)	2050	98.4	170.4	38.4	64.0%	72.0	73.2%
65	#64 - 30th percentile	2050	91.2	146.4	31.2	52.0%	48.0	48.8%
66	#64 - 70th percentile	2050	100.8	175.2	40.8	68.0%	76.8	78.0%
67	#64 - 90th percentile	2050	100.8	187.2	40.8	68.0%	88.8	90.2%
68	Oakville grid SRES A1B / Gumbel (Mean)	2080	90.0	160.8	30.0	50.0%	62.4	63.4%
69	#68 - 30th percentile	2080	89.8	155.5	29.8	49.6%	57.1	58.0%
70	#68 - 70th percentile	2080	91.0	173.5	31.0	51.6%	75.1	76.3%
71	#68 - 90th percentile	2080	108.0	196.8	48.0	80.0%	98.4	100.0%
MTO Trending Tool								
72	Toronto City: Base	2010	74.4	124.8	14.4	24.0%	26.4	26.8%
73	#72 - 5th percentile	2010	57.6	84.0	-2.4	-4.0%	-14.4	-14.6%
74	#72 - 95th percentile	2010	91.2	165.6	31.2	52.0%	67.2	68.3%
75	Toronto City +15%	2050	85.6	143.5	25.6	42.6%	45.1	45.9%
76	#75 - 5th percentile	2050	66.2	96.6	6.2	10.4%	-1.8	-1.8%
77	#75 - 95th percentile	2050	104.9	190.4	44.9	74.8%	92.0	93.5%
78	Toronto City +20%	2080	89.3	149.8	29.3	48.8%	51.4	52.2%

All Scenarios 5 Year and 100 Year 24 Hour Duration Events Comparison – Rainfall Depth

Rainfall Scenario / Representative Time Frame			Return Period		Comparison with Oakville Design Event (#1)			
			5 year	100 year	5 year		100 year	
			(mm)	(mm)	(mm)	%	(mm)	%
79	#78 - 5th percentile	2080	69.1	100.8	9.1	15.2%	2.4	2.4%
80	#78 - 95th percentile	2080	109.4	198.7	49.4	82.4%	100.3	102.0%
81	Oakville: Base	2010	74.4	122.4	14.4	24.0%	24.0	24.4%
82	#81 - 5th percentile	2010	57.6	84.0	-2.4	-4.0%	-14.4	-14.6%
83	#81 - 95th percentile	2010	91.2	160.8	31.2	52.0%	62.4	63.4%
84	Oakville + 15%	2050	85.6	140.8	25.6	42.6%	42.4	43.0%
85	#84 - 5th percentile	2050	66.2	96.6	6.2	10.4%	-1.8	-1.8%
86	#84 - 95th percentile	2050	104.9	184.9	44.9	74.8%	86.5	87.9%
87	Oakville + 20%	2080	89.3	146.9	29.3	48.8%	48.5	49.3%
88	#87 - 5th percentile	2080	69.1	100.8	9.1	15.2%	2.4	2.4%
89	#87 - 95th percentile	2080	109.4	193.0	49.4	82.4%	94.6	96.1%

Notes:

1. The +15% and +20% and associated scenarios have been associated with the 2050 and 2080 time frames for the purposes of statistical analysis.

Table 4-8 All Scenarios Statistical Analysis – 5 Year and 100 Year 24 Hour Duration Events

All Scenarios Statistical Analysis based on Information Presented in Table 4-7

Return Period	Minimum	25th percentile	Median	Average	75th percentile	90th percentile	Maximum
				Present Day			
5 Year (Oakville Design Event 60.0 mm)	57.6	59.3	60.0	65.6	67.7	84.5	91.2
100 Year (Oakville Design Event 98.4 mm)	84.0	94.5	96.6	107.3	112.1	146.4	165.6
				2050s			
5 Year	62.4	69.0	80.6	82.6	95.3	100.8	110.4
100 Year	96.6	128.0	159.3	163.2	191.0	221.8	277.5
				2080s			
5 Year	65.8	73.1	86.6	87.5	96.0	109.4	127.2
100 Year	100.8	145.5	174.5	179.0	214.0	246.2	276.3
Deviation from the Average (as noted above)							
5 Year	-12%	-10%	-9%	0%	3%	29%	39%
100 Year	-22%	-12%	-10%	0%	4%	36%	54%
				2050s			
5 Year	-24%	-16%	-2%	0%	15%	22%	34%
100 Year	-41%	-22%	-2%	0%	17%	36%	70%
				2080s			
5 Year	-25%	-16%	-1%	0%	10%	25%	45%
100 Year	-44%	-19%	-2%	0%	20%	38%	54%

As well, Table 4-14 provides a summary of possible rainfall options, based on the GEV RCP 8.5 based approach, which should be given consideration as the basis for stress testing infrastructure design, where the GEV based estimates are conservative by comparison to the estimates provided in Table 4-13.

Table 4-13 Screened Scenarios Statistical Analysis – Summary

Return Period	Minimum	25th Percentile	Median	Average	75th Percentile	90th Percentile	Maximum
				Present Day			
5 Year (Oakville Design Event 60.0 mm)	58.3	59.5	59.8	59.7	60.2	60.3	60.9
100 Year (Oakville Design Event 98.4 mm)	93.0	94.7	95.5	96.4	98.1	99.1	101.8
				2050s RCP 4.5			
5 Year	64.8	66.9	69.5	76.8	81.7	95.3	104.9
100 Year	96.6	105.6	113.0	126.6	135.9	167.0	190.4
				2080s RCP 4.5			
5 Year	67.2	69.8	72.6	80.0	85.3	99.4	109.4
100 Year	100.6	111.9	117.9	132.5	141.9	174.3	198.7
				2050s RCP 8.5			
5 Year	62.4	66.9	69.5	76.4	81.7	95.2	104.9
100 Year	96.6	103.8	113.0	126.2	135.9	167.0	190.4
				2080s RCP 8.5			
5 Year	69.1	71.0	72.5	80.6	85.2	99.4	109.4
100 Year	100.8	125.3	149.8	149.8	174.2	188.9	198.7

Table 4-14 2050 and 2080 GEV Scenarios Summary

Toronto City Station	Rainfall Depth Estimates based on the University of Western Ontario IDFCC Tool V3					
	2050			2080		
	25th Percentile	Mean	75th Percentile	25th Percentile	Mean	75th Percentile
			RCP 4.5			
5 year	63.8	67.4	78.3	66.0	78.2	82.5
100 year	119.8	130.8	154.5	118.9	149.0	179,3
			RCP 8.5			
5 year	68.5	71.3	76.6	75.2	80.0	85.9
100 year	128.0	139.2	159.3	140.6	145.0	173.9