EVALUATION OF ETOBICOKE EXFILTRATION SYSTEM APPLICATIONS IN THE CITY OF BARRIE

by

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Master of Engineering

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Abstract

Evaluation of Etobicoke Exfiltration System Applications in the City of Barrie

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These days engineers reduce the adverse effects of urbanizations using Low Impact Developments (LID) on their municipal design. Etobicoke Exfiltration System (EES) as a LID Best Management Practice (BMP) was demonstrated in 1993 and is being implemented at a hospital rehabilitation project in Toronto. To evaluate EES through modeling, a methodology was used to implement EES in SWMM 5.1.012, and the outcome was applied for a case study in Barrie. The primary components of EES include inlets, void space storage of granular material laid beneath the main sewer system. These components were modeled by orifices and a storage unit to simulate the exfiltration of water from the stone trench into the surrounding native soil. The model was applied in a case study in Barrie regarding hydrologic performance analysis. The results indicated a significant reduction of runoff volume and peak flow reduction for a single design storm. However, some challenges revealed by these results regarding the case study.

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Table of Contents

A	uthor's	Declaration	ii
A	bstract		iii
A	cknow	ledgements	iv
L	ist of F	igures	vii
L	ist of T	ables	ix
1	Intr	oduction	1
	1.1	Background	1
	1.2	Objective	1
	1.3	Methods	2
2	Eto	bicoke Exfiltration System (EES)	3
	2.1	Description of EES	3
	2.2	Stone Trench Capacity Design	5
3	The	e Princess Margaret Boulevard/ Princess Anne Boulevard	8
	3.1	EES Simulation	8
	3.2	Exfiltration storage Model	9
	3.3	The EES stone trench simulation via storage unit and Green-Ampt method	9
	3.3.	1 The Storage Curve	11
	3.4	Water Conveyance to the storage unit by orifices	12
	3.5	The design specification regarding Princess Margarette Boulevard	14
	3.6	EES simulation using Tabular curve	16
	3.6.	1 Peak flow and total Volume Analysis	
	3.6.	2 Seepage Properties and Sensitivity analysis	22
	3.6.	3 The orifice discharge coefficient sensitivity analysis	23
	3.7	EES simulation using Functional curve	25
	3.7.	1 Design Specification	26
	3.7.	2 Peak flow and total Volume Analysis	26
4	Cas	e Study	31
	4.1	Site Description	31
	4.2	Barrie major and minor system deficiencies	31
	4.3	EES Locations Considerations	

4.4	Design Specification for Kidds Creek Watershed Area	33
4.5	Barrie watershed/ Drainage Areas	35
4.5.1	Kidd's Creek	35
4.5.2	Scenario1	38
4.5.3	Scenario2	46
Quantit	y Reduction	49
4.5.4	Volume Reduction	49
4.5.5	Flow Reduction	51
4.6	Modified Model:	53
5 Conc	lusion	56
Appendix	A	57
Reference	S	64

List of Figures:

Figure 1. Flow dynamics of EES (James Li 2013)	
Figure 2. The Exfiltration System (A.M. Candaras Associates Inc. 1997)	4
Figure 3. EES layout (James Li 2013)	4
Figure 4. Approximate relationship between hydraulic conductivity, percolation time. (TRCA 2011)	6
Figure 5. Approximate relationship between hydraulic conductivity, percolation time. (TRCA 2011)	6
Figure 6. Green and Ampt Method Parameters, (NVCA Stormwater Technical Guide), Table 10.4 (Gle	enn
Switzer 2013)	7
Figure 7. Princess Margarete Boulevard/Princess Anne Crescent. (Google earth)	8
Figure 8. The exfiltration storage lay out model in SWMM 5.1.012 for Princess Margarete	9
Figure 9. The trend of the increased surface area of the trench versus the depth	12
Figure 10. Different Streamlines of Orifices (Nally 2018)	13
Figure 11. Typical cross section of EES in Etobicoke. (A.M. Candaras Associates Inc. 1997)	15
Figure 12. Storage Tabular Curve between MH2-MH3	15
Figure 13. Storage unit cross section gained from PC SWMM	
Figure 14. The Princess Margaret flow test MH2-MH3 (A.M. Candaras Associates Inc. 1997)	17
Figure 15. Measured Total inflow to MH2	17
Figure 16. Princess Margarette Exfiltration System Summary	
Figure 17. Flow Routing Continuity results	19
Figure 18. The water depth in manhole 2(MH2) and the storage unit (SU), using Tabular curve	19
Figure 19. The piezometric head of Water in Manhole2 (MH2) and the storage Unit (SU), using Tabul	
curve	
Figure 20. The measured Depth versus Simulation Result, using Tabular curve	
Figure 21. Exfiltration Summary of Storage Unit for 72 hours	
Figure 22. Sensitivity analysis regarding the seepage properties of the soil	
Figure 23. A typical profile of EES, A) the Sewer gradient is less than 2%, B) the sewer gradient is me	
than 2%	
Figure 24. Flow Routing Continuity results, using Functional Curve	
Figure 25. The water depth in manhole 2(MH2) and the storage unit (SU), using Functional Curve	27
Figure 26. The Piezometric head of Water in Manhole2 (MH2) and the storage Unit (SU), using	
Functional Curve	
Figure 27. Measured Depth versus Simulation Result, using Functional curve	
Figure 28. Measured Depth versus Simulation Result	
Figure 29. Watershed areas in Barrie (DRAINAGE MASTER PLAN City of Barrie 2017)	
Figure 30. EES locations throughout Kidds Creek watershed area shown in brown routes	
Figure 31. EES model, Kidds Creek watershed area	
Figure 32. EES model, Kidds Creek watershed area including storage units routes	
Figure 33. Route 1, profile, the first manhole is excluded regarding EES design	
Figure 34. Route 2, profile, the first manhole is excluded regarding EES design	
Figure 35. Route 3, profile, the first manhole is excluded regarding EES design	
Figure 36. Route 4 profile, the first manhole is excluded regarding EES design	41

Figure 37.	Route 5, profile, the first manhole is excluded regarding EES design	41
Figure 38.	Route 6, profile, the first manhole is excluded regarding EES design	42
Figure 39.	Route 7, profile, the first manhole is excluded regarding EES design	43
Figure 40.	Route 8, profile, the first manhole is excluded regarding EES design	43
Figure 41.	Route 9, profile, the first manhole is excluded regarding EES design	44
Figure 42.	Exfiltration Summary for SU1-SU38, Kidds Creek watershed area for 72 hours	45
Figure 43.	Exfiltration Summary for SU1-SU38, Kidds Creek watershed area for 72 hours	48
Figure 44.	Flow Routing Summary, without EES	49
Figure 45.	Flow Routing Continuity Summary, with EES regarding Scenario 1	50
Figure 46.	Flow Routing Continuity Summary, with EES regarding Scenario 2	50
Figure 47.	Flow reduction analysis for SCS,5-year-6-hour, with EES, scenario1,	51
Figure 48.	Flow reduction analysis for SCS,5-year-6-hour, with EES and without EES, scenario2	52
Figure 49.	Flow routing summary for modified model	53
Figure 50.	Flow reduction analysis for SCS,5-year-6-hour, with EES and without EES, modified model	54
Figure 51.	Exfiltration Summary for modified model	55
Figure 52.	Tabular Curve, Case Study	59

List of Tables:

Table 1. Sensitivity analysis of seepage properties according to (Glenn Switzer 2013)	23
Table 2. Orifice Discharge Coefficients Sensitivity Analysis	24
Table 3. The attribute table of the storage units, regarding Scenario1	
Table 4. The attribute table of the storage units, regarding Scenario2	46
Table 5. Tabular Curve, Case Study	58
Table 6. The attribute table of storage units, and main storm sewers	60
Table 7. Subcatchment attribute table	61
Table 8. Flooding Summary, Case Study, Scenario 1	62
Table 9. Flooding Summary, Case study, Scenario 2	63

1 Introduction

1.1 Background

Intensification of urban development changes the hydrologic cycle, resulting in increased flooding, deterioration of receiving water quality and ecological change of receiving water. Sustainable Low Impact development (LID), is a hot topic aims at reduction of the adverse hydrologic impacts of urbanization. Etobicoke exfiltration system (EES) was proposed and constructed as a LID in 1993 in the City of Etobicoke. The EES would reduce both the runoff peak flow and volume, resulting in increased carrying capacity of the minor systems.

Etobicoke Exfiltration System (EES) conveys the storm runoff via catch basins to two 200 mm PVC perforated pipes connected to manholes laid below the main storm sewer in a stone trench. The captured storm runoff would exfiltrate to the surrounding soil from the stone trench. (A.M. Candaras Associates Inc. 1997).

Many studies have been done recently to address the minor and major storm system deficiencies in Barrie by different consulting engineering firms such as AECOM and C.C Tatham & Associates Ltd and some alternative solutions are also proposed. Different types of potential LID BMPs are simulated in PC SWMM (DRAINAGE MASTER PLAN City of Barrie 2017). However, EES is not created as a default LID in PC SWMM software.

Eventually, EES is implemented by exfiltration storage model in SWMM 5.01.012, and the resulting model was applied for a case study in Barrie to monitor hydrological performance analysis.

1.2 Objective

The objective of this study is to evaluate the runoff control performance of EES with a focus on quantity control in Kidds Creek watershed area in Barrie for SCS 5-year-6-hours single design storms for three days. The exfiltration storage model of SWMM will be tested with recommendations for future applications.

1.3 Methods

A flow test from Candaras report,1997 (A.M. Candaras Associates Inc. 1997) were utilized to monitor the appropriateness of the exfiltration storage model. The Princess Margaret Boulevard/Princess Anne Boulevard was chosen to calibrate the exfiltration storage model.

The exfiltration storage model in this study includes orifices and a storage unit which represent the exfiltration loss. The exfiltration trench consists of the granular stone with 40% porosity. (James Li 2013). Since the exfiltration trench invert elevation is about 1 m above the groundwater table (James Li 2013), the soil is unsaturated at the beginning of exfiltration, and the exfiltration flow occurs in the vertical and horizontal direction due to head loss along the media length.

Consequently, the Green Ampt method is one of the suitable approaches to calculate the infiltration rate and cumulative infiltration into the surrounding native soil. However, the storage unit in SWMM is defined as an open pond such as lake or reservoirs which conflicts the underground EES trench design; As soon as the capacity of the storage unit in SWMM is exceeded, flooding would occur which represents overflow in the upstream manhole. Regarding the perforated pipes, the orifices with the discharge coefficient 0.65 were chosen. The sensitivity analysis was also conducted regarding the variation of the orifice outflows for different discharge coefficients. Another sensitivity analysis was also conducted regarding the seepage properties of the soil to address the suitable type of soil regarding EES performance.

Eventually, the exfiltration storage model is applied to evaluate the runoff control performance of EES in a case study in the City of Barrie which can be considered as a linear LID alternative solution to solve the minor system deficiencies.

2 Etobicoke Exfiltration System (EES)

2.1 Description of EES

Etobicoke Exfiltration System (EES) conveys the runoff via catch basins to two perforated pipes connected to manholes. Accordingly, the runoff exfiltrates to the surrounding soil via stone trench. (A.M. Candaras Associates Inc. 1997). The flow routing and the cross section of the EES are shown in Figures 1 and 2 respectively. As it is illustrated in Figure 2, the granular stone was placed from the bottom of the trench up to the inlet elevation of the main storm sewer. Accordingly, the granular stones are provided over and under the perforated pipes. The stone trench prepares a storage volume laid under the main storm sewer. The overflow to the main storm sewer occurs when the stone trench capacity is full.

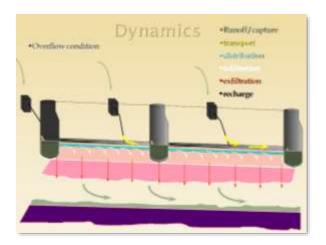


Figure 1. Flow dynamics of EES (James Li 2013)

The Etobicoke Exfiltration System (EES) in comparison with standard municipal storm sewer system has the following components. The EES layout is shown in Figure 3.

- Two perforated pipes under sewer pipe
- Cut-off walls (to force the stored water into the surrounding soil and to prevent the migration of water to downstream trench)
- Gross trap (to collect the spills in the avenues with high traffic volume or any area with oil spill such as old residential areas with oil furnace)

• Mechanical plug (which are installed in the downstream and upstream of perforated pipes (Li and Tran,2015)

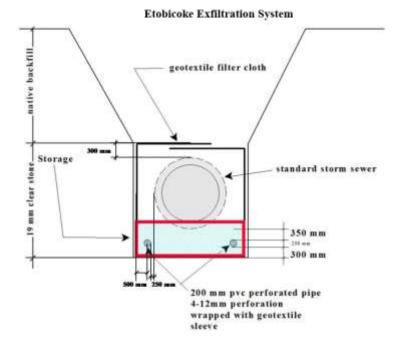


Figure 2. The Exfiltration System (A.M. Candaras Associates Inc. 1997)

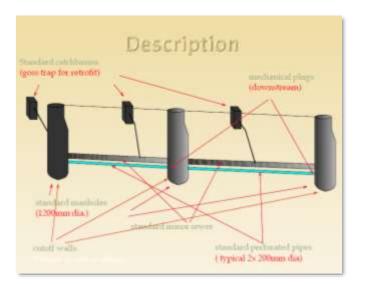


Figure 3. EES layout (James Li 2013)

2.2 Stone Trench Capacity Design

The storage capacity of the Exfiltration Trench includes void space of clear stone and the volume of perforated pipes which can be achieved in a manner similar to the reservoir routing method as follows:

Equation 1

I - Q = dS/dt

Where

I=inflow per unit time

Q=Outflow per unit

dS/dt=Change in storage within the system per unit time (A.M. Candaras Associates Inc. 1997)

Equation 2

Q = -K.A.i

Where

A=exfiltration area

K=hydraulic conductivity of the soil

Q=flow rate across the area A

 $i = \sigma h/\sigma l$ (Hydraulic Gradient)

Where

h=piezometric head

l=flow distance. (A.M. Candaras Associates Inc. 1997)

or

The infiltration rate (Q) would be calculated via the following procedure:

Table C1: Approximate relationships between hydraulic conductivity, percolation time and infiltration rate

Hydraulic Conductivity, K _{fs} (centimetres/second)	Percolation Time, T (minutes/centimetre)	Infiltration Rate, 1/T (millimetres/hour)
0.1	2	300
0.01	4	150
0.001	8	75
0.0001	12	50
0.00001	20	30
0.000001	50	12

Source: Ontario Ministry of Municipal Affairs and Housing (OMMAH). 1997. Supplementary Guidelines to the Ontario Building Code 1997. SG-6 Percolation Time and Soil Descriptions. Toronto, Ontario.

Figure 4. Approximate relationship between hydraulic conductivity, percolation time. (TRCA 2011)

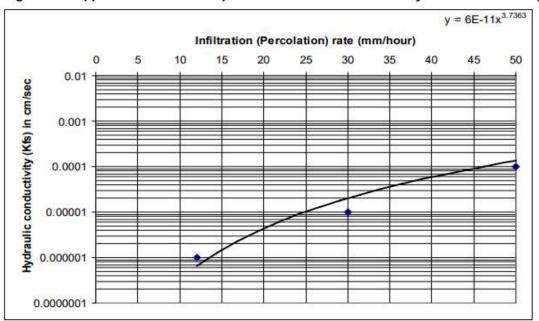


Figure C1: Approximate relationship between infiltration rate and hydraulic conductivity

Source: Ontario Ministry of Municipal Affairs and Housing (OMMAH). 1997. Supplementary Guidelines to the Ontario Building Code 1997. SG-6 Percolation Time and Soil Descriptions. Toronto, Ontario.

Figure 5. Approximate relationship between hydraulic conductivity, percolation time. (TRCA 2011)

USDA Soil Texture	SUCT Avg. Capillary Suction		HYDCON Saturated Hydraulic Conductivity		SMDMAX Initial Moisture Deficit for Soil (Vol. of Air / Vol. of Voids, expressed as a fraction)		
Classification	(in)	(mm)	(in/hr)	(mm/hr)	Moist Soil Climates (Eastern US)	Dry Soil Climates (Western US	
Sand	1.95	49.5	9.27	235.6	.346	.404	
Loamy Sand	2.41	61.3	2.35	59.8	.312	.382	
Sandy Loam	4.33	110.1	0.86	21.8	.246	.358	
Loam	3.50	88.9	0.52	13.2	.193	.346	
Silt Loam	6.57	166.8	0.27	6.8	.171	.368	
Sandy Clay Loam	8.60	218.5	0.12	3.0	.143	.250	
Clay Loam	8.22	208.8	0.08	2.0	.146	.267	
Silty Clay Loam	10.75	273.0	0.08	2.0	.105	.263	
Sandy Clay	9.41	239.0	0.05	1.2	.091	.191	
Silty Clay	11.50	292.2	0.04	1.0	.092	.229	
Clay	12.45	316.3	0.02	0.6	.079	.203	

Figure 6. Green and Ampt Method Parameters, (NVCA Stormwater Technical Guide), Table 10.4 (Glenn Switzer 2013)

Equation 3. Infiltration rate (DRAINAGE MASTER PLAN City of Barrie 2017)

Exfiltration rate $\left(\frac{mm}{hr}\right) = 1.6667 * 10^{10} * k_{fs}^{1/3.7363}$

Where k_{fs} = Saturated Hydraulic Conductivity (cm/s)

(DRAINAGE MASTER PLAN City of Barrie 2017)

Accordingly, the exfiltration rate(Q) should be adjusted by some safety factors depending on the type of the soil, (DRAINAGE MASTER PLAN City of Barrie 2017). The inflow rate(I) is calculated according to hydrograph generated by a design storm event. For example, a 15 mm AES 1-hour design storm was used for this study. The required storage of the exfiltration trench is calculated by Equation (1) every 5 minutes. Then, the maximum required storage volume would be calculated. Consequently, the required depth of the exfiltration trench would be calculated by the surface area of the trench.

Moreover, the stored volume in the exfiltration trench is assumed to be drained within 48 hours after the rain is stopped.

3 The Princess Margaret Boulevard/ Princess Anne Boulevard

3.1 EES Simulation

In this study, EES was modeled as exfiltration storage via PC SWMM 5.1.012. To evaluate the exfiltration storage model appropriateness, a measured flow test in 1994 was conducted (A.M. Candaras Associates Inc. 1997). This flow test was conducted on July 12th, 1994 via fire hose between manhole 2(MH2) and manhole 3(MH3) for 110 minutes located in the Princess Margarete Boulevard/ Princess Anne Crescent in the city of Etobicoke which is shown in Figure 7.

For a large storm event, the rate of exfiltration from the trench eventually approach a steady value while overflow occurs in the upstream manhole. Accordingly, the flow in MH3 represents the overflow.

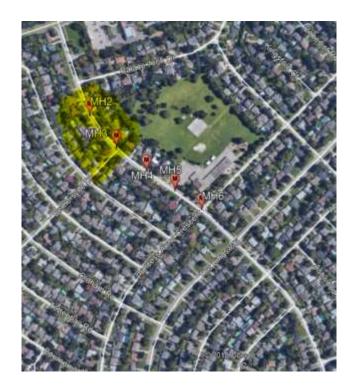


Figure 7. Princess Margarete Boulevard/Princess Anne Crescent. (Google earth)

3.2 Exfiltration storage Model

The exfiltration storage model includes a storage unit (SU) and two orifices (orifice 1 & orifice 2) to present exfiltration loss. The layout of an exfiltration storage model is shown in Figure 8. As it is illustrated in Figure 8, manhole 2 (MH2) and manhole 3 (MH3) represents upstream and downstream manholes in Princess Margarete Boulevard respectively. Main storm sewer above the perforated pipes is specified by C1. The outfall (OF1) and conduit 2 (C2) were used to complete the model, and they would not monitor any runoff in this model. The surface runoff from the sub catchment was assigned to the upstream manhole. Orifices convey water with a discharge coefficient 0.65 to the storage unit. The volume of a storage unit was reduced by 60 percent due to the 40 % porosity of the 13mm granular stones. The void space storage volume was defined by storage curve comprised tabular & functional curves. The seepage properties of the storage unit were assumed as same as the corresponding subcatchment area seepage properties. Eventually, the equivalent situation in princess Margarette was simulated between manhole 2 and 3 in this model.

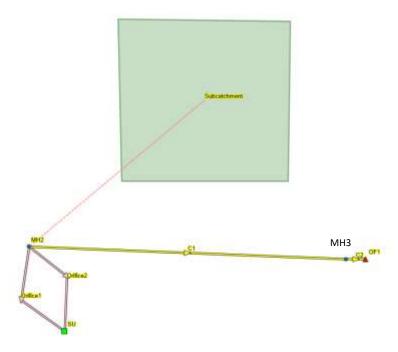


Figure 8. The exfiltration storage lay out model in SWMM 5.1.012 for Princess Margarete

3.3 The EES stone trench simulation via storage unit and Green-Ampt method

According to the Open SWMM, a storage unit can be represented by a loss code from SWMM code (International(CHI) 2017) viewer and be calculated according to the Green-Ampt method.

Since the surrounding soil of the EES is not saturated at the beginning of the rainfall event, the hydraulic conductivity is a function of the suction head and the soil moisture content. Consequently, the infiltration rate into the soil beneath the trench and the potential cumulated infiltration are similarly to those in the Green-Ampt method. Accordingly, the characteristics of the soil (e.g., initial moisture deficit, hydraulic conductivity, and suction head) are the variables of the Green-Ampt method which become the input data to PC SWMM. The infiltration rate and the cumulative infiltration are calculated via Eqs (4) and (5) respectively. It should be noted that when the capacity of the trench is full, the overflow will occur in the upstream manhole and the flow will be conveyed via main sewer system (i.e., the depth of water in manhole reaches 0.85 m from the manhole bottom). However, the storage unit in PC SWMM is represented as a pond, lake, impoundment, or chamber that provides water storage (A.Rossman 2016). When the runoff water reaches the maximum depth of the storage, it will flood or surcharge. As a result, the flooded amount of water from storage units should be added to final outfall from the catchments. However, PC SWMM will give the total exfiltration volume.

Equation 4. Green Ampt Infiltration Rate, (W.Mays 2010)

$$f = K(\frac{\psi \Delta \theta}{F(t)} + 1)$$

Equation 5. The Cumulative Infiltration, (W.Mays 2010)

$$F(t) = Kt + \psi \Delta \theta \ln(1 + \frac{F(t)}{\psi \Delta \theta})$$

Where

K= hydraulic conductivity

 Ψ = Suction head

 θ = Soil moisture content

3.3.1 The Storage Curve

PC SWMM calculates the volume of the storage unit using the storage curve specified by the user. The storage curve is the relationship between the depth of the storage unit and the surface area. (*A. Rossman 2017*). There are two types of storage curves:

- Functional Curve
- Tabular Curve

3.3.1.1 Tabular Curve

The tabular curve can be used to define the relationship between water depth and water surface area of a stone trench in the exfiltration storage model. The relationship between the increasing surface area of the trench and the increasing depth in the sloped trench is illustrated in Figure 9. This trend is applicable where the upstream invert elevation is less than the stone trench depth. As it is illustrated in Figure 9, for water depth reaches the upstream invert elevation, the water area becomes constant. To calculate the effective storage volume of the trench, the porosity of the clear stones was assumed to be 0.4. Equation (6) shows the relationship between the water surface areas of the trench for different depths of water.

Equation 6

Surface area of the trench = 0.4 * Width $* \frac{\min(depth of water, the invert junction elevation difference)}{slope}$

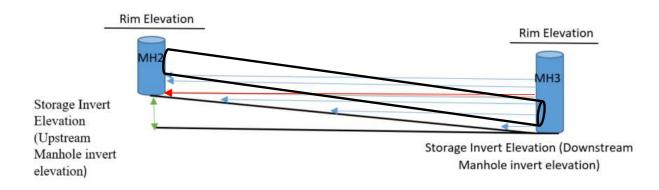


Figure 9. The trend of the increased surface area of the trench versus the depth

3.3.1.2 Functional Curve

The functional curve can also be used to demonstrate the relationship between the water surface area and the water depth regarding EES. Since water infiltrates into the surrounding void space volume along the length of the stone trench at the same time, the increasing surface area of the stone trench could be considered almost constant.

The functional curve has the general form:

Equation 7

 $A = c0 + c1Y^{c2}$

Where C0, C1, and C2 are user supplied constants and Y is the water depth. The corresponding volume is achieved as follows:

Equation 8

$$V = c0Y + \left(\frac{C1}{C2+1}\right)Y^{c2+1}$$

(A. Rossman 2017)

3.4 Water Conveyance to the storage unit by orifices

The exfiltration rate of the perforated pipes was simulated via side orifices with the invert offset of 0.3 m from the bottom of the upstream manhole. The other property of the orifice such as discharge coefficient was assumed to be 0.65. However, the discharge coefficient of orifices (which is similar to the minor loss coefficient in the Energy equation and is a function of entrance constriction and exit expansion) was studied via a sensitivity analysis described in the following sections. Different streamlines and their corresponding discharge coefficients are shown in Figure 10. The relationship between a flow, the cross section of an orifice, and the discharge coefficient of an orifice is indicated in Equation (10)

Equation 9. The discharge through an orifice

$$Q_0 = C_d \cdot A_0 \cdot \sqrt{2gh}$$

Where

 C_d = discharge coefficient

 A_0 =cross-sectional area of the orifice

h = the difference between the headwater and tailwater elevations (A.Chin 2013)

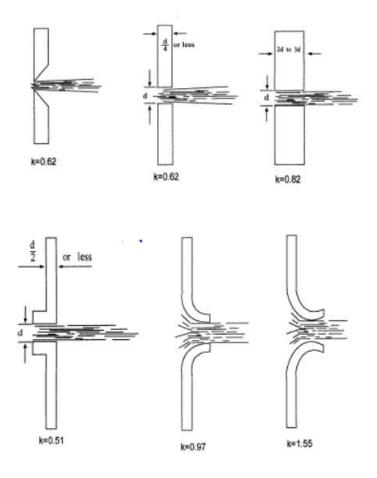


Figure 10. Different Streamlines of Orifices (Nally 2018)

3.5 The design specification regarding Princess Margarette Boulevard

The design specifications regarding the flow test of Princess Margarete Boulevard are as follows:

- The head difference between manhole 2 and 3 was 0.637 m (Sewer gradient 0.65% with 98 m length).
- The inlet offset elevation of the main storm sewer was 0.65 m according to a typical cross section of EES in princess Margarette, which is shown in Figure 11. As it is shown in Figure 11, the stone trench depth was assumed 0.3 m above the main conduit.
- The stone trench depth according to Candars report (1997) (A.M. Candaras Associates Inc. 1997) was estimated 1.287 m between MH2 and MH3.
- The tabular curve was used to define the relationship between the water depth and water surface area which is shown in Figure 12.
- The two orifices with diameter 0.2 m and invert offset 0.3 m were used in this system.
- The soil type of the studied location was reported sandy loam to loamy sand according to the borehole samples data (table 3.6, (A.M. Candaras Associates Inc. 1997)).
- The seepage properties of the loamy sand were collected from Green and Ampt Method Parameters, (NVCA Stormwater Technical Guide), Table 10.4 (Glenn Switzer 2013) as follows:
- Hydraulic Conductivity: 59.8 mm/hr.
- Suction Head:61.3 mm
- Initial Deficit: 0.312
- The invert elevation of the trench was considered as same as downstream manhole invert elevation (154.3 m).
- The stone trench width (2.264 m) was defined according to a typical cross-section of the EES.
- The equivalent radius of the stone trench is shown in Figure 13. As it is shown in Figure 13, the surface area increases steadily after reaching the upstream manhole elevation.

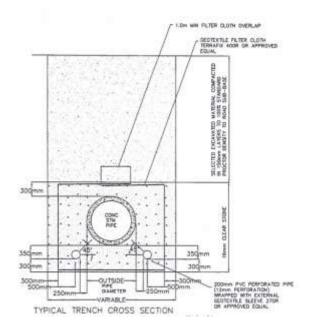


Figure 11. Typical cross section of EES in Etobicoke. (A.M. Candaras Associates Inc. 1997)

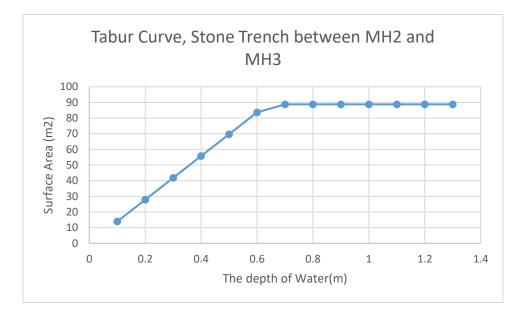


Figure 12. Storage Tabular Curve between MH2-MH3

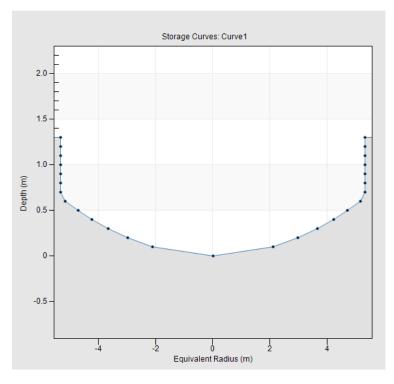


Figure 13. Storage unit cross section gained from PC SWMM

3.6 EES simulation using Tabular curve

A flow test was conducted in 1994 via fire hose between manhole 2 (MH2) and manhole 3 (MH3) for 110 minutes in princess Margarete Boulevard. According to the data collected from this flow test, total inflow to MH2 was reported 42 m3. The maximum water head in the stone trench was recorded 0.45 m from the base of the stone trench. The exfiltration loss volume, and the water stored volume was recorded 14 m3 and 27.28 m3 respectively. It was reported that no overflow was observed during the test and the monitored overflow was due to flow from an abandoned culvert connected to MH3 which is shown in Figure 16. (*A.M. Candaras Associates Inc. 1997*).

All the recorded data from this test is shown in Figure 14. The total inflow to MH2 was simulated by Excel which is shown in Figure 15. The MH2 stone filter head which is shown in Figure 14 was defined as the water depth in the upstream side of the stone trench, and the MH3 stone filter head was defined as the water depth in the downstream side of the stone trench. (A.M. Candaras Associates Inc. 1997).

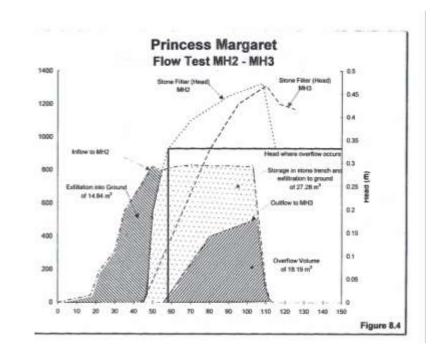


Figure 14. The Princess Margaret flow test MH2-MH3 (A.M. Candaras Associates Inc. 1997)

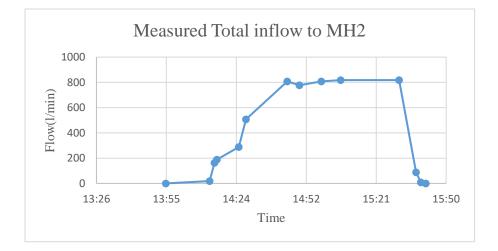


Figure 15. Measured Total inflow to MH2

Flow I/min

Date	Storm Duration (hr)	Rainfall Depth (mm)	Peak Inflow (MH2) (l/s)	Total Inflow Volume (1)	Maximum Filter Head Upstream MH2 (mm)	Maximum Filter Head Downstream MH3 (mm)	Peak Outflow (MH3) (I/s)	Total Outflow Volume (I)	Comments
May 26 1994 (See Fig. 7.8)	22.5	28.3	9.7	73,668	Nä	65	0.3 th	4,486	Stone trench not full No overflow at MH2
May 31 1994 (See Fig. 7.9)	0.5	11.1	8.1	28,340	NB	5	1.5 (1)	2,003	Stone trench not full No overflow at MH2
June 24 1994 (See Fig.7.10)	24.0	24.1	2.2	7,587	Nil	3	0.1 ^{eq}	1,131	Stone trench not full No overflow at MH2
Oct. 5-6 1995 (See Fig. 7.11)	18.0	63	10.0	130,015	380	500	3.0 ^{co}	18,895	Stone trench full No overflow at MH2
July 12 1994 (See Fig. 8.2)		Flow Testing	13.3		430	430	8.3 ⁱⁿ		Overflow occurs after 45 minutes of inflow at MH2, with the 13.3 l/s peak inflow occurring for a 10 minute period

Table 7.8: Princess Margaret Blvd. Exfiltration System Summary of Monitoring Results

(1) The observed flows at MH3 were due to an abandoned culvert that was connected to the sealed catchhasin dowastream of MH2.

(2) The overflow in MH2 occurs prior to the theoretical static head of 650 being achieved. Overflows occured due to the inflow at MH2 exceeding the inlet capacity of the perforated pipes.

Figure 16. Princess Margarette Exfiltration System Summary

3.6.1 Peak flow and total Volume Analysis

According to the flow test in 1994, the total inflow volume, total exfiltration loss and the water stored volume were reported 42 m3, 14 m3 and 27.28 m3 respectively. After running the model for 110 minutes, the exfiltration loss and the water stored volume was reported 11 m3 and 31 m3 for loamy sand soil type which is shown in Figure 17. The maximum water depth in MH2 and the storage unit was founded 0.3672 m and 0.6983m respectively shown in Figure 18. The water head in MH2 and storage unit is also shown in Figure 19 which indicates that piezometric head (elevation head + pressure head) of water in MH2 is higher than the piezometric head in the storage unit.

**************************************	Volume hectare-m	Volume 10^6 ltr
Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	0.000	0.000
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.004	0.043
External Outflow	0.000	0.000
Flooding Loss	0.000	0.000
Evaporation Loss	0.000	0.000
Exfiltration Loss	0.001	0.011
Initial Stored Volume	0.000	0.000
Final Stored Volume	0.003	0.031
Continuity Error (%)	0.000	



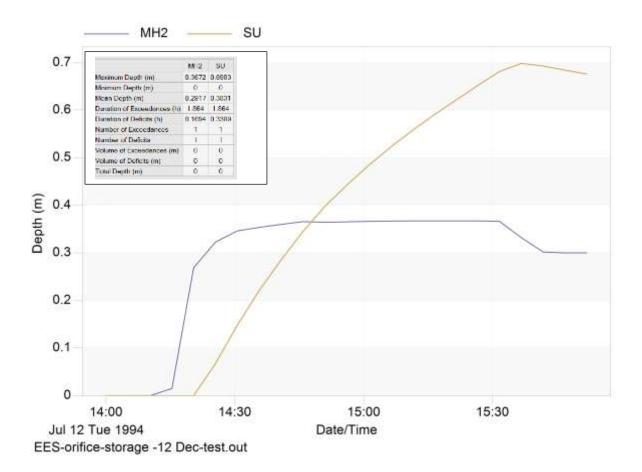


Figure 18. The water depth in manhole 2(MH2) and the storage unit (SU), using Tabular curve

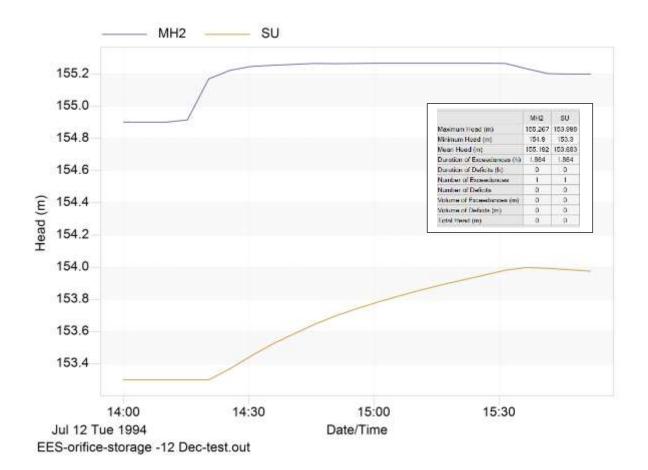


Figure 19. The piezometric head of Water in Manhole2 (MH2) and the storage Unit (SU), using Tabular curve

The water depth in the stone filter and storage unit achieved from the flow test, and the simulation result is compared in Figure20. Figure 20 indicates that the water depth will increase after 40 minutes in the stone trench regarding the flow test. However, the simulation result shows that after 25 minutes the water depth will increase. It means that exfiltration rate will drop sooner in the simulated model.

The maximum water depth for the flow test and simulation is recorded 0.45 m and 0.7m respectively which shows the compatibility of the trend of exfiltration rate.

The system should also be drained within 48 hours after the rain has been stopped. Subsequently, the system is monitored for 72 hours which is shown in Figure 21. The storage unit exfiltrates completely in less than 12 hours according to figure 21.

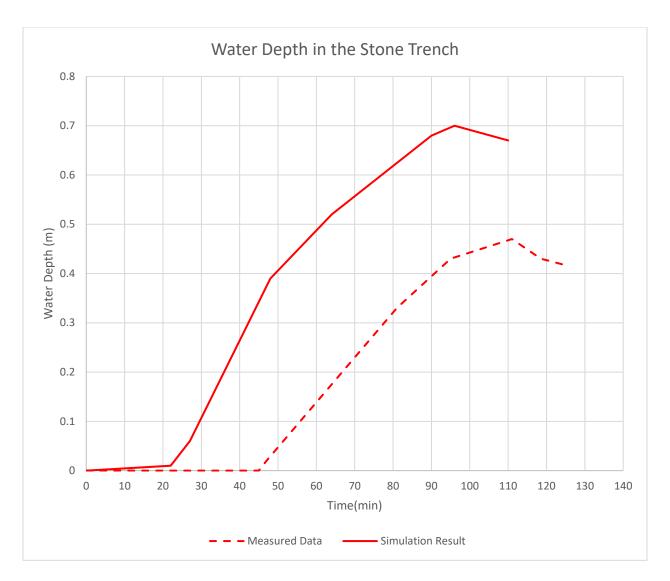


Figure 20. The measured Depth versus Simulation Result, using Tabular curve

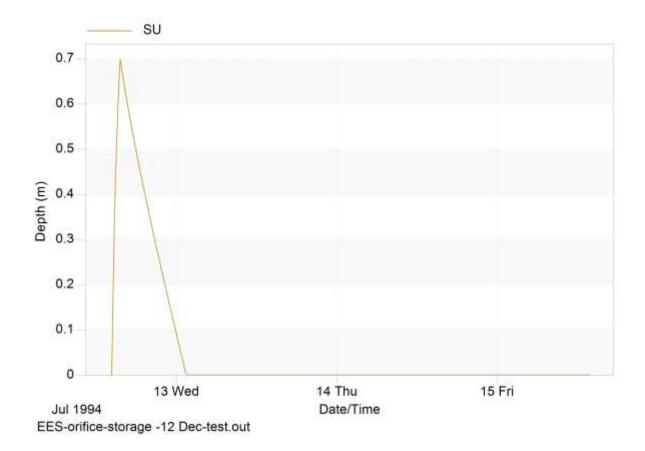


Figure 21. Exfiltration Summary of Storage Unit for 72 hours

3.6.2 Seepage Properties and Sensitivity analysis

As it was mentioned in Section 3.5, the type of the soil in Princess Margaret Boulevard was reported to be sandy loam to loamy sand below the trench. Accordingly, the storage unit seepage properties of loamy sand were used in the exfiltration storage model. A sensitivity analysis was also conducted for other types of soil as shown in Figure 22 and Table1. According to the sensitivity analysis, the seepage rate plays a critical role in determining the exfiltration in PC SWMM. For instance, the exfiltration loss becomes more prominent below a hydraulic conductivity of 60 mm/hr. (i.e., loamy sand).

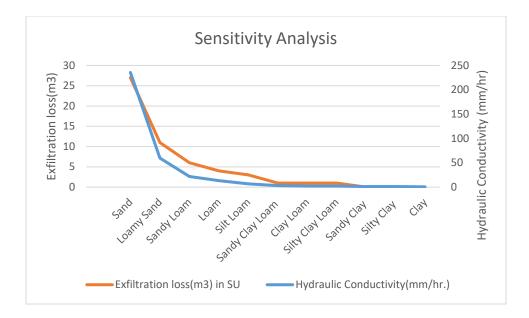


Figure 22. Sensitivity analysis regarding the seepage properties of the soil

Soil Type	Suction Head(mm)	Hydraulic Conductivity(mm/hr.)	Initial Deficit	Exfiltration loss(m3) in SU	Total inflow(m3) To MH2	Exfiltration Difference
Sand	49.5	235.6	0.346	27	42	0.015
Loamy Sand	61.3	59.8	0.312	11	42	0.000
Sandy Loam	110.1	21.8	0.246	6	42	-0.005
Loam	88.9	13.2	0.193	4	42	-0.006
Silt Loam	166.8	6.8	0.171	3	42	-0.007
Sandy Clay Loam	218.5	3	0.143	1	42	-0.009
Clay Loam	208.8	2	0.146	1	42	-0.009
Silty Clay Loam	273	2	0.105	1	42	-0.009
Sandy Clay	239	1.2	0.091	0	42	-0.010
Silty Clay	292.2	1	0.092	0	42	-0.010
Clay	316.3	0.6	0.079	0	42	-0.010

Table 1. Sensitivity analysis of seepage properties according to (Glenn Switzer 2013)

3.6.3 The orifice discharge coefficient sensitivity analysis

The orifice represents the perforated pipes in the exfiltration storage model with invert offset 0.3 m and discharge coefficient 0.65 in an exfiltration storage model. A sensitivity analysis was conducted for different orifice discharge coefficients between MH2- MH3 shown in Table 2. The

sensitivity analysis shows that the discharge coefficient is not significant in determining the exfiltration loss by PC SWMM.

Orifice Exit Coefficient	Head (m)	Exfiltration Loss(m3)
0.51	154.716	11
0.62	154.716	11
0.65	154.716	11
0.82	154.716	11
0.97	154.716	11
1.55	154.716	11

Table 2. Orifice Discharge Coefficients Sensitivity Analysis

3.7 EES simulation using Functional curve

The exfiltration storage model was also monitored by the functional storage curve regarding the flow test in 1994. The tabular curve trend that was described earlier is not applicable when the stone trench depth is lower than the upstream invert elevation. For instance, if the stone trench designed up to the inlet offset of the main storm sewer, it will be less than the trench depth in many cases. This situation is shown in Figure 23. Case B in Figure 23 illustrates that the upstream invert elevation will be higher than the stone trench. Consequently, increasing water surface area will meet the stone trench depth prior to the upstream elevation and the described tabular curve trend is not be applicable.

Resultantly, a functional curve with a constant surface area was utilized to monitor the result. The invert elevation of the storage unit is assumed as same as upstream manhole invert elevation (154.9 m) in this model.

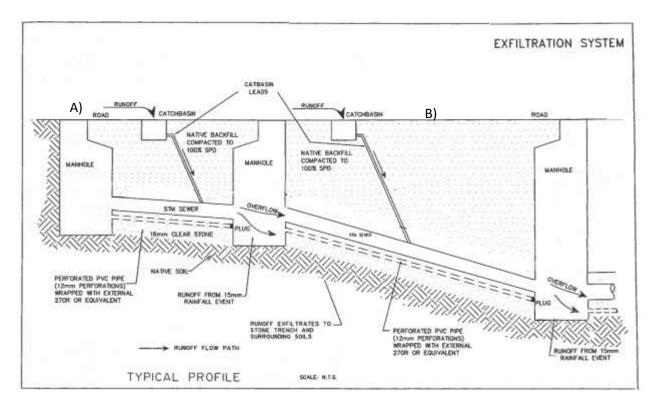


Figure 23. A typical profile of EES, A) the Sewer gradient is less than 2%, B) the sewer gradient is more than 2%

3.7.1 Design Specification

All the design specification was considered as same as the previous model except the following specifications:

- The storage curve was considered as a functional curve with a constant area 81.5 m2(40% porosity was applied), coefficient (C1) & exponent (C2) was considered zero
- The stone trench depth was considered as same as the inlet offset of the main sewer system 0.65 m.
- The invert elevation of the storage unit was considered as same as the upstream invert elevation.

3.7.2 Peak flow and total Volume Analysis

According to the flow test in 1994, the total inflow volume, total exfiltration loss, and the water stored volume were reported 42 m3, 14 m3 and 27.28 m3 respectively. After running the model for 110 minutes, the exfiltration loss and the water stored volume was reported 13m3 and 30 m3 for loamy sand soil type which is shown in Figure 24. The maximum water depth in MH2 and the storage unit was founded 0.33846m and 0.381m respectively. These numbers illustrate that the water movement in the stone trench and the upstream manhole is similar. The water depth in MH2 and the storage unit is shown in Figure 25. Figure 26 indicates the piezometric head (elevation head + pressure head) for upstream manhole and the storage unit.

The water depth in stone filter and storage unit for flow test and the SWMM simulation are compared in Figure 27. As Figure 27 shows, the water depth will increase after 40 minutes in the stone trench regarding the flow test. However, the simulation result shows that the water depth will increase after 25 minutes. It means the stone trench will meet its capacity sooner than the flow test. It means that exfiltration rate will drop sooner in the simulated model.

******	Volume	Volume
Flow Routing Continuity	hectare-m	10^6 ltr

Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	0.000	0.000
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.004	0.043
External Outflow	0.000	0.000
Flooding Loss	0.000	0.000
Evaporation Loss	0.000	0.000
Exfiltration Loss	0.001	0.013
Initial Stored Volume	0.000	0.000
Final Stored Volume	0.003	0.030
Continuity Error (%)	1.070	

Figure 24. Flow Routing Continuity results, using Functional Curve

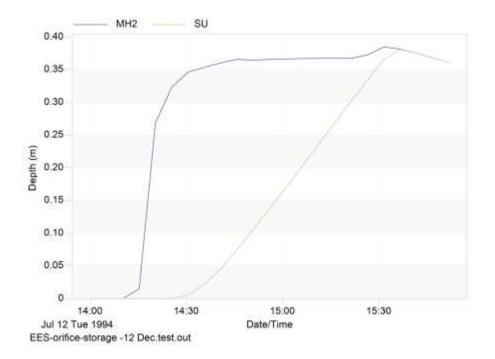


Figure 25. The water depth in manhole 2(MH2) and the storage unit (SU), using Functional Curve

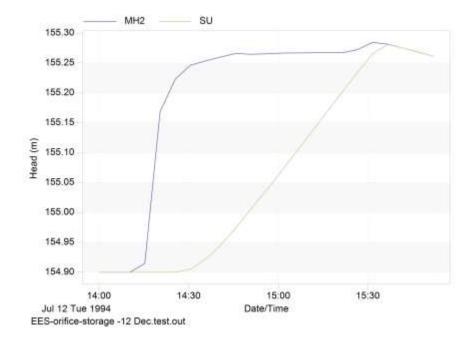


Figure 26. The Piezometric head of Water in Manhole2 (MH2) and the storage Unit (SU), using Functional Curve

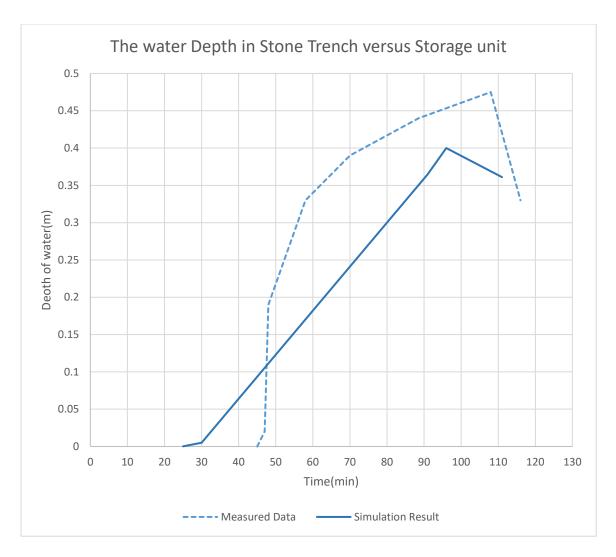


Figure 27. Measured Depth versus Simulation Result, using Functional curve

Eventually, the exfiltration loss and the water head were studied for two scenarios for the flow test in princess Margarete:

- 1-The stone trench depth was considered above the main storm sewer simulated by the exfiltration storage and the corresponding tabular curve
- 2-The stone trench depth was considered up to the inlet offset of the main sewer system simulated by the exfiltration storage model and corresponding functional curve

Comparing the SWMM results and the flow test data, it is founded that the exfiltration storage is compatible with EES. The comparison of water depth in storage units and the stone filter for the simulation and flow test is shown in Figure 28.

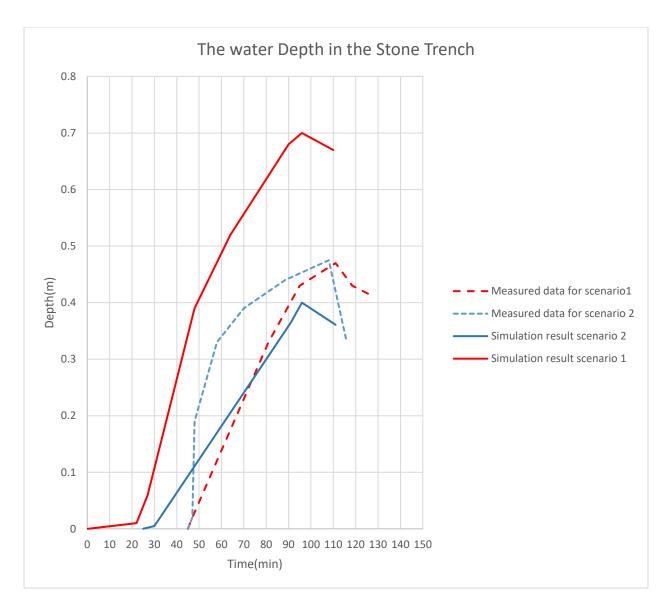


Figure 28. Measured Depth versus Simulation Result

4 Case Study

4.1 Site Description

To address the storm sewers system deficiencies, the City of Barrie retained C.C Tatham & Associates Ltd. (CCTA) to study Barrie watershed areas. Consequently, Barrie was divided into three main watershed areas:

- Barrie Creeks Drainage Study Area;
- NVCA Watershed Drainage Study Area
- Lovers Creek, Hewitt's Creek and Sandy Cover Drainage Study Area.

It should be noted that Sophia Creek watershed and Mulcaster drainage area were excluded from the study by the city of Barrie. Accordingly, the major and minor deficiencies of the stormwater system were detected all over the city, and alternative solutions were proposed. In this study, Kidds Creek watershed area from Barrie Creek drainage study area was nominated to evaluate the EES regarding potential for quantity control. The location of Barrie watershed areas and subwatershed areas are shown in Figure 29. (DRAINAGE MASTER PLAN City of Barrie 2017)

4.2 Barrie major and minor system deficiencies

Flooding of both major and minor stormwater system was detected from recent studies. This flooding is due to lack of channel and culvert capacities. Accordingly, the minor and major system deficiency was addressed by the city of Barrie, and alternative solutions including centralized LIDs, linear LID's, and major and minor improvements are proposed. (DRAINAGE MASTER PLAN City of Barrie 2017). EES was considered as a LID solution to solve the minor system deficiencies. Subsequently, the EES were evaluated for Kidds creek watershed area using exfiltration storage model.

4.3 EES Locations Considerations

The highly favorable EES locations throughout Barrie was determined by the city of Toronto considering the following properties for an area using SUSTAIN:

- All local public roads that are not in the intake protection zone (In this study all the polygon layers of the roads have been created from polyline layers via Arc GIS10.)
- Wellhead zone A-B is excluded

- The groundwater > 8 ft is considered
- Storm sewer installed before 1998 are considered
- Pavement installed before 1993 are considered
- Soil group A and B has been selected

Accordingly, the highly favorable places of EES throughout Kidds Creek watershed area are shown in Figure 30.

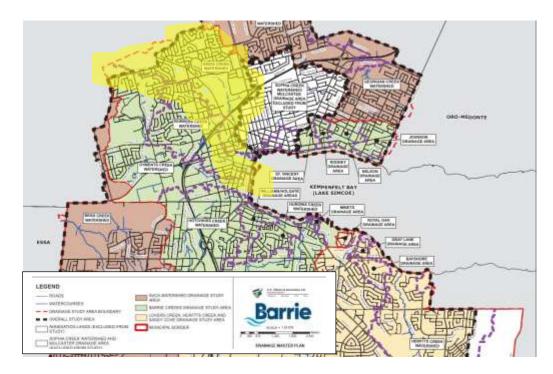


Figure 29. Watershed areas in Barrie (DRAINAGE MASTER PLAN City of Barrie 2017)



Figure 30. EES locations throughout Kidds Creek watershed area shown in brown routes

4.4 Design Specification for Kidds Creek Watershed Area

The EES design specifications throughout Kidds Creek are considered as follows:

- Storage seepage properties (Suction Head, hydraulic conductivity, initial deficit) are considered as same as the corresponding sub-catchments. The seepage properties of the storage units are attached in Appendix A.
- The inlet offset of the sewer conduits is designed 0.85 m across manhole invert elevation.
- The maximum required depth for a storage unit up to the main storm sewer is achieved (0.9 m) for all the watershed areas throughout Barrie according to (DRAINAGE MASTER PLAN City of Barrie 2017)
- To meet the EES required design criteria 0.85 m is added to the inlet offsets of existing conduits in highly favorable location regarding EES design.
- The inlet offset of the existing sewer pipes was set 0 by the city of Barrie. According to Design Criteria for water sewers and water mains (Toronto 2009) minimum drop required

in a manhole is 0.03 m. As a result, only the qualified paths should be selected to meet Design Criteria for water sewers and water mains (Toronto 2009).

• The Depth and width of the storage units are considered for two scenarios:

Equation 10

1-Depth of the trench = *Pipe Outer Diameter* + 0.85m + 0.3m (if the storage unit capacity is assumed 0.3 m above the main storm sewer), which meets the design criteria of the city of Barrie (Depth of trench = maximum 0.9 m) (DRAINAGE MASTER PLAN City of Barrie 2017)

2-Depth of the trench =

0.9 m if the storage unit capacity is assumed equal to inlet offset of the main storm sewer

Equation 11

The Width of the trench = Pipe OD + 1.7 m(according to a typical cross section of EES)

- The Major system was created by the city of Barrie in the model, and it conveyed water for large events.
- The design storm, SCS 5-year,6-Hours (with a 15% increase due to future condition) was proposed by the City of Barrie
- The volume reduction and peak flow reduction were achieved for EES by comparing the results with the conventional method
- Extra overflow to upstream manholes presented as flooding in storage units. Since the storage unit is an open ponded area (A.Rossman 2016) not a pressurized storage unit.
- The peak flow could not be compared by utilizing the PC SWMM graphs since the flooded volume of the storage units was not detected in the charts. Consequently, the results were modified via Excel.
- Water should be drained entirely during 48 hours after the rain stopped, so infiltration summary was conducted for 3 days.

- Storage units were organized according to the invert elevation from the highest to lowest for every rout designated in different colors.
- Tabular Curve design for 38 storage units was attached in Appendix A. The trend of the tabular curves are considered according to section 3.3.1.

4.5 Barrie watershed/ Drainage Areas

4.5.1 Kidd's Creek

Kidds creek watershed area includes 581 sub-catchments with 463 ha area and 47 % imperviousness and two outfalls located in west side of Simcoe lake. This watershed area is Shown in Figure 30. Consequently, 70 exfiltration storage units were designed for this watershed area. However, 38 storage units in a sequence were chosen to monitor the peak flow and volume reduction before entering an existing water course. These storage units are shown in Figure 31. The components of the exfiltration storage model such as orifices were not possible to show in Figure 31 due to the zoom view. The storage unit routes are presented by different colors which are shown in Figure 32, and their corresponding attributes are shown in Table 3 & 4.

The storage units were monitored for two scenarios:

1-Scenario1

- Storage unit depth= outer diameter +0.85m (the inlet offset of main storm sewer) +0.3 m above the main storm sewer
- Storage curve =Tabular curve (the tabular curve detail is attached in Appendix A)
- Stone trench elevation= Downstream manhole invert elevation

2-Scenario2

- Storage unit depth = 0.9 m
- Storage curve =Functional curve with a constant area=0.4(void ratio of the granular stone) *width of the trench * length of the trench,
- Stone trench elevation= upstream manhole invert elevation

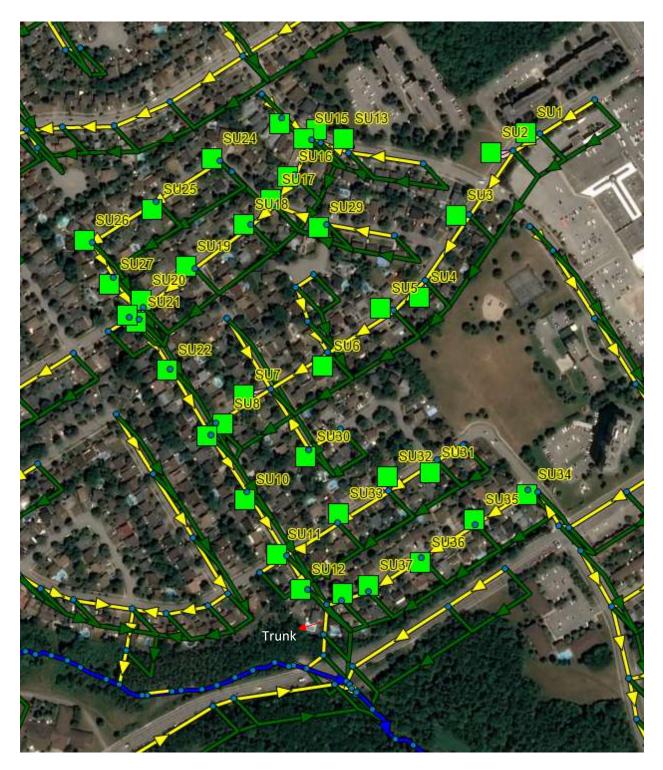


Figure 31. EES model, Kidds Creek watershed area



Figure 32. EES model, Kidds Creek watershed area including storage units routes

4.5.2 Scenario1

4.5.2.1 Rout1 (SU1-SU12)

This route comprises storage unit 1 to storage unit 12 which is shown in yellow color in Figure 32. The profile of this route is shown in Figure 33. The attribute table of the storage units is shown in Table 3. The storage units 4,5,6,7 meet their capacity after running the model.

		Trench	Trench					Junction
	Trench	Invert	Rim	Length		Storm sewer	Trench	difference
SU	Depth	Elevation	elevation	(m)	slope	diameter(m)	Width(m)	elevation
SU1	1.938	291.559	293.497	36.802	0.008043	0.6	2.488	0.296
SU2	1.938	290.749	292.687	90.418	0.008958	0.6	2.488	0.81
SU3	1.938	289.197	291.135	91.746	0.016916	0.6	2.488	1.552
SU4	1.938	287.122	289.06	50.507	0.041083	0.6	2.488	2.075
SU5	1.538	283.464	285.002	90.826	0.040275	0.3	2.088	3.658
SU6	1.938	280.782	282.72	79.056	0.033925	0.6	2.488	2.682
SU7	1.938	278.465	280.403	74.96	0.03091	0.6	2.488	2.317
SU8	1.938	277.929	279.867	15.329	0.034966	0.6	2.488	0.536
SU9	2.201	276.935	279.136	78.414	0.012676	0.825	2.751	0.994
SU10	2.201	275.554	277.755	86.562	0.015954	0.825	2.751	1.381
SU11	2.288	275.021	277.309	46.362	0.011496	0.9	2.838	0.533
SU12	2.288	273.71	275.998	28.262	0.046387	0.9	2.838	1.311
SU13	1.714	287.579	289.293	34.828	0.026243	0.45	2.264	0.914
SU14	1.714	285.89	287.604	11.429	0.147782	0.45	2.264	1.689
SU15	1.813	285.122	286.935	45.607	0.01684	0.525	2.363	0.768
SU16	1.813	284.43	286.243	42.131	0.016425	0.525	2.363	0.692
SU17	1.813	283.455	285.268	35.558	0.02742	0.525	2.363	0.975
SU18	1.813	281.321	283.134	82.578	0.025842	0.525	2.363	2.134
SU19	1.938	280.498	282.436	74.89	0.010989	0.6	2.488	0.823
SU20	1.938	280.236	282.174	14.982	0.017488	0.6	2.488	0.262
SU21	2.114	279.642	281.756	67.568	0.008791	0.75	2.664	0.594
SU22	2.114	277.929	280.043	90.1	0.019012	0.75	2.664	1.713
SU23	1.538	285.89	287.428	41.865	0.008671	0.3	2.088	0.363
SU24	1.538	281.699	283.237	87.574	0.020851	0.3	2.088	1.826
SU25	1.619	281.105	282.724	88.79	0.00669	0.375	2.169	0.594
SU26	1.714	280.843	282.557	47.516	0.005514	0.45	2.264	0.262
SU27	1.714	280.236	281.95	57.867	0.01049	0.45	2.264	0.607
SU28	1.538	280.236	281.774	11.628	0.01677	0.3	2.088	0.195
SU29	1.538	284.43	285.968	65.903	0.033671	0.3	2.088	2.219
SU30	1.619	281.361	282.98	83.323	0.006949	0.375	2.169	0.579
SU31	1.538	280.84	282.378	66.481	0.025722	0.3	2.088	1.71 2.39
SU32	1.538	278.45	279.988	69.972	0.034157	0.3	2.088	
SU33	1.619	275.554	277.173	70.138	0.04129	0.375	2.169	2.896
SU34	2.201	278.532	280.733	73.139	0.018759	0.825	2.751	1.372
SU35	2.201	277.185	279.386	73.536	0.018318	0.825	2.751	1.347
SU36	2.201	276.316	278.517	73.133	0.011882	0.825	2.751	0.869
SU37	-	275.856	278.057	32.585	0.014117	0.825	2.751	
SU38	2.201	273.71	275.911	19.108	0.112309	0.825	2.751	2.146

Table 3. The attribute table of the storage units, regarding Scenario1

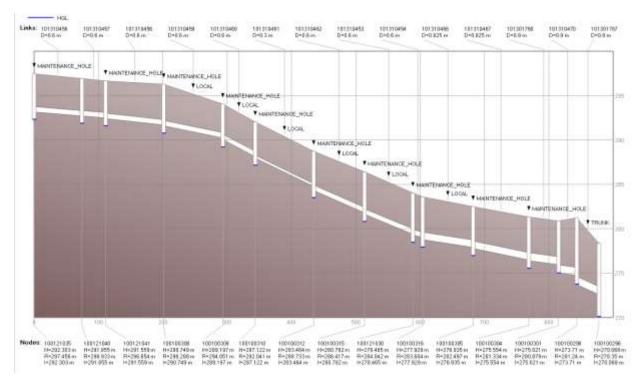


Figure 33. Route 1, profile, the first manhole is excluded regarding EES design

4.5.2.2 Rout2 (SU 13-22)

This route comprises storage unit 13 to storage unit 22 which is shown in pink color in Figure 32. The profile of this route is shown in Figure 34. The attribute table of the storage units is shown in Table 3. The storage units 13,17 met their capacity.

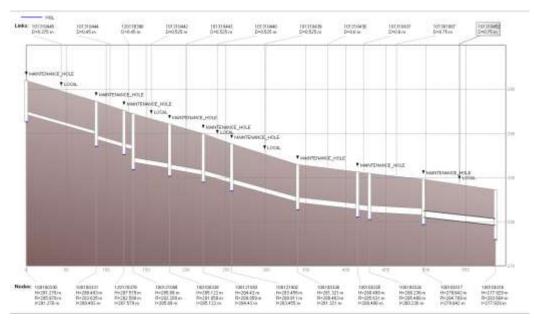


Figure 34. Route 2, profile, the first manhole is excluded regarding EES design

4.5.2.3 Rout3(SU23)

This route comprises storage unit 23 which is shown in blue color in Figure 32. The profile of this route is shown in Figure 35. The attribute table of the storage units are shown in Table3.

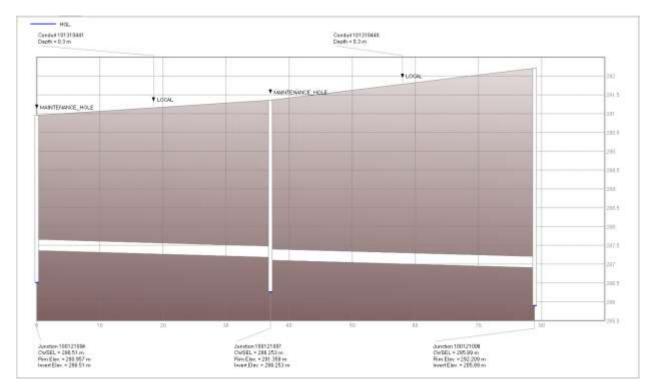


Figure 35. Route 3, profile, the first manhole is excluded regarding EES design

4.5.2.4 Route4(SU 24-27)

This route comprises storage unit 24 to storage unit 27 which is shown in green color in Figure 32. The profile of this route is shown in Figure 36. The attribute table of the storage units is shown in Table3. The storage unit 24 met its capacity.

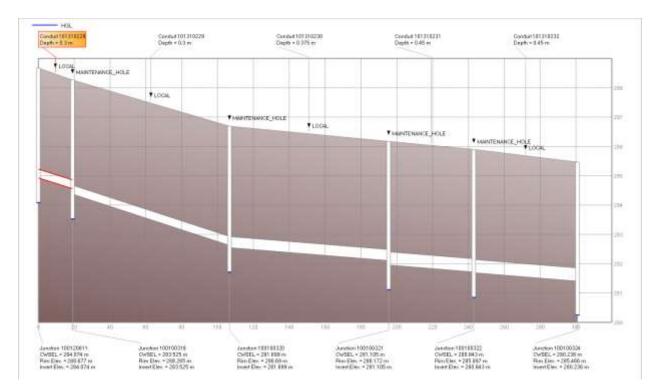


Figure 36. Route 4 profile, the first manhole is excluded regarding EES design

4.5.2.5 Route5 (SU28)

This route comprises storage unit 28 which is shown in orange color in Figure 32. The profile of this route is shown in Figure 37. The attribute table of the storage units are shown in Table 3.

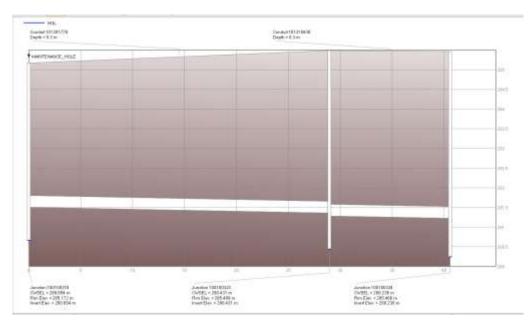


Figure 37. Route 5, profile, the first manhole is excluded regarding EES design

4.5.2.6 Route6 (SU29)

This route comprises storage unit 29 which is shown in light blue in Figure 32. The profile of this route is shown in Figure 38. The attribute table of the storage units is shown in Table 3. The storage unit 29 met its capacity.

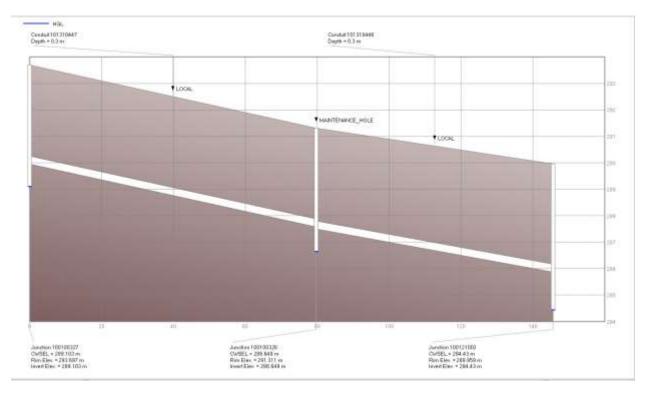


Figure 38. Route 6, profile, the first manhole is excluded regarding EES design

4.5.2.7 Route7 (SU30)

This route comprises storage unit 30 which is shown in grey color in Figure 32. The profile of this route is shown in Figure 39. The attribute table of the storage units is shown in Table 3.

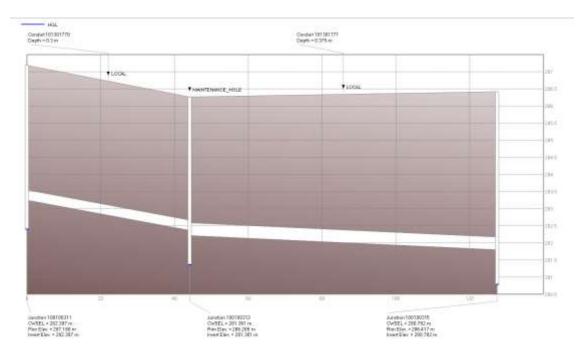


Figure 39. Route 7, profile, the first manhole is excluded regarding EES design

4.5.2.8 Route 8 (SU31-33)

This route comprises storage unit 31 to storage unit 33 which is shown in red color in Figure 32. The profile of this route is shown in Figure 40. The attribute table of the storage units is shown in Table 3. Storage unit 33 met the capacity.

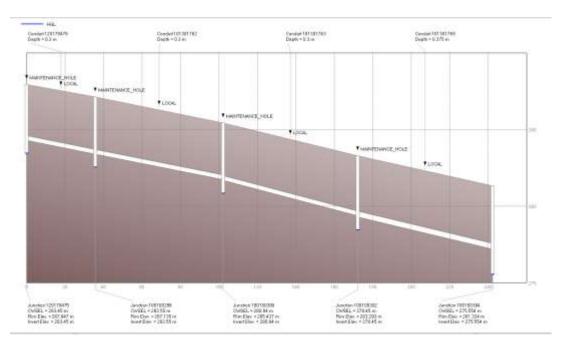


Figure 40. Route 8, profile, the first manhole is excluded regarding EES design

4.5.2.9 *Route* 9 (SU34-SU38)

This route comprises storage unit 34 to storage unit 38 which is shown in dark blue color in Figure 32. The profile of this route is shown in Figure 41. The attribute table of the storage units is shown in Table 3. The storage units 34,35,38 meet their capacity. The flooding summary is attached in Appendix A.

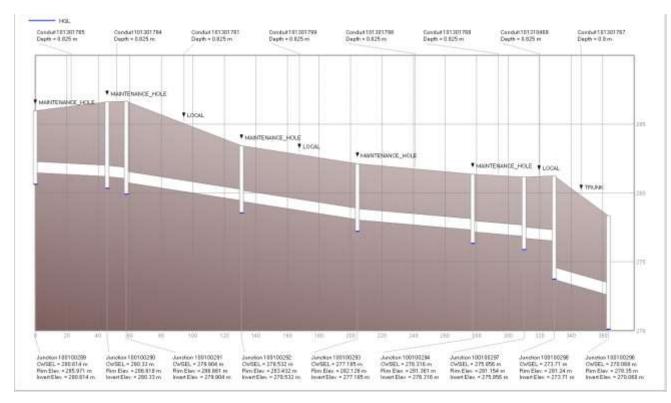


Figure 41. Route 9, profile, the first manhole is excluded regarding EES design

4.5.2.10 Infiltration Summary

The exfiltration summary was monitored for SU1-SU38 shown in Figure 42 which indicates that all of the storage units exfiltrated for 48 hours.

4.5.2.11 Discussion

The attributes of the storage units which met their capacity were monitored. This monitoring revealed that this issue could be explained in different ways. However, they had at least one of the following attributes:

- The maximum surface area was less than 80 m2
- There was a substantial total inflow volume into the upstream manhole greater than 80 m3

Moreover, the minor system deficiency might affect this issue. For example, corresponding storm sewer to the storage unit 5 had the deficiency.

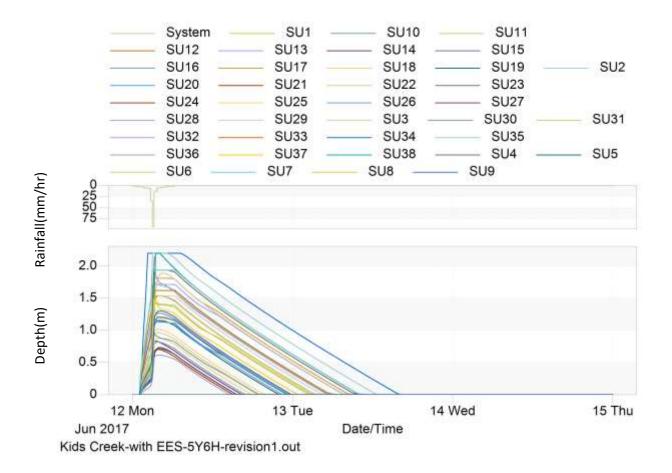


Figure 42. Exfiltration Summary for SU1-SU38, Kidds Creek watershed area for 72 hours

4.5.3 Scenario2

4.5.3.1 Route1 (SU1-SU12)

This route comprises storage unit 1 to storage unit 12 which is shown in yellow color in Figure 32. The profile of this route is shown in Figure 33. The attributes of the storage units are shown in Table 4. The storage units 1,7,8,9 and 11 meet their capacity.

SU2 0.9 291.559 292.687 90.418 0.008958 0.6 2.488 89.983993 SU3 0.9 290.749 291.135 91.746 0.016916 0.6 2.488 91.305619 SU4 0.9 289.197 289.002 90.826 0.040027 0.3 2.088 75.857875 SU5 0.9 283.464 282.72 79.056 0.033925 0.6 2.488 74.60019 SU7 0.9 280.782 280.403 74.96 0.03091 0.6 2.488 74.60019 SU8 0.9 277.929 279.136 78.414 0.012676 0.825 2.751 86.286765 SU10 0.9 275.554 277.755 86.562 0.011496 0.9 2.838 32.083022 SU11 0.9 275.554 277.59 86.567 0.01488 0.9 2.838 32.083022 SU12 0.9 275.021 275.998 28.626 0.046387 0.9 2.838<								1	
Trench SU Invert Depth Rim Elevation Length (m) slope Storm sewer diameter(m) Trench Width(m) Constant suface area SU1 0.9 291.855 293.497 36.802 0.008043 0.6 2.488 36.62330 SU2 0.9 291.559 292.687 90.418 0.008928 0.6 2.488 39.939393 SU3 0.9 290.749 291.135 91.746 0.016916 0.6 2.488 59.26456 SU5 0.9 283.142 285.002 90.826 0.040275 0.3 2.488 78.87575 SU6 0.9 283.464 282.72 7.9056 0.03992 0.6 2.488 78.676531 SU7 0.9 283.464 27.9867 71.5.39 0.03091 0.6 2.488 78.525420 SU10 0.9 275.051 277.55 86.562 0.015954 0.825 2.751 95.252824 SU11 0.9 275.021 275.987 28.764 0.012674									
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SU4 0.9 289.197 289.06 50.507 0.041083 0.6 2.488 50.264566 SU5 0.9 287.122 285.002 90.826 0.040275 0.3 2.088 75.857875 SU6 0.9 283.484 282.72 79.056 0.033925 0.6 2.488 74.60019 SU7 0.9 280.782 280.403 74.96 0.034966 0.6 2.488 74.60019 SU8 0.9 277.845 279.867 15.239 0.034966 0.6 2.488 74.60019 SU10 0.9 275.554 277.309 46.362 0.011496 0.9 2.838 52.630142 SU12 0.9 275.554 277.398 82.862 0.046387 0.9 2.838 32.083022 SU13 0.9 288.493 289.293 34.828 0.026243 0.45 2.264 10.350102 SU14 0.9 287.579 287.604 11.429 0.147782 0.45 2.26	SU2	0.9	291.559	292.687	90.418	0.008958	0.6	2.488	89.9839936
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SU16 0.9 285.122 286.243 42.131 0.016425 0.525 2.363 39.82221 SU17 0.9 284.43 285.268 35.558 0.02742 0.525 2.363 33.609421 SU18 0.9 283.455 283.134 82.578 0.025842 0.525 2.363 78.052725 SU19 0.9 281.321 282.436 74.89 0.010989 0.6 2.488 74.53052 SU20 0.9 280.498 281.74 14.982 0.017488 0.6 2.488 74.53052 SU21 0.9 280.236 281.756 67.568 0.008791 0.75 2.664 72.000460 SU22 0.9 279.642 280.043 90.1 0.01901 0.75 2.664 96.0105 SU23 0.9 286.253 287.428 41.865 0.008671 0.3 2.088 73.141804 SU24 0.9 281.699 282.724 88.79 0.00669 0.375 <td< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></td<>									
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SU18 0.9 283.455 283.134 82.578 0.025842 0.525 2.363 78.052725 SU19 0.9 281.321 282.436 74.89 0.010989 0.6 2.488 74.53052 SU20 0.9 280.498 282.174 14.982 0.017488 0.6 2.488 74.53052 SU21 0.9 280.236 281.756 67.568 0.008791 0.75 2.664 72.000460 SU22 0.9 279.642 280.043 90.1 0.019012 0.75 2.664 96.0105 SU23 0.9 286.253 287.428 41.865 0.008671 0.3 2.088 34.96564 SU24 0.9 281.525 283.237 87.574 0.020851 0.3 2.088 73.141804 SU25 0.9 281.105 282.577 47.516 0.005514 0.45 2.264 43.030489 SU27 0.9 280.843 281.95 57.867 0.01049 0.45 <td< td=""><td>SU16</td><td>0.9</td><td>285.122</td><td>286.243</td><td>42.131</td><td>0.016425</td><td>0.525</td><td>2.363</td><td>39.8222212</td></td<>	SU16	0.9	285.122	286.243	42.131	0.016425	0.525	2.363	39.8222212
SU19 0.9 281.321 282.436 74.89 0.010989 0.6 2.488 74.53052 SU20 0.9 280.498 282.174 14.982 0.017488 0.6 2.488 14.91086 SU21 0.9 280.236 281.756 67.568 0.008791 0.75 2.664 72.000460 SU22 0.9 279.642 280.03 90.1 0.019012 0.75 2.664 96.0105 SU23 0.9 286.253 287.428 41.865 0.008671 0.3 2.088 34.96564 SU24 0.9 281.525 283.237 87.574 0.020851 0.3 2.088 73.141804 SU25 0.9 281.105 282.557 47.516 0.005514 0.45 2.264 43.030489 SU27 0.9 280.843 281.95 57.867 0.01049 0.45 2.264 43.030489 SU28 0.9 281.105 281.774 11.628 0.01677 0.3 2.0	SU17	0.9	284.43	285.268	35.558	0.02742	0.525	2.363	33.6094216
SU20 0.9 280.498 282.174 14.982 0.017488 0.6 2.488 14.910086 SU21 0.9 280.236 281.756 67.568 0.008791 0.75 2.664 72.000460 SU22 0.9 279.642 280.043 90.1 0.019012 0.75 2.664 96.0105 SU23 0.9 286.253 287.428 41.865 0.008671 0.3 2.088 34.96564 SU24 0.9 281.699 282.724 88.79 0.00669 0.375 2.169 77.03420 SU26 0.9 281.105 282.557 47.516 0.00551 0.45 2.264 43.030489 SU27 0.9 280.843 281.95 57.867 0.01049 0.45 2.264 43.030489 SU29 0.9 286.649 285.968 65.903 0.03671 0.3 2.088 9.711705 SU29 0.9 286.649 285.98 65.903 0.03671 0.3 2.08	SU18	0.9	283.455	283.134	82.578	0.025842	0.525	2.363	78.0527256
SU21 0.9 280.236 281.756 67.568 0.008791 0.75 2.664 72.00460 SU22 0.9 279.642 280.043 90.1 0.019012 0.75 2.664 96.0105 SU23 0.9 286.253 287.428 41.865 0.008671 0.3 2.088 33.96564 SU24 0.9 283.525 283.237 87.574 0.020851 0.3 2.088 73.141804 SU25 0.9 281.699 282.724 88.79 0.00669 0.375 2.169 77.03420 SU26 0.9 281.105 282.557 47.516 0.005514 0.45 2.264 43.030489 SU27 0.9 280.843 281.55 57.867 0.01049 0.45 2.264 52.404355 SU28 0.9 281.105 281.774 11.628 0.01677 0.3 2.088 9.711705 SU29 0.9 286.49 285.968 65.903 0.03671 0.3 2.08	SU19	0.9	281.321	282.436	74.89	0.010989	0.6	2.488	74.530528
SU22 0.9 279.642 280.043 90.1 0.019012 0.75 2.664 96.0105 SU23 0.9 286.253 287.428 41.865 0.008671 0.3 2.088 34.96564 SU24 0.9 283.525 283.237 87.574 0.020851 0.3 2.088 73.141804 SU25 0.9 281.699 282.724 88.79 0.00669 0.375 2.169 77.03420 SU26 0.9 281.105 282.557 47.516 0.005514 0.45 2.264 43.030489 SU27 0.9 280.843 281.95 57.867 0.01049 0.45 2.264 52.404355 SU28 0.9 281.61 285.968 6.0303 0.03671 0.3 2.088 55.42185 SU30 0.9 281.61 282.98 83.323 0.00699 0.375 2.169 72.21034 SU31 0.9 282.55 282.37 66.431 0.025772 0.3 2.088 </td <td>SU20</td> <td>0.9</td> <td>280.498</td> <td>282.174</td> <td>14.982</td> <td>0.017488</td> <td>0.6</td> <td>2.488</td> <td>14.9100864</td>	SU20	0.9	280.498	282.174	14.982	0.017488	0.6	2.488	14.9100864
SU23 0.9 286.253 287.428 41.865 0.008671 0.3 2.088 34.96564 SU24 0.9 283.525 283.237 87.574 0.020851 0.3 2.088 73.141804 SU25 0.9 281.699 282.724 88.79 0.00669 0.375 2.169 77.03420 SU26 0.9 281.105 282.557 47.516 0.005514 0.45 2.264 43.030489 SU27 0.9 280.843 281.95 57.867 0.01049 0.45 2.264 43.030489 SU27 0.9 280.843 281.95 57.867 0.01049 0.45 2.264 52.404355 SU28 0.9 281.61 282.98 65.903 0.03671 0.3 2.088 55.42185 SU30 0.9 281.61 282.98 66.923 0.03671 0.3 2.088 55.24931 SU31 0.9 282.55 282.378 66.421 0.02572 0.3 2.08 <td>SU21</td> <td>0.9</td> <td>280.236</td> <td>281.756</td> <td>67.568</td> <td>0.008791</td> <td>0.75</td> <td>2.664</td> <td>72.0004608</td>	SU21	0.9	280.236	281.756	67.568	0.008791	0.75	2.664	72.0004608
SU24 0.9 283.525 283.237 87.574 0.020851 0.3 2.088 77.141804 SU25 0.9 281.699 282.724 88.79 0.00669 0.375 2.169 77.03420 SU26 0.9 281.105 282.557 47.516 0.00551 0.45 2.264 43.030489 SU27 0.9 280.843 281.95 57.867 0.01049 0.45 2.264 43.030489 SU27 0.9 280.843 281.95 57.867 0.01049 0.45 2.264 52.404355 SU28 0.9 281.105 281.774 11.628 0.01677 0.3 2.088 9.711705 SU30 0.9 281.361 282.98 65.933 0.03671 0.3 2.088 55.542185 SU31 0.9 282.55 282.378 66.481 0.02572 0.3 2.088 55.524931 SU32 0.9 278.45 277.173 70.138 0.0429 0.375 2.169	SU22	0.9	279.642	280.043	90.1	0.019012	0.75	2.664	96.01056
SU25 0.9 281.699 282.724 88.79 0.00669 0.375 2.169 77.03420 SU26 0.9 281.105 282.557 47.516 0.005514 0.45 2.264 43.030489 SU27 0.9 280.843 281.95 57.867 0.01049 0.45 2.264 43.030489 SU28 0.9 281.105 281.774 11.628 0.01677 0.3 2.088 9.711705 SU29 0.9 286.649 285.968 65.903 0.033671 0.3 2.088 55.042185 SU30 0.9 281.361 282.98 83.323 0.00699 0.375 2.169 72.291034 SU31 0.9 282.55 282.378 66.972 0.3 2.088 55.524931 SU32 0.9 280.84 279.988 69.972 0.3 2.088 55.524931 SU33 0.9 278.45 277.173 70.138 0.04129 0.375 2.169 60.851728	SU23	0.9	286.253	287.428	41.865	0.008671	0.3	2.088	34.965648
SU25 0.9 281.699 282.724 88.79 0.00669 0.375 2.169 77.03420 SU26 0.9 281.105 282.557 47.516 0.005514 0.45 2.264 43.030489 SU27 0.9 280.843 281.95 57.867 0.01049 0.45 2.264 43.030489 SU28 0.9 281.105 281.774 11.628 0.01677 0.3 2.088 9.711705 SU29 0.9 286.649 285.968 65.903 0.033671 0.3 2.088 55.042185 SU30 0.9 281.361 282.98 83.323 0.00699 0.375 2.169 72.291034 SU31 0.9 282.55 282.378 66.972 0.3 2.088 55.524931 SU32 0.9 280.84 279.988 69.972 0.3 2.088 55.524931 SU33 0.9 278.45 277.173 70.138 0.04129 0.375 2.169 60.851728	SU24	0.9	283.525	283.237	87.574	0.020851	0.3	2.088	73.1418048
SU26 0.9 281.105 282.557 47.516 0.005514 0.45 2.264 43.030489 SU27 0.9 280.843 281.95 57.867 0.01049 0.45 2.264 52.404355 SU28 0.9 281.105 281.774 11.628 0.01677 0.3 2.088 9.711705 SU29 0.9 286.649 285.968 65.903 0.033671 0.3 2.088 55.042185 SU30 0.9 281.61 282.98 83.323 0.00679 0.375 2.169 72.291034 SU31 0.9 282.55 282.378 66.9972 0.034157 0.3 2.088 55.524931 SU32 0.9 280.84 279.988 69.972 0.34157 0.3 2.088 55.824931 SU33 0.9 278.84 277.173 70.138 0.04129 0.375 2.169 60.851728 SU34 0.9 279.94 280.733 73.139 0.018759 0.825 <th< td=""><td></td><td>0.9</td><td></td><td></td><td></td><td></td><td></td><td></td><td>77.034204</td></th<>		0.9							77.034204
SU27 0.9 280.843 281.95 57.867 0.01049 0.45 2.264 52.404355 SU28 0.9 281.105 281.774 11.628 0.01677 0.3 2.088 9.711705 SU29 0.9 286.649 285.968 65.903 0.033671 0.3 2.088 9.711705 SU30 0.9 281.361 282.98 83.323 0.006949 0.375 2.169 72.291034 SU31 0.9 282.55 282.378 66.481 0.02572 0.3 2.088 55.524931 SU32 0.9 280.84 279.988 69.972 0.034157 0.3 2.088 55.524931 SU33 0.9 278.84 277.173 70.188 0.04129 0.375 2.169 60.851728 SU34 0.9 279.94 280.73 73.139 0.018759 0.825 2.751 80.482155 SU35 0.9 278.532 279.386 73.536 0.018318 0.825 <th< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>43.0304896</td></th<>									43.0304896
SU28 0.9 281.105 281.774 11.628 0.01677 0.3 2.088 9.711705 SU29 0.9 286.649 285.968 65.903 0.033671 0.3 2.088 55.042185 SU30 0.9 281.361 282.98 83.323 0.006949 0.375 2.169 72.291034 SU31 0.9 282.55 282.378 66.481 0.02722 0.03 2.088 55.524931 SU32 0.9 280.84 279.988 69.972 0.034157 0.3 2.088 55.524931 SU32 0.9 278.45 277.173 70.138 0.04129 0.375 2.169 60.851728 SU34 0.9 279.94 280.733 73.139 0.01879 0.825 2.751 80.482155 SU35 0.09 278.532 279.386 73.536 0.018318 0.825 2.751 80.919014									
SU29 0.9 286.649 285.968 65.903 0.033671 03 2.088 55.042185 SU30 0.9 281.361 282.98 83.323 0.006949 0.375 2.169 72.291034 SU31 0.9 282.55 282.378 66.481 0.025722 0.3 2.088 55.524931 SU32 0.9 280.84 279.988 69.972 0.34157 0.3 2.088 55.440614 SU33 0.9 278.45 277.173 70.138 0.04129 0.375 2.169 60.851728 SU34 0.9 279.944 280.733 73.139 0.018759 0.825 2.751 80.482155 SU35 0.09 278.52 279.386 73.536 0.018318 0.825 2.751 80.919014									9.7117056
SU30 0.9 281.361 282.98 83.323 0.006949 0.375 2.169 77.291034 SU31 0.9 282.55 282.378 66.481 0.02572 0.3 2.088 55.524931 SU32 0.9 280.84 279.988 69.972 0.34157 0.3 2.088 55.524931 SU33 0.9 278.45 277.173 70.138 0.04129 0.375 2.169 60.851728 SU34 0.9 279.944 280.733 73.139 0.018759 0.825 2.751 80.482155 SU35 0.9 278.52 279.386 73.536 0.018318 0.825 2.751 80.919014									
SU31 0.9 282.55 282.378 66.481 0.025722 0.3 2.088 55.524931 SU32 0.9 280.84 279.988 69.972 0.034157 0.3 2.088 55.524931 SU33 0.9 278.45 277.173 70.138 0.04129 0.375 2.169 60.851728 SU34 0.9 279.944 280.733 73.139 0.018759 0.825 2.751 80.482155 SU35 0.09 278.52 279.386 73.536 0.018318 0.825 2.751 80.919014									
SU32 0.09 280.84 279.988 69.972 0.034157 0.3 2.088 58.440614 SU33 0.09 278.45 277.173 70.138 0.04129 0.375 2.169 60.851728 SU34 0.09 279.904 280.733 73.139 0.018759 0.825 2.751 80.482155 SU35 0.09 278.532 279.386 73.536 0.018318 0.825 2.751 80.919014									
SU33 0.09 278.45 277.173 70.138 0.04129 0.375 2.169 60.851728 SU34 0.09 279.904 280.733 73.139 0.018759 0.825 2.751 80.482155 SU35 0.09 278.532 279.386 73.536 0.018318 0.825 2.751 80.919014									
SU34 0.9 279.904 280.733 73.139 0.018759 0.825 2.751 80.482155 SU35 0.9 278.532 279.386 73.536 0.018318 0.825 2.751 80.919014									
SU35 0.9 278.532 279.386 73.536 0.018318 0.825 2.751 80.919014									
	SU36	0.9	277.185	278.517	73.133	0.011882	0.825	2.751	80.4755532
									35.856534
	SU38	0.9	275.856	275.911	19.108	0.112309	0.825	2.751	21.0264432

Table 4. The attribute table of the storage units, regarding Scenario2

4.5.3.2 Route 2 (SU 13-22)

This route comprises storage unit 13 to storage unit 22 which is shown in pink color in Figure 32. The profile of this route is shown in Figure 34. The attributes of the storage units are shown in Table 4. The storage units 14, 15, 16, 17 meet their capacity.

4.5.3.3 Route 3 (SU23)

This route comprises storage unit 23 which is shown in blue color in Figure 32. The profile of this route is shown in Figure 35. The attributes of the storage units are shown in Table 4.

4.5.3.4 Route 4 (SU 24-27)

This route comprises storage unit 24 to storage unit 27 which is shown in green color in Figure 32. The profile of this rout is shown in Figure 36. The attribute table of the storage units is shown in Table 4.

4.5.3.5 Route 5 (SU28)

This route comprises storage unit 28 which is shown in orange color in Figure 32. The profile of this route is shown in Figure 37. The attribute table of the storage units is shown in Table 4.

4.5.3.6 Route 6 (SU29)

This route comprises storage unit 29 which is shown in light blue in Figure 32. The profile of this route is shown in Figure 38. The attribute table of the storage units is shown in Table 4.

4.5.3.7 Route 7 (SU30)

This route comprises storage unit 30 which is shown in grey color in Figure 32. The profile of this route is shown in Figure 39. The attributes of the storage units are shown in Table 4.

4.5.3.8 Route 8 (SU31-33)

This route comprises storage unit 31 to storage unit 33 which is shown in red color in Figure 32. The profile of this route is shown in Figure 40. The attributes of the storage units are shown in Table 4.

4.5.3.9 Route 9 (SU34-SU38)

This route comprises storage unit 34 to storage unit 38 which is shown in dark blue color in Figure 32. The profile of this route is shown in Figure 41. The attribute table of the storage units is shown in Table 4. The storage units 34,37,38 meet their capacity

The flooding summary is attached in appendix A.

4.5.3.10 Infiltration Summary

According to the figure 43, water exfiltrated during 48 hours for the SU1-SU38.

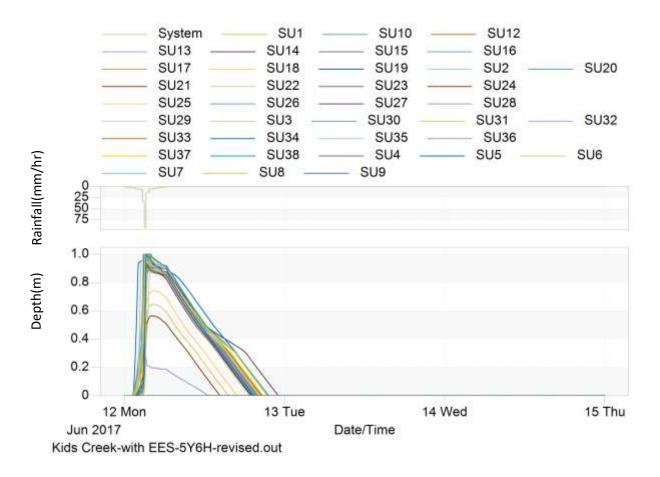


Figure 43. Exfiltration Summary for SU1-SU38, Kidds Creek watershed area for 72 hours

4.5.3.11 Discussion

Similar to scenario1, attributes of the storage units which met their capacity were verified. This monitoring revealed that this issue could be explained in different ways. However, they had at least one of the following attributes:

• The maximum surface area was less than 80 m2

• There was a substantial total inflow volume into the upstream manhole greater than 80 m3

Moreover, the minor system deficiency might affect this issue. For example, corresponding storm sewer to the storage unit 5 had the deficiency.

Quantity Reduction

4.5.4 Volume Reduction

The volume reduction for Kidds Creek watershed area was achieved from the flow routing summary report for 3 following conditions:

1-Without EES

2-With EES regarding scenario1

3- With EES regarding scenario2

The flow routing summary is shown in Figure 44-46. The volume reduction was reported 3303 m3 and 2955 m3 for scenario1, and scenario2 respectively. The exfiltration loss for scenario2 is less than scenario 1 since the storage unit capacity was considered smaller.

**************************************	Volume hectare-m	Volume 10^6 ltr
Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	6.865	68.652
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.001	0.008
External Outflow	5.234	52.336
Flooding Loss	0.000	0.000
Evaporation Loss	0.000	0.000
Exfiltration Loss	0.000	0.000
Initial Stored Volume	0.001	0.010
Final Stored Volume	1.541	15.409
Continuity Error (%)	1.348	

Figure 44. Flow Routing Summary, without EES

*****	Volume	Volume
Plan Pauties Gentieultes		
Flow Routing Continuity	hectare-m	10^6 ltr

Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	6.865	68.653
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.001	0.008
External Outflow	4.585	45.846
Flooding Loss	0.167	1.675
Evaporation Loss	0.000	0.000
Exfiltration Loss	0.330	3.303
Initial Stored Volume	0.003	0.031
Final Stored Volume	1.780	17.802
Continuity Error (%)	0.096	

Figure 45. Flow Routing Continuity Summary, with EES regarding Scenario 1

**************************************	Volume hectare-m 0.000 6.865	Volume 10^6 ltr 0.000 68.653
Groundwater Inflow RDII Inflow	0.000	0.000
External Inflow External Outflow	0.001 4.695	0.008 46.953
Flooding Loss Evaporation Loss	0.093	0.926
Exfiltration Loss Initial Stored Volume Final Stored Volume	0.295 0.003 1.780	2.955 0.031 17.802
Continuity Error (%)	0.082	17.802

Figure 46. Flow Routing Continuity Summary, with EES regarding Scenario 2

4.5.5 Flow Reduction

4.5.5.1 Scenario1

The flow reduction analysis in an exfiltration storage model is not reliable since as soon as exfiltration rate dropped in a storage unit, the water will overflow to the surrounding instead of overflowing to main conduit. Accordingly, the SWMM graphs for monitoring peak flow reduction should be modified by Excel. The flow reduction was analyzed in the last trunk (101301767) prior to an existing watercourse for both scenarios. This trunk is shown in Figure 31.

The modified simulation results are shown in Figure 47 and 48 for both scenarios. According to these results, 40 % and 32 % peak flow reduction is monitored for scenario 1 & 2 respectively.

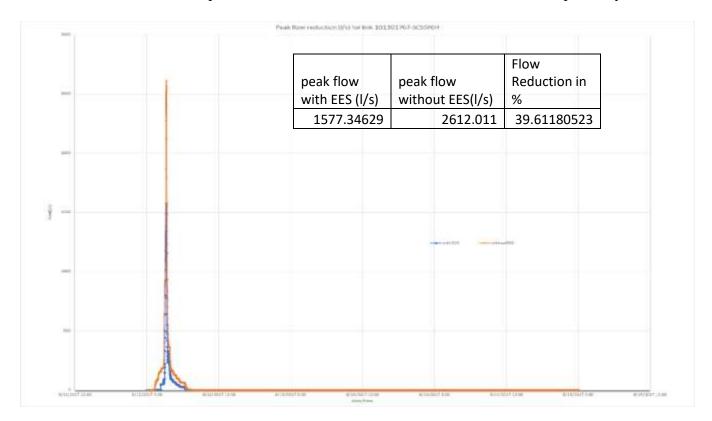


Figure 47. Flow reduction analysis for SCS,5-year-6-hour, with EES, scenario1,

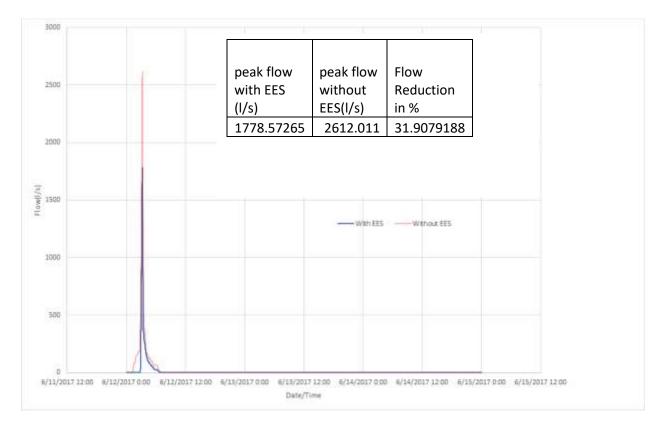


Figure 48. Flow reduction analysis for SCS,5-year-6-hour, with EES and without EES, scenario2

4.6 Modified Model:

As it was mentioned earlier in Section 3.7.2, if the same value is considered for the storage unit invert elevation and the upstream manhole (the same head elevation), the water movements in the upstream manhole and the storage unit will be similar. This will let the system to drain water when its depth reaches the main conduit inlet elevation. Resultantly flooding will not occur.

Consequently, scenario 2 was monitored one more time by considering the storage unit depth 0.3 m above main conduit.

The monitored results are as follows:

- The exfiltration loss 2958 m3 which is shown in flow routing summary in Figure 49.
- The flow reduction is 40 percent. The flow reduction is shown in Figure 50.
- Exfiltration Summary is shown in Figure 51 which confirms that the water drained in less than 48 hours.

**************************************	Volume hectare-m	Volume 10^6 ltr
Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	6.865	68.653
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.001	0.008
External Outflow	4.786	47.865
Flooding Loss	0.000	0.000
Evaporation Loss	0.000	0.000
Exfiltration Loss	0.296	2.958
Initial Stored Volume	0.003	0.031
Final Stored Volume	1.780	17.803
Continuity Error (%)	0.096	

Figure 49. Flow routing summary for modified model

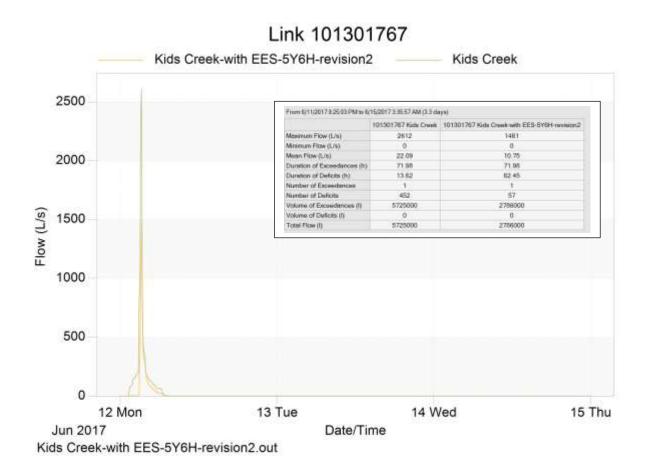


Figure 50. Flow reduction analysis for SCS,5-year-6-hour, with EES and without EES, modified model

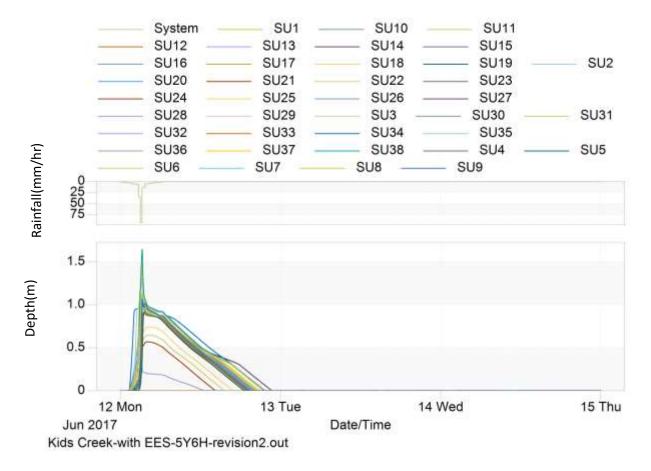


Figure 51. Exfiltration Summary for modified model

5 Conclusion

Regarding this study, the exfiltration storage model was compatible with EES according to Princess Margaret flow test. The exfiltration loss in the exfiltration storage model was well matched with EES regarding Green Ampt infiltration method.

Moreover, in this study, the exfiltration storage model was evaluated for a design storm SCS 5year,6-Hour regarding Kidds Creek watershed area in Barrie. Resultantly, some issue was monitored regarding the case study as follows:

- Flooding occurred instead of overflowing to the upstream manhole when the capacity of the storage unit was met
- The flow graphs should be modified by Excel

Eventually, to fix this issue the model was modified to make the storage unit water head similar to the EES. Thus, the invert elevation of the storage unit was considered as same as upstream manhole. As a result, the flooding issue was solved and the exfiltration loss and peak flow reduction for 38 storage units were reported 2958 m3 and 40 % for 72 hours respectively.

Recommendations:

- A new measured data might be used to evaluate the reliability the system
- The pressurized situation in the exfiltration storage model such as artesian condition might also be studied
- Applying the functional curve with a constant surface area and constant stone trench depth compared to tabular curve might be easier and faster regarding exfiltration storage model

Appendix A

Note:

- The inlet and outlet offset of conduits are for existing conditions, and 0.85 m is added in PC SWMM model regarding the design of EES.
- Every EES route is shown in different color. In each rout(color), the storage units are ordered regarding the invert elevation from the highest invert elevation to the smallest one.

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100		S. H	(- Charles Area	Contractory of	1205721		1000			C Lasts		1.111.5	11.54				5.0 11.2						48-51			1			223110	Salaria 1				Sec. 1	6. 17 in	1
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States and a set	910	111	1 1000		1.000	3001	1111	1.1.00	1.000	er 6.65	1.011			a	A 1001	100	1001 - 44	1, 1, 1, 10	1 1000	1100	1.000	time .	0.094	1.00		1.00	3.09	0.00	11961	3.000		1.001		1.000		100-10.000
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		20 K MACTINE	11.0000-000	A Shiskenet	A Terraria	8.241111414	A COMPANY IN	00000 28.	COLUMN AN ADD	ALL TROUGH	The second second			3.46246.103				the state	21414	10,000,000	10.2000	A THEFT	11.111.000	38. VL20404	SK.YTLAMO	10,000,000	6.36066331	34.803236	A CONTRACT.	A OPPORTUNE	1.00	C. Links City	11.764670	10000	11.41140604	No. of Concession, Name
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	44.0004.0804	Add to College of the	10 Million and	14.9423434	R.A.TOCTORE	11 manhaans	11.000.04	CODELL WAR	Lanas 34.27	17 -0.00110	MURLETTER.	to beact of	COLORADO A	CHEST AL	FTERE DA.	18804 UL 1	10.001 BL 801	12 10.4444	1 21.144	41.08342	mi (m) 14	in TITLE	10.100710.00	at sustain.	11 10 1 10 1	NAME AND	14.4411200	40.4882007	ALCORTING.	accession.	12.000	04.444FETT	Ad. Identical		44.80°08.087	al generation
1.1	al transie	al laborates i	In approximit	Vision activity	13 August 74	01.0.100.0000.	an exercise of	contract and	Marcel and most	an an onna	in calmins	10 Junio a	a. Pilaka 2	College M.	hansel of	ATTA DAM	100 0000	11 m. addit	1 10.0	a neri	diameter.	an enter .	di similari	al south	AL. 1704441	O'ALMONT !!	- 10, 4907004 800	\$1.438e(1)	18.0375111	12-1201240	11.00	of Assessed	al.710xmp1	1.00.001	SA AMADION	\$3. permits of
10	411 (1973 (40)-	Ch. (2010)	10 (0.000)	to intraductor	La loss maint	20.10010141	an month in	AND IN 18-	STRATE AL RET	TT ALL BULLET	ALLIBORT.	da ulases. 5	a stream of	1 18411 .44	1116 23.	4004 23.1	TRAL VALUES	14 71.8889	1 181 1984		201.000.04	20.000701	Co. same in		International Content			100.071.044	20.0403012	TR. AARTTUCK		In contractor		46.034	11 144/1001	by Assessed
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1.000	1111011100	107.347.058	44.824084425	26.52071493	10.000141100	11.2565111	W. TITEL A	Lacard max	1254 71.04	94 01.000PT	1200.0004038	COLUMN TO A	6.1734-883-8	tanan in	KR001 (1991)	网络拉拉 法人的	20161 82.04	104 STL III BRAN	41236-0911	1 1001 00101	164.05671	61.35084	101-18482-014	07.23211.04	100 1300He	ALL ADDRESS AND	AL DURING	100.8/1146	11. Phillippi	21.2622.00	28.4.6	61.0044804	41.07986872	-40.83416.1		101 abit 10
1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.	410 1004 1004	134.071148	1012442408	10 110000		44.04034003																							00 1044004	11.254/1915	10.011	0.001101	41-522 (manual	10.014.00		
1.0	411 2010 (HC*	10.0110.00	THUS PRIMA	31,74488,239	26,458(1)(7)	11.410.0394	BATTE A	1,002,00 (198.5	1004 01481	OP 81.00817	MADINE	ALMONT Y	0.410 4	SHITLER.	1501 B.	EPT 40.4	\$600 BLO	11,22,488	1, 236,980	3/7.7444	84,080.14	10.22.271	101-10403-00	45,238,538	205.120490	12,5100,762	40.4191008	100.071144	40.0731706	80.1880046	91,794	11.1203211	TL/MERH	W1.0.M %6	11.14341127	1211.71791116
1.1	all sole beck	100.001934	48.480.08181	ALENIFELM	10.7astman	uk/eestaahi.	41,2012-36	Linia de Carco	22/04/ 44/992	04/101.888391	LINE DELEMBER	21.1/11.01	28.2114	1.300001 (00.)	8.5003 T INC.	at and 1 are in	REAL VILLA	144 D. J. MARK	1 210.0011	1084-0440	10.09715	10.11130	\$25. minute into	ST-SHELTER	910 120400	Ici krani Aci	3130301	100-071168	1010014	14.45200		191.621600		40.6406 1	14. Nes2000	LTh Islands
	41 224 80	100.007108	1212208084	10.008(0001)	In Proposal	HATTENSTON.	ALC: NO. 1 1 10	CONTRACTOR OF	10001	m	1110.00100004	*********		1.01000 00.		BO 899 7 10 8 87	test bire		11.000.0000		1 414 4980 141	100 10 10 10	E 12, 100 00 111	401,010713.04	22,101144	20.0300-044	41,11800111	400.812544	10.712005	01.1094004	05.688	81.839552	11,0005-044	000000000		110.00.000
1.00	41.003.002	10.31256	45.786.0928	MCROBERT N	50.A307528	10040344.00	48,00017_38	100102-041	CROBA SHEAR	06[41.6h31	1014711444	TURIN'S	8.1913	58100 (A)	F181 (b)	KU11 564	111 11.0	11,400	1, 2,0,940	104,4809	64,096.14	ALC: NO.	12, 18(8) 11	85,898,508	200-120880	10.836783	NUMBER	100.071346	SLITING.	10400989	-91.00	81,8184,0	32.0084107	\$14M 96 1	LUMBER .	118-1912032
1.0	\$3-1008.20Cr	101.0577208	100.2419678	10.70111985	In assessment						1514175464												ald_landslip	20.3987438	106 730100	50 K 200 K. (21110000	100.571548	Statistifie:	an stances	- 46.233	#1.056363	Ad #088(185)	NUMBER OF	11.5462309	191-1012112
1.1	44 1004 PEP	101.007406	10UMINE	44.40038144	48,270(26446	14 (M19823)	W. Set In.	URDER NO.	10004 301.01	m_41.20121	100.001644	1110003	0.7017 4	141.01 .01			901 M.M			381.971	84.088.14	31,0004	214.46000.00	01.00011.00	201.10/094	10 h months	31444-0294	100,010,046	10.2709710	42.008023	00.044	ALCOROL!	TO DESCRIPTION	21,014 %	1LHHHMM	COMPARISON N
1.00	AL 1014 ROY	100.007030	MI 2003090	107,01711384	In excepted	1444530234444	14,004.04	44114 98.0	1004 001-00	26 01 3017	Wi47544	JURNEY R	0.0011	100003-96	and w	al 14 al 14	4141 \$1.00	21,25,0880	 CRU/1814 	100.048	84.096118	75.804	ESA ARABANY	10.165131	306-125MB	10.0184/10.1	64,111388	100.871588	17.1044341	ections:		81.218443	32.8984/879	94.6MB		148-261247
1		138.36.7726	100,245,9474	40.62520641	AP 355794311						151.4775404			101111 10	12001 84	0.011.211	6909 43.04	N1 0.4881	113263844	387,9545	04,05624	10.75791	105.48485.10	47.29610.00	209.120504	IC KOMPANY	14,0304081	100.0715440	TO MAKE ST	41,0554810	14,948	#8.88886ci	31,8085.40	10062436	11.5AA2922	158,745440
	44-3004.PEV	(10.0000	100.000000	U.HH881	NARA	10.011001	10.0011.0	URINY SAL	LEVEL DELAS	M ALINA C	[100,00189H	253001038	0.00123	1.80.01, 24	10月1(月)	网络红苏油	HO], M.H	01,2.000	1,20,000	1381,0141	14.00.00	3.881	105.48498.00		318.100394	NAMES/	12.849/111	10041108	31,099.012	ID-6408077	10.00	41.55502	35.3944(6.0)	91,014.96	11,0001111	199,70100
	Au-hone serve	101-107-208	100.2659576	3430013491	AD STREET		HEATEL N	444.841.441	LADEAT SHE M	00.01.001.01	Wi-Athiel4	11-54111 1	41.1011 1	1.01.01.01	1444 16.	Arees 20.0	0014 BJ.ml	171 71.4850	1 18,411	183.1545	and strept hit.	16.75701	\$06. MBABE NO	107.02673.00	-305 Typesec	to ensure the	70.05553.34	200 (471.584)	57.0048484	11.0045554		41.048552		WLANDA /		114400-0171
	41.3054.3004		 301 (MR/W/W) 	24,20039431	ACCREASED 1	VALUEROPOOT	73.20294 20	180101	5804 380.87	99-43.86111	120.04375494	312011-3	68,58331 4	1.01212 33.	1793 36.	机树口机带	1441 81.04	10.000	1 126.2611	1,001,0149	64,036,14	76.71791	NO. ABART NO	40.09873.86	308.1308941	PARTICIPACIÓN NO	A.1100104	100.871544	22,3940.001	71.1085565	81,819	REFERENCE	31.3084167	ID.A.M.By	33.346(7)(7)	104.415230
	++: 1004 1001	100.0071046	100-210236/%	.114.3000.5494	AA, MARLETTER	TLAUTTUR.	W-14411 J	1.011 (1) (0.1	10/01/100.00	m[11.10111	1012-0479-044	TAURT 1	4.1811.1	1.81111 (8)	THE PL	8.971 BL/B	ONNI DIN	111	1.100-0411	1 334 2149	101.04914	30.71271	101.10101.00	117 (108.13.46)	100 1010444	10.10867812			10.110101	AFORTING AN	16.236	81.638.031	32.8088-044	madd to 7	11.34A57002	200.010102
	11/2021000	100.007426	110.2453424	54.20013411	56.811120C													94 T) 4880	1, 19, 7911	301.1546	164.08/14	34.75791	104,4848930	47.3481716				100 811 5682		10.1312062				95-0.04 84		(09.47471)
-	41 100 100	C LECTRON	 Antipension 	54,5003443	TAURIST BAL	36.08734775	TOOLES 3	CROAD NO.	304 38.83	No. of All South	10.1475494	1200.3	08.083114	UNDER 199	COLUM	erer ar se	0401 10.04	1 10.0881	1.06.3813	30.04	141,042,14	8,8191	CA ABORT TO	AD YERTLE	356.020886	CASE NO.	143051508	100.07566	PLANE IN CONTRACT OF	NC URADEF	- 338	AT THE MAY	AT PRACES.	in and the	U. MA(2001	Construction of the second

Table 5. Tabular Curve, Case Study

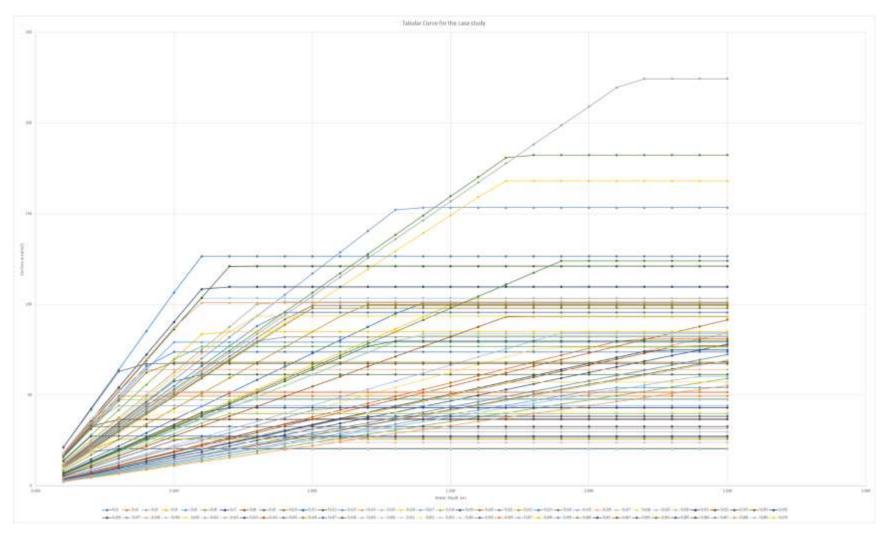


Figure 52. Tabular Curve, Case Study

		Trench	French															F	Pipe	
	Trench	Invert	Rim			Junction								Inlet Elev.	Outlet	Cross-			hickness	Trench
SU	Depth I	Elevation	elevation	Inlet Junction	Outlet Junction	difference	Path	Conduit Name	Inlet Node	Outlet Node	Tag	Length (m)	Roughness	(m)	Elev. (m)	Section	Geom1 (m)	Slope (m)	Width
SU1	1.938	291.559	293.497	100121040	100121041	0.296	SU1	101310457	100121040	100121041	LOCAL	37	0.013	291.855	291.636	5 CIRCULAR	0.6	0.00595	0.094	2.488
SU2	1.938	290.749	292.687	100121041	100100308	0.810	SU2	101310458	100121041	100100308	LOCAL	90	0.013	291.559	290.840	CIRCULAR	0.6	0.00795	0.094	2.488
SU3	1.938	289.197	291.135	100100308	100100309	1.552	SU3	101310459	100100308	100100309	LOCAL	92	0.013	290.749	289.377	7 CIRCULAR	t 0.6	0.01496	0.094	2.488
SU4	1.938	287.122	289.060	100100309	100100310	2.075	SU4	101310460	100100309	100100310	LOCAL	51	0.013	289.197	287.274	1 CIRCULAR	0.6	0.0381	0.094	2.488
SU5	1.538	283.464	285.002	100100310	100100312	3.658	SU5	101310461	100100310	100100312	LOCAL	91	0.013	287.122	283.921	LCIRCULAR	0.3	0.03527	0.044	2.088
SU6	1.938	280.782	282.720	100100312	100100315	2.682	SU6	101310462	100100312	100100315	LOCAL	79	0.013	283.464	280.946	5 CIRCULAR	0.6	0.03187	0.094	2.488
SU7	1.938	278.465	280.403	100100315	100121030	2.317		101310453	100100315	100121030	LOCAL	75	0.013	280.782		LCIRCULAR		0.02991	0.094	2.488
SU8	1.938	277.929	279.867	100121030	100100316	0.536		101310454	100121030	100100316		15	0.013	278.465		CIRCULAR		0.0199	0.094	2.488
SU9	2.201	276.935	279.136	100100316	100100305	0.994	SU9	101310468	100100316	100100305	LOCAL	78	0.013	277.929		1 CIRCULAR		0.01116	0.113	2.751
SU10	2.201	275.554	277.755	100100305	100100304		SU10	101310467	100100305	100100304		87	0.013	276.935		LCIRCULAR		0.01507	0.113	2.751
SU11	2.288	275.021	277.309	100100304	100100301	0.533		101301760	100100304	100100301		46	0.013	275.554		7 CIRCULAR		0.00986	0.119	2.838
SU12	2.288	273.710	275.998	100100301	100100298	-	SU12	101310470	100100301	100100298		28	0.013	275.021		7 CIRCULAR		0.0097	0.119	2.838
SU13	1.714	287.579	289.293	100100331	120178379		SU13	101310444	100100331	120178379		35	0.013	288.493		CIRCULAR		0.02625	0.057	2.264
SU14	1.714	285.89	287.604	120178379	100121008		SU14	120178380	120178379	100121008		11	0.013	287.683		CIRCULAR		0.0091	0.057	2.264
SU15	1.813	285.122	286.935	100121008	100100329	0.768		101310442	100121008	100100329		46	0.013	285.890		3 CIRCULAR		0.01517	0.069	2.363
SU16	1.813	284.43	286.243	100100329	100121003		SU16	101310443	100100329	100121003		42	0.013	285.122		CIRCULAR		0.01643	0.069	2.363
SU17	1.813	283.455	285.268	100121003	100121002		SU17	101310440	100121003	100121002		36	0.010	284.430		CIRCULAR		0.02504	0.069	2.363
SU18	1.813	281.321	283.134	100121002	100100326		SU18	101310439	100121002	100100326		83	0.013	283.455		7 CIRCULAR		0.02493	0.069	2.363
SU19	1.938	280.498	282.436	100100326	100100325	0.823		101310438	100100326	100100325		75	0.013	281.321		1 CIRCULAR		0.00998	0.094	2.488
SU20	1.938	280.236	282.174	100100325	100100324		SU20	101310437	100100325	100100324		15	0.013	280.498		5 CIRCULAR		0.01015	0.094	2.488
SU21	2.114	279.642	281.756	100100324	100100317		SU21	101301867	100100324	100100317		68	0.013	280.236		3 CIRCULAR		0.005	0.107	2.664
SU22	2.114	277.929	280.043	100100317	100100316		SU22	101310452	100100317	100100316		90	0.013	279.642		CIRCULAR		0.01001	0.107	2.664
SU23	1.538		287.428	100121007	100121008	0.363		101310446	100121007	100121008		42	0.013	286.253		5 CIRCULAR		0.00473	0.044	2.088
SU24	1.538	281.699	283.237	100100319	100100320		SU24	101310229	100100319	100100320		88	0.013	283.525		5 CIRCULAR		0.01999	0.044	2.088
SU25	1.619	281.105	282.724	100100320	100100321		SU25	101310230	100100320	100100321		89	0.013	281.699		7 CIRCULAR		0.00498	0.047	2.169
SU26	1.714	280.843	282.557	100100321	100100322		SU26	101310231	100100321	100100322		48	0.013	281.105		7 CIRCULAR		0.00501	0.057	2.264
SU27	1.714	280.236	281.950	100100322	100100324		SU27	101310232	100100322	100100324		58	0.013	280.843		3 CIRCULAR		0.00501	0.057	2.264
SU28	1.538	280.236	281.774	100100323	100100324		SU28	101310436	100100323	100100324		12	0.013	280.431		3 CIRCULAR		0.00499	0.044	2.088
SU29	1.538	284.43	285.968	100100328	100121003	2.219		101310448	100100328	100121003		66	0.013	286.649		3 CIRCULAR		0.02476	0.044	2.088
SU30	1.619	281.361	282.980	100100313	100100315		SU30	101301771	100100313	100100315		83	0.013	281.361		5 CIRCULAR		0.00498	0.047	2.169
SU31	1.538	280.84	282.378	100100299	100100300	1.710		101301762	100100299	100100300		66	0.013	282.550		3 CIRCULAR		0.02501	0.044	2.088
SU32	1.538	278.45	279.988	100100300	100100302		SU32	101301763	100100300	100100302		70	0.013	280.840		5 CIRCULAR		0.03309	0.044	2.088
SU33	1.619	275.554	277.173	100100302	100100304	2.896		101301769	100100302	100100304		70	0.013	278.450		7 CIRCULAR		0.03	0.047	2.169
SU34	2.201	278.532	280.733	100100291	100100292	-	SU34	101301761	100100291	100100292		73	0.013	279.904		7 CIRCULAR		0.01801	0.113	2.751
SU35	2.201	277.185	279.386	100100292	100100293	1.347		101301799	100100292	100100293		74	0.013	278.532		5 CIRCULAR		0.0179	0.113	2.751
SU36	2.201	276.316	278.517	100100293	100100294		SU36	101301798	100100293	100100294		73	0.013	277.185		1 CIRCULAR		0.01	0.113	2.751
SU37	2.201	275.856	278.057	100100294	100100297		SU37	101301768	100100294	100100297		33	0.013	276.316		CIRCULAR		0.00982	0.113	2.751
SU38	2.201	273.71	275.911	100100297	100100298	2.146	SU38	101310469	100100297	100100298	LOCAL	19	0.013	275.856	275.655	CIRCULAR	0.825	0.01052	0.113	2.751

Table 6. The attribute table of storage units, and main storm sewers

Schmidter Schmidter Stand Stand S	Name	X-Coordinate	Y-Coordinate	Tag	Rain Gage	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mn Z	ero Imperv (%)	Ostore Perv (mm)
50000000 6001816.00 600181 6000001 60.55 6001901 60.55 6001901 60.55 6001901 60.55 6001901 60.55 6001901 60.55 6001901 60.55 6001901 60.55 600190 60.55 600190 60.55 600190 60.55 600190 60.55 600190 60.55 600190 60.55 600190 60.55 600190 60.55 600190 60.55 60.95 60.55 60.95 60.55 60.95 60.55 60.95 60.55 60.95 60.55 60.95 60.55 60.95 60.55 60.95 60.55 60.95 60.55 60.95 60.55 60.95 60.55 60.95 60.95 60.95 60.95 60.95 60.95 60.95 60.95 60.95 60.95 60.95 60.95 60.95 60.95 60.95 60.95 60.95 60.95 60.95 60.95 60.95 60.95 60.95 60.95 60.95 60.95 60.95 60.95	S-100100290	602884.991	4917622.346	WDT	SCS5y6H	100100290	2.207	81.744	269.989	2.87	25.568	0.013	0.15	2	0	5
Submode 4079-58 4079-175 4079 5000000 60.59 40.70 50.00000 60.50 40.70 50.00000 60.50 40.70 50.00000 60.50 60.70 50.00000 60.50 60.70 50.00000 60.50 60.70 50.00000 60.50 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70 60.70	S-100100291	602838.129	4917572.642	WDT	SCS5y6H	100100291	0.332	26.88	123.512	7.358	20.909	0.013	0.15	2	0	5
Schmader	S-100100292	602816.855	4917520.262	WDT	SCS5y6H	100100292	0.486	99.834	48.681	7.631	50.73	0.013	0.15	2	0	5
191000000 60214.050 6071 64.05 0.07 64.05 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01	S-100100293	602754.589	4917491.756	WDT	SCS5y6H	100100293	0.775	134.668	57.549	8.91	40.869	0.013	0.15	2	0	5
510000097 60042.097 60042.097 60042.097 60042.097 60042.097 60042.097 60042.097 60042.097 60042.097 60042.097 60042.097 60042.097 60042.097 60042.097 60042.097 60042.097 60042.097 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 60042.007 <t< td=""><td>S-100100294</td><td>602695.94</td><td>4917424.182</td><td>WDT</td><td>SCS5y6H</td><td>100100294</td><td>0.297</td><td>75.837</td><td>39.163</td><td>8.365</td><td>63.191</td><td>0.013</td><td>0.15</td><td>2</td><td>0</td><td>5</td></t<>	S-100100294	602695.94	4917424.182	WDT	SCS5y6H	100100294	0.297	75.837	39.163	8.365	63.191	0.013	0.15	2	0	5
Stondorge 60203.30 64273.20 947786-0 97786-0 97786-0 97786-0 97786-0 97786-0 97786-0 97786-0 97786-0 97786-0 97786-0 97786-0 97786-0 97786-0 97786-0 9778 97786-0 97786-0 97786-0 97786-0 97786-0 9778 97786-0 9778 97786-0 97786-0 97786-0 97786-0 97786-0 97786-0 9778 97786-0 9778 97786-0 97786-0 97786-0 97786-0 97786-0 97786-0 97786-0 97786-0 97786-0 97786-0 97786-0 97786-0 97786-0 97786-0 97788-0 97788-0 97788-0 97788-0 97788-0 97788-0 97788-0 97788-0 97788-0 97788-0 97788-0 97788-0 97788-0 97788-0 97788-0 97788-0 97788-0 97788-0 97788-0 97788-0 97788-0 9778<0 9778<0 9778<0 9778<0 9778<0 9778<0 9778<0 9778<0 9778<0 9778<0 9778<0	S-100100296	602616.595	4917365.458	WDT	SCS5y6H	100100296	0.077	43.629	17.649	13.261	26.415	0.013	0.15	2	0	5
15000009 6077700 497775 358 (0VT) CSS694 1000000 0.12 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.475 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.474 7.44	S-100100297	602662.074	4917441.864	WDT	SCS5y6H	100100297	0.558	87.776	63.571	7.022	26.917	0.013	0.15	2	0	5
Submoxim Control Contro Control Control <t< td=""><td>S-100100298</td><td>602615.389</td><td>4917396.42</td><td>WDT</td><td>SCS5y6H</td><td>100100298</td><td>0.157</td><td>95.088</td><td>16.511</td><td>6.988</td><td>62.875</td><td>0.013</td><td>0.15</td><td>2</td><td>0</td><td>5</td></t<>	S-100100298	602615.389	4917396.42	WDT	SCS5y6H	100100298	0.157	95.088	16.511	6.988	62.875	0.013	0.15	2	0	5
S1000000 COD201900 COD201900 COD200000 COD200000 COD2000000 COD2000000 COD20000000 COD20000000 COD200000000 COD2000000000 COD2000000000000000000000000000000000000	S-100100299	602757.009	4917570.585	WDT	SCS5y6H	100100299	0.162	74.924	21.622	8.24	48.292	0.013	0.15	2	0	5
5100000000 6007000000 6007000000 60070000000 60070000000000000000000000000000000000	S-100100300	602717.348	4917580.182	WDT	SCS5y6H	100100300	0.712	129.335	55.051	7.005	46.092	0.013	0.15	2	0	5
510000004 600399.0 601390.00 00139 013 01 0 0 51000005 603318.18 601375.32 WT 655661 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	S-100100301	602591.788	4917421.047	WDT	SCS5y6H	100100301	0.166	66.201	25.075	5.373	62.304	0.013	0.15	2	0	5
Subscription 0000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 0000000 0000000 0000000 00000000 0000000 0000000 00000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 00000000 0000000 00000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 0000000 00000000 00000000 00000000 00000000 000000000 00000000 <td>S-100100302</td> <td>602660.386</td> <td>4917503.406</td> <td>WDT</td> <td>SCS5y6H</td> <td>100100302</td> <td>0.329</td> <td>91.331</td> <td>36.023</td> <td>6.92</td> <td>55.217</td> <td>0.013</td> <td>0.15</td> <td>2</td> <td>0</td> <td>5</td>	S-100100302	602660.386	4917503.406	WDT	SCS5y6H	100100302	0.329	91.331	36.023	6.92	55.217	0.013	0.15	2	0	5
5000000b 60058046 64777588 Virty SSSMH 0000000 0.37 78.49 47.88 6.17 92.74 0.013 0.15 2 0 51000000 602003.12 441783.84 W07 SSSMH 10000008 0.38 77.20 47.127 6.756 4.061 0.015 2 0 9 51000000 60200.32 641786.424 0000010 0.35 1000001 0.35 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	S-100100304	602592.505	4917504.014	WDT	SCS5y6H	100100304	1.526	288.649	52.867	8.255	37.677	0.013	0.15	2	0	5
50000397 69606382 497773.98 VM V SSS(eff 10000397 0.231 0.8.70 2.4.22 9.5.84 2.1.18 0.0.15 2 0 5 510000308 662803.38 49778.48 VM VT SSS(eff 10010308 0.531 6.92 54.43 0.013 0.15 2 0 95 510000301 602706.74 49778.48 VM VT SSS(eff 10010031 0.51 2 0 95 510000311 60260.02 49778.48 VM VT SSS(eff 10010031 0.51 2 0 15 2 0 15 510000314 66364.00 49778.386 0.077 SS64 6.508 6.122 0.013 0.15 2 0 15 510000314 66364.00 49778.386 0.07778 8.648 6.508 6.122 0.013 0.13 0.13 0.13 0.13 0.13 0.13 0.13 0.13 0.13 0.13 0.13 0.13	S-100100305	602518.138	4917557.532	WDT	SCS5y6H	100100305	0.568	118.754	47.83	7.627	48.869	0.013	0.15	2	0	5
510000300 60201.28 491788.48 W0T CS394H 10010030 0.30 7726 47.12 6.766 45.081 0.013 0.15 2 0 95 510000301 602756.45 491784.42 W0T CS396H 10010031 0.25 8138 4553 6592 6.76 6.73 0.013 0.15 2 0 95 510000312 60264.06 491751.050 W0T CS596H 10010012 0.672 11733 48.01 8.602 46.2 0.013 0.15 2 0 95 5100100131 60264.06 491751.050 W0T CS596H 10010131 0.51 4.667 117.78 7.805 4.312 0.013 0.15 2 0 95 510000131 60246.66 491768.030 W0T CS596H 10010131 0.66 116.798 5.194 7.201 0.13 0.13 0.13 0.13 0.13 0.13 0.13 0.13 0.13 0.13 0.10	S-100100306	602580.446	4917779.581	WDT	SCS5y6H	100100306	0.37	78.141	47.35	6.121	52.794	0.013	0.15	2	0	5
S1000039 602705.46 643780.022 WOT CSS,964 1000039 0.28 45.83 45.82 56.468 0.031 0.15 2 0 S1000030 602707.24 491786.427 W01786.47 W1718.67 W017 S5.94 1000031 0.051 24.00 0.013 0.015 2 0 0.015 2 0 0.015 2 0 0.015 2 0 0.015 2 0 0.015 2 0 0.015 2 0 0.015 2 0 0.015 2 0 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015 <t< td=""><td>S-100100307</td><td>602603.812</td><td>4917737.699</td><td>WDT</td><td>SCS5y6H</td><td>100100307</td><td>0.231</td><td>81.703</td><td>28.273</td><td>9.534</td><td>24.128</td><td>0.013</td><td>0.15</td><td>2</td><td>0</td><td>5</td></t<>	S-100100307	602603.812	4917737.699	WDT	SCS5y6H	100100307	0.231	81.703	28.273	9.534	24.128	0.013	0.15	2	0	5
10000300 60279:74 491794:47 WOT SSS;64 10010311 0.29 8.77 5.72 0.03 0.15 2 0 55 510000311 602884.05 491771.678 WOT SSS;64 10010312 0.672 116.318 8.404 8.622 49.2 0.033 0.15 2 0 55 5100100312 602844.05 491778.163 WOT SSS;644 100100314 0.57 35.44 6.94 6.128 0.033 0.15 2 0 0.55 5100100315 602555.02 491785.03 WOT SSS;644 100100315 0.877 120.66 6.8.818 8.424 39.817 0.033 0.15 2 0 0.55 5.10010315 0.655 6.4.378 0.013 0.15 2 0 0.55 6.138 0.013 0.15 2 0 0.55 1.0100317 0.023 0.15 2 0 0.55 1.0100317 0.024 0.033 0.15 2	S-100100308	602801.328	4917881.84	WDT	SCS5y6H	100100308	0.363	77.026	47.127	6.756	45.081	0.013	0.15	2	0	5
10000311 00280.82 041750.032 [WOT SSychet 10000312 0.517 142.77 115.333 8.404 30.869 0.013 0.15 2 0 95 510000312 60284.056 491771.167, WOT SSychet 10000314 0.577 335.642 6.904 6.1231 0.013 0.15 2 0 95 510000314 60258.06 491783.816 WOT SSychet 10000315 0.57 120.656 6.8.818 8.424 38.817 0.013 0.15 2 0 95 510000315 60256.54 491763.036 WOT SSychet 10010031 0.681 167.997 51.956 6.553 43.707 0.013 0.15 2 0 95 510010037 0.628 13.56 5.851 8.542 30.688 0.013 0.15 2 0 0 55 510010032 0.628 12.756 48.353 7.067 31.33 0.013 0.15 2 0 0 55 510010022 <t< td=""><td>S-100100309</td><td>602756.45</td><td>4917800.723</td><td>WDT</td><td>SCS5y6H</td><td>100100309</td><td>0.391</td><td>85.834</td><td>45.553</td><td>6.992</td><td>56.436</td><td>0.013</td><td>0.15</td><td>2</td><td>0</td><td>5</td></t<>	S-100100309	602756.45	4917800.723	WDT	SCS5y6H	100100309	0.391	85.834	45.553	6.992	56.436	0.013	0.15	2	0	5
510000312 60264406 6477541.06 (WDT SCS64H 100100312 0.672 137.395 48.91 8.622 40.2 0.013 0.15 2 0 55 5100100314 60263406 6417581.06 (WDT SCS64H 100100315 0.537 105.774 35.642 6.033 0.013 0.015 2 0 55 5100100315 602536.02 6417630.038 (WDT SCS64H 100100315 0.637 122.585 51.964 6.031 0.15 2 0 55 5100100316 602364.564 6417653.071 (WDT SCS64H 100100317 0.637 122.585 51.964 6.535 44.352 0.013 0.15 2 0 55 5100100319 602354.564 6417921.591 (WDT SCS64H 100100317 0.548 5.854 43.507 0.013 0.15 2 0 55 5100100321 602354.564 6417921.591 (WDT SCS64H 100100322 0.248 53.35 1.542 0 0.55	S-100100310	602709.724	4917748.447	WDT	SCS5y6H	100100310	0.29	111.917	25.912	8.776	53.7	0.013	0.15	2	0	5
191000313 40934406 44173380 VOT SCSpH 10010314 0.3774 35.642 6.904 6.1.29 0.0.13 0.15 2 0 95 510010314. 609350.01 441773380 VOT SCSpH 100100316 0.15 2 0 95 510010315.2 607350.02 441763.300 VOT SCSpH 100100315 0.861 167.997 51.201 42.177 0.0.13 0.15 2 0 95 510010031. 60245.46 441763.300 VOT SCSpH 10010031 0.598 115.74 40.031 0.55 44.322 0.013 0.15 2 0 95 510010031 60237.247 441783.390 VOT SCSpH 10010021 0.581 117.76 48.353 7.067 12.22 0.013 0.15 2 0 95 510010032 60237.277 441795.541 10010032 0.481 17.676 48.372 10.013 0.15 2 0 <td>S-100100311</td> <td>602680.82</td> <td>4917650.592</td> <td>WDT</td> <td>SCS5y6H</td> <td>100100311</td> <td>0.515</td> <td>44.277</td> <td>116.313</td> <td>8.404</td> <td>30.869</td> <td>0.013</td> <td>0.15</td> <td>2</td> <td>0</td> <td>5</td>	S-100100311	602680.82	4917650.592	WDT	SCS5y6H	100100311	0.515	44.277	116.313	8.404	30.869	0.013	0.15	2	0	5
E1000334 66292.001 491793.881 W0T SCSp6H 10000315 0.77 12.056 63.818 84.44 39.817 0.013 0.15 2 0 5 510000315.2 602956.02 491793.381 W0T SCSp6H 10000315 0.677 12.2665 63.818 84.44 39.817 0.013 0.15 2 0 55 510000315 6602465.464 491783.027 W0T SCSp6H 10000316 0.667 112.2885 51.046 65.55 44.377 0.013 0.15 2 0 55 510000319 602631.464 4917921.598 W0T SCSp6H 10000320 0.88 53.36 55.51 44.372 0.013 0.15 2 0 55 510000321 602374.64 491792.588 W0T SCSp6H 10000321 0.533 115.92 47.701 6.179 51.38 0.013 0.15 2 0 55 151000324 60237.39 40.328 40.3783.86 W0T SCSp6H	S-100100312	602649.103	4917711.676	WDT	SCS5y6H	100100312	0.672	137.395	48.91	8.622	49.2	0.013	0.15	2	0	5
10000315 1 002356.8 0917088.361 WOT SCS56H 10000315 0.81 167.987 51.254 7.201 42.178 0.013 0.15 2 0 95 10000315 0 66245.024 491763.037 WOT SCS56H 10010317 0.581 122.585 51.264 65.55 43.70 0.013 0.15 2 0 95 10000317 60242.794 491763.399 VOT SCS56H 100100317 0.598 15.574 44.009 S.525 44.352 0.013 0.15 2 0 95 10000316 662457.272 4917894.3194 WOT SCS56H 100100310 0.845 147.76 64.833 0.767 57.282 0.013 0.15 2 0 95 10000321 66247.272 491784.3149 WOT SCS56H 10010032 0.34 100.93 52.771 6.415 56.253 0.013 0.15 2 0 95 100100325 60238.426 491778.178	S-100100313	602634.056	4917581.609	WDT	SCS5y6H	100100313	0.377	105.774	35.642	6.904	61.291	0.013	0.15	2	0	5
5:0000315 6:00295:02 002700.328 0000315 0.851 1.97 pp 5.128 7.201 0.217 pp 0.013 0.15 2 0 5:0000316 602466.56 401763.027 W0T SCS56H 100100317 0.033 0.15 2 0 5 5:0000317 66243.2744 401763.799 W0T SCS56H 100100317 0.509 1115.674 44.003 5.525 44.352 0.013 0.15 2 0 5 5:100100317 660245.274 4917884.364 00100310 0.484 114756 44.8351 7.067 37.292 0.013 0.15 2 0 5 5:100100321 602371.39 4917784.840 W0T SCS56H 10010032 0.281 10.59 47.701 6.179 5.13 0.013 0.15 2 0 5 5:100100324 602371.39 4917761.874 W0T SCS56H 10010032 0.423 35.46 5.407 37.74 0.013 0.15 <td>S-100100314</td> <td>602502.001</td> <td>4917753.889</td> <td>WDT</td> <td>SCS5y6H</td> <td>100100314</td> <td>0.51</td> <td>43.667</td> <td>116.793</td> <td>7.805</td> <td>43.532</td> <td>0.013</td> <td>0.15</td> <td>2</td> <td>0</td> <td>5</td>	S-100100314	602502.001	4917753.889	WDT	SCS5y6H	100100314	0.51	43.667	116.793	7.805	43.532	0.013	0.15	2	0	5
101001316 602466.546 4917035.027 VOT SCSsy6H 100100317 0.697 122.885 51.964 6.555 44.307 0.013 0.15 2 0 95 5100100319 602431.406 4917921.559 WOT SCSsy6H 10000030 0.486 55.851 8.492 39.688 0.013 0.15 2 0 95 5100100321 602376.465 491728.586 WOT SCSsy6H 100100321 0.533 115.93 47.701 6.179 51.33 0.013 0.15 2 0 95 5100100322 60234 .465 49177.947.410 VT SCSsy6H 10010032 0.24 1000951 52.732 64.15 56.22 0.013 0.15 2 0 95 5100100324 60238 .426 491716.471 WOT SCSsy6H 100100325 0.403 53.86 54.071 41.1225 0.013 0.15 2 0 95 5100100325 60238.045 4917768.374 W	S-100100315_1	602536.8	4917698.361	WDT	SCS5y6H	100100315	0.77	120.656	63.818	8.424	39.817	0.013	0.15	2	0	5
10100137 602427.84 417933.79 [WDT SCS9(H) 10010131 0.500 115.674 44.003 5.525 44.332 0.013 0.15 2 0 95 100100320 602457.227 491789.479 [WDT SCS9(H) 100100320 0.485 174.756 48.353 7.067 37.292 0.013 0.15 2 0 95 5100100321 66235.4561 491782.846 WDT SCS9(H) 100100321 0.55 115.93 47.701 6.179 51.33 0.013 0.15 2 0 95 5100100322 60235.4561 491776.1474 [WDT SCS9(H) 100100321 0.687 52.53 16.562 5.732 45.122 0.013 0.15 2 0 95 5100100325 602430.15 491776.344 WDT SCS9(H) 10010032 0.438 54.46 54.07 93.724 0.013 0.15 2 0 55 5100100326 602430.45 491776.304 [WDT SCS9(H) 100100	S-100100315_2	602595.022	4917630.308	WDT	SCS5y6H	100100315	0.861	167.987	51.254	7.201	42.178	0.013	0.15	2	0	5
S1000039 605313.406 4917921.599 WOT S2596H 100100310 0.298 53.356 55.851 8.542 39.688 0.013 0.15 2 0 55 5100100321 66037272 4917884.866 WOT SCS96H 100100321 0.553 115.93 47.701 6.173 51.33 0.013 0.15 2 0 55 5100100321 6602374.66 491782.866 WOT SCS96H 10010032 0.243 100.663 23.771 6.413 56.259 0.013 0.15 2 0 55 5100100324 602378.46 4917761.478 WOT SCS96H 10010032 0.043 35.846 5.407 39.724 0.013 0.15 2 0 55 10010032 6.02489.856 491708.426 491783.866 WOT SCS96H 10010032 0.423 7.842 7.631 41.57 0.013 0.15 2 0 55 10010032 0.423 7.744 7.632 42.867	S-100100316	602466.546	4917635.027	WDT	SCS5y6H	100100316	0.637	122.585	51.964	6.555	43.707	0.013	0.15	2	0	5
101000320 602457.227 4917884.121 WOT SCSSy6H 100100320 0.945 174.756 48.333 7.067 37.292 0.013 0.15 2 0 5.10010321 602376.465 4917785.43 WOT SCSSy6H 100100322 0.24 100.663 23.771 6.415 56.229 0.013 0.15 2 0 55 5.10010322 602374.361 4917768.892 WOT SCSSy6H 100100324 0.067 52.53 16.562 5.732 45.122 0.013 0.15 2 0 55 5.100100324 602480.15 4917766.304 WOT SCSSy6H 100100326 0.403 85.345 47.22 6.071 41.225 0.013 0.15 2 0 55 5.100100327 602430.15 491786.304 WOT SCSSy6H 100100327 0.401 55.352 77.245 7.422 6.071 41.225 0.013 0.15 2 0 55 510010032 602724.346 <t< td=""><td>S-100100317</td><td>602429.784</td><td>4917693.799</td><td>WDT</td><td>SCS5y6H</td><td>100100317</td><td>0.509</td><td>115.674</td><td>44.003</td><td>5.525</td><td>44.352</td><td>0.013</td><td>0.15</td><td>2</td><td>0</td><td>5</td></t<>	S-100100317	602429.784	4917693.799	WDT	SCS5y6H	100100317	0.509	115.674	44.003	5.525	44.352	0.013	0.15	2	0	5
Endbolizit 602376.465 4917828.866 WOT SSSpeth 100100321 0.533 119.93 47.701 6.179 51.33 0.013 0.15 2 0 55 5100100322 602354.561 491779.842 WOT SCSSy6H 100100322 0.24 100.963 23.711 6.415 56.259 0.013 0.15 2 0 55 5100100324 602354.561 491776.478 WOT SCSSy6H 100100324 0.36 10.0.43 35.846 5.407 39.724 0.013 0.15 2 0 55 5100100325 602489.856 491786.304 WOT SCSSy6H 100100326 0.479 98.944 44.411 7.633 51.457 0.013 0.15 2 0 55 5100100327 602489.856 491789.356 WOT SCSSy6H 100100328 0.642 121.171 52.983 7.632 42.967 0.013 0.15 2 0 55 5100100326 602645.19	S-100100319	602513.406	4917921.559	WDT	SCS5y6H	100100319	0.298	53.356	55.851	8.542	39.688	0.013	0.15	2	0	5
F)0100322 602354501 491779.543 WOT SCSsy6H 10010323 0.0467 S2.53 16.542 5.732 4.512 0.013 0.15 2 0 55 510010324 602371.39 4917708.482 WOT SCSsy6H 100100324 0.86 5.732 45.122 0.013 0.15 2 0 55 510010325 602430.15 4917766.348 WOT SCSsy6H 10010022 0.403 85.345 47.22 6.071 41.25 0.013 0.15 2 0 55 5100100326 60248.86 491786.869 WOT SCSsy6H 10010022 0.403 85.345 47.22 6.071 41.25 0.013 0.15 2 0 55 5100100327 60278.436 491789.049 WOT SCSsy6H 10010032 0.42 121.17 52.885 9.154 48.657 0.013 0.15 2 0 55 510010329 602586.036 491789.049 WOT	S-100100320	602457.227	4917884.121	WDT	SCS5y6H	100100320	0.845	174.756	48.353	7.067	37.292	0.013	0.15	2	0	5
School 2023 602371.39 4917708.89 WD SCSSy6H 100100324 0.087 20.35 0.013 0.15 2 0 5-100100324 602388.426 491776.478 WDT SCSSy6H 100100324 0.36 100.43 38.445 5.407 39.724 0.013 0.15 2 0 55 5100100325 602430.15 4917766.304 WDT SCSSy6H 100100326 0.493 88.44 5.407 39.724 0.013 0.15 2 0 55 5100100325 602480.856 4917808.969 WDT SCSSy6H 100100327 0.401 55.352 7.2445 7.6622 42.967 0.013 0.15 2 0 55 5100100327 602783.46 491782.786 WDT SCSSy6H 100100328 0.642 121.171 59.83 7.832 47.184 0.013 0.15 2 0 55 5100100330 602784.036 4917897.049 WDT SCSSy6H 1000100331	S-100100321	602376.465	4917828.866	WDT	SCS5y6H	100100321	0.553	115.93	47.701	6.179	51.33	0.013	0.15	2	0	5
5-100100324 602388.426 4917761.478 WDT SCSy6H 100100325 0.36 100.43 35.846 5.407 39.724 0.013 0.15 2 0 55 5-100100325 602430.15 4917766.344 WDT SCSy6H 100100326 0.403 85.345 47.22 6.071 41.225 0.013 0.15 2 0 55 5-100100326 602489.856 4917883.968 WDT SCSy6H 100100327 0.401 55.332 7.622 42.967 0.013 0.15 2 0 55 5-100100329 602586.036 491789.068 WDT SCSy6H 100100328 0.642 121.171 52.983 7.832 47.184 0.013 0.15 2 0 55 5-100100329 602586.036 491789.049 WDT SCSy6H 100100330 0.319 79.107 40.325 7.492 50.252 0.013 0.15 2 0 55 5-100100330 602788.32 491790.473 WDT SCSy6H 100100331 0.405 90.45 44.776 7.3	S-100100322	602354.561	4917779.543	WDT	SCS5y6H	100100322	0.24	100.963	23.771	6.415	56.259	0.013	0.15	2	0	5
5-100100325 602430.15 4917766.304 WDT SCSsy6H 100100325 0.403 85.345 47.22 6.071 41.225 0.013 0.15 2 0 55 5-100100376 602489.866 4917808.969 WDT SCSsy6H 100100327 0.479 98.944 48.411 7.631 51.457 0.013 0.15 2 0 55 5100100377 602724.364 4917832.568 WDT SCSsy6H 100100329 0.403 55.327 7.2445 7.622 42.967 0.013 0.15 2 0 55 5100100328 602686.36 4917897.049 WDT SCSsy6H 100100329 0.126 52.731 23.895 9.154 48.657 0.013 0.15 2 0 55 510010031 602682.59 491796.471 WDT SCSsy6H 100100329 0.045 44.776 7.396 57.226 0.013 0.15 2 0 55 510010039 602484.039 491798.574 WDT SCSsy6H 100100395 0.676 123.361 54.843 6	S-100100323	602371.39	4917708.892	WDT	SCS5y6H	100100323	0.087	52.53	16.562	5.732	45.122	0.013	0.15	2	0	5
5-10010326 602489.856 4917808.969 WDT SCS5y6H 100100327 0.479 98.944 48.411 7.631 51.457 0.013 0.15 2 0 55 5-100100327 602724.346 4917832.066 WDT SCS5y6H 100100327 0.401 55.352 72.445 7.622 42.967 0.013 0.15 2 0 55 5-10010328 6622586.036 4917897.049 WDT SCS5y6H 100100329 0.126 52.731 23.895 9.154 48.657 0.013 0.15 2 0 55 5-100100330 602758.302 491789.15 WDT SCS5y6H 100100330 0.319 79.107 40.325 7.492 50.252 0.013 0.15 2 0 55 5-10010359 602788.30 4917901.673 WDT SCS5y6H 100100399 0.676 123.261 54.843 6.383 42.516 0.013 0.15 2 0 55 5-100100598 602498.55 491744.146 WDT SCS5y6H 10012061 0.345 53.503 <	S-100100324	602388.426	4917761.478	WDT	SCS5y6H	100100324	0.36	100.43	35.846	5.407	39.724	0.013	0.15	2	0	5
\$10010327 602724.346 4917832.586 WDT SCS5y6H 100100327 0.401 55.352 72.445 7.622 42.967 0.013 0.15 2 0 55 5-100100328 602566.356 4917832.066 WDT SCS5y6H 100100329 0.126 52.731 23.895 9.154 48.657 0.013 0.15 2 0 55 5-100100330 602586.306 4917897.049 WDT SCS5y6H 100100329 0.126 52.731 23.895 9.154 48.657 0.013 0.15 2 0 55 5-100100331 602582.30 491790.673 WDT SCS5y6H 100100330 0.676 123.261 54.843 6.383 42.516 0.013 0.15 2 0 55 51001059 602498.55 491794.1416 WDT SCS5y6H 100100339 0.676 123.261 54.842 9.868 33.434 0.013 0.15 2 0 55 5100120611 602498.55 491794.847 WDT SCS5y6H 100121002 0.135 67.054 20.133	S-100100325	602430.15	4917766.304	WDT	SCS5y6H	100100325	0.403	85.345	47.22	6.071	41.225	0.013	0.15	2	0	5
S10010328 602661.57 4917839.006 WDT SCS5y6H 100100328 0.642 121.171 52.983 7.832 47.184 0.013 0.15 2 0 55 S-100100329 602586.036 4917897.049 WDT SCS5y6H 100100329 0.126 52.731 23.895 9.154 48.657 0.013 0.15 2 0 55 S-100100310 602788.302 4917891.153 WDT SCS5y6H 100100331 0.405 90.45 44.776 7.336 57.296 0.013 0.15 2 0 55 S-100100359 602498.55 491779.411.416 WDT SCS5y6H 10010039 0.676 123.261 54.843 6.833 42.15 0.013 0.15 2 0 55 55 510010059 602498.55 4917941.416 WDT SCS5y6H 100100698 0.345 53.503 64.442 77.491 8.056 44.205 0.013 0.15 2 0 55 55 510012100 602540.513 4917981.428 WDT SCS5y6H 100121002 0.135 <th< td=""><td>S-100100326</td><td>602489.856</td><td>4917808.969</td><td>WDT</td><td>SCS5y6H</td><td>100100326</td><td>0.479</td><td>98.944</td><td>48.411</td><td>7.631</td><td>51.457</td><td>0.013</td><td>0.15</td><td>2</td><td>0</td><td>5</td></th<>	S-100100326	602489.856	4917808.969	WDT	SCS5y6H	100100326	0.479	98.944	48.411	7.631	51.457	0.013	0.15	2	0	5
\$10010329 602586.036 4917897.049 WDT SCS5y6H 100100329 0.126 52.731 23.895 9.154 48.657 0.013 0.15 2 0 55 5100100330 602785.302 4917897.049 WDT SCS5y6H 100100330 0.319 79.107 40.325 7.492 50.252 0.013 0.15 2 0 55 5100100350 602785.302 4917491.416 WDT SCS5y6H 100100339 0.676 123.261 54.843 6.383 42.516 0.013 0.15 2 0 55 510010059 602644.039 491779.811 WDT SCS5y6H 100100698 0.345 53.503 64.482 9.868 33.434 0.013 0.15 2 0 55 5100120611 602540.513 4917893.647 WDT SCS5y6H 100121002 0.35 67.054 20.133 6.899 0.013 0.15 2 0 55 5100121007 602540.513 4917893.882 WDT SCS5y6H 100121002 0.51 124.314 41.025 <td< td=""><td>S-100100327</td><td>602724.346</td><td>4917832.586</td><td>WDT</td><td>SCS5y6H</td><td>100100327</td><td>0.401</td><td>55.352</td><td>72.445</td><td>7.622</td><td>42.967</td><td>0.013</td><td>0.15</td><td>2</td><td>0</td><td>5</td></td<>	S-100100327	602724.346	4917832.586	WDT	SCS5y6H	100100327	0.401	55.352	72.445	7.622	42.967	0.013	0.15	2	0	5
1000000000000000000000000000000000000	S-100100328	602661.57	4917839.006	WDT	SCS5y6H	100100328	0.642	121.171	52.983	7.832	47.184	0.013	0.15	2	0	5
S-100100331 602682.29 4917901.673 WDT SCSSyGH 100100331 0.405 90.45 44.776 7.396 57.296 0.013 0.15 2 0 55 5-100100359 602498.25 4917441.416 WDT SCSSyGH 100100389 0.676 123.261 54.843 6.833 42.16 0.013 0.15 2 0 55 5-10010269 602594.83 491779.811 WDT SCSSyGH 100100698 0.345 53.503 64.482 9.868 33.434 0.013 0.15 2 0 55 5-10012002 602540.513 491789.8147 WDT SCSSyGH 10012001 0.35 67.054 20.13 6.899 51.042 0.013 0.15 2 0 55 5-100121002 602540.513 4917853.82 WDT SCSSyGH 100121003 0.51 124.314 41.025 7.142 49.712 0.013 0.15 2 0 55 5.100121007 602543.105	S-100100329	602586.036	4917897.049	WDT	SCS5y6H	100100329	0.126	52.731	23.895	9.154	48.657	0.013	0.15	2	0	5
S100100359 602498.55 491741.416 WDT SCS5y6H 100100359 0.676 123.261 54.843 6.383 42.516 0.013 0.15 2 0 55 5-100100698 602644.039 491779.911 WDT SCS5y6H 100100698 0.345 53.503 64.422 9.868 33.434 0.013 0.15 2 0 55 5-100121002 602539.483 4917890.447 WDT SCS5y6H 100121002 0.13 6.699 51.08 0.013 0.15 2 0 55 5-100121002 602590.196 4917828.76 WDT SCS5y6H 100121002 0.15 67.054 20.13 6.899 51.084 0.013 0.15 2 0 55 5-100121007 602590.196 4917853.882 WDT SCS5y6H 100121007 0.162 46.429 34.892 2.13 68.338 0.013 0.15 2 0 55 5-100121007 602596.305 4917954.809 WDT SCS5y6H 100121008 0.466.03 66.03 2.99 42.937 <td< td=""><td>S-100100330</td><td>602758.302</td><td>4917892.15</td><td>WDT</td><td>SCS5y6H</td><td>100100330</td><td>0.319</td><td>79.107</td><td>40.325</td><td>7.492</td><td>50.252</td><td>0.013</td><td>0.15</td><td>2</td><td>0</td><td>5</td></td<>	S-100100330	602758.302	4917892.15	WDT	SCS5y6H	100100330	0.319	79.107	40.325	7.492	50.252	0.013	0.15	2	0	5
S-100100698 602644.039 491779.811 WDT SCS5y6H 100100698 0.345 53.503 64.482 9.868 33.434 0.013 0.15 2 0 55 5-100120611 602539.483 491789.047 [WDT SCS5y6H 100120611 0.36 46.482 77.449 8.056 44.05 0.013 0.15 2 0 55 5-100121002 602540.513 4917828.76 [WDT SCS5y6H 100121002 0.15 2 0 55 5-100121007 602590.196 4917828.82 [WDT SCS5y6H 100121003 0.51 124.314 41.025 7.142 49.712 0.013 0.15 2 0 55 5-100121007 602596.305 4917954.479 MDT SCS5y6H 100121003 0.466.03 6.603 2.99 42.37 0.013 0.15 2 0 55 5-100121008 602596.305 491795.417 WDT SCS5y6H 100121030 0.25 6.6.03 2.99 42.37 0.013	S-100100331	602682.29	4917901.673	WDT	SCS5y6H	100100331	0.405	90.45	44.776	7.396	57.296	0.013	0.15	2	0	5
5-100120611 602539.483 4917890.447 WDT SCSsy6H 10012061 0.36 46.482 77.49 8.066 44.205 0.013 0.15 2 0 55 5-100121002 602540.513 4917890.447 WDT SCSsy6H 100121002 0.13 67.054 20.13 6.899 51.042 0.013 0.15 2 0 55 5-100121002 602540.513 4917853.828 WDT SCSsy6H 100121003 0.51 124.314 41.025 7.142 49.712 0.013 0.15 2 0 55 5-100121007 602543.105 4917954.178 WDT SCSsy6H 100121007 0.162 46.429 34.892 2.13 68.338 0.013 0.15 2 0 55 5-100121008 602596.305 4917954.178 WDT SCSsy6H 100121000 0.24 66.03 66.03 2.99 42.937 0.013 0.15 2 0 55 5-100121040 60294.282 491793.317 WDT SCSsy6H 10012104 </td <td>S-100100359</td> <td>602498.55</td> <td>4917441.416</td> <td>WDT</td> <td>SCS5y6H</td> <td>100100359</td> <td>0.676</td> <td>123.261</td> <td>54.843</td> <td>6.383</td> <td>42.516</td> <td>0.013</td> <td>0.15</td> <td>2</td> <td>0</td> <td>5</td>	S-100100359	602498.55	4917441.416	WDT	SCS5y6H	100100359	0.676	123.261	54.843	6.383	42.516	0.013	0.15	2	0	5
\$100121002 602540.513 4917828.76 WDT SCSSy6H 100121002 0.135 67.054 20.133 6.889 51.084 0.013 0.15 2 0 55 5-100121003 602590.196 4917853.882 WDT SCSSy6H 100121003 0.51 124.314 41.025 7.142 49.712 0.013 0.15 2 0 55 5-100121007 602543.105 4917964.809 WDT SCSSy6H 100121007 0.162 44.429 34.892 2.13 68.393 0.013 0.15 2 0 55 5-100121008 602596.305 4917954.178 WDT SCSSy6H 100121008 0.426 66.03 66.031 2.99 42.937 0.013 0.15 2 0 55 5-100121040 602594.326 4917954.718 WDT SCSSy6H 100121040 0.254 61.393 41.373 7.711 47 0.013 0.15 2 0 55 5-100121040 602904.8	S-100100698	602644.039	4917779.811	WDT	SCS5y6H	100100698	0.345	53.503	64.482	9.868	33.434	0.013	0.15	2	0	5
\$-100121003 602590.196 4917853.882 WDT SCS5y6H 100121003 0.51 124.314 41.025 7.142 49.712 0.013 0.15 2 0 55 5-100121007 602543.105 4917954.809 WDT SCS5y6H 100121007 0.162 46.429 34.892 2.13 68.338 0.013 0.15 2 0 55 5-100121007 602543.105 4917954.178 WDT SCS5y6H 100121008 0.436 66.03 6.031 2.99 42.373 0.013 0.15 2 0 55 5-100121030 602514.1 4917617.514 WDT SCS5y6H 100121030 0.254 61.393 41.373 7.711 47 0.013 0.15 2 0 55 5-100121040 602904.282 4917939.317 WDT SCS5y6H 100121040 1.028 96.028 107.052 1.14 72.205 0.013 0.15 2 0 55 5-100121041 602839.26	S-100120611	602539.483	4917890.447	WDT		100120611	0.36	46.482	77.449	8.056	44.205	0.013	0.15	2	0	5
S-100121007 602543.105 4917964.809 WDT SCS5y6H 100121007 0.162 46.429 34.892 2.13 68.338 0.013 0.15 2 0 55 5-100121008 602596.305 4917954.178 WDT SCS5y6H 100121008 0.436 66.03 66.03 2.99 42.937 0.013 0.15 2 0 55 5-100121008 602904.282 4917695.341 WDT SCS5y6H 100121000 0.254 61.393 41.73 7.711 47 0.013 0.15 2 0 55 5-100121040 602904.282 4917939.317 WDT SCS5y6H 100121040 1.028 96.028 107.052 1.14 72.205 0.013 0.15 2 0 55 5-100121041 602839.265 4917933.017 WDT SCS5y6H 100121041 0.15 63.7 2.43.33 5.23 48.621 0.013 0.15 2 0 55 5-120178475 602779.93 4	S-100121002	602540.513	4917828.76	WDT	SCS5y6H	100121002	0.135	67.054	20.133	6.899	51.084	0.013	0.15	2	0	5
S-100121008 602596.305 4917954.178 WDT SCSSy6H 100121008 0.436 66.03 66.03 2.99 42.937 0.013 0.15 2 0 55 5-100121040 602596.305 4917954.178 WDT SCSSy6H 100121008 0.436 66.03 66.03 2.99 42.937 0.013 0.15 2 0 55 5-100121040 602594.28 4917939.317 WDT SCSSy6H 100121040 1.028 96.028 107.052 1.14 72.205 0.013 0.15 2 0 55 5-100121040 602894.282 4917933.017 WDT SCSSy6H 100121040 1.028 96.028 107.052 1.14 72.205 0.013 0.15 2 0 55 5-100121041 602894.282 4917933.017 WDT SCSSy6H 100121041 0.15 63.7 24.333 5.23 48.621 0.013 0.15 2 0 55 5-120178475 602779.93<	S-100121003	602590.196	4917853.882	WDT	SCS5y6H	100121003	0.51	124.314	41.025	7.142	49.712	0.013	0.15	2	0	5
S-100121008 602596.305 4917954.178 WDT SCSSyGH 100121008 0.436 66.03 66.03 2.99 42.937 0.013 0.15 2 0 55 5-100121030 602514.1 4917617.514 WDT SCSSyGH 100121030 0.254 61.393 41.373 7.711 47 0.013 0.15 2 0 55 5-100121040 602904.282 4917939.317 WDT SCSSyGH 100121040 1.028 96.028 107.052 1.14 77.205 0.013 0.15 2 0 55 5-100121041 60289.265 4917933.017 WDT SCSSyGH 100121040 0.155 63.7 24.333 5.23 48.621 0.013 0.15 2 0 55 5-120178379 602626.661 4917915.95 WDT SCSSyGH 120178379 0.63 84.763 19.23 5.909 46.013 0.013 0.15 2 0 55 5-120178475 602779.93	S-100121007	602543.105	4917964.809	WDT	SCS5y6H	100121007	0.162	46.429	34.892	2.13	68.338	0.013	0.15	2	0	5
S-100121040 602904.282 4917939.317 WDT SCS5y6H 100121040 1.028 96.028 107.052 1.14 72.205 0.013 0.15 2 0 55 5-100121041 602839.265 4917933.017 V/OT SCS5y6H 100121041 0.155 63.7 24.333 5.23 48.621 0.013 0.15 2 0 55 5-120178379 60262.6061 4917916.95 WDT SCS5y6H 120178379 0.163 84.763 19.23 5.909 46.013 0.013 0.15 2 0 55 5-120178475 602779.93 4917693.387 WDT SCS5y6H 120178475 1.745 88.263 197.705 5.493 5.829 0.013 0.15 2 0 55 5-120178475 602779.93 4917693.387 WDT SCS5y6H 120178475 1.745 88.263 197.705 5.493 5.829 0.013 0.15 2 0 55	S-100121008	602596.305	4917954.178	WDT		100121008	0.436	66.03	66.031	2.99	42.937	0.013	0.15	2	0	5
S-100121040 602904.282 4917939.317 WDT SCS5y6H 100121040 1.028 96.028 107.052 1.14 72.205 0.013 0.15 2 0 55 5-100121041 602839.265 4917933.017 V/UT SCS5y6H 100121041 0.15 63.7 24.333 5.23 48.621 0.013 0.15 2 0 55 5-120178475 602626.061 9417916.955 VDT SCS5y6H 120178475 1.745 88.263 197.705 5.493 5.629 0.013 0.15 2 0 55 5-120178475 602779.93 4917693.87 VDT SCS5y6H 120178475 1.745 88.263 197.705 5.493 5.629 0.013 0.15 2 0 55	S-100121030	602514.1	4917617.514	WDT		100121030	0.254	61.393	41.373	7.711	47	0.013	0.15	2	0	5
S-100121041 602839.265 4917933.017 WDT SCS5y6H 100121041 0.155 63.7 24.333 5.23 48.621 0.013 0.15 2 0 55 S-120178379 602626.061 4917916.95 WDT SCS5y6H 120178379 0.163 84.763 19.23 5.909 46.013 0.013 0.15 2 0 55 S-120178475 602779.93 4917693.387 WDT SCS5y6H 120178475 1.745 88.263 197.705 5.493 5.829 0.013 0.15 2 0 55	S-100121040	602904.282	4917939.317	WDT		100121040	1.028	96.028	107.052	1.14	72.205	0.013	0.15	2	0	5
5-120178475 602779.93 4917693.387 WDT SCS5y6H 120178475 1.745 88.263 197.705 5.493 5.829 0.013 0.15 2 0 5	S-100121041	602839.265	4917933.017	WDT	SCS5y6H	100121041	0.155	63.7	24.333	5.23	48.621	0.013	0.15	2	0	5
S-120178475 602779.93 4917693.387 WDT SCS5y6H 120178475 1.745 88.263 197.705 5.493 5.829 0.013 0.15 2 0 5	S-120178379	602626.061	4917916.95	WDT	SCS5y6H	120178379	0.163	84.763	19.23	5.909	46.013	0.013	0.15	2	0	5
	S-120178475	602779.93	4917693.387	WDT		120178475	1.745	88.263	197.705	5.493	5.829	0.013	0.15	2	0	5
5-J900KD_2 602596.088 4917336.815 WDT SC55y6H J900KD 0.217 63.985 33.914 24.278 10.075 0.013 0.15 2 0 5	S-J900KD_2	602596.088	4917336.815	WDT	SCS5y6H	J900KD	0.217	63.985	33.914	24.278	10.075	0.013	0.15	2	0	5

Table 7. Subcatchment attribute table

Node	Hours Flooded	Maximum Rate LPS	days	hr:min	Total Flood Volume10^6	ltr
			uays		VOIUMEIO	
SU13	2.76	58.85	0	3:15	0.097	0
SU17	1.58		0	3:15	0.02	0
SU24	0.11	1.64	0	3:47	0	0
SU29	3.22	60.27	0	3:15	0.073	0
SU31	0.86	2.08	0	3:45	0.003	0
SU32	3.31	56.14	0	3:10	0.079	0
SU33	1.58	29.71	0	3:15	0.014	0
SU34	4.65	116.99	0	3:15	0.688	0
SU35	2.06	109.49	0	3:15	0.25	0
SU38	0.5	112.65	0	3:30	0.06	0
SU4	2.05	39.18	0	3:15	0.021	0
SU5	1.57	22.06	0	3:15	0.01	0
SU6	3.29	99.51	0	3:12	0.135	0
SU7	3.38	127.27	0	3:15	0.224	0

Table 8. Flooding Summary, Case Study, Scenario 1

					Total
	Hours	Maximum			Flood
	Flooded	Rate LPS			Volume1
Node			days	hr:min	0^6
SU1	0.32	44.76	0	3:15	0.034
SU11	0.31	34.57	0	3:16	0.016
SU14	0.22	16.23	0	3:15	0.011
SU15	0.1	7	0	3:10	0.002
SU16	0.04	8.38	0	3:15	0.001
SU17	0.13	35.2	0	3:15	0.013
SU34	0.82	93.3	0	3:15	0.148
SU35	0.89	90.11	0	3:15	0.138
SU36	1.01	100.6	0	3:15	0.171
SU37	1	100.21	0	3:15	0.159
SU38	1.06	110.74	0	3:15	0.173
SU7	0.19	31.82	0	3:15	0.016
SU8	0.29	49.69	0	3:15	0.038

Table 9. Flooding Summary, Case study, Scenario 2

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