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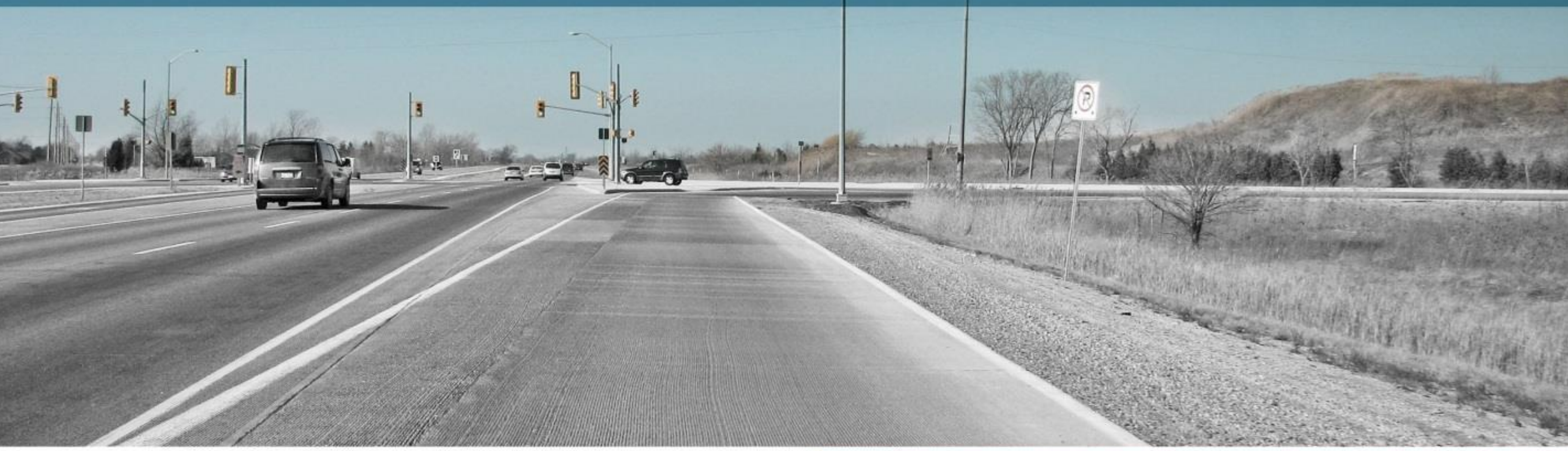

HIGHWAY 3 Improvements

GWP 317-98-00

Culvert Hydrology and Condition Report

December 2018

DILLON
CONSULTING

December 21, 2018

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Attention: Mr. Anthony Saraceni
Project Engineer

Ministry of Transportation, Ontario
Highway 3 Improvements – Town of Essex (GWP 317-98-00)
Culvert Hydrology and Condition Report

Dear Mr. Saraceni:

Enclosed for your records are three hard copies of the Final Culvert Hydrology and Condition Report for the above referenced project.

Sincerely,

DILLON CONSULTING LIMITED

Sarah Grady, P.Eng.
Project Manager

SJG:lpt
Enclosures

Our file: 12-6452

Dillon Consulting Limited

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1. BACKGROUND INFORMATION SUMMARY

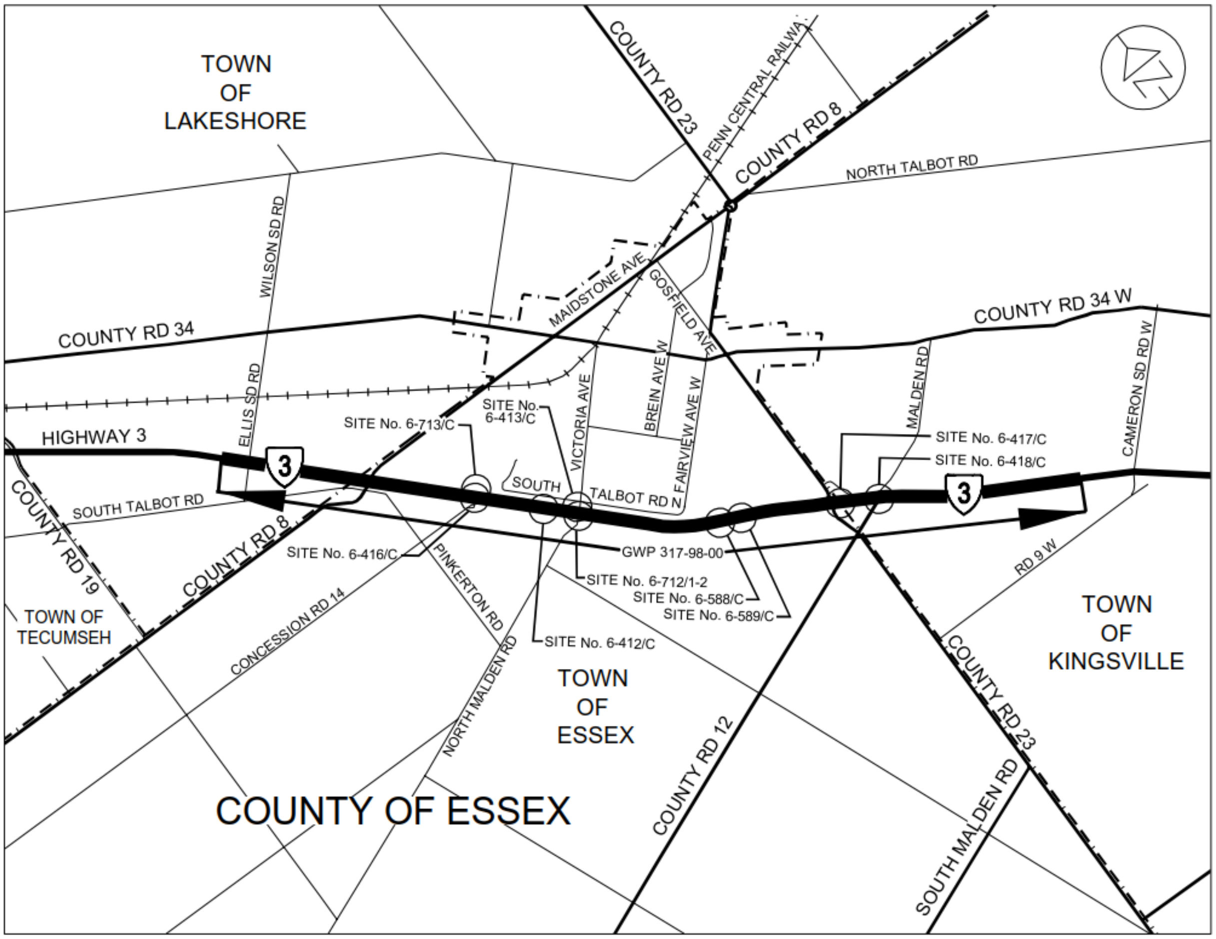
In January 2006, the Ministry of Transportation, Ontario (MTO) completed the Highway 3 Planning and Preliminary Design Study from Outer Drive in Windsor easterly 33.5 km to the east junction of Essex County Road 34 in Leamington (GWP 315-98-00). The Transportation Environmental Study Report (TESR) prepared for the project recommended widening the highway to four lanes with a 15 m grassed median and improving all at-grade intersections. It also recommended that a more comprehensive study be undertaken to address safety, traffic and operational issues through the Town of Essex.

The more detailed study recommended by the TESR was completed in 2010 and is documented in a Transportation Needs Assessment Report, Town of Essex Transportation Study, covering Highway 3 from 3.1 km west of Essex County Road 8 (Maidstone Avenue) to 1.3 km east of Essex County Road 23 (GWP 3008-06-00). To address future safety, traffic and operations issues, the 2010 study recommended a southerly shift of the highway alignment through the Town of Essex and modifications to highway intersections and the local municipal road network. The 2010 study was not completed as an environmental assessment (EA).

Some of the improvements included in the 2006 TESR, such as the widening of Highway 3 to four lanes from Windsor to Leamington, received environmental clearance under the *Environmental Assessment Act* in August 2006. The purpose of the current Class EA, Preliminary Design and initial Detailed Design Study is to revisit the alternatives developed in the 2010 study, building on the preferred alternatives identified in the 2006 TESR and 2010 study, and to assess the alternatives according to the requirements of MTO's Class EA for Provincial Transportation Facilities (2006). The TESR Addendum documents the decision-making process leading to the selection of the updated preferred Preliminary Design of improvements to Highway 3 through the Town of Essex.

The Study Area for the project extends along Highway 3 for 7.4 km from 0.5 km west of Ellis Sideroad easterly to 2 km east of Essex County Road 23. The location of the Highway 3 Improvement project is illustrated on **Figure 1**.

Figure 1: Highway 3 Project Limits



1.1 Previous Drainage Studies

In 2006, Earth Tech completed the Preliminary Design and Environmental Assessment of Highway 3 from Outer Drive 33.5 km easterly to the junction of County Road 34 under GWP 315-98-00. As part of the Preliminary Design, Earth Tech prepared a Drainage Report with recommendations for replacement and sizing of existing and proposed drainage infrastructure. In general, the report recommended that all existing CSP culverts be replaced based on the observed conditions of the culverts and the installation dates of the drainage infrastructure. A hydraulic analysis completed for the structural culverts concluded that several have deficient capacity. The condition of the existing drainage infrastructure and the hydraulic capacity of the key structural and non-structural culverts have been evaluated as part of this study.

1.2 Project Scope and Data Collection

The 2006 TESR recommended that Highway 3, through the project limits, be widened to four lanes with a 15 m wide grassed median. Improved at-grade intersections with turning lanes were recommended at all intersections. The recommended widening of Highway 3 requires the extension of structural and non-structural culverts that convey municipal drain system flows from the north side of Highway 3, through the corridor, to the south. The proposed grade separation at Victoria Avenue also requires the construction of a new culvert through the Highway 3 corridor to convey stormwater discharge from the Essex Outlet Drain to the downstream receiving watercourse. Specifically, the highway improvements recommended as part of the current Preliminary Design study include:

- Southerly shift of the Highway 3 alignment through the Town of Essex
- Partial closure of Highway 3/Ellis Sideroad intersection and construction of a cul-de-sac on the south side of the Highway corridor
- Realignment of South Talbot Road, Essex County Road 8 and Pinkerton Sideroad
- Overpass grade separation at Highway 3 and Victoria Avenue, combined with a multi-use trail constructed north of the proposed overpass embankment
- Municipal improvements at various intersections throughout the Study Area.

The primary purpose of Dillon's Culvert Hydrology and Condition Report is to document the drainage and hydrology engineering component of the Preliminary Design process. Specifically, this report covers:

- Physical condition of the existing structural and non-structural culvert impacted by the highway improvements
- Field investigations and background review of historic flooding or erosion issues at the existing culvert locations
- Hydraulic performance of the existing culverts impacted by the proposed highway improvements compared to MTO Drainage Design Standards
- Hydraulic performance of the proposed culvert configurations compared to MTO Drainage Design Standards
- Summary of recommended mitigation/improvement works for the proposed culvert configurations. These will be included in the Detailed Design of the structural and non-structural culverts.

To complete the condition assessment and hydraulic performance evaluation, several field investigations were completed by the drainage and structural design teams. The structural design team focused on the structural culvert condition assessments, while members of the drainage team undertook the non-structural culvert condition assessment, making note of any signs of flooding and erosion/scour in the watercourses. To complete the required hydrologic and hydraulic assessment of the existing and proposed culvert configurations, the following mapping and data sources were used:

- GIS base mapping from Ministry of Natural Resources and Forestry (MNRF), MTO and the County of Essex
- Ground survey data produced as part of the Preliminary Design
- Municipal Drain reports obtained from the local municipalities and County of Essex
- 2006 Earth Tech Preliminary Design/TESR Drainage Report.

1.3 Existing Condition Summary

As shown on **Figure 2**, six structural and three non-structural culverts cross Highway 3 within the project limits. The structural culverts consist of a group of five open-footing concrete non-rigid frame culverts and one horizontal elliptical corrugated steel structural plate culvert. The non-structural culverts consist of a group of two small diameter corrugated steel pipe culverts and one 2.44 m span open-footing concrete non-rigid frame culvert. In addition, there are several non-structural culverts located within the Study Area at Pinkerton Sideroad and an existing storm sewer outfall structure at the intersection of Victoria Avenue and South Talbot Road that form key components of the surface water drainage system within the Highway 3 corridor. Several other non-structural small diameter corrugated steel pipe culverts that also facilitate highway drainage will be eliminated or reconfigured as part of the Highway 3 improvements.

Figure 2: Structural and Non-Structural Culvert Locations within Project Limits

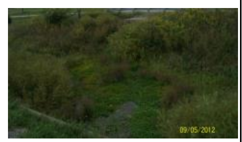
2. CONDITION ASSESSMENT

As indicated in the 2006 Preliminary Design study completed by Earth Tech, the general condition of all corrugated steel pipe (CSP) culverts within the project limits were found to be moderate to poor. Due to the proposed widening of Highway 3 and reconfiguration of side-roads, most of the non-structural CSP culverts will be eliminated or significantly impacted, therefore necessitating replacement. The non-structural CSP culverts impacted by the proposed improvements were not assessed in detail as part of the Preliminary Design update. The final location, configuration and size of the drainage ditch, side-road and entrance culverts (if necessary) will be determined during Detailed Design.

2.1 Non-Structural CSP and Concrete Culverts

There are two non-structural CSP culverts and one non-structural open-footing non-rigid-frame concrete culverts crossing the existing lanes of Highway 3 within the project limits. **Table 1** summarizes the physical configuration and condition of the existing non-structural culverts.

Table 1: Condition Assessment of Non-Structural Culverts Crossing Highway 3

Drain Name/ Classification	Existing Size	Location (Station)	Inlet	Outlet	Barrel	Condition Assessment
Unnamed Drain	750 mm x 29.67 m	14+018 Hwy 3				General condition – Poor, rusted spring line, damaged inlet/outlet Less than minimum acceptable (800 mm) size
Talbot Road South Drain A	750 mm x 22.31 m	15+489 Hwy 3				General condition – Poor, rusted spring line, damaged inlet/outlet Less than minimum acceptable (800 mm) size
Barlow Drain	2400 mm x 1830 mm x 28.58 m	11+623 Hwy 3			Not available	General Condition – Good, some minor surface scaling and leaking construction joints - Well vegetated channel and minimal channel degradation due to erosion and scour - No signs of capacity related deficiencies, including flooding or local erosion

The two CSP culverts crossing the existing lanes of Highway 3 are in poor condition and have reached the end of their useful lifespan. Both 750 mm CSP culverts require replacement and upsizing to meet current MTO Design Criteria for minimum size. The Barlow Drain culvert, a 2400 mm x 1830 mm concrete culvert, is in generally good condition and will provide an opportunity for an interim extension to the south to accommodate the proposed lane transitions at the easterly end of the project, as well as the ultimate culvert extension required for the twinning of Highway 3 to the east. Several other roadside ditch drainage culverts located within the project limits require replacement or modification due to the proposed local municipal road improvements. The final configuration and sizing of these roadside ditch culverts will be addressed during Detailed Design of Structural Culverts.

Six additional structural culverts cross the existing lanes of Highway 3 within the project limits. The condition assessment of these culverts was completed as part of the preparation of the Structural Design Reports (SDRs). **Table 2** summarizes the condition assessment, including the condition of the channel embankment and watercourse within the culvert barrels.

Table 2: Condition Assessment of Structural Culverts Crossing Highway 3

Drain Name/ Classification	Existing Size (Width x Height x Length)	Site Number	Location (Highway 3 Station)	Inlet/Outlet	Culvert Barrel	Embankment and Watercourse
14th Concession East Drain	3050 mm x 1524 mm x 26.95 m	6-416/C	13+892	No existing headwalls	Inside of culvert in good condition. Minor surface scaling and narrow and medium width shrinkage cracks. Efflorescence and rust staining at crack locations.	Approximately 350 mm of silt and sediment measured over top of footings. Embankments are in good condition.
Essex Outlet Drain	3600 mm x 1830 mm x 36.79 m and 1830 mm x 1220 mm x 40.16 m	6-412/C	14+750	Grouted natural stone retaining walls in fair to poor condition	Inside of culvert is in good condition. Isolated transverse shrinkage cracking and small areas of spalling and delamination. Area of delamination of the soffit with exposed corroded reinforcing steel in soffit. CSP overflow culvert in generally good condition.	Silt aggradation along east side of stream inside culvert. Some accumulated sediments and standing water within culvert. Embankment slopes are steep and irregular at inlet and outlet of culvert. No significant erosion observed.
Canaan Drain	3350 mm x 2070 mm x 26.28 m	6-588/C	15+954	Concrete end walls in good condition with isolated narrow to wide cracking	Inside of culvert in good condition, with widespread loss of galvanization and light corrosion along the spring line.	Approximately 400 mm to 460 mm of standing water inside culvert limiting visual inspection below spring line. No signs of settlement or defects in streambed or embankment.

Drain Name/ Classification	Existing Size (Width x Height x Length)	Site Number	Location (Highway 3 Station)	Inlet/Outlet	Culvert Barrel	Embankment and Watercourse
Talbot Road South Drain B	3050 mm x 1220 mm x 22.76 m	6-589/C	16+137	Concrete wingwalls in good condition but isolated severe spalling near culvert side walls. Appears to be some movement of walls causing stresses and spalling at joints.	Inside of culvert in good condition but shrinkage cracks in side wall and soffit. Cracks at side wall drain locations. A wide crack was noted near inlet with an area of delamination.	Approximately 150 mm of silt and sediment measured over tops of footings. No standing water or flow within culvert at time of inspection. Embankments in good condition with cinder blocks stacked at southwest wingwall indicating a historical erosion problem.
East Townline/ West Townline Drain	3660 mm x 2100 mm x 41.63 m	6-417/C	10+017	Concrete wingwalls at south end of culvert are in good condition.	Inside of culvert in good condition but several shrinkage cracks in side walls and soffit ranging from narrow to wide. A narrow crack in the soffit was noted near the inlet with an area of soffit delamination.	Approximately 300 mm of silt and sediment measured over top of footings. No standing water or flow within culvert at time of inspection. Existing rip-rap protection appears to be functioning but appears excessively steep in northwest corner.
Russell Drain	3050 mm x 1650 mm x 25.66 m	6-419/C	10+331	Concrete wingwalls at north end are in generally good condition.	Inside of culvert is in very good condition with minor transverse shrinkage cracking.	Approximately 300 mm of silt and sediment measured over top of footings. No standing water or flow within culvert at time of inspection. No embankment or erosion issues noted.

In general, all of the structural culverts are in good condition. All of the culverts, with exception of the Canaan Drain, will require minor concrete repairs and rehabilitation. A number of crossings with wingwalls at the inlet/outlet require rehabilitation. These culverts will be considered for extension to eliminate the need for costly wingwall repairs and the need to install guardrail systems along Highway 3 to protect motorists from roadside hazards.

2.2 Design Criteria for Watercourse Crossing

This section includes the required hydrologic and hydraulic design criteria for use in the design and rehabilitation of highway drainage infrastructure under MTO's jurisdiction. The MTO 2008 Drainage Design Standard was used to define the relevant design criteria for each crossing and represents a consolidation of hydraulic performance indicators considered as part of the evaluation of the culverts impacted by the proposed highway improvements.

Table 3 contains design criteria for the group of structural and non-structural culverts crossing Highway 3 that are directly impacted by the highway widening from two lanes undivided to a four lane divided configuration. The table also presents the relevant design criteria for a new culvert required to accommodate the extension of South Talbot Road over 14th Concession Drain, west of Victoria Avenue.

Since Talbot Road South Drain crosses the Highway 3 corridor in two separate locations, the two branches have been designated as Branch 'A' and Branch 'B'. This designation applies to this culvert hydrology study only and should not be misinterpreted as part of the official Municipal Drain designation.

Table 3: Culvert Design Criteria

Drain Name/Classification	Location	Classification and Type	Design Flow Return Period	Check Flow Return Period	Freeboard Requirement	Clearance Requirement	Max Headwater/Depth Ratio or 1.5 Max Depth
Hyland Drain (CR8) – *New Culvert*	Regional Road 8 at Realigned Pinkerton Road	Non-Structural Closed-Footing	25-Year	115% of 100-Year	1.0 m	n/a	1.5
14th Concession Drain	13+892 Highway 3	Structural – Open-Footing	50-Year	130% of 100-Year	1.0 m	0.3 m	n/a
14th Concession Drain – South Talbot Road Extension	9+108 South Talbot Road	Structural – Open-Footing	25-Year	115% of 100-Year	1.0 m	0.3 m	n/a
Unnamed Drain	14+018 Highway 3	Non-Structural Closed Footing	50-Year	130% of 100-Year	1.0 m	n/a	1.5
Essex Outlet Drain	14+742 Highway 3	Structural – Open-Footing	50-Year	130% of 100-Year	1.0 m	0.3 m	n/a
Talbot Road South Drain A	15+489 Highway 3	Non-Structural Closed Footing	50-Year	130% of 100-Year	1.0 m	n/a	1.5
Canaan Drain	15+954 Highway 3	Structural – Closed Footing	50-Year	130% of 100-Year	1.0 m	n/a	4.5 m
Talbot Road South Drain B	16+138 Highway 3	Structural – Open-Footing	50-Year	130% of 100-Year	1.0 m	0.3 m	n/a
East Townline/West Townline Drain	10+016 Highway 3	Structural – Open-Footing	50-Year	130% of 100-Year	1.0 m	0.3 m	n/a
Russell Drain	10+331 Highway 3	Structural – Open-Footing	50-Year	130% of 100-Year	1.0 m	0.3 m	n/a
Barlow Drain	11+623 Highway 3	Non-Structural Open-Footing	50-Year	130% of 100-Year	1.0 m	0.3 m	n/a

3. HYDROLOGIC/HYDRAULIC PERFORMANCE ASSESSMENT

3.1 Hydrologic Analysis

The hydrologic analysis was completed in accordance with accepted methods outlined in the MTO Drainage Design Manual. The hydrologic drainage area characteristics presented in the following sections were obtained from the previously completed Preliminary Design drainage study, official Municipal Drain mapping obtained from the local municipalities and County of Essex, and topographic mapping from MNRF.

Figure 3 illustrates the individual drainage areas consolidated from all sources of municipal drain information available for the Study Area. The Municipal Drains fall within the Canard River subwatershed area and generally flow in a north to south direction through the study area and an east to west direction downstream of the Highway 3 corridor. The Canard River is a significant tributary to the Detroit River, terminating in the Town of Amherstburg. The drainage areas associated with this section of Highway 3 are comprised of a combination of rural agricultural and low density rural residential land use. The Essex Outlet Drain drainage area comprises primarily urbanized lands within the Town of Essex.

All of the municipal drains within the Study Area are artificially created watercourses that convey characteristically peaky flows from frequent low-intensity rainfall events based on the configuration of the conveyance system, lack of definable floodplain area and minimal detention storage within the subcatchment areas. Infrequent high-intensity rainfall events (25-Year Return Period and above) characteristically use up available storage within the conveyance systems and result in the municipal drains overtopping their natural banks and spilling out into adjacent low-lying areas or the agricultural fields that they drain. Due to the surrounding topography, once the conveyance systems spill to adjacent lands, runoff is stored and attenuated to a high degree, controlling peak flows through the system and generally significantly reducing peak flows discharged to the lower reaches of the drainage systems. For the purpose of the assessment and design of the proposed highway improvement works, a conservative approach was taken to applying peak flow reductions due to storage and attenuation. In general, only minor storage reduction factors were incorporated into the hydrologic modeling of the drainage areas.

Figure 3: Study Area Municipal Drain Drainage Boundaries

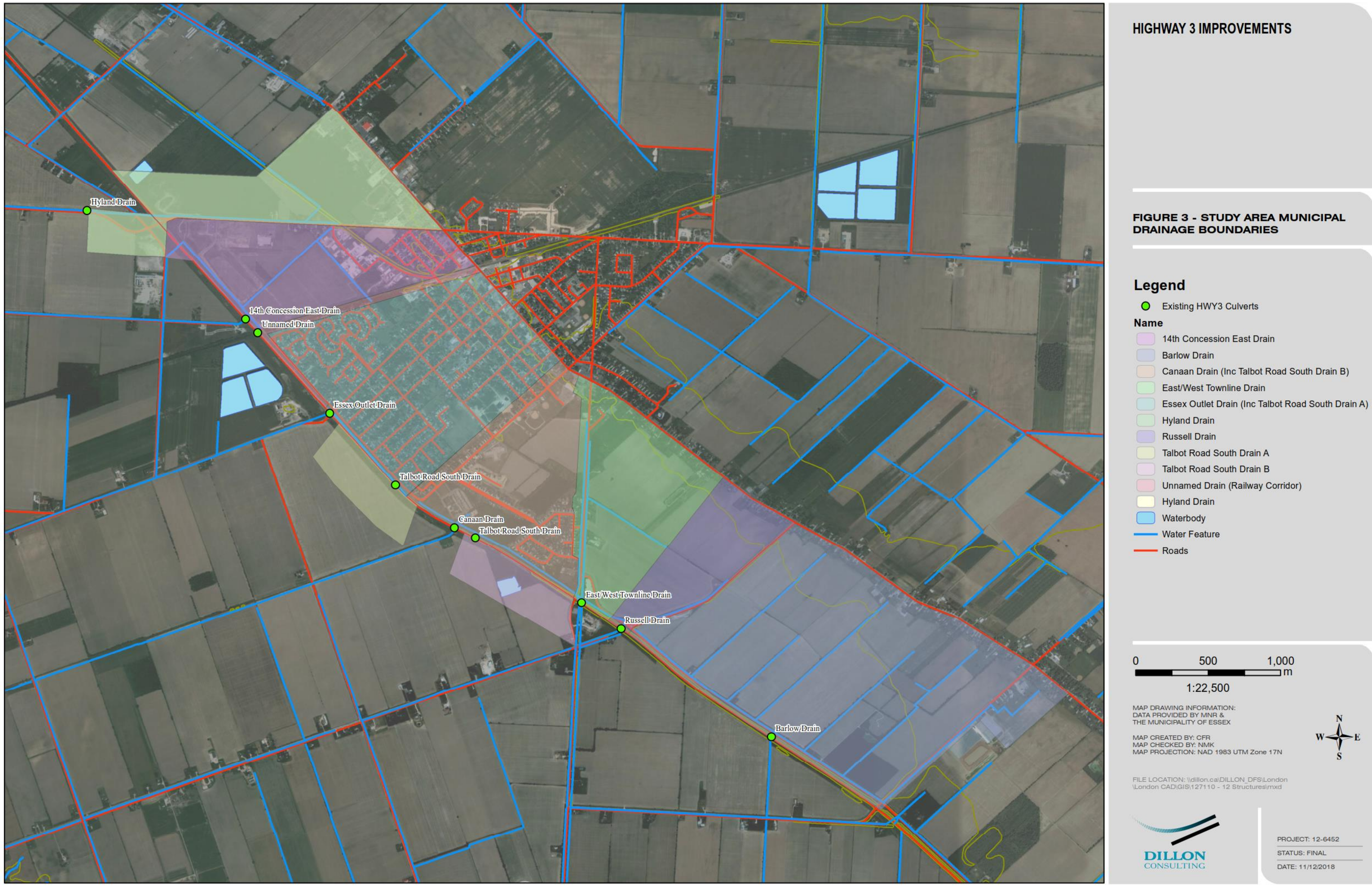


Table 4 summarizes hydrologic characteristic data based on existing land use mapping, topographic mapping and aerial photo interpretation. The hydrologic characteristics reflect the existing land use characteristics within the drainage area and do not consider future urbanization of the lands north of the Highway 3 corridor. Future development north and south of the Highway 3 corridor will require site stormwater management plans based on the objective of maintaining existing flows to each municipal drain system or re-evaluation of the existing/proposed Highway 3 infrastructure.

Table 4: Drainage Area Hydrologic Characteristics Summary

Crossing Location	Watershed Area (ha)	Watershed Length (m)	Watershed Slope (%)	Estimated Runoff Coefficient
Hyland Drain (CR8)	104.56	2450	0.07	0.35
14th Concession Drain	99.03	1200	0.07	0.35
14th Concession Drain – South Talbot Road Extension	99.03	1200	0.07	0.35
Unnamed Drain	11.09	1600	0.01	0.35
Essex Outlet Drain	186.85	1800	0.12	0.60
Talbot Road South Drain A	24.84	600	0.10	0.35
Canaan Drain	129.56	1300	0.15	0.40
Talbot Road South Drain B	27.63	600	0.10	0.35
East Townline/West Townline Drain	97.77	1400	0.11	0.35
Russell Drain	54.82	1350	0.06	0.35
Barlow Drain	284.79	2250	0.04	0.35

Tables 5 and **6** summarize the calculated peak flow data determined by the hydrologic analysis completed for this assignment. The MTO Modified Rational Method and peak flows generated by a Visual Otthymo model of the drainage area are presented in the summary tables. Typically, the peak flow data generated by the MTO Modified Rational Method is suitable for small watershed areas up to a maximum of 50 ha to 75 ha. The Modified Rational Method tends to over-estimate peak runoff flow rates for drainage areas exceeding this size. **Table 7** summarizes the consolidated design flows applicable to each crossing location based on watershed characteristics and size. Annual maximum rainfall intensities for each return period design storm were obtained from the MTO IDF curve lookup web-based application. The detailed Visual Otthymo hydrologic modeling output summaries are included in **Appendix A**.

Table 5: MTO Modified Rational Method Peak Flow Summary

Crossing Location	2-Year Design Flow (cms)	5-Year Design Flow (cms)	10-Year Design Flow (cms)	25-Year Design Flow (cms)	50-Year Design Flow (cms)	100-Year Design Flow (cms)
Hyland Drain (CR8)	0.8	1.0	1.3	1.5	1.7	1.9
14th Concession Drain	1.0	1.3	1.7	2.1	2.6	3.3
14th Concession Drain – South Talbot Road Extension	1.0	1.3	1.7	2.1	2.6	3.3
Unnamed Drain	0.1	0.1	0.1	0.1	0.2	0.2
Essex Outlet Drain	6.1	7.8	10.0	12.2	15.3	19.9
Talbot Road South Drain A	0.4	0.5	0.6	0.7	0.9	1.2
Canaan Drain	1.9	2.4	3.1	3.8	4.8	6.3
Talbot Road South Drain B	0.4	0.5	0.7	0.8	1.0	1.3
East Townline/West Townline Drain	1.1	1.3	1.8	2.1	2.7	3.5
Russell Drain	0.5	0.6	0.9	1.0	1.3	1.7
Barlow Drain	1.6	1.9	2.6	3.9	4.9	6.4

Table 6: Visual Otthymo Peak Flow Summary

Crossing Location	2-Year Design Flow (cms)	5-Year Design Flow (cms)	10-Year Design Flow (cms)	25-Year Design Flow (cms)	50-Year Design Flow (cms)	100-Year Design Flow (cms)
Hyland Drain (CR8)	0.6	0.9	1.5	2.0	2.4	2.8
14th Concession Drain	0.8	1.2	1.8	2.5	3.0	3.5
14th Concession Drain – South Talbot Road Extension	0.8	1.2	1.8	2.5	3.0	3.5
Unnamed Drain	0.1	0.1	0.1	0.1	0.2	0.2
Essex Outlet Drain	3.1	4.6	6.9	9.2	11.0	12.7
Talbot Road South Drain A	0.3	0.4	0.7	0.9	1.1	1.3
Canaan Drain	1.3	1.9	3.0	4.1	4.9	5.7
Talbot Road South Drain B	0.3	0.5	0.7	1.0	1.2	1.4
East Townline/West Townline Drain	0.8	1.2	1.9	2.6	3.1	3.7
Russell Drain	0.4	0.6	0.9	1.3	1.5	1.8
Barlow Drain	1.2	1.8	2.8	3.8	4.5	5.2

Table 7: Consolidated Design Flows

Crossing Location	Return Period of Design Flow	Design Flow – Freeboard and Clearance Assessment (cms)	Check Flow – Erosion Potential Assessment (cms)
Hyland Drain (CR8)	25-Year	2.0	3.2
14th Concession Drain	50-Year	3.0	4.5
14th Concession Drain – South Talbot Road Extension	25-Year	2.5	4.0
Unnamed Drain	50-Year	0.2	0.3
Essex Outlet Drain	50-Year	11.0	16.5
Talbot Road South Drain A	50-Year	1.1	1.7
Canaan Drain	50-Year	4.9	7.4
Talbot Road South Drain B	50-Year	1.2	1.8
East Townline/West Townline Drain	50-Year	3.1	4.8
Russell Drain	50-Year	1.5	2.3
Barlow Drain	50-Year	4.5	6.8

Following the completion of this study the Town of Essex initiated a large scale urban drainage study that includes several of the noted municipal drain watershed areas. The Town's drainage master plan study includes detailed hydraulic/hydrologic modeling of the storm sewer collection system. Upon completion of that study design flows from the Town's hydrologic model should be used to re-evaluate existing and proposed Highway 3 infrastructure. It is noted that hydrologic input used in the Essex Outlet Drain hydraulic evaluation are flows generated by a simplified 'lumped' upstream drainage area Visual Otthymo model.

3.2 Hydraulic Performance Assessment

The following sections summarize the hydraulic performance assessment completed on the existing structural and non-structural culverts directly impacted by the proposed highway widening and side-road realignments. The purpose of the existing conditions performance assessment was to provide a baseline condition to assess the performance of the proposed culverts required to accommodate the improvements. **Section 3.2.1** summarizes the hydraulic assessment completed for the existing culvert configurations, **Section 3.2.2** summarizes the hydraulic assessment completed for the proposed culvert arrangements and **Section 3.2.3** compares existing versus proposed hydraulic conditions.

3.2.1 Existing Conditions Hydraulic Performance Assessment

The existing municipal drain culverts were evaluated to assess the hydraulic performance of the structures and establish the baseline conditions against which the new culvert arrangements required to accommodate the proposed highway improvements will be compared. The hydraulic performance of the existing culverts was also evaluated against the required design criteria for each culvert location, as shown in **Table 3**.

Table 8 summarizes the hydraulic performance indicators resulting from applying the design and check flows to the existing culvert geometry.

Table 8: Existing Culvert Hydraulic Performance Assessment Summary

Crossing Location	Existing Culvert Configuration (Width x Height x Length)	Design Storm Computed Headwater Elevation	Headwater Depth/ Height Ratio	Flow Regime	Check Storm Outlet Velocity (m/s)	Resultant Freeboard (m)	Resultant Clearance (m)
14th Concession East Drain	3050 mm x 1524 mm x 26.95 m	192.920	73%	Subcritical	1.18	1.04	0.41
Unnamed Drain	750 mm x 29.67 m	193.790	63%	Subcritical	1.51	1.12	n/a
Essex Outlet Drain	3600 mm x 1830 mm x 36.79 m and 1830 mm x 1220 mm x 40.16 m	193.670	113%	Surcharged	2.08	1.26	-0.24
Talbot Road South Drain A	750 mm x 22.31 m	195.150	252%	Surcharged	3.68	0.10	n/a
Canaan Drain	3350 mm x 2070 mm x 26.28 m	192.700	71%	Subcritical	1.57	2.56	n/a
Talbot Road South Drain B	3050 mm x 1220 mm x 22.76 m	193.700	34%	Subcritical	1.81	1.58	0.80
East Townline/ West Townline Drain	3660 mm x 2100 mm x 41.63 m	193.340	66%	Subcritical	1.06	2.12	0.71
Russell Drain	3050 mm x 1650 mm x 25.66 m	192.960	36%	Subcritical	1.61	2.49	1.06
Barlow Drain	2400 mm x 1830 mm x 28.58 m	194.210	105%	Surcharged	1.52	1.24	-0.10

In existing condition, 14th Concession East, Unnamed Drain, Canaan Drain, Talbot Road South Drain B, East Townline/West Townline and Russell Drain all meet or exceed the required performance targets based on the existing culvert configuration, type and location within the Highway 3 corridor. Currently, Essex Outlet Drain, Talbot Road South Drain A and Barlow Drain are all operating below the expected level of service based on the existing culvert configuration, type and location. Notably, the Branch 'A' crossing of the Talbot Road South Drain, an existing 750 mm CSP culvert, is operating with a project headwater depth to diameter ratio of 252%. Typically, surcharging of a small diameter CSP of this configuration would be limited to approximately 150%. The projected design flow freeboard depth is also deficient at this location, leading to the possibility of overtopping of Highway 3 during extreme precipitation events. Essex Outlet Drain and Barlow Drain are both operating below ideal levels of service and experience minor surcharging for the design storm flows at each crossing location. At both locations, the structures are submerged and the required clearance between the projected headwater elevation and the underside of the culvert soffit are not achieved. However, both locations have sufficient freeboard depths based on the required design criteria for the structures. Based on the existing hydraulic performance of the Essex Outlet Drain, Talbot Road South Branch 'A' Drain, and Barlow Drain, consideration should be given to upsizing the structures to compensate for excessive headwater to depth ratios, lack of freeboard or deficient clearance at the structure inlets.

For all locations, the calculated freeboard depth for the existing culvert, referenced from the lowest edge of pavement elevation at the culvert crossing location, was established based on the existing profile of Highway 3. The projected downstream channel velocities for the check storm flows are projected to exceed the scour protection qualities of natural vegetation at Essex Outlet and Talbot Road South Branch 'A' Drain. Additional erosion protection or channel hardening should be considered at these locations to guard against future erosion and scour at the culvert inlet and outlet locations.

The detailed CulvertMaster Hydraulic output data for the existing condition assessment is included in **Appendix B**.

3.2.2 Proposed Conditions Hydraulic Performance Assessment

The proposed municipal drain culverts were assessed to evaluate the resultant hydraulic performance of the culvert arrangements required to accommodate the proposed highway improvements. The hydraulic performance of the proposed culvert arrangements were also evaluated against the required design criteria summarized in **Table 3** for each crossing location.

Table 9 summarizes the proposed modifications to the existing municipal drain culvert arrangements that are required to accommodate the proposed highway improvements.

Table 9: Proposed Culvert Configurations

Crossing Location (New Construction Culvert #)	Summary of Proposed Highway 3 Improvement Works	Site/Culvert Design Considerations	Proposed Culvert Configuration
New Hyland Drain at Pinkerton Road/County Road 8 *(Culvert #17)*	• Realignment of Pinkerton Road and new intersection at CR8 requires a new crossing of Hyland Drain along the north side of the RR8 right-of-way.	• 28.95 m long culvert required to convey flow along north side of RR8 right-of-way to the west side of the new Pinkerton Road intersection.	Determine based on Hydraulic Assessment
Extended 14th Concession East Drain *(Culvert #3)*	• Widening of Highway 3 from 2-lane undivided to 4-lane divided.	• 33.34 m right extension required to accommodate new EBL of Highway 3 and proposed 15 m open-ditch median.	3050 mm x 1524 mm x 60.29 m
New Proposed 14th Concession East Drain (South Talbot Road Extension) *(Culvert #2)*	• Construction of South Talbot Road Extension.	• The South Talbot Road Extension creates the need for a new crossing of 14th Concession East Drain approximately 8 m upstream of the existing Highway 3, 14th Concession East Drain culvert • Establish culvert sizing based on freeboard and clearance requirements of future South Talbot Road Extension profile.	Determine based on Hydraulic Assessment
Unnamed Drain *(Culvert #4)*	• Widening of Highway 3 from 2-lane undivided to 4-lane divided.	• Existing CSP culvert is in poor condition requiring replacement • Existing CSP culvert does not meet MTO minimum diameter requirements based on location within Highway 3 corridor • Establish culvert sizing based on 800 mm minimum diameter and required headwater/freeboard.	Determine based on Hydraulic Assessment
Proposed Essex Outlet Drain (Victoria Avenue) *(Culvert #6)*	• Intersection improvements at South Talbot Road and Victoria Avenue • Pavement and radii improvements in southwest quadrant and proposed multi-use trail system require a modified outlet to be constructed.	• Existing outlet consists of two drainage enclosures that join together in one common headwall arrangement • Existing drainage enclosures are non-structural modified box sections.	Determine based on Hydraulic Assessment

Crossing Location (New Construction Culvert #)	**Summary of Proposed Highway 3 Improvement Works**	**Site/Culvert Design Considerations**	**Proposed Culvert Configuration**
Proposed Essex Outlet Drain *(Culvert #5)*	• Widening of Highway 3 from 2-lane undivided to 4-lane divided configuration • Construction of Victoria Avenue overpass structure • Addition of a multi-use trail system within Highway 3 corridor • Minor reconfiguration of intersection of Victoria Avenue and South Talbot Road.	• Existing culvert arrangement to be replaced with single span culvert crossing proposed (shifted) lanes of Highway 3 and overpass embankment • Consider construction staging and geotechnical requirements for placement of final culvert crossing Highway 3 • Establish culvert sizing based on existing headwater elevation, freeboard and clearance requirements.	Determine based on Hydraulic Assessment
Talbot Road South Drain A *(Culvert # 8)*	• Widening of Highway 3 from 2-lane undivided to 4-lane divided.	• Existing CSP culvert is in poor condition requiring replacement • Existing CSP culvert does not meet MTO minimum diameter requirements based on location within the Highway 3 corridor • Establish culvert sizing based on 800 mm minimum diameter and required headwater/freeboard.	Determine based on Hydraulic Assessment
Canaan Drain *(Culvert #9 and 10)*	• Widening of Highway 3 from 2-lane undivided to 4-lane divided.	• 34.00 m right extension required to accommodate new EBL of Highway 3 and proposed 15 m open-ditch median • 8.14 m left extension required to accommodate 4:1 side-slopes, grading detail, and no guiderail for WBL.	3350 mm x 2070 mm x 68.45 m
Talbot Road South Drain B *(Culvert #11)*	• Widening of Highway 3 from 2-lane undivided to 4-lane divided.	• 29.21 m right extension required to accommodate new EBL of Highway 3 and proposed 15 m open-ditch median.	3050 mm x 1220 mm x 51.99 m

Crossing Location (New Construction Culvert #)	Summary of Proposed Highway 3 Improvement Works	Site/Culvert Design Considerations	Proposed Culvert Configuration
East Townline/West Townline Drain *(Culvert #12)*	• Widening of Highway 3 from 2-lane undivided to 4-lane divided.	• 32.79 m right extension required to accommodate new EBL of Highway 3 and proposed 15 m open-ditch median.	
Russell Drain *(Culvert #13 and 14)*	• Widening of Highway 3 from 2-lane undivided to 4-lane divided.	• 29.52 m right extension required to accommodate new EBL of Highway 3 and proposed 15 m open-ditch median • 7.45 m left extension required to accommodate 4:1 side-slopes, grading detail, and no guiderail for WBL.	3050 mm x 1650 mm x 55.18 m
Barlow Drain *(Culvert #15 and 16)*	• Construction of a 4-lane divided to 2-lane undivided cross-over lane transition.	• 36.87 m right extension required to accommodate new EBL of Highway 3 and proposed 15 m open-ditch median • 16.38 m right interim extension required to accommodate proposed 4-lane to 2-lane transition at the east end of the project • 8.86 m left extension required to accommodate 4:1 side-slopes, grading detail, and no guiderail for WBL.	2400 mm x 1830 mm x 71.39 m (Ultimate 4-Lane Divided Highway) 2400 mm x 1830 mm x 50.90 m (Interim Lane Transition to 2-Lane Undivided)

Table 10 summarizes the hydraulic performance indicators resulting from applying the design and check flows to the proposed culvert geometry at each culvert site. The hydraulic sizing of the 14th Concession East Drain at South Talbot Road Extension, the unnamed drain at Sta. 14+018, Essex Outlet Drain, and Talbot Road South Drain Branch 'A' were established based on the design criteria in **Table 3**. Key design considerations included achieving the required clearance and/or freeboard depths and maintaining existing headwater elevations at the crossing to avoid impacts on drainage infrastructure upstream of the Highway 3 corridor, notably at Essex Outlet Drain. **Table 10** summarizes the final hydraulic sizing based on an iterative design process for each of the four 'new' culvert locations.

The proposed new culvert crossing 14th Concession Drain has been sized based on the future profile of South Talbot Road. Currently, the existing profile of the service road located west of the crossing results in deficient freeboard for the new culvert. Under future conditions, it is expected that the existing service road profile will be improved and required freeboard depths are achieved. The proposed culvert configuration has been established based on freeboard and minimum cover for the structure at the proposed 14th Concession East Drain crossing location.

Complex geotechnical and construction staging requirements for the proposed Highway 3/Victoria Avenue overpass structure/embankment required that culvert options be developed for Essex Outlet Drain. The following describes the layout characteristics of three crossing options:

Option 1 – On-line Culvert Replacement

Option 1 includes the construction of a new 'on-line' culvert oriented along the existing Essex Outlet Drain channel. With this option, the existing Essex Outlet Drain culverts crossing existing Highway 3 would be replaced within a single span structure to convey flow from the north side of the proposed overpass embankment to the south side of the right-of-way. The location and skew of the proposed culvert would result in an overall required length of approximately 95 m from north toe of slope to south toe of slope. There will be a net 60 m reduction in the length of open-channel resulting from the removal of the existing multi-cell culvert arrangement and construction of the proposed on-line culvert.

The on-line replacement strategy for the Essex Outlet Drain would require that the culvert be constructed prior to the construction of the Highway 3 overpass embankment. The use of light-weight fill will, therefore, likely be required to minimize the negative impacts of settlement on the newly constructed culvert. The on-line requirement of the Essex Outlet Drain culvert will minimize the length of open channel required to be maintained in the future but would introduce a lengthy culvert that would be both complicated and costly to maintain. To maintain a consistent configuration with the downstream channel, the Essex Outlet Drain channel will have a trapezoidal cross-section with a 3 m to 4 m bottom width. Erosion and scour protection for the culvert and channel will be minimal due to the aligned nature of the crossing. Inlet and outlet erosion protection will include a rip-rap apron protecting the side slopes of the channel to the top of banks. Rip-rap protection will consist of Type I rock protection with geotextile. Based on the hydraulic characteristics of the existing drain (a wide flat bottom and low gradient profile), it is expected that future maintenance will primarily involve removal of accumulated sediments discharged from the enclosed portion of the municipal drain within the Town of Essex.

In addition to the main Essex Outlet Drain culvert under Highway 3, an additional culvert or modified storm sewer outlet arrangement is required to accommodate the proposed municipal road improvements at the intersection of South Talbot Road and Victoria Avenue. The proposed improvements include 2.0 m wide on-street parking bays, the use of 15 m radius curves at all four quadrants of the intersection and the addition of a multi-use trail paralleling the roadway. For the on-line replacement strategy, the additional culvert or modified storm sewer outlet system will be aligned with the existing Essex Outlet Drain and have to include a headwall arrangement to accommodate the adjacent fill slopes from South Talbot Road and Victoria Avenue. The proposed outlet arrangement will extend approximately 20 m in a southerly direction. The downstream end of the outlet arrangement will be located close to the inlet of the Essex Outlet Drain Highway 3 culvert, further complicating future maintenance of both the outlet arrangement and municipal drain culvert.

Option 2 – Municipal Drain Diversion to westerly crossing outside of Highway 3/Victoria Avenue Overpass Embankment

Option 2 includes the construction of a new ‘off-line’ municipal drain diversion to relocate the Essex Outlet Drain culvert under Highway 3, approximately 300 m west of its current location. This location would require the construction of approximately 600 m of municipal drain channel along the north and south side of the Highway 3 right-of-way and a 94.6 m long culvert to convey flows through the proposed overpass embankment. The location and configuration of the proposed culvert requires an overall length of approximately 95 m from the north side of the existing Highway 3 highway embankment to the toe of slope of the new embankment. There will be a net 540 m increase in the length of open-channel resulting from the removal of the existing multi-cell culvert arrangement and construction of the proposed culvert and a 55 m increase in the length of culvert compared to existing conditions.

The drain diversion replacement strategy for the Essex Outlet Drain will allow the culvert to be constructed prior to the construction of the Highway 3 overpass embankment in an area of low fill height. The low fill height will minimize the negative effects of settlement on the newly constructed culvert and allow a standard pre-cast concrete box culvert section to be used. To construct the drain diversion while maintaining the existing Highway 3 roadway configuration, the drain will have to be temporarily realigned between existing Highway 3 and South Talbot Road. The temporary alignment of the channel requires the use of a trapezoidal channel with a 4.0 m bottom width and 2:1 side slopes to fit between the existing Highway 3 and South Talbot Road alignments. After existing Highway 3 is decommissioned, drainage channel enhancements, including modification of the alignment and integration with the proposed multi-use trail system, could be completed.

In addition to the main Essex Outlet Drain culvert under Highway 3, an additional culvert or modified storm sewer outlet arrangement is required to accommodate the proposed municipal road improvements at the intersection of South Talbot Road and Victoria Avenue. The proposed improvements include 2.0 m wide on-street parking bays, the use of 15 m radius curves at all four quadrants of the intersection and a new multi-use trail paralleling the roadway. For the municipal drain diversion strategy, the additional culvert or modified storm sewer outlet system will be aligned to direct flows in a westerly direction along the north side of existing Highway 3. The proposed outlet arrangement will extend approximately 25 m in a westerly direction.

The hydraulic performance assessments of the remaining culverts to be extended as part of the Highway 3 improvements are also summarized in **Table 10**. With the exception of the Barlow Drain, all of the proposed culvert modifications result in acceptable levels of performance when compared to existing conditions and required design criteria for the crossing locations. As mentioned, although the existing Barlow Drain culvert surcharges under design flow conditions and does not provide the required 0.3 m of clearance from the calculated headwater elevation to the underside of soffit, it does achieve the required freeboard depth at the crossing location. Under proposed conditions, the Barlow Drain culvert continues to operate with deficient clearance, surcharging to a depth of approximately 0.3 m above the soffit of the culvert inlet, but does achieve the required freeboard depth of 1.0 m measured from the projected headwater elevation to the Highway 3 low edge of pavement near the culvert. The structure’s hydraulic performance is only marginally reduced, compared to existing conditions, for the interim 50.9 m length required to accommodate the Highway 3 4-lane divided to 2-lane undivided lane transition at the east project limit. Since there is no history of flooding at this location and the existing open-footing concrete culvert is in good condition, it is recommended that this culvert not be replaced because it has insufficient clearance. Consideration should be given to future municipal drain maintenance to improve the gradient of the existing channel, improve the cross-sectional area of the channel and lower tail-water conditions at the culvert outlet. Municipal Drain improvements to lower the existing channel by approximately 0.3 m will result in approximately 0.2 m of clearance at the inlet of the culvert.

Table 10 includes a range of hydraulic performance indicators, such as headwater depth to height ratio, flow regime, outlet velocities and freeboard/clearance values, for each of the culvert sites impacted by improvements to the Highway 3 corridor.

Table 10: Proposed Culvert Hydraulic Performance Assessment Summary

Crossing Location	Proposed Culvert Configuration (Width x Height x Length)	Design Storm Computed Headwater Elevation	Headwater Depth/ Height Ratio	Flow Regime	Check Storm Outlet Velocity (m/s)	Resultant Freeboard (m)	Resultant Clearance (m)
Hyland Drain (CR8)	1830 mm x 1520 mm x 28.55 m	192.810	77%	Subcritical	1.92	1.05	n/a
Extended 14th Concession East Drain	3050 mm x 1524 mm x 60.29 m	192.940	75%	Subcritical	1.13	1.13	0.37
New Proposed 14th Concession East Drain (South Talbot Road Extension)	3050 mm x 1524 mm x 29.74 m	192.930	66%	Subcritical	1.13	0.47 (Reference from Existing Service Road Profile Sag)	0.51
Proposed Unnamed Drain	825 mm x 54.84 m	193.560	48%	Subcritical	1.47	1.35	n/a
Proposed Essex Outlet Drain	4260 mm x 2440 mm x 97.95 m	193.650	88%	Subcritical	1.59	1.28	0.30
Proposed Talbot Road South Drain A	1200 mm x 50.15 m	194.230	66%	Subcritical	2.38	1.02	n/a

Crossing Location	Proposed Culvert Configuration (Width x Height x Length)	Design Storm Computed Headwater Elevation	Headwater Depth/ Height Ratio	Flow Regime	Check Storm Outlet Velocity (m/s)	Resultant Freeboard (m)	Resultant Clearance (m)
Canaan Drain	3350 mm x 2070 mm x 68.45 m	192.750	73%	Subcritical	1.59	2.51	n/a
Talbot Road South Drain B	3050 mm x 1220 mm x 51.99 m	193.700	34%	Subcritical	1.81	1.58	0.80
East Townline/West Townline Drain	3660 mm x 2100 mm x 74.42 m	193.350	67%	Subcritical	1.06	2.11	0.70
Russell Drain	3050 mm x 1650 mm x 55.18 m	193.000	38%	Subcritical	1.61	2.45	1.02
Barlow Drain (Interim 4-Lane to 2-Lane Transition Length)	2400 mm x 1830 mm x 50.9 m	194.250	108%	Surcharged	1.52	1.20	-0.14

The detailed CulvertMaster Hydraulic output data for the proposed condition assessment is included in **Appendix C**.

3.2.3 Site Specific Impact Summary and Mitigation Strategy

Hyland Drain – County Road 8/Pinkerton Road Intersection

The realignment of Pinkerton Road and the addition of an intersection along the County Road 8 corridor results in the need for an additional crossing of the Hyland Municipal Drain. The proposed culvert is 28.55 m in length and is oriented parallel to the County Road 8 centerline on the northerly side of the road corridor. The existing Hyland Drain channel is very flat with projected flow velocities below 2.0 m/s. The projected flow velocities will be mitigated by using standard R50 rip-rap apron at the inlet and outlet of the proposed culvert. The rip-rap apron will extend from the bottom of ditch to an elevation of 192.810 or to the top of bank of the channel immediately up and downstream of the crossing. The low projected velocities will allow the bottom of the drain channel to remain natural and allow for vegetation to re-establish following the completion of construction. In total, 28.55 m of existing open-channel will be replaced with concrete box culvert. The configuration of the erosion protection system is illustrated on Sheet NC12 of the preliminary new construction drawings.

14th Concession East Drain – Highway 3

The proposed 33.34 m culvert extension will be oriented parallel to the existing culvert. The existing 14th Concession East Drain channel is aligned with the existing culvert and will not require alignment modifications beyond the right-of-way. The proposed culvert extension results in a small decrease in outlet velocities and a small decrease in resultant clearance. The projected flow velocities will be mitigated by using standard R50 rip-rap apron at the inlet and outlet of the proposed culvert. The rip-rap apron will extend from the bottom of ditch to an elevation of 192.930 or to the top of bank of the channel immediately up and downstream of the crossing. The low projected velocities will allow the bottom of the drain channel to remain natural and allow for vegetation to re-establish following the completion of construction. In total, 33.34 m of existing open-channel will be replaced with concrete box culvert. The configuration of the erosion protection system is illustrated on Sheet NC6 of the preliminary new construction drawings.

14th Concession East Drain – South Talbot Road Extension

The new proposed 29.74 m long culvert will be oriented perpendicular to the proposed extension of South Talbot Road. The existing 14th Concession East Drain, referred to as Rush Drain north of the Highway 3 corridor, will enter the proposed culvert by making a 90 degree turn immediately upstream of the new culvert. The dramatic change in the alignment will require the addition of erosion/scour protection on the outside of the bend in the channel. The close proximity of the bend to the inlet of the culvert will result in a 10 m section of the outside of the drain channel being lined with rip-rap to an elevation of 192.940 or the top of bank. Based on the configuration of channel and culvert inlet, it is recommended that Type I rock protection be used on the outside of the channel bend immediately upstream of the proposed new culvert crossing South Talbot Road. A standard R50 rip-rap apron will be used at the culvert to mitigate potential erosion of the channel side slopes at the culvert outlet. The configuration of the erosion protection system is illustrated on Sheet NC6 of the preliminary new construction drawings.

Unnamed Drain

The existing Unnamed Drain 750 mm CSP culvert crossing Highway 3 at Sta. 14+019 will be replaced with a 825 mm concrete pipe or a circular culvert of an equivalent material to meet the MTO's required 75-year Design Service Life. The proposed culvert hydraulics result in moderate to low projected inlet and outlet velocities requiring a standard R50 rip-rap apron to control potential scour and erosion. The configuration of the erosion protection system is illustrated on Sheet NC7 of the preliminary new construction drawings.

Essex Outlet Drain

The proposed location of the Essex Outlet Drain crossing of Highway 3 requires the construction of approximately 600 m of municipal drain channel along the north and south side of the highway right-of-way and a 94.6 m long culvert to convey flows through the proposed overpass embankment. It is anticipated that the drainage works will be constructed in the following sequence:

- Construction of the permanent Essex Outlet Drain culvert approximately 300 m west of Victoria Avenue (Sta. 14+485) will be completed off-line from the existing drainage system. Installation of the culvert crossing existing Highway 3 will require construction staging with temporary lane restrictions to facilitate installation of the northerly portion of the new culvert
- Following completion of the culvert, the diversion channel along the north and south side of the Highway 3 right-of-way will be constructed off-line from the existing drainage system. Flows will be maintained through the existing culvert until grading works are completed and erosion protection measures have been constructed
- When the municipal drain diversion works are completed, flows from the existing drain will be directed to the new diversion channel and culvert. At this time, the existing culvert and channel crossing the highway right-of-way can be abandoned and construction of the preload/overpass embankment can begin
- Following the preloading/consolidation stage of the Highway 3 overpass embankment construction, traffic will be shifted to the eastbound lanes of new Highway 3 and existing Highway 3 will be removed, including the existing Essex Outlet Drain culverts.

Since the existing Essex Outlet Drain culverts and channel will be maintained during construction of Highway 3 and the new Essex Outlet Drain diversion, a temporary flow passage system at Essex Outlet Drain will not be required. Following the decommissioning and removal of the existing Highway 3 roadway embankment, the 300 m channel along the north side of the right-of-way could be modified to include additional environmental enhancements, such as a widened floodplain, benched side-slopes for enhanced landscaping and a meandering low-flow channel. A widened floodplain and benched side-slopes would dramatically improve the conveyance capacity of the channel and provide enhanced storage of runoff volume and subsequent attenuation/reduction of flows conveyed to the downstream municipal drain channel. Following removal of the existing Highway 3 roadway embankment, there will be an opportunity to shorten the Essex Outlet Drain culvert by removing the northerly section of the culvert (27 m) that was installed to accommodate existing Highway 3. These enhancements are over and above the basic design requirements for the crossing but would serve to enhance the natural system within the right-of-way and downstream of the Highway 3 corridor.

The proposed Essex Outlet Drain alignment utilizes a curvilinear alignment with smooth transitions in the open-channel portion of the drain to minimize long-term erosion potential. To avoid dramatic bends in the open-channel at the inlet and outlet of the Essex Outlet Drain culvert, 45 degree bends have been incorporated into the up and downstream ends of the culvert. Erosion potential resulting from the bends will be mitigated by using a closed footing pre-cast culvert arrangement and 1.2 m cut-off walls at the inlet and outlet of the proposed culvert. Erosion protection measures, in the form of rip-rap channel lining, have been incorporated into the Essex Outlet Drain channel design at critical locations, such as bends along the channel alignment and transitions at the inlets and outlets of critical culvert locations. The channel lining will consist of 300 mm thick Type I rock protection with geotextile and include a 600 mm key at the toe of slope to mitigate potential degradation of the channel side-slopes. The channel lining will be extended from the toe of slope to an elevation of 193.650. The channel itself will incorporate a 4 m bottom width and 2:1 side-slopes. Side-slopes not protected with rip-rap or rock protection will incorporate the use of erosion control blanket to protect slopes prior to the re-establishment of vegetation within the channel. Erosion control blanket will extend from the toe to the top of channel bank along the entire length of the Essex Outlet Drain realignment.

Essex Outlet Drain represents the ultimate outlet for a large urban storm drainage system within the Town of Essex. An additional culvert or modified storm sewer outlet arrangement is required to accommodate the proposed municipal road improvements at the intersection of South Talbot Road and Victoria Avenue. As previously described, the proposed improvements include 2.0 m wide on-street parking bays, the use of 15 m radius curves at all four quadrants of the intersection and a new multi-use trail paralleling the roadway. The proposed outlet arrangement, consisting of a pre-cast or cast-in-place junction maintenance hole will consolidate the three existing storm sewer systems into one outlet. The outlet section, proposed to be a 4260 mm x 2440 mm box section similar in size to the main Essex Drain crossing of Highway 3, will extend approximately 25 m in a westerly direction. The preliminary design sizing for the outlet structure has been completed assuming that the storm sewer systems connected to the Victoria Street outlet are capable of conveying the 50-Year design storm. As previously described, the Town's Drainage Master Plan Study currently under way will further refine the design flows at this outlet location and therefore confirmation of the size of the outlet structure will be required during detailed design.

In existing conditions, the urban storm drainage system delivers a significant amount of sediment from road maintenance activities within the upstream drainage area. Much of the urban drainage system consists of small diameter storm sewers and drainage tiles connected to front and rear yard catch basins. Surface drainage is facilitated by shallow grass swales which effectively reduce the volume of sediments conveyed to the main drainage system. As urban intensification occurs within the upstream drainage area, it is anticipated that the existing grass swales will be replaced by traditional curb and gutter and more formal storm drainage systems which will inherently deliver increased amounts of sediment from paved surfaces within the drainage area. Total suspended solids (TSS) originating from the urban portion of the drainage area are a concern for two reasons. First, TSS carries with it pollutants, heavy metals and hydrocarbons and is often the cause of degraded water quality within municipal drain systems. Second, TSS is generally the source of most of the sediment within a municipal drain system. Deposition of TSS by way of sedimentation often leads to channel and culvert infilling and a reduction in hydraulic conveyance capacity.

To mitigate water quality and future maintenance (sediment removal) issues for the urban drainage system, the Essex Outlet Drain channel incorporates the following features to promote sedimentation prior to surface flow reaching the proposed Essex Outlet Drain culvert:

- The curvilinear design of the channel alignment maximizes the overall length of open channel prior to flow entering the proposed culvert under Highway 3
- The channel gradient and bottom width have been widened and flattened to further promote TSS settlement and the additional surface area maximizes potential for vegetative uptake
- Incorporation of two OPSD 219.211 permanent rock flow check dams into the northerly portion of the channel, further promoting TSS settlement in an area that can be easily accessed for future maintenance (by the municipality) via the multi-use trail system. Sediment removal in the area upstream of the proposed Highway 3 culvert will reduce future maintenance requirements for MTO’s drainage infrastructure at the crossing and within the southerly portion of the drain channel.

The proposed Essex Outlet Drain alignment, culvert and channel enhancements are illustrated on Sheets NC8 and NC9 of the preliminary new construction drawings. The preliminary configuration of the Essex Outlet Drain at Victoria Road is described in more detail in the Dillon prepared Structural Design Report for Storm Sewer Outlet Site No. 6-413/C.

Talbot Road South Drain Branch 'A'

The existing Talbot Road South Drain Branch 'A' consists of a 750 mm CSP culvert crossing Highway 3 at Sta. 15+490 which will be replaced with a 1200 mm concrete pipe or a circular culvert of an equivalent material to meet MTO's required 75-year Design Service Life. The proposed culvert hydraulics result in moderate projected inlet and outlet velocities that will require a standard R50 rip-rap apron to control potential scour and erosion. To minimize the length of the culvert, a 25 m channel realignment is required at the downstream end of the culvert. To protect against future erosion, the portion of the channel within the Highway 3 right-of-way will be lined with standard R50 rip-rap. The configuration of the erosion protection system is illustrated on Sheet NC11 of the preliminary new construction drawings.

Canaan Drain

The existing Canaan Drain culvert will be extended to the north and south 42.14 m. The proposed culvert extension will be oriented parallel to the existing culvert and eliminate the need for the existing concrete retaining wall system at the inlet and outlet of the culvert. At the downstream end of the culvert, the Canaan Drain will require a 32 m realignment to direct flows from the extended culvert to the existing drain channel south of the Highway 3 right-of-way. The proposed culvert extension results in a small increase in outlet velocities and a small decrease in resultant clearance. The existing culvert inlet is protected by an extensive rip-rap apron which will be modified to suit the upstream culvert extension. The projected flow velocities will be mitigated by the use of a standard R50 rip-rap apron at the outlet of the proposed culvert and extended to include the bend in the channel near the south right-of-way limit. The rip-rap apron will extend from the bottom of ditch to an elevation of 192.750. The low projected velocities will allow the bottom of the drain channel to remain natural and for vegetation to re-establish following the completion of construction. The configuration of the erosion protection system is illustrated on Sheet NC12 of the preliminary new construction drawings.

Talbot Road South Drain Branch 'B'

The existing Talbot Road South Drain culvert will be extended to the south 32.79 m. The proposed culvert extension will be oriented parallel to the existing culvert. There is no formal drain channel south of the Highway 3 right-of-way so the existing roadside ditches that intercept overland flow from the drainage area to the south will be reconstructed along the new eastbound lanes. Flow from the roadside ditches will be directed to the upstream (south) end of the culvert extension. The proposed culvert extension results in a negligible change in outlet velocities and resultant clearance. The projected flow velocities will be mitigated by standard R50 rip-rap apron at the inlet and outlet of the proposed culvert. The rip-rap apron will extend from the bottom of ditch to an elevation of 193.700. The low projected velocities will allow the bottom of the drain channel on the north side of the right-of-way to remain natural and for vegetation to re-establish following the completion of construction. A continuous rip-rap apron will be used on the upstream end of the culvert since there is no formal channel to protect from erosion and scour. The configuration of the erosion protection system is illustrated on Sheet NC13 of the preliminary new construction drawings.

East Townline/West Townline Drain

The existing East Townline/West Townline Drain culvert will be extended to the south 32.79 m. The proposed culvert extension will be oriented parallel to the existing culvert. The existing drain channel extends parallel with the existing culvert in the northerly and southerly direction outside the Highway 3 corridor. No additional channelization or channel improvements are necessary at the inlet and outlet of the proposed culvert. The proposed culvert extension results in a negligible change in outlet velocities and resultant clearance. The projected flow velocities will be mitigated by standard R50 rip-rap apron at the inlet and outlet of the proposed culvert. The rip-rap apron will extend from the bottom of ditch to an elevation of 193.350. The low projected velocities will allow the bottom of the drain channel on the north side of the right-of-way to remain natural and for vegetation to re-establish following the completion of construction. The configuration of the erosion protection system is illustrated on Sheet NC15 of the preliminary new construction drawings.

Russell Drain

The existing Russell Drain culvert will be extended to the north and south 29.52 m. The proposed culvert extension will be oriented parallel to the existing culvert and eliminate the need for the existing concrete retaining wall system at the inlet and outlet of the culvert. At the downstream end of the culvert, the Russell Drain will require a 20 m realignment to direct flows from the extended culvert to the existing drain channel south of the Highway 3 right-of-way. The proposed culvert extension results in a small increase in outlet velocities and a small decrease in resultant clearance. The projected flow velocities will be mitigated by the use of a standard R50 rip-rap apron at the outlet of the proposed culvert and extended to include the bend in the proposed channel near the south right-of-way limit. The upstream end of the proposed culvert extension requires an irregularly shaped rip-rap apron based on the configuration of the ditches. The rip-rap apron will extend from the bottom of ditch to an elevation of 193.000. The low projected velocities will allow the bottom of the drain channel to remain natural and for vegetation to re-establish following the completion of construction. The configuration of the erosion protection system is illustrated on Sheet NC16 of the preliminary new construction drawings.

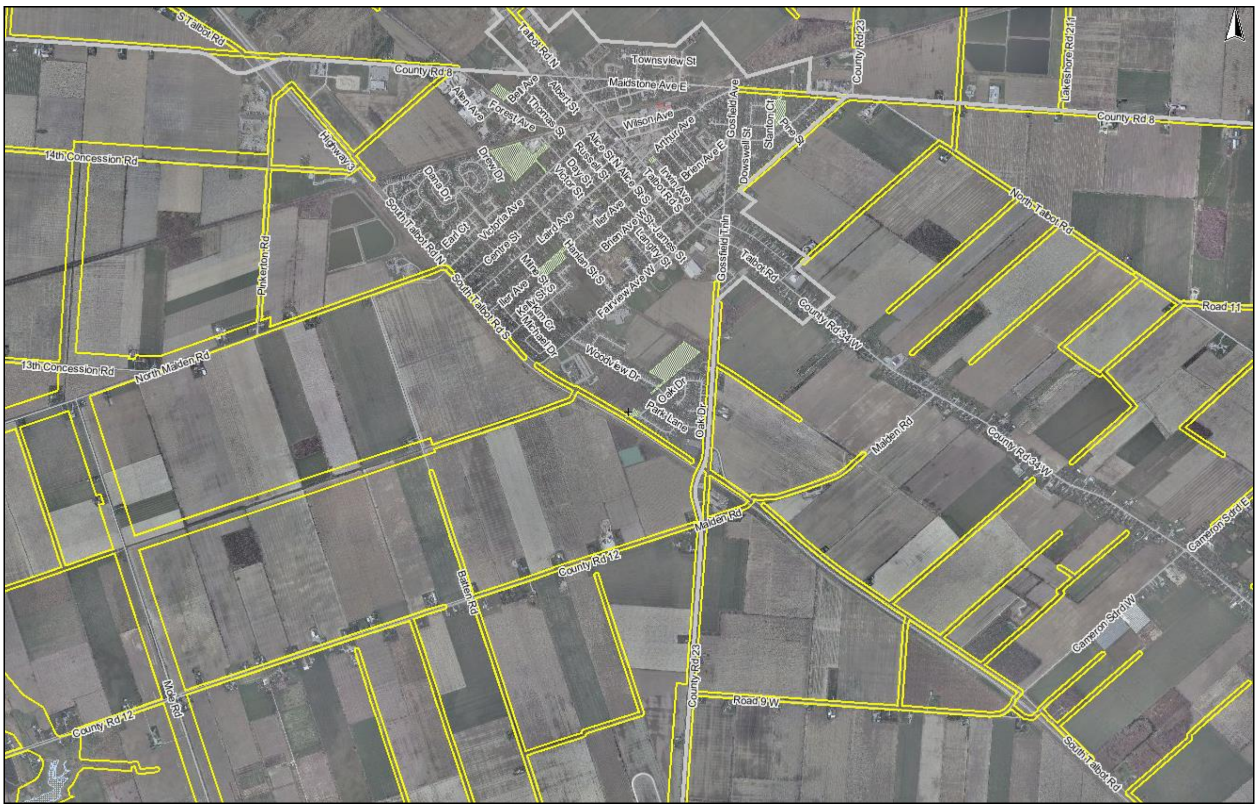
Barlow Drain

The existing Barlow Drain culvert will be extended to the north and south 22.32 m. The required culvert extension at the Barlow Drain accommodates the proposed 4-lane to 2-lane transition back to the existing highway cross-section. In the future, the Barlow Drain culvert will require an additional extension to the south to accommodate the ultimate 4-lane divided highway configuration. Based on the hydraulic assessment completed for the drain, additional downstream improvements to the municipal drain will be required when the ultimate highway configuration is constructed. The proposed culvert extension will be oriented parallel to the existing culvert and eliminate the need for the existing concrete retaining wall system at the inlet of the culvert. At the upstream end of the culvert, the Barlow Drain will require a 10 m realignment to direct flows from the existing drain channel north of the Highway 3 right-of-way to the extended culvert inlet. The proposed culvert extension results in a small increase in outlet velocities and a small decrease in resultant clearance for the interim Highway 3 configuration. The projected flow velocities will be mitigated by the use of a standard R50 rip-rap apron at the outlet of the proposed culvert. The proposed rip-rap apron at the upstream end of the proposed culvert extension will tie into rip-rap protection located downstream of the culvert crossing South Talbot Road immediately north of the Highway 3 corridor. The rip-rap apron will extend from the bottom of ditch to an elevation of 194.250. The low projected velocities will allow the bottom of the drain channel to remain natural and for vegetation to re-establish following the completion of construction. The configuration of the erosion protection system is illustrated on Sheet NC20 of the preliminary new construction drawings.

3.3 Design Considerations for Regulatory Storm and Floodplain Mapping Elevations

The results of the hydraulic analysis of the existing and proposed culvert hydraulic performance were also compared against Essex Region Conservation Authority (ERCA) Regulatory Floodplain mapping for the area impacted by highway improvements within the Highway 3 corridor. **Figure 4** illustrates the regulated watercourses within the Highway 3 corridor. The regulatory limits shown in **Figure 4** were established based on generic regulations and standard watercourse/drain offsets. None of the watercourses/drains within the study limits have been hydraulically modeled to establish floodwater elevations.

Figure 4: ERCA Regulatory Mapping along Highway 3 Corridor



To assess the impacts that the proposed culvert modifications will have on the regulated areas associated with each of the municipal drains crossing the Highway 3 right-of-way, the 100-year (Regulatory Event) design flows were applied to the existing and proposed culvert configurations. The headwater elevations resulting from the proposed culvert geometry at each of the crossing locations were compared with the headwater elevations generated in existing condition. **Table 11** summarizes the existing and proposed condition headwater elevations resulting from the 100-year design flows at each culvert crossing location. All existing non-rigid frame culverts shall be extended with box culverts, and the horizontal elliptical corrugated structural pipe culvert (Site No. 6-588/C – Canaan Drain Culvert) shall be extended with a horizontal elliptical structural plate corrugated steel pipe. In the locations that the crossing culvert is being replaced, the proposed headwater elevations have either been maintained or improved. The extensions required to accommodate improvements to Highway 3 result in headwater increases between 0.02 m and 0.06 m for the 100-year design flows. Mitigation for the noted increase in headwater elevations at 14th Concession East, Canaan, Talbot Road South, East/West Townline, Russell and Barlow Drain is not anticipated at this time. Confirmation of the final culvert geometry and hydraulic impacts on the regulated lands will be assessed during the final detailed design of the crossings.

Table 11: Summary of Impacts for the Regulatory (100-Year) Storm Event

Crossing Location	Existing Culvert Configuration (Width x Height x Length)	Existing Design Storm Computed Headwater Elevation	Proposed Culvert Configuration (Width x Height x Length)	Proposed Design Storm Computed Headwater Elevation	Change in Projected Headwater Elevation (m)
Proposed Hyland Drain (CR8)	NEW	NEW	1830 mm x 1520 mm x 28.55 m	192.920	N/A
Extended 14th Concession East Drain	3050 mm x 1524 mm x 26.95 m	192.990	3050 mm x 1524 mm x 60.29 m	193.020	+0.030
New Proposed 14th Concession East Drain (South Talbot Road Extension)	NEW	NEW	3050 mm x 1524 mm x 29.74 m	193.080	N/A
Proposed Unnamed Drain	750 mm x 29.67 m	193.830	825 mm x 54.84 m	193.600	-0.230
Proposed Essex Outlet Drain	3600 mm x 1830 mm x 36.79 m and 1830 mm x 1220 mm x 40.16 m	193.880	4260 mm x 2440 mm x 97.95 m	193.810	-0.070
Proposed Talbot Road South Drain A	750 mm x 22.31 m	195.690	1200 mm x 50.15 m	194.330	-1.360
Canaan Drain	3350 mm x 2070 mm x 26.28 m	192.830	3350 mm x 2070 mm x 68.45 m	192.890	+0.060
Talbot Road South Drain B	3050 mm x 1220 mm x 22.76 m	193.740	3050 mm x 1220 mm 51.99 m	193.760	+0.020

Crossing Location	Existing Culvert Configuration (Width x Height x Length)	Existing Design Storm Computed Headwater Elevation	Proposed Culvert Configuration (Width x Height x Length)	Proposed Design Storm Computed Headwater Elevation	Change in Projected Headwater Elevation (m)
East Townline/West Townline Drain	3660 mm x 2100 mm x 41.63 m	193.430	3660 mm x 2100 mm x 74.42 m	193.450	+0.020
Russell Drain	3050 mm x 1650 mm x 25.66 m	193.000	3050 mm x 1650 mm x 55.18 m	193.050	+0.050
Barlow Drain (Interim 4-Lane to 2-Lane Transition Length)	2400 mm x 1830 mm x 28.58 m	194.210	2400 mm x 1830 mm x 50.9 m	194.250	+0.040

4. IMPACT MITIGATION

4.1 General Erosion and Scour Protection

As described in the previous sections of this report, it is anticipated that standard erosion and scour protection systems will be adequate to protect receiving water systems within the project limits. To guard against future channel down-cutting and potential undermining of the proposed new culverts and culvert extensions, it is recommended that cut-off walls with a standard depth of 1.2 m be integrated into the proposed culvert arrangements.

In general, disturbance of existing well-vegetated roadway embankment and channel slopes should be avoided where possible. Where disturbance of vegetative slopes is unavoidable and point-discharge from spillways and storm sewers will be directed along slopes and ditches, it is recommended that standard R50 rip-rap aprons be installed with underlying geotextile to control the migration of fine-grained soils from under the rip-rap. Rip-rap protection should be installed to an elevation matching the proposed/existing ditch grades to avoid creating barriers for surface water runoff.

For newly graded roadway embankment slopes, erosion control blanket should be placed on all slopes exceeding 3:1, particularly those slopes located directly adjacent to the Essex Outlet Drain. Standard silt fence should be placed at the base of disturbed slopes parallel with the drain channel to guard against sediment entering the drain channel during construction. For newly graded “v” and flat-bottom ditches, temporary straw bale flow checks should be placed at critical junctions with undisturbed ditches, in locations of grade changes, and immediately upstream of receiving watercourses. The proposed permanent sediment and erosion control systems are illustrated on Sheets NC1 to NC24 of the preliminary new construction drawings.

4.2 Fisheries Mitigation

Although the municipal drain culverts within the study area do not present sensitive fish habitat, where feasible a low flow channel will be constructed within the base of the drain throughout the length of the proposed culvert extensions. With exception to the Canaan Drain culvert the proposed culvert configurations provide approximately 300 mm of embedment depth to accommodate the low flow channel design and to facilitate fish passage through the culvert. For all major drains, erosion protection in the form of rip-rap or rock-protection channel lining has been limited to the side slopes of the channels. Continuous rip-rap aprons have only been used where fisheries resources will not be compromised. The proposed Essex Outlet Drain channel represents a significant increase in fish habitat within the Highway 3 right-of-way. Approximately 600 m of new open channel will be introduced within the right-of-way. The channel will consist of a trapezoidal section with a 4 m bottom width and 2:1 side slopes. Critical bends in the channel alignment will be protected from local erosion with rip-rap. The full length of the channel will also be protected with erosion control blanket on all 2:1 channel side slopes. OPSD 219.211 rock flow check dams will also be incorporated into the Essex Outlet Drain channel along the north side of the Highway 3 right-of-way to promote sedimentation and improve water quality in an area of the drain that can easily be maintained in the future.

4.3 Preliminary Temporary Flow Passage System Design

The new and proposed culvert extensions included as part of the Highway 3 improvements will require a temporary flow passage system to provide a dry work area for material, equipment and personnel involved with the improvement works. The return period for the design of drainage measures during construction was assessed based on site specific information including the length of anticipated construction, construction methodology, public safety, worker safety, flooding potential and environmental impacts. Based on the requirements of TW-1 Section 1.2, the minimum return period for temporary drainage work at the municipal drain culverts within the project limits is the 2-Year return period storm. **Table 12** summarizes the relevant flow data for the full range of design storms and highlights the 2-Year flows for the structural and non-structural culverts.

Table 12: Temporary Flow Passage Requirements

Return Period (years)	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Hyland Drain (CR8)	0.8	1.0	1.3	1.5	1.7	1.9
14th Concession Drain	1.0	1.3	1.7	2.1	2.6	3.3
14th Concession Drain – South Talbot Road Extension	1.0	1.3	1.7	2.1	2.6	3.3
Unnamed Drain	0.1	0.1	0.1	0.1	0.2	0.2
Essex Outlet Drain	6.1	7.8	10.0	12.2	15.3	19.9
Talbot Road South Drain A	0.4	0.5	0.6	0.7	0.9	1.2
Canaan Drain	1.9	2.4	3.1	3.8	4.8	6.3
Talbot Road South Drain B	0.4	0.5	0.7	0.8	1.0	1.3
East Townline/West Townline Drain	1.1	1.3	1.8	2.1	2.7	3.5
Russell Drain	0.5	0.6	0.9	1.0	1.3	1.7
Barlow Drain	1.6	1.9	2.6	3.9	4.9	6.4

Based on the unique characteristics of the municipal drain crossing locations, the following temporary flow passage methods are considered feasible:

- Dam and divert
- Dam and pump.

The feasibility of the dam and divert or dam and pump system depends on the volume of water flow at the site. These options involve damming the waterway upstream and redirecting the water either across the roadway, through the existing culvert or through a temporary culvert installed adjacent to the existing culvert. The diversion through the existing culvert or through a temporary culvert could be accomplished using by-pass pipe(s), sandbags to separate flows or using small diameter discharge pipe(s) from a pumping operation. The dam and divert or dam and pump system can provide feasible solutions for providing a dry working space for short duration works but the expectation is the critical work which is to be completed in the dry is completed during periods of low-flows.

For the municipal drain culverts within the study limits, both systems are considered feasible. The dam and divert method is best suited for the cast-in-place culvert option where excavation adjacent to the existing culvert, installation of a temporary pipe, and backfilling in order to accommodate construction staging is possible. The dam and pump method is being considered for the pre-cast concrete box culvert option in order to facilitate installation of the new culvert with minimal impact on the roadway above. For both systems, the waterway upstream of the culvert would be dammed and the water redirected through the pipe. The diversion pipe would be a gravity pipe (small diameter HDPE pipe) or a small diameter discharge pipe constituent of the pumping operation. The site specific temporary flow passage system design for each crossing location is detailed in the individual Culvert Structural Design Reports.

DILLON CONSULTING LIMITED
LONDON, ONTARIO

Nicholas Krygsman, P.Eng.
Water Resource Engineer

APPENDIX A

Visual Otthymo Hydrologic Modeling Output

Existing Conditions Flows

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================================================================================
========================

       V    V   I    SSSSS  U   U    A    L
       V    V   I    SS     U   U   A A   L
        V  V    I     SS    U   U  AAAAA  L
        V  V    I      SS   U   U  A   A  L
         VV     I    SSSSS  UUUUU  A   A  LLLLL

        OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O

        OOO     T      T    H   H    Y    M   M   OOO
```

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***** D E T A I L E D   O U T P U T *****

Input   filename: C:\Program Files\Visual OTTHYMO 2.2.4\voin.dat

Output filename: j:\PROJECTS\DRAFT\126452 Highway 3 Widening\Drainage & Hydrology\Hwy3CulvertHydrology\Existing Conditions Flows.out
Summary filename: j:\PROJECTS\DRAFT\126452 Highway 3 Widening\Drainage & Hydrology\Hwy3CulvertHydrology\Existing Conditions Flows.sum

DATE: 15/04/2014   TIME: 12:08:45 PM

USER:

COMMENTS: ____

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  ****************************
  ** SIMULATION NUMBER:   1 **
  ****************************

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```

```
                              Existing Conditions Flows
| CHICAGO STORM    |     IDF curve parameters: A= 823.084
| Ptotal= 40.55 mm |                           B=   7.500
--------------------                           C=    .813
                         used in:   INTENSITY =  A / (t + B)^C

                         Duration of storm  =  6.00 hrs
                         Storm time step    = 10.00 min
                         Time to peak ratio =   .33

                     The CORRELATION coefficient is = 1.0000

                      TIME       INPUT INT.          TAB. INT.
                     (min)        (mm/hr)             (mm/hr)
                        5.         108.10              105.60
                       10.          78.60               80.33
                       15.          65.20               65.48
                       30.          43.20               43.23
                       60.          26.60               26.81
                      120.          16.00               15.98
                      360.           6.80                6.76
                      720.           3.90                3.88
                     1440.           2.20                2.22


                  TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                   .17    1.51 |  1.67    8.34 |  3.17    4.18 |  4.67    1.96
                   .33    1.64 |  1.83   20.77 |  3.33    3.69 |  4.83    1.85
                   .50    1.80 |  2.00   80.33 |  3.50    3.30 |  5.00    1.76
                   .67    2.01 |  2.17   27.39 |  3.67    3.00 |  5.17    1.68
                   .83    2.28 |  2.33   14.19 |  3.83    2.74 |  5.33    1.61
                  1.00    2.64 |  2.50    9.52 |  4.00    2.53 |  5.50    1.54
                  1.17    3.14 |  2.67    7.17 |  4.17    2.36 |  5.67    1.48
                  1.33    3.93 |  2.83    5.77 |  4.33    2.20 |  5.83    1.42
                  1.50    5.30 |  3.00    4.84 |  4.50    2.07 |  6.00    1.37


--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0001) |   Area    (ha)=  99.03   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   2.26

     Unit Hyd Qpeak  (cms)=   1.674

     PEAK FLOW       (cms)=    .798 (i)
     TIME TO PEAK    (hrs)=   4.833
```

```
     RUNOFF VOLUME    (mm)=  15.057
     TOTAL RAINFALL   (mm)=  40.549
     RUNOFF COEFFICIENT   =    .371

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB             |
| NASHYD    (0002) |   Area    (ha)=  11.09   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   4.96

     Unit Hyd Qpeak  (cms)=    .085

     PEAK FLOW       (cms)=    .048 (i)
     TIME TO PEAK    (hrs)=   7.833
     RUNOFF VOLUME    (mm)=  15.056
     TOTAL RAINFALL   (mm)=  40.549
     RUNOFF COEFFICIENT   =    .371

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| CALIB             |
| NASHYD    (0003) |   Area    (ha)= 186.85   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   2.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.03

     Unit Hyd Qpeak  (cms)=   6.929

     PEAK FLOW       (cms)=   3.119 (i)
     TIME TO PEAK    (hrs)=   3.167
     RUNOFF VOLUME    (mm)=  17.094
     TOTAL RAINFALL   (mm)=  40.549
     RUNOFF COEFFICIENT   =    .422

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| CALIB             |
| NASHYD    (0004) |   Area    (ha)=  24.84   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.42

     Unit Hyd Qpeak  (cms)=    .668
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```
     PEAK FLOW       (cms)=    .282 (i)
     TIME TO PEAK    (hrs)=   3.833
     RUNOFF VOLUME    (mm)=  15.057
     TOTAL RAINFALL   (mm)=  40.549
     RUNOFF COEFFICIENT   =    .371

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0005) |   Area    (ha)= 129.56   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.71

     Unit Hyd Qpeak  (cms)=   2.894

     PEAK FLOW       (cms)=   1.283 (i)
     TIME TO PEAK    (hrs)=   4.167
     RUNOFF VOLUME    (mm)=  15.057
     TOTAL RAINFALL   (mm)=  40.549
     RUNOFF COEFFICIENT   =    .371

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0006) |   Area    (ha)=  27.63   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.42

     Unit Hyd Qpeak  (cms)=    .743

     PEAK FLOW       (cms)=    .313 (i)
     TIME TO PEAK    (hrs)=   3.833
     RUNOFF VOLUME    (mm)=  15.057
     TOTAL RAINFALL   (mm)=  40.549
     RUNOFF COEFFICIENT   =    .371

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0007) |   Area    (ha)=  97.77   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
```

```
--------------------   U.H. Tp(hrs)=   2.10

     Unit Hyd Qpeak  (cms)=   1.778

     PEAK FLOW       (cms)=    .832 (i)
     TIME TO PEAK    (hrs)=   4.667
     RUNOFF VOLUME    (mm)=  15.057
     TOTAL RAINFALL   (mm)=  40.549
     RUNOFF COEFFICIENT   =    .371

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0008) |   Area    (ha)=  54.82   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   2.52

     Unit Hyd Qpeak  (cms)=    .831

     PEAK FLOW       (cms)=    .407 (i)
     TIME TO PEAK    (hrs)=   5.167
     RUNOFF VOLUME    (mm)=  15.057
     TOTAL RAINFALL   (mm)=  40.549
     RUNOFF COEFFICIENT   =    .371

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0009) |   Area    (ha)= 284.79   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   4.93

     Unit Hyd Qpeak  (cms)=   2.206

     PEAK FLOW       (cms)=   1.238 (i)
     TIME TO PEAK    (hrs)=   7.833
     RUNOFF VOLUME    (mm)=  15.057
     TOTAL RAINFALL   (mm)=  40.549
     RUNOFF COEFFICIENT   =    .371

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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| CALIB              |
| NASHYD    (0010) |   Area    (ha)=  88.96   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   2.94

     Unit Hyd Qpeak  (cms)=   1.156

     PEAK FLOW       (cms)=    .588 (i)
     TIME TO PEAK    (hrs)=   5.667
     RUNOFF VOLUME    (mm)=  15.057
     TOTAL RAINFALL   (mm)=  40.549
     RUNOFF COEFFICIENT   =    .371

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0011) |   Area    (ha)= 104.56   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   3.23

     Unit Hyd Qpeak  (cms)=   1.236

     PEAK FLOW       (cms)=    .644 (i)
     TIME TO PEAK    (hrs)=   6.167
     RUNOFF VOLUME    (mm)=  15.057
     TOTAL RAINFALL   (mm)=  40.549
     RUNOFF COEFFICIENT   =    .371

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
  ****************************
  ** SIMULATION NUMBER:   2 **
  ****************************

--------------------
| CHICAGO STORM    |    IDF curve parameters: A=1347.917
| Ptotal= 49.25 mm |                          B=   9.023
--------------------                          C=    .863
                        used in:   INTENSITY =  A / (t + B)^C

                        Duration of storm  =  6.00 hrs
                        Storm time step    = 10.00 min
                        Time to peak ratio =   .33

                    The CORRELATION coefficient is =  .9999
```

Existing Conditions Flows

TIME (min)	INPUT INT. (mm/hr)	TAB. INT. (mm/hr)
5.	141.60	138.02
10.	102.60	106.08
15.	86.40	86.73
30.	57.40	57.06
60.	35.30	34.88
120.	20.30	20.33
360.	8.30	8.21
720.	4.60	4.56
1440.	2.50	2.52

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
.17	1.43	1.67	9.93	3.17	4.54	4.67	1.92
.33	1.58	1.83	27.11	3.33	3.93	4.83	1.81
.50	1.76	2.00	106.08	3.50	3.47	5.00	1.71
.67	1.98	2.17	36.34	3.67	3.11	5.17	1.62
.83	2.28	2.33	17.93	3.83	2.81	5.33	1.54
1.00	2.69	2.50	11.51	4.00	2.57	5.50	1.47
1.17	3.28	2.67	8.37	4.17	2.37	5.67	1.40
1.33	4.23	2.83	6.54	4.33	2.20	5.83	1.34
1.50	5.94	3.00	5.36	4.50	2.05	6.00	1.29

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--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0001) |   Area    (ha)=  99.03   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   2.26

     Unit Hyd Qpeak  (cms)=   1.674

     PEAK FLOW       (cms)=   1.166 (i)
     TIME TO PEAK    (hrs)=   4.667
     RUNOFF VOLUME    (mm)=  21.137
     TOTAL RAINFALL   (mm)=  49.249
     RUNOFF COEFFICIENT   =    .429

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0002) |   Area    (ha)=  11.09   Curve Number   (CN)= 84.0
```

```
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   4.96

     Unit Hyd Qpeak  (cms)=    .085

     PEAK FLOW       (cms)=    .068 (i)
     TIME TO PEAK    (hrs)=   7.667
     RUNOFF VOLUME    (mm)=  21.137
     TOTAL RAINFALL   (mm)=  49.249
     RUNOFF COEFFICIENT   =    .429

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0003) |   Area    (ha)= 186.85   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   2.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.03

     Unit Hyd Qpeak  (cms)=   6.929

     PEAK FLOW       (cms)=   4.580 (i)
     TIME TO PEAK    (hrs)=   3.167
     RUNOFF VOLUME    (mm)=  23.344
     TOTAL RAINFALL   (mm)=  49.249
     RUNOFF COEFFICIENT   =    .474

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0004) |   Area    (ha)=  24.84   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.42

     Unit Hyd Qpeak  (cms)=    .668

     PEAK FLOW       (cms)=    .423 (i)
     TIME TO PEAK    (hrs)=   3.667
     RUNOFF VOLUME    (mm)=  21.137
     TOTAL RAINFALL   (mm)=  49.249
     RUNOFF COEFFICIENT   =    .429

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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```

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--------------------
| CALIB              |
| NASHYD    (0005) |   Area    (ha)= 129.56   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.71

     Unit Hyd Qpeak  (cms)=   2.894

     PEAK FLOW       (cms)=   1.906 (i)
     TIME TO PEAK    (hrs)=   4.000
     RUNOFF VOLUME    (mm)=  21.137
     TOTAL RAINFALL   (mm)=  49.249
     RUNOFF COEFFICIENT   =    .429

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0006) |   Area    (ha)=  27.63   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.42

     Unit Hyd Qpeak  (cms)=    .743

     PEAK FLOW       (cms)=    .471 (i)
     TIME TO PEAK    (hrs)=   3.667
     RUNOFF VOLUME    (mm)=  21.137
     TOTAL RAINFALL   (mm)=  49.249
     RUNOFF COEFFICIENT   =    .429

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0007) |   Area    (ha)=  97.77   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   2.10

     Unit Hyd Qpeak  (cms)=   1.778

     PEAK FLOW       (cms)=   1.221 (i)
     TIME TO PEAK    (hrs)=   4.500
     RUNOFF VOLUME    (mm)=  21.137
     TOTAL RAINFALL   (mm)=  49.249
     RUNOFF COEFFICIENT   =    .429
```

```
     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0008) |   Area    (ha)=  54.82   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   2.52

     Unit Hyd Qpeak  (cms)=    .831

     PEAK FLOW       (cms)=    .592 (i)
     TIME TO PEAK    (hrs)=   5.000
     RUNOFF VOLUME    (mm)=  21.137
     TOTAL RAINFALL   (mm)=  49.249
     RUNOFF COEFFICIENT   =    .429

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0009) |   Area    (ha)= 284.79   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   4.93

     Unit Hyd Qpeak  (cms)=   2.206

     PEAK FLOW       (cms)=   1.751 (i)
     TIME TO PEAK    (hrs)=   7.667
     RUNOFF VOLUME    (mm)=  21.137
     TOTAL RAINFALL   (mm)=  49.249
     RUNOFF COEFFICIENT   =    .429

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0010) |   Area    (ha)=  88.96   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   2.94

     Unit Hyd Qpeak  (cms)=   1.156

     PEAK FLOW       (cms)=    .847 (i)
     TIME TO PEAK    (hrs)=   5.500
     RUNOFF VOLUME    (mm)=  21.137
```

```
     TOTAL RAINFALL   (mm)=  49.249
     RUNOFF COEFFICIENT   =    .429

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0011) |   Area    (ha)= 104.56   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   3.23

     Unit Hyd Qpeak  (cms)=   1.236

     PEAK FLOW       (cms)=    .923 (i)
     TIME TO PEAK    (hrs)=   5.833
     RUNOFF VOLUME    (mm)=  21.137
     TOTAL RAINFALL   (mm)=  49.249
     RUNOFF COEFFICIENT   =    .429

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
  ****************************
  ** SIMULATION NUMBER:   3 **
  ****************************

--------------------
| CHICAGO STORM    |    IDF curve parameters: A=1502.215
| Ptotal= 66.09 mm |                          B=  10.559
--------------------                          C=    .831
                        used in:   INTENSITY =  A / (t + B)^C

                        Duration of storm  =  6.00 hrs
                        Storm time step    = 10.00 min
                        Time to peak ratio =   .33

                    The CORRELATION coefficient is =  .9997

                     TIME       INPUT INT.           TAB. INT.
                    (min)        (mm/hr)              (mm/hr)
                      5.         160.80               153.53
                     10.         117.00               121.79
                     15.          98.40               101.64
                     30.          68.80                69.25
                     60.          43.90                43.71
                    120.          26.50                26.21
                    360.          11.30                11.02
```

720.	6.40	6.27
1440.	3.40	3.54

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
.17	2.33	1.67	14.46	3.17	6.95	4.67	3.08
.33	2.56	1.83	36.27	3.33	6.07	4.83	2.91
.50	2.83	2.00	121.79	3.50	5.40	5.00	2.76
.67	3.18	2.17	47.56	3.67	4.86	5.17	2.62
.83	3.63	2.33	25.02	3.83	4.43	5.33	2.50
1.00	4.24	2.50	16.61	4.00	4.07	5.50	2.39
1.17	5.12	2.67	12.35	4.17	3.76	5.67	2.29
1.33	6.50	2.83	9.81	4.33	3.50	5.83	2.19
1.50	8.96	3.00	8.13	4.50	3.28	6.00	2.11

```
--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0001) |   Area    (ha)=  99.03   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   2.26

     Unit Hyd Qpeak  (cms)=   1.674

     PEAK FLOW       (cms)=   1.849 (i)
     TIME TO PEAK    (hrs)=   4.667
     RUNOFF VOLUME    (mm)=  34.087
     TOTAL RAINFALL   (mm)=  66.085
     RUNOFF COEFFICIENT   =    .516

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0002) |   Area    (ha)=  11.09   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   4.96

     Unit Hyd Qpeak  (cms)=    .085

     PEAK FLOW       (cms)=    .109 (i)
     TIME TO PEAK    (hrs)=   7.667
     RUNOFF VOLUME    (mm)=  34.086
     TOTAL RAINFALL   (mm)=  66.085
     RUNOFF COEFFICIENT   =    .516
```

```
     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0003) |   Area    (ha)= 186.85   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   2.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.03

     Unit Hyd Qpeak  (cms)=   6.929

     PEAK FLOW       (cms)=   6.885 (i)
     TIME TO PEAK    (hrs)=   3.167
     RUNOFF VOLUME    (mm)=  36.515
     TOTAL RAINFALL   (mm)=  66.085
     RUNOFF COEFFICIENT   =    .553

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0004) |   Area    (ha)=  24.84   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.42

     Unit Hyd Qpeak  (cms)=    .668

     PEAK FLOW       (cms)=    .664 (i)
     TIME TO PEAK    (hrs)=   3.667
     RUNOFF VOLUME    (mm)=  34.087
     TOTAL RAINFALL   (mm)=  66.085
     RUNOFF COEFFICIENT   =    .516

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0005) |   Area    (ha)= 129.56   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.71

     Unit Hyd Qpeak  (cms)=   2.894

     PEAK FLOW       (cms)=   3.003 (i)
     TIME TO PEAK    (hrs)=   4.000
```

```
     RUNOFF VOLUME    (mm)=  34.087
     TOTAL RAINFALL   (mm)=  66.085
     RUNOFF COEFFICIENT   =    .516

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0006) |   Area    (ha)=  27.63   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.42

     Unit Hyd Qpeak  (cms)=    .743

     PEAK FLOW       (cms)=    .739 (i)
     TIME TO PEAK    (hrs)=   3.667
     RUNOFF VOLUME    (mm)=  34.087
     TOTAL RAINFALL   (mm)=  66.085
     RUNOFF COEFFICIENT   =    .516

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0007) |   Area    (ha)=  97.77   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   2.10

     Unit Hyd Qpeak  (cms)=   1.778

     PEAK FLOW       (cms)=   1.934 (i)
     TIME TO PEAK    (hrs)=   4.500
     RUNOFF VOLUME    (mm)=  34.087
     TOTAL RAINFALL   (mm)=  66.085
     RUNOFF COEFFICIENT   =    .516

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0008) |   Area    (ha)=  54.82   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   2.52

     Unit Hyd Qpeak  (cms)=    .831
```

```
     PEAK FLOW       (cms)=    .940 (i)
     TIME TO PEAK    (hrs)=   5.000
     RUNOFF VOLUME    (mm)=  34.087
     TOTAL RAINFALL   (mm)=  66.085
     RUNOFF COEFFICIENT   =    .516

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0009) |   Area    (ha)= 284.79   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   4.93

     Unit Hyd Qpeak  (cms)=   2.206

     PEAK FLOW       (cms)=   2.814 (i)
     TIME TO PEAK    (hrs)=   7.667
     RUNOFF VOLUME    (mm)=  34.087
     TOTAL RAINFALL   (mm)=  66.085
     RUNOFF COEFFICIENT   =    .516

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0010) |   Area    (ha)=  88.96   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   2.94

     Unit Hyd Qpeak  (cms)=   1.156

     PEAK FLOW       (cms)=   1.351 (i)
     TIME TO PEAK    (hrs)=   5.667
     RUNOFF VOLUME    (mm)=  34.087
     TOTAL RAINFALL   (mm)=  66.085
     RUNOFF COEFFICIENT   =    .516

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0011) |   Area    (ha)= 104.56   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
```

```
--------------------   U.H. Tp(hrs)=   3.23

     Unit Hyd Qpeak  (cms)=   1.236

     PEAK FLOW       (cms)=   1.475 (i)
     TIME TO PEAK    (hrs)=   6.000
     RUNOFF VOLUME    (mm)=  34.087
     TOTAL RAINFALL   (mm)=  66.085
     RUNOFF COEFFICIENT   =    .516

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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  ****************************
  ** SIMULATION NUMBER:   4 **
  ****************************

--------------------
| CHICAGO STORM    |    IDF curve parameters: A=2143.714
| Ptotal= 80.01 mm |                          B=  15.188
--------------------                          C=    .857
                        used in:   INTENSITY =  A / (t + B)^C

                        Duration of storm  =  6.00 hrs
                        Storm time step    = 10.00 min
                        Time to peak ratio =   .33

                    The CORRELATION coefficient is =  .9997
```

TIME (min)	INPUT INT. (mm/hr)	TAB. INT. (mm/hr)
5.	174.00	163.19
10.	129.00	135.00
15.	110.80	115.60
30.	82.60	81.81
60.	53.20	52.88
120.	32.40	31.99
360.	13.60	13.34
720.	7.60	7.49
1440.	4.10	4.17

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
.17	2.63	1.67	18.95	3.17	8.68	4.67	3.56
.33	2.90	1.83	46.88	3.33	7.49	4.83	3.35
.50	3.25	2.00	135.00	3.50	6.59	5.00	3.15
.67	3.68	2.17	60.77	3.67	5.88	5.17	2.98

```
   .83    4.26 |  2.33   33.06 |  3.83    5.30 |  5.33    2.83
  1.00    5.06 |  2.50   21.88 |  4.00    4.83 |  5.50    2.69
  1.17    6.22 |  2.67   16.07 |  4.17    4.43 |  5.67    2.57
  1.33    8.07 |  2.83   12.58 |  4.33    4.10 |  5.83    2.46
  1.50   11.42 |  3.00   10.29 |  4.50    3.81 |  6.00    2.35


--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0001) |   Area    (ha)=  99.03   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   2.26

     Unit Hyd Qpeak  (cms)=   1.674

     PEAK FLOW       (cms)=   2.509 (i)
     TIME TO PEAK    (hrs)=   4.667
     RUNOFF VOLUME    (mm)=  45.596
     TOTAL RAINFALL   (mm)=  80.007
     RUNOFF COEFFICIENT   =    .570

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0002) |   Area    (ha)=  11.09   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   4.96

     Unit Hyd Qpeak  (cms)=    .085

     PEAK FLOW       (cms)=    .146 (i)
     TIME TO PEAK    (hrs)=   7.667
     RUNOFF VOLUME    (mm)=  45.595
     TOTAL RAINFALL   (mm)=  80.007
     RUNOFF COEFFICIENT   =    .570

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0003) |   Area    (ha)= 186.85   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   2.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.03
```

```
     Unit Hyd Qpeak  (cms)=   6.929

     PEAK FLOW       (cms)=   9.211 (i)
     TIME TO PEAK    (hrs)=   3.167
     RUNOFF VOLUME    (mm)=  48.144
     TOTAL RAINFALL   (mm)=  80.007
     RUNOFF COEFFICIENT   =    .602

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0004) |   Area    (ha)=  24.84   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.42

     Unit Hyd Qpeak  (cms)=    .668

     PEAK FLOW       (cms)=    .905 (i)
     TIME TO PEAK    (hrs)=   3.667
     RUNOFF VOLUME    (mm)=  45.596
     TOTAL RAINFALL   (mm)=  80.007
     RUNOFF COEFFICIENT   =    .570

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0005) |   Area    (ha)= 129.56   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.71

     Unit Hyd Qpeak  (cms)=   2.894

     PEAK FLOW       (cms)=   4.087 (i)
     TIME TO PEAK    (hrs)=   4.000
     RUNOFF VOLUME    (mm)=  45.596
     TOTAL RAINFALL   (mm)=  80.007
     RUNOFF COEFFICIENT   =    .570

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0006) |   Area    (ha)=  27.63   Curve Number   (CN)= 84.0
```

```
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.42

     Unit Hyd Qpeak  (cms)=    .743

     PEAK FLOW       (cms)=   1.007 (i)
     TIME TO PEAK    (hrs)=   3.667
     RUNOFF VOLUME    (mm)=  45.596
     TOTAL RAINFALL   (mm)=  80.007
     RUNOFF COEFFICIENT   =    .570

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB             |
| NASHYD    (0007) |   Area    (ha)=  97.77   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   2.10

     Unit Hyd Qpeak  (cms)=   1.778

     PEAK FLOW       (cms)=   2.626 (i)
     TIME TO PEAK    (hrs)=   4.500
     RUNOFF VOLUME    (mm)=  45.596
     TOTAL RAINFALL   (mm)=  80.007
     RUNOFF COEFFICIENT   =    .570

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB             |
| NASHYD    (0008) |   Area    (ha)=  54.82   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   2.52

     Unit Hyd Qpeak  (cms)=    .831

     PEAK FLOW       (cms)=   1.274 (i)
     TIME TO PEAK    (hrs)=   5.000
     RUNOFF VOLUME    (mm)=  45.596
     TOTAL RAINFALL   (mm)=  80.007
     RUNOFF COEFFICIENT   =    .570

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
```

```
--------------------
| CALIB              |
| NASHYD    (0009) |   Area    (ha)= 284.79   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   4.93

     Unit Hyd Qpeak  (cms)=   2.206

     PEAK FLOW       (cms)=   3.776 (i)
     TIME TO PEAK    (hrs)=   7.667
     RUNOFF VOLUME    (mm)=  45.596
     TOTAL RAINFALL   (mm)=  80.007
     RUNOFF COEFFICIENT   =    .570

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0010) |   Area    (ha)=  88.96   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   2.94

     Unit Hyd Qpeak  (cms)=   1.156

     PEAK FLOW       (cms)=   1.826 (i)
     TIME TO PEAK    (hrs)=   5.500
     RUNOFF VOLUME    (mm)=  45.596
     TOTAL RAINFALL   (mm)=  80.007
     RUNOFF COEFFICIENT   =    .570

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0011) |   Area    (ha)= 104.56   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   3.23

     Unit Hyd Qpeak  (cms)=   1.236

     PEAK FLOW       (cms)=   1.988 (i)
     TIME TO PEAK    (hrs)=   5.833
     RUNOFF VOLUME    (mm)=  45.596
     TOTAL RAINFALL   (mm)=  80.007
     RUNOFF COEFFICIENT   =    .570
```

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

```
--------------------------------------------------------------------------------
  ****************************
  ** SIMULATION NUMBER:   5 **
  ****************************

--------------------
| CHICAGO STORM    |     IDF curve parameters: A=2684.564
| Ptotal= 89.66 mm |                           B=  17.063
--------------------                           C=    .875
                         used in:   INTENSITY =  A / (t + B)^C

                         Duration of storm  =  6.00 hrs
                         Storm time step    = 10.00 min
                         Time to peak ratio =   .33

                     The CORRELATION coefficient is =  .9996

                      TIME       INPUT INT.          TAB. INT.
                     (min)        (mm/hr)             (mm/hr)
                        5.         192.00              179.13
                       10.         142.80              149.81
                       15.         122.80              129.16
                       30.          92.60               92.32
                       60.          60.10               59.96
                      120.          36.60               36.23
                      360.          15.20               14.95
                      720.           8.60                8.31
                     1440.           4.40                4.58


                  TIME     RAIN |  TIME     RAIN |  TIME     RAIN |  TIME     RAIN
                   hrs    mm/hr |   hrs    mm/hr |   hrs    mm/hr |   hrs    mm/hr
                   .17     2.74 |  1.67    21.73 |  3.17     9.67 |  4.67     3.79
                   .33     3.05 |  1.83    54.03 |  3.33     8.29 |  4.83     3.54
                   .50     3.43 |  2.00   149.81 |  3.50     7.24 |  5.00     3.33
                   .67     3.92 |  2.17    69.89 |  3.67     6.42 |  5.17     3.14
                   .83     4.57 |  2.33    38.25 |  3.83     5.76 |  5.33     2.97
                  1.00     5.48 |  2.50    25.18 |  4.00     5.22 |  5.50     2.82
                  1.17     6.82 |  2.67    18.35 |  4.17     4.77 |  5.67     2.68
                  1.33     8.97 |  2.83    14.24 |  4.33     4.39 |  5.83     2.56
                  1.50    12.88 |  3.00    11.55 |  4.50     4.07 |  6.00     2.44


--------------------------------------------------------------------------------
--------------------
| CALIB            |
```

```
| NASHYD    (0001) |   Area    (ha)=  99.03   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   2.26

     Unit Hyd Qpeak  (cms)=   1.674

     PEAK FLOW       (cms)=   2.997 (i)
     TIME TO PEAK    (hrs)=   4.667
     RUNOFF VOLUME    (mm)=  53.874
     TOTAL RAINFALL   (mm)=  89.661
     RUNOFF COEFFICIENT   =    .601

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0002) |   Area    (ha)=  11.09   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   4.96

     Unit Hyd Qpeak  (cms)=    .085

     PEAK FLOW       (cms)=    .173 (i)
     TIME TO PEAK    (hrs)=   7.667
     RUNOFF VOLUME    (mm)=  53.873
     TOTAL RAINFALL   (mm)=  89.661
     RUNOFF COEFFICIENT   =    .601

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0003) |   Area    (ha)= 186.85   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   2.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.03

     Unit Hyd Qpeak  (cms)=   6.929

     PEAK FLOW       (cms)=  10.983 (i)
     TIME TO PEAK    (hrs)=   3.167
     RUNOFF VOLUME    (mm)=  56.484
     TOTAL RAINFALL   (mm)=  89.661
     RUNOFF COEFFICIENT   =    .630

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.
```

```
--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0004) |   Area    (ha)=  24.84   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.42

     Unit Hyd Qpeak  (cms)=    .668

     PEAK FLOW       (cms)=   1.086 (i)
     TIME TO PEAK    (hrs)=   3.667
     RUNOFF VOLUME    (mm)=  53.873
     TOTAL RAINFALL   (mm)=  89.661
     RUNOFF COEFFICIENT   =    .601

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0005) |   Area    (ha)= 129.56   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.71

     Unit Hyd Qpeak  (cms)=   2.894

     PEAK FLOW       (cms)=   4.898 (i)
     TIME TO PEAK    (hrs)=   4.000
     RUNOFF VOLUME    (mm)=  53.874
     TOTAL RAINFALL   (mm)=  89.661
     RUNOFF COEFFICIENT   =    .601

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0006) |   Area    (ha)=  27.63   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.42

     Unit Hyd Qpeak  (cms)=    .743

     PEAK FLOW       (cms)=   1.208 (i)
     TIME TO PEAK    (hrs)=   3.667
     RUNOFF VOLUME    (mm)=  53.873
     TOTAL RAINFALL   (mm)=  89.661
     RUNOFF COEFFICIENT   =    .601
```

```
     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0007) |   Area    (ha)=  97.77   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   2.10

     Unit Hyd Qpeak  (cms)=   1.778

     PEAK FLOW       (cms)=   3.139 (i)
     TIME TO PEAK    (hrs)=   4.500
     RUNOFF VOLUME    (mm)=  53.874
     TOTAL RAINFALL   (mm)=  89.661
     RUNOFF COEFFICIENT   =    .601

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0008) |   Area    (ha)=  54.82   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   2.52

     Unit Hyd Qpeak  (cms)=    .831

     PEAK FLOW       (cms)=   1.519 (i)
     TIME TO PEAK    (hrs)=   5.000
     RUNOFF VOLUME    (mm)=  53.874
     TOTAL RAINFALL   (mm)=  89.661
     RUNOFF COEFFICIENT   =    .601

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0009) |   Area    (ha)= 284.79   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   4.93

     Unit Hyd Qpeak  (cms)=   2.206

     PEAK FLOW       (cms)=   4.472 (i)
     TIME TO PEAK    (hrs)=   7.500
```

```
     RUNOFF VOLUME    (mm)=  53.874
     TOTAL RAINFALL   (mm)=  89.661
     RUNOFF COEFFICIENT   =    .601

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0010) |   Area    (ha)=  88.96   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   2.94

     Unit Hyd Qpeak  (cms)=   1.156

     PEAK FLOW       (cms)=   2.173 (i)
     TIME TO PEAK    (hrs)=   5.500
     RUNOFF VOLUME    (mm)=  53.874
     TOTAL RAINFALL   (mm)=  89.661
     RUNOFF COEFFICIENT   =    .601

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0011) |   Area    (ha)= 104.56   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   3.23

     Unit Hyd Qpeak  (cms)=   1.236

     PEAK FLOW       (cms)=   2.364 (i)
     TIME TO PEAK    (hrs)=   5.833
     RUNOFF VOLUME    (mm)=  53.874
     TOTAL RAINFALL   (mm)=  89.661
     RUNOFF COEFFICIENT   =    .601

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
  ****************************
  ** SIMULATION NUMBER:   6 **
  ****************************

--------------------
| CHICAGO STORM    |    IDF curve parameters: A=2954.369
| Ptotal= 99.77 mm |                          B=  17.403
```

```
--------------------                             C=    .873
                        used in:   INTENSITY =  A / (t + B)^C

                        Duration of storm  =  6.00 hrs
                        Storm time step    = 10.00 min
                        Time to peak ratio =   .33

                    The CORRELATION coefficient is =  .9996
```

TIME (min)	INPUT INT. (mm/hr)	TAB. INT. (mm/hr)
5.	210.00	195.73
10.	156.60	164.16
15.	135.20	141.82
30.	102.60	101.74
60.	66.70	66.31
120.	40.70	40.18
360.	16.80	16.63
720.	9.50	9.27
1440.	5.00	5.11

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
.17	3.10	1.67	24.35	3.17	10.89	4.67	4.28
.33	3.44	1.83	60.03	3.33	9.34	4.83	4.00
.50	3.87	2.00	164.16	3.50	8.16	5.00	3.76
.67	4.43	2.17	77.47	3.67	7.24	5.17	3.55
.83	5.16	2.33	42.67	3.83	6.49	5.33	3.35
1.00	6.18	2.50	28.19	4.00	5.89	5.50	3.18
1.17	7.69	2.67	20.58	4.17	5.38	5.67	3.03
1.33	10.10	2.83	16.00	4.33	4.95	5.83	2.89
1.50	14.48	3.00	12.99	4.50	4.59	6.00	2.76

```
--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0001) |   Area    (ha)=  99.03   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   2.26

     Unit Hyd Qpeak  (cms)=   1.674

     PEAK FLOW       (cms)=   3.492 (i)
     TIME TO PEAK    (hrs)=   4.667
     RUNOFF VOLUME    (mm)=  62.742
     TOTAL RAINFALL   (mm)=  99.771
```

```
     RUNOFF COEFFICIENT   =    .629

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0002) |   Area    (ha)=  11.09   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   4.96

     Unit Hyd Qpeak  (cms)=    .085

     PEAK FLOW       (cms)=    .202 (i)
     TIME TO PEAK    (hrs)=   7.667
     RUNOFF VOLUME    (mm)=  62.741
     TOTAL RAINFALL   (mm)=  99.771
     RUNOFF COEFFICIENT   =    .629

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0003) |   Area    (ha)= 186.85   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   2.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.03

     Unit Hyd Qpeak  (cms)=   6.929

     PEAK FLOW       (cms)=  12.713 (i)
     TIME TO PEAK    (hrs)=   3.167
     RUNOFF VOLUME    (mm)=  65.403
     TOTAL RAINFALL   (mm)=  99.771
     RUNOFF COEFFICIENT   =    .656

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0004) |   Area    (ha)=  24.84   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.42

     Unit Hyd Qpeak  (cms)=    .668

     PEAK FLOW       (cms)=   1.266 (i)
```

```
     TIME TO PEAK    (hrs)=   3.667
     RUNOFF VOLUME    (mm)=  62.741
     TOTAL RAINFALL   (mm)=  99.771
     RUNOFF COEFFICIENT   =    .629

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB             |
| NASHYD    (0005) |   Area    (ha)= 129.56   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.71

     Unit Hyd Qpeak  (cms)=   2.894

     PEAK FLOW       (cms)=   5.708 (i)
     TIME TO PEAK    (hrs)=   4.000
     RUNOFF VOLUME    (mm)=  62.741
     TOTAL RAINFALL   (mm)=  99.771
     RUNOFF COEFFICIENT   =    .629

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB             |
| NASHYD    (0006) |   Area    (ha)=  27.63   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.42

     Unit Hyd Qpeak  (cms)=    .743

     PEAK FLOW       (cms)=   1.408 (i)
     TIME TO PEAK    (hrs)=   3.667
     RUNOFF VOLUME    (mm)=  62.741
     TOTAL RAINFALL   (mm)=  99.771
     RUNOFF COEFFICIENT   =    .629

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB             |
| NASHYD    (0007) |   Area    (ha)=  97.77   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   2.10
```

```
     Unit Hyd Qpeak  (cms)=   1.778

     PEAK FLOW       (cms)=   3.657 (i)
     TIME TO PEAK    (hrs)=   4.500
     RUNOFF VOLUME    (mm)=  62.741
     TOTAL RAINFALL   (mm)=  99.771
     RUNOFF COEFFICIENT   =    .629

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0008) |   Area    (ha)=  54.82   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   2.52

     Unit Hyd Qpeak  (cms)=    .831

     PEAK FLOW       (cms)=   1.770 (i)
     TIME TO PEAK    (hrs)=   5.000
     RUNOFF VOLUME    (mm)=  62.742
     TOTAL RAINFALL   (mm)=  99.771
     RUNOFF COEFFICIENT   =    .629

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0009) |   Area    (ha)= 284.79   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   4.93

     Unit Hyd Qpeak  (cms)=   2.206

     PEAK FLOW       (cms)=   5.208 (i)
     TIME TO PEAK    (hrs)=   7.500
     RUNOFF VOLUME    (mm)=  62.742
     TOTAL RAINFALL   (mm)=  99.771
     RUNOFF COEFFICIENT   =    .629

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0010) |   Area    (ha)=  88.96   Curve Number   (CN)= 84.0
```

```
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   2.94

     Unit Hyd Qpeak  (cms)=   1.156

     PEAK FLOW       (cms)=   2.531 (i)
     TIME TO PEAK    (hrs)=   5.500
     RUNOFF VOLUME    (mm)=  62.742
     TOTAL RAINFALL   (mm)=  99.771
     RUNOFF COEFFICIENT   =    .629

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0011) |   Area    (ha)= 104.56   Curve Number   (CN)= 84.0
|ID= 1 DT=10.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   3.23

     Unit Hyd Qpeak  (cms)=   1.236

     PEAK FLOW       (cms)=   2.754 (i)
     TIME TO PEAK    (hrs)=   5.833
     RUNOFF VOLUME    (mm)=  62.742
     TOTAL RAINFALL   (mm)=  99.771
     RUNOFF COEFFICIENT   =    .629

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------

 FINISH
====================================================================================
========================
```

Existing Conditions Flows

```
===============================================================================
========================

       V     V   I    SSSSS  U    U     A     L
       V     V   I    SS     U    U    A A    L
        V   V    I     SS    U    U   AAAAA   L
        V   V    I      SS   U    U   A    A  L
         VV      I    SSSSS  UUUUU   A    A  LLLLL

        OOO   TTTTT  TTTTT  H    H  Y    Y  M    M   OOO     TM
       O   O    T      T    H    H   Y Y    MM MM  O   O
       O   O    T      T    H    H    Y     M    M  O   O

        OOO     T      T    H    H    Y     M    M   OOO
```

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***** S U M M A R Y   O U T P U T *****

Input   filename: C:\Program Files\Visual OTTHYMO 2.2.4\voin.dat

Output filename: j:\PROJECTS\DRAFT\126452 Highway 3 Widening\Drainage & Hydrology\Hwy3CulvertHydrology\Existing Conditions Flows.out
Summary filename: j:\PROJECTS\DRAFT\126452 Highway 3 Widening\Drainage & Hydrology\Hwy3CulvertHydrology\Existing Conditions Flows.sum

DATE: 15/04/2014   TIME: 12:08:45 PM

USER:

COMMENTS: ____

```
****************************
** SIMULATION NUMBER:   1 **
****************************
```

W/E COMMAND	HYD ID	DT	AREA	Qpeak	Tpeak	R.V.	R.C.	Qbase
		min	ha	cms	hrs	mm		cms

Existing Conditions Flows

```
     START @    .00 hrs
     --------------------
     CHIC STORM                   10.0
     [ Ptot= 40.55 mm ]
*
  ** CALIB NASHYD       0001  1 10.0   99.03     .80  4.83  15.06  .37    .000
     [CN=84.0          ]
     [ N = 3.0:Tp 2.26]
*
  ** CALIB NASHYD       0002  1 10.0   11.09     .05  7.83  15.06  .37    .000
     [CN=84.0          ]
     [ N = 3.0:Tp 4.96]
*
  ** CALIB NASHYD       0003  1 10.0  186.85    3.12  3.17  17.09  .42    .000
     [CN=84.0          ]
     [ N = 3.0:Tp 1.03]
*
  ** CALIB NASHYD       0004  1 10.0   24.84     .28  3.83  15.06  .37    .000
     [CN=84.0          ]
     [ N = 3.0:Tp 1.42]
*
  ** CALIB NASHYD       0005  1 10.0  129.56    1.28  4.17  15.06  .37    .000
     [CN=84.0          ]
     [ N = 3.0:Tp 1.71]
*
  ** CALIB NASHYD       0006  1 10.0   27.63     .31  3.83  15.06  .37    .000
     [CN=84.0          ]
     [ N = 3.0:Tp 1.42]
*
  ** CALIB NASHYD       0007  1 10.0   97.77     .83  4.67  15.06  .37    .000
     [CN=84.0          ]
     [ N = 3.0:Tp 2.10]
*
  ** CALIB NASHYD       0008  1 10.0   54.82     .41  5.17  15.06  .37    .000
     [CN=84.0          ]
     [ N = 3.0:Tp 2.52]
*
  ** CALIB NASHYD       0009  1 10.0  284.79    1.24  7.83  15.06  .37    .000
     [CN=84.0          ]
     [ N = 3.0:Tp 4.93]
*
  ** CALIB NASHYD       0010  1 10.0   88.96     .59  5.67  15.06  .37    .000
     [CN=84.0          ]
     [ N = 3.0:Tp 2.94]
*
  ** CALIB NASHYD       0011  1 10.0  104.56     .64  6.17  15.06  .37    .000
     [CN=84.0          ]
     [ N = 3.0:Tp 3.23]
```

```
*
  ****************************
  ** SIMULATION NUMBER:   2 **
  ****************************

  W/E COMMAND             HYD ID   DT    AREA    Qpeak Tpeak   R.V. R.C.    Qbase
                                   min     ha     cms   hrs     mm           cms

      START @   .00 hrs
      --------------------
      CHIC STORM                  10.0
      [ Ptot= 49.25 mm ]
*
  **  CALIB NASHYD       0001  1 10.0   99.03    1.17  4.67  21.14  .43    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 2.26]
*
  **  CALIB NASHYD       0002  1 10.0   11.09     .07  7.67  21.14  .43    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 4.96]
*
  **  CALIB NASHYD       0003  1 10.0  186.85    4.58  3.17  23.34  .47    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 1.03]
*
  **  CALIB NASHYD       0004  1 10.0   24.84     .42  3.67  21.14  .43    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 1.42]
*
  **  CALIB NASHYD       0005  1 10.0  129.56    1.91  4.00  21.14  .43    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 1.71]
*
  **  CALIB NASHYD       0006  1 10.0   27.63     .47  3.67  21.14  .43    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 1.42]
*
  **  CALIB NASHYD       0007  1 10.0   97.77    1.22  4.50  21.14  .43    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 2.10]
*
  **  CALIB NASHYD       0008  1 10.0   54.82     .59  5.00  21.14  .43    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 2.52]
*
  **  CALIB NASHYD       0009  1 10.0  284.79    1.75  7.67  21.14  .43    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 4.93]
```

```
*
  **  CALIB NASHYD       0010  1 10.0   88.96     .85  5.50  21.14  .43    .000
      [CN=84.0          ]
      [ N = 3.0:Tp 2.94]
*
  **  CALIB NASHYD       0011  1 10.0  104.56     .92  5.83  21.14  .43    .000
      [CN=84.0          ]
      [ N = 3.0:Tp 3.23]
*
  ****************************
  ** SIMULATION NUMBER:   3 **
  ****************************

  W/E COMMAND             HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                  min     ha     cms   hrs     mm          cms

      START @   .00 hrs
      --------------------
      CHIC STORM                 10.0
      [ Ptot= 66.09 mm ]
*
  **  CALIB NASHYD       0001  1 10.0   99.03    1.85  4.67  34.09  .52    .000
      [CN=84.0          ]
      [ N = 3.0:Tp 2.26]
*
  **  CALIB NASHYD       0002  1 10.0   11.09     .11  7.67  34.09  .52    .000
      [CN=84.0          ]
      [ N = 3.0:Tp 4.96]
*
  **  CALIB NASHYD       0003  1 10.0  186.85    6.89  3.17  36.52  .55    .000
      [CN=84.0          ]
      [ N = 3.0:Tp 1.03]
*
  **  CALIB NASHYD       0004  1 10.0   24.84     .66  3.67  34.09  .52    .000
      [CN=84.0          ]
      [ N = 3.0:Tp 1.42]
*
  **  CALIB NASHYD       0005  1 10.0  129.56    3.00  4.00  34.09  .52    .000
      [CN=84.0          ]
      [ N = 3.0:Tp 1.71]
*
  **  CALIB NASHYD       0006  1 10.0   27.63     .74  3.67  34.09  .52    .000
      [CN=84.0          ]
      [ N = 3.0:Tp 1.42]
*
  **  CALIB NASHYD       0007  1 10.0   97.77    1.93  4.50  34.09  .52    .000
      [CN=84.0          ]
      [ N = 3.0:Tp 2.10]
```

```
*
  **  CALIB NASHYD       0008  1 10.0   54.82     .94  5.00  34.09  .52    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 2.52]
*
  **  CALIB NASHYD       0009  1 10.0  284.79    2.81  7.67  34.09  .52    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 4.93]
*
  **  CALIB NASHYD       0010  1 10.0   88.96    1.35  5.67  34.09  .52    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 2.94]
*
  **  CALIB NASHYD       0011  1 10.0  104.56    1.47  6.00  34.09  .52    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 3.23]
*
  ****************************
  ** SIMULATION NUMBER:   4 **
  ****************************

  W/E COMMAND              HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                   min     ha     cms   hrs     mm          cms

      START @   .00 hrs
      --------------------
      CHIC STORM                  10.0
      [ Ptot= 80.01 mm ]
*
  **  CALIB NASHYD       0001  1 10.0   99.03    2.51  4.67  45.60  .57    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 2.26]
*
  **  CALIB NASHYD       0002  1 10.0   11.09     .15  7.67  45.60  .57    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 4.96]
*
  **  CALIB NASHYD       0003  1 10.0  186.85    9.21  3.17  48.14  .60    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 1.03]
*
  **  CALIB NASHYD       0004  1 10.0   24.84     .90  3.67  45.60  .57    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 1.42]
*
  **  CALIB NASHYD       0005  1 10.0  129.56    4.09  4.00  45.60  .57    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 1.71]
```

```
*
  **  CALIB NASHYD       0006  1 10.0   27.63    1.01  3.67  45.60  .57    .000
      [CN=84.0          ]
      [ N = 3.0:Tp 1.42]
*
  **  CALIB NASHYD       0007  1 10.0   97.77    2.63  4.50  45.60  .57    .000
      [CN=84.0          ]
      [ N = 3.0:Tp 2.10]
*
  **  CALIB NASHYD       0008  1 10.0   54.82    1.27  5.00  45.60  .57    .000
      [CN=84.0          ]
      [ N = 3.0:Tp 2.52]
*
  **  CALIB NASHYD       0009  1 10.0  284.79    3.78  7.67  45.60  .57    .000
      [CN=84.0          ]
      [ N = 3.0:Tp 4.93]
*
  **  CALIB NASHYD       0010  1 10.0   88.96    1.83  5.50  45.60  .57    .000
      [CN=84.0          ]
      [ N = 3.0:Tp 2.94]
*
  **  CALIB NASHYD       0011  1 10.0  104.56    1.99  5.83  45.60  .57    .000
      [CN=84.0          ]
      [ N = 3.0:Tp 3.23]
*
  ****************************
  ** SIMULATION NUMBER:   5 **
  ****************************

  W/E COMMAND             HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                  min     ha     cms   hrs     mm          cms

      START @   .00 hrs
      --------------------
      CHIC STORM                 10.0
      [ Ptot= 89.66 mm ]
*
  **  CALIB NASHYD       0001  1 10.0   99.03    3.00  4.67  53.87  .60    .000
      [CN=84.0          ]
      [ N = 3.0:Tp 2.26]
*
  **  CALIB NASHYD       0002  1 10.0   11.09     .17  7.67  53.87  .60    .000
      [CN=84.0          ]
      [ N = 3.0:Tp 4.96]
*
  **  CALIB NASHYD       0003  1 10.0  186.85   10.98  3.17  56.48  .63    .000
      [CN=84.0          ]
      [ N = 3.0:Tp 1.03]
```

```
*
  **  CALIB NASHYD       0004  1 10.0   24.84    1.09  3.67  53.87  .60    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 1.42]
*
  **  CALIB NASHYD       0005  1 10.0  129.56    4.90  4.00  53.87  .60    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 1.71]
*
  **  CALIB NASHYD       0006  1 10.0   27.63    1.21  3.67  53.87  .60    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 1.42]
*
  **  CALIB NASHYD       0007  1 10.0   97.77    3.14  4.50  53.87  .60    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 2.10]
*
  **  CALIB NASHYD       0008  1 10.0   54.82    1.52  5.00  53.87  .60    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 2.52]
*
  **  CALIB NASHYD       0009  1 10.0  284.79    4.47  7.50  53.87  .60    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 4.93]
*
  **  CALIB NASHYD       0010  1 10.0   88.96    2.17  5.50  53.87  .60    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 2.94]
*
  **  CALIB NASHYD       0011  1 10.0  104.56    2.36  5.83  53.87  .60    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 3.23]
*
  ****************************
  ** SIMULATION NUMBER:   6 **
  ****************************

  W/E COMMAND              HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                                    min     ha     cms   hrs     mm          cms

      START @   .00 hrs
      --------------------
      CHIC STORM                  10.0
      [ Ptot= 99.77 mm ]
*
  **  CALIB NASHYD       0001  1 10.0   99.03    3.49  4.67  62.74  .63    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 2.26]
```

```
*
  **  CALIB NASHYD       0002  1 10.0   11.09     .20  7.67  62.74  .63    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 4.96]
*
  **  CALIB NASHYD       0003  1 10.0  186.85   12.71  3.17  65.40  .66    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 1.03]
*
  **  CALIB NASHYD       0004  1 10.0   24.84    1.27  3.67  62.74  .63    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 1.42]
*
  **  CALIB NASHYD       0005  1 10.0  129.56    5.71  4.00  62.74  .63    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 1.71]
*
  **  CALIB NASHYD       0006  1 10.0   27.63    1.41  3.67  62.74  .63    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 1.42]
*
  **  CALIB NASHYD       0007  1 10.0   97.77    3.66  4.50  62.74  .63    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 2.10]
*
  **  CALIB NASHYD       0008  1 10.0   54.82    1.77  5.00  62.74  .63    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 2.52]
*
  **  CALIB NASHYD       0009  1 10.0  284.79    5.21  7.50  62.74  .63    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 4.93]
*
  **  CALIB NASHYD       0010  1 10.0   88.96    2.53  5.50  62.74  .63    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 2.94]
*
  **  CALIB NASHYD       0011  1 10.0  104.56    2.75  5.83  62.74  .63    .000
      [CN=84.0         ]
      [ N = 3.0:Tp 3.23]
*
 FINISH

==================================================================================
========================
```

APPENDIX B

CulvertMaster Existing Conditions

Hydraulic Assessment

Culvert Designer/Analyzer Report
14th Concession East Drain

Analysis Component			
Storm Event	Check	Discharge	4.5400 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	3.0000 m³/s	Check Discharge	4.5400 m³/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Check Storm.			
Discharge	4.5400 m³/s	Bottom Elevation	192.14 m
Depth	0.88 m	Velocity	1.09 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-3050 x 1520 mm Box	4.5400 m³/s	193.14 m	1.18 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
14th Concession East Drain

Component:Culvert-1

Culvert Summary			
Computed Headwater Eleva	193.14 m	Discharge	4.5400 m³/s
Inlet Control HW Elev.	193.02 m	Tailwater Elevation	193.02 m
Outlet Control HW Elev.	193.14 m	Control Type	Outlet Control
Headwater Depth/Height	0.88		

Grades			
Upstream Invert	191.79 m	Downstream Invert	191.75 m
Length	26.95 m	Constructed Slope	0.001484 m/m

Hydraulic Profile			
Profile	M1	Depth, Downstream	1.27 m
Slope Type	Mild	Normal Depth	1.21 m
Flow Regime	Subcritical	Critical Depth	0.61 m
Velocity Downstream	1.18 m/s	Critical Slope	0.010433 m/m

Section			
Section Shape	Box	Mannings Coefficient	0.024
Section Material	Concrete	Span	3.05 m
Section Size	3050 x 1520 mm	Rise	1.52 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	193.14 m	Upstream Velocity Head	0.07 m
Ke	0.20	Entrance Loss	0.01 m

Inlet Control Properties			
Inlet Control HW Elev.	193.02 m	Flow Control	N/A
Inlet Type	90° headwall w 3/4 inch chamfers	Area Full	4.6 m²
K	0.51500	HDS 5 Chart	10
M	0.66700	HDS 5 Scale	1
C	0.03750	Equation Form	2
Y	0.79000		

Culvert Designer/Analyzer Report
Unnamed Drain

Analysis Component			
Storm Event	Check	Discharge	0.2600 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	0.1700 m³/s	Check Discharge	0.2600 m³/s

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	N/A m

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-750 mm Circular	0.2600 m³/s	193.90 m	1.51 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
Unnamed Drain

Component:Culvert-1

Culvert Summary					
Computed Headwater Eleva	193.90	m	Discharge	0.2600	m³/s
Inlet Control HW Elev.	193.78	m	Tailwater Elevation	N/A	m
Outlet Control HW Elev.	193.90	m	Control Type	Outlet Control	
Headwater Depth/Height	0.77				

Grades					
Upstream Invert	193.32	m	Downstream Invert	193.16	m
Length	29.67	m	Constructed Slope	0.000000	m/m

Hydraulic Profile					
Profile	H2		Depth, Downstream	0.31	m
Slope Type	Horizontal		Normal Depth	N/A	m
Flow Regime	Subcritical		Critical Depth	0.31	m
Velocity Downstream	1.51	m/s	Critical Slope	0.014474	m/m

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	0.76	m
Section Size	750 mm		Rise	0.76	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	193.90	m	Upstream Velocity Head	0.03	m
Ke	0.90		Entrance Loss	0.03	m

Inlet Control Properties					
Inlet Control HW Elev.	193.78	m	Flow Control	N/A	
Inlet Type	Projecting		Area Full	0.5	m²
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

Culvert Designer/Analyzer Report
Essex Outlet Drain

Analysis Component			
Storm Event	Check	Discharge	16.5300 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	10.9800 m³/s	Check Discharge	16.5300 m³/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Check Storm.			
Discharge	16.5300 m³/s	Bottom Elevation	191.58 m
Depth	2.31 m	Velocity	0.88 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-3660 x 1830 mm Box	13.9241 m³/s	194.33 m	2.08 m/s
Culvert-2	1-1230 x 1920 mm Horiz Ellipse	2.6036 m³/s	194.33 m	1.37 m/s
Weir	Not Considered	N/A	N/A	N/A
Total	----------------	16.5277 m³/s	194.33 m	N/A

Culvert Designer/Analyzer Report
Essex Outlet Drain

Component:Culvert-1

Culvert Summary					
Computed Headwater Eleva	194.33	m	Discharge	13.9241	m³/s
Inlet Control HW Elev.	193.89	m	Tailwater Elevation	193.89	m
Outlet Control HW Elev.	194.33	m	Control Type	Outlet Control	
Headwater Depth/Height	1.49				

Grades					
Upstream Invert	191.60	m	Downstream Invert	191.54	m
Length	36.79	m	Constructed Slope	0.001631	m/m

Hydraulic Profile					
Profile	PressureProfile		Depth, Downstream	2.35	m
Slope Type	N/A		Normal Depth	N/A	m
Flow Regime	N/A		Critical Depth	1.14	m
Velocity Downstream	2.08	m/s	Critical Slope	0.010315	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.024	
Section Material	Concrete		Span	3.66	m
Section Size	3660 x 1830 mm		Rise	1.83	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	194.33	m	Upstream Velocity Head	0.22	m
Ke	0.20		Entrance Loss	0.04	m

Inlet Control Properties					
Inlet Control HW Elev.	193.89	m	Flow Control	N/A	
Inlet Type	90° headwall w 3/4 inch chamfers		Area Full	6.7	m²
K	0.51500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	1	
C	0.03750		Equation Form	2	
Y	0.79000				

Culvert Designer/Analyzer Report
Essex Outlet Drain

Component:Culvert-2

Culvert Summary					
Computed Headwater Eleva	194.33	m	Discharge	2.6036	m³/s
Inlet Control HW Elev.	193.89	m	Tailwater Elevation	193.89	m
Outlet Control HW Elev.	194.33	m	Control Type	Outlet Control	
Headwater Depth/Height	1.81				

Grades					
Upstream Invert	192.11	m	Downstream Invert	191.82	m
Length	40.16	m	Constructed Slope	0.007221	m/m

Hydraulic Profile					
Profile	PressureProfile		Depth, Downstream	2.07	m
Slope Type	N/A		Normal Depth	1.06	m
Flow Regime	N/A		Critical Depth	0.67	m
Velocity Downstream	1.37	m/s	Critical Slope	0.021843	m/m

Section					
Section Shape	Horizontal Ellipse		Mannings Coefficient	0.035	
Section Material	Concrete		Span	1.92	m
Section Size	1230 x 1920 mm		Rise	1.23	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	194.33	m	Upstream Velocity Head	0.10	m
Ke	0.50		Entrance Loss	0.05	m

Inlet Control Properties					
Inlet Control HW Elev.	193.89	m	Flow Control	N/A	
Inlet Type	Square edge with headwall (horizontal ellipse)		Area Full	1.9	m²
K	0.01000		HDS 5 Chart	29	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Culvert Designer/Analyzer Report
Talbot Road South Drain A

Analysis Component			
Storm Event	Check	Discharge	0.0000 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	1.0900 m³/s	Check Discharge	1.6500 m³/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Check Storm.			
Discharge	1.6500 m³/s	Bottom Elevation	193.29 m
Depth	0.61 m	Velocity	1.22 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-750 mm Circular	1.6500 m³/s	196.77 m	3.68 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
Talbot Road South Drain A

Component:Culvert-1

Culvert Summary					
Computed Headwater Eleva	196.77	m	Discharge	1.6500	m³/s
Inlet Control HW Elev.	196.05	m	Tailwater Elevation	193.90	m
Outlet Control HW Elev.	196.77	m	Control Type	Outlet Control	
Headwater Depth/Height	4.61				

Grades					
Upstream Invert	193.26	m	Downstream Invert	193.22	m
Length	22.31	m	Constructed Slope	0.001793	m/m

Hydraulic Profile					
Profile	CompositeM2PressureProfile		Depth, Downstream	0.73	m
Slope Type	Mild		Normal Depth	N/A	m
Flow Regime	Subcritical		Critical Depth	0.73	m
Velocity Downstream	3.68	m/s	Critical Slope	0.059645	m/m

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	0.76	m
Section Size	750 mm		Rise	0.76	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	196.77	m	Upstream Velocity Head	0.67	m
Ke	0.90		Entrance Loss	0.60	m

Inlet Control Properties					
Inlet Control HW Elev.	196.05	m	Flow Control	N/A	
Inlet Type	Projecting		Area Full	0.5	m²
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

Culvert Designer/Analyzer Report
Canaan Drain

Analysis Component			
Storm Event	Check	Discharge	0.0000 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	4.9000 m³/s	Check Discharge	7.4200 m³/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Check Storm.			
Discharge	7.4200 m³/s	Bottom Elevation	191.21 m
Depth	1.64 m	Velocity	0.72 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-2080 x 3250 mm Horiz Ellipse	7.4200 m³/s	193.08 m	1.57 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
Canaan Drain

Component:Culvert-1

Culvert Summary					
Computed Headwater Eleva	193.08	m	Discharge	7.4200	m³/s
Inlet Control HW Elev.	192.85	m	Tailwater Elevation	192.85	m
Outlet Control HW Elev.	193.08	m	Control Type	Outlet Control	
Headwater Depth/Height	0.90				

Grades					
Upstream Invert	191.22	m	Downstream Invert	191.19	m
Length	26.28	m	Constructed Slope	0.001142	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	1.66	m
Slope Type	Mild		Normal Depth	N/A	m
Flow Regime	Subcritical		Critical Depth	1.03	m
Velocity Downstream	1.57	m/s	Critical Slope	0.008598	m/m

Section					
Section Shape	Horizontal Ellipse		Mannings Coefficient	0.024	
Section Material	Concrete		Span	3.25	m
Section Size	2080 x 3250 mm		Rise	2.08	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	193.08	m	Upstream Velocity Head	0.12	m
Ke	0.50		Entrance Loss	0.06	m

Inlet Control Properties					
Inlet Control HW Elev.	192.85	m	Flow Control	N/A	
Inlet Type	Square edge with headwall (horizontal ellipse)		Area Full	5.5	m²
K	0.01000		HDS 5 Chart	29	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Culvert Designer/Analyzer Report
Talbot Road South Drain B

Analysis Component			
Storm Event	Check	Discharge	1.8300 m^3/s

Peak Discharge Method: User-Specified			
Design Discharge	1.2100 m^3/s	Check Discharge	1.8300 m^3/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Check Storm.			
Discharge	1.8300 m^3/s	Bottom Elevation	193.36 m
Depth	0.00 m	Velocity	0.00 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-3050 x 1220 mm Box	1.8300 m^3/s	193.83 m	1.81 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
Talbot Road South Drain B

Component:Culvert-1

Culvert Summary					
Computed Headwater Eleva	193.83	m	Discharge	1.8300	m³/s
Inlet Control HW Elev.	193.82	m	Tailwater Elevation	193.36	m
Outlet Control HW Elev.	193.83	m	Control Type	Outlet Control	
Headwater Depth/Height	0.45				

Grades					
Upstream Invert	193.28	m	Downstream Invert	193.27	m
Length	22.76	m	Constructed Slope	0.000439	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.33	m
Slope Type	Mild		Normal Depth	0.64	m
Flow Regime	Subcritical		Critical Depth	0.33	m
Velocity Downstream	1.81	m/s	Critical Slope	0.003112	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	3.05	m
Section Size	3050 x 1220 mm		Rise	1.22	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	193.83	m	Upstream Velocity Head	0.10	m
Ke	0.20		Entrance Loss	0.02	m

Inlet Control Properties					
Inlet Control HW Elev.	193.82	m	Flow Control	N/A	
Inlet Type	90° headwall w 3/4 inch chamfers		Area Full	3.7	m²
K	0.51500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	1	
C	0.03750		Equation Form	2	
Y	0.79000				

Culvert Designer/Analyzer Report
East/West Townline Drain

Analysis Component			
Storm Event	Check	Discharge	4.7500 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	3.1400 m³/s	Check Discharge	4.7500 m³/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Check Storm.			
Discharge	4.7500 m³/s	Bottom Elevation	192.57 m
Depth	0.89 m	Velocity	1.12 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-3660 x 2130 mm Box	4.7500 m³/s	193.60 m	1.06 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
East/West Townline Drain

Component:Culvert-1

Culvert Summary					
Computed Headwater Eleva	193.60	m	Discharge	4.7500	m³/s
Inlet Control HW Elev.	193.46	m	Tailwater Elevation	193.46	m
Outlet Control HW Elev.	193.60	m	Control Type	Outlet Control	
Headwater Depth/Height	1.34				

Grades					
Upstream Invert	191.95	m	Downstream Invert	191.93	m
Length	41.63	m	Constructed Slope	0.000480	m/m

Hydraulic Profile					
Profile	PressureProfile		Depth, Downstream	1.53	m
Slope Type	N/A		Normal Depth	N/A	m
Flow Regime	N/A		Critical Depth	0.56	m
Velocity Downstream	1.06	m/s	Critical Slope	0.009787	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.024	
Section Material	Concrete		Span	3.66	m
Section Size	3660 x 2130 mm		Rise	1.23	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	193.60	m	Upstream Velocity Head	0.06	m
Ke	0.20		Entrance Loss	0.01	m

Inlet Control Properties					
Inlet Control HW Elev.	193.46	m	Flow Control	N/A	
Inlet Type	90° headwall w 3/4 inch chamfers		Area Full	4.5	m²
K	0.51500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	1	
C	0.03750		Equation Form	2	
Y	0.79000				

Culvert Designer/Analyzer Report
Russell Drain

Analysis Component			
Storm Event	Check	Discharge	2.3000 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	1.5200 m³/s	Check Discharge	2.3000 m³/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Check Storm.			
Discharge	2.3000 m³/s	Bottom Elevation	192.84 m
Depth	0.00 m	Velocity	0.00 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-610 x 610 mm Box	2.3000 m³/s	193.08 m	8.03 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
Russell Drain

Component:Culvert-1

Culvert Summary					
Computed Headwater Eleva	193.08	m	Discharge	2.3000	m^3/s
Inlet Control HW Elev.	193.00	m	Tailwater Elevation	192.84	m
Outlet Control HW Elev.	193.08	m	Control Type	Outlet Control	
Headwater Depth/Height	1.17				

Grades					
Upstream Invert	192.37	m	Downstream Invert	192.37	m
Length	25.66	m	Constructed Slope	0.000000	m/m

Hydraulic Profile					
Profile	PressureProfile		Depth, Downstream	0.47	m
Slope Type	N/A		Normal Depth	N/A	m
Flow Regime	N/A		Critical Depth	0.61	m
Velocity Downstream	8.03	m/s	Critical Slope	0.271051	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.024	
Section Material	Concrete		Span	0.61	m
Section Size	610 x 610 mm		Rise	0.61	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	193.08	m	Upstream Velocity Head	0.08	m
Ke	0.20		Entrance Loss	0.02	m

Inlet Control Properties					
Inlet Control HW Elev.	193.00	m	Flow Control	N/A	
Inlet Type	90° headwall w 3/4 inch chamfers		Area Full	0.4	m^2
K	0.51500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	1	
C	0.03750		Equation Form	2	
Y	0.79000				

Culvert Designer/Analyzer Report
Barlow Drain

Analysis Component			
Storm Event	Check	Discharge	6.7700 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	5.2100 m³/s	Check Discharge	6.7700 m³/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Check Storm.			
Discharge	6.7700 m³/s	Bottom Elevation	192.70 m
Depth	1.56 m	Velocity	0.77 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-2440 x 1830 mm Box	6.7700 m³/s	194.49 m	1.52 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
Barlow Drain

Component:Culvert-1

Culvert Summary

Computed Headwater Eleva	194.49	m	Discharge	6.7700	m^3/s
Inlet Control HW Elev.	194.26	m	Tailwater Elevation	194.26	m
Outlet Control HW Elev.	194.49	m	Control Type	Outlet Control	
Headwater Depth/Height	1.21				

Grades

Upstream Invert	192.28	m	Downstream Invert	192.19	m
Length	28.58	m	Constructed Slope	0.003149	m/m

Hydraulic Profile

Profile	PressureProfile		Depth, Downstream	2.07	m
Slope Type	N/A		Normal Depth	N/A	m
Flow Regime	N/A		Critical Depth	0.92	m
Velocity Downstream	1.52	m/s	Critical Slope	0.012300	m/m

Section

Section Shape	Box		Mannings Coefficient	0.024	
Section Material	Concrete		Span	2.44	m
Section Size	2440 x 1830 mm		Rise	1.83	m
Number Sections	1				

Outlet Control Properties

Outlet Control HW Elev.	194.49	m	Upstream Velocity Head	0.12	m
Ke	0.20		Entrance Loss	0.02	m

Inlet Control Properties

Inlet Control HW Elev.	194.26	m	Flow Control	N/A	
Inlet Type	90° headwall w 3/4 inch chamfers		Area Full	4.5	m^2
K	0.51500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	1	
C	0.03750		Equation Form	2	
Y	0.79000				

APPENDIX C

CulvertMaster Proposed Conditions

Hydraulic Assessment

Culvert Designer/Analyzer Report
Hyland Drain RR8

Analysis Component				
Storm Event	Design	Discharge	2.0000	m^3/s

Peak Discharge Method: User-Specified					
Design Discharge	2.0000	m^3/s	Check Discharge	3.2000	m^3/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.					
Discharge	2.0000	m^3/s	Bottom Elevation	191.85	m
Depth	0.73	m	Velocity	0.66	m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-1830 x 1220 mm Box	2.0000 m^3/s	192.81 m	1.50 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
Hyland Drain RR8

Component:Culvert-1

Culvert Summary

Computed Headwater Eleva	192.81	m	Discharge	2.0000	m³/s
Inlet Control HW Elev.	192.68	m	Tailwater Elevation	192.58	m
Outlet Control HW Elev.	192.81	m	Control Type	Outlet Control	
Headwater Depth/Height	0.77				

Grades

Upstream Invert	191.87	m	Downstream Invert	191.85	m
Length	28.55	m	Constructed Slope	0.000701	m/m

Hydraulic Profile

Profile	M2		Depth, Downstream	0.73	m
Slope Type	Mild		Normal Depth	N/A	m
Flow Regime	Subcritical		Critical Depth	0.50	m
Velocity Downstream	1.50	m/s	Critical Slope	0.012717	m/m

Section

Section Shape	Box		Mannings Coefficient	0.024	
Section Material	Concrete		Span	1.83	m
Section Size	1830 x 1220 mm		Rise	1.22	m
Number Sections	1				

Outlet Control Properties

Outlet Control HW Elev.	192.81	m	Upstream Velocity Head	0.09	m
Ke	0.20		Entrance Loss	0.02	m

Inlet Control Properties

Inlet Control HW Elev.	192.68	m	Flow Control	N/A	
Inlet Type	90° headwall w 3/4 inch chamfers		Area Full	2.2	m²
K	0.51500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	1	
C	0.03750		Equation Form	2	
Y	0.79000				

Culvert Designer/Analyzer Report
14th Concession East Drain <proposed>

Analysis Component			
Storm Event	Check	Discharge	4.5400 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	3.0000 m³/s	Check Discharge	4.5400 m³/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Check Storm.			
Discharge	4.5400 m³/s	Bottom Elevation	192.14 m
Depth	0.88 m	Velocity	1.09 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-3050 x 1520 mm Box	4.5400 m³/s	193.17 m	1.13 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
14th Concession East Drain <proposed>

Component:Culvert-1

Culvert Summary					
Computed Headwater Eleva	193.17	m	Discharge	4.5400	m^3/s
Inlet Control HW Elev.	193.02	m	Tailwater Elevation	193.02	m
Outlet Control HW Elev.	193.17	m	Control Type	Outlet Control	
Headwater Depth/Height	0.90				

Grades					
Upstream Invert	191.79	m	Downstream Invert	191.70	m
Length	60.29	m	Constructed Slope	0.001493	m/m

Hydraulic Profile					
Profile	M1		Depth, Downstream	1.32	m
Slope Type	Mild		Normal Depth	1.20	m
Flow Regime	Subcritical		Critical Depth	0.61	m
Velocity Downstream	1.13	m/s	Critical Slope	0.010433	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.024	
Section Material	Concrete		Span	3.05	m
Section Size	3050 x 1520 mm		Rise	1.52	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	193.17	m	Upstream Velocity Head	0.07	m
Ke	0.20		Entrance Loss	0.01	m

Inlet Control Properties					
Inlet Control HW Elev.	193.02	m	Flow Control	N/A	
Inlet Type	90° headwall w 3/4 inch chamfers		Area Full	4.6	m^2
K	0.51500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	1	
C	0.03750		Equation Form	2	
Y	0.79000				

Culvert Designer/Analyzer Report
14th Concession East Drain <proposed> <SouthTalbotExt>

Analysis Component			
Storm Event	Check	Discharge	4.0100 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	2.5100 m³/s	Check Discharge	4.0100 m³/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Check Storm.			
Discharge	4.0100 m³/s	Bottom Elevation	192.22 m
Depth	0.82 m	Velocity	1.05 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-3050 x 1520 mm Box	4.0100 m³/s	193.16 m	1.13 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
14th Concession East Drain <proposed> <SouthTalbotExt>

Component:Culvert-1

Culvert Summary					
Computed Headwater Eleva	193.16	m	Discharge	4.0100	m³/s
Inlet Control HW Elev.	193.04	m	Tailwater Elevation	193.04	m
Outlet Control HW Elev.	193.16	m	Control Type	Outlet Control	
Headwater Depth/Height	0.81				

Grades					
Upstream Invert	191.92	m	Downstream Invert	191.88	m
Length	29.74	m	Constructed Slope	0.001345	m/m

Hydraulic Profile					
Profile	M1		Depth, Downstream	1.16	m
Slope Type	Mild		Normal Depth	1.14	m
Flow Regime	Subcritical		Critical Depth	0.56	m
Velocity Downstream	1.13	m/s	Critical Slope	0.010402	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.024	
Section Material	Concrete		Span	3.05	m
Section Size	3050 x 1520 mm		Rise	1.52	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	193.16	m	Upstream Velocity Head	0.07	m
Ke	0.20		Entrance Loss	0.01	m

Inlet Control Properties					
Inlet Control HW Elev.	193.04	m	Flow Control	N/A	
Inlet Type	90° headwall w 3/4 inch chamfers		Area Full	4.6	m²
K	0.51500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	1	
C	0.03750		Equation Form	2	
Y	0.79000				

Culvert Designer/Analyzer Report
Unnamed Drain <proposed>

Analysis Component			
Storm Event	Check	Discharge	0.2600 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	0.1700 m³/s	Check Discharge	0.2600 m³/s

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	N/A m

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-825 mm Circular	0.2600 m³/s	193.67 m	1.47 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
Unnamed Drain <proposed>

Component:Culvert-1

Culvert Summary					
Computed Headwater Eleva	193.67	m	Discharge	0.2600	m³/s
Inlet Control HW Elev.	193.59	m	Tailwater Elevation	N/A	m
Outlet Control HW Elev.	193.67	m	Control Type	Outlet Control	
Headwater Depth/Height	0.60				

Grades					
Upstream Invert	193.16	m	Downstream Invert	192.94	m
Length	54.84	m	Constructed Slope	0.004012	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.30	m
Slope Type	Mild		Normal Depth	0.42	m
Flow Regime	Subcritical		Critical Depth	0.30	m
Velocity Downstream	1.47	m/s	Critical Slope	0.013774	m/m

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	0.84	m
Section Size	825 mm		Rise	0.84	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	193.67	m	Upstream Velocity Head	0.04	m
Ke	0.90		Entrance Loss	0.04	m

Inlet Control Properties					
Inlet Control HW Elev.	193.59	m	Flow Control	N/A	
Inlet Type	Projecting		Area Full	0.6	m²
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

Culvert Designer/Analyzer Report
Essex Outlet Drain <proposed>

Analysis Component			
Storm Event	Check	Discharge	16.5300 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	10.9800 m³/s	Check Discharge	16.5300 m³/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Check Storm.			
Discharge	16.5300 m³/s	Bottom Elevation	191.58 m
Depth	2.31 m	Velocity	0.88 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-610 x 610 mm Box	16.5300 m³/s	194.24 m	44.48 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
Essex Outlet Drain <proposed>

Component:Culvert-1

Culvert Summary					
Computed Headwater Eleva	194.24	m	Discharge	16.5300	m³/s
Inlet Control HW Elev.	193.89	m	Tailwater Elevation	193.89	m
Outlet Control HW Elev.	194.24	m	Control Type	Outlet Control	
Headwater Depth/Height	4.48				

Grades					
Upstream Invert	191.51	m	Downstream Invert	191.35	m
Length	97.95	m	Constructed Slope	0.001633	m/m

Hydraulic Profile					
Profile	PressureProfile		Depth, Downstream	2.54	m
Slope Type	N/A		Normal Depth	N/A	m
Flow Regime	N/A		Critical Depth	0.61	m
Velocity Downstream	44.48	m/s	Critical Slope	14.000434	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.024	
Section Material	Concrete		Span	0.61	m
Section Size	610 x 610 mm		Rise	0.61	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	194.24	m	Upstream Velocity Head	0.13	m
Ke	0.20		Entrance Loss	0.03	m

Inlet Control Properties					
Inlet Control HW Elev.	193.89	m	Flow Control	N/A	
Inlet Type	90° headwall w 3/4 inch chamfers		Area Full	0.4	m²
K	0.51500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	1	
C	0.03750		Equation Form	2	
Y	0.79000				

Culvert Designer/Analyzer Report
Talbot Road South Drain A <proposed>

Analysis Component			
Storm Event	Check	Discharge	1.6500 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	1.0900 m³/s	Check Discharge	1.6500 m³/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Check Storm.			
Discharge	1.6500 m³/s	Bottom Elevation	193.29 m
Depth	0.53 m	Velocity	1.20 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-1200 mm Circular	1.6500 m³/s	194.50 m	2.38 m/s
Weir	Not Considered	N/A	N/A	N/A

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Culvert Designer/Analyzer Report
Talbot Road South Drain A <proposed>

Component:Culvert-1

Culvert Summary					
Computed Headwater Eleva	194.50	m	Discharge	1.6500	m³/s
Inlet Control HW Elev.	194.39	m	Tailwater Elevation	193.82	m
Outlet Control HW Elev.	194.50	m	Control Type	Outlet Control	
Headwater Depth/Height	1.02				

Grades					
Upstream Invert	193.26	m	Downstream Invert	193.22	m
Length	22.31	m	Constructed Slope	0.001793	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.70	m
Slope Type	Mild		Normal Depth	N/A	m
Flow Regime	Subcritical		Critical Depth	0.70	m
Velocity Downstream	2.38	m/s	Critical Slope	0.014207	m/m

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	1.22	m
Section Size	1200 mm		Rise	1.22	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	194.50	m	Upstream Velocity Head	0.14	m
Ke	0.90		Entrance Loss	0.12	m

Inlet Control Properties					
Inlet Control HW Elev.	194.39	m	Flow Control	N/A	
Inlet Type	Projecting		Area Full	1.2	m²
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

Culvert Designer/Analyzer Report
Canaan Drain <proposed>

Analysis Component			
Storm Event	Check	Discharge	7.4200 m^3/s

Peak Discharge Method: User-Specified			
Design Discharge	4.9000 m^3/s	Check Discharge	7.4200 m^3/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Check Storm.			
Discharge	7.4200 m^3/s	Bottom Elevation	191.21 m
Depth	1.64 m	Velocity	0.72 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-2080 x 3250 mm Horiz Ellipse	7.4200 m^3/s	193.16 m	1.59 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
Canaan Drain <proposed>

Component:Culvert-1

Culvert Summary					
Computed Headwater Eleva	193.16	m	Discharge	7.4200	m³/s
Inlet Control HW Elev.	192.85	m	Tailwater Elevation	192.85	m
Outlet Control HW Elev.	193.16	m	Control Type	Outlet Control	
Headwater Depth/Height	0.92				

Grades					
Upstream Invert	191.23	m	Downstream Invert	191.21	m
Length	68.45	m	Constructed Slope	0.000292	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	1.64	m
Slope Type	Mild		Normal Depth	N/A	m
Flow Regime	Subcritical		Critical Depth	1.03	m
Velocity Downstream	1.59	m/s	Critical Slope	0.008598	m/m

Section					
Section Shape	Horizontal Ellipse		Mannings Coefficient	0.024	
Section Material	Concrete		Span	3.25	m
Section Size	2080 x 3250 mm		Rise	2.08	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	193.16	m	Upstream Velocity Head	0.11	m
Ke	0.50		Entrance Loss	0.06	m

Inlet Control Properties					
Inlet Control HW Elev.	192.85	m	Flow Control	N/A	
Inlet Type	Square edge with headwall (horizontal ellipse)		Area Full	5.5	m²
K	0.01000		HDS 5 Chart	29	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Culvert Designer/Analyzer Report
Talbot Road South Drain B <proposed>

Analysis Component			
Storm Event	Check	Discharge	1.8300 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	1.2100 m³/s	Check Discharge	1.8300 m³/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Check Storm.			
Discharge	1.8300 m³/s	Bottom Elevation	193.36 m
Depth	0.00 m	Velocity	0.00 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-3050 x 1220 mm Box	1.8300 m³/s	193.85 m	1.81 m/s
Weir	Not Considered	N/A	N/A	N/A

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Culvert Designer/Analyzer Report
Talbot Road South Drain B <proposed>

Component:Culvert-1

Culvert Summary					
Computed Headwater Eleva	193.85	m	Discharge	1.8300	m³/s
Inlet Control HW Elev.	193.82	m	Tailwater Elevation	193.36	m
Outlet Control HW Elev.	193.85	m	Control Type	Outlet Control	
Headwater Depth/Height	0.47				

Grades					
Upstream Invert	193.28	m	Downstream Invert	193.27	m
Length	51.99	m	Constructed Slope	0.000439	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.33	m
Slope Type	Mild		Normal Depth	0.64	m
Flow Regime	Subcritical		Critical Depth	0.33	m
Velocity Downstream	1.81	m/s	Critical Slope	0.003112	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	3.05	m
Section Size	3050 x 1220 mm		Rise	1.22	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	193.85	m	Upstream Velocity Head	0.08	m
Ke	0.20		Entrance Loss	0.02	m

Inlet Control Properties					
Inlet Control HW Elev.	193.82	m	Flow Control	N/A	
Inlet Type	90° headwall w 3/4 inch chamfers		Area Full	3.7	m²
K	0.51500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	1	
C	0.03750		Equation Form	2	
Y	0.79000				

Culvert Designer/Analyzer Report
East/West Townline Drain <proposed>

Analysis Component			
Storm Event	Check	Discharge	4.7500 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	3.1400 m³/s	Check Discharge	4.7500 m³/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Check Storm.			
Discharge	4.7500 m³/s	Bottom Elevation	192.57 m
Depth	0.89 m	Velocity	1.12 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-3660 x 2130 mm Box	4.7500 m³/s	193.64 m	1.06 m/s
Weir	Not Considered	N/A	N/A	N/A

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Culvert Designer/Analyzer Report
East/West Townline Drain <proposed>

Component:Culvert-1

Culvert Summary

Computed Headwater Eleva	193.64	m	Discharge	4.7500	m³/s
Inlet Control HW Elev.	193.46	m	Tailwater Elevation	193.46	m
Outlet Control HW Elev.	193.64	m	Control Type	Outlet Control	
Headwater Depth/Height	1.37				

Grades

Upstream Invert	191.95	m	Downstream Invert	191.92	m
Length	74.42	m	Constructed Slope	0.000721	m/m

Hydraulic Profile

Profile	PressureProfile		Depth, Downstream	1.54	m
Slope Type	N/A		Normal Depth	N/A	m
Flow Regime	N/A		Critical Depth	0.56	m
Velocity Downstream	1.06	m/s	Critical Slope	0.009787	m/m

Section

Section Shape	Box		Mannings Coefficient	0.024	
Section Material	Concrete		Span	3.66	m
Section Size	3660 x 2130 mm		Rise	1.23	m
Number Sections	1				

Outlet Control Properties

Outlet Control HW Elev.	193.64	m	Upstream Velocity Head	0.06	m
Ke	0.20		Entrance Loss	0.01	m

Inlet Control Properties

Inlet Control HW Elev.	193.46	m	Flow Control	N/A	
Inlet Type	90° headwall w 3/4 inch chamfers		Area Full	4.5	m²
K	0.51500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	1	
C	0.03750		Equation Form	2	
Y	0.79000				

Culvert Designer/Analyzer Report
Russell Drain <proposed>

Analysis Component			
Storm Event	Check	Discharge	2.3000 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	1.5200 m³/s	Check Discharge	2.3000 m³/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Check Storm.			
Discharge	2.3000 m³/s	Bottom Elevation	192.84 m
Depth	0.00 m	Velocity	0.00 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-610 x 610 mm Box	2.3000 m³/s	193.17 m	8.03 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
Russell Drain <proposed>

Component:Culvert-1

Culvert Summary					
Computed Headwater Eleva	193.17	m	Discharge	2.3000	m³/s
Inlet Control HW Elev.	193.00	m	Tailwater Elevation	192.84	m
Outlet Control HW Elev.	193.17	m	Control Type	Outlet Control	
Headwater Depth/Height	1.30				

Grades					
Upstream Invert	192.37	m	Downstream Invert	192.37	m
Length	55.18	m	Constructed Slope	0.000000	m/m

Hydraulic Profile					
Profile	PressureProfile		Depth, Downstream	0.47	m
Slope Type	N/A		Normal Depth	N/A	m
Flow Regime	N/A		Critical Depth	0.61	m
Velocity Downstream	8.03	m/s	Critical Slope	0.271051	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.024	
Section Material	Concrete		Span	0.61	m
Section Size	610 x 610 mm		Rise	0.61	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	193.17	m	Upstream Velocity Head	0.05	m
Ke	0.20		Entrance Loss	0.01	m

Inlet Control Properties					
Inlet Control HW Elev.	193.00	m	Flow Control	N/A	
Inlet Type	90° headwall w 3/4 inch chamfers		Area Full	0.4	m²
K	0.51500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	1	
C	0.03750		Equation Form	2	
Y	0.79000				

Culvert Designer/Analyzer Report
Barlow Drain <proposed>

Analysis Component			
Storm Event	Design	Discharge	5.2100 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	5.2100 m³/s	Check Discharge	6.7700 m³/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.			
Discharge	5.2100 m³/s	Bottom Elevation	192.70 m
Depth	1.37 m	Velocity	0.72 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-2440 x 1830 mm Box	5.2100 m³/s	194.42 m	1.17 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
Barlow Drain <proposed>

Component:Culvert-1

Culvert Summary					
Computed Headwater Eleva	194.42	m	Discharge	5.2100	m³/s
Inlet Control HW Elev.	194.07	m	Tailwater Elevation	194.07	m
Outlet Control HW Elev.	194.42	m	Control Type	Outlet Control	
Headwater Depth/Height	1.17				

Grades					
Upstream Invert	192.28	m	Downstream Invert	192.06	m
Length	71.39	m	Constructed Slope	0.001261	m/m

Hydraulic Profile					
Profile	PressureProfile		Depth, Downstream	2.01	m
Slope Type	N/A		Normal Depth	N/A	m
Flow Regime	N/A		Critical Depth	0.78	m
Velocity Downstream	1.17	m/s	Critical Slope	0.011851	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.024	
Section Material	Concrete		Span	2.44	m
Section Size	2440 x 1830 mm		Rise	1.83	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	194.42	m	Upstream Velocity Head	0.07	m
Ke	0.20		Entrance Loss	0.01	m

Inlet Control Properties					
Inlet Control HW Elev.	194.07	m	Flow Control	Unsubmerged	
Inlet Type	90° headwall w 3/4 inch chamfers		Area Full	4.5	m²
K	0.51500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	1	
C	0.03750		Equation Form	2	
Y	0.79000				

Culvert Designer/Analyzer Report
Barlow Drain <proposed> <improved> <interim>

Analysis Component

Storm Event	Design	Discharge	5.2100 m³/s

Peak Discharge Method: User-Specified

Design Discharge	5.2100 m³/s	Check Discharge	6.7700 m³/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.

Discharge	5.2100 m³/s	Bottom Elevation	192.36 m
Depth	1.37 m	Velocity	0.72 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-2440 x 1830 mm Box	5.2100 m³/s	193.93 m	1.32 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
Barlow Drain <proposed> <improved> <interim>

Component:Culvert-1

Culvert Summary

Computed Headwater Eleva	193.93	m	Discharge	5.2100	m³/s
Inlet Control HW Elev.	193.73	m	Tailwater Elevation	193.73	m
Outlet Control HW Elev.	193.93	m	Control Type	Outlet Control	
Headwater Depth/Height	0.90				

Grades

Upstream Invert	192.28	m	Downstream Invert	192.12	m
Length	50.90	m	Constructed Slope	0.003143	m/m

Hydraulic Profile

Profile	M1		Depth, Downstream	1.61	m
Slope Type	Mild		Normal Depth	1.26	m
Flow Regime	Subcritical		Critical Depth	0.78	m
Velocity Downstream	1.32	m/s	Critical Slope	0.011851	m/m

Section

Section Shape	Box		Mannings Coefficient	0.024	
Section Material	Concrete		Span	2.44	m
Section Size	2440 x 1830 mm		Rise	1.83	m
Number Sections	1				

Outlet Control Properties

Outlet Control HW Elev.	193.93	m	Upstream Velocity Head	0.10	m
Ke	0.20		Entrance Loss	0.02	m

Inlet Control Properties

Inlet Control HW Elev.	193.73	m	Flow Control	N/A	
Inlet Type	90° headwall w 3/4 inch chamfers		Area Full	4.5	m²
K	0.51500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	1	
C	0.03750		Equation Form	2	
Y	0.79000				

Culvert Designer/Analyzer Report
Barlow Drain <proposed> <improved>

Analysis Component			
Storm Event	Design	Discharge	5.2100 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	5.2100 m³/s	Check Discharge	6.7700 m³/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.			
Discharge	5.2100 m³/s	Bottom Elevation	192.36 m
Depth	1.37 m	Velocity	0.72 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-2440 x 1830 mm Box	5.2100 m³/s	194.07 m	1.28 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
Barlow Drain <proposed> <improved>

Component:Culvert-1

Culvert Summary					
Computed Headwater Eleva	194.07	m	Discharge	5.2100	m³/s
Inlet Control HW Elev.	193.73	m	Tailwater Elevation	193.73	m
Outlet Control HW Elev.	194.07	m	Control Type	Outlet Control	
Headwater Depth/Height	0.98				

Grades					
Upstream Invert	192.28	m	Downstream Invert	192.06	m
Length	71.39	m	Constructed Slope	0.001261	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	1.67	m
Slope Type	Mild		Normal Depth	N/A	m
Flow Regime	Subcritical		Critical Depth	0.78	m
Velocity Downstream	1.28	m/s	Critical Slope	0.011851	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.024	
Section Material	Concrete		Span	2.44	m
Section Size	2440 x 1830 mm		Rise	1.83	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	194.07	m	Upstream Velocity Head	0.08	m
Ke	0.20		Entrance Loss	0.02	m

Inlet Control Properties					
Inlet Control HW Elev.	193.73	m	Flow Control	N/A	
Inlet Type	90° headwall w 3/4 inch chamfers		Area Full	4.5	m²
K	0.51500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	1	
C	0.03750		Equation Form	2	
Y	0.79000				

Culvert Designer/Analyzer Report
Barlow Drain <proposed> <interim>

Analysis Component			
Storm Event	Check	Discharge	6.7700 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	5.2100 m³/s	Check Discharge	6.7700 m³/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Check Storm.			
Discharge	6.7700 m³/s	Bottom Elevation	192.70 m
Depth	1.56 m	Velocity	0.77 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-2440 x 1830 mm Box	6.7700 m³/s	194.56 m	1.52 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
Barlow Drain <proposed> <interim>

Component:Culvert-1

Culvert Summary					
Computed Headwater Eleva	194.56	m	Discharge	6.7700	m³/s
Inlet Control HW Elev.	194.26	m	Tailwater Elevation	194.26	m
Outlet Control HW Elev.	194.56	m	Control Type	Outlet Control	
Headwater Depth/Height	1.25				

Grades					
Upstream Invert	192.28	m	Downstream Invert	192.12	m
Length	50.90	m	Constructed Slope	0.003143	m/m

Hydraulic Profile					
Profile	PressureProfile		Depth, Downstream	2.14	m
Slope Type	N/A		Normal Depth	N/A	m
Flow Regime	N/A		Critical Depth	0.92	m
Velocity Downstream	1.52	m/s	Critical Slope	0.012300	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.024	
Section Material	Concrete		Span	2.44	m
Section Size	2440 x 1830 mm		Rise	1.83	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	194.56	m	Upstream Velocity Head	0.12	m
Ke	0.20		Entrance Loss	0.02	m

Inlet Control Properties					
Inlet Control HW Elev.	194.26	m	Flow Control	N/A	
Inlet Type	90° headwall w 3/4 inch chamfers		Area Full	4.5	m²
K	0.51500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	1	
C	0.03750		Equation Form	2	
Y	0.79000				