Water AECOM

GO Transit

Lakeshore East Train Service Extension to Clarington
Corbett Creek Flood Study

Prepared by:

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Project Number:

E073-067-00

Date:

November, 2010

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November 1, 2010

Warren Coulter
Environmental Engineering Analyst
Central Lake Ontario Conservation Authority
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Dear Mr. Coulter:

Project No: **E073-067-00 / 60115182**

Regarding: Lakeshore East Train Service Extension to Clarington
Corbett Creek Flood Study

Thank you for your comments dated September 3, 2010 regarding our Corbett Creek Flood Study in support of the proposed GO Transit Service Extension to Clarington. We have reviewed the comments and updated our analyses and report accordingly. Our responses are as follows:

1. *The submitted study investigates the hydraulic impact on Corbett Creek only. The proposed extension will be stretching across several other watersheds and crossing many creek systems. They impacts of the extension on all creek crossings must be investigated and mitigated*

   It is recognized that there are many other watercourse crossings along the preferred route. Aside from the connecting track across the East Corbett Creek valley corridor, the proposed route is parallel to the existing CPR tracks. The analysis of the required culvert extensions and mitigation of potential flooding impacts (which may require replacement or twinning of existing culverts and bridges) will be undertaken at the next design phase.

2. *Any proposed stream crossing analysis must also consider the fluvial geomorphic requirements (meander belt, migration, etc.) of the subject stream. No such analysis was submitted as part of this study. Please refer to the analysis performed for the Highway 407 extension, also prepared by AECOM.*

   The Corbett Creek flood study presents the minimum spans needed for the two new crossings of East Corbett Creek to mitigate potential upstream flooding impacts. A detailed fluvial geomorphology assessment of East Corbett Creek will be prepared at the next design phase to refine the crossing structure spans and/or recommend modifications to the channel to avoid potential future erosion problems at the crossings. A statement has been added to the summary/recommendations section in this regard. It is further recognized that fluvial geomorphology assessments may be required for any required culvert replacements along the remainder of the study corridor.

3. *The report details that AECOM recalculated the storage-discharge relationship and the corresponding routed water surface elevation upstream of the CNR and compared the results to the Greck & Associates values. However, the existing conditions plan ("Calculate Critical Depth"), continues to use the Greck & Associates values. Through a telephone conversation with Steve Hollingworth, it is understood that AECOM wanted to stay consistent with the Approved model and the comparison was to ensure confidence in the mapping and modeling before proceeding. In addition, a detailed analysis, using the revised storage-discharge information will be completed at a later stage.*

   An additional scenario has been added to the existing conditions model, using the AECOM routed surface water elevations for comparison to the proposed conditions model (with the cut and fill balance).

4. *In close proximity to the proposed north crossing, Consumer's Road is also being extended through the floodplain. The Consumer's Road EA is currently completed (2001) and can be found on the Region of Durham's web page: http://www.durham.ca/departments/works/studies/consumers/Consumers DrExtESR.pdf. To ensure that there is no cumulative effect on the floodplain at this location we feel it would be beneficial to include the proposed Consumer's Road in the hydraulic analysis.*

   The proposed conditions model has been updated to include the future Consumers Road. Information on the future Consumers Road crossing of East Corbett Creek (plan, profile, culvert sizes) was taken from the November 2005 Environmental Study Report for the road extension.

5. *The ineffective areas for both the north and south crossings were not entered into the HEC-RAS model. Please include.*

   The proposed conditions model has been revised to include ineffective areas at both the north and south crossings

6. *The routed water surface elevations used in this scenario were taken from the Greck & Associates Model. Since significant changes in the floodplain are proposed and were investigated, the storage-discharge relationship should be revised to reflect the changes. It was confirmed, in a telephone conversation with Steve Hollingworth, that the analysis will be revisited with such details at a later stage.*

   The proposed conditions model has been revised to use the AECOM proposed routed surface water elevations upstream of the CNR embankment.

7. *In addition to the above comment, a detailed cut and fill analysis will be required. CLOCA cannot support a net loss in floodplain storage.*

   The cut and fill balance analysis has been updated and a routing analysis has been completed. A negligible increase in the elevation of the Regional storm flood plain is predicted.

8. *The ineffective areas for both the north and south crossings were not entered into the HEC-RAS model. Please include.*

   All scenarios in the proposed conditions model have been revised to include ineffective areas at both the north and south crossings

9. *The report summary indicates that the south crossing will raise the Regional floodplain elevation by 0.2 to 0.3m and that the impact can be mitigated by steeping embankment slopes and re-grading the floodplain to create additional storage. CLOCA cannot support any increase in floodplain elevation on private or public lands. The current submission does not include a cut and fill analysis of the proposed area to be*

regraded, therefore we do not feel that it can be confidently concluded that the increase in the floodplain can be eliminated.

Refer to the response to Comment # 7.

10. *The report states only the spans of the proposed culverts. Please include the length, span and height of the proposed culverts in the report*

    The report has been revised to include the span, height and length of the proposed culverts.

Please contact the undersigned with any questions on the revised report.

Sincerely,
AECOM Canada Ltd.

Steve Hollingworth, P.Eng.
Senior Water Resources Engineer
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SH:sh

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Revision Log

Revision #	Revised By	Date	Issue / Revision Description
1	S. Hollingworth	2010-11-01	Revised as per CLOCA Comments

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Jan 5, 2011
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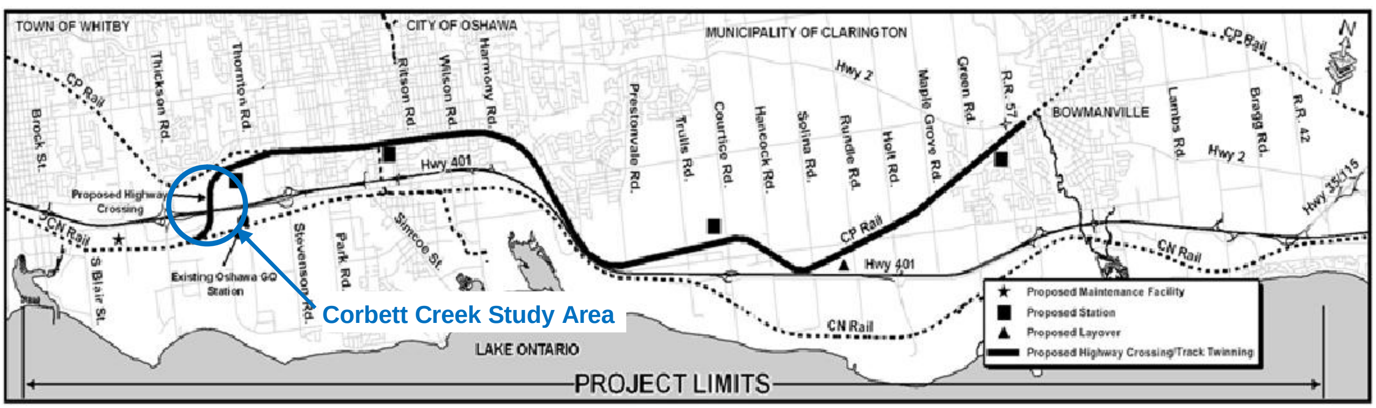
1. Introduction

GO Transit is undertaking an Environmental Assessment (EA) for an expansion of rail service from Oshawa to Bowmanville along the Lakeshore East corridor. Further to a recently completed Feasibility Study by Metrolinx for the Oshawa East track extension and new rail maintenance facility, the need was confirmed to expand rail services by twinning the existing Canadian Pacific Railway (CPR) rail line and to identify possible locations to build new GO stations, layover sites as well as a rail maintenance facility yard (AECOM, 2009).

The overall EA study area extends from 500 m west of Brock Street in the Town of Whitby to 500 m east of Regional Road 42/Darlington-Clarke Townline Road in the Municipality of Clarington, and is illustrated in Figure 1.1. The preferred alignment includes a new section of track from the CN corridor at Thickson Road to the CP corridor at Stevenson Road. The connecting track will need to cross over Victoria Street, Highway 401, the future extended Consumers Drive and Thornton Road. The preferred alignment also crosses Corbett Creek at three locations. Corbett Creek is managed by the Central Lake Ontario Conservation Authority (CLOCA).

The purpose of this Flood Study is to establish existing hydrologic and hydraulic conditions in Corbett Creek through the study area, assess the potential impact of the proposed connecting track on flooding in Corbett Creek, and evaluate alternatives to mitigate any potential flooding impacts.

Figure 1.1. Study Area



2. Existing Conditions

East Corbett Creek crosses under the CPR rail corridor just west of Thornton Road and continues in a southerly direction to Highway 401. Immediately downstream of Highway 401, Corbett Creek flows westward along the north side of Victoria Street. A smaller tributary joins the east branch at Victoria Street, and the creek continues southward to a relatively small culvert under the CNR corridor. Information on the physical and environmental conditions in the Corbett Creek stream corridor can be found in the Environmental Project Report for the overall project.

CLOCA provided AECOM with the hydraulic modelling and flood plain mapping for Corbett Creek, along with the report 'Digital Floodline Mapping Update for the Corbett Creek Watershed (Greck & Associates, 2006) that documented the development of the hydrologic and hydraulic models and flood plain mapping.

The 2006 Greck report for Corbett Creek found that the existing 2.0 m diameter culvert under the CNR tracks is significantly undersized relative to the Regional storm (Hurricane Hazel) peak flow to the crossing. Using traditional (conservative) flood plain mapping practices, the CNR tracks were predicted to be overtopped. Given the significant height of the CNR embankment and the relatively flat land to the north, the resulting flood plain covered an unreasonably large area.

Greck & Associates therefore used an alternative approach to establish flood levels in the area upstream of the CNR culvert. The flood plain upstream of the CNR embankment was treated as a reservoir, and the XP-CULVERT software was used to route the East Corbett Creek hydrographs through the 'reservoir' for the 2-100 year return period storms and Regional storm. The maximum water level in the 'reservoir' was taken as the flood elevation for the respective storms.

Given the potential for the proposed GO track to impact the Corbett Creek flood plain, the 100 year storm and Regional storm hydrographs for East Corbett Creek at the CNR crossing were obtained from Greck & Associates. AECOM updated the stage-storage characteristics of the flood plain using the same approach as Greck & Associates, but with the aid of more detailed topographic mapping. The stage-discharge relationship for the existing CNR culvert was calculated using the HEC-RAS model for Corbett Creek. The combined stage-storage-discharge relationship is presented in Table 2.1.

Table 2.1. Stage-Storage-Discharge Relationship for East Corbett Creek Routing Analysis

Elevation(m)	Greck & Associates	AECOM		
	Area (ha)	Area (ha)	Storage Volume (ha•m)*	Discharge (m^3/s)
81.0	0.5	0.02	0.0	0.00
82.0		0.35	0.13	3.85
83.0	1.5	1.34	0.94	7.70
84.0		3.21	3.15	9.54
85.0	6.9	6.49	7.90	11.18
86.0		9.35	15.92	12.72
87.0	11.6	10.85	26.06	14.07
88.0		12.41	37.68	15.36
89.0	15.9	24.74	57.75	16.52

* *Area measured and Storage Volume calculated at 0.5 m increments*

The ROUTE RESERVOIR command in the SWMHYMO hydrology software program was used to re-calculate the routed water surface elevations upstream of the CNR embankment. The results from the analyses are summarized in Table 2.2 below.

Table 2.2. Routed Water Surface Elevations (m) for East Corbett Creek

Storm Event	Greck & Associates	AECOM
100 Year	85.65	85.99
Regional	89.17	89.14

The 100 year water surface elevation calculated by AECOM is 0.34 m higher than that calculated by Greck & Associates. There is only a 3 cm difference in the Regional storm flood plain elevation.

3. Proposed Conditions

The proposed GO connecting track will extend from the CNR corridor east of Thickson Road to the CPR corridor west of Stevenson Road (See Figure 3.1). A single large bridge will carry the connecting track over Victoria Street and Highway 401. The connecting track will also cross over the future Consumers Drive, Thornton Road and the CPR spur line east of Thornton Road.

Figure 3.1. Proposed Conditions

The proposed alignment crosses Corbett Creek three times. The first, and most significant, is the proposed crossing of East Corbett Creek south of Victoria Street. The majority of the connecting track between the CNR and Victoria Street is within Regional storm flood plain behind the CNR embankment. The second crossing of East Corbett Creek is located north of Victoria Street. No analysis is required for this crossing, as it is located under the significant bridge proposed to carry the tracks over Victoria Street and Highway 401. The final crossing of East Corbett Creek occurs west of Thornton Road and north of the future Consumers Drive extension.

3.1 Hydraulic Design Criteria

Freeboard is a factor of safety used in the bridge design that represents the vertical distance between the High Water Levels for the Design Flow and the lowest point on the road or rail profile. Clearance is the distance between the High Water Levels and the lowest point of the structure obvert elevation. According to the American Railway Engineering and Maintenance-of-Way Association (AREMA) design guides and the Canadian Highway Bridge Design Code (CHBDC), the hydraulic clearance for structures carrying railway traffic is 1 m minimum over the design flow high water levels. In this application, the Design Flow is the 100 year storm event.

In addition, the proposed crossings over East Corbett Creek must not increase flood levels upstream or downstream for the 2 through 100 year and Regional storm events.

3.2 South Corbett Creek Crossing

The crossing of East Corbett Creek south of Victoria Street is referred to as the South Crossing. The proposed connecting track will be elevated significantly above the Corbett Creek flood plain. The tracks must connect with the existing CNR tracks to the south and west (approx. elev. 94.0 m), and need to cross over Highway 401 with adequate clearance (proposed track elev. of approx. 96.5 m). Existing ground elevations along the alignment are as low as 82.0 m near the creek channel. Given the relatively flat grades required for rail traffic, it is not possible to drop the track profile close to existing ground along this alignment.

3.2.1 HEC-RAS Model Revisions

The HEC-RAS model received from CLOCA was modified to assess the impact of the proposed connecting track on flood levels in East Corbett Creek.

Two new cross sections were added to the HEC-RAS model, using information from the flood plain map sheets provided by CLOCA and the detailed topographic mapping through the study area. These sections, labelled 5004.3 and 5004.8, reflect the downstream and upstream faces of the proposed bridge, respectively. The remaining HEC-RAS model cross sections between the CNR corridor and Victoria Street (Sections 5004 through 5007) were also modified to reflect the proposed fill embankments for the connecting tracks.

3.2.2 Bridge Design

In the HEC-RAS model received from CLOCA, flood levels in East Corbett Creek between the CNR embankment and Victoria Street were manually set at the water surface elevations from the XP-CULVERT routing analysis described in Section 2 of this report. The impact of the proposed connecting track crossing on the hydraulics of Corbett Creek could not easily be determined. One cannot simply remove the manually set water elevations from the model, as the resulting flood levels (overtopping the CNR embankment) are unreasonable high and place all of the upstream crossings, including Highway 401, in the backwater from the embankment.

It is possible that the existing culvert under the CNR embankment may be replaced in the future. If the CNR culvert were replaced and flood levels upstream dropped significantly, it will be important to prevent the proposed GO connecting track from becoming a new significant obstruction along Corbett Creek.

With no information on potential alternatives for future replacement culverts, it was decided to set the water surface elevation on first cross section upstream of the CNR embankment (5004) at the critical water surface elevation (with the ineffective flow option removed). The critical water surface elevation at Section 5004 and the resulting water surface elevation at the upstream sections in the existing conditions HEC-RAS model are summarized in Table 3.2.

Table 3.1. Critical Water Levels in East Corbett Creek with the CNR Embankment Removed

Storm Event	Flow Rate (m^3/s)	Critical Depth at Section 5004 (m)
100 Year	83.26	83.35
Regional	65.57	83.27

Applying the same starting water surface elevation at Section 5004 to the proposed conditions HEC-RAS model described in Section 3.2.1, the model was iterated to determine the size of bridge needed to prevent any increase in upstream flood levels. It was determined that a span of 20 m would be needed to prevent upstream impacts. The results of the HEC-RAS modelling exercise are summarized in Table 3.2, demonstrating that the proposed 20 m span x 3.25 m high x 40 m long bridge will be adequate to prevent impacts on upstream flooding if the CNR culvert is replaced in the future.

Table 3.2. HEC-RAS Model Output (Ignoring Backwater from CNR Culvert)

HEC-RAS Model Section	100 Year Storm Water Levels (m)		Regional Storm Water Levels (m)	
	Existing	**Proposed**	**Existing**	**Proposed**
5004	83.35	83.35	83.27	83.27
Proposed GO Connecting Track – 20 m Span				
5005	83.81	83.80	83.68	83.63
5006	84.14	84.14	83.74	83.74
Victoria Street				
5007	86.55	86.55	86.41	86.41

3.2.3 Flood Storage Analysis

As described in Section 2, flood levels along East Corbett Creek upstream of the CNR embankment are established from a routing analysis, which considers the storage upstream of the embankment as a reservoir.

Construction of the proposed GO connecting track across the Corbett Creek flood plain has the potential to reduce the available flood storage in the Corbett Creek flood plain, which may lead to increased water surface elevations during extreme storm events.

The initial concept design for the GO connecting track was based on a 12 m wide platform and 2 H:1 V side slopes down to existing ground. With 2:1 side slopes and fill depths of more than 10 m, the embankment represents a significant volume of fill in the flood plain.

To assess the impact of the proposed embankment on flood levels in East Corbett Creek, the routing analysis prepared for existing conditions (Section 2) was updated with the proposed embankment in place. The fill in the flood plain at each elevation was calculated, and totals a volume of almost 90,000 m^3 at the Regional flood plain elevation of 89.17 m. The discharge through the CNR culvert at the various elevations is unchanged from existing conditions.

Table 3.3. East Corbett Creek Flood Storage

Elevation (m)	Existing Flood Storage (ha•m)*	Proposed Flood Storage, 20 m bridge, 2:1 Side Slopes (ha•m)*
81.0	0.00	0.00
82.0	0.13	0.01
83.0	0.94	0.35
84.0	3.15	1.45
85.0	7.90	4.85
86.0	15.92	11.38
87.0	26.06	20.06
88.0	37.68	30.28
89.0	57.75	49.08

Notes: Area measured and Storage Volume calculated at 0.5 m increments

The updated stage-storage-discharge table was inserted into the SWMHYMO model created for the routing analysis for existing conditions. The resulting water levels for the 100 year and Regional storm are summarized in Table 3.4. The analysis predicts that with a fill embankment with 2:1 side slopes, the 100 year flood level would increase by almost 0.5 m, and the Regional flood level would increase by 0.31 m.

Table 3.4. Routed Water Surface Elevations (m) for East Corbett Creek

Storm Event	Existing	Proposed - 20 m bridge, 2:1 Side Slopes
100 Year	85.99	86.47
Regional	89.14	89.45

Given the significant increase in predicted flood levels, the concept design for the rail embankment was revised for 1:1 side slopes. The steeper side slopes will need to be engineered, possibly with retaining structures or reinforcing, to remain stable for the life of the railway.

The corresponding stage-storage relationship is presented in Table 3.5, and the resulting routed water surface elevations are summarized in Table 3.6

Table 3.5. East Corbett Creek Flood Storage

Elevation (m)	Existing Flood Storage (ha•m)*	Proposed Flood Storage, 20 m bridge, 1:1 Side Slopes (ha•m)*
81.0	0.00	0.00
82.0	0.13	0.01
83.0	0.94	0.47
84.0	3.15	1.96
85.0	7.90	5.83
86.0	15.92	12.89
87.0	26.06	22.06
88.0	37.68	32.73
89.0	57.75	51.91

Table 3.6. Routed Water Surface Elevations (m) for East Corbett Creek

Storm Event	Existing	Proposed - 20 m bridge, 1:1 Side Slopes
100 Year	85.99	86.28
Regional	89.14	89.34

With the fill slopes steepened to 1 H:1 V, the volume of fill in the flood plain is reduced to approximately 60,000 m^3. The 100 year flood level upstream of the CNR embankment is predicted to increase by approximately 0.3 m over existing conditions, and the Regional flood level is expected to increase by 0.2 m.

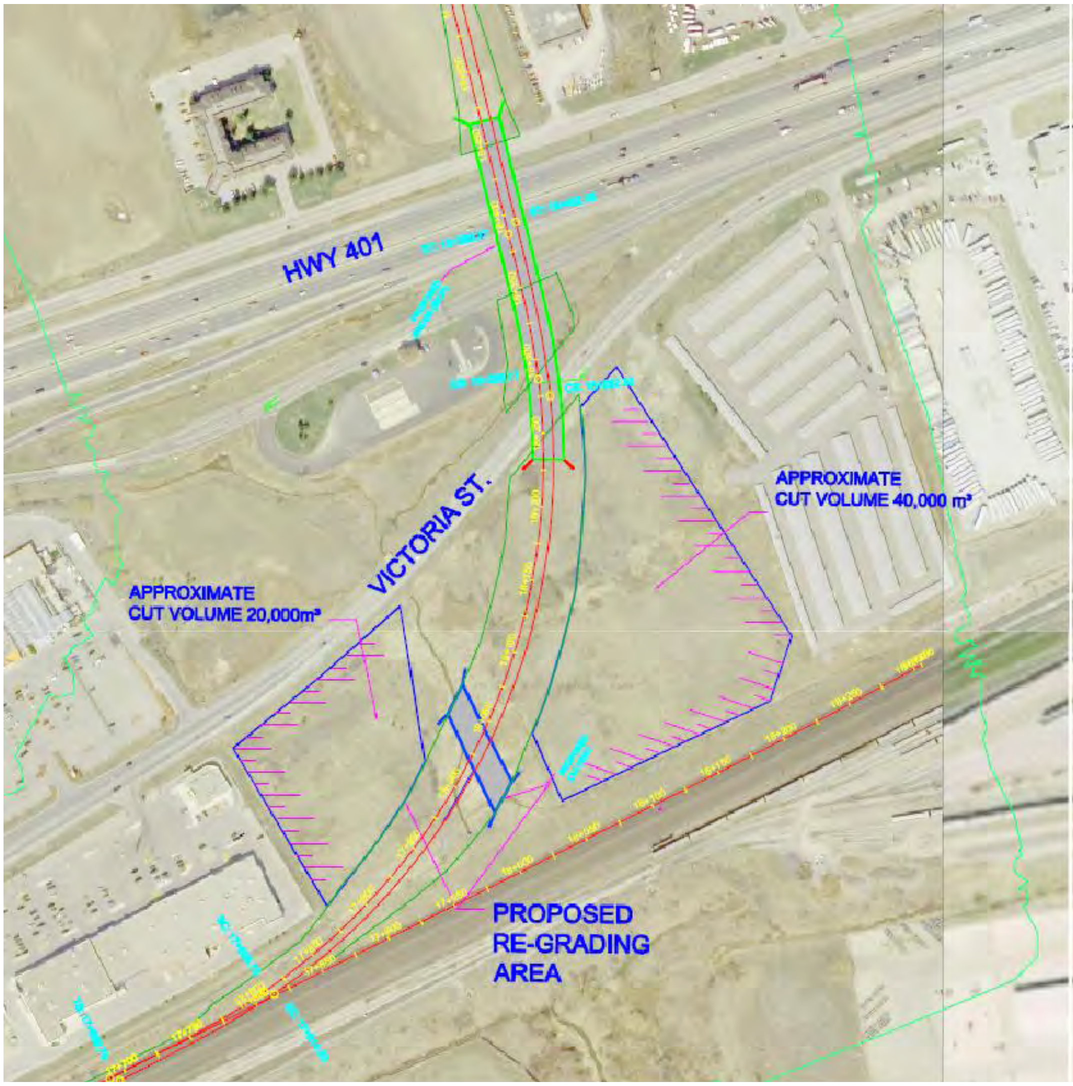
While steepening the side slopes to 1:1 will lessen the impact on flood levels in East Corbett Creek, increases are still anticipated, with potential impacts to upstream property and infrastructure. It is not reasonable to span the entire flood plain with a multi-span (trestle) bridge to eliminate any fill in the flood plain.

An alternative to mitigate the impacts of the proposed connecting track on flooding would be to remove an equivalent volume of material from the flood plain, such that there would be no net loss of flood storage.

The flood plain currently extends from the limit of the commercial development along Victoria Street west of Corbett Creek to the limit of the self-storage development east of Corbett Creek. The land current slopes down from the self-storage development at a relatively steady, gentle slope to the creek. The ground drops steeply from the edge of development west of Corbett Creek to an elevation of approximately 85.5 m, and then slopes steadily down to the edge of the creek (approx. 81.5 m).

An alternative to offset the fill in the flood plain would be to re-grade the flood plain on either side of the creek to be nearly flat, and steepen the valley side slopes at the existing limits of development east and west of Corbett Creek. An initial grading investigation was completed, grading up from the edge of the creek / edge of the railway embankment at a slope of 1 %, and with 5:1 slopes to match back into existing grades at the limits of development on the east and west sides, and with Victoria Avenue to the north. The proposed cut areas are illustrated in Figure 3.2.

Figure 3.2. Potential Offsetting Cut Areas



Initial calculations indicate that re-grading the flood plain to the west of Corbett Creek could create approximately 15,000 m^3 of additional flood storage, and approximately 45,000 m^3 of additional flood storage could be created east of Corbett Creek. The total flood storage volume of 60,000 m^3 is approximately equal to the predicted fill volume of 60,000 m^3 for the rail embankment constructed with engineered 1:1 fill slopes.

A stage-storage-discharge table was prepared for the above scenario, with the fill volume offset by an equivalent cut. The calculated volumes are presented in Table 3.7. The storage and discharge pairs were entered into the SWMHYMO model for East Corbett Creek, and the results are summarized in Table 3.8.

The SWMHYMO model demonstrates that, with the offsetting cut, the routed water levels upstream of the CNR embankment will be 0.26 m lower than existing conditions for the 100 year event, and will be only 2 cm higher than existing for the Regional storm event. The predicted increase of 2 cm is considered negligible relative to the accuracy of the HEC-RAS modelling and storage routing analysis, and will not change the extent of the Regional storm flood plain.

Table 3.7. East Corbett Creek Flood Storage – Cut and Fill Balance

Elevation (m)	Existing Flood Storage (ha•m)	Proposed Fill Volume (ha•m)	Cut Volume – West of Corbett Creek (ha•m)	Cut Volume – East of Corbett Creek (ha•m)	Proposed Balanced Flood Storage (ha•m)
81.0	0.00	-	-	-	0.00
82.0	0.13	0.12	-	-	0.01
83.0	0.94	0.48	0.18	-	0.65
84.0	3.15	1.19	1.06	1.03	4.05
85.0	7.90	2.07	1.49	2.86	10.18
86.0	15.92	3.04	1.50	3.98	18.38
87.0	26.06	4.00	1.50	4.41	27.99
88.0	37.68	4.95	1.50	4.51	38.74
89.0	57.75	5.84	1.50	4.51	57.93

Table 3.8. Routed Water Surface Elevations (m) for East Corbett Creek – Cut and Fill Balance

Storm Event	Existing	Proposed - 20 m bridge, 1:1 Side Slopes
100 Year	85.99	85.73
Regional	89.14	89.16

As a final check, the HEC-RAS model for proposed conditions was updated with the routed flood elevations at the face of the CNR culvert. The output from the model is summarized in Table 3.9 below.

Table 3.9. HEC-RAS Model Output (Applying Routed Water Level at CNR Culvert)

HEC-RAS Model Section	100 Year Storm Water Levels (m)		Regional Storm Water Levels (m)	
	Existing	Proposed	Existing	Proposed
5004	85.99	85.73	89.14	89.16
Proposed GO Connecting Track – 20 m Span				
5005	85.99	85.83	89.14	89.23
5006	86.00	85.83	89.14	89.23
Victoria Street				
5007	86.62	86.60	89.14	89.23

For the 100 year storm event, the routing analysis predicted a drop in flood levels for proposed conditions. This reduction in flood levels continues past the proposed GO crossing to upstream of Victoria Street.

For the Regional storm event, the HEC-RAS model predicts that the proposed GO crossing will cause a 9 cm increase in upstream flood levels. However, this is an extremely conservative modelling scenario. In the proposed conditions model, the water level is only fixed at the upstream face of the CNR embankment. The proposed GO tracks are within the ‘reservoir’, and it could be argued that the routing analysis should be used to establish flood levels through the ‘reservoir’ upstream to at least Victoria Street. Alternatively, the routing analysis found that the ‘reservoir’ upstream of the CNR embankment would reduce the 100 year peak flow from 83 m^3/s to 12 m^3/s, and reduce the Regional storm peak flow from 65 m^3/s to 17 m^3/s. Given the proximity of the proposed GO crossing to the CNR embankment, it could be argued that the routed flow of 17 m^3/s should be applied to the proposed GO crossing for the Regional storm event. It is therefore concluded that, given the overly conservative assumptions used in the analysis, the predicted 9 cm increase is not significant and the proposed 20 m span crossing will be adequate to mitigate any impacts on flooding in East Corbett Creek from the proposed GO connecting track.

3.3 North Corbett Creek Crossing

The proposed crossing of East Corbett Creek south of the CPR corridor, west of Thornton Road is referred to as the North Crossing. This reach of East Corbett Creek a considerable distance upstream of the south crossing, and is not affected by the backwater from the CNR embankment.

In order to cross over the future Consumers Drive extension to the south and Thornton Road to the east, the proposed connecting track must be at an elevation of approximately 97 m in the area of the north crossing. Existing ground adjacent the creek channel is approximately 89 m.

3.3.1 HEC-RAS Model Revisions

The HEC-RAS model for East Corbett Creek was modified to represent the proposed connecting track. Two new cross sections were added to the model between existing sections 5014 and 5015 to represent the downstream and upstream faces of the proposed bridge crossing, respectively. The sections were coded using information from the CLOCA's flood plain map sheets and the detailed topographic mapping for the study area. The HEC-RAS sections upstream and downstream of the North Crossing (5013, 5014 and 5015) were also updated to reflect the proposed fill embankment for the connecting track.

As requested by CLOCA, the model was further updated to include the proposed Consumers Drive extension across Corbett Creek. The crossing is located at existing Section 5014. To represent the crossing in the model, section 5014 was removed and two new sections, 5013.8 and 5014.1, were added to the model to represent the Corbett Creek valley corridor upstream and downstream of the future Consumers Drive. Information on the proposed road design were taken from the EA for Consumers Drive (Chisholm Fleming, 2006). The EA proposed twin 4.5 m wide x 2.5 m high concrete box culverts at the East Corbett Creek crossing.

3.3.2 Bridge Design

The design for the North Crossing bridge was much simpler than for the south crossing. With the proposed connecting track and associated embankments coded into the HEC-RAS model, the proposed bridge opening was iterated to determine the size of span required to prevent any increase in upstream flood levels.

In a previous analysis by AECOM which did not consider the future Consumers Drive extension, it was determined that a 9.75 m span x 3.0 m high x 40 m long Conspan or equivalent culvert was required to mitigate the impact of the proposed connecting track on flood levels at the North Crossing. The output from the revised HEC-RAS model, considering the future Consumers Drive crossing, and using the updated (routed) water levels at the South Crossing, is summarized in Table 3.10.

Table 3.10. HEC-RAS Model Output for North Crossing

HEC-RAS Model Section	100 Year Storm Water Levels (m)		Regional Storm Water Levels (m)	
	Existing	Proposed	Existing	Proposed
5013	88.52	88.52	90.02	90.07
5014	89.38	n/a – Consumers Dr.	90.09	n/a – Consumers Dr.
Proposed GO Connecting Track – 9.75 m Conspan Culvert				
5015	90.38	90.43	90.55	90.73
5019	91.40	91.34	91.53	91.30
5020	92.13	92.13	92.52	92.52

Using the previously recommended 9.75 m wide x 3.0 m high Conspan culvert, with 2H:1V fill slopes for the rail embankment and including the future Consumers Drive crossing, the HEC-RAS model predicts an increase of up to 5 cm for the 100 year event, and up to 18 cm for the Regional storm event. Note that part of the reason for the large increase in Regional storm flood level at Section 5015 is because the section is at critical depth in the existing conditions model. When the energy gradeline is compared, the increase is only 7 cm for the Regional event at Section 5015.

The reason is also due to a higher tailwater elevation from the future Consumers Drive extension. Using the culvert sizes, invert elevations and road profile from the EA, the HEC-RAS model predicts that the culvert would be surcharged (water level above the obvert) for the 100 year storm, and would be overtopped by the Regional flood.

A final HEC-RAS scenario was prepared to evaluate the proposed North Crossing without the tailwater effect of the Consumers Drive culvert. The water level on the upstream side of the future Consumers Drive culverts (Section 5014.1) was fixed at the flood levels at Section 5014 from the existing conditions model. The HEC-RAS results, summarized in Table 3.11, confirm that the proposed 9.75 m span x 3.0 m high culvert can adequately mitigate impacts on upstream flood levels. It is recommended that the sizes of the Consumers Drive culverts be reviewed and enlarged as part of the detailed design of the roadway extension.

Table 3.11. HEC-RAS Model Output for North Crossing – Ignoring Effect of Consumers Drive

HEC-RAS Model Section	100 Year Storm Water Levels (m)		Regional Storm Water Levels (m)	
	Existing	Proposed	Existing	Proposed
5013	88.52	88.52	90.02	90.07
5014	89.38	89.38*	90.09	90.09*
Proposed GO Connecting Track – 9.75 m Conspan Culvert				
5015	90.38	90.38	90.55	90.56
5019	91.40	91.39	91.53	91.52
5020	92.13	92.13	92.52	92.51

** Fixed water level on the upstream side of the future Consumers Drive culverts (5014.1)*

With 2H:1V embankment slopes, the connecting track will result in a loss of flood storage of less than 5,000 m^3 for the Regional storm event. This is insignificant relative to the total Regional storm hydrograph volume of 1,120,000 m^3 for East Corbett Creek (less than 0.5%). Regardless, at the next stage of design, all reasonable alternatives should be explored to offset the fill in the floodplain with an equivalent cut volume.

4. Summary

The extension of the GO rail service from Oshawa to Bowmanville requires a new track connection from the CNR corridor east of Thickson Road to the CPR corridor west of Stevenson Road. The preferred track alignment crosses East Corbett Creek in three locations.

The most significant crossing of East Corbett Creek occurs south of Victoria Street, between Thickson Road and Thornton Road. The majority of the proposed alignment between the CNR corridor and Victoria Street is within the Regional storm flood plain, which is unusually large due to the restriction caused by the culvert under the CNR embankment.

To prevent the proposed GO connecting track from becoming a restriction to flow in the event that the existing CNR culvert is enlarged, a bridge with a total span of 20 m and a height of 3.25 m is recommended for the proposed south Corbett Creek crossing.

The proposed connecting track between the CNR corridor and Victoria Street will require 60,000 m^3 to 90,000 m^3 of fill in the Regional storm flood plain for the embankment, depending on the steepness of the embankment side slopes. This fill volume has the potential to increase 100 year storm flood levels by 0.3 m to 0.45 m, and to increase Regional storm flood levels by 0.2 m to 0.3 m. The impact on flood levels can be mitigated if steeper 1H:1V side slopes are used for the embankment, and the flood plain on both the east and west sides of Corbett Creek are re-graded to create 60,000 m^3 of offsetting flood storage.

The second East Corbett Creek crossing is located immediately north of Victoria Street. A continuous bridge is proposed to cross over Victoria Street, East Corbett Creek and Highway 401. No impacts on flooding in East Corbett Creek are anticipated.

The final crossing of East Corbett Creek occurs between the future Consumers Drive extension and the CPR corridor west of Thornton Road. A 9.75 m span x 3.0 m high Conspan or equivalent culvert is recommended at this location to prevent any impacts on upstream flooding. It is further recommended that the culverts for the future Consumers Drive be reviewed and enlarged during the detailed design of the extension to avoid any backwater impacts on the GO connecting track.

Note that the above bridge/culvert spans are the minimum required to prevent an increase in upstream flood levels. At the next design stage, fluvial geomorphology assessments are recommended to refine the size of the crossing structures to accommodate future stream movement over the life of the structures.

Appendix A

Supporting Calculations

GO Transit Expansion, Oshawa to Clarington
Corbett Creek Flood Plain Analysis

East Corbett Creek--Existing storage, South Section
Storage Volume as per contour bounding area
Drawing: P:\E073\067-00\4 Development\4 Test Results and Analysis E073-067-00_01-Existing Storage South Section -100118.dwg

Elevation	Area - CN to Victoria Street	Area - North of Victoria Street	Total Area	Incremental Volume	Cumulative Volume	Cumulative Volume
(m)	(m^2)	(m^2)	(m^2)	(m^3)	(m^3)	(ha x m)
81.0	211	0	211			
81.5	621	0	621	208	208	0.02
82.0	3379	157	3536	1039	1247	0.12
82.5	7346	567	7912	2862	4109	0.41
83.0	11754	1669	13423	5334	9443	0.94
83.5	17368	4056	21424	8712	18155	1.82
84.0	25879	6180	32058	13371	31525	3.15
84.5	37864	8658	46522	19645	51171	5.12
85.0	48903	15971	64874	27849	79020	7.90
85.5	56847	24369	81216	36522	115542	11.55
86.0			93474	43673	159215	15.92
86.5			101844	48829	208044	20.80
87.0			108496	52585	260629	26.06
87.5			116000	56124	316753	31.68
88.0			124129	60032	376785	37.68
88.5			215689	84954	461739	46.17
89.0			247447	115784	577524	57.75

GO Transit Expansion, Oshawa to Clarington
Corbett Creek Flood Plain Analysis

Stage-Discharge Relationship for the Flood Plain upstream of the CNR Embankment

HEC-RAS Model Output (Section 5004)

Flow Rate (m^3/s)	Water Surface Elevation (m) Upstream of CNR
5.0	82.28
7.5	82.89
10.0	84.25
12.5	85.84
15.0	87.69
16.0	88.55
17.0	89.41
18.0	90.32

Interpolated Values

Water Surface Elevation (m) Upstream of CNR	Flow Rate (m^3/s)
82.0	3.85
83.0	7.70
84.0	9.54
85.0	11.18
85.5	11.97
86.0	12.72
86.5	13.39
87.0	14.07
87.5	14.74
88.0	15.36
88.5	15.94
89.0	16.52

GO Transit Expansion, Oshawa to Clarington
Corbett Creek Flood Plain Analysis

Stage-Storage-Discharge Relationship for the Flood Plain upstream of the CNR Embankment

Water Surface Elevation (m) Upstream of CNR	Flow Rate (m^3/s)	Flood Storage Volume (m^3)
82.0	3.85	0.12
83.0	7.70	0.94
84.0	9.54	3.15
85.0	11.18	7.90
85.5	11.97	11.55
86.0	12.72	15.92
86.5	13.39	20.80
87.0	14.07	26.06
87.5	14.74	31.68
88.0	15.36	37.68
88.5	15.94	46.17
89.0	16.52	57.75

SWMHYMO Model Output

Storm Event	Routed Flow Rate (m^3/s)	Maximum Storage Volume (m^3)	Interpolated Water Surface Elevation (m)
100 Year	12.709	15.86	85.99
Regional	16.682	61.00	89.14

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

 SSSSS  W   W  M   M  H   H  Y   Y  M   M   OOO        999    999  =========
 S      W W W  MM MM  H   H   Y Y   MM MM  O   O      9   9  9   9
 SSSSS  W W W  M M M  HHHHH    Y    M M M  O   O  ##  9   9  9   9 Ver. 4.02
     S   W W   M   M  H   H    Y    M   M  O   O       9999   9999 July 1999
 SSSSS   W W   M   M  H   H    Y    M   M   OOO           9      9 =========
                                                      9   9  9   9 # 3005209
      StormWater Management HYdrologic Model           999    999  =========

 **********************************************************************
 ************************* SWMHYMO-99 Ver/4.02 ************************
 *******  A single event and continuous hydrologic simulation model  *******
 *******     based on the principles of HYMO and its successors      *******
 *******                OTTHYMO-83 and OTTHYMO-89.                   *******
 **********************************************************************
 ******* Distributed by:  J.F. Sabourin and Associates Inc.           *******
 *******                 Ottawa,  Ontario: (613) 727-5199            *******
 *******                 Gatineau, Quebec: (819) 243-6858            *******
 *******                 E-Mail: swmhymo@jfsa.Com                    *******
 **********************************************************************

 ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
 +++++++ Licensed user: UMA Engineering Ltd.                         +++++++
 +++++++               Mississauga          SERIAL#:3005209          +++++++
 ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

 **********************************************************************
 *******          ++++++ PROGRAM ARRAY DIMENSIONS ++++++             *******
 *******          Maximum value for ID numbers  :     10             *******
 *******          Max. number of rainfall points:  15000             *******
 *******          Max. number of flow points    :  15000             *******
 **********************************************************************


 ********************   D E T A I L E D   O U T P U T   ********************
 **********************************************************************
 *      DATE: 2010-10-25     TIME: 11:32:43     RUN COUNTER: 000038       *
 **********************************************************************
 * Input   filename: C:\PROGRA~1\SWMHYMO\projects\CNREXREG.dat           *
 * Output  filename: C:\PROGRA~1\SWMHYMO\projects\CNREXREG.out           *
 * Summary filename: C:\PROGRA~1\SWMHYMO\projects\CNREXREG.sum           *
 * User comments:                                                        *
 * 1:____________________________________________________________________*
 * 2:____________________________________________________________________*
 * 3:____________________________________________________________________*
 **********************************************************************

--------------------------------------------------------------------------------
001:0001------------------------------------------------------------------------
*#******************************************************************************
*#  Project Name: [  E073-067 CORBETT CREEK CNR STORAGE] Project Number: [E073-0
*#  Date        : 01-26-2010
*#  Modeller    : [   E. LIU     ]
*#  Company     : UMA Engineering Ltd.
*#  License #   :  3005209
*#******************************************************************************
*# EAST CORBETT CREEK
*# STORAGE ROUTING ANALYSIS BEHIND THE CNR EMBANKMENT
*# EXISTING CONDITIONS
*# REGIONAL STORM - INPUT HYDROGRAPH RECEIVED FROM GRECK & ASSOCIATES
********************************************************************************
--------------------
| START             |  Project  dir.: C:\PROGRA~1\SWMHYMO\projects\
--------------------  Rainfall dir.: C:\PROGRA~1\SWMHYMO\projects\
    TZERO =   .00 hrs on        0
    METOUT=   2 (output = METRIC)
    NRUN  = 001
    NSTORM=   0
```

```
--------------------------------------------------------------------------------
001:0002------------------------------------------------------------------------
--------------------
| READ HYD           |   AREA      (ha)=  590.590
| ID=01 (000100)     |   QPEAK     (cms)=   65.597
| DT= 5.00 PCYC= 1   |   TPEAK     (hrs)=   10.083
--------------------     VOLUME    (mm)=  189.575
  Filename: C:\PROGRA~1\SWMHYMO\projects\REGCNR.hyd
  Comments: THIS IS THE REGIONAL STORM AT 1245 MON
```

TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms
.00	.000	4.25	15.229	8.50	21.622	12.75	13.221	17.00	.060
.08	.000	4.33	15.871	8.58	21.423	12.83	12.019	17.08	.056
.17	.400	4.42	16.434	8.67	21.237	12.92	10.336	17.17	.052
.25	1.384	4.50	16.950	8.75	21.079	13.00	9.921	17.25	.049
.33	2.114	4.58	17.430	8.83	20.375	13.08	8.974	17.33	.045
.42	2.506	4.67	17.886	8.92	20.905	13.17	8.032	17.42	.042
.50	2.732	4.75	18.331	9.00	20.633	13.25	7.244	17.50	.039
.58	3.061	4.83	18.766	9.08	25.129	13.33	6.457	17.58	.036
.67	3.306	4.92	19.189	9.17	32.999	13.42	5.784	17.67	.034
.75	3.525	5.00	19.597	9.25	38.009	13.50	5.151	17.75	.031
.83	3.721	5.08	19.549	9.33	41.837	13.58	4.552	17.83	.029
.92	3.896	5.17	19.156	9.42	45.114	13.67	3.889	17.92	.027
1.00	4.059	5.25	19.025	9.50	48.169	13.75	3.479	18.00	.025
1.08	4.000	5.33	19.009	9.58	51.134	13.83	3.000	18.08	.023
1.17	3.780	5.42	19.027	9.67	54.059	13.92	2.610	18.17	.022
1.25	3.696	5.50	19.059	9.75	56.965	14.00	2.234	18.25	.020
1.33	3.679	5.58	19.089	9.83	58.809	14.08	2.017	18.33	.019
1.42	3.634	5.67	19.105	9.92	62.533	14.17	1.773	18.42	.017
1.50	3.724	5.75	19.111	10.00	65.033	14.25	1.559	18.50	.016
1.58	3.759	5.83	19.109	10.08	65.597	14.33	1.367	18.58	.015
1.67	3.735	5.92	19.097	10.17	64.591	14.42	1.132	18.67	.014
1.75	3.833	6.00	19.083	10.25	64.437	14.50	1.029	18.75	.013
1.83	3.871	6.08	20.173	10.33	64.518	14.58	.877	18.83	.012
1.92	3.909	6.17	22.074	10.42	64.614	14.67	.752	18.92	.011
2.00	3.943	6.25	23.269	10.50	64.663	14.75	.651	19.00	.010
2.08	4.135	6.33	24.134	10.58	64.669	14.83	.569	19.08	.009
2.17	4.605	6.42	24.851	10.67	64.566	14.92	.502	19.17	.009
2.25	4.839	6.50	25.509	10.75	64.411	15.00	.445	19.25	.009
2.33	4.935	6.58	26.142	10.83	64.217	15.08	.397	19.33	.007
2.42	5.136	6.67	26.756	10.92	63.884	15.17	.343	19.42	.007
2.50	5.259	6.75	27.350	11.00	63.774	15.25	.303	19.50	.006
2.58	5.371	6.83	27.933	11.08	60.429	15.33	.272	19.58	.006
2.67	5.475	6.92	28.506	11.17	54.949	15.42	.245	19.67	.005
2.75	5.573	7.00	29.061	11.25	51.264	15.50	.224	19.75	.005
2.83	5.667	7.08	28.443	11.33	48.261	15.58	.206	19.83	.004
2.92	5.759	7.17	26.383	11.42	45.662	15.67	.180	19.92	.004
3.00	5.805	7.25	26.221	11.50	43.385	15.75	.176	20.00	.003
3.08	6.605	7.33	25.732	11.58	41.296	15.83	.164	20.08	.003
3.17	8.012	7.42	25.372	11.67	38.325	15.92	.153	20.17	.003
3.25	8.839	7.50	25.043	11.75	37.560	16.00	.142	20.25	.002
3.33	9.519	7.58	24.734	11.83	35.347	16.08	.133	20.33	.002
3.42	10.010	7.67	24.422	11.92	34.483	16.17	.124	20.42	.002
3.50	10.431	7.75	24.101	12.00	33.018	16.25	.115	20.50	.001
3.58	10.815	7.83	23.787	12.08	30.171	16.33	.108	20.58	.001
3.67	11.189	7.92	23.477	12.17	26.385	16.42	.100	20.67	.001
3.75	11.555	8.00	23.173	12.25	23.618	16.50	.088	20.75	.000
3.83	11.913	8.08	22.879	12.33	21.339	16.58	.087		
3.92	12.263	8.17	22.535	12.42	19.377	16.67	.081		
4.00	12.607	8.25	22.327	12.50	17.627	16.75	.075		
4.08	13.369	8.33	22.075	12.58	16.021	16.83	.070		
4.17	14.403	8.42	21.843	12.67	14.559	16.92	.065		

```
--------------------------------------------------------------------------------
001:0003------------------------------------------------------------------------
---------------------
| ROUTE RESERVOIR    |    Requested routing time step =  5.0 min.
|  IN>01:(000100)    |
| OUT<02:(000200)    |    =========  OUTLFOW STORAGE TABLE  =========
```

```
---------------------    OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
                          (cms)    (ha.m.)    |    (cms)    (ha.m.)
                           .000  .0000E+00    |   13.390  .2080E+02
                          3.850  .1250E+00    |   14.070  .2606E+02
                          7.700  .9440E+00    |   14.740  .3167E+02
                          9.540  .3153E+01    |   15.360  .3764E+02
                         11.180  .7902E+01    |   15.940  .4617E+02
                         11.970  .1155E+02    |   16.520  .5775E+02
                         12.720  .1592E+02    |     .000  .0000E+00
      *** WARNING: STORAGE-Q values were extrapolated.
                   Increase curve or use overflow option.

     ROUTING RESULTS            AREA     QPEAK     TPEAK       R.V.
     --------------------       (ha)     (cms)     (hrs)       (mm)
     INFLOW >01: (000100)     590.59    65.597    10.083    189.575
     OUTFLOW<02: (000200)     590.59    16.682    12.583    189.575

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=   25.432
                   TIME SHIFT OF PEAK FLOW         (min)=   150.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=.6100E+02

-------------------------------------------------------------------------------
001:0004-----------------------------------------------------------------------
      FINISH
-------------------------------------------------------------------------------
*******************************************************************************
     WARNINGS / ERRORS / NOTES
     -------------------------
 001:0003 ROUTE RESERVOIR
      *** WARNING: STORAGE-Q values were extrapolated.
                   Increase curve or use overflow option.
   Simulation ended on 2010-10-25     at 11:32:43
===============================================================================
```

GO Transit Expansion, Oshawa to Clarington
Corbett Creek Flood Plain Analysis

Stage-Storage-Discharge Relationship for the Flood Plain upstream of the CNR Embankment

Water Surface Elevation (m) Upstream of CNR	Flow Rate (m^3/s)	Existing Flood Storage Volume (m^3)	Proposed Fill Volume (m^3)	Proposed Flood Storage Volume (m^3)
82.0	3.85	0.12	0.24	0.00
83.0	7.70	0.94	0.71	0.23
84.0	9.54	3.15	1.82	1.33
85.0	11.18	7.90	3.17	4.73
85.5	11.97	11.55	*3.91*	7.64
86.0	12.72	15.92	4.66	11.26
86.5	13.39	20.80	*5.39*	15.42
87.0	14.07	26.06	6.12	19.94
87.5	14.74	31.68	*6.82*	24.85
88.0	15.36	37.68	7.52	30.16
88.5	15.94	46.17	*8.16*	38.01
89.0	16.52	57.75	8.80	48.96

SWMHYMO Model Output

Storm Event	Routed Flow Rate (m^3/s)	Maximum Storage Volume (m^3)	Interpolated Water Surface Elevation (m)
100 Year	13.327	15.15	86.47
Regional	17.04	58.89	89.45

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

 SSSSS  W   W  M   M  H   H  Y   Y  M   M   OOO        999    999  =========
 S      W W W  MM MM  H   H   Y Y   MM MM  O   O      9   9  9   9
 SSSSS  W W W  M M M  HHHHH    Y    M M M  O   O  ##  9   9  9   9 Ver. 4.02
     S   W W   M   M  H   H    Y    M   M  O   O       9999   9999 July 1999
 SSSSS   W W   M   M  H   H    Y    M   M   OOO           9      9 =========
                                                      9   9  9   9 # 3005209
      StormWater Management HYdrologic Model           999    999  =========

 **********************************************************************
 ************************* SWMHYMO-99 Ver/4.02 ************************
 *******  A single event and continuous hydrologic simulation model  *******
 *******     based on the principles of HYMO and its successors      *******
 *******                 OTTHYMO-83 and OTTHYMO-89.                  *******
 **********************************************************************
 ******* Distributed by:  J.F. Sabourin and Associates Inc.          *******
 *******                 Ottawa,  Ontario: (613) 727-5199            *******
 *******                 Gatineau, Quebec: (819) 243-6858            *******
 *******                 E-Mail: swmhymo@jfsa.Com                    *******
 **********************************************************************

 ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
 +++++++ Licensed user: UMA Engineering Ltd.                       +++++++
 +++++++               Mississauga          SERIAL#:3005209        +++++++
 ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

 **********************************************************************
 *******          ++++++ PROGRAM ARRAY DIMENSIONS ++++++           *******
 *******          Maximum value for ID numbers  :     10           *******
 *******          Max. number of rainfall points:  15000           *******
 *******          Max. number of flow points    :  15000           *******
 **********************************************************************


 ********************   D E T A I L E D   O U T P U T   ********************
 **********************************************************************
 *      DATE: 2010-10-25     TIME: 11:41:21     RUN COUNTER: 000041      *
 **********************************************************************
 * Input   filename: C:\PROGRA~1\SWMHYMO\projects\CNRP1REG.dat           *
 * Output  filename: C:\PROGRA~1\SWMHYMO\projects\CNRP1REG.out           *
 * Summary filename: C:\PROGRA~1\SWMHYMO\projects\CNRP1REG.sum           *
 * User comments:                                                        *
 * 1:____________________________________________________________________*
 * 2:____________________________________________________________________*
 * 3:____________________________________________________________________*
 **********************************************************************

--------------------------------------------------------------------------------
001:0001------------------------------------------------------------------------
*#******************************************************************************
*#  Project Name: [  E073-067 CORBETT CREEK CNR STORAGE] Project Number: [E073-0
*#  Date        : 01-26-2010
*#  Modeller    : [   E. LIU     ]
*#  Company     : UMA Engineering Ltd.
*#  License #   :  3005209
*#******************************************************************************
*# EAST CORBETT CREEK
*# STORAGE ROUTING ANALYSIS BEHIND THE CNR EMBANKMENT
*# PROPOSED CONDITIONS SCENARIO 1:  2:1 FILL SLOPES, NO COMPENSATING CUT
*# REGIONAL STORM - INPUT HYDROGRAPH RECEIVED FROM GRECK & ASSOCIATES
********************************************************************************
--------------------
| START            |  Project  dir.: C:\PROGRA~1\SWMHYMO\projects\
--------------------  Rainfall dir.: C:\PROGRA~1\SWMHYMO\projects\
    TZERO =   .00 hrs on       0
    METOUT=   2 (output = METRIC)
    NRUN  = 001
    NSTORM=   0
```

```
--------------------------------------------------------------------------------
001:0002------------------------------------------------------------------------
--------------------
| READ HYD           |   AREA      (ha)=  590.590
| ID=01 (000100)     |   QPEAK    (cms)=   65.597
| DT= 5.00 PCYC= 1   |   TPEAK    (hrs)=   10.083
--------------------   VOLUME     (mm)=  189.575
  Filename: C:\PROGRA~1\SWMHYMO\projects\REGCNR.hyd
  Comments: THIS IS THE REGIONAL STORM AT 1245 MON

  TIME    FLOW |  TIME    FLOW |  TIME    FLOW |  TIME    FLOW |  TIME    FLOW
   hrs     cms |   hrs     cms |   hrs     cms |   hrs     cms |   hrs     cms
   .00    .000|   4.25  15.229|   8.50  21.622|  12.75  13.221|  17.00    .060
   .08    .000|   4.33  15.871|   8.58  21.423|  12.83  12.019|  17.08    .056
   .17    .400|   4.42  16.434|   8.67  21.237|  12.92  10.336|  17.17    .052
   .25   1.384|   4.50  16.950|   8.75  21.079|  13.00   9.921|  17.25    .049
   .33   2.114|   4.58  17.430|   8.83  20.375|  13.08   8.974|  17.33    .045
   .42   2.506|   4.67  17.886|   8.92  20.905|  13.17   8.032|  17.42    .042
   .50   2.732|   4.75  18.331|   9.00  20.633|  13.25   7.244|  17.50    .039
   .58   3.061|   4.83  18.766|   9.08  25.129|  13.33   6.457|  17.58    .036
   .67   3.306|   4.92  19.189|   9.17  32.999|  13.42   5.784|  17.67    .034
   .75   3.525|   5.00  19.597|   9.25  38.009|  13.50   5.151|  17.75    .031
   .83   3.721|   5.08  19.549|   9.33  41.837|  13.58   4.552|  17.83    .029
   .92   3.896|   5.17  19.156|   9.42  45.114|  13.67   3.889|  17.92    .027
  1.00   4.059|   5.25  19.025|   9.50  48.169|  13.75   3.479|  18.00    .025
  1.08   4.000|   5.33  19.009|   9.58  51.134|  13.83   3.000|  18.08    .023
  1.17   3.780|   5.42  19.027|   9.67  54.059|  13.92   2.610|  18.17    .022
  1.25   3.696|   5.50  19.059|   9.75  56.965|  14.00   2.234|  18.25    .020
  1.33   3.679|   5.58  19.089|   9.83  58.809|  14.08   2.017|  18.33    .019
  1.42   3.634|   5.67  19.105|   9.92  62.533|  14.17   1.773|  18.42    .017
  1.50   3.724|   5.75  19.111|  10.00  65.033|  14.25   1.559|  18.50    .016
  1.58   3.759|   5.83  19.109|  10.08  65.597|  14.33   1.367|  18.58    .015
  1.67   3.735|   5.92  19.097|  10.17  64.591|  14.42   1.132|  18.67    .014
  1.75   3.833|   6.00  19.083|  10.25  64.437|  14.50   1.029|  18.75    .013
  1.83   3.871|   6.08  20.173|  10.33  64.518|  14.58    .877|  18.83    .012
  1.92   3.909|   6.17  22.074|  10.42  64.614|  14.67    .752|  18.92    .011
  2.00   3.943|   6.25  23.269|  10.50  64.663|  14.75    .651|  19.00    .010
  2.08   4.135|   6.33  24.134|  10.58  64.669|  14.83    .569|  19.08    .009
  2.17   4.605|   6.42  24.851|  10.67  64.566|  14.92    .502|  19.17    .009
  2.25   4.839|   6.50  25.509|  10.75  64.411|  15.00    .445|  19.25    .009
  2.33   4.935|   6.58  26.142|  10.83  64.217|  15.08    .397|  19.33    .007
  2.42   5.136|   6.67  26.756|  10.92  63.884|  15.17    .343|  19.42    .007
  2.50   5.259|   6.75  27.350|  11.00  63.774|  15.25    .303|  19.50    .006
  2.58   5.371|   6.83  27.933|  11.08  60.429|  15.33    .272|  19.58    .006
  2.67   5.475|   6.92  28.506|  11.17  54.949|  15.42    .245|  19.67    .005
  2.75   5.573|   7.00  29.061|  11.25  51.264|  15.50    .224|  19.75    .005
  2.83   5.667|   7.08  28.443|  11.33  48.261|  15.58    .206|  19.83    .004
  2.92   5.759|   7.17  26.383|  11.42  45.662|  15.67    .180|  19.92    .004
  3.00   5.805|   7.25  26.221|  11.50  43.385|  15.75    .176|  20.00    .003
  3.08   6.605|   7.33  25.732|  11.58  41.296|  15.83    .164|  20.08    .003
  3.17   8.012|   7.42  25.372|  11.67  38.325|  15.92    .153|  20.17    .003
  3.25   8.839|   7.50  25.043|  11.75  37.560|  16.00    .142|  20.25    .002
  3.33   9.519|   7.58  24.734|  11.83  35.347|  16.08    .133|  20.33    .002
  3.42  10.010|   7.67  24.422|  11.92  34.483|  16.17    .124|  20.42    .002
  3.50  10.431|   7.75  24.101|  12.00  33.018|  16.25    .115|  20.50    .001
  3.58  10.815|   7.83  23.787|  12.08  30.171|  16.33    .108|  20.58    .001
  3.67  11.189|   7.92  23.477|  12.17  26.385|  16.42    .100|  20.67    .001
  3.75  11.555|   8.00  23.173|  12.25  23.618|  16.50    .088|  20.75    .000
  3.83  11.913|   8.08  22.879|  12.33  21.339|  16.58    .087|
  3.92  12.263|   8.17  22.535|  12.42  19.377|  16.67    .081|
  4.00  12.607|   8.25  22.327|  12.50  17.627|  16.75    .075|
  4.08  13.369|   8.33  22.075|  12.58  16.021|  16.83    .070|
  4.17  14.403|   8.42  21.843|  12.67  14.559|  16.92    .065|
--------------------------------------------------------------------------------
001:0003------------------------------------------------------------------------
--------------------
| ROUTE RESERVOIR    |    Requested routing time step =  5.0 min.
|  IN>01:(000100)    |
| OUT<02:(000200)    |    =========  OUTLFOW STORAGE TABLE  =========
```

```
---------------------    OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
                          (cms)    (ha.m.)    |    (cms)    (ha.m.)
                           .000  .0000E+00    |   13.390  .1553E+02
                          3.850  .5000E-02    |   14.070  .2006E+02
                          7.700  .3500E+00    |   14.740  .2497E+02
                          9.540  .1448E+01    |   15.360  .3027E+02
                         11.180  .4850E+01    |   15.940  .3813E+02
                         11.970  .7760E+01    |   16.520  .4908E+02
                         12.720  .1138E+02    |     .000  .0000E+00
      *** WARNING: STORAGE-Q values were extrapolated.
                   Increase curve or use overflow option.

     ROUTING RESULTS            AREA     QPEAK     TPEAK       R.V.
     --------------------       (ha)     (cms)     (hrs)       (mm)
     INFLOW >01: (000100)     590.59    65.597    10.083    189.575
     OUTFLOW<02: (000200)     590.59    17.040    12.500    189.584

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=   25.976
                   TIME SHIFT OF PEAK FLOW         (min)=   145.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=.5889E+02

-------------------------------------------------------------------------------
001:0004-----------------------------------------------------------------------
      FINISH
-------------------------------------------------------------------------------
*******************************************************************************
     WARNINGS / ERRORS / NOTES
     -------------------------
 001:0003 ROUTE RESERVOIR
      *** WARNING: STORAGE-Q values were extrapolated.
                   Increase curve or use overflow option.
   Simulation ended on 2010-10-25     at 11:41:21
===============================================================================
```

GO Transit Expansion, Oshawa to Clarington
Corbett Creek Flood Plain Analysis

Stage-Storage-Discharge Relationship for the Flood Plain upstream of the CNR Embankment
1 Horizontal:1 Vertical Embankment Slopes

Water Surface Elevation (m) Upstream of CNR	Flow Rate (m^3/s)	Existing Flood Storage Volume (m^3)	Proposed Fill Volume (m^3)	Proposed Flood Storage Volume (m^3)
82.0	3.85	0.12	0.20	0.00
83.0	7.70	0.94	0.48	0.47
84.0	9.54	3.15	1.19	1.96
85.0	11.18	7.90	2.07	5.83
85.5	11.97	11.55	*2.55*	9.00
86.0	12.72	15.92	3.04	12.89
86.5	13.39	20.80	*3.52*	17.29
87.0	14.07	26.06	4.00	22.06
87.5	14.74	31.68	*4.47*	27.20
88.0	15.36	37.68	4.95	32.73
88.5	15.94	46.17	*5.40*	40.78
89.0	16.52	57.75	5.84	51.91

SWMHYMO Model Output

Storm Event	Routed Flow Rate (m^3/s)	Maximum Storage Volume (m^3)	Interpolated Water Surface Elevation (m)
100 Year	13.097	15.35	86.28
Regional	16.916	59.52	89.34

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

 SSSSS  W   W  M   M  H   H  Y   Y  M   M   OOO        999    999  =========
 S      W W W  MM MM  H   H   Y Y   MM MM  O   O      9   9  9   9
 SSSSS  W W W  M M M  HHHHH    Y    M M M  O   O  ##  9   9  9   9 Ver. 4.02
     S   W W   M   M  H   H    Y    M   M  O   O       9999   9999 July 1999
 SSSSS   W W   M   M  H   H    Y    M   M   OOO           9      9 =========
                                                      9   9  9   9 # 3005209
      StormWater Management HYdrologic Model           999    999  =========

 **********************************************************************
 ************************* SWMHYMO-99 Ver/4.02 ************************
 *******  A single event and continuous hydrologic simulation model  *******
 *******     based on the principles of HYMO and its successors     *******
 *******                 OTTHYMO-83 and OTTHYMO-89.                 *******
 **********************************************************************
 ******* Distributed by:  J.F. Sabourin and Associates Inc.          *******
 *******                  Ottawa,  Ontario: (613) 727-5199           *******
 *******                  Gatineau, Quebec: (819) 243-6858           *******
 *******                  E-Mail: swmhymo@jfsa.Com                   *******
 **********************************************************************

 ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
 +++++++ Licensed user: UMA Engineering Ltd.                    +++++++
 +++++++                Mississauga           SERIAL#:3005209   +++++++
 ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

 **********************************************************************
 *******          ++++++ PROGRAM ARRAY DIMENSIONS ++++++             *******
 *******          Maximum value for ID numbers  :     10             *******
 *******          Max. number of rainfall points:  15000             *******
 *******          Max. number of flow points    :  15000             *******
 **********************************************************************


 *******************   D E T A I L E D   O U T P U T   *******************
 **********************************************************************
 *      DATE: 2010-10-25     TIME: 12:11:49     RUN COUNTER: 000044      *
 **********************************************************************
 * Input   filename: C:\PROGRA~1\SWMHYMO\projects\CNRP2REG.dat           *
 * Output  filename: C:\PROGRA~1\SWMHYMO\projects\CNRP2REG.out           *
 * Summary filename: C:\PROGRA~1\SWMHYMO\projects\CNRP2REG.sum           *
 * User comments:                                                        *
 * 1:____________________________________________________________________*
 * 2:____________________________________________________________________*
 * 3:____________________________________________________________________*
 **********************************************************************

--------------------------------------------------------------------------------
001:0001------------------------------------------------------------------------
*#******************************************************************************
*#  Project Name: [  E073-067 CORBETT CREEK CNR STORAGE] Project Number: [E073-0
*#  Date        : 01-26-2010
*#  Modeller    : [   E. LIU     ]
*#  Company     : UMA Engineering Ltd.
*#  License #   :  3005209
*#******************************************************************************
*# EAST CORBETT CREEK
*# STORAGE ROUTING ANALYSIS BEHIND THE CNR EMBANKMENT
*# PROPOSED CONDITIONS SCENARIO 2:  1:1 FILL SLOPES, NO COMPENSATING CUT
*# REGIONAL STORM - INPUT HYDROGRAPH RECEIVED FROM GRECK & ASSOCIATES
********************************************************************************
--------------------
| START            |  Project  dir.: C:\PROGRA~1\SWMHYMO\projects\
--------------------  Rainfall dir.: C:\PROGRA~1\SWMHYMO\projects\
    TZERO =    .00 hrs on        0
    METOUT=    2 (output = METRIC)
    NRUN  = 001
    NSTORM=    0
```

```
--------------------------------------------------------------------------------
001:0002------------------------------------------------------------------------
--------------------
| READ HYD          |    AREA      (ha)=  590.590
| ID=01 (000100)    |    QPEAK    (cms)=   65.597
| DT= 5.00 PCYC= 1  |    TPEAK    (hrs)=   10.083
--------------------     VOLUME     (mm)=  189.575
  Filename: C:\PROGRA~1\SWMHYMO\projects\REGCNR.hyd
  Comments: THIS IS THE REGIONAL STORM AT 1245 MON
```

TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms
.00	.000	4.25	15.229	8.50	21.622	12.75	13.221	17.00	.060
.08	.000	4.33	15.871	8.58	21.423	12.83	12.019	17.08	.056
.17	.400	4.42	16.434	8.67	21.237	12.92	10.336	17.17	.052
.25	1.384	4.50	16.950	8.75	21.079	13.00	9.921	17.25	.049
.33	2.114	4.58	17.430	8.83	20.375	13.08	8.974	17.33	.045
.42	2.506	4.67	17.886	8.92	20.905	13.17	8.032	17.42	.042
.50	2.732	4.75	18.331	9.00	20.633	13.25	7.244	17.50	.039
.58	3.061	4.83	18.766	9.08	25.129	13.33	6.457	17.58	.036
.67	3.306	4.92	19.189	9.17	32.999	13.42	5.784	17.67	.034
.75	3.525	5.00	19.597	9.25	38.009	13.50	5.151	17.75	.031
.83	3.721	5.08	19.549	9.33	41.837	13.58	4.552	17.83	.029
.92	3.896	5.17	19.156	9.42	45.114	13.67	3.889	17.92	.027
1.00	4.059	5.25	19.025	9.50	48.169	13.75	3.479	18.00	.025
1.08	4.000	5.33	19.009	9.58	51.134	13.83	3.000	18.08	.023
1.17	3.780	5.42	19.027	9.67	54.059	13.92	2.610	18.17	.022
1.25	3.696	5.50	19.059	9.75	56.965	14.00	2.234	18.25	.020
1.33	3.679	5.58	19.089	9.83	58.809	14.08	2.017	18.33	.019
1.42	3.634	5.67	19.105	9.92	62.533	14.17	1.773	18.42	.017
1.50	3.724	5.75	19.111	10.00	65.033	14.25	1.559	18.50	.016
1.58	3.759	5.83	19.109	10.08	65.597	14.33	1.367	18.58	.015
1.67	3.735	5.92	19.097	10.17	64.591	14.42	1.132	18.67	.014
1.75	3.833	6.00	19.083	10.25	64.437	14.50	1.029	18.75	.013
1.83	3.871	6.08	20.173	10.33	64.518	14.58	.877	18.83	.012
1.92	3.909	6.17	22.074	10.42	64.614	14.67	.752	18.92	.011
2.00	3.943	6.25	23.269	10.50	64.663	14.75	.651	19.00	.010
2.08	4.135	6.33	24.134	10.58	64.669	14.83	.569	19.08	.009
2.17	4.605	6.42	24.851	10.67	64.566	14.92	.502	19.17	.009
2.25	4.839	6.50	25.509	10.75	64.411	15.00	.445	19.25	.009
2.33	4.935	6.58	26.142	10.83	64.217	15.08	.397	19.33	.007
2.42	5.136	6.67	26.756	10.92	63.884	15.17	.343	19.42	.007
2.50	5.259	6.75	27.350	11.00	63.774	15.25	.303	19.50	.006
2.58	5.371	6.83	27.933	11.08	60.429	15.33	.272	19.58	.006
2.67	5.475	6.92	28.506	11.17	54.949	15.42	.245	19.67	.005
2.75	5.573	7.00	29.061	11.25	51.264	15.50	.224	19.75	.005
2.83	5.667	7.08	28.443	11.33	48.261	15.58	.206	19.83	.004
2.92	5.759	7.17	26.383	11.42	45.662	15.67	.180	19.92	.004
3.00	5.805	7.25	26.221	11.50	43.385	15.75	.176	20.00	.003
3.08	6.605	7.33	25.732	11.58	41.296	15.83	.164	20.08	.003
3.17	8.012	7.42	25.372	11.67	38.325	15.92	.153	20.17	.003
3.25	8.839	7.50	25.043	11.75	37.560	16.00	.142	20.25	.002
3.33	9.519	7.58	24.734	11.83	35.347	16.08	.133	20.33	.002
3.42	10.010	7.67	24.422	11.92	34.483	16.17	.124	20.42	.002
3.50	10.431	7.75	24.101	12.00	33.018	16.25	.115	20.50	.001
3.58	10.815	7.83	23.787	12.08	30.171	16.33	.108	20.58	.001
3.67	11.189	7.92	23.477	12.17	26.385	16.42	.100	20.67	.001
3.75	11.555	8.00	23.173	12.25	23.618	16.50	.088	20.75	.000
3.83	11.913	8.08	22.879	12.33	21.339	16.58	.087		
3.92	12.263	8.17	22.535	12.42	19.377	16.67	.081		
4.00	12.607	8.25	22.327	12.50	17.627	16.75	.075		
4.08	13.369	8.33	22.075	12.58	16.021	16.83	.070		
4.17	14.403	8.42	21.843	12.67	14.559	16.92	.065		

```
--------------------------------------------------------------------------------
001:0003------------------------------------------------------------------------
---------------------
| ROUTE RESERVOIR    |    Requested routing time step =  5.0 min.
|  IN>01:(000100)    |
| OUT<02:(000200)    |    =========  OUTLFOW STORAGE TABLE  =========
```

```
---------------------    OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
                          (cms)    (ha.m.)   |    (cms)    (ha.m.)
                           .000  .0000E+00   |   13.390  .1728E+02
                          3.850  .0000E+00   |   14.070  .2006E+02
                          7.700  .4600E+00   |   14.740  .2721E+02
                          9.540  .1960E+01   |   15.360  .3273E+02
                         11.180  .5830E+01   |   15.940  .4078E+02
                         11.970  .9000E+01   |   16.520  .5191E+02
                         12.720  .1287E+02   |     .000  .0000E+00
      *** WARNING: STORAGE-Q values were extrapolated.
                   Increase curve or use overflow option.

     ROUTING RESULTS            AREA     QPEAK     TPEAK       R.V.
     --------------------       (ha)     (cms)     (hrs)       (mm)
     INFLOW >01: (000100)     590.59    65.597    10.083    189.575
     OUTFLOW<02: (000200)     590.59    16.916    12.500    189.610

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=   25.788
                   TIME SHIFT OF PEAK FLOW         (min)=   145.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=.5952E+02

-------------------------------------------------------------------------------
001:0004-----------------------------------------------------------------------
      FINISH
-------------------------------------------------------------------------------
*******************************************************************************
     WARNINGS / ERRORS / NOTES
     -------------------------
 001:0003 ROUTE RESERVOIR
      *** WARNING: STORAGE-Q values were extrapolated.
                   Increase curve or use overflow option.
   Simulation ended on 2010-10-25     at 12:11:50
===============================================================================
```

GO Transit Expansion, Oshawa to Clarington
Corbett Creek Flood Plain Analysis

Stage-Storage-Discharge Relationship for the Flood Plain upstream of the CNR Embankment
1 Horizontal:1 Vertical Embankment Slopes
Compensating Cut Volume in East Corbett Creek Valley

Water Surface Elevation (m) Upstream of CNR	Flow Rate (m^3/s)	Existing Flood Storage Volume (ha x m)	Proposed Fill Volume (ha x m)	Compensating Cut Volume - West of Creek (m^3)	Compensating Cut Volume - East of Creek (m^3)	Proposed Flood Storage Volume (ha x m)
82.0	3.85	0.12	0.20			0.00
83.0	7.70	0.94	0.48	1829		0.65
84.0	9.54	3.15	1.19	10584	10302	4.05
85.0	11.18	7.90	2.07	14866	28642	10.18
85.5	11.97	11.55	2.55	15049	35292	14.03
86.0	12.72	15.92	3.04	15049	39845	18.38
86.5	13.39	20.80	3.52	15049	42660	23.06
87.0	14.07	26.06	4.00	15049	44162	27.99
87.5	14.74	31.68	4.47	15049	44632	33.17
88.0	15.36	37.68	4.95	15049	45102	38.74
88.5	15.94	46.17	5.40	15049	45102	46.79
89.0	16.52	57.75	5.84	15049	45102	57.93

SWMHYMO Model Output

Storm Event	Routed Flow Rate (m^3/s)	Maximum Storage Volume (m^3)	Interpolated Water Surface Elevation (m)
100 Year	12.315	16.03	85.73
Regional	16.709	61.58	89.16

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

 SSSSS  W   W  M   M  H   H  Y   Y  M   M   OOO        999    999  =========
 S      W W W  MM MM  H   H   Y Y   MM MM  O   O      9   9  9   9
 SSSSS  W W W  M M M  HHHHH    Y    M M M  O   O  ##  9   9  9   9 Ver. 4.02
     S   W W   M   M  H   H    Y    M   M  O   O       9999   9999 July 1999
 SSSSS   W W   M   M  H   H    Y    M   M   OOO           9      9 =========
                                                      9   9  9   9 # 3005209
      StormWater Management HYdrologic Model           999    999  =========

 **********************************************************************
 ************************* SWMHYMO-99 Ver/4.02 ************************
 *******  A single event and continuous hydrologic simulation model  *******
 *******     based on the principles of HYMO and its successors     *******
 *******                OTTHYMO-83 and OTTHYMO-89.                   *******
 **********************************************************************
 ******* Distributed by:  J.F. Sabourin and Associates Inc.          *******
 *******                 Ottawa,  Ontario: (613) 727-5199            *******
 *******                 Gatineau, Quebec: (819) 243-6858            *******
 *******                 E-Mail: swmhymo@jfsa.Com                    *******
 **********************************************************************

 ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
 +++++++ Licensed user: UMA Engineering Ltd.                        +++++++
 +++++++               Mississauga          SERIAL#:3005209         +++++++
 ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

 **********************************************************************
 *******          ++++++ PROGRAM ARRAY DIMENSIONS ++++++            *******
 *******          Maximum value for ID numbers  :     10            *******
 *******          Max. number of rainfall points:  15000            *******
 *******          Max. number of flow points    :  15000            *******
 **********************************************************************


 *******************   D E T A I L E D   O U T P U T   *******************
 **********************************************************************
 *      DATE: 2010-10-25     TIME: 12:14:02     RUN COUNTER: 000047       *
 **********************************************************************
 * Input   filename: C:\PROGRA~1\SWMHYMO\projects\CNRP3REG.dat            *
 * Output  filename: C:\PROGRA~1\SWMHYMO\projects\CNRP3REG.out            *
 * Summary filename: C:\PROGRA~1\SWMHYMO\projects\CNRP3REG.sum            *
 * User comments:                                                         *
 * 1:_____________________________________________________________________*
 * 2:_____________________________________________________________________*
 * 3:_____________________________________________________________________*
 **********************************************************************

--------------------------------------------------------------------------------
001:0001------------------------------------------------------------------------
*#******************************************************************************
*#  Project Name: [  E073-067 CORBETT CREEK CNR STORAGE] Project Number: [E073-0
*#  Date        : 01-26-2010
*#  Modeller    : [   E. LIU     ]
*#  Company     : UMA Engineering Ltd.
*#  License #   :  3005209
*#******************************************************************************
*# EAST CORBETT CREEK
*# STORAGE ROUTING ANALYSIS BEHIND THE CNR EMBANKMENT
*# PROPOSED CONDITIONS SCENARIO 3:  1:1 FILL SLOPES,
*# EQUIVALENT CUT VOLUME FROM FLOOD PLAIN BETWEEN CNR AND VICTORIA STREET
*# REGIONAL STORM - INPUT HYDROGRAPH RECEIVED FROM GRECK & ASSOCIATES
********************************************************************************
--------------------
| START             |  Project  dir.: C:\PROGRA~1\SWMHYMO\projects\
--------------------  Rainfall dir.: C:\PROGRA~1\SWMHYMO\projects\
    TZERO =    .00 hrs on        0
    METOUT=   2 (output = METRIC)
    NRUN  = 001
    NSTORM=   0
--------------------------------------------------------------------------------
001:0002------------------------------------------------------------------------
--------------------
| READ HYD          |   AREA      (ha)=  590.590
| ID=01 (000100)    |   QPEAK     (cms)=   65.597
| DT= 5.00 PCYC= 1  |   TPEAK     (hrs)=   10.083
--------------------    VOLUME     (mm)=  189.575
  Filename: C:\PROGRA~1\SWMHYMO\projects\REGCNR.hyd
  Comments: THIS IS THE REGIONAL STORM AT 1245 MON
```

TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms
.00	.000	4.25	15.229	8.50	21.622	12.75	13.221	17.00	.060
.08	.000	4.33	15.871	8.58	21.423	12.83	12.019	17.08	.056
.17	.400	4.42	16.434	8.67	21.237	12.92	10.336	17.17	.052
.25	1.384	4.50	16.950	8.75	21.079	13.00	9.921	17.25	.049
.33	2.114	4.58	17.430	8.83	20.375	13.08	8.974	17.33	.045
.42	2.506	4.67	17.886	8.92	20.905	13.17	8.032	17.42	.042
.50	2.732	4.75	18.331	9.00	20.633	13.25	7.244	17.50	.039
.58	3.061	4.83	18.766	9.08	25.129	13.33	6.457	17.58	.036
.67	3.306	4.92	19.189	9.17	32.999	13.42	5.784	17.67	.034
.75	3.525	5.00	19.597	9.25	38.009	13.50	5.151	17.75	.031
.83	3.721	5.08	19.549	9.33	41.837	13.58	4.552	17.83	.029
.92	3.896	5.17	19.156	9.42	45.114	13.67	3.889	17.92	.027
1.00	4.059	5.25	19.025	9.50	48.169	13.75	3.479	18.00	.025
1.08	4.000	5.33	19.009	9.58	51.134	13.83	3.000	18.08	.023
1.17	3.780	5.42	19.027	9.67	54.059	13.92	2.610	18.17	.022
1.25	3.696	5.50	19.059	9.75	56.965	14.00	2.234	18.25	.020
1.33	3.679	5.58	19.089	9.83	58.809	14.08	2.017	18.33	.019
1.42	3.634	5.67	19.105	9.92	62.533	14.17	1.773	18.42	.017
1.50	3.724	5.75	19.111	10.00	65.033	14.25	1.559	18.50	.016
1.58	3.759	5.83	19.109	10.08	65.597	14.33	1.367	18.58	.015
1.67	3.735	5.92	19.097	10.17	64.591	14.42	1.132	18.67	.014
1.75	3.833	6.00	19.083	10.25	64.437	14.50	1.029	18.75	.013
1.83	3.871	6.08	20.173	10.33	64.518	14.58	.877	18.83	.012
1.92	3.909	6.17	22.074	10.42	64.614	14.67	.752	18.92	.011
2.00	3.943	6.25	23.269	10.50	64.663	14.75	.651	19.00	.010
2.08	4.135	6.33	24.134	10.58	64.669	14.83	.569	19.08	.009
2.17	4.605	6.42	24.851	10.67	64.566	14.92	.502	19.17	.009
2.25	4.839	6.50	25.509	10.75	64.411	15.00	.445	19.25	.009
2.33	4.935	6.58	26.142	10.83	64.217	15.08	.397	19.33	.007
2.42	5.136	6.67	26.756	10.92	63.884	15.17	.343	19.42	.007
2.50	5.259	6.75	27.350	11.00	63.774	15.25	.303	19.50	.006
2.58	5.371	6.83	27.933	11.08	60.429	15.33	.272	19.58	.006
2.67	5.475	6.92	28.506	11.17	54.949	15.42	.245	19.67	.005
2.75	5.573	7.00	29.061	11.25	51.264	15.50	.224	19.75	.005
2.83	5.667	7.08	28.443	11.33	48.261	15.58	.206	19.83	.004
2.92	5.759	7.17	26.383	11.42	45.662	15.67	.180	19.92	.004
3.00	5.805	7.25	26.221	11.50	43.385	15.75	.176	20.00	.003
3.08	6.605	7.33	25.732	11.58	41.296	15.83	.164	20.08	.003
3.17	8.012	7.42	25.372	11.67	38.325	15.92	.153	20.17	.003
3.25	8.839	7.50	25.043	11.75	37.560	16.00	.142	20.25	.002
3.33	9.519	7.58	24.734	11.83	35.347	16.08	.133	20.33	.002
3.42	10.010	7.67	24.422	11.92	34.483	16.17	.124	20.42	.002
3.50	10.431	7.75	24.101	12.00	33.018	16.25	.115	20.50	.001
3.58	10.815	7.83	23.787	12.08	30.171	16.33	.108	20.58	.001
3.67	11.189	7.92	23.477	12.17	26.385	16.42	.100	20.67	.001
3.75	11.555	8.00	23.173	12.25	23.618	16.50	.088	20.75	.000
3.83	11.913	8.08	22.879	12.33	21.339	16.58	.087		
3.92	12.263	8.17	22.535	12.42	19.377	16.67	.081		
4.00	12.607	8.25	22.327	12.50	17.627	16.75	.075		
4.08	13.369	8.33	22.075	12.58	16.021	16.83	.070		
4.17	14.403	8.42	21.843	12.67	14.559	16.92	.065		

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--------------------------------------------------------------------------------
001:0003------------------------------------------------------------------------
--------------------
| ROUTE RESERVOIR   |    Requested routing time step =  5.0 min.
|  IN>01:(000100)   |
```

```
| OUT<02:(000200)   |    =========  OUTLFOW STORAGE TABLE  =========
---------------------    OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
                           (cms)    (ha.m.)   |    (cms)    (ha.m.)
                            .000  .0000E+00   |   13.390  .2306E+02
                           3.850  .0000E+00   |   14.070  .2799E+02
                           7.700  .6500E+00   |   14.740  .3317E+02
                           9.540  .4050E+01   |   15.360  .3874E+02
                          11.180  .1018E+02   |   15.940  .4679E+02
                          11.970  .1403E+02   |   16.520  .5793E+02
                          12.720  .1838E+02   |     .000  .0000E+00
      *** WARNING: STORAGE-Q values were extrapolated.
                   Increase curve or use overflow option.

     ROUTING RESULTS            AREA     QPEAK     TPEAK       R.V.
     --------------------       (ha)     (cms)     (hrs)       (mm)
     INFLOW >01: (000100)     590.59    65.597    10.083    189.575
     OUTFLOW<02: (000200)     590.59    16.709    12.583    189.649

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=   25.473
                   TIME SHIFT OF PEAK FLOW         (min)=   150.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=.6158E+02

-------------------------------------------------------------------------------
001:0004-----------------------------------------------------------------------
      FINISH
-------------------------------------------------------------------------------
*******************************************************************************
     WARNINGS / ERRORS / NOTES
     -------------------------
 001:0003 ROUTE RESERVOIR
      *** WARNING: STORAGE-Q values were extrapolated.
                   Increase curve or use overflow option.
   Simulation ended on 2010-10-25     at 12:14:02
===============================================================================
```