



WEST HANTS REGIONAL MUNICIPALITY REPORT

Information 	Recommendation ☐	Decision Request ☐	Councillor Activity ☐
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To: West Hants Regional Municipality Committee of the Whole

Submitted by: Mark Phillips, CAO and Todd Richard, Director of Public Works

Date: February 11, 2025

Subject: Tremain Crescent Stormwater Improvements Update

LEGISLATIVE AUTHORITY

UPDATE

The Public Works Department have extended notices to those residents on Tremain Crescent that may be impacted by easement requests in order to accommodate the scheduled infrastructure improvements to the stormwater system in the area. Public Works have not received responses or feedback from those residents regarding the easements, so the department is coordinating a meeting with residents as an alternative means to communicate the need for these easements and the infrastructure upgrades. Recent communications from a resident in this area indicates a meeting might be beneficial.

The stormwater plan and its design is attached for Council's information. The 2024/25 Capital Budget reflects a cost of \$515,000 for the completion of this work.

BACKGROUND

Property 	Public Opinion ☐	Environment 	Social ☐	Economic ☐	Councillor Activity ☐
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DISCUSSION

NEXT STEPS

1. Meeting with Tremain Crescent residents impacted by the required easements.

FINANCIAL IMPLICATIONS

2024/25 Capital Budget – Tremain Crescent Stormwater Culvert \$515,000

ALTERNATIVES

ATTACHMENTS

Tremain Crescent Stormwater – CBCL, March 2024

CHIEF ADMINISTRATIVE OFFICER REVIEW

N/A



Tremain Crescent Stormwater

Cross-Culvert near Civic #335

Draft Design Report



231049.00 • March 2024

1	Draft Design Report	Aaron Baillie	22-Mar-2024	Abram Lee
Rev.	Issue	Reviewed By:	Date	Issued By:
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March 22, 2024

Todd Richard
Director of Public Works
West Hants Regional Municipality
PO Box 3000
100 King Street
Windsor, NS B0N 2T0

Dear Mr. Richard:

RE: Tremain Crescent Stormwater – Cross-Culvert near Civic #335 – Draft Design Report

West Hants Regional Municipality (WHRM) retained CBCL Limited (CBCL) to complete a stormwater assessment and crossing design to reduce flood risk at the cross-culvert near Civic #335 Tremain Crescent in Windsor, Nova Scotia. This report summarizes the work completed to date on this project, and focuses on the design rationale and presents the Issued for Review design drawings.

Yours very truly,

CBCL Limited

Draft
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Project No.: 231049.00

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- A Issued for Review Drawing Set
- B Opinion of Probable Cost
- C Stormwater Memo 'Tremain Cresent Stormwater – Cross Culvert near Civic #335' (CBCL, 2024)

1 Introduction

The West Hants Regional Municipality (WHRM) retained CBCL Limited (CBCL) to complete a stormwater assessment and crossing design to reduce flood risk at the cross-culvert near Civic #335 Tremain Crescent in Windsor, Nova Scotia. This report summarizes the work completed to date on this project, and focuses on the design rationale and presents the Issued for Review design drawings.

This Design Report builds upon the previously stormwater memo “Tremain Crescent Stormwater – Cross-Culvert near Civic #335” issued on January 19, 2024, which focused on the stormwater assessment, site-specific model adjustments to the existing Windsor Stormwater Model and preliminary sizing.

2 Background Information

In July 2021, the resident at Civic #335 Tremain Crescent and surrounding neighbors, experienced significant flooding of their properties. The resident at Civic #335 Tremain Crescent had also experienced flooding in the past. Flooding is reported to be increasing in frequency and volume at this location.

In November 2021, localized flooding occurred following a rainfall event. It was determined that this flooding was a result of a collapsed cross-culvert downstream of the storm infrastructure at Civic #335 Tremain Crescent. During this flooding event, the ditch downstream of the collapsed pipe was empty, identifying that the localized flooding may have been a result of the collapse and not necessarily undersized conveyance infrastructure. Following the replacement of the collapsed cross-culvert, flooding in the area has continued. The cross-culvert was replaced with a similarly sized pipe. No improvements to drainage were made. The flooding in this area is thought to be a result of undersized stormwater drainage infrastructure that is backing up the upstream ditch and flooding the adjacent properties. Stormwater flows overland, through a series of culverts, storm sewer, and ditches, before draining into the Tregothic Marsh.

3 Existing Conditions and Stormwater Capacity

A hydrologic and hydraulic stormwater model was constructed in PCSWMM for the Tremain Cresent area based on survey information collected by CBCL personnel on November 9th and 10th, 2023. The Tremain Cresent stormwater model focused on the crossing at #335 Tremain Cresent and builds on the larger-scale stormwater model created for the ongoing Windsor Stormwater Plan undertaken by CBCL. Stormwater infrastructure on Tremain Cresent consists of a mix of ditches, small driveway culverts, cross-culverts, catch basins and piped infrastructure (storm sewer). Storm infrastructure is shallow bury along Tremain Cresent as a result of the area's topography, with slopes flattening out before discharging into Tregothic Marsh. The stormwater infrastructure near Civic #335 Tremain Cresent includes a swale that collects water from the lands uphill and behind Civic 335 that discharges into a 375mm diameter HDPE stormwater pipe in front of the property that runs parallel to Tremain Cresent crossing Tremain Cresent in 450mm diameter HDPE cross culvert near the sewer pump station at the bottom of the hill, refer to Figure 1.

The major system drainage catchment upstream of this crossing is presented in Figure 2, generally bounded by King Street and Tremain Cresent plus a section at the northern quadrant collecting major drainage overland flows from the Wilson Street area. The catchment upstream of the King Street area (Edgehill area) flows to this stormwater crossing via overland flow paths.

Additional details of the stormwater assessment are included in the previously issued stormwater memo enclosed in Appendix C.



Figure 1: Tremain Crescent – Storm Sewer Infrastructure near Civic #335



Figure 2: Tremain Crescent – Major System Catchment in Blue of Cross-culvert near Civic #335

4 Historical Rainfall Events

A number of rainfall events which resulted in flooding at this location on Tremain Crescent were identified through discussion with WHRM staff, as well as from review of previous service request documents submitted by the resident at Civic #335 and provided to CBCL by WHRM. These events included the July 21, 2021 Rainfall Event; the November 27, 2021 Rainfall Event; an undated Winter Rainfall Event; the July 21/22, 2023 Rainfall Event; and the November 27, 2023 Rainfall Event.

To quantify anecdotal flooding evidence, Environment and Climate Change Canada (ECCC) and Weather Underground databases were queried for historical rainfall data. The closest ECCC station is located in Kentville and reports daily rainfall amounts. Daily rainfall is typically insufficient to adequately characterise small, urbanized rainfall events. Instead, 5-minute rainfall data was retrieved from Weather Underground (WU), operated by the Weather Company, which collects and tabulates weather data from over 250,000 personal weather stations across the world. Multiple personal precipitation stations on the WU network are operated in the Windsor area (refer to Figure 3). Data from these stations was reviewed and selected for each of the identified events. Note that Weather Underground data is publicly collected and uploaded from private weather stations, and considered less reliable than ECCC data; however, in this case serves as the best information available for the analysis of previous rainfall events.

The rainfall events analysed, and the respective Weather Underground stations used, are presented below:

- ▶ July 21, 2021 Rainfall Event: IGARLA2.
- ▶ November, 2021 Rainfall Event: IWESTHA2.
- ▶ July 21/22, 2023 Rainfall Event: IWESTHA2.
- ▶ November 27, 2023 Rainfall Event: IWESTHA2.

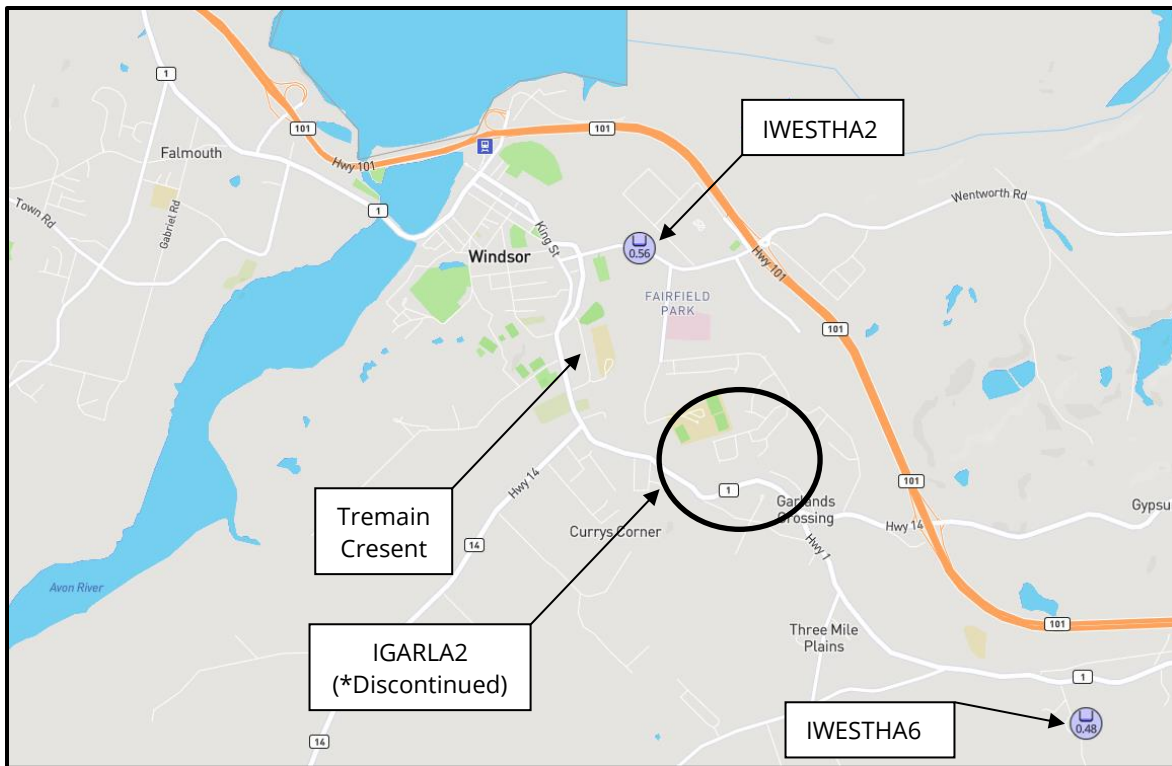


Figure 3: WunderMap – Precipitation Stations in the Vicinity of Tremain Crescent in Windsor, NS (Weather Underground, 2023)

July 27, 2021 Rainfall Event

On July 27, 2021, an intense rainfall event reportedly caused Windsor’s stormwater conveyance system to be overwhelmed, resulting in localized flooding. A local resident on Tremain Crescent provided the following statement “The recent rain fall on Tuesday, July 27, 2021 resulted in excessive amounts of water spilling into the swale/ditch and the existing municipal infrastructure could not handle the amount of water flowing into the culvert under the street at Tremain Crescent. As a result, the water flooded an area around the culvert and our property. The runoff actually flowed over the street curb which is some 22 – 24 inches higher than the culvert below. This rain lasted for some time with water spilling over the curb and across the street to neighbouring properties.”

The IGARLA2 Weather Underground station was used to analyse this weather event, and the stormwater model shows that this event resulted in significant flow in the ditch between Civic #335 and #353, to the point that it overtopped and flowed onto Tremain Crescent at this location.



Figure 4: July 27, 2021 Rainfall Event, Swale by Civic #335 Flowing onto Tremain Crescent (Source: Local Tremain Crescent Resident)

November 2021 Rainfall Event

A resident identified that the cross-culvert near the pumphouse was faulty, and that the upstream ditches were full of standing water but the downstream ditch near the pumphouse was empty. Investigation by the municipality found that the cross-culvert was clogged/plugged by a dead animal during a subsequent repair. This event was not used for calibration as comparing model results to anecdotal evidence for this event would not

provide realistic, useful information because of the many uncertainties related to the hydraulic capacity of the clogged/plugged pipe.

July 21/22, 2023 Rainfall Event

The July, 2023 Rainfall event caused widespread flooding across Nova Scotia on July 21st and 22nd. Photos supplied by the municipality collected the day following the rainfall event (July 23, 2023 at approximately 7:30 am) show downstream water levels reached an elevation of at least 6.0 metres CGVD2013. This photo was taken at high tide and the water levels receded after high tide. Refer to the photo below of the Coyote Park big field. The existing conditions model shows the Tremain Cresnet crossing overtopping based on rainfall data pulled from the IGARLA2 Weather Underground station, but due to the magnitude of the event and comparatively undersized crossing, it does not provide a good source of calibration due to uncontrolled flooding. Due to the significance of this rainfall event and the resulting widespread flooding, it is difficult to isolate the flood results at Tremain Cresnet.



Figure 5: Aftermath of July 21/22, 2023 Rainfall Event – Flooding at the Coyote Park ‘Big Field’

November 27, 2023 Rainfall Event

According to the local resident at Civic #335 Tremain Crescent, the November 27, 2023 rainfall event resulted in a water depth in the upstream ditch that did not overtop the roadway during this event, but did exceed to the top of the culvert (Tremain Crescent cross-culvert). No photos were available to confirm these statements.

The top of the existing culvert is at an elevation of approximately 7.0m, the catch basin rim is at an elevation of 7.35m (i.e., the basin starts to flood the road at this elevation), and the roadway overtopping elevation is 7.49m (top of curb). The existing conditions stormwater model for the November 27, 2023 rainfall event produced a peak hydraulic grade line of 7.3m at the culvert inlet location. Model results align with anecdotal observations and provide an additional level of confidence in the catchment parameters selected for the stormwater model.

5 Flood Pathways

The house located at Civic #335 Tremain Crescent, as well as the surrounding properties, are low-lying. Foundations are at or near the bottom of the existing ditch system, with the foundation drains visible discharging at the bottom of the ditch from Civic #335 Tremain Crescent. The flooding mechanism at Civic #335 cannot be determined without intrusive investigation of the drain tile and foundation, however it appears to be linked directly (through holes, or the drain tile discharge into the bottom of the existing ditch) or indirectly (through cracks) to a high hydraulic grade line causing water ingress through the foundation or floor slab as a result of hydrostatic pressure. Refer to **Figure 6**.

Upgrading the municipal stormwater system is unlikely to fully address the reported residential flooding at this location as drain tiles discharge into the bottom of the ditch and will be submerged when water is present in the ditch, which may result in lateral backup.



Figure 6: #335 Tremain Crescent, Google Streetview 2023

6 Design Event

The design event selected and agreed upon with WHRM is the 1-in-100 year design event accounting for 2090 climate change as per discussions with WHRM staff. The climate change projections are based on precipitation increases developed in the previous report Windsor Stormwater Report (CBCL, Final Draft, 2023). This crossing acts as a major drainage channel for upstream flows and was sized accordingly.

Through discussions with WHRM staff, it was also agreed upon to design the crossing with the inclusion of the catchment upstream of King Street (Edgehill area) flowing into the Tremain Crescent stormwater crossing, as future projects that may redirect some of these overland flows are not yet designed or slated for construction. Any future work to reroute these flows would result in a benefit and lower the hydraulic grade line below what is proposed.

7 Crossing Design Rationale

The existing crossing consists of a small diameter stormwater system with an inlet junction box, a 90° turn into a 375mm diameter storm sewer, followed by a 90° junction into a 450mm diameter storm sewer. Refer to Drawing C01 in Appendix A for existing conditions.

The proposed crossing consists of a low rise, wide span 4-sided concrete box culvert. Various alignments for the proposed crossing were considered and discussed with WHRM, including:

- ▶ Following the existing storm sewer alignment with a larger hydraulic opening
- ▶ Eliminating a section of storm sewer by reverting to open ditching in front of Civic #353 and making a more direct alignment into the downstream channel
- ▶ Skewing the culvert from the existing stormwater inlet to the outlet channel

The option to skew the culvert from the existing stormwater inlet to the outlet channel was selected to reduce overall new culvert length required (compared to following the existing alignment), improved hydraulic efficiency (compared to following the existing alignment by reducing the bend angles) and maintain the existing limits of underground stormwater infrastructure (i.e., not daylighting new sections of ditch that are currently piped).

Clearance to the existing municipal infrastructure under the roadway (water and sewer) was identified as a potential constraint. WHRM staff completed test digs and daylighted the 200mm diameter PVC watermain at a depth of 1.498m below asphalt, as well as the 300mm diameter concrete sanitary sewer at a depth of 2.007m below asphalt, along the proposed skewed culvert alignment. These depths were used to confirm clearances to the proposed culvert and are included on the design drawings in Appendix A.

The proposed crossing is a skewed 27 metre long, 2,700mm wide x 600mm tall 4-sided concrete box culvert with 2,700mmx600mm concrete box 45° bends on the inlet and outlet. Issued for Review design drawings are enclosed in Appendix A.

Supplementary design rationale is presented in the following sections.

7.1 Existing Municipal Infrastructure

The water main was relocated to gain clearance to the underside of the box, and a casing pipe was included for protection and also because the invert of the relocated watermain will be below the crown of the existing sanitary sewer main.

The existing gravity sanitary sewer was left in place. The proposed box culvert will be installed over this sewer.

Laterals to #353 and #354 Tremain Crescent are anticipated to require realignment due to conflicts with the proposed box culvert, or from the water main casing pipe. Refer to Section 7.9 for further details.

7.2 Culvert Grates

Stormwater grates were not included on the proposed crossing. The proposed culvert is a wide box culvert and debris will pass through rather than get caught on the culvert walls. If installed, an inlet grate will clog with debris that would otherwise pass through the culvert. No large debris (trees, etc.) are anticipated as it is a municipal drainage channel with no upstream forested areas.

7.3 Culvert Inlet and Outlet

Modifications are required to the inlet and outlet channels to accommodate the new box culvert structure. Redi-rock inlet walls are included on the inlet to accommodate grade changes and the upstream and downstream channels will be riprap-lined to tie into the existing channels.

Box culvert bends (45°) are included on the inlet and outlet to align the skewed culvert with the straight inlet and outlet channels.

A cutoff wall is included on the inlet to prevent water piping through the culvert bedding material and migrating into the water and sewer pipe trenches in Tremain Crescent.

7.4 Safety Measures

Guardrail, handrails and fencing is included for vehicular and pedestrian safety around the inlet and outlet of the culvert.

7.5 Street Design

Existing street grades and cross-fall will be maintained due to the limited road reinstatement area (limits consist of repairing the trench required to install the proposed infrastructure). The curb and gutter will be reinstated where existing curb and gutter is present.

Existing catch basin locations have been maintained, with the exception of the basin in the inlet junction structure that will be removed and replaced.

Existing storm sewer and the new catch basin will be connected to the box culvert (upstream) and via a structure and outlet pipe (downstream).

7.6 Right of Way

The proposed culvert arrangement extends onto upstream and downstream properties. On the upstream end, the culvert and channel encroach onto #335 and #353. On the downstream end, the culvert and new storm sewer outfall encroach onto #354. Refer to Section 7.9 for additional commentary.

7.7 Existing Overhead Utilities

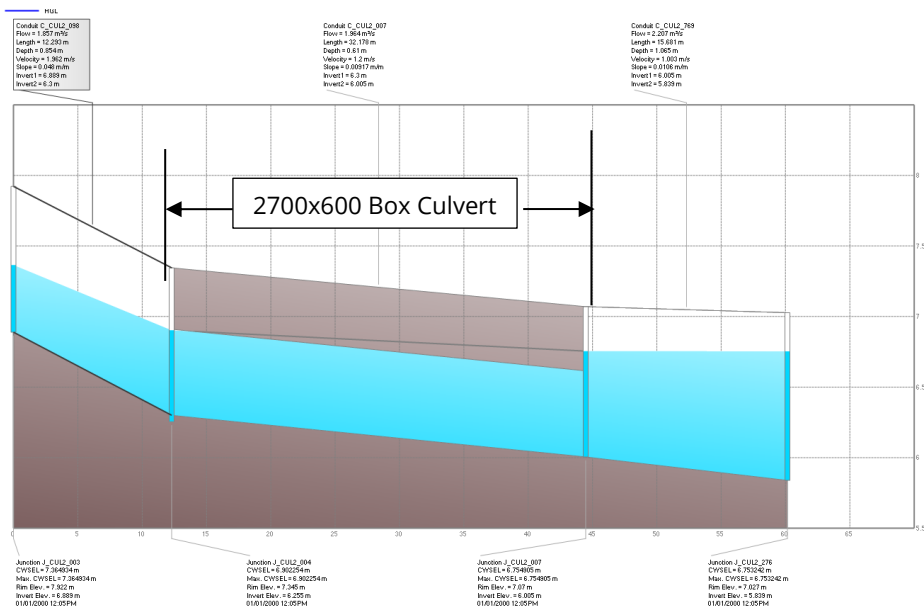
Power and communications lines are present along Tremain Crescent and cross the proposed culvert inlet to service the houses at #335 and #353, as well as crossing the outlet parallel to the road centerline. These overhead lines will result in potential constructability concerns as a crane will likely be used to install the proposed box culvert sections. Refer to Section 7.9 for additional commentary.

7.8 Hydraulics

The culvert is sized to maintain a peak headwater to depth (H/D) ratio of 1.0 or less at the design event (1 in 100 year, 2090 climate change design event) in accordance with the West Hants Municipal Services Specifications Manual (2023).

A plan/profile from the model is presented below. For specifics on the design, refer to the Issued for Review design drawings enclosed in Appendix A.





1 in 100 year, 2090 Climate Change design event Hydraulic Grade Line Profile

7.9 Outstanding Items

The following items are identified as potential or actual concerns that may impact construction and should be discussed with WHRM and addressed prior to tendering:

- ▶ Discuss Right of Way acquisition/easements to be completed by WHRM to undertake this work.
- ▶ Locate curb stops to confirm lateral locations from the properties at #335, #354 and #353. Confirm if laterals will be realigned (i.e. will temporary water be required).
- ▶ Confirm that Tremain Cresnet watermain can service from the O'Brien Street as well as King Street connections (i.e., valves work and both sides will have water) while new section for water main is installed in the work area. Discuss specifics of temporary water and disinfection plan.
- ▶ Confirm sewer lateral locations #335, #354 and #353 (or base off of curb stop locations) to confirm proposed sewer lateral relocation is viable.
- ▶ Discuss with WHRM potential for temporary or permanent relocation of the overhead electrical lines to #335 and #353, and also at the outlet, to facilitate construction of the proposed structure.
- ▶ The historical forcemain south of the existing lift station as shown on the 1990's pathway drawings is shown on the current set of design drawings. The proposed culvert may intersect this force main, if it is still in place and should be discussed with WHRM.

8 Opinion of Probable Cost

An Opinion of Probable Cost was developed based on the design drawings. The Class B opinion of probable construction cost, including contingencies and allowances, is **\$447,400 + HST**. A unit price breakdown is enclosed in Appendix A.

9 Other Considerations for Flood Risk Mitigation

Property owners in areas of identified flood risk, or that have encountered property flooding in the past, should implement flood risk mitigation measures around their properties. Some general flood risk mitigation measures include:

- ▶ Disconnecting downspouts from foundation drains, and extending the downspout at least 1.8 metres away from the house;
- ▶ Making sure there is at least a 2 percent slope away from the house and that there are no low spots close to the house where water can accumulate;
- ▶ Providing drainage swales (shallow ditches with gentle side slopes) on the back and sides of the property to intercept surface flow that might come towards the building;
- ▶ If water tends to enter the basement, constructing a shallow sump pit that is watertight to the outside and installing a sump pump that discharges to the ground or a seep pit or rain garden located well away from the building ("interior sump pump system");
- ▶ Installing a backwater valve on the storm (if applicable) and sanitary sewer laterals in compliance with the most recent version of the National Building Code; and
- ▶ Constructing a seep pit or rain garden to limit storm water flows to the municipal storm infrastructure or neighbouring lands.

Additional measures that could be taken specific to the flood risk identified at #335 Tremain Crescent:

- ▶ Foundation waterproofing to prevent water entering the basement through cracks or holes.
- ▶ Installing an exterior sump pit and pump to discharge foundation drainage away from the building ('exterior sump pump system'). Include an air gap at the end of the discharge pipe to prevent back-siphoning.
- ▶ Installing a backwater valve on the foundation drain outlet pipe, or disconnect the foundation drain from the gravity outlet if a backup power source is available to run interior and exterior sump pumps in event of power outage.

10 Conclusion

This report summarizes and builds upon the Tremain Crescent stormwater memo as well as develops the proposed box culvert crossing concept to a detailed design stage for review by West Hants Regional Municipality.

Following discussion and acceptance by WHRM, tender-ready drawings will be prepared and issued.

Draft

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E-mail: alee@cbcl.ca

Draft

Reviewed by:
Aaron Baillie, P.Eng.
Manager, Municipal

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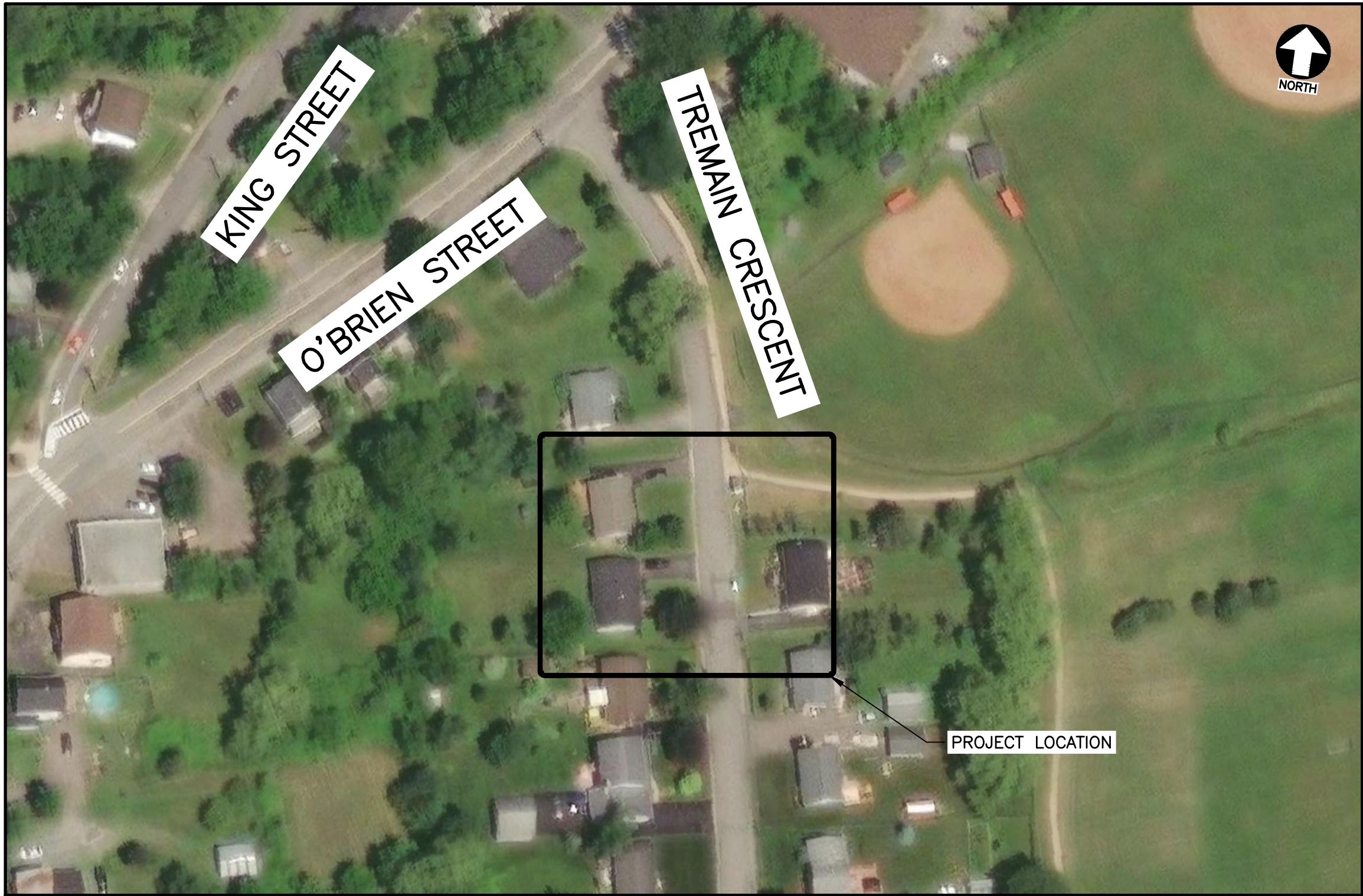
APPENDIX A

Issued for Review Drawing Set

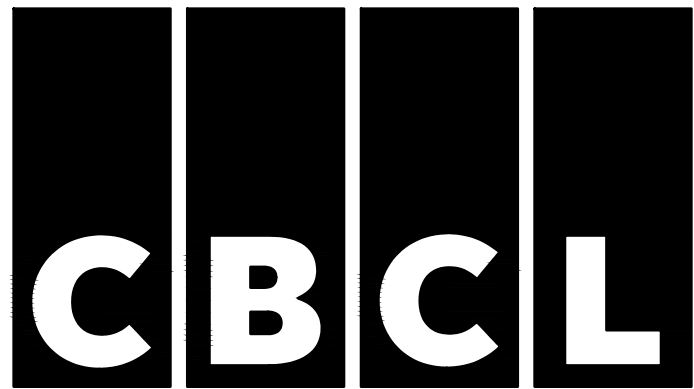
Sheet List Table	
Sheet Number	Sheet Title
COVER SHEET	
000	COVER SHEET
CIVIL	
C01	EXISTING CONDITIONS & REMOVALS
C02	PROPOSED PLAN AND PROFILE
C03	REINSTATEMENT PLAN
C04	CIVIL DETAILS SHEET 1 OF 2
C05	CIVIL DETAILS SHEET 2 OF 2



TREMAIN CRESCENT STORMWATER REPLACEMENT



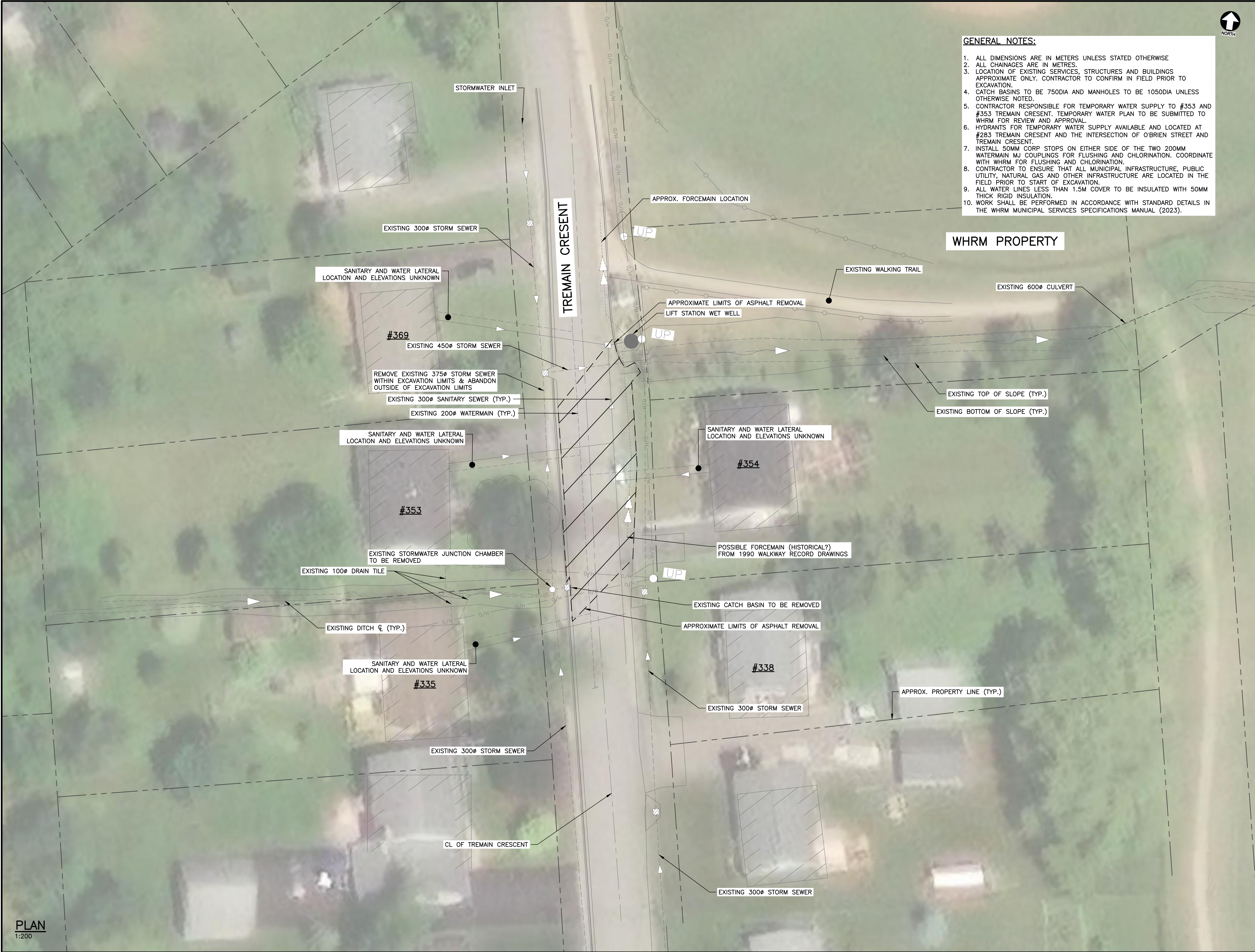
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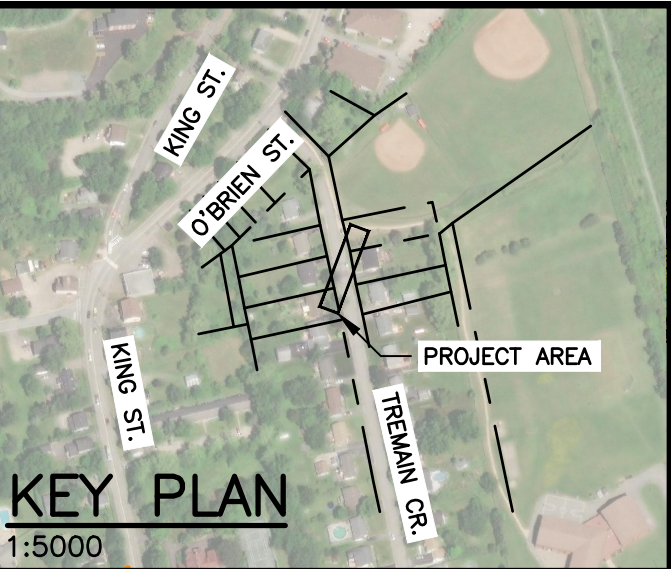
PRELIMINARY
NOT FOR CONSTRUCTION

ISSUED FOR
90% REVIEW

MARCH 20/2024



- GENERAL NOTES:**
1. ALL DIMENSIONS ARE IN METERS UNLESS STATED OTHERWISE
 2. ALL CHAINAGES ARE IN METRES.
 3. LOCATION OF EXISTING SERVICES, STRUCTURES AND BUILDINGS APPROXIMATE ONLY. CONTRACTOR TO CONFIRM IN FIELD PRIOR TO EXCAVATION.
 4. CATCH BASINS TO BE 750DIA AND MANHOLES TO BE 1050DIA UNLESS OTHERWISE NOTED.
 5. CONTRACTOR RESPONSIBLE FOR TEMPORARY WATER SUPPLY TO #353 AND #353 TREMAIN CRESENT. TEMPORARY WATER PLAN TO BE SUBMITTED TO WHRM FOR REVIEW AND APPROVAL.
 6. HYDRANTS FOR TEMPORARY WATER SUPPLY AVAILABLE AND LOCATED AT #283 TREMAIN CRESENT AND THE INTERSECTION OF O'BRIEN STREET AND TREMAIN CRESENT.
 7. INSTALL 50MM CORP STOPS ON EITHER SIDE OF THE TWO 200MM WATERMAIN MJ COUPLINGS FOR FLUSHING AND CHLORINATION. COORDINATE WITH WHRM FOR FLUSHING AND CHLORINATION.
 8. CONTRACTOR TO ENSURE THAT ALL MUNICIPAL INFRASTRUCTURE, PUBLIC UTILITY, NATURAL GAS AND OTHER INFRASTRUCTURE ARE LOCATED IN THE FIELD PRIOR TO START OF EXCAVATION.
 9. ALL WATER LINES LESS THAN 1.5M COVER TO BE INSULATED WITH 50MM THICK RIGID INSULATION.
 10. WORK SHALL BE PERFORMED IN ACCORDANCE WITH STANDARD DETAILS IN THE WHRM MUNICIPAL SERVICES SPECIFICATIONS MANUAL (2023).



- NOTES**
1. PROPERTY LINES AND BUILDING FOOTPRINTS APPROXIMATE FROM GEONOVA
 2. HORIZONTAL DATUM NAD83 CSRS UTM20
 3. VERTICAL DATUM CGVD2013

- LEGEND**
- PROPERTY LINE (EX.)
 - SANITARY SEWER (EX.)
 - SANITARY MH (EX.)
 - SANITARY FORCEMAIN (EX.)
 - STORM CATCHBASIN (SQ.) (EX.)
 - STORM CATCHBASIN (SQ.) (PR.)
 - STORM HEADWALL (EX.)
 - STORM HEADWALL (PR.)
 - STORM SEWER (EX.)
 - STORM SEWER (PR.)
 - STORM MH (EX.)
 - STORM MH (PR.)
 - STORM CATCHBASIN (SINGL.) (EX.)
 - STORM CATCHBASIN (SINGL.) (PR.)
 - DITCH (EX.)
 - DITCH (PR.)
 - TREE (HARDWOOD) (EX.)
 - TREE (SOFTWOOD) (EX.)
 - CHAINLINK FENCE (EX.)
 - CHAINLINK FENCE (PR.)
 - TOP OF SLOPE (EX.)
 - TOP OF SLOPE (PR.)
 - BOTTOM OF SLOPE (EX.)
 - BOTTOM OF SLOPE (PR.)
 - 20.0 MAJOR CONTOUR (EX.)
 - 20.0 MAJOR CONTOUR (PR.)
 - 19.0 MINOR CONTOUR (EX.)
 - 19.0 MINOR CONTOUR (PR.)

PRELIMINARY
NOT FOR CONSTRUCTION

No.	Description	Date	By
A	ISSUED FOR 90% DESIGN REVIEW	2024/03/20	AL

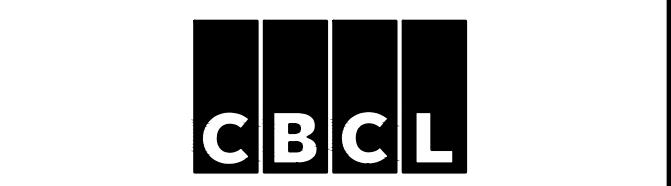
Revision or Issue

File No. 231049.00

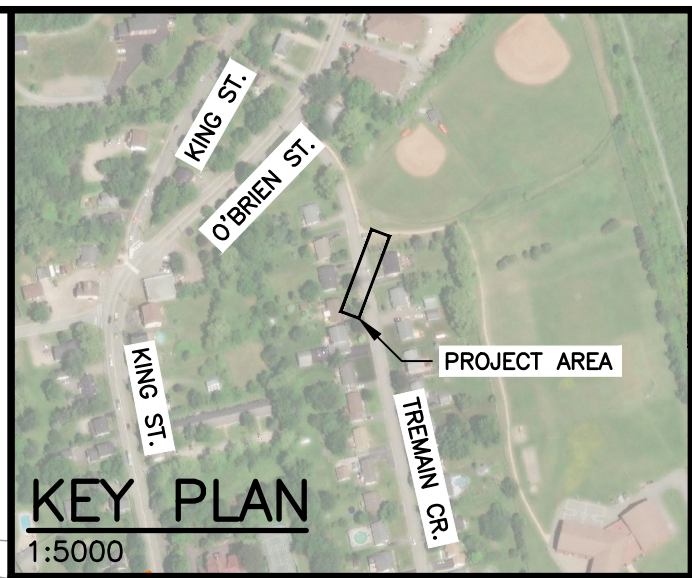
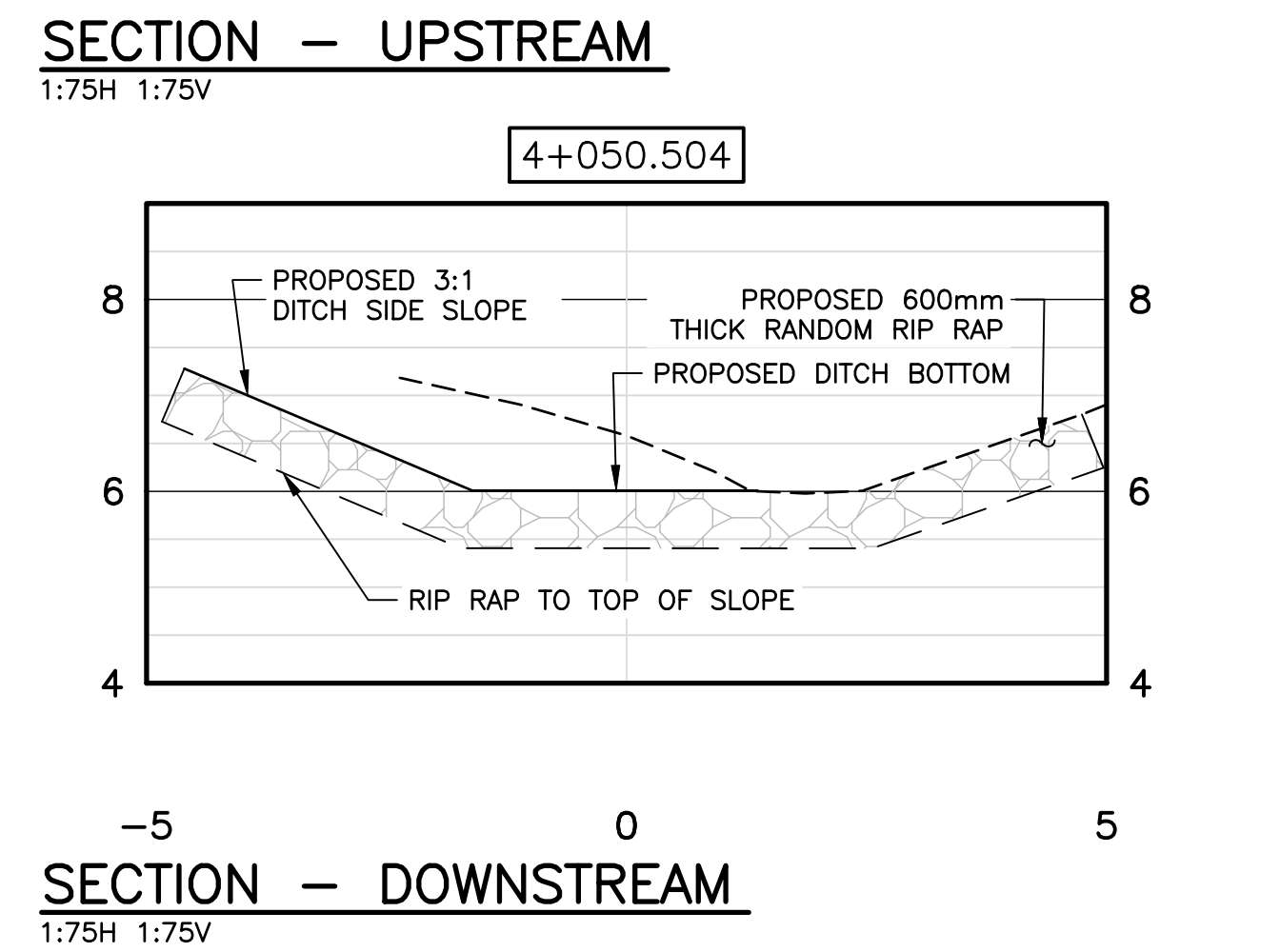
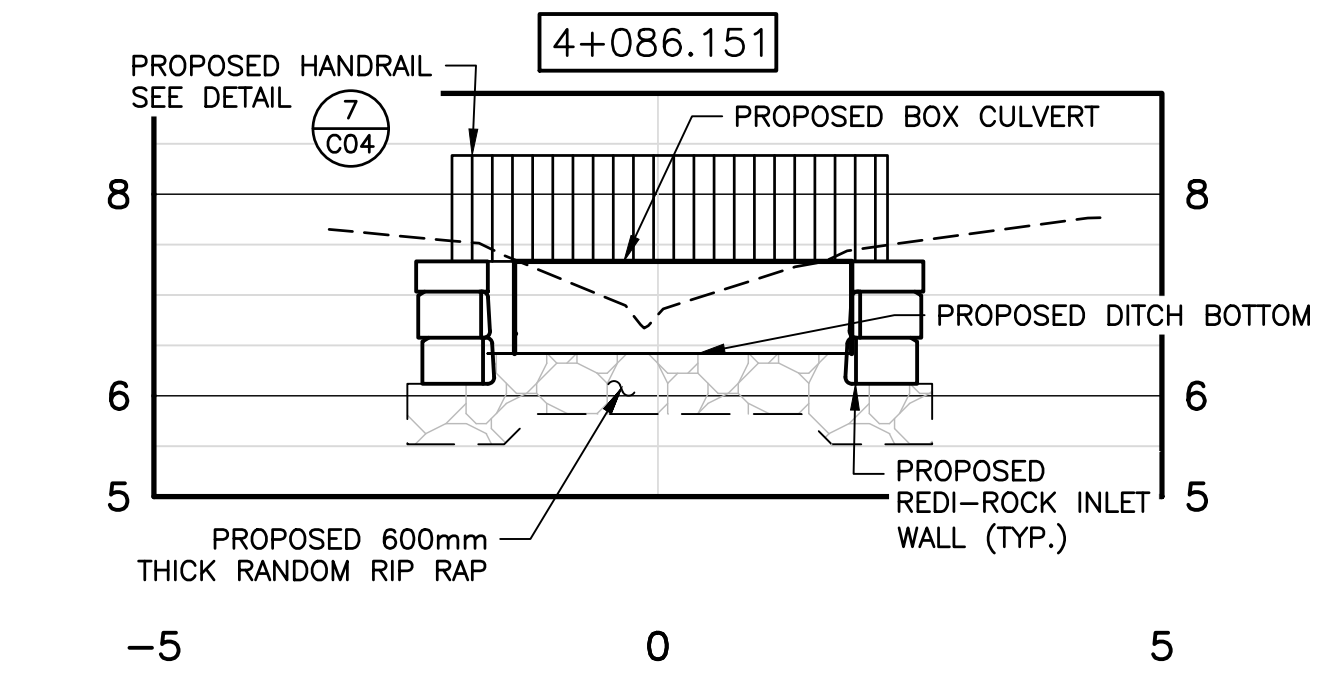
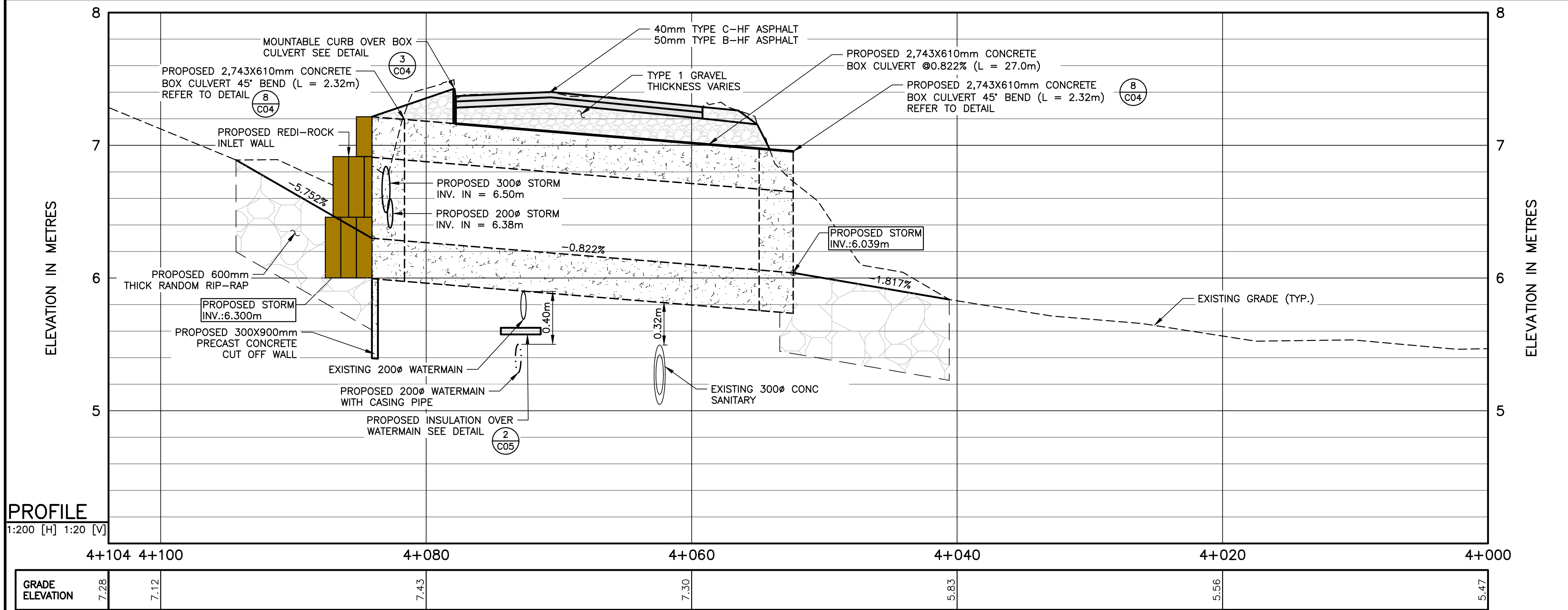
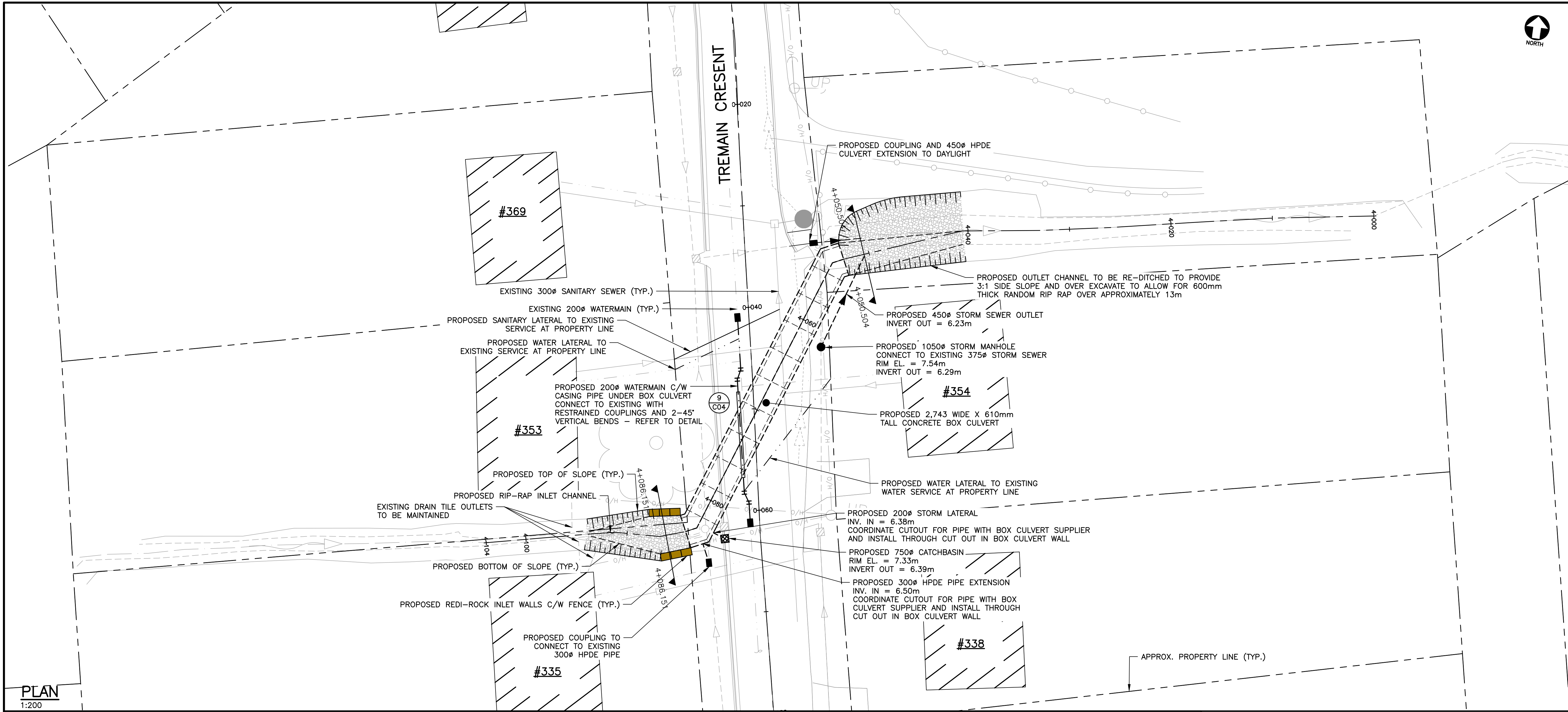
WEST HANTS REGIONAL MUNICIPALITY
TREMAIN CRESENT STORMWATER CROSSING NEAR CIVIC #355

CIVIL

EXISTING CONDITIONS AND REMOVALS PLAN



CBCL No.	Contract No.	Date	Scale
231049.00		FEB. 2024	AS NOTED
Designed	AL	Drawn	DS
Checked	AL	Approved	AB
Sheet No.	01	of	05
Drawing No.	C01		



- NOTES
- PROPERTY LINES AND BUILDING FOOTPRINTS APPROXIMATE FROM GEONOVA
 - HORIZONTAL DATUM NAD83 CSRS UTM20
 - VERTICAL DATUM CGVD2013

- LEGEND
- PROPERTY LINE (EX.)
 - SANITARY SEWER (EX.)
 - SANITARY MH (EX.)
 - SANITARY FORCEMAIN (EX.)
 - STORM CATCHBASIN (SQ.) (EX.)
 - STORM CATCHBASIN (SQ.) (PR.)
 - STORM HEADWALL (EX.)
 - STORM HEADWALL (PR.)
 - STORM SEWER (EX.)
 - STORM SEWER (PR.)
 - STORM MH (EX.)
 - STORM MH (PR.)
 - STORM CATCHBASIN (SINGL.) (EX.)
 - STORM CATCHBASIN (SINGL.) (PR.)
 - DITCH (EX.)
 - DITCH (PR.)
 - TREE (HARDWOOD) (EX.)
 - TREE (SOFTWOOD) (EX.)
 - CHAINLINK FENCE (EX.)
 - CHAINLINK FENCE (PR.)
 - TOP OF SLOPE (EX.)
 - TOP OF SLOPE (PR.)
 - BOTTOM OF SLOPE (EX.)
 - BOTTOM OF SLOPE (PR.)
 - 20.0 MAJOR CONTOUR (EX.)
 - 20.0 MAJOR CONTOUR (PR.)
 - 19.0 MINOR CONTOUR (EX.)
 - 19.0 MINOR CONTOUR (PR.)

PRELIMINARY
NOT FOR CONSTRUCTION

No.	Description	Date	By
B	ISSUED FOR 90% DESIGN REVIEW	2024/03/20	AL
A	ISSUED FOR INFRASTRUCTURE DAYLIGHTING	2024/02/08	AL

Revision or Issue



File No. 231049.00

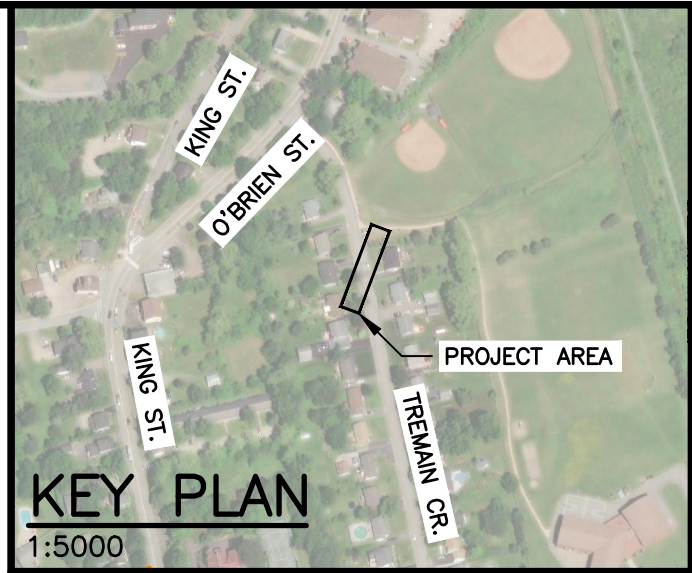
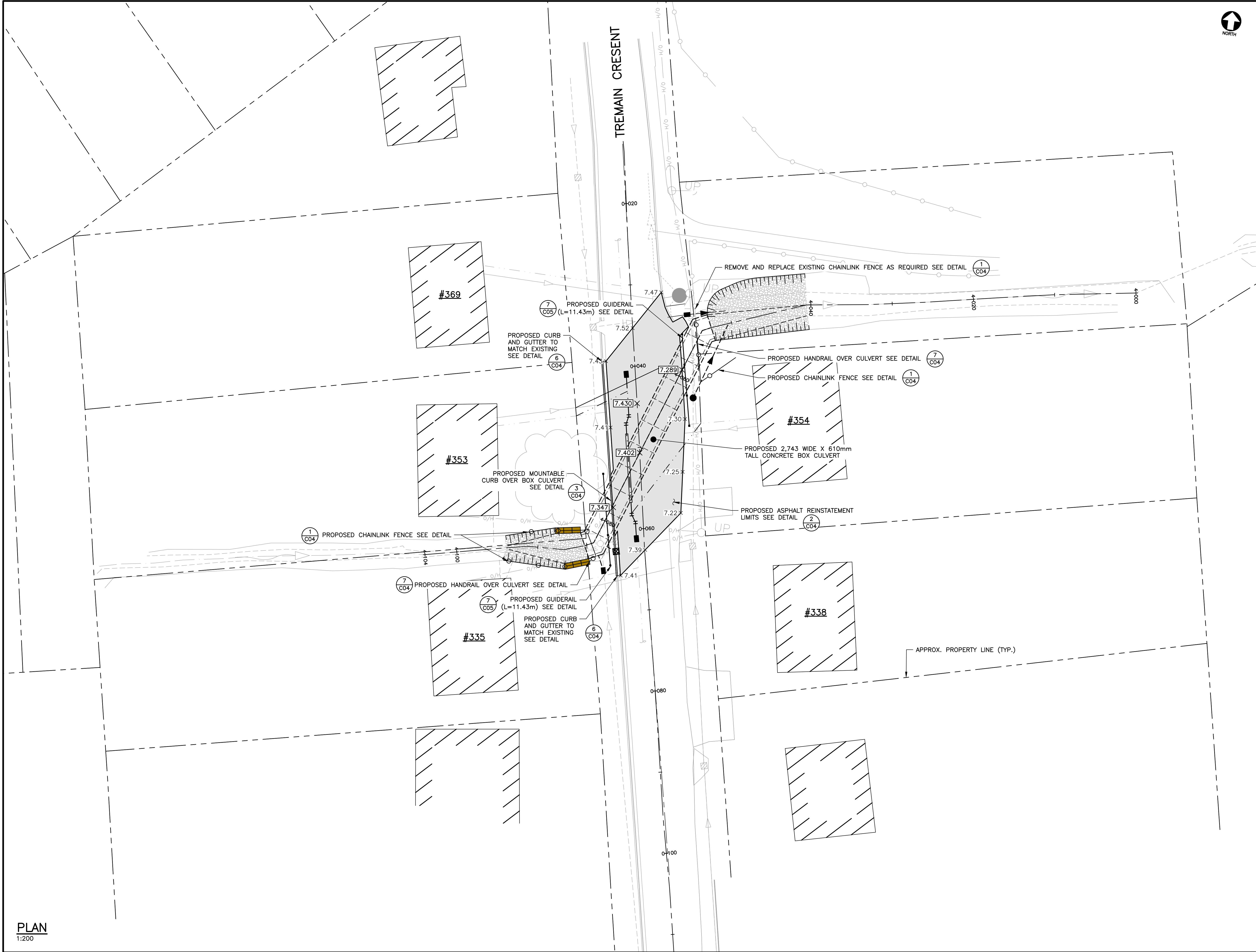
WEST HANTS REGIONAL
MUNICIPALITY
TREMAIN CRESCENT STORMWATER
CROSSING NEAR CIVIC #355

CIVIL

PROPOSED PLAN AND PROFILE



CBCL No. 231049.00	Contract No.	Date FEB. 2024	Scale AS NOTED
Designed AL	Drawn DS	Checked AL	Approved AB
Sheet No. 02 of 05			
Drawing No. C02			



- NOTES**
- PROPERTY LINES AND BUILDING FOOTPRINTS APPROXIMATE FROM GEONOVA
 - HORIZONTAL DATUM NAD83 CSRS UTM20
 - VERTICAL DATUM CGVD2013

- LEGEND**
- PROPERTY LINE (EX.)
 - SANITARY SEWER (EX.)
 - SANITARY MH (EX.)
 - SANITARY FORCEMAIN (EX.)
 - STORM CATCHBASIN (SQ.) (EX.)
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 - STORM MH (EX.)
 - STORM MH (PR.)
 - STORM CATCHBASIN (SINGL.) (EX.)
 - STORM CATCHBASIN (SINGL.) (PR.)
 - DITCH (EX.)
 - DITCH (PR.)
 - TREE (HARDWOOD) (EX.)
 - TREE (SOFTWOOD) (EX.)
 - CHAINLINK FENCE (EX.)
 - CHAINLINK FENCE (PR.)
 - TOP OF SLOPE (EX.)
 - TOP OF SLOPE (PR.)
 - BOTTOM OF SLOPE (EX.)
 - BOTTOM OF SLOPE (PR.)
 - 20.0 MAJOR CONTOUR (EX.)
 - 20.0 MAJOR CONTOUR (PR.)
 - 19.0 MINOR CONTOUR (EX.)
 - 19.0 MINOR CONTOUR (PR.)

PRELIMINARY
NOT FOR CONSTRUCTION

8	ISSUED FOR 90% DESIGN REVIEW	2024/03/20	AL
A	ISSUED FOR INFRASTRUCTURE DAYLIGHTING	2024/02/08	AL
No.	Description	Date	By

Revision or Issue



File No. 231049.00

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MUNICIPALITY
TREMAIN CRESCENT STORMWATER
CROSSING NEAR CIVIC #355

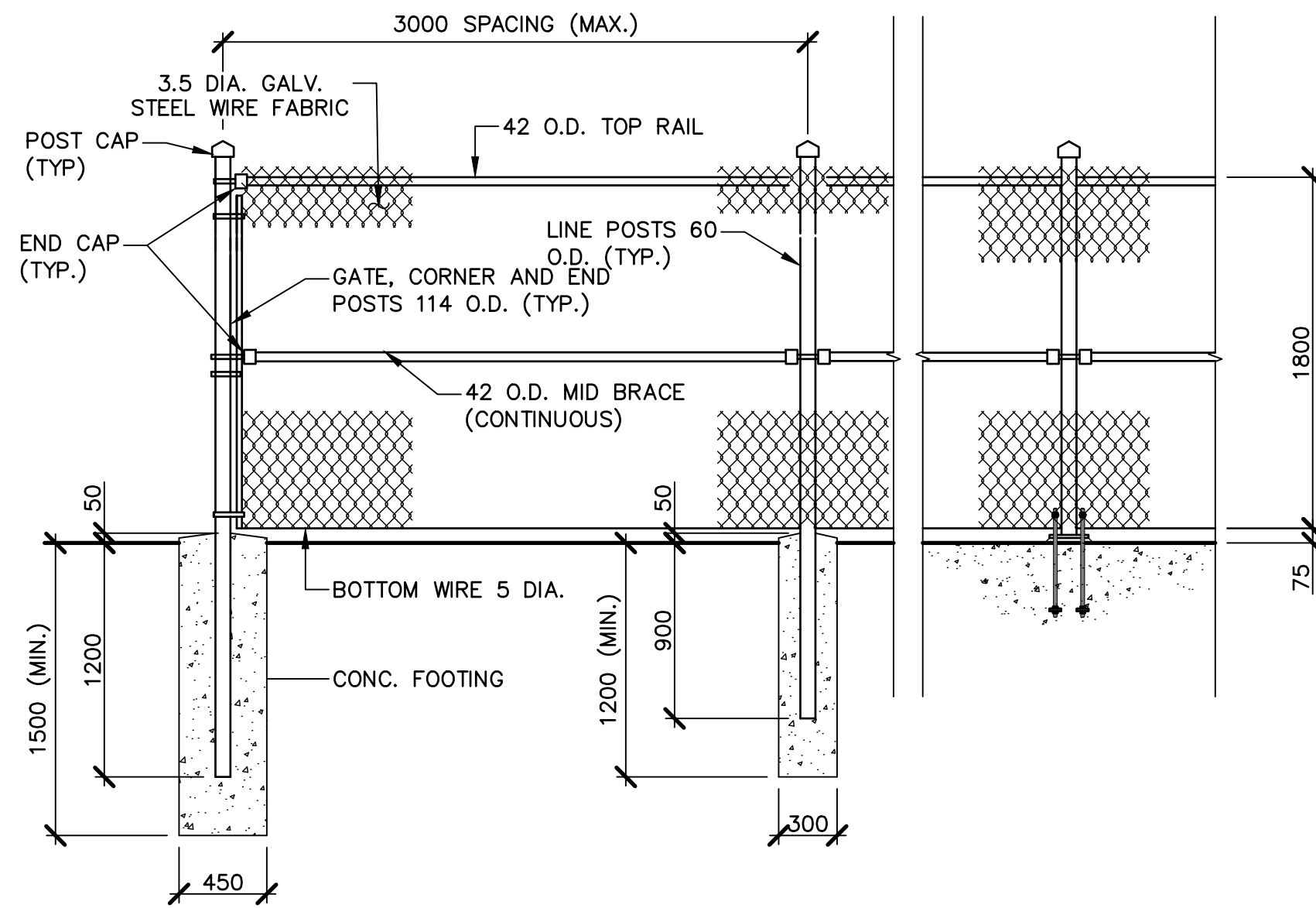
CIVIL

REINSTATEMENT PLAN

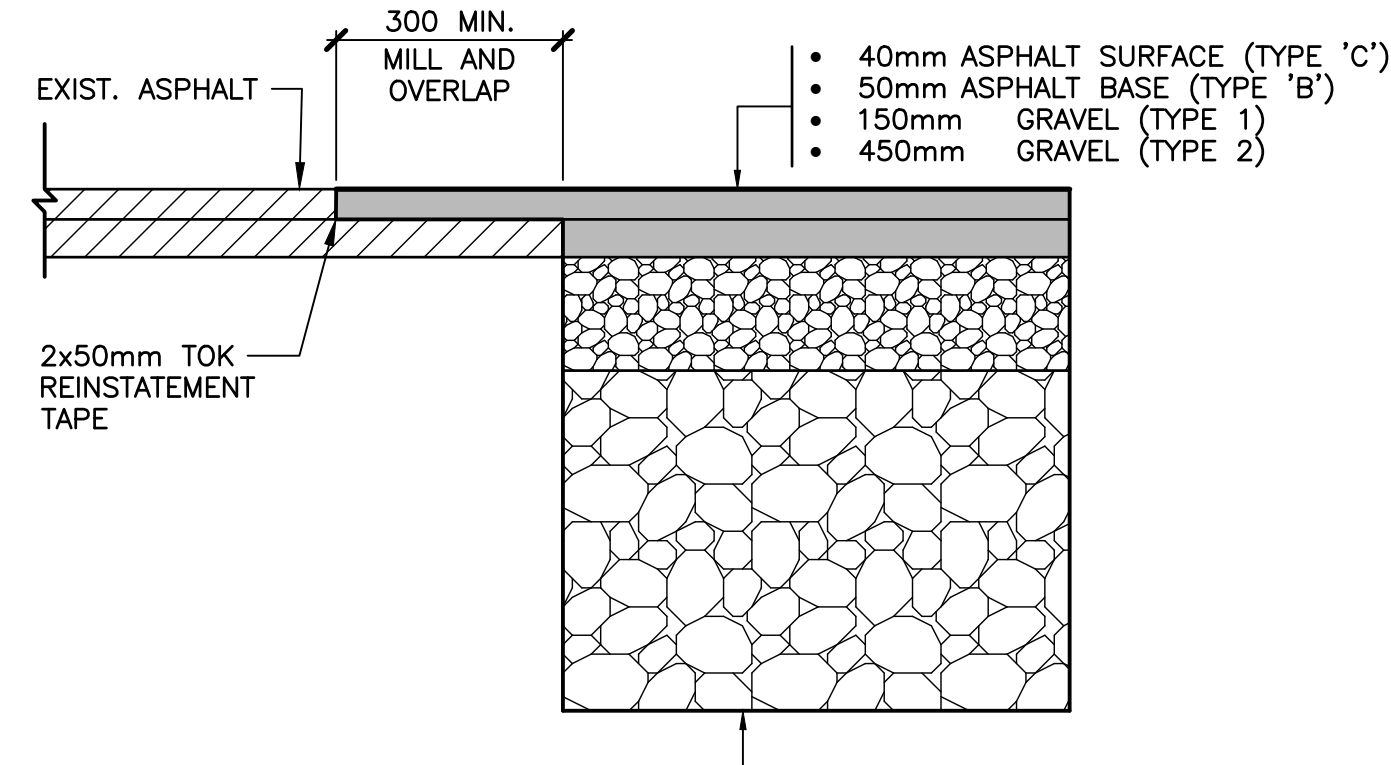


CBCL No. 231049.00	Contract No.	Date FEB. 2024	Scale AS NOTED
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		Checked AL	Approved AB
		Sheet No. 03	of 05
		Drawing No. C03	

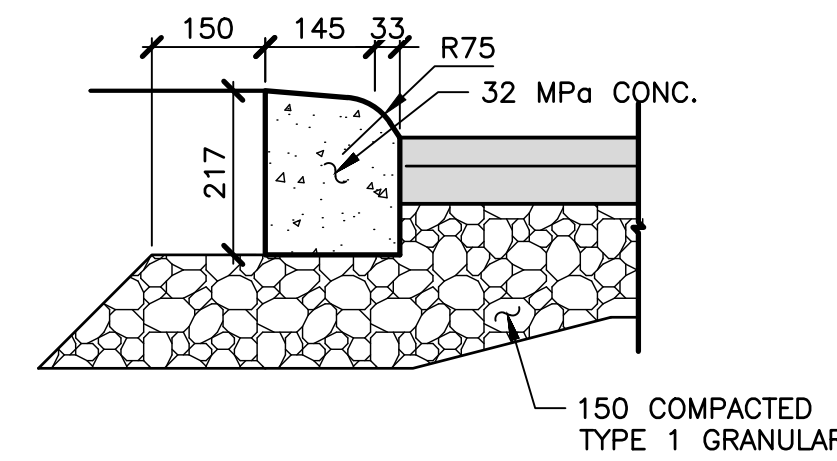
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1:200



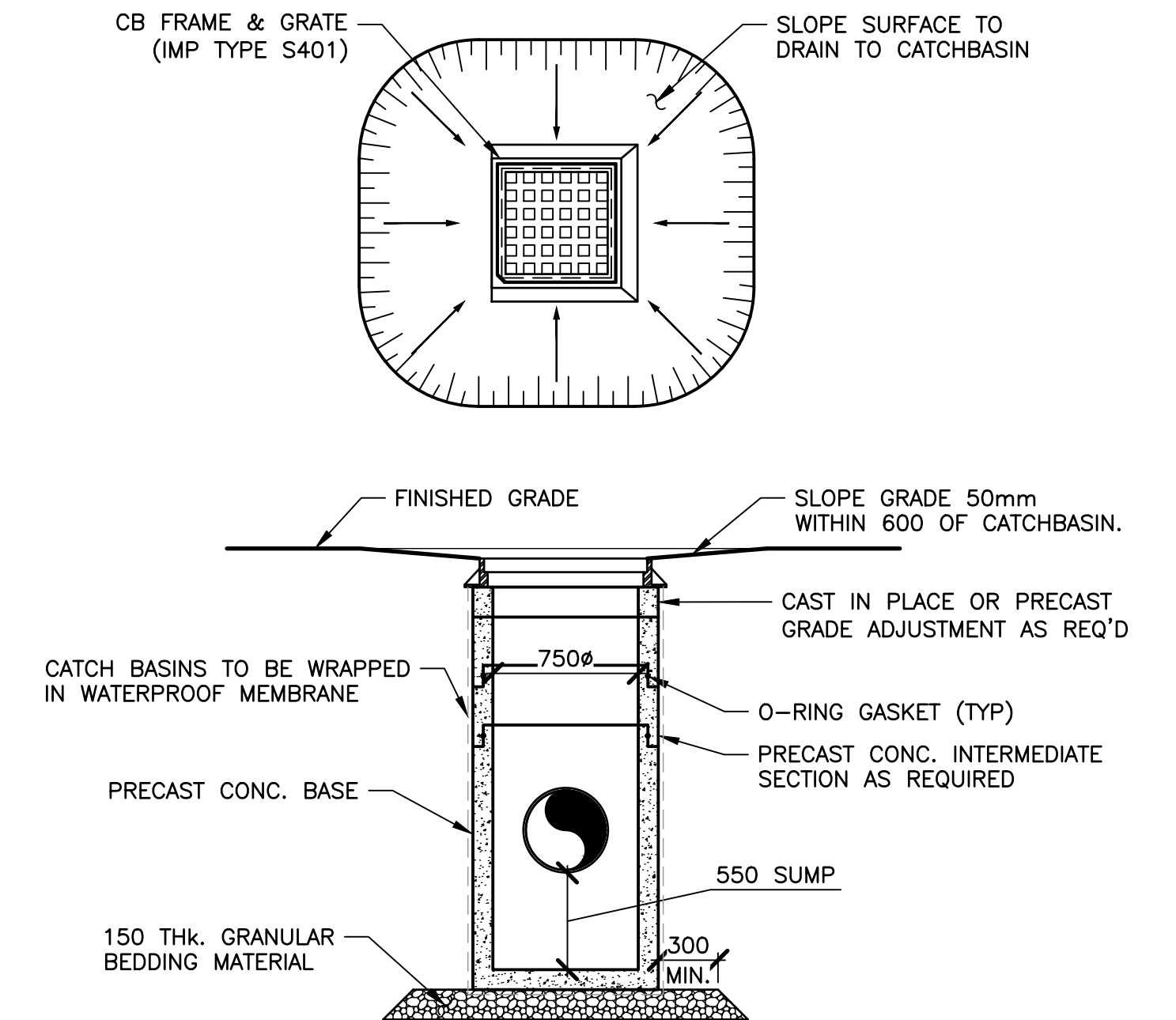
1 DETAIL—1.80m CHANLINK FENCE
C02 1:30



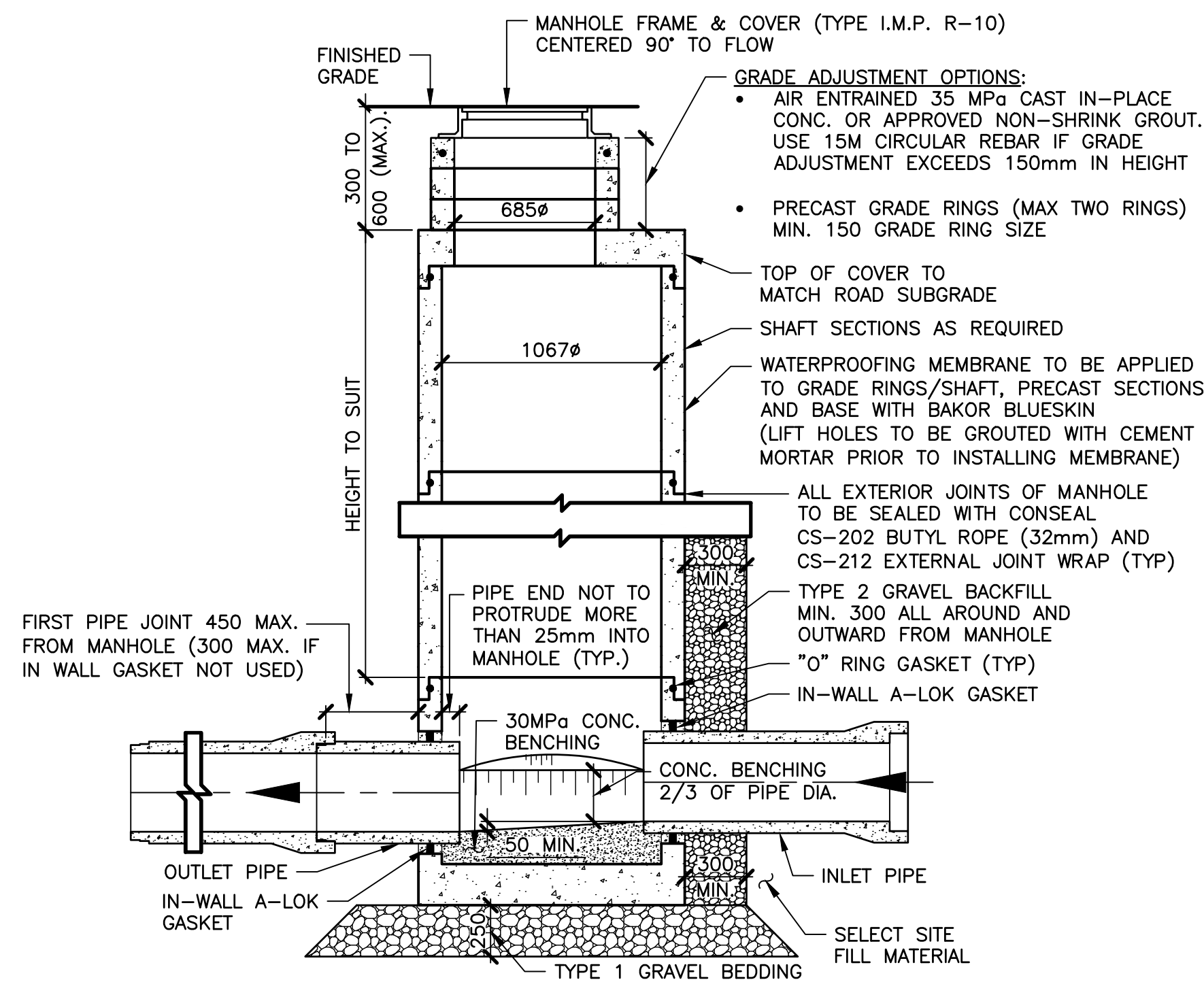
2 DETAIL—ASPHALT REINSTATEMENT
C02 1:10



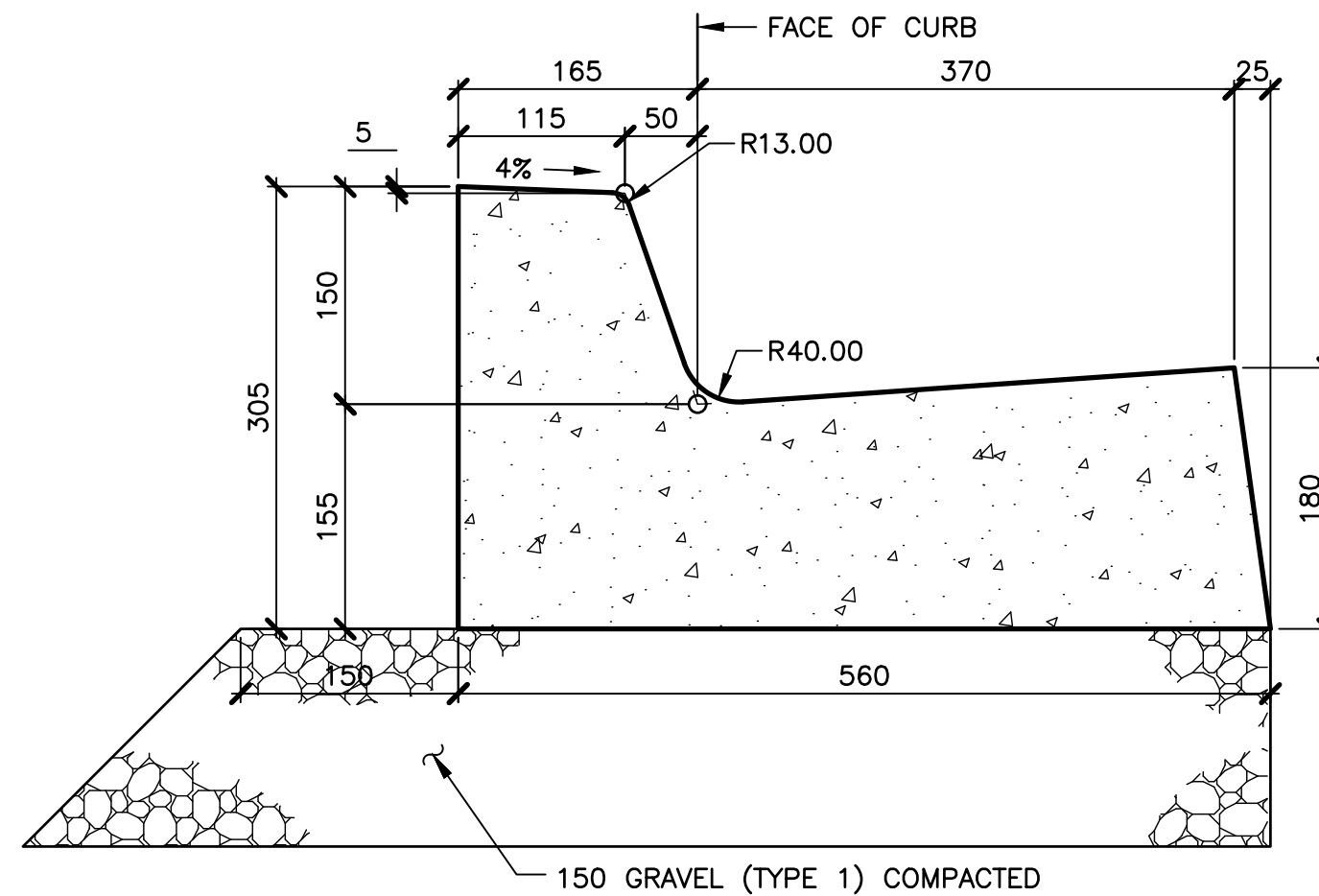
3 DETAIL—MOUNTABLE CONCRETE CURB
(FOR OVER BOX CULVERT)
C02 1:10



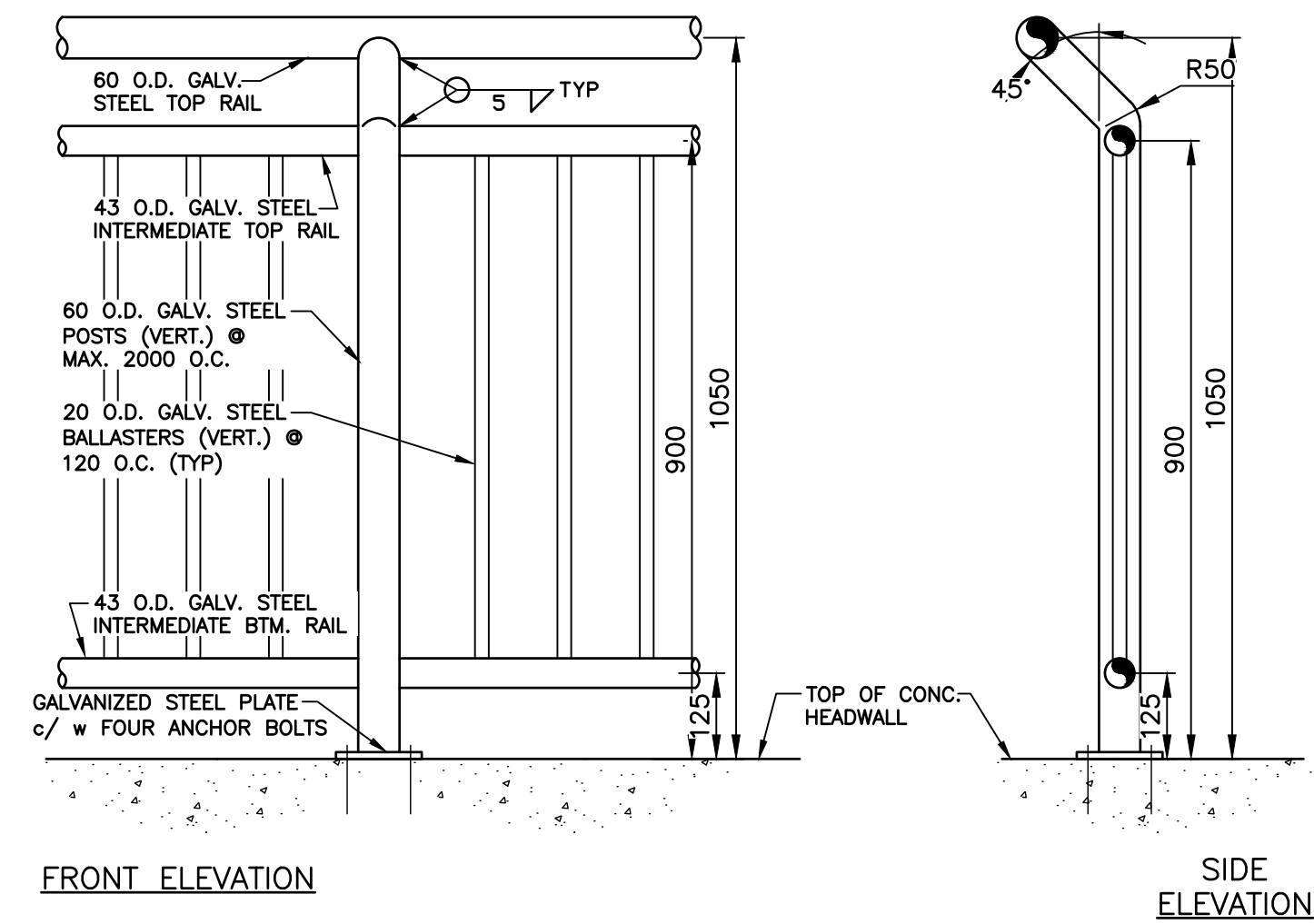
4 DETAIL—750ø CATCHBASIN
C02 1:30



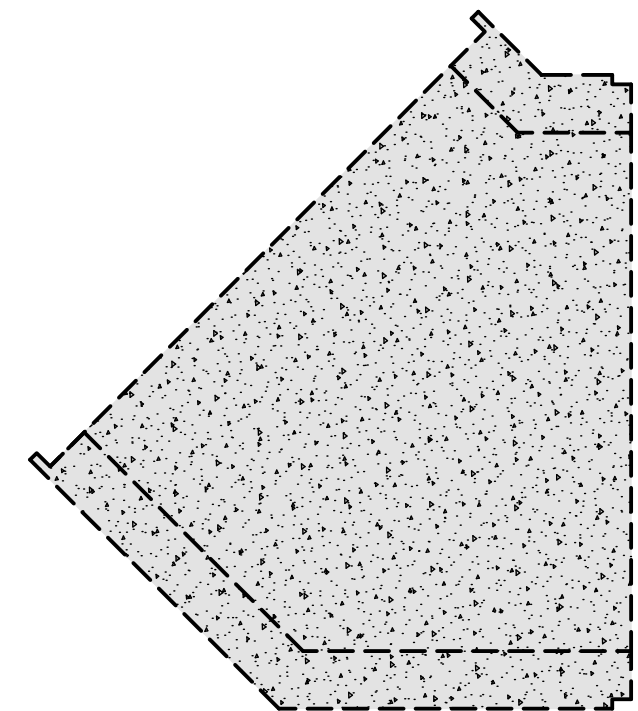
5 DETAIL—1050ø PRECAST MANHOLE
C02 1:25



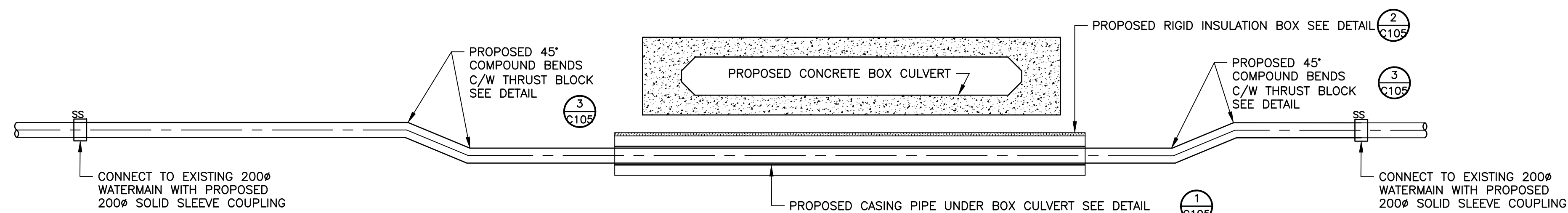
6 DETAIL—CONCRETE CURB AND GUTTER
C02 1:10



7 DETAIL—HAND RAIL
C02 1:25



8 DETAIL—45° BOX CULVERT BEND
C02 1:40



9 DETAIL—WATERMAIN CONFIGURATION UNDER BOX CULVERT
C02 1:25

PRELIMINARY
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A	ISSUED FOR 90% DESIGN REVIEW	2024/03/20	AL

Revision or Issue



File No. 231049.00

WEST HANTS REGIONAL MUNICIPALITY
TREMAIN CRESCENT STORMWATER CROSSING NEAR CIVIC #355

CIVIL

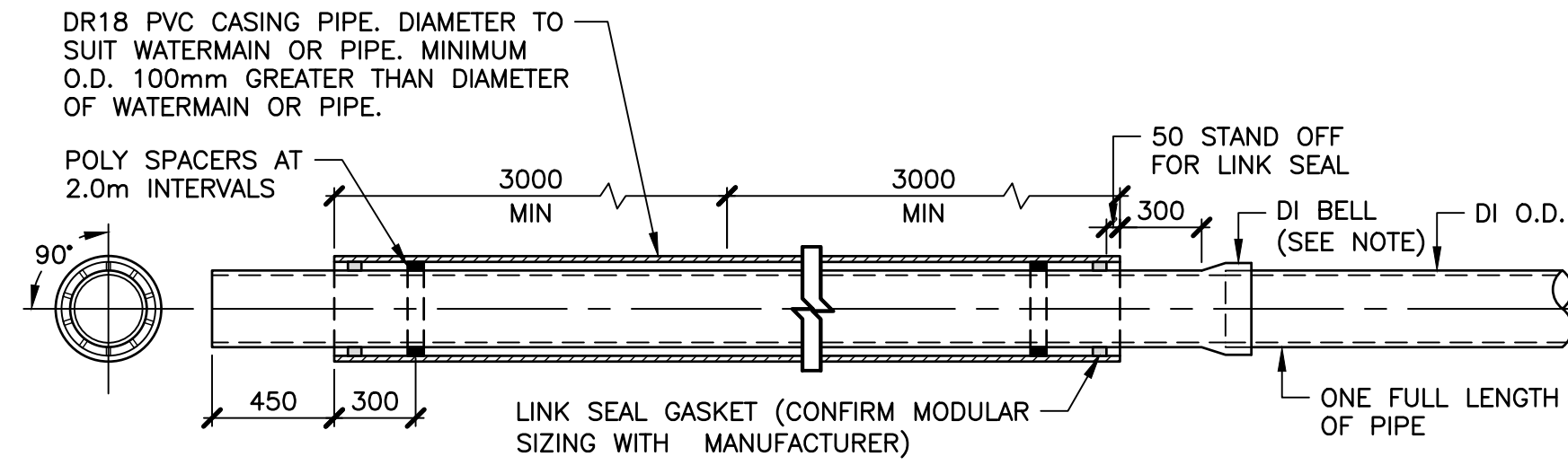
CIVIL DETAILS SHEET 1 OF 2



CBCL No. 231049.00	Contract No.
Date FEB. 2024	Scale AS NOTED
Designed AL	Drawn DS
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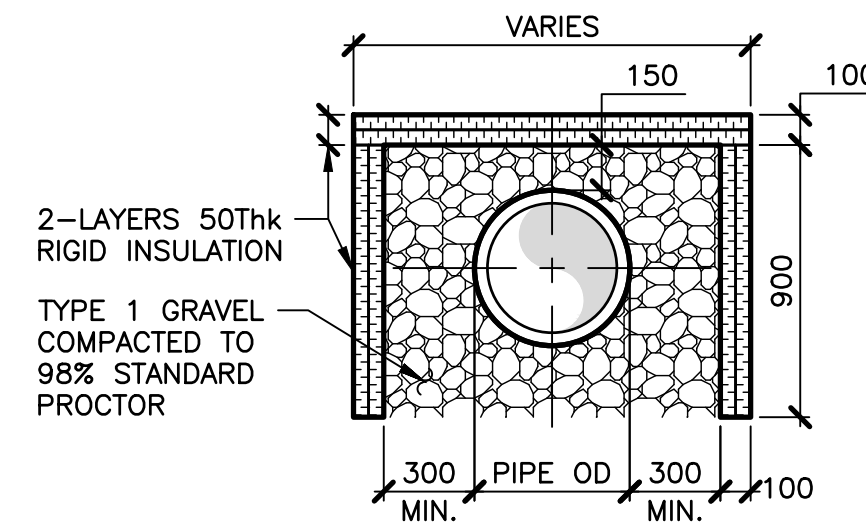
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Drawing No.

C04

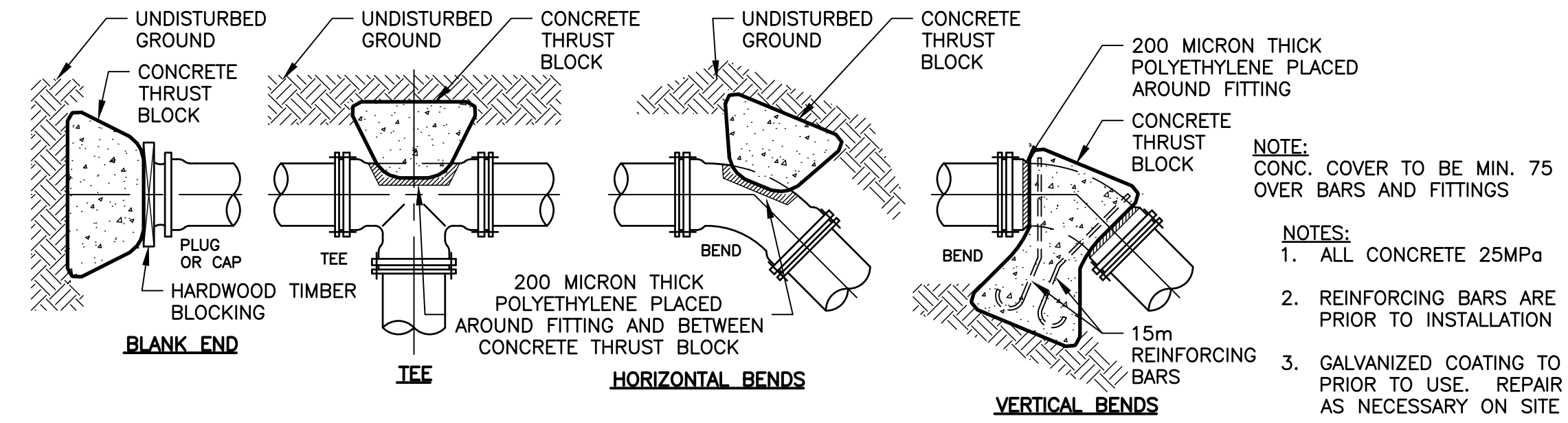


DI PIPE Ø	CASING PIPE Ø	CASING PIPE Ø
	SINGLE DI PIPE LENGTH	MULTIPLE DI PIPE LENGTHS
100	200 DR18	250 DR18
150	250 DR18	300 DR18
200	350 DR18	400 DR18
250	400 DR18	450 DR18
300	450 DR18	500 DR18
400	600 DR18	CUSTOM

1 DETAIL—WATERMAIN CASING
C02 1:25

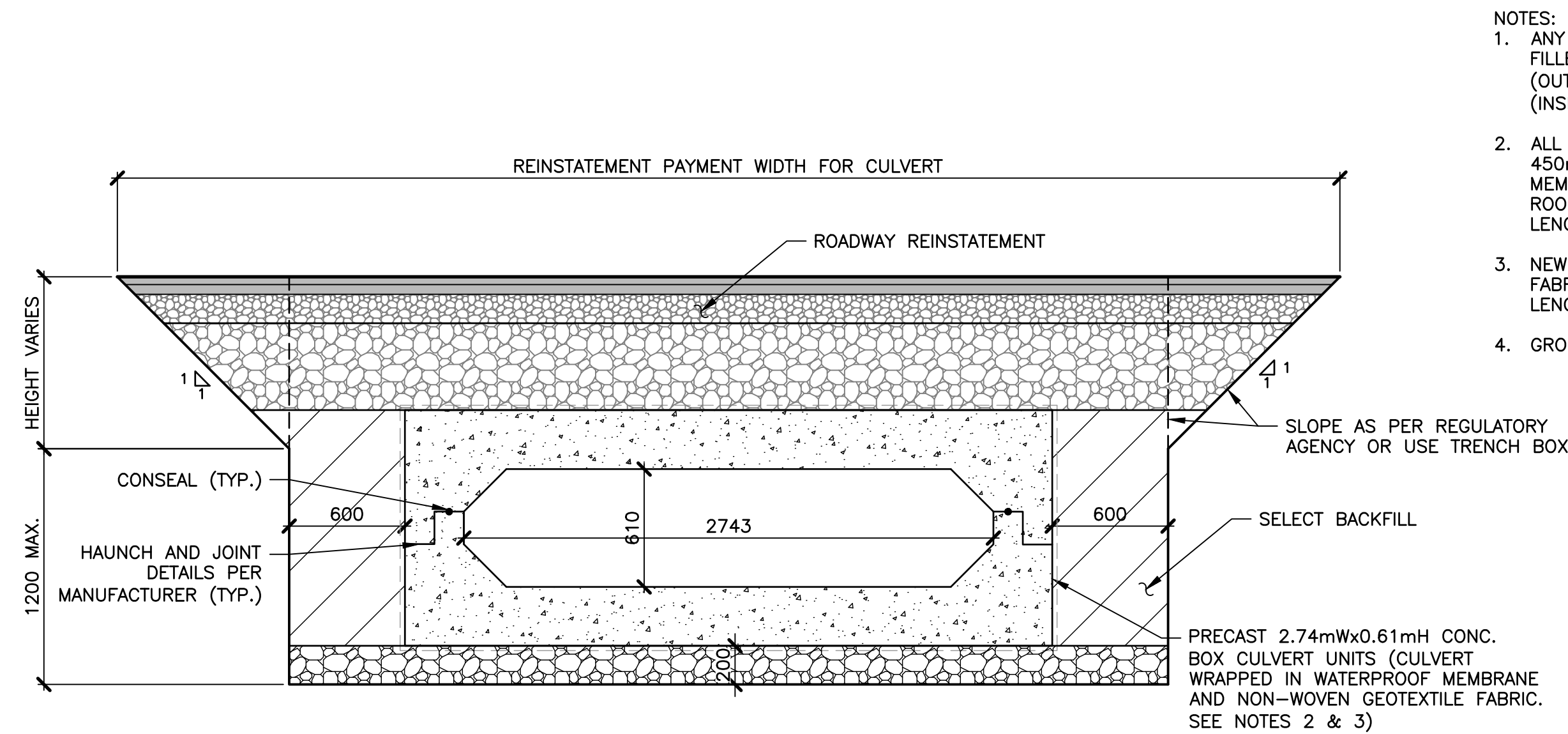


2 DETAIL—PIPE INSULATION
C02 1:25

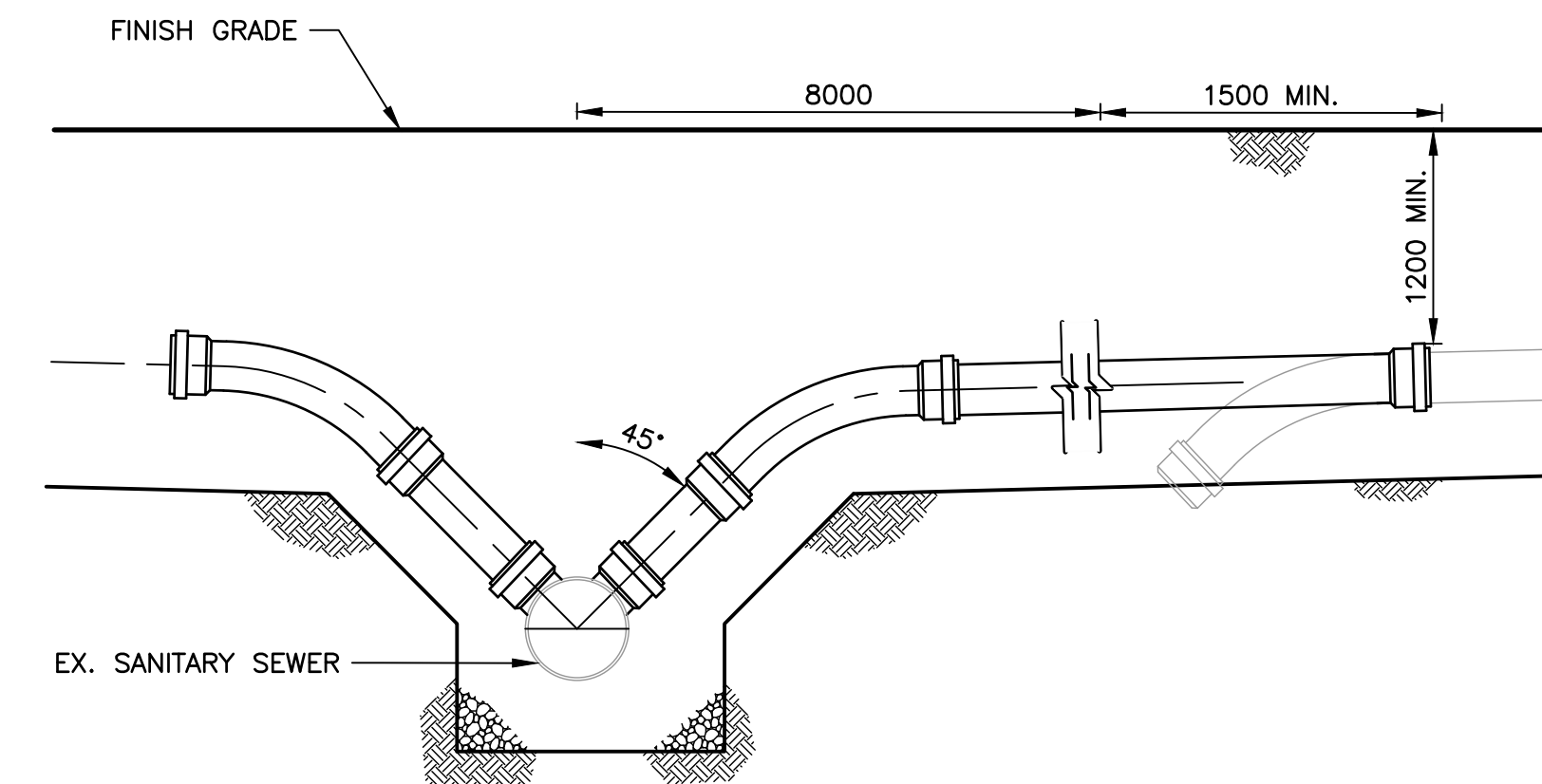


MINIMUM CONTACT AREAS FOR CONC. THRUST BLOCKS							MINIMUM DISTANCE FROM FITTING TO UNDISTURBED GROUND		VERTICAL THRUST BLOCKS THRUST COMPENSATED FOR BY MASS OF CONCRETE (m³)			
PIPE Ø mm	CAP/PLUG	TEE	90° BEND	45° BEND	22.5° BEND	1.25° BEND	PIPE Ø mm	mm	PIPE Ø mm	45° BEND	22.5° BEND	1.25° BEND
100	0.25	0.25	0.32	0.20	0.16	0.16	100	450	100	0.40	0.20	0.20
150	0.48	0.48	0.64	0.40	0.32	0.16	150	450	150	0.80	0.40	0.40
200	0.80	0.80	1.12	0.64	0.32	0.16	200	450	200	1.40	0.70	0.70
250	1.28	1.28	1.76	0.96	0.48	0.24	250	600	250	2.10	1.10	1.10
300	1.76	1.76	2.56	1.44	0.72	0.40	300	750	300	3.00	1.50	1.50

3 DETAIL—CONCRETE THRUST BLOCKS
C02 N.T.S.

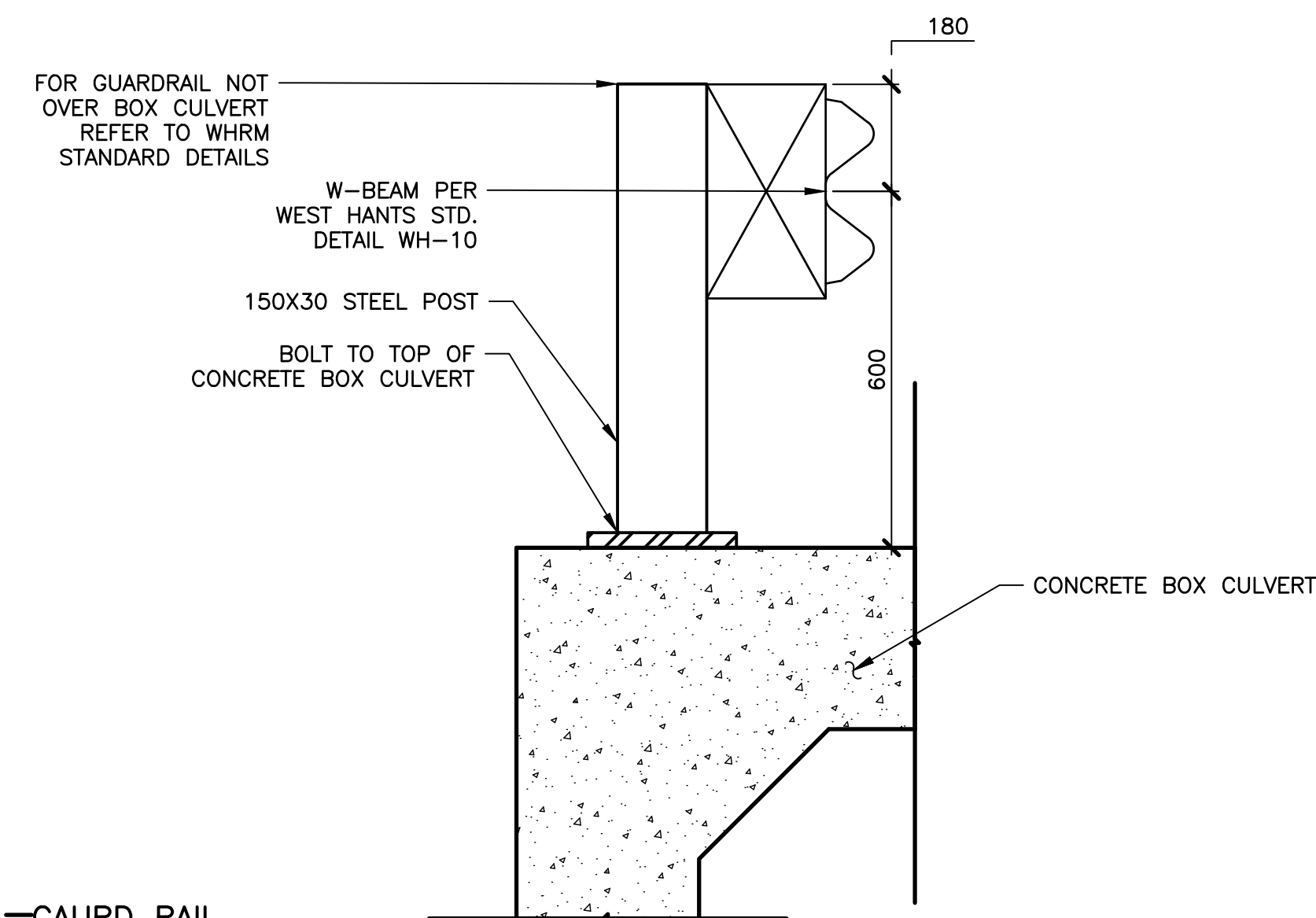


4 DETAIL—CONCRETE BOX CULVERT TRENCH
C02 1:25



- NOTES:
- EXISTING WATERLINE AND WATER SERVICE LOCATIONS ARE UNKNOWN. CONTRACTOR TO VERIFY LOCATION IN FIELD.

5 DETAIL—WATER SERVICE CONNECTION TO EXISTING
C02 1:20



6 DETAIL—SANITARY SERVICE CONNECTION TO EXISTING
C02 1:20

7 DETAIL—GAURD RAIL (BOLTED TO BOX CULVERT)
C02 1:10

PRELIMINARY
NOT FOR CONSTRUCTION

No.	Description	Date	By
A	ISSUED FOR 90% DESIGN REVIEW	2024/03/20	AL

Revision or Issue



File No. 231049.00

WEST HANTS REGIONAL
MUNICIPALITY
TREMAIN CRESCENT STORMWATER
CROSSING NEAR CIVIC #355

CIVIL

CIVIL DETAILS SHEET 2 OF 2



CBCL No. 231049.00	Contract No.
Date FEB. 2024	Scale AS NOTED
Designed AL	Drawn DS
Checked AL	Approved AB

Sheet No. 05 of 05
Drawing No.

C05

APPENDIX C

Stormwater Memo 'Tremain Cresent Stormwater
– Cross Culvert near Civic #335' (CBCL, 2024)

January 19, 2024

Todd Richard
Director of Public Works
West Hants Regional Municipality
PO Box 3000
100 King Street
Windsor, NS B0N 2T0

Dear Mr. Richard:

RE: Tremain Crescent Stormwater – Cross-Culvert near Civic #335

West Hants Regional Municipality (WHRM) retained CBCL Limited (CBCL) to complete a stormwater assessment and crossing design to reduce flood risk at the cross-culvert near Civic #335 Tremain Crescent in Windsor, Nova Scotia. This letter summarizes the work completed to date on this project, including the background review, existing conditions model construction and preliminary concept options.

Background Information

In July 2021, the resident at Civic #335 Tremain Crescent and surrounding neighbors, experienced significant flooding of their properties. The resident at Civic #335 Tremain Crescent had also experienced flooding in the past. Flooding is reported to be increasing in frequency and volume at this location.

In November 2021, localized flooding occurred following a rainfall event. It was determined that this flooding was a result of a collapsed cross-culvert downstream of the storm infrastructure at Civic #335 Tremain Crescent. During this flooding event, the ditch downstream of the collapsed pipe was empty, identifying that the localized flooding may have been a result of the collapse and not necessarily undersized conveyance infrastructure. Following the replacement of the collapsed cross-culvert, flooding in the area has continued. The cross-culvert was replaced with a similarly sized pipe. No improvements to drainage were made. The flooding in this area is thought to be a result of undersized stormwater drainage infrastructure that is backing up the upstream ditch and flooding the adjacent properties. Stormwater flows overland, through a series of culverts, storm sewer, and ditches, before draining into the Tregothic Marsh.

Existing Conditions and Stormwater Capacity

A hydrologic and hydraulic stormwater model was constructed in PCSWMM for the Tremain Crescent area based on survey information collected by CBCL personnel on November 9th and 10th, 2023. The Tremain Crescent stormwater model focused on the crossing at #335 Tremain Crescent and builds on the larger-scale stormwater model created for the ongoing Windsor Stormwater Plan undertaken by CBCL. Stormwater infrastructure on Tremain Crescent consists of a mix of ditches, small driveway culverts, cross-culverts, catch basins and piped infrastructure (storm sewer). Storm infrastructure is shallow bury along Tremain Crescent as a result of the area's topography, with slopes flattening out before discharging into Tregothic Marsh. The stormwater infrastructure near Civic #335 Tremain Crescent includes a swale that collects water from the lands uphill and behind Civic 335 that discharges into a 375mm diameter HDPE stormwater pipe in front of the property that runs parallel to Tremain Crescent crossing Tremain Crescent in 450mm diameter HDPE cross culvert near the sewer pump station at the bottom of the hill, refer to Figure 1. The major system drainage catchment upstream of this crossing is presented in Figure 2, generally bounded by King Street and Tremain Crescent plus a section at the northern quadrant collecting major drainage overland flows from the Wilson Street area.



Figure 1: Tremain Crescent – Storm Sewer Infrastructure near Civic #335

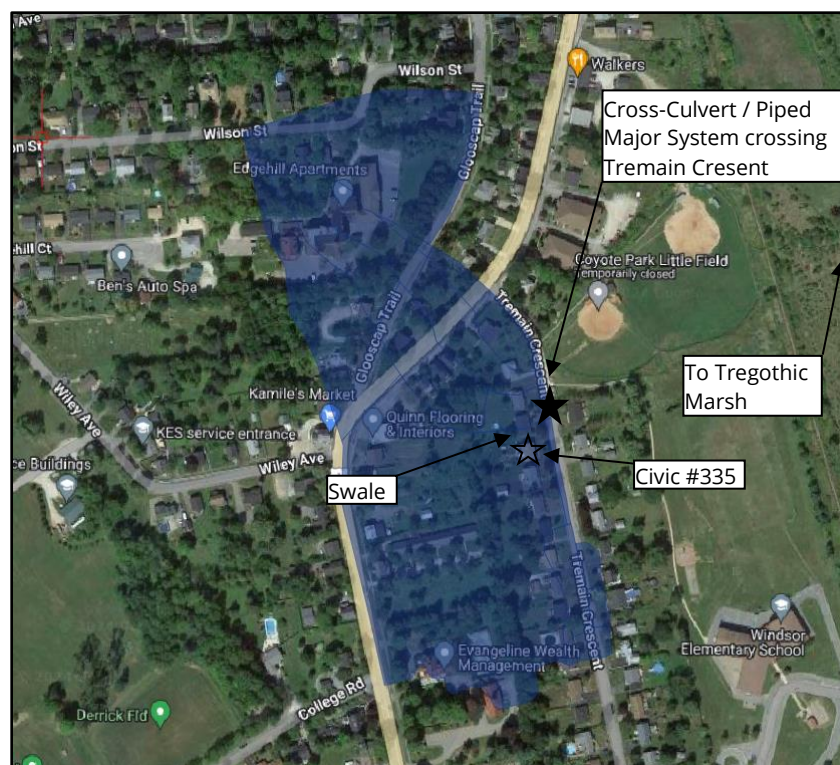


Figure 2: Tremain Crescent – Major System Catchment in Blue of Cross-culvert near Civic #335

Historical Rainfall Events

A number of rainfall events which resulted in flooding at this location on Tremain Crescent were identified through discussion with WHRM staff, as well as from review of previous service request documents submitted by the resident at Civic #335 and provided to CBCL by WHRM. These events included the July 21, 2021 Rainfall Event; the November 27, 2021 Rainfall Event; an undated Winter Rainfall Event; the July 21/22, 2023 Rainfall Event; and the November 27, 2023 Rainfall Event.

To quantify anecdotal flooding evidence, Environment and Climate Change Canada (ECCC) and Weather Underground databases were queried for historical rainfall data. The closest ECCC station is located in Kentville and reports daily rainfall amounts. Daily rainfall is typically insufficient to adequately characterise small, urbanized rainfall events. Instead, 5-minute rainfall data was retrieved from Weather Underground (WU), operated by the Weather Company, which collects and tabulates weather data from over 250,000 personal weather stations across the world. Multiple personal precipitation stations on the WU network are operated in the Windsor area (refer to Figure 3). Data from these stations was reviewed and selected for each of the identified events. Note that Weather Underground data is publicly collected and uploaded from private weather stations, and considered less reliable than ECCC

data; however, in this case serves as the best information available for the analysis of previous rainfall events.

The rainfall events analysed, and the respective Weather Underground stations used, are presented below:

- ▶ July 21, 2021 Rainfall Event: IGARLA2.
- ▶ November, 2021 Rainfall Event: IWESTHA2.
- ▶ July 21/22, 2023 Rainfall Event: IWESTHA2.
- ▶ November 27, 2023 Rainfall Event: IWESTHA2.

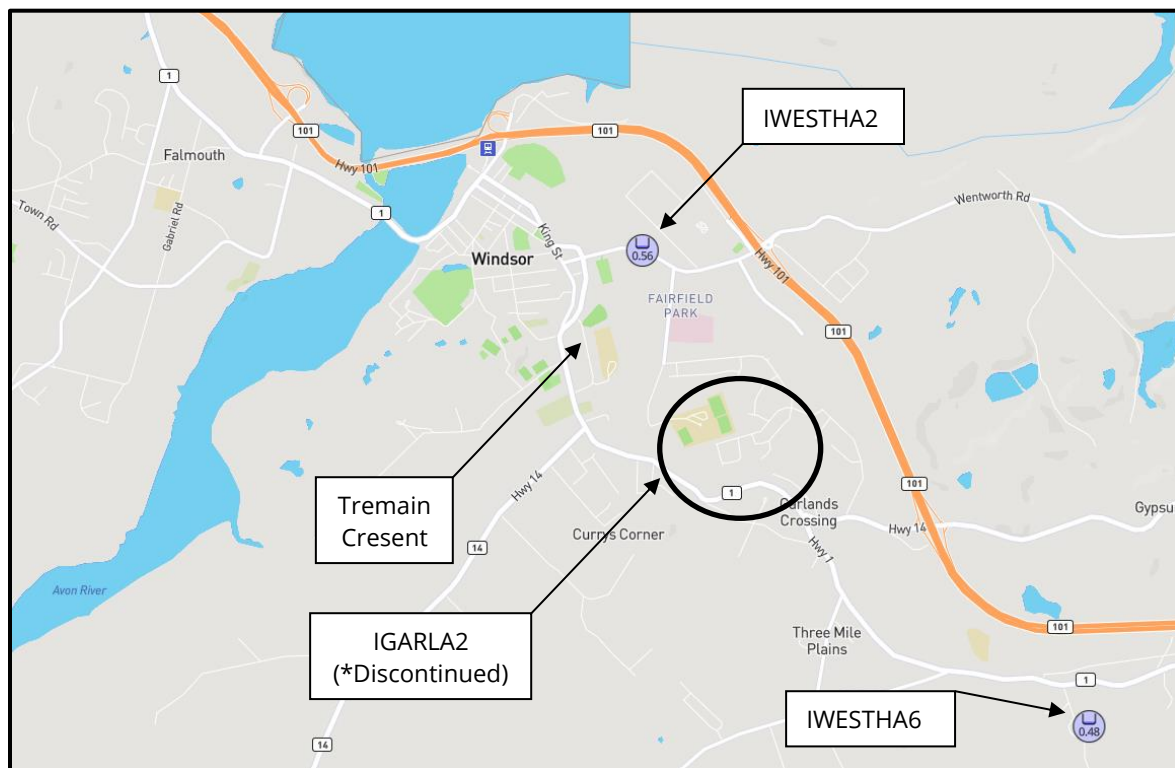


Figure 3: WunderMap – Precipitation Stations in the Vicinity of Tremain Crescent in Windsor, NS (Weather Underground, 2023)

July 27, 2021 Rainfall Event

On July 27, 2021, an intense rainfall event reportedly caused Windsor's stormwater conveyance system to be overwhelmed, resulting in localized flooding. A local resident on Tremain Crescent provided the following statement "The recent rain fall on Tuesday, July 27, 2021 resulted in excessive amounts of water spilling into the swale/ditch and the existing municipal infrastructure could not handle the amount of water flowing into the culvert under the street at Tremain Crescent. As a result, the water flooded an area around the culvert and our property. The runoff actually flowed over the street curb which is some 22 – 24 inches higher

than the culvert below. This rain lasted for some time with water spilling over the curb and across the street to neighbouring properties."

The IGARLA2 Weather Underground station was used to analyse this weather event, and the stormwater model shows that this event resulted in significant flow in the ditch between Civic #335 and #353, to the point that it overtopped and flowed onto Tremain Crescent at this location.



Figure 4: July 27, 2021 Rainfall Event, Swale by Civic #335 Flowing onto Tremain Crescent (Source: Local Tremain Crescent Resident)

November, 2021 Rainfall Event

A resident identified that the cross-culvert near the pumphouse was faulty, and that the upstream ditches were full of standing water but the downstream ditch near the pumphouse was empty. Investigation by the municipality found that the cross-culvert was clogged/plugged by a dead animal during a subsequent repair. This event was not used for calibration as comparing model results to anecdotal evidence for this event would not provide realistic, useful information because of the many uncertainties related to the hydraulic capacity of the clogged/plugged pipe.

July 21/22, 2023 Rainfall Event

The July, 2023 Rainfall event caused widespread flooding across Nova Scotia on July 21st and 22nd. Photos supplied by the municipality collected the day following the rainfall event (July 23, 2023 at approximately 7:30 am) show downstream water levels reached an elevation of at least 6.0 metres CGVD2013. Refer to the photo below of the Coyote Park big field. The existing conditions model shows the Tremain Crescent crossing overtopping based on rainfall data pulled from the IGARLA2 Weather Underground station, but due to the magnitude of the event and comparatively undersized crossing, it does not provide a good source of calibration due to uncontrolled flooding. Due to the significance of this rainfall event and the resulting widespread flooding, it is difficult to isolate the flood results at Tremain Crescent.



Figure 5: Aftermath of July 21/22, 2023 Rainfall Event – Flooding at the Coyote Park 'Big Field'

November 27, 2023 Rainfall Event

According to the local resident at Civic #335 Tremain Crescent, the November 27, 2023 rainfall event resulted in a water depth in the upstream ditch that did not overtop the roadway during this event, but did exceed the top of the culvert (Tremain Crescent cross-culvert). No photos were available to confirm these statements.

The top of the existing culvert is at an elevation of approximately 7.0m, the catch basin rim is at an elevation of 7.35m (i.e., the basin starts to flood the road at this elevation), and the roadway overtopping elevation is 7.49m (top of curb). The existing conditions stormwater model for the November 27, 2023 rainfall event produced a peak hydraulic grade line of 7.3m at the culvert inlet location. Model results align with anecdotal observations and provide an additional level of confidence in the catchment parameters selected for the stormwater model.

Stormwater Analysis

The WHRM Municipal Services Specifications Manual (2022) prescribes: *storm sewer systems be designed based on a storm frequency of 1-in-5 years, except in areas designated for commercial or industrial development where a design storm frequency of 1-in-10 years should be used; and roadways, road cross culverts, watercourse crossings, and other major drainage systems should have a capacity to convey stormwater from a design storm frequency of 1-in-100 years.* WHRM culvert design requirements are presented below:

- ▶ Driveway culverts shall be designed for the 1-in-5 year peak flow with a headwater depth not greater than the diameter of the pipe ($H/D \leq 1.0$).
- ▶ Road cross-culverts shall be designed for the 1-in-10 year peak flow with a headwater depth not greater than the diameter of the pipe.
- ▶ Culverts on a watercourse shall be designed for the 1-in-100 year peak flow with a headwater depth not greater than the diameter of the pipe ($H/D \leq 1.0$).

The Tremain Crescent crossing is considered a 'road cross-culvert' on the major drainage system, as it is used to convey flows from a notable upstream catchment. However, there is no option for stormwater flows to overflow the road and act as a hydraulic relief, as the property at #335 has reported flooding when (or before) this occurs in the past. The 1-in-10 year design event is considered to be insufficient for this crossing. Therefore;

- ▶ Conceptual design of the Tremain Crescent cross-culvert is based on the requirement to convey the 1-in-100 year peak flow with a headwater depth not greater than the diameter of the pipe ($H/D \leq 1.0$).
- ▶ Concepts presented are based on sufficient downstream capacity through the Tregothic Marsh. Downstream culverts are currently undersized and may result in elevated hydraulic grade lines at the Tremain Crescent crossing.

CBCL recently completed the Windsor Stormwater drainage Study for WHRM (Windsor Stormwater Plan, Final Draft, CBCL, 2023), which included development of the 24-hour Chicago Storm distributions for the present-day 1-in-5 year, 1-in-10 year, and 1-in-100 year storm events based on ECCC's Kentville CDA station (existing conditions). A 2090 climate change scenario was also developed as part of that work, which included a 30% increase in precipitation compared when compared to the present-day design storm.

The WHRM Municipal Services Specifications Manual presents a design storm that accounts for a stated 15% increase for climate change, which has a 24-hour total rainfall amount approximately equivalent to the 2090 climate change scenario previously developed by CBCL (166mm versus 172mm). It is not defined if the design storm accounting for climate change presented in the Manual is a requirement for stormwater infrastructure design.

Concepts are presented based on the current (existing) and future (climate change) 1-in-100 year design storm events based on the storm distributions developed for the Windsor Stormwater drainage Study (2023), model plan and profiles of the concepts are presented in Attachment A. Final sizing selection will depend on the design (alignment and any improvements hydraulic inlet conditions). Refer to Figure 6 below for the alignment, which includes a section parallel to Tremain Crescent and a section perpendicular to Tremain Crescent:

- ▶ **1-in-100 Year Design Storm (Existing):** 2,400mm span x 600mm rise concrete box.
- ▶ **1-in-100 Year Design Storm (2090) Climate Change:** 3,000mm span x 600mm rise concrete box.

Options presented meet the WHRM headwater depth requirements. Unfortunately, due to the elevation of the ditch with respect to neighbouring building elevations, the hydraulic grade line in the ditch will continue to pose a potential flood risk.

- ▶ **Alignment and grade:** The alignment and grade of the existing cross-culvert was maintained to avoid grade conflicts with water and sanitary infrastructure (26.5m section parallel to Tremain Crescent and 12.5m section crossing Tremain Crescent). Confirmation of these utilities and their elevations by the Municipality may permit alterations to the proposed alignment or grade, including a section of ditching parallel to Tremain Crescent (eliminating a section of the parallel run).
- ▶ **Size:** Limited vertical space is available to install stormwater structure taller than the existing 450mm pipe. A low rise, wide span box culvert is required to meet hydraulic requirements while fitting within the road. The proposed 600mm rise box culvert appears to fit between the road surface and the underground utilities, under the assumption that the top of all water infrastructure is **at least 1.5m** depth of bury from existing grade.
- ▶ **Existing Infrastructure:** Water and sanitary elevations should be confirmed at crossing locations.

The existing minor system on Tremain Crescent, consisting of catch basins and pipes, shows some surcharging in the 10-year event but is beyond the scope of this study. The minor system is expected to be surcharged/flooded during the design event (1-in-100 year event).

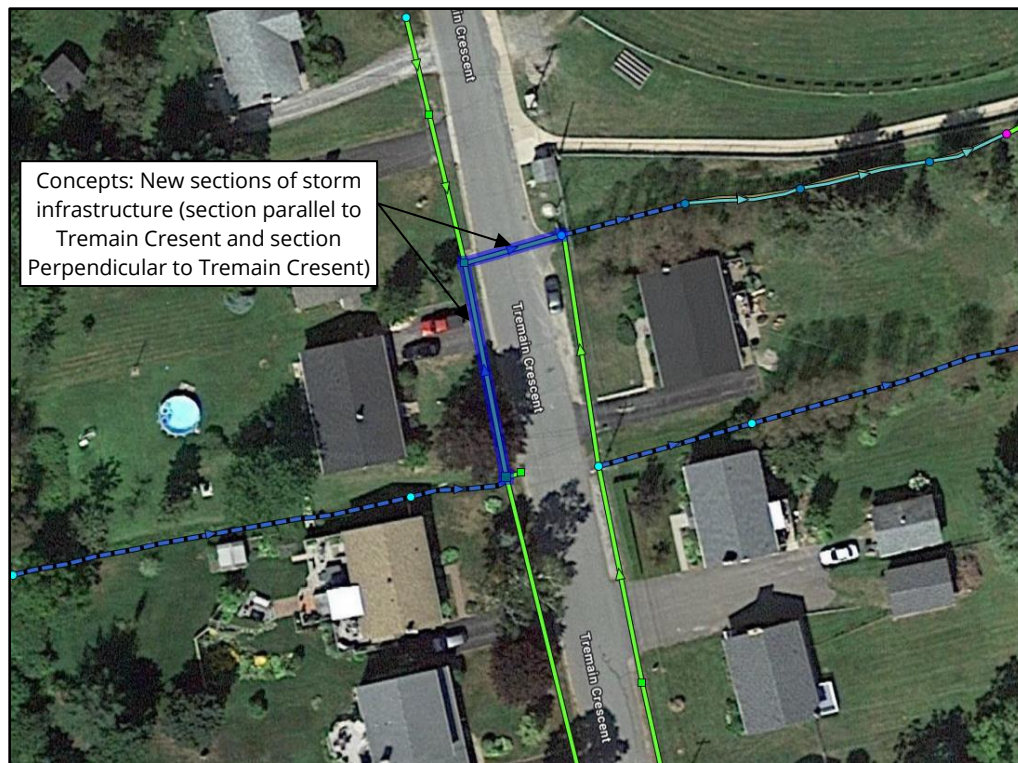


Figure 6: Tremain Crescent Options - Alignment

King Street Upgrades

It is understood that future capital work on King Street could include stormwater work to reduce flows into the Tremain Crescent catchment. Design flows at the Tremain Crescent crossing can be reduced if both minor and **major system** runoff is captured and diverted at King Street. Major storm runoff capture and conveyance along King Street would require ditches or other major system drainage infrastructure upstream of Tremain Crescent. One possible option would be to convey and discharge stormwater from King Street into the College Road ditch system. Detailed analysis of the College Road stormwater system, outside the scope of this project, would be required to confirm that this system has adequate capacity to accept these additional flows.

For the 1-in-100 year design event, the total flow to the ditch immediately upstream of the Tremain Crescent crossing is reduced by $0.4 \text{ m}^3/\text{s}$, or 30%, if the King Street sub-catchments noted in Figure 7 are rerouted. Actual flows diverted will depend on the design of any future King Street infrastructure upgrades.

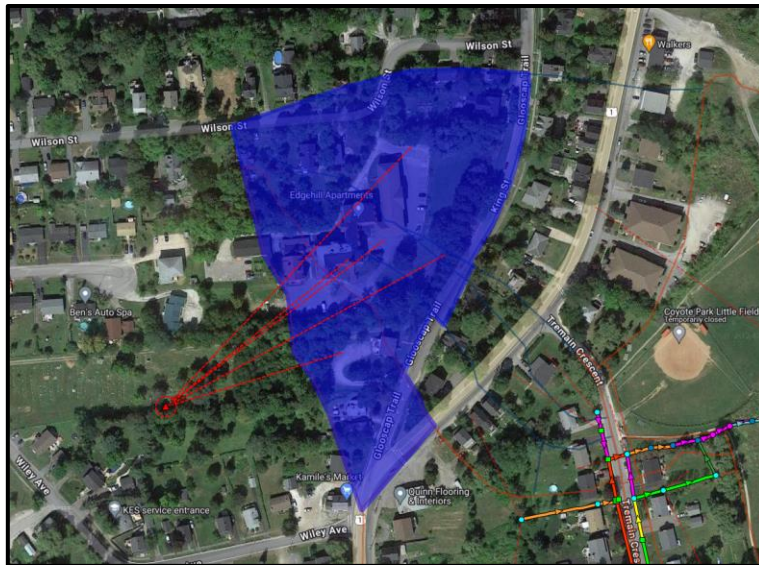


Figure 7: Sub-Catchments Upstream of King Street

The reduction in flows from removal of the King Street catchments is equivalent to the increase of flows from the existing condition design event to the 2090 climate change design event. A phased climate-change oriented approach could be to install the Tremain Crescent cross-culvert based on the existing 1-in-100 year design storm, and remove major drainage stormwater flows from upstream of King Street as capital works permit to allow the culvert to convey the 1-in-100 year climate change design storm while maintaining a similar peak hydraulic grade line in the future.

Flood Pathways

The house located at Civic #335 Tremain Crescent, as well as the surrounding properties, are low-lying. Foundations are at or near the bottom of the existing ditch system, with the foundation drains visible discharging at the bottom of the ditch from Civic #335 Tremain Crescent. The flooding mechanism at Civic #335 cannot be determined without intrusive investigation of the drain tile and foundation, however it appears to be linked directly (through holes, or the drain tile discharge into the bottom of the existing ditch) or indirectly (through cracks) to a high hydraulic gradeline causing water ingress through the foundation or floor slab as a result of hydrostatic pressure.

Next Steps

Hydrologic and hydraulic modelling was used to develop culvert upgrade options for two design events:

- ▶ Existing 1-in-100 year design event.
- ▶ Future 1-in-100 year design event (2090 climate change).

Todd Richard
January 19, 2024

Catchment flows originating upstream of King Street are a significant portion of the total flow at Tremain Crescent and may be able to be diverted away from the Tremain Crescent catchment in the future. This would result in additional capacity of the culvert system on Tremain with climate change.

The following key assumptions and confirmations should be agreed upon before proceeding with the design:

- ▶ Confirm the selection of the 1-in-100 year design storm event through agreement with WHRM. It is not recommended to size the Tremain Crescent crossing for the 1-in-10 year design event because of the flood risk at this location before water spills over the road.
- ▶ Discuss if future rerouting of runoff from the King Street area to the adjacent stormwater catchment is feasible. It would be beneficial to confirm that the downstream system has capacity to receive these additional flows prior to relying on this option for future work.
- ▶ Confirm elevation/location of underground municipal infrastructure (by WHRM). Once completed, CBCL will review the design alignment and grade to fit within existing infrastructure.
- ▶ Optimize the hydraulic opening (span and rise) based on utility clearances and prepare design drawings.

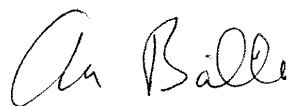
If you have any questions please contact the undersigned.

Yours very truly,

CBCL Limited



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Attachments: A – Plan/Profiles

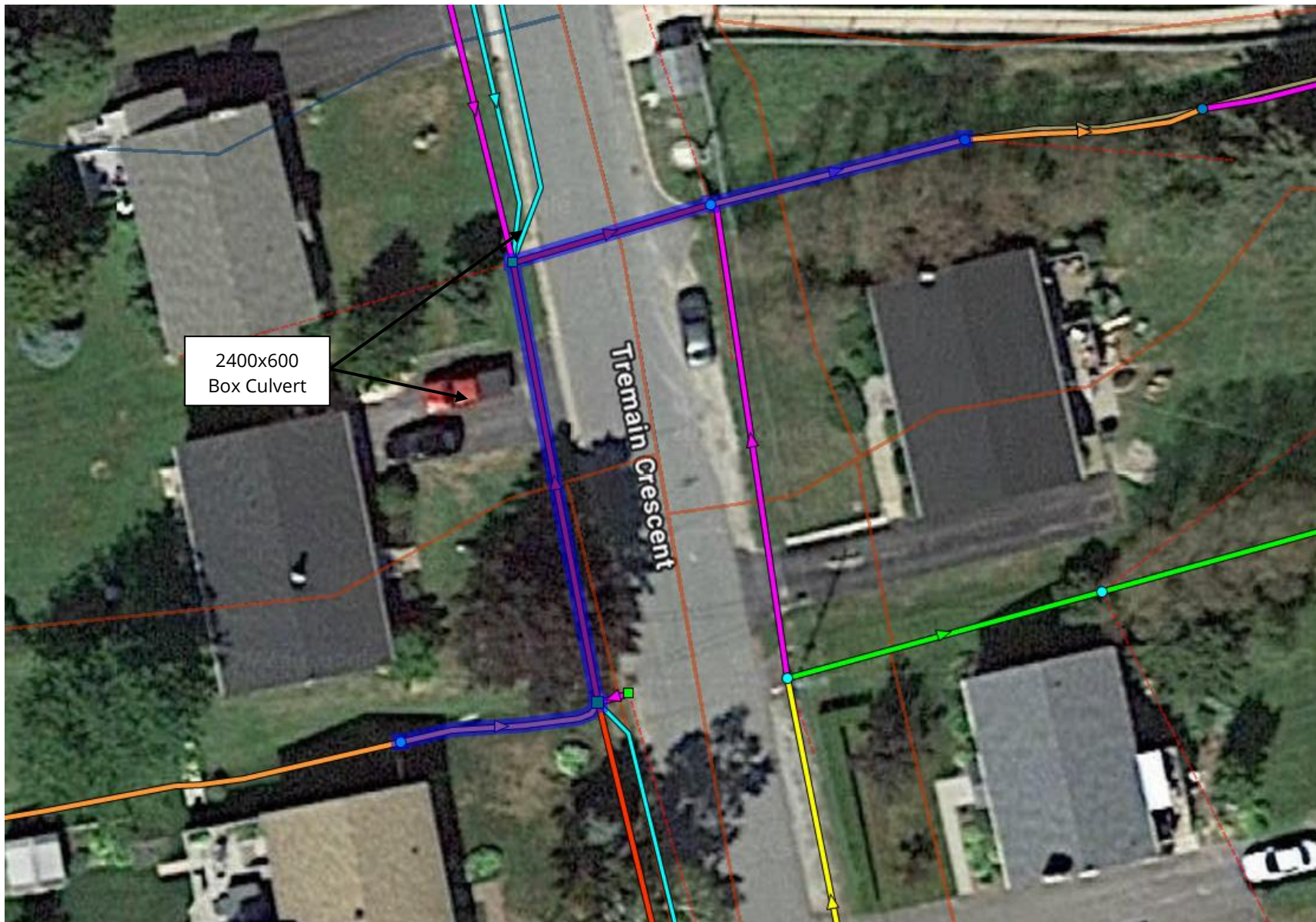
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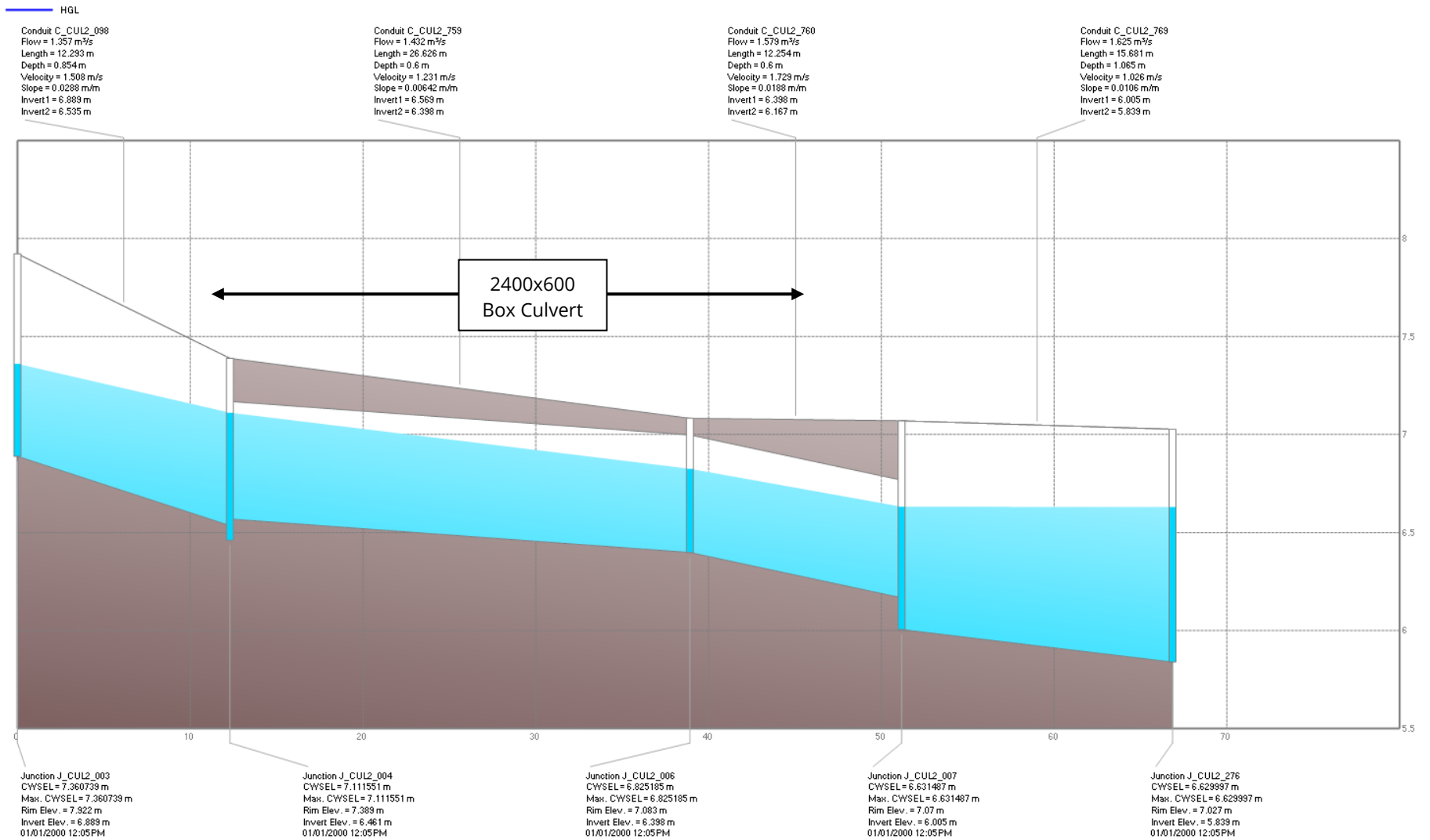
Attachment A

Concept Plan/Profiles

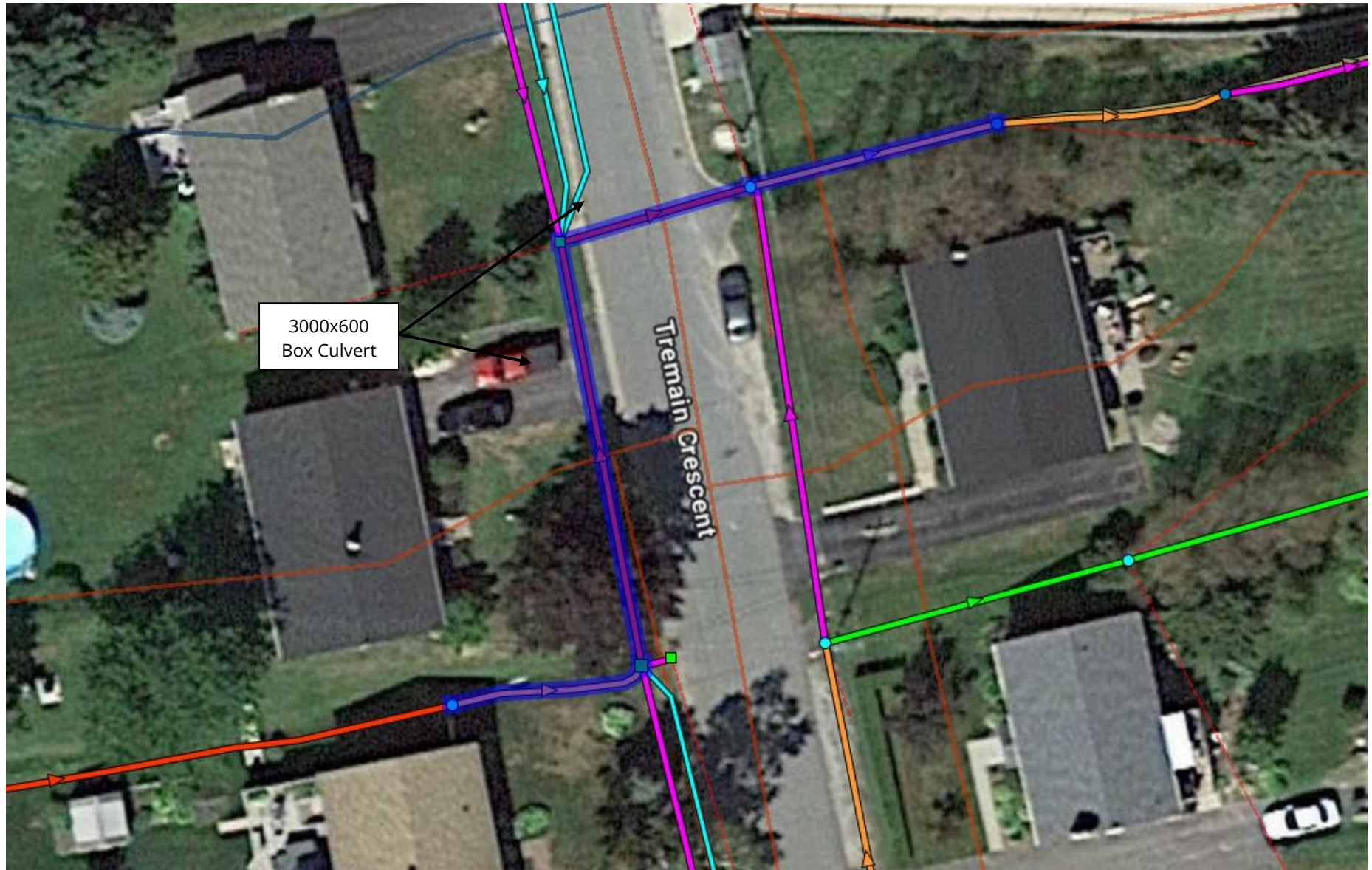
Concept: 1-in-100 Year (Existing) Design Event
Plan View



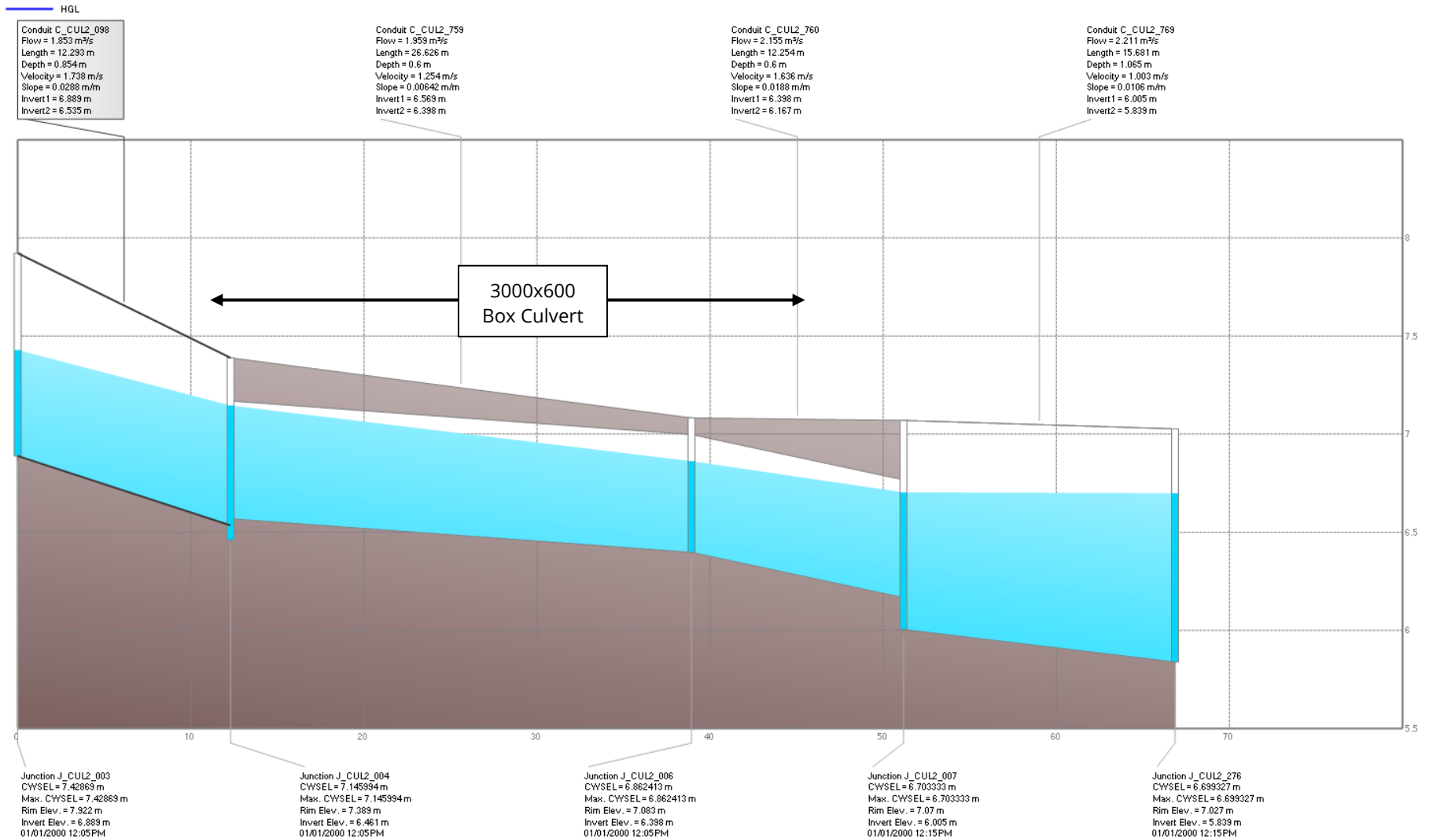
Concept: 1-in-100 Year (Existing) Design Event Profile View



Concept: 1-in-100 Year (2090 Climate Change) Design Event
Plan View



Concept: 1-in-100 Year (2090 Climate Change) Design Event Profile View





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