MAC WILLIAMS ENGINEERING LIMITED

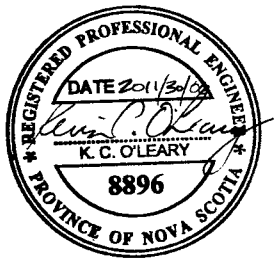
Stormwater Management Plan

Emscote Lands
Bedford, NS

Prepared by:

Mac Williams Engineering Limited
109 Chain Lake Drive
Halifax, Nova Scotia, B3S1B3

Tel: 902-450-1414
Fax: 902-450-1424



For:

Emscote Limited
Summit Place, Suite 700
1601 Lower Water Street
P.O. Box 1074
Halifax, NS B3J 2X1

Principal Contact:
Don Williams, P.Eng.
Mac Williams Engineering limited
Tel: 902-450-1414

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Project Number 10575

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APPENDICES

1.0 INTRODUCTION

This report outlines the Stormwater Management Plan (SWMP) for the proposed subdivision owned by Emscote Limited as shown on the General Site Plans in Appendix A. This development is located near the intersection of the Bicentennial Highway and Larry Uteck Boulevard (Appendix A). The site has a Property Identification Number (PID) of 00016576.

This SWMP is intended for use in the planning and construction of the site as noted above. The plan presents conceptual design considerations for the site that will ultimately meet or exceed the goals and objectives of the Nova Scotia Department of Environment when the final design is developed. Drainage calculations and retention ponds are based on preliminary design concepts and site layout. During final design, drainage areas and related design factors will be revisited to finalize stormwater control features.

Erosion and sediment control measures discussed in this report shall be implemented in accordance with the most current version of the Nova Scotia Department of Environment Erosion and Sedimentation Control Handbook for Construction Sites. It shall be the responsibility of the site works contractor as well as the owner or their representative to ensure that this is adhered to during all construction phases.

2.0 WATERSHED DRAINAGE

The project site has three distinct drainage areas. One area drains in a westerly direction and discharges to a detention pond located near the intersection of Transom Drive and Starboard Drive (refer to Drawings 10575-D01 through 10575-D03 in Appendix A). A portion of this flow may be diverted to a detention pond located further north along Starboard Drive. The second drainage area will discharge to a detention pond located near the intersection of Bosun Run and Fleetview Drive (refer to Drawings 10575-D01 through 10575-D03 in Appendix A). A third drainage area will also discharge to a detention pond located near the intersection of Bosun Run and Fleetview Drive (refer to Drawings 10575-D01 through 10575-D03 in Appendix A) and generally consists of the CRESCO Holdings Limited lands.

Apartment buildings and their associate property within the main project area will be designed to be self balanced with regards to stormwater flow using features such as roof storage and on-site detention. Flow from uncontrolled areas not discharging to a detention pond will be compensated for by increasing the storage in the proposed detention storage ponds by an equivalent amount of increased stormwater flow due to any development of the uncontrolled lands.

The project site will undergo cut and fill operations in order to construct roadways. As a result of the roadway construction, some wetlands will be impacted and will require wetland compensation. To the extent that is possible, existing on-site wetlands will be maintained and utilized as a part of the overall

storm water management system. Wetlands which are unavoidably lost will be compensated for as per provincial policy.

The construction of roads in two areas create zones that dam the natural flow of stormwater. These areas, designated J and N (refer to Drawings 10575-D01 through 10575-D03 in Appendix A), form private retention ponds. They will drain via a piped collection system which will be sized to pass the five year storm. The 100 year storm event will be retained and released at the five year flow rate.

In general, stormwater runoff from the developed areas of the site (i.e. areas covered with pavement or buildings and other facilities) will be collected in a system of street gutters, catch basins and storm water collection piping, discharged into a detention pond and ultimately discharged back into the wetlands or watercourses.

A Spill Management Plan and Emergency Response and Contingency Plan will need to be developed and implemented by all future roadway contractors in order to minimize the chances of a spill reaching any water body including groundwater. It should also include mitigation measures to minimize impact if a spill does occur and manages to reach a water body. In order to minimize, contain, and control any potential releases of hazardous materials, a site-specific Hazardous Waste Spill Management Plan should also be developed. All construction personnel must be appropriately trained in the handling, storage, and disposal of hazardous materials (i.e. WHMIS, TDG). Chemical storage and handling will be done in accordance with the manufacturers' recommendations and federal and provincial regulations, where applicable.

3.0 PLAN GOALS AND OBJECTIVES

This stormwater management plan addresses the potential effects upon water quality and quantity from within this development on the associated watersheds. The intent of this plan is to adhere to all relevant policies and objectives for development as set forth in the Department of Environment (and other regulatory bodies) policies and procedures.

The goal of stormwater management is to preserve the natural hydrologic cycle. At present there are a number of watershed management plans in this local area, all of which have been reviewed for compliance with this SWMP. The goal of the SWMP will be realized through objectives that maximize pollution prevention opportunities and conservation practices to protect water quality and control water quantity. Objectives for stormwater drainage are as follows:

- To prevent loss of life and to protect structures and property from damage due to major storm events;
- To provide safe and convenient use of roadways, lot areas, and other improvements during and following rain and snow events;
- To adequately convey the 100 year stormwater flow from upstream sources;

- To mitigate the adverse effects of stormwater flows, such as flooding and erosion, onto downstream areas;
- To preserve natural watercourses;
- To minimize the long term effects of development on receiving watercourses and on groundwater, therefore;
- Stormwater management should be an integral part of the overall site design and development.

4.0 Environmental Setting

4.1 Watercourses and Wetlands

A watercourse and wetland study has been performed for the site by Terra Firma Consultants (dated June 14, 2011). This study includes an assessment, delineation and inventory of the number, type and size of wetlands and water courses present in the various areas, and to identify potential impacts to these wetlands and water courses as a result of the development of the project.

4.2 Geology and soil

The area of the property is currently 43.2 Ha (106.8 acres). The footprint for the proposed project which does not include the construction of the apartment buildings at the northern and southern end of the property is 27.5 Ha (67.8 acres). The surface geology of the site consists mainly of bedrock with some overlying glacial till.

4.3 Soil Erosion

Overall, the project area is considered to have low risk of soil erosion. Any imported soil required for construction will mostly be limited to topsoil needed for landscaping. Standard erosion and sedimentation control measures will be employed for all erodible soils (Appendix B: Erosion and Sediment Minimization Plan).

5.0 Conceptual Stormwater Management Plan Facilities

The goal of the stormwater management plan is to minimize and reduce peak flows and contaminant inputs to nearby watercourses. These goals will be met through implementation of the following two strategies:

- minimize peak flows by providing retention, and
- reduce contaminant inputs through the use of wet detention ponds.

The overall strategy for the site is to provide an integrated approach to stormwater management, which is premised on controlling runoff and pollution at the source. Therefore, a hierarchy, or train, of stormwater management practices shall be implemented on the site and include:

- stormwater lot level controls, which wherever possible will be achieved by directing roof leader downspouts overland to the natural drainage corridors,
- end-of-pipe stormwater management facilities, wherever necessary, will consist of extended detention dry ponds, grassed swales, and velocity breaks,
- use of wet retention forebays to serve as storm water quality control and treatment measures.

5.1 STORMWATER QUANTITY/RATE CONTROL PRACTICES

The goal of the SWMP for stormwater quantity control is to match, as closely as possible, the pre-development hydrologic conditions to the post-development conditions on areas that drain into freshwater brooks/rivers. A hierarchical approach to stormwater management shall be utilized. This process results in a series of stormwater control measures, as opposed to one single end-of-pipe technology selection.

The Stormwater Drainage Plans, drawings 10575-D01 through 10575-D03 is attached in Appendix A.

The basic design criteria shall be to balance freshwater brooks/rivers in such a manner that pre-development peak flows closely match post-development peak flows from the five and the 100-year 24-hour storm events. The closest Atmospheric Canada weather station to this site is CFB Shearwater and storm event data from this station was used for all hydraulic modeling.

5.1.1 Pre and Post Development Modeling Results

The water quantity and flow rate modeling for the project was performed by Mac Williams Engineering. The site was modeled using HydroCAD and modeled stormwater runoff rates for specific storm events based on pre- and post-development scenarios. The pre-development modeling results are summarized in Appendix C. The pre-development drainage conditions are summarized below:

Balance Point or Drainage Area	Area ha [ac]	Coeff.		t_c	Intensity mm/hr [in/hr]		5 Year Flow m^3/s [ft^3/sec]	100 Year Flow m^3/s [ft^3/sec]
		5 yr	100 yr	min	5 yr	100 yr	5 yr	100 yr
A	9.2 [22.7]	0.30	0.50	19.6	46.6 [1.83]	74.0 [2.91]	0.353 [12.5]	0.934 [33.0]
B	26.9 [66.4]	0.30	0.50	26.5	39.4 [1.55]	62.6 [2.46]	0.874 [30.9]	2.31 [81.7]
C	7.3 [18.0]	---	---	---	---	---	---	---
D	3.8 [9.5]	---	---	---	---	---	---	---

Balance Point or Drainage Area	Area ha [ac]	Coeff.		t_c	Intensity mm/hr [in/hr]		5 Year Flow m^3/s [ft^3/sec]	100 Year Flow m^3/s [ft^3/sec]
		5 yr	100 yr	min	5 yr	100 yr	5 yr	100 yr
E	10.7 [26.4]	0.30	0.50	23.5	42.1 [1.66]	66.9 [2.63]	0.37 [13.1]	0.983 [34.7]
F	9.6 [23.8]	---	---	---	---	---	---	---
G	7.2 [17.9]	---	---	---	---	---	---	---
H	0.7 [1.7]	---	---	---	---	---	---	---

Notes:

1. Area C, D and H represent the headwaters of a catchment area and drains off-site. The drainage area indicated only represents the area bounded by the property line; the catchment area extends onto adjacent properties. Portions of these drainage areas are uncontrolled in the post-development scenario.

2. Uncontrolled areas are defined as those areas which do not drain to the proposed retention ponds. Any increase in stormwater flow due to development in the uncontrolled areas is compensated for within the retention pond design.

3. Areas C, D, F, G and H are not directly impacting retention pond sizing and pre- and post-development stormwater flow balancing. Post development, most of these areas are controlled and their flows are discharged to one of the on-site retention ponds. Those uncontrolled areas with areas C, D, F, G and H are accounted for as in Note 2. Areas A, B and E are used as balance points, therefore the entire catchment area is required for analysis.

The post-development modeling results for the one in five year and one in 100 year storm event are also summarized in Appendix D. Overall, the post-development drainage consists of the following:

Balance Point or Drainage Area	Cont-rolled Area ha [ac]	Uncont-rolled Area ha [ac]	Coeff.		t_c	Intensity [in/hr]		5 Year Flow m^3/s [ft^3/sec]	100 Year Flow m^3/s [ft^3/sec]
			5 yr	100 yr	min	5 yr	100 yr	5 yr	100 yr
A	---	---	---	---	---	---	---	10.6	30.0
B	---	---	---	---	---	---	---	29.1	82.3
E	---	---	---	---	---	---	---	12.2	33.5
J	0.83 [2.0]	---	0.375	0.625	5.7	92.5 [3.64]	146.6 [5.77]	0.079 [2.8]	.207 [7.32]
K+L	6.4 [15.7]	---	0.4	0.65	17	50.4 [1.98]	80.0 [3.15]	0.35 [12.4]	0.931 [32.9]
M	4.2 [10.4]	---	0.64	0.95	14.2	55.7 [2.19]	88.4 [3.48]	0.411 [14.52]	1.089 [38.5]
N	1.3 [3.3]	---	0.3	0.5	8.0	79.4 [3.13]	125.9 [4.96]	0.086 [3.03]	0.22 [7.77]
P	12.2 [30.1]		0.44	0.75	34.0	34.3 [1.35]	54.5 [2.14]	0.508 [18.0]	1.34 [47.4]
Q	---	1.3 [3.2]	0.45	0.75	5	91.2 [3.59]	153.6 [6.05]	0.146 [5.17]	0.41 [14.52]

Balance Point or Drainage Area	Cont-rolled Area ha [ac]	Uncont-rolled Area ha [ac]	Coeff.		t_c	Intensity [in/hr]		5 Year Flow m^3/s [ft^3/sec]	100 Year Flow m^3/s [ft^3/sec]
			5 yr	100 yr	min	5 yr	100 yr	5 yr	100 yr
R	---	4.7 [11.6]	0.35	0.5	5	91.2 [3.59]	153.6 [6.05]	0.41 [14.57]	0.99 [35.09]
S	---	3.1 [7.6]	0.3	.5	5	91.2 [3.59]	153.6 [6.05]	0.23 [8.18]	0.65 [22.9]
T	---	0.71 [1.75]	0.45	0.75	5	91.2 [3.59]	153.6 [6.05]	0.080 [2.83]	0.22 [7.94]
Q, R, S & T	---	---	---	---	---	---	---	0.0868 [3.06]	0.180 [6.38]

Notes:

1. Areas labels I and O are omitted intentionally from use to avoid confusion with 1 and 0.
2. Areas J and Q are controlled areas but discharges via the collection system to the adjacent property.
3. Areas R and S are uncontrolled and discharge to adjacent property. Any increase in stormwater flow due to development in the uncontrolled areas is compensated for within the retention pond design and discharged to one of the on-site retention ponds.
4. Areas J, Q, R and S are modeled conservatively with a time of concentration of 5 minutes for each area.
5. Row labeled Q, R, S and T is the net increase in runoff rate due to development within the uncontrolled areas and compensated for within the retention pond design and discharged to one of the on-site retention ponds.

Stormwater detention ponds will be necessary in order to balance these flows to pre-developed conditions. The storage requirements are listed below.

Retention Pond	Required Storage m^3 [ft^3]
RP4	1,650 [58,300]
RP5	970 [34,300]
KL2	1,300 [45,900]
RP4* (Area J)	280 [9,900]
RP5* (Area N)	200 [7,100]

It should be noted that these values are based on preliminary concept layouts and final detailed design will be necessary. At that stage, these boundaries and volumes will be revisited in order to ensure accuracy in relation to layouts and site design. Overall, the boundaries are subject to change and the main design criteria is the implementation of a stormwater detention pond which is capable of

balancing the one in five and one in 100 year design storms discharging into wetlands and watercourses.

5.1.2 Stormwater Lot-Level Controls

Stormwater lot-level controls involve measures to store and treat stormwater before it reaches the roadway conveyance system.

The lot controls for this development may include, where possible:

ROOF LEADERS

Wherever possible, roof leaders shall be directed to vegetated areas in order to recharge groundwater and minimize the volume of water entering the roadway conveyance system. This control measure is designed to infiltrate stormwater and to reduce runoff.

The advantages of incorporating roof leader strategies into stormwater management are:

- Reduced total volume of runoff
- Reduced peak stormwater flows
- Reduction of erosion
- Treatment/removal, and soil saturation, filtration of stormwater pollutants

ROOF STORAGE

It is anticipated that the apartment buildings will have a flat roof construction and therefore be conducive to roof storage. On flat roofs, rooftop hoppers can be raised, and downspouts designed, so that water is detained and slowly released. Rooftops will be used for short term storage, where feasible, and can be designed to support a maximum of 7.6 cm of rain. This will provide storage time during any storm. There will be a controlled release downspout to regulate the discharge of stormwater from the roof to any infiltration areas near each building. To prevent the water depth from exceeding 7.6 cm, downspouts will include an overflow. Apartment building sites will be designed to be self balanced with regards to their pre- and post-development flow.

PARKING LOT STORAGE AND CONVEYANCE

Parking lot storage is another Best Management Practice (BMP) for stormwater quantity control. Outlet pipes from apartment parking lot storage catch basins can be sized to control the flow rate from storage into downstream stormwater management components. The outlet control structures in this situation shall be designed to control the rate of flow leaving the parking lot, utilizing the parking lot as a storage area when flows exceed the controlled discharge rate.

5.1.3 Stormwater End of Pipe Controls

End-of-pipe stormwater management facilities have been found to be most suitable for the treatment of stormwater. They include a retention wet pond system in subwatershed areas M, K and P and an dry detention pond for subwatershed areas F and J and grassed swales wherever possible. An extended detention wet pond is a reliable end-of-pipe stormwater management facility for rate control and quality improvements for the following reasons:

- performance does not depend upon soil characteristics;
- the settling pond prevents re-suspension of particulates;
- the permanent pool minimizes blockage of the outlet;
- extended detention times allow for increased particulate removal.

Overall, the stormwater management system shall be designed to attempt to take advantage of the natural depressions on the site, where ever possible, in order to provide detention of storm water as well as the opportunity to recharge the groundwater.

Natural wetlands which are able to be retained are proposed for integration into the overall stormwater management system. In general, wetlands extend detention time and utilize high surface area to volume ratios to effectively remove water pollutants. Typically, water is released from a wetland at a slower rate than the influent water flow rate. The pollutant removal pathways within wetlands include:

- sedimentation;
- adsorption to sediments, vegetation, detritus;
- physical filtration of runoff;
- microbial uptake and transformation;
- uptake by wetland plants;
- extra detention and/or retention.

Hence, wetlands perform a useful function and shall continue to do so as part of the developed stage of this subdivision. However, the storm water collection and detention system designed for the site has not directly or indirectly accounted for the presence of wetlands in the pre- and post-development flow balance analysis.

5.2 Stormwater Quality Practices

5.2.1 Stormwater Retention Systems

Stormwater retention basins will be designed to the latest applicable design standards as issued by Halifax Water, HRM and Nova Scotia Department of the Environment. Design will accommodate required levels of both treatment and retention for quality and quantity respectively.

5.2.2 Erosion Control Measures

To prevent deterioration of the freshwater bodies in the area, stormwater runoff shall be treated on the site. During construction, the erosion and sediment minimization plan shall be followed to minimize sediment mobilization (see Appendix B). Mobilized sediments will be contained by the use of silt fences, checkdams and stormwater ponding on individual sites.

Water quality improvements as part of the treatment train approach will be achieved by the implementation of the following technologies:

GRASSED SWALES

A vegetated swale is a broad, shallow channel that is planted to promote dense vegetation. Vegetated swales serve a variety of functions including: particulate filtration, infiltration, stormwater velocity reduction and stormwater conveyance. Vegetated swales are considered to greatly increase the water quality on a site as well as increase the potential for soil infiltration.

BEST MANAGEMENT PRACTICES FOR LAWN CARE

Building owners will be encouraged to promote a sustainable approach to managing stormwater, reduce the reliance on fertilizers and pesticides, suggest the best native plant species for landscaping, educate responsible lawn irrigation practices and offer advice on other sustainable lawn care practices that can positively impact green areas, while improving the effectiveness of the stormwater management system.

6.0 PROTECTION MEASURES DURING AND AFTER SITE DEVELOPMENT

Some degree of erosion and sedimentation can be expected from equipment activity and earth moving on the property during site development. This temporary effect can be minimized by appropriate erosion and sedimentation prevention and control measures. All personnel shall comply with applicable environmental laws, regulations, standards and practices, permits, approvals, and requirements of federal, provincial, and municipal authorities. Guidelines shall also be enforced throughout the tender/contract period. Clear and concise guidelines and site specific erosion control plans shall be provided to all contractors.

For construction projects, there are three categories of erosion and sediment control: runoff controls, erosion protection, and sediment interception. Runoff controls limit or contain soil movement from the construction site, minimizing raindrop impact on the soil and reduce runoff volume and runoff velocities.

Erosion protection measures are used to reduce or eliminate the detachment of soil particles by falling raindrops or to resist sheet or channel flow. These measures are placed on, or applied to, the soil surface and are often used in conjunction with runoff control and sediment interception measures.

Soil loss from slopes may occur even with erosion and runoff control measures. If this soil can enter a waterbody, mitigative measures will be required to intercept it. Methods used to trap sediment include vegetated buffer strips, silt fences, filter berms, and sediment traps.

6.1 Temporary Protection Measures

The geology of the site consists mainly of bedrock overlain with some glacial till. As a result, the area is generally considered to have low risk of soil erosion. Imported soil will be limited to topsoil needed for some landscaping areas. Standard erosion and sedimentation control measures will be employed for all erodible soils (see Appendix B).

During construction, an inspection and maintenance program must be adhered to in order to ensure the effectiveness of the above noted sedimentation and control measures. We recommend a daily inspection of all measures, especially following precipitation events in order to check for damage. Damaged erosion control measures must be repaired immediately.

A detailed erosion and sedimentation control plan shall be required from the contractor prior to the commencement of construction preferably at the subdivision approval stage and should outline the amount and type of mitigative measures. This plan shall be specific to the contractor's method of work and at a minimum should include:

- Silt fences, etc., installed before grubbing operation;
- Silt bags shall be installed in all existing catchbasins or storm pipe intakes adjacent to this site and maintained during construction;
- Clean run-on water controlled/diverted by installation of channels, berms, and grading;
- Exposed soil minimized via rapid cover by mulch, gravel, straw etc.;
- Soil exposure controlled relative to forecasted weather conditions;
- Site grading to low slopes complete with ponding depression areas and shallow ditches to retain stormwater; and
- Monitoring

The installation of all erosion control measures shall be confirmed on site prior to construction and shall be at the discretion of the site engineer to determine whether or not additional measures are required, especially in consideration to the method of construction or unforeseen circumstances.

It should also be noted that in an effort to minimize the potential for stormwater erosion as well as hazardous material contamination, the contractor/owner must ensure compliance with the following issues:

a) No mud, debris or other excavation material shall be placed on the streets. Fill material shall not be stored next to curb. Fill shall be piled within the interior perimeter of the lot only.

b) Imported fill material shall be assessed to ensure that the material is not composed of a high percentage of fines which would be extremely susceptible to erosion.

c) All stockpiled fill material, which is erodible, shall be covered with tarps or other material, to provide some protection from rainfall.

d) Maintain a gravel driveway entrance during construction to a minimum thickness of six inches. This surface should minimize tracking of mud onto the adjacent roadway.

e) Accidental spills of fuels, lubricants or other chemicals will not be contained by erosion control measures. Hence, contractor shall exercise considerable caution when working with hazardous fuels and materials.

f) Machinery maintenance shall not be performed on this site. Some examples of machinery maintenance include washing out concrete mixers, changing oil, greasing, cleaning or spraying equipment or painting equipment, etc.

g) Any spillage of a hazardous material shall be reported to the Nova Scotia Department of Environment's Environmental Emergencies 24 hour service (424-5620).

6.2 Permanent Protection Measures

The erosion and sedimentation control plan for permanent stabilization should include:

- Stabilization of all disturbed surfaces;
- Periodic inspection of erosion and sedimentation control measures to ensure continued effectiveness.

7.0 Stormwater Facilities Maintenance Program

The maintenance program to ensure the effectiveness of the erosion and sedimentation control plan should include:

- Removal of silt, debris and excess vegetation in detention ponds.
- Inspection of temporary measures to be performed daily (and during precipitation events) to check for damage. Damaged structures must be repaired.

- Environmental protection structures to be maintained (including removal of silt material) until stabilization of disturbed areas has occurred. The structures shall then be removed and the area shall be re-graded and stabilized.
- Inspection and maintenance of BMP's at a minimum quarterly frequency and as site conditions warrant during the construction phases within each sub-watershed.

8.0 STORMWATER MANAGEMENT SUMMARY

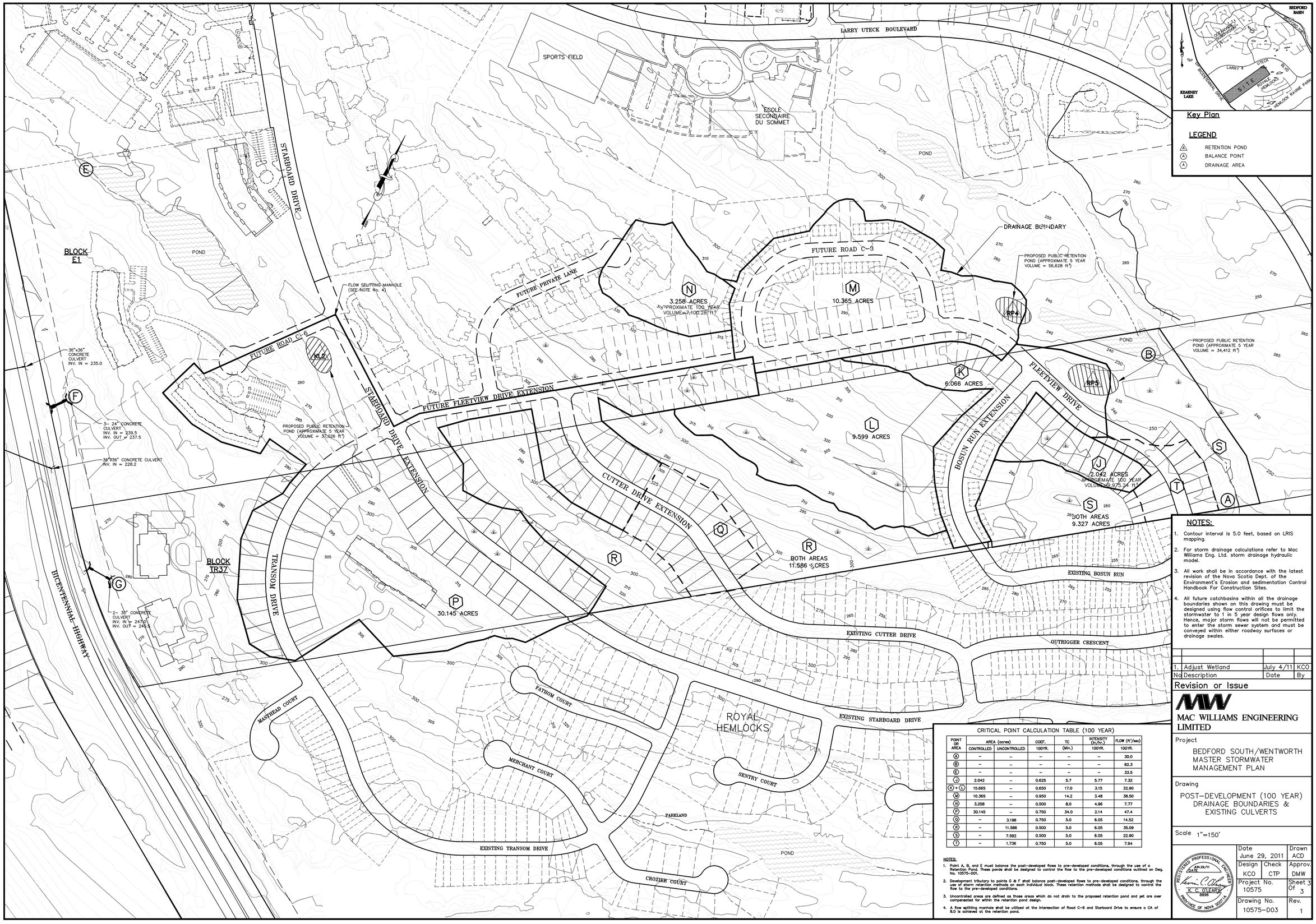
A series of stormwater management facilities are presented to manage the water quantity and quality in the surface runoff from the sites within this Stormwater Management Plan. Water quantity facilities such as disconnected roof leaders, retention wet ponds and extended detention dry ponds shall be used to prevent downstream flooding and to prevent erosion of off-site watercourses and wetlands. Water quality shall be enhanced by a treatment train approach to stormwater management. Some of Best Management Practices facilities that are being considered for use include: a comprehensive erosion and sediment control program, grassed swales and retention and detention ponds.

The use of the Best Management Practices facilities is intended to meet the following objectives:

- To adequately convey stormwater flow from upstream sources;
- To mitigate the adverse effects of stormwater flows, such as flooding and erosion, onto downstream areas;
- To prevent flooding of properties and safeguard flood plains;
- To preserve the water quality of lakes and rivers; and
- To preserve groundwater flows.

APPENDIX A

General Site Maps and Drainage Plans Pre- and Post-Development



CRITICAL POINT CALCULATION TABLE (100 YEAR)

POINT OR AREA	AREA (acres) CONTROLLED	AREA (acres) UNCONTROLLED	COEF. 100YR.	TC (Min.)	INTENSITY (in/hr.) 100YR.	FLOW (ft³/sec) 100YR.
A	–	–	–	–	–	30.0
B	–	–	–	–	–	82.3
E	–	–	–	–	–	33.5
J	2.042	–	0.625	5.7	5.77	7.32
K + L	15.665	–	0.650	17.0	3.15	32.90
M	10.365	–	0.950	14.2	3.48	38.50
N	3.258	–	0.500	8.0	4.96	7.77
P	30.145	–	0.750	34.0	2.14	47.4
Q	–	3.196	0.750	5.0	6.05	14.52
R	–	11.586	0.500	5.0	6.05	35.09
S	–	7.592	0.500	5.0	6.05	22.90
T	–	1.736	0.750	5.0	6.05	7.94

NOTES:

1. Point A, B, and E must balance the post-developed flows to pre-developed conditions, through the use of a Retention Pond. These ponds shall be designed to control the flow to the pre-developed conditions outlined on Dwg. No. 10575-001.
2. Development tributary to points G & F shall balance post-developed flows to pre-developed conditions, through the use of storm retention methods on each individual block. These retention methods shall be designed to control the flow to the pre-developed conditions.
3. Uncontrolled areas are defined as those areas which do not drain to the proposed retention pond and yet are over compensated for within the retention pond design.
4. A flow splitting manhole shall be utilized at the intersection of Road C-6 and Starboard Drive to ensure a CA of 8.0 is achieved at the retention pond.

NOTES:

1. Contour interval is 5.0 feet, based on LRIS mapping.
2. For storm drainage calculations refer to Mac Williams Eng. Ltd. storm drainage hydraulic model.
3. All work shall be in accordance with the latest revision of the Nova Scotia Dept. of the Environment's Erosion and sedimentation Control Handbook For Construction Sites.
4. All future catchbasins within all the drainage boundaries shown on this drawing must be designed using flow control orifices to limit the stormwater to 1 in 5 year design flows only. Hence, major storm flows will not be permitted to enter the storm sewer system and must be conveyed within either roadway surfaces or drainage swales.

No.	Description	Date	By
1.	Adjust Wetland	July 4/11	KCO

Revision or Issue

MAC WILLIAMS ENGINEERING LIMITED

Project

BEDFORD SOUTH/WENTWORTH MASTER STORMWATER MANAGEMENT PLAN

Drawing

POST-DEVELOPMENT (100 YEAR) DRAINAGE BOUNDARIES & EXISTING CULVERTS

Scale 1"=150'

REGISTERED PROFESSIONAL ENGINEER — DATE JUL 29/11 — K. C. O'LEARY 8896 — PROVINCE OF NOVA SCOTIA

Date June 29, 2011		Drawn ACD
Design KCO	Check CTP	Approv. DMW
Project No. 10575		Sheet 3 Of 3
Drawing No. 10575-D03		Rev. 1

LARRY UTECK BOULEVARD

SPORTS FIELD

ECOLE SECONDAIRE DU SOMMET

POND

STARBOARD DRIVE

BLOCK E1

POND

FLOW SPLITTING MANHOLE (SEE NOTE No. 4)

FUTURE PRIVATE LANE

FUTURE ROAD C-3

DRAINAGE BOUNDARY

PROPOSED PUBLIC RETENTION POND (APPROXIMATE 5 YEAR VOLUME = 56,828 ft³)

N 3.258 ACRES

M 10.365 ACRES

RP4

FUTURE ROAD C-6

KL2

36"x36" CONCRETE CULVERT INV. IN = 235.0

F

3- 24" CONCRETE CULVERT INV. IN = 239.5 INV. OUT = 237.5

PROPOSED PUBLIC RETENTION POND (APPROXIMATE 5 YEAR VOLUME = 37,026 ft³)

FUTURE FLEETVIEW DRIVE EXTENSION

STARBOARD DRIVE EXTENSION

CUTTER DRIVE EXTENSION

K 6.066 ACRES

L 9.599 ACRES

BOSUN RUN EXTENSION

FLEETVIEW DRIVE

POND

PROPOSED PUBLIC RETENTION POND (APPROXIMATE 5 YEAR VOLUME = 34,412 ft³)

RP5

B

J 2.042 ACRES

S

T

A

36"x36" CONCRETE CULVERT INV. IN = 228.2

BLOCK TR37

G

2- 39" CONCRETE CULVERT INV. IN = 247.0 INV. OUT = 245.5

TRANSOM DRIVE

P 30.145 ACRES

Q

R

BOTH AREAS 11.586 ACRES

BOTH AREAS 9.327 ACRES

EXISTING BOSUN RUN

EXISTING CUTTER DRIVE

OUTRIGGER CRESCENT

EXISTING STARBOARD DRIVE

BICENTENNIAL HIGHWAY

MASTHEAD COURT

FATHOM COURT

MERCHANT COURT

SENTRY COURT

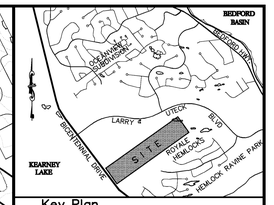
ROYAL HEMLOCKS

PARKLAND

POND

EXISTING TRANSOM DRIVE

CROZIER COURT



Key Plan

LEGEND

- (A) RETENTION POND
- (A) BALANCE POINT
- A DRAINAGE AREA

CRITICAL POINT CALCULATION TABLE (5 YEAR)

POINT OR AREA	AREA (acres) CONTROLLED	AREA (acres) UNCONTROLLED	COEF. 5YR.	TC (Min.)	INTENSITY (in/hr.) 5YR.	FLOW (ft³/sec) 5YR.
(A)	–	–	–	–	–	10.8
(B)	–	–	–	–	–	29.1
(E)	–	–	–	–	–	12.2
(J)	2.042	–	0.375	5.7	3.64	2.80
(K) + (L)	15.665	–	0.400	17.0	1.98	12.40
(M)	10.365	–	0.640	14.2	2.19	14.52
(N)	3.258	–	0.300	8.0	3.13	3.03
(P)	30.145	–	0.440	34.0	1.35	18.00
(Q)	–	3.196	0.450	5.0	3.59	5.17
(R)	–	11.586	0.350	5.0	3.59	14.57
(S)	–	7.592	0.300	5.0	3.59	8.18
(T)	–	1.736	0.450	5.0	3.59	2.83

NOTES:

1. Point A, B, and E must balance the post-developed flows to pre-developed conditions, through the use of a Retention Pond. These ponds shall be designed to control the flow to the pre-developed conditions outlined on Dwg. No. 10575-D01.
2. Development tributary to points G & F shall balance post-developed flows to pre-developed conditions, through the use of storm retention methods on each individual block. These retention methods shall be designed to control the flow to the pre-developed conditions.
3. Uncontrolled areas are defined as those areas which do not drain to the proposed retention pond and yet are over compensated for within the retention pond design.
4. A flow splitting manhole shall be utilized at the intersection of Road C-6 and Starboard Drive to ensure a CA of 8.0 is achieved at the retention pond.

NOTES:

1. Contour interval is 5.0 feet, based on LRIS mapping.
2. For storm drainage calculations refer to Mac Williams Eng. Ltd. storm drainage hydraulic model.
3. All work shall be in accordance with the latest revision of the Nova Scotia Dept. of the Environment's Erosion and sedimentation Control Handbook For Construction Sites.
4. All future catchbasins within all the drainage boundaries shown on this drawing must be designed using flow control orifices to limit the stormwater to 1 in 5 year design flows only. Hence, major storm flows will not be permitted to enter the storm sewer system and must be conveyed within either roadway surfaces or drainage swales.

No.	Description	Date	By
1.	Adjust Wetland	July 4/11	KCO

Revision or Issue

MAC WILLIAMS ENGINEERING LIMITED

Project

BEDFORD SOUTH/WENTWORTH MASTER STORMWATER MANAGEMENT PLAN

Drawing

POST-DEVELOPMENT (5 YEAR) DRAINAGE BOUNDARIES & EXISTING CULVERTS

Scale 1"=150'

REGISTERED PROFESSIONAL ENGINEER — DATE JAN.29/11 — K. C. O'LEARY 8896 — PROVINCE OF NOVA SCOTIA

Date	Drawn
June 29, 2011	ACD
Design: KCO / Check: CTP	Approv.: DMW
Project No.: 10575	Sheet 2 Of 3
Drawing No.: 10575-D02	Rev.: 1

LARRY UTECK BOULEVARD

SPORTS FIELD

ECOLE SECONDAIRE DU SOMMET

STARBOARD DRIVE

POND

E1
9.175 ACRES

B
66.392 ACRES

DRAINAGE BOUNDARY

POND

A
22.718 ACRES

CULVERT No.6 36"x36" CONCRETE CULVERT INV. IN = 235.0

F
23.843 ACRES

EXISTING 3- 24" CONCRETE CULVERT INV. IN = 239.5 INV. OUT = 237.5

CULVERT No.5 36"x36" CONCRETE CULVERT INV. IN = 228.2

E2
17.241 ACRES

D

C

BICENTENNIAL Highway

245.45 CMP

G

EXISTING 2- 30" CONCRETE CULVERT INV. IN = 247.0 INV. OUT = 245.5

H
1.739 ACRES

G
17.910 ACRES

MASTHEAD COURT

FATHOM COURT

MERCHANT COURT

ROYAL HEMLOCKS

SENTRY COURT

HELMSMAN COURT

PARKLAND

POND

EXISTING TRANSOM DRIVE

CROZIER COURT

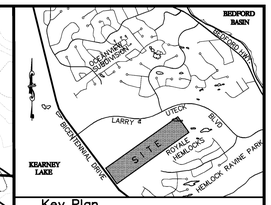
EXISTING BOSUN RUN

EXISTING FLEETVIEW DR

EXISTING CUTTER DRIVE

OUTRIGGER CRESCENT

EXISTING STARBOARD DRIVE



Key Plan

LEGEND

- RETENTION POND
- BALANCE POINT
- DRAINAGE AREA

CRITICAL POINTS CALCULATION TABLE (PRE DEVELOPED)

BALANCE POINT	AREA IDENTIFIER	AREA ACRES	COEF. 5YR.	COEF. 100YR.	TC (Min.)	INTENSITY (in/hr.) 5YR.	INTENSITY (in/hr.) 100YR.	FLOW (ft³/sec) 5YR.	FLOW (ft³/sec) 100YR.
(A)	(A)	22.718	0.30	0.50	19.6	1.83	2.91	12.5	33.0
(B)	(B)	66.392	0.30	0.50	26.5	1.55	2.46	30.9	81.7
	(C)	18.022	–	–	–	–	–	–	–
	(D)	9.489	–	–	–	–	–	–	–
(E)	(E1)	9.175	0.30	0.50	23.5	1.66	2.63	13.1	34.7
	(E2)	17.241	–	–	–	–	–	–	–
	(F)	23.843	–	–	–	–	–	–	–
	(G)	17.910	–	–	–	–	–	–	–
	(H)	1.739	–	–	–	–	–	–	–

NOTES:

1. Contour interval is 5.0 feet, based on LRIS mapping.
2. For storm drainage calculations refer to Mac Williams Eng. Ltd. storm drainage hydraulic model.
3. All work shall be in accordance with the latest revision of the Nova Scotia Dept. of the Environment's Erosion and sedimentation Control Handbook For Construction Sites.
4. All future catchbasins within all the drainage boundaries shown on this drawing must be designed using flow control orifices to limit the stormwater to 1 in 5 year design flows only. Hence, major storm flows will not be permitted to enter the storm sewer system and must be conveyed within either roadway surfaces or drainage swales.

No.	Description	Date	By
1.	Adjust Wetland	July 4/11	KCO

Revision or Issue

MAC WILLIAMS ENGINEERING LIMITED

Project

BEDFORD SOUTH/WENTWORTH MASTER STORMWATER MANAGEMENT PLAN

Drawing

PRE-DEVELOPMENT DRAINAGE BOUNDARIES & EXISTING CULVERTS

Scale 1"=150'

REGISTERED PROFESSIONAL ENGINEER
JAN.29/11
DATE
K. C. O'LEARY
8896
PROVINCE OF NOVA SCOTIA

Date June 29, 2011			Drawn ACD
Design KCO	Check CTP		Approv. DMW
Project No. 10575			Sheet 1 Of 3
Drawing No. 10575-D01			Rev. 1

APPENDIX B

EROSION AND SEDIMENTATION MINIMIZATION PLAN

EROSION AND SEDIMENT MINIMIZATION PLAN

CONSTRUCTION SCHEDULE

Environmental Concern

The probability for erosion and sedimentation on construction sites is highest during precipitation events. Generally speaking, the greatest amounts of precipitation occur during winter and spring months.

The area of the entire property is currently 43.2 Ha (106.8 acres). The footprint for the proposed project is 27.5 Ha (67.8 acres). The geology of the site consists mainly of bedrock with some overlying glacial till.

Overall, the area is considered to have low risk of soil erosion. Imported soil will mostly be limited to topsoil needed for landscaping. Standard erosion and sedimentation control measures will be employed for all erodible soils (Appendix B: Erosion and Sediment Minimization Plan).

CLEARING AND GRUBBING

Environmental Concern

Clearing activities in the vicinity of a watercourse will cause disturbance of the 20m protective vegetative buffer or riparian zone adjacent to the watercourse and could subsequently lead to erosion of the approach slopes and sedimentation into and the obstruction of the watercourse. For construction projects, there are three categories of erosion and sediment control: runoff controls, erosion protection, and sediment interception.

Runoff controls limit or contain soil movement from the construction site, minimizing raindrop impact on the soil and reducing runoff volume and runoff velocities. Generic controls considered for this Project are discussed below.

Erosion protection measures are used to reduce or eliminate the detachment of soil particles by falling raindrops or to resist sheet or channel flow. These measures are placed on, or applied to, the soil surface and are often used in conjunction with runoff control and sediment interception measures. Erosion protection measures to be used as appropriate to this type of construction include:

- gravel sheeting;
- mulches;
- tackifiers;
- erosion control blankets; and
- re-vegetation.

Re-vegetation is generally used only for permanent protection and often requires another form of temporary protection measure to be successfully established.

The key to managing runoff and stormwater flows is to minimize erosion and sedimentation. Methods for managing stormwater flows include:

- wet and dry ponds for stormwater detention;
- infiltration systems;
- engineered stormwater systems;
- onsite detention facilities; and
- constructed wetlands.

Best Management Practices

- Before any clearing or grubbing commences, clearing limits, easements, setbacks, sensitive/critical areas and their buffers, trees and drainage courses will be delineated with flagging tape. This practice ensures workers can clearly recognize areas to be protected.
- No clearing or construction will occur within the protective green/belts/protected sensitive areas as identified on the construction plans.
- To reduce the velocity of runoff, crop residues, plants, and rough soil surfaces are applied to help spread the flow of water over a greater area and into a thin layer.
- Diversion berms are commonly used on slopes to intercept sheet flow on exposed surfaces and to reroute flow into undisturbed areas. Erosion protection is required at the berm outlets.
- Check dams are a temporary measure constructed in ditches, swales, or chutes to reduce hydraulic gradient and flow velocity, thus minimizing the potential for erosion of the channel.
- Sediment traps and swales or dikes (diversion channels) shall be installed around each lot before construction begins in order to control excavation water and where required to intercept runoff from sheet flow from entering the disturbed building pad areas. Necessary erosion control measures such as interception ditches will be completed prior to clearing of each work site.
- The work site shall not be cleared nor will topsoil be removed prior to commencement of construction
- Cleared and graded areas shall be limited to minimize the area of exposed soil
- Minimal amount of natural vegetation and topsoil shall be removed at each construction site
- Building sites being cleared and grubbed shall be stabilized immediately following the completed excavation.
- Mulches consisting of wood chips, stone or commercial anti-erosion mats shall be used to limit erosion on land, which is cleared of vegetation.
- All non-mercantile timber shall be chipped on site and used as temporary protective cover over exposed and disturbed areas.
- Grubbed material, which is not used for fill on-site, shall be disposed offsite in accordance with Nova Scotia Department of Environment legislation.
- The contractor shall maintain a stockpile of erosion control material onsite.

GRADING

Environmental Concern

Grading requirements can tend to be extensive in order to accommodate lot and street construction. Accordingly, slopes may be contoured in order to allow for the site development. Disturbance of the slopes may cause instability, which could result in erosion and subsequent sedimentation of nearby watercourses.

Soil loss from slopes may occur even with erosion and runoff control measures. If this soil can enter a waterbody, mitigative measures will be required to intercept it. Methods used to trap sediment include vegetated buffer strips, silt fences, filter berms, and sediment traps.

Best Management Practices

- Construction should be sequenced such that each section is to be completed and stabilized before proceeding to the next section unless overlapping work is approved by the project engineer.
- The contractor shall work continuously until the travelled ways or building pads are completed. If work is halted for 5 days, temporary stabilization structures and material shall be installed.
- A crushed rock construction entrance shall be established to prevent tracking of mud offsite and through the new or adjacent roadways.
- Lot grading shall entail completion of each lot driveway first and vehicular travel on the lot shall be restricted to the driveway. Access to each lot shall be restricted to one driveway location.
- The temporary driveway shall consist of clear stone or gravel to a thickness of 75 to 150mm. If necessary, filter fabric will be laid under the stone if fines are encountered. This surface will be maintained during construction.
- Once the building pad is graded, the exposed pad, unless prepared from rock fill, shall be graveled with clear stone. All exposed soil areas shall be stabilized no more than 5 days upon completion of the construction.
- Imported fill material shall be assessed to ensure that the material is not composed of a high percentage of fines.
- Diversions shall be constructed at the top of each fill slope at the end of each work day, as needed. Diversions will be located at least 0.6 m uphill from the top edge of each fill. The outlet of diversions, if free of sediment, will be located on undisturbed or stabilized areas when possible. Otherwise, sediment laden runoff must be diverted to a sediment retention structure.
- Sediment traps, smaller than sediment basins, are more easily installed and moved as grading progresses, shall be incorporated into the drainage pattern around each building lot. Sediment traps shall serve areas less than 2 ha (5 acres). These structures shall be placed downslope of the building lots in order to intercept runoff on relatively level areas or natural depressions.
- Sediment barriers shall be used to treat small areas and include enviro-fencing, straw bales, filter fabric, gravel and earth berms. Barriers shall be placed below disturbed areas subject to erosion including along the contour of exposed slopes; at the base of a slope; along a street or at storm drain inlets. Barriers will not be placed in a drainage way with high volume or high velocity.
- All water pumped from ditches, swales or sumps shall be discharged away from the watercourse and filtered through a sediment trap, 2 m^3 (3 yd^3) of class B gravel, filter bag, or undisturbed vegetation to filter out solid material before the water enters the watercourse.

- Silt accumulation along silt fences and swales shall be removed regularly.
- Long and steep slopes on the construction site shall be minimized to prevent erosional velocities from developing. If long slopes are present, they will be benched to interrupt the flow of water and minimize erosion.

CULVERT INSTALLATIONS IN WATERCOURSES

- A 20m buffer zone will be established along all watercourse being retained, by placing geotextile silt fences on both sides of the channel. Work must be completed in the dry; therefore water shall be diverted around the construction site.
- Diversion channels can consist of a ditch lined with polyethylene liners that are properly placed and secured. Sandbags or an impermeable dam will be installed at the inlet to divert the flow. Inlet and outlet protection to prevent erosion and scouring at the ends will be installed.
- Unlimited fording of watercourses by construction equipment will not be permitted.
- Culverts will be properly designed to handle the increased flows as a result of development and comply with NSDOEL regulations with respect to the associated Watercourse Alteration Permit.
- Side banks of the channel will be stabilized and re-vegetated subsequent to completion of the culvert installation.

INSPECTION AND ENFORCEMENT

Environmental Concern

Thorough maintenance of all temporary and permanent erosion and sediment control measures will ensure the integrity of the aquatic resources they protect. Monitoring of the site following major rainstorms will determine that runoff control devices are effective and allow for the removal of accumulated sediment.

Best Management Practices

- With respect to sediment control, all work is to be completed to the satisfaction of the project engineer and owner.
- On-site inspection will be an active part of any development and management program. The effectiveness of control measures will be inspected and monitored during rain events and maintained and upgraded as necessary or as directed by the Project Engineer or Environmental Inspectors.
- The Contractor and Project Engineer will incorporate a routine end-of-day check to ensure the integrity of the protection measures.
- Monitoring of meteorological conditions and forecasts as a proactive means will be conducted to minimize the potential for erosion.

RESTORATION AND PERMANENT PROTECTION MEASURES

The final restoration phase is critical for mitigation long-term impacts to watercourses. The owner shall incorporate all appropriate mitigating measures to ensure proper restoration of the sites adjacent to any watercourses which are being maintained and channel of each watercourse.

Environmental Concern

Proper restoration of the watercourses and adjacent areas will minimize post-construction impacts to these areas. Implementation of permanent protection measures such as a stormwater management plan will minimize the volume of stormwater constituents into watercourses.

Best Management Practices

- The sites will be reclaimed immediately to limit sustained erosion.
- Wood chips, vegetative growth or rock facing (riprap) on steep slopes will be restored in all exposed areas.
- Prompt re-establishment of vegetation will reduce the need for costly remedial measures caused by erosion damage to slopes.
- The target is to minimize and reduce contaminant input into the freshwater rivers and the Strait of Canso. This will be met through the implementation of control devices that have proven to reduce contaminant inputs. The strategy recommended for this site is to provide an integrated approach to stormwater management that is premised on controlling surface runoff and pollution at the source. Therefore, a hierarchy, or train, of stormwater management practices may include:
    - Stormwater lot level controls, which will be achieved using an overflow catchbasin piping arrangement, storage upon the roof and parking lots, Stormwater oil/water separation units; and
    - End-of-pipe stormwater management facilities and velocity breaks prior to storm water entering the natural water courses.
- Stormwater lot level controls involve measures to store and treat stormwater before it reaches the street conveyance system.
- End-of-pipe stormwater management facilities found to be most suitable for the proposed industrial development for treatment of the stormwater is an Oil and Grit Separator system for the following reasons:

  - performance does not depend upon soil characteristics;

  - no additional disturbance to the natural areas to create retention ponds or artificial wetlands;

  - the performance is definable and measurable; and

  - maintenance is simple.

HAZARDOUS MATERIAL STORAGE AND HANDLING OF FUELS AND HAZARDOUS MATERIALS

Environmental Concern

Accidental spills of fuels, lubricants or other chemicals may enter watercourse and eventually reach the Strait of Canso. Proper storage and handling of these materials should prevent the probability of accidents.

Best Management Practice

- Machinery maintenance will not be performed in or near a watercourse, ditch or storm sewer. Some examples of maintenance include washing out cement mixers, changing oil, greasing, spray painting, cleaning of spraying equipment or painting equipment, etc.
- Any hazardous liquid including fuel and lubricants will be stored in a designated area surrounded by an impervious berm, which would contain a spill of the volume of all stored liquid.
- Solid hazardous materials including cement, lime and sulphur should not be stored within 25 m of a watercourse.
- Any spillage of a hazardous material into any watercourse will be reported to the Nova Scotia Department of Environments Environmental Emergencies 24 Hour Service (424-5620).

CONTINGENCY PLANNING

Extreme Storm Events

Extreme storm events (usually subtropical storms) can result in extensive erosion due to heavy rainfall impact and the associated stormwater runoff. Erosion of approach slopes adjacent to watercourses is to be expected during these events. Watercourse flows can be expected to increase suddenly, possibly exceeding the capacity of ditches, swales and sediment traps. Throughout the course of construction, the Environmental Inspectors must be aware of current meteorological predictions and the potential ramifications. Subject to a review of the construction activities planned for the day and the locations of these activities, the prediction of storm events will result in the suspension in the vicinity of watercourses and wetlands.

Excessive runoff can be mitigated or controlled by the use of additional diversion berms, straw-bale check dams, sediment fences and/or sandbag barriers. Additional sediment interception measures such as sediment traps can also be constructed quickly. The CONTRACTOR will ensure that, equipment, personnel and required materials will be available for application as required.

Following extreme storm events, Environmental Inspectors, will conduct environmental monitoring in those areas deemed at risk. Recommendations regarding erosion control will be made by the Environmental Inspectors as required.

APPENDIX C

RAINFALL INTENSITY DURATION FREQUENCY VALUES

PN 10295
EMSCOTE

2011/06/23
KW.

Environment Canada/Environnement Canada

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2010/04/13

SHEARWATER A NS 8205090

Latitude: 44 38'N Longitude: 63 30'W Elevation/Altitude: 50 m

Years/Années : 1955 - 2006 # Years/Années : 51

Table 1 : Annual Maximum (mm)/Maximum annuel (mm)

Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
1955	5.1	7.1	8.9	13.7	19.3	23.4	27.7	30.7	45.0
1956	4.3	5.6	6.6	8.6	13.5	19.0	35.1	35.1	41.1
1958	3.8	5.1	6.9	10.4	17.3	25.1	43.7	47.5	47.8
1959	5.8	9.7	12.4	17.0	25.4	30.2	59.9	67.6	68.1
1960	5.3	8.1	10.9	16.0	18.3	19.8	25.1	35.3	38.1
1961	4.1	6.1	8.1	8.6	14.5	19.6	37.1	54.1	70.9
1962	3.6	5.6	7.1	10.9	15.7	27.7	42.7	55.9	71.6
1963	5.3	7.1	8.4	9.7	16.0	23.1	46.7	64.0	67.6
1964	11.2	13.0	15.0	17.5	17.8	31.5	68.8	75.2	75.2
1965	5.3	9.7	11.7	14.0	20.6	28.2	55.6	58.9	61.2
1966	8.1	9.9	10.7	11.7	13.0	18.0	33.5	42.9	43.2
1967	8.4	15.0	16.8	21.3	25.9	30.5	59.4	60.5	87.4
1968	5.6	9.7	13.5	17.0	24.1	32.3	38.9	55.6	68.3
1969	5.3	9.9	13.5	17.8	30.2	50.5	65.8	65.8	66.8
1970	6.6	9.4	10.7	16.5	20.1	25.4	51.8	72.9	77.5
1971	12.7	17.0	18.5	20.8	24.6	44.2	81.0	116.1	199.1
1972	5.6	8.6	11.2	16.0	19.8	24.1	45.0	66.3	72.4
1973	10.2	10.9	11.2	12.2	17.3	22.1	42.7	54.9	62.7
1974	5.6	7.9	8.9	13.2	18.0	23.4	33.3	48.5	49.8
1975	4.8	7.6	8.6	12.2	19.0	37.1	66.8	67.1	70.6
1976	6.6	10.9	14.0	17.8	29.5	58.9	84.6	84.6	84.6
1977	11.4	13.0	13.2	17.3	28.4	39.9	50.0	50.0	51.3
1978	4.2	7.5	8.0	9.3	16.1	26.2	52.2	56.4	57.1
1979	5.7	9.0	11.6	17.4	26.1	42.8	72.1	75.7	76.1
1980	4.1	4.9	7.1	9.9	15.6	23.4	36.8	48.9	50.3
1981	7.5	13.0	14.1	25.5	28.4	37.4	52.4	65.4	66.7
1982	6.3	10.2	13.5	23.9	31.2	39.8	52.5	66.6	98.9
1983	2.5	4.9	6.9	13.6	27.1	49.6	94.7	113.0	113.0
1984	5.3	7.3	9.7	17.7	27.8	41.6	61.2	62.7	68.7
1985	8.7	15.6	18.3	24.3	30.3	33.6	52.6	59.3	63.2
1986	10.6	13.7	15.1	17.8	22.2	29.2	38.3	45.0	46.6
1987	4.8	6.5	8.8	12.1	14.0	21.8	32.8	38.2	41.0
1988	4.3	8.3	11.1	14.4	24.2	27.1	45.1	60.5	79.8
1989	7.8	13.1	15.9	20.8	20.9	30.7	47.2	60.6	60.6
1990	5.1	7.5	9.7	13.0	16.2	24.2	62.8	86.7	100.0
1991	6.6	7.7	11.0	20.7	22.0	25.6	42.2	59.0	87.1
1992	3.7	5.0	5.4	7.5	12.1	16.0	32.3	38.3	49.0
1993	6.0	10.7	16.0	18.8	21.3	27.7	40.8	51.3	71.5
1994	4.6	6.5	8.3	11.9	19.4	34.3	49.0	64.3	68.8
1995	5.9	9.4	13.7	15.5	26.5	49.0	82.9	94.2	94.2
1996	6.0	8.4	9.3	13.0	23.4	39.4	69.4	70.2	91.2
1997	4.7	8.6	11.8	18.0	21.4	28.8	45.0	48.6	48.6
1998	7.1	11.0	13.3	19.0	26.5	36.4	67.9	76.8	87.4
1999	7.2	11.0	16.4	24.3	27.4	28.7	43.0	56.9	66.5
2000	5.7	9.3	10.9	13.8	18.8	25.9	58.0	72.0	72.2
2001	6.8	10.7	13.7	17.7	22.2	24.8	39.1	57.8	88.6
2002	4.3	5.9	8.6	13.5	18.0	27.2	43.3	47.9	56.7
2003	5.6	8.3	12.3	15.0	24.1	31.0	59.1	92.3	103.7
2004	5.2	8.6	12.7	15.0	15.6	20.3	37.6	39.8	52.6
2005	4.0	6.7	9.2	17.1	22.1	26.4	44.8	64.1	91.3
2006	5.3	9.6	12.2	17.7	23.1	32.7	53.6	57.6	57.6
# Yrs. Années	51	51	51	51	51	51	51	51	51
Mean Moyenne	6.1	9.1	11.4	15.7	21.4	30.5	51.1	61.6	71.2
Std. Dev. Écart-type	2.1	2.8	3.2	4.3	5.1	9.2	15.4	17.8	25.6
Skew. Dissymétrie	1.33	0.72	0.29	0.28	0.12	1.02	0.81	1.02	2.57
Kurtosis	4.76	3.46	2.62	2.86	2.19	3.97	3.50	4.82	14.46

*-99.9 Indicates Missing Data/Données manquantes

Warning: annual maximum amount greater than 100-yr return period amount
Avertissement : la quantité maximale annuelle excède la quantité pour une période de retour de 100 ans

Year/Année	Duration/Durée	Data/Données	100-yr/ans
1971	24 h	199.1	151.4

PN 10575
EMSCOTE

2011/06/23
Ken.

****

Table 2a : Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	5.7	7.6	8.9	10.5	11.7	12.8	51
10 min	8.7	11.2	12.8	14.9	16.5	18.0	51
15 min	10.9	13.7	15.5	17.9	19.6	21.3	51
30 min	14.9	18.8	21.3	24.5	26.8	29.2	51
1 h	20.6	25.1	28.0	31.8	34.6	37.3	51
2 h	29.0	37.2	42.6	49.4	54.5	59.5	51
6 h	48.5	62.1	71.1	82.5	90.9	99.3	51
12 h	58.6	74.4	84.8	97.9	107.7	117.3	51
24 h	67.0	89.6	104.5	123.5	137.5	151.4	51

3.53 in/hr 5.96 in/hr

****

Table 2b :

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	68.8	91.6	106.6	125.7	139.8	153.9	51
	+/- 6.5	+/- 10.9	+/- 14.8	+/- 19.9	+/- 23.8	+/- 27.8	51
10 min	52.0	67.0	77.0	89.6	98.9	108.1	51
	+/- 4.3	+/- 7.2	+/- 9.7	+/- 13.1	+/- 15.7	+/- 18.3	51
15 min	43.5	54.7	62.1	71.4	78.3	85.2	51
	+/- 3.2	+/- 5.4	+/- 7.2	+/- 9.8	+/- 11.7	+/- 13.6	51
30 min	29.9	37.5	42.5	48.9	53.6	58.3	51
	+/- 2.2	+/- 3.7	+/- 4.9	+/- 6.7	+/- 8.0	+/- 9.3	51
1 h	20.6	25.1	28.0	31.8	34.6	37.3	51
	+/- 1.3	+/- 2.2	+/- 2.9	+/- 3.9	+/- 4.7	+/- 5.5	51
2 h	14.5	18.6	21.3	24.7	27.2	29.8	51
	+/- 1.2	+/- 2.0	+/- 2.7	+/- 3.6	+/- 4.3	+/- 5.0	51
6 h	8.1	10.4	11.9	13.7	15.2	16.5	51
	+/- 0.6	+/- 1.1	+/- 1.5	+/- 2.0	+/- 2.4	+/- 2.8	51
12 h	4.9	6.2	7.1	8.2	9.0	9.8	51
	+/- 0.4	+/- 0.6	+/- 0.8	+/- 1.1	+/- 1.4	+/- 1.6	51
24 h	2.8	3.7	4.4	5.1	5.7	6.3	51
	+/- 0.3	+/- 0.5	+/- 0.6	+/- 0.8	+/- 1.0	+/- 1.1	51

****

Table 3 : Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

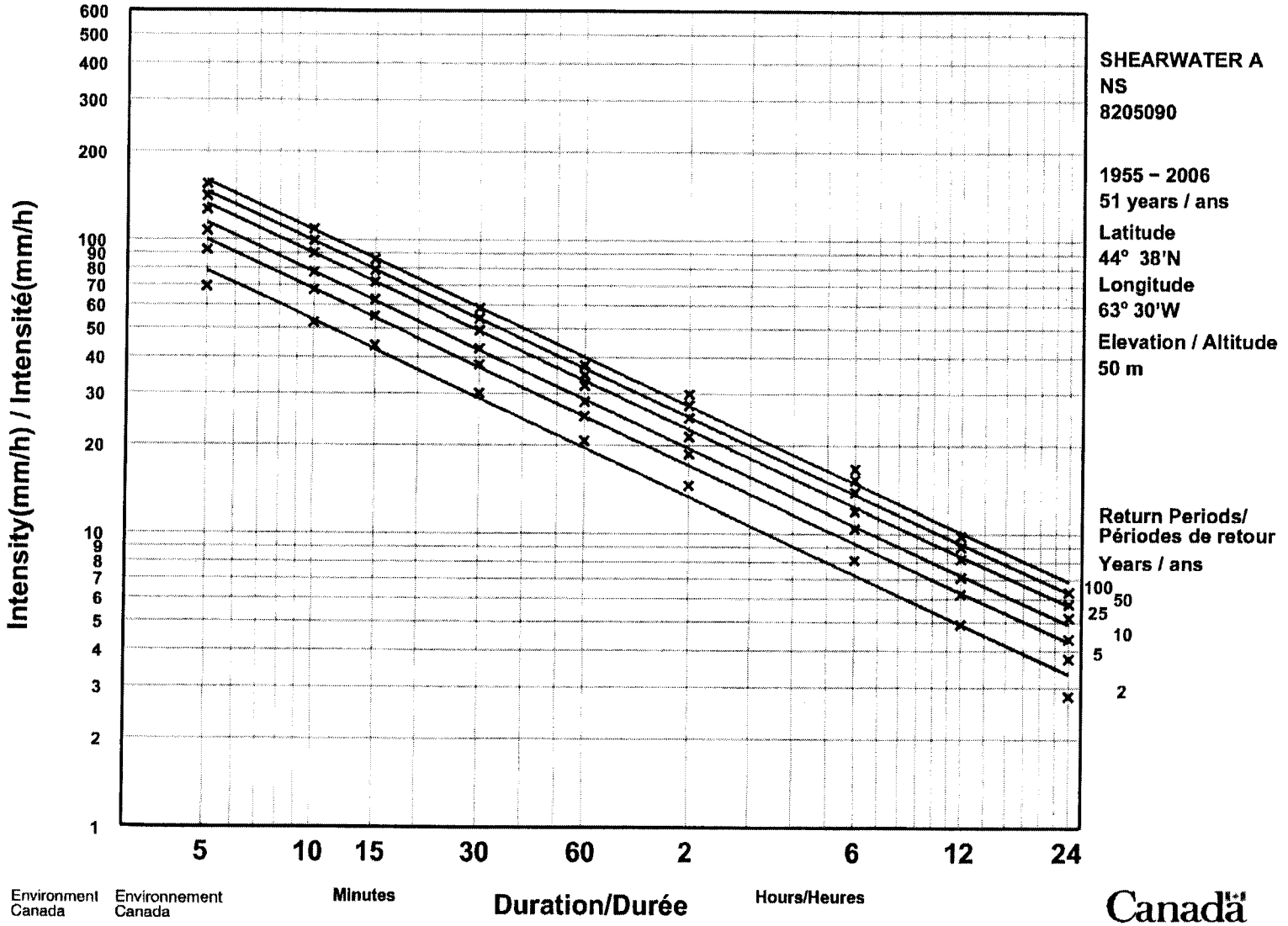
****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	27.2	35.0	40.1	46.6	51.4	56.1
Std. Dev. /Écart-type (RR)	23.1	30.4	35.3	41.4	45.9	50.4
Std. Error/Erreur-type	3.7	3.1	2.8	2.5	2.3	2.2
Coefficient (A)	19.5	25.0	28.6	33.1	36.5	39.8
Exponent/Exposant (B)	-0.558	-0.556	-0.555	-0.555	-0.554	-0.554
Mean % Error/% erreur moyenne	7.3	5.4	4.9	4.6	4.6	4.7

Short Duration Rainfall Intensity–Duration–Frequency Data

2010/04/13

Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée



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APPENDIX D

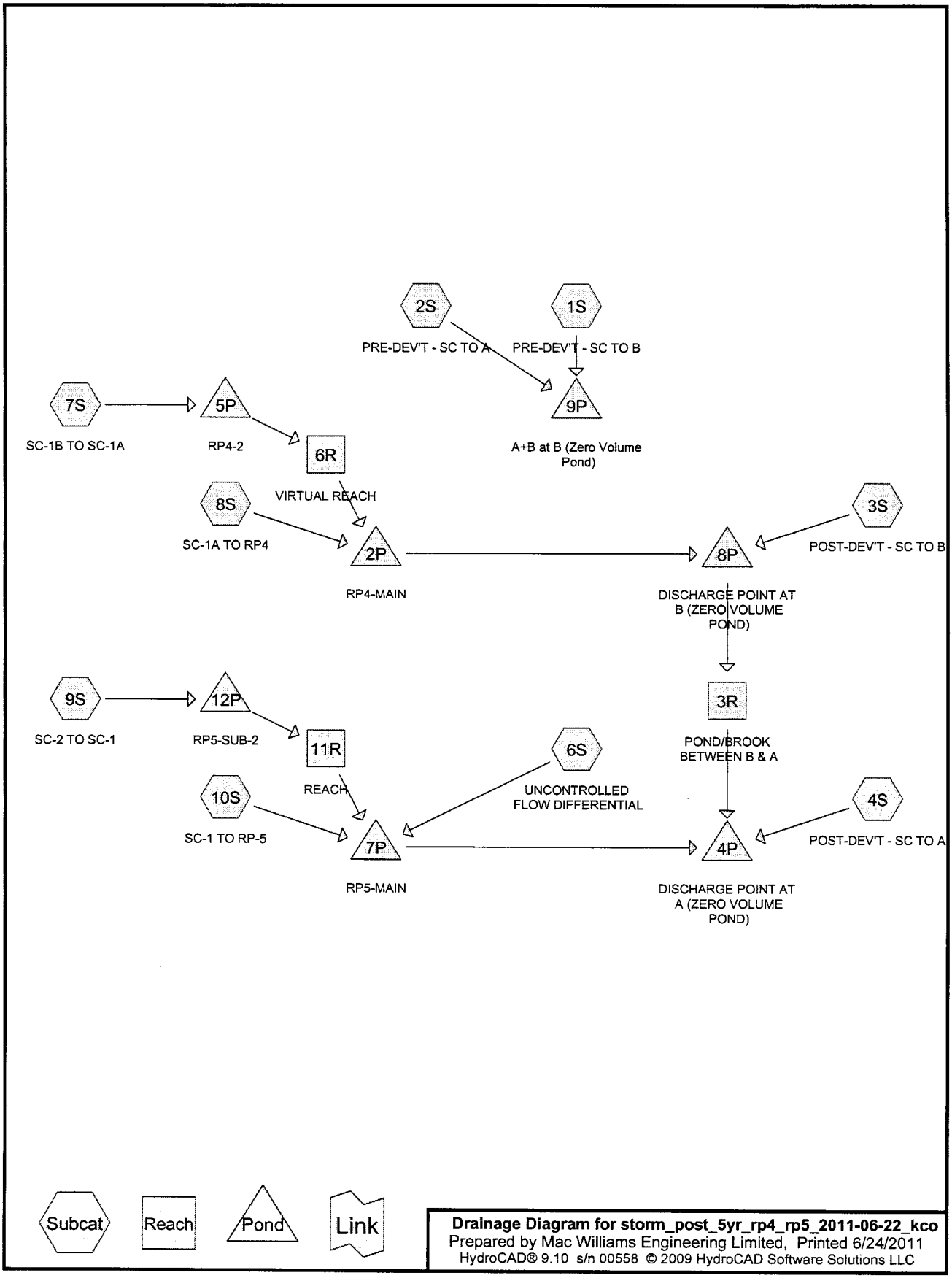
PRE-DEVELOPMENT AND POST-DEVELOPMENT MODELING RESULTS FOR DESIGN STORM EVENTS

APPENDIX D-1

5 YEAR RP4 AND RP5

PRE-DEVELOPMENT AND POST-DEVELOPMENT

MODELING RESULTS FOR DESIGN STORM EVENTS



Drainage Diagram for storm_post_5yr_rp4_rp5_2011-06-22_kco
Prepared by Mac Williams Engineering Limited, Printed 6/24/2011
HydroCAD® 9.10 s/n 00558 © 2009 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
20.690	54	(6S)
2.050	60	(9S)
125.830	65	(1S, 3S)
29.680	66	(2S, 4S)
3.240	69	(7S)
10.370	79	(8S)
15.660	80	(10S)
207.520		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
207.520	Other	1S, 2S, 3S, 4S, 6S, 7S, 8S, 9S, 10S
207.520		**TOTAL AREA**

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Fill (inches)
1	3R	236.50	217.00	650.0	0.0300	0.070	48.0	0.0	0.0
2	6R	289.00	260.00	1,400.0	0.0207	0.015	12.0	0.0	0.0
3	11R	249.50	245.00	275.0	0.0164	0.015	24.0	0.0	0.0
4	2P	238.00	237.00	50.0	0.0200	0.012	6.0	0.0	0.0
5	5P	296.50	295.50	150.0	0.0067	0.010	6.0	0.0	0.0
6	7P	236.00	235.00	50.0	0.0200	0.011	12.0	0.0	0.0
7	12P	256.50	250.00	160.0	0.0406	0.015	6.0	0.0	0.0

Time span=5.00-36.00 hrs, dt=0.02 hrs, 1551 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: PRE-DEV'T - SC TO B Runoff Area=66.400 ac 0.00% Impervious Runoff Depth=0.77"
Tc=26.5 min CN=65 Runoff=30.06 cfs 4.248 af

Subcatchment 2S: PRE-DEV'T - SC TO A Runoff Area=22.700 ac 0.00% Impervious Runoff Depth=0.82"
Tc=19.6 min CN=66 Runoff=12.60 cfs 1.545 af

Subcatchment 3S: POST-DEV'T - SC TO B Runoff Area=59.430 ac 0.00% Impervious Runoff Depth=0.77"
Tc=26.5 min CN=65 Runoff=26.91 cfs 3.802 af

Subcatchment 4S: POST-DEV'T - SC TO A Runoff Area=6.980 ac 0.00% Impervious Runoff Depth=0.82"
Tc=19.6 min CN=66 Runoff=3.88 cfs 0.475 af

Subcatchment 6S: UNCONTROLLED FLOW Runoff Area=20.690 ac 0.00% Impervious Runoff Depth=0.32"
Tc=5.0 min CN=54 Runoff=3.06 cfs 0.556 af

Subcatchment 7S: SC-1B TO SC-1A Runoff Area=3.240 ac 0.00% Impervious Runoff Depth=0.97"
Tc=8.0 min CN=69 Runoff=3.12 cfs 0.262 af

Subcatchment 8S: SC-1A TO RP4 Runoff Area=10.370 ac 0.00% Impervious Runoff Depth=1.59"
Tc=14.2 min CN=79 Runoff=14.76 cfs 1.373 af

Subcatchment 9S: SC-2 TO SC-1 Runoff Area=2.050 ac 0.00% Impervious Runoff Depth=0.54"
Tc=5.7 min CN=60 Runoff=0.91 cfs 0.093 af

Subcatchment 10S: SC-1 TO RP-5 Runoff Area=15.660 ac 0.00% Impervious Runoff Depth=1.66"
Tc=17.0 min CN=80 Runoff=21.76 cfs 2.167 af

Reach 3R: POND/BROOK BETWEEN B Avg. Flow Depth=2.29' Max Vel=3.88 fps Inflow=29.12 cfs 5.438 af
48.0" Round Pipe n=0.070 L=650.0' S=0.0300 '/' Capacity=46.21 cfs Outflow=28.84 cfs 5.438 af

Reach 6R: VIRTUAL REACH Avg. Flow Depth=0.28' Max Vel=4.26 fps Inflow=0.78 cfs 0.262 af
12.0" Round Pipe n=0.015 L=1,400.0' S=0.0207 '/' Capacity=4.44 cfs Outflow=0.78 cfs 0.262 af

Reach 11R: REACH Avg. Flow Depth=0.25' Max Vel=3.65 fps Inflow=0.82 cfs 0.093 af
24.0" Round Pipe n=0.015 L=275.0' S=0.0164 '/' Capacity=25.08 cfs Outflow=0.81 cfs 0.093 af

Pond 2P: RP4-MAIN Peak Elev=248.53' Storage=0.572 af Inflow=15.41 cfs 1.636 af
6.0" Round Culvert n=0.012 L=50.0' S=0.0200 '/' Outflow=2.37 cfs 1.636 af

Pond 4P: DISCHARGE POINT AT A (ZERO VOLUME POND) Inflow=39.66 cfs 8.469 af
Primary=39.66 cfs 8.469 af

Pond 5P: RP4-2 Peak Elev=298.03' Storage=0.063 af Inflow=3.12 cfs 0.262 af
6.0" Round Culvert n=0.010 L=150.0' S=0.0067 '/' Outflow=0.78 cfs 0.262 af

Pond 7P: RP5-MAIN Peak Elev=239.81' Storage=0.923 af Inflow=25.54 cfs 2.815 af
12.0" Round Culvert n=0.011 L=50.0' S=0.0200 '/' Outflow=8.07 cfs 2.556 af

Pond 8P: DISCHARGE POINT AT B (ZERO VOLUME POND) Inflow=29.12 cfs 5.438 af
Primary=29.12 cfs 5.438 af

Pond 9P: A+B at B (Zero Volume Pond) Inflow=41.60 cfs 5.793 af
Primary=41.60 cfs 5.793 af

Pond 12P: RP5-SUB-2 Peak Elev=258.58' Storage=0.003 af Inflow=0.91 cfs 0.093 af
6.0" Round Culvert n=0.015 L=160.0' S=0.0406 '/' Outflow=0.82 cfs 0.093 af

Total Runoff Area = 207.520 ac Runoff Volume = 14.522 af Average Runoff Depth = 0.84"
100.00% Pervious = 207.520 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: PRE-DEV'T - SC TO B

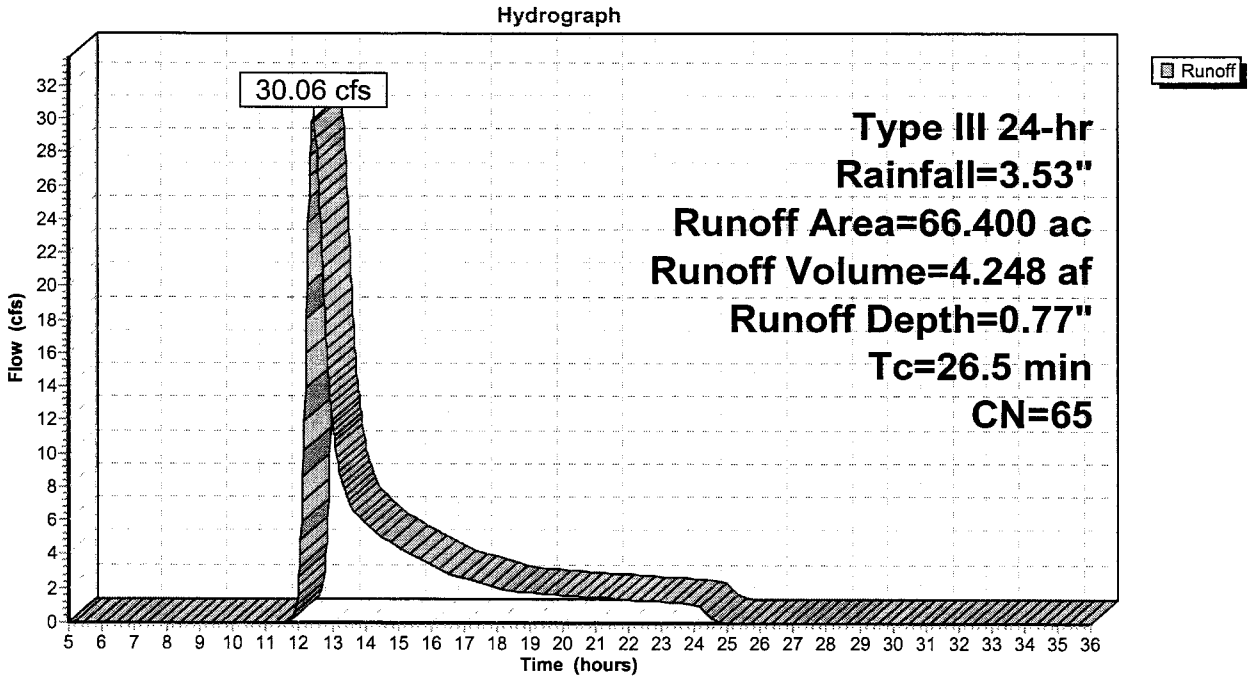
Runoff = 30.06 cfs @ 12.44 hrs, Volume= 4.248 af, Depth= 0.77"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-36.00 hrs, dt= 0.02 hrs
Type III 24-hr Rainfall=3.53"

	Area (ac)	CN	Description
*	66.400	65	
	66.400		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.5					**Direct Entry,**

Subcatchment 1S: PRE-DEV'T - SC TO B



Summary for Subcatchment 2S: PRE-DEV'T - SC TO A

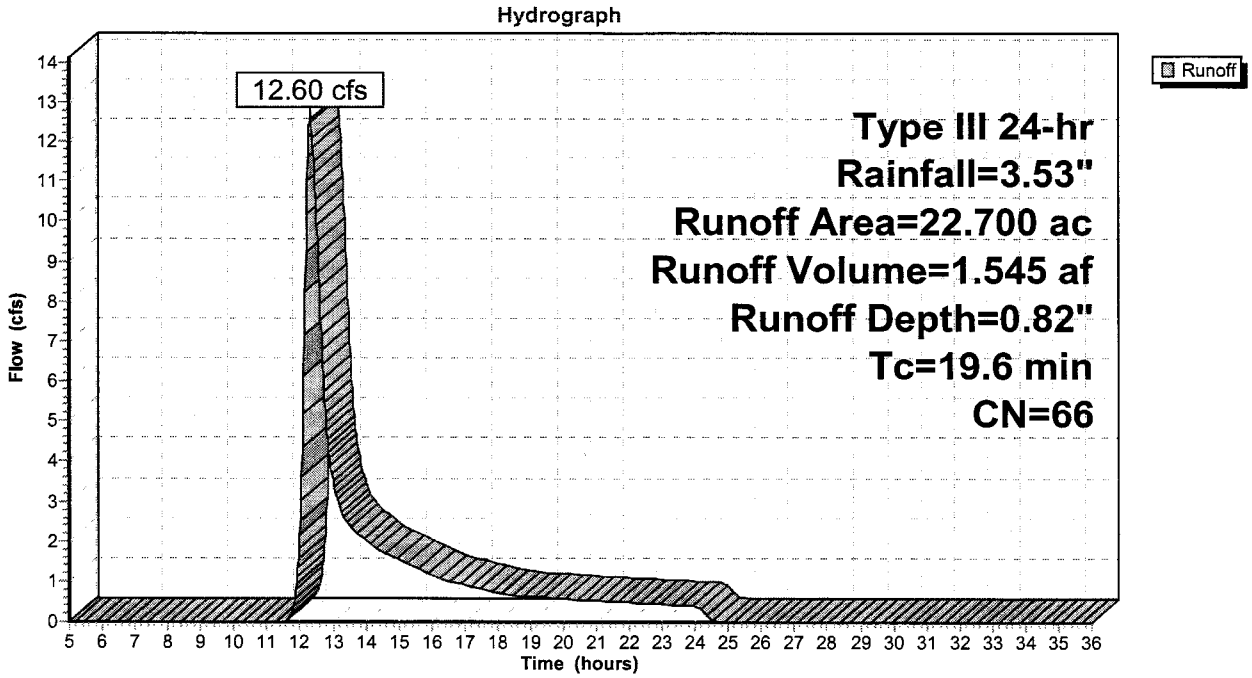
Runoff = 12.60 cfs @ 12.31 hrs, Volume= 1.545 af, Depth= 0.82"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-36.00 hrs, dt= 0.02 hrs
Type III 24-hr Rainfall=3.53"

	Area (ac)	CN	Description
*	22.700	66	
	22.700		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
19.6					**Direct Entry,**

Subcatchment 2S: PRE-DEV'T - SC TO A



Summary for Subcatchment 3S: POST-DEV'T - SC TO B

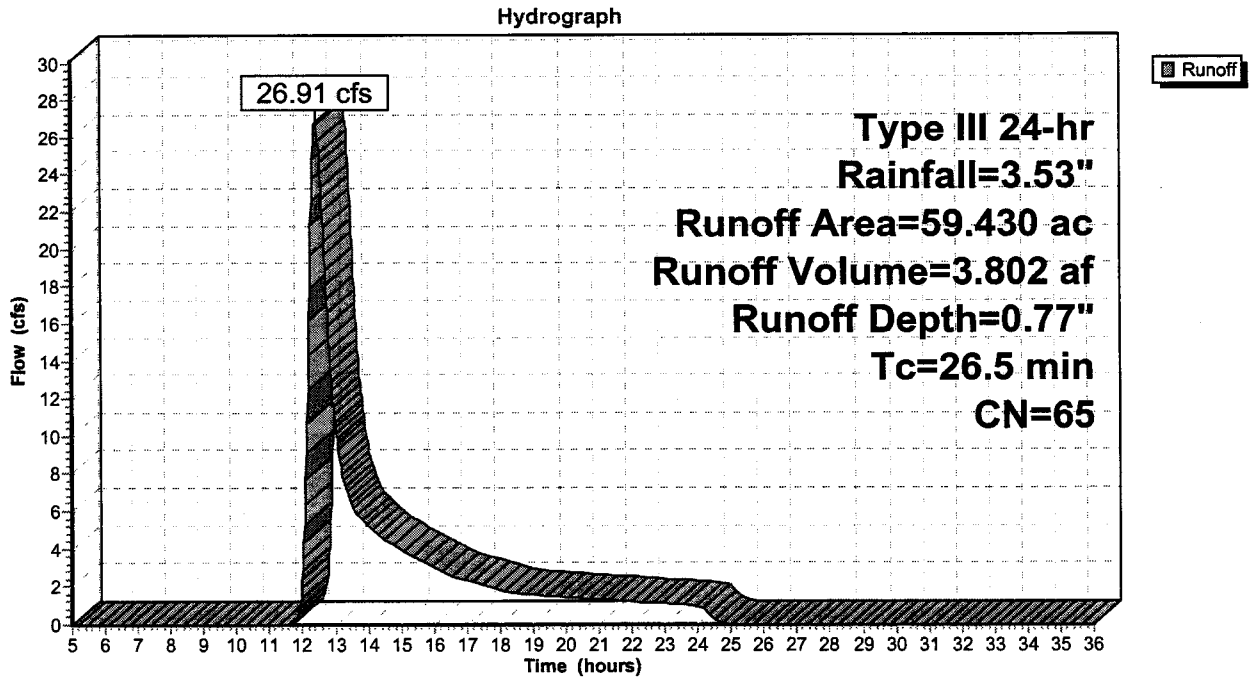
Runoff = 26.91 cfs @ 12.44 hrs, Volume= 3.802 af, Depth= 0.77"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-36.00 hrs, dt= 0.02 hrs
Type III 24-hr Rainfall=3.53"

	Area (ac)	CN	Description
*	59.430	65	
	59.430		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.5					**Direct Entry,**

Subcatchment 3S: POST-DEV'T - SC TO B



Summary for Subcatchment 4S: POST-DEV'T - SC TO A

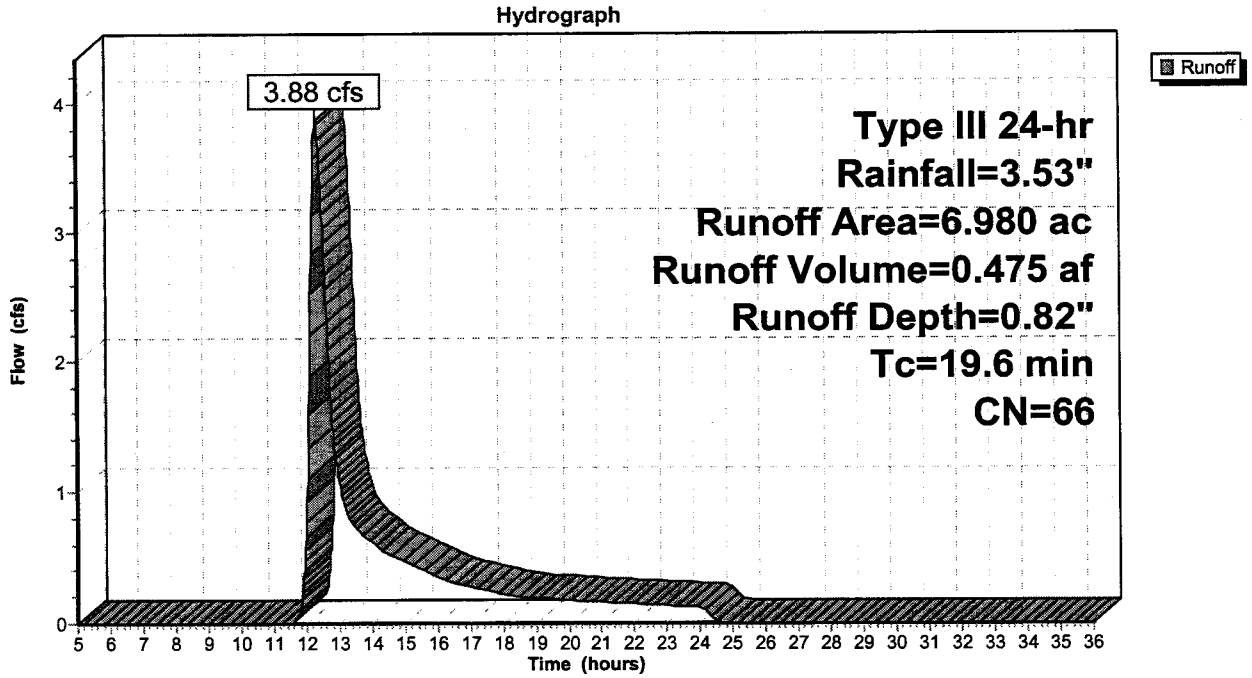
Runoff = 3.88 cfs @ 12.31 hrs, Volume= 0.475 af, Depth= 0.82"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-36.00 hrs, dt= 0.02 hrs
Type III 24-hr Rainfall=3.53"

	Area (ac)	CN	Description
*	6.980	66	
	6.980		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
19.6					**Direct Entry,**

Subcatchment 4S: POST-DEV'T - SC TO A



Summary for Subcatchment 6S: UNCONTROLLED FLOW DIFFERENTIAL

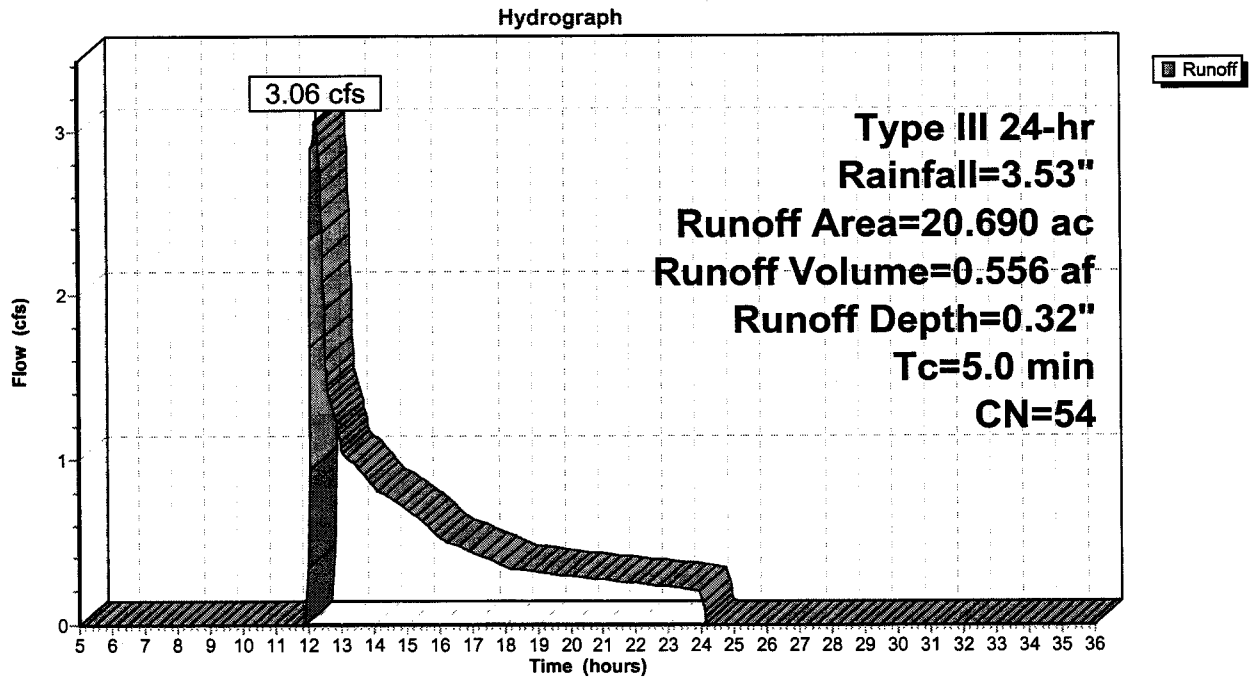
Runoff = 3.06 cfs @ 12.28 hrs, Volume= 0.556 af, Depth= 0.32"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-36.00 hrs, dt= 0.02 hrs
Type III 24-hr Rainfall=3.53"

	Area (ac)	CN	Description
*	20.690	54	
	20.690		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 6S: UNCONTROLLED FLOW DIFFERENTIAL



Summary for Subcatchment 7S: SC-1B TO SC-1A

This area backs onto the rear lots on unnamed street C-3. 5 year storm to be passed. 100 yr storm to be stored and released at ~5 year rate

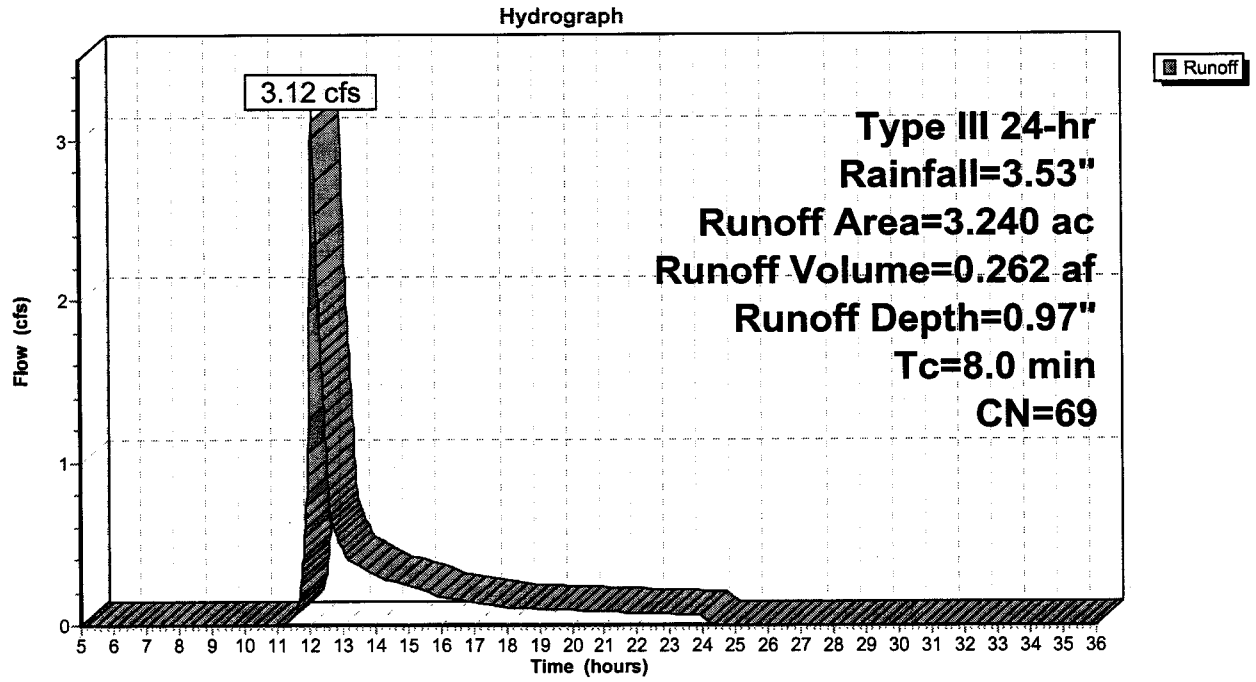
Runoff = 3.12 cfs @ 12.13 hrs, Volume= 0.262 af, Depth= 0.97"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-36.00 hrs, dt= 0.02 hrs
Type III 24-hr Rainfall=3.53"

	Area (ac)	CN	Description
*	3.240	69	
	3.240		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.0					**Direct Entry,**

Subcatchment 7S: SC-1B TO SC-1A



Summary for Subcatchment 8S: SC-1A TO RP4

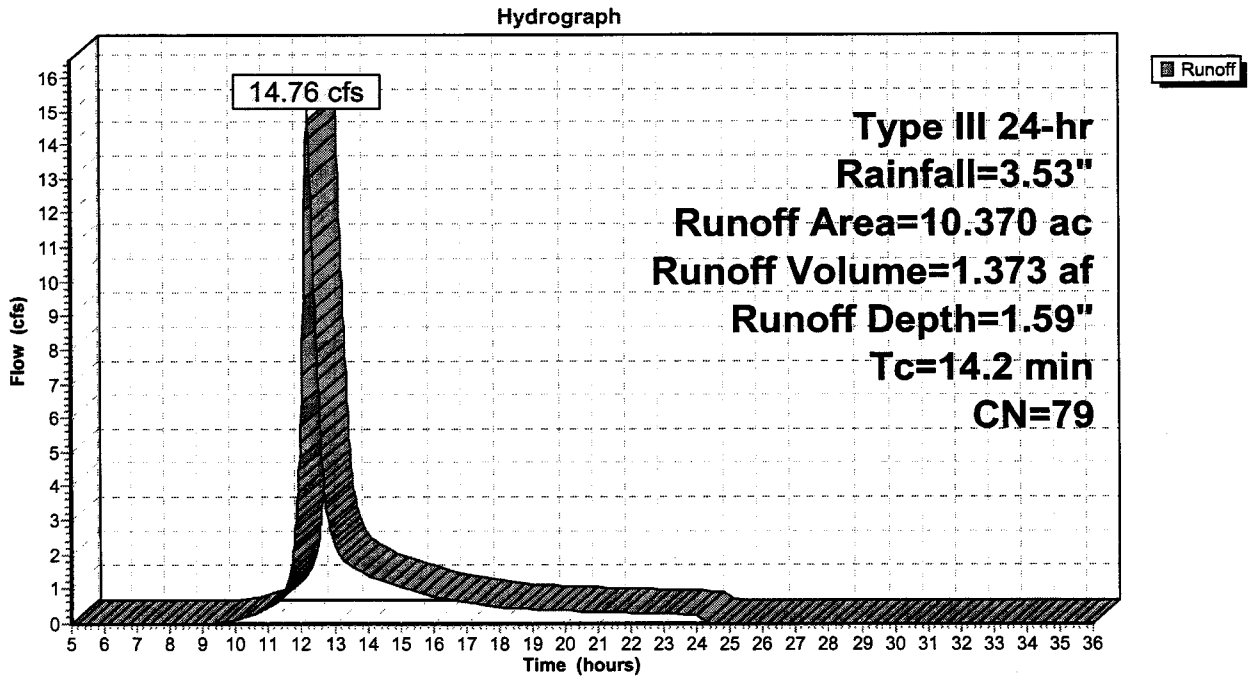
Runoff = 14.76 cfs @ 12.20 hrs, Volume= 1.373 af, Depth= 1.59"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-36.00 hrs, dt= 0.02 hrs
Type III 24-hr Rainfall=3.53"

	Area (ac)	CN	Description
*	10.370	79	
	10.370		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.2					**Direct Entry,**

Subcatchment 8S: SC-1A TO RP4



Summary for Subcatchment 9S: SC-2 TO SC-1

SC-2 to SC-1 drains SC-2 into SC-1. The 100 year flood is retained and released at the equivalent 5 year flow rate.

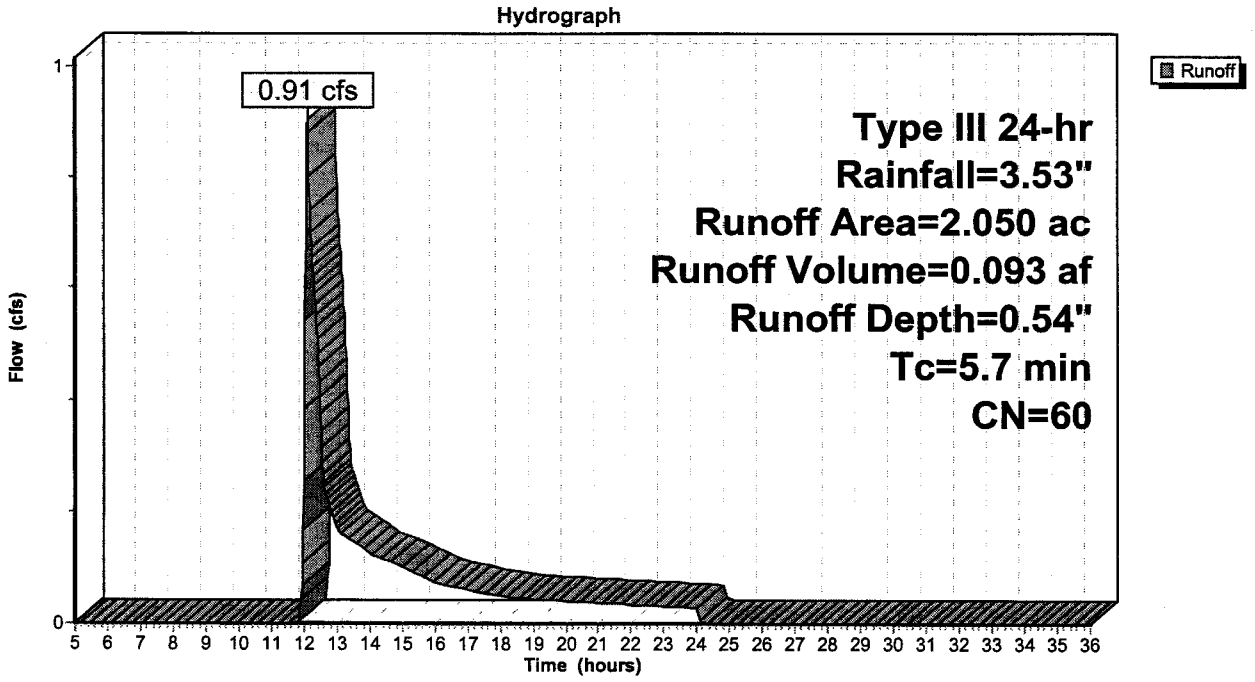
Runoff = 0.91 cfs @ 12.11 hrs, Volume= 0.093 af, Depth= 0.54"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-36.00 hrs, dt= 0.02 hrs
Type III 24-hr Rainfall=3.53"

	Area (ac)	CN	Description
*	2.050	60	
	2.050		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.7					**Direct Entry,**

Subcatchment 9S: SC-2 TO SC-1



Summary for Subcatchment 10S: SC-1 TO RP-5

SC-1 to RP-5 drains directly to RP-5

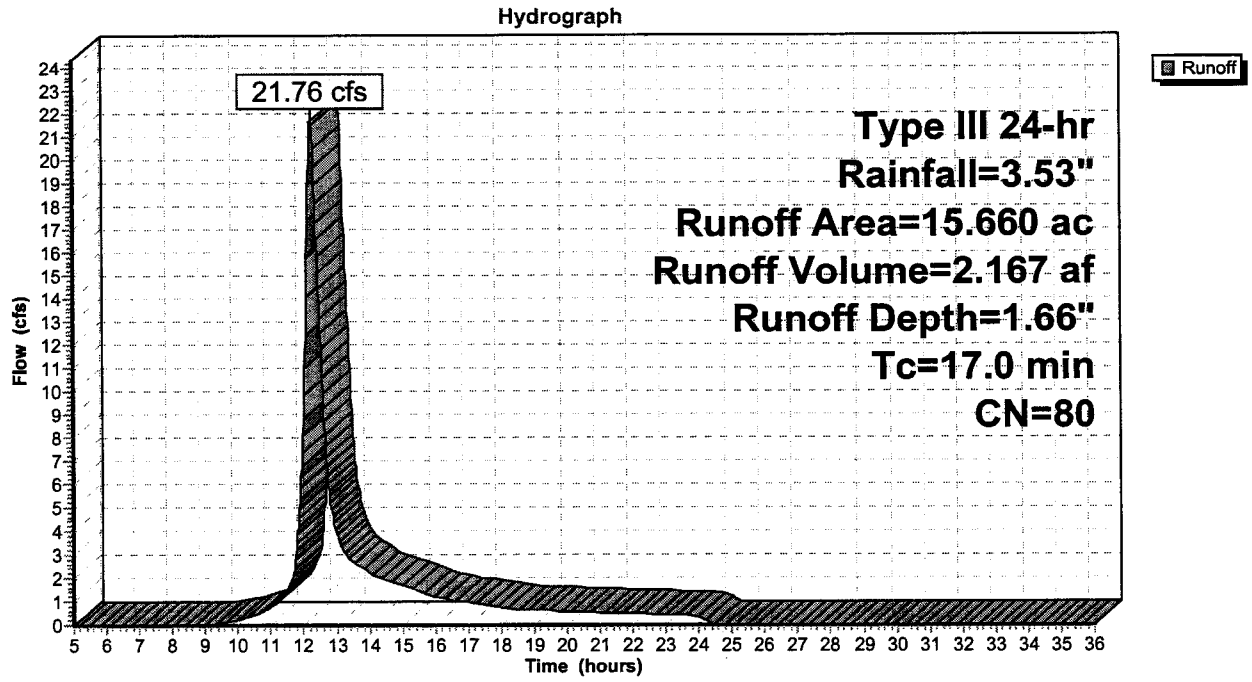
Runoff = 21.76 cfs @ 12.24 hrs, Volume= 2.167 af, Depth= 1.66"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-36.00 hrs, dt= 0.02 hrs
Type III 24-hr Rainfall=3.53"

	Area (ac)	CN	Description
*	15.660	80	
	15.660		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.0					**Direct Entry,**

Subcatchment 10S: SC-1 TO RP-5



Summary for Reach 3R: POND/BROOK BETWEEN B & A

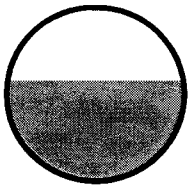
[52] Hint: Inlet/Outlet conditions not evaluated

Inflow Area = 73.040 ac, 0.00% Impervious, Inflow Depth = 0.89"
Inflow = 29.12 cfs @ 12.44 hrs, Volume= 5.438 af
Outflow = 28.84 cfs @ 12.52 hrs, Volume= 5.438 af, Atten= 1%, Lag= 5.0 min

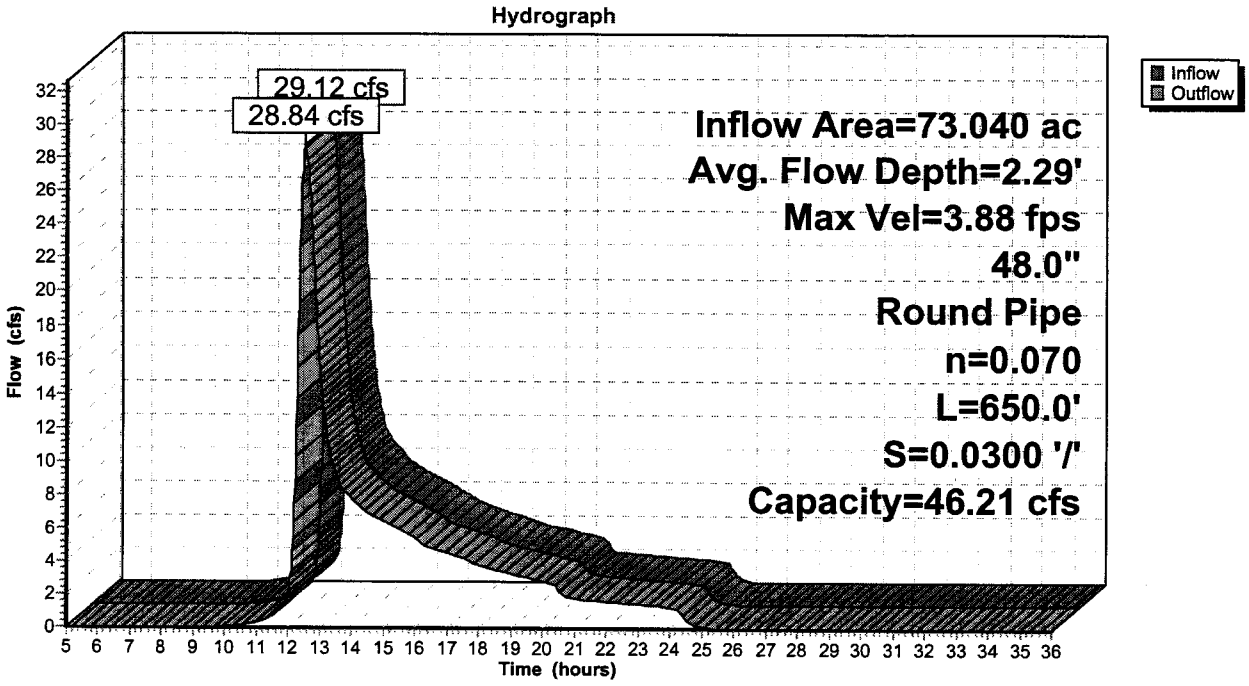
Routing by Stor-Ind+Trans method, Time Span= 5.00-36.00 hrs, dt= 0.02 hrs
Max. Velocity= 3.88 fps, Min. Travel Time= 2.8 min
Avg. Velocity = 1.64 fps, Avg. Travel Time= 6.6 min

Peak Storage= 4,835 cf @ 12.48 hrs
Average Depth at Peak Storage= 2.29'
Bank-Full Depth= 4.00', Capacity at Bank-Full= 46.21 cfs

48.0" Round Pipe
n= 0.070 Sluggish weedy reaches w/pools
Length= 650.0' Slope= 0.0300 '/'
Inlet Invert= 236.50', Outlet Invert= 217.00'



Reach 3R: POND/BROOK BETWEEN B & A



Summary for Reach 6R: VIRTUAL REACH

Used virtual reach to allow travel time to RP4

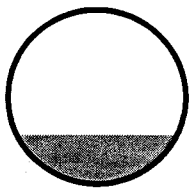
[52] Hint: Inlet/Outlet conditions not evaluated

Inflow Area = 3.240 ac, 0.00% Impervious, Inflow Depth = 0.97"
Inflow = 0.78 cfs @ 12.60 hrs, Volume= 0.262 af
Outflow = 0.78 cfs @ 12.77 hrs, Volume= 0.262 af, Atten= 0%, Lag= 10.4 min

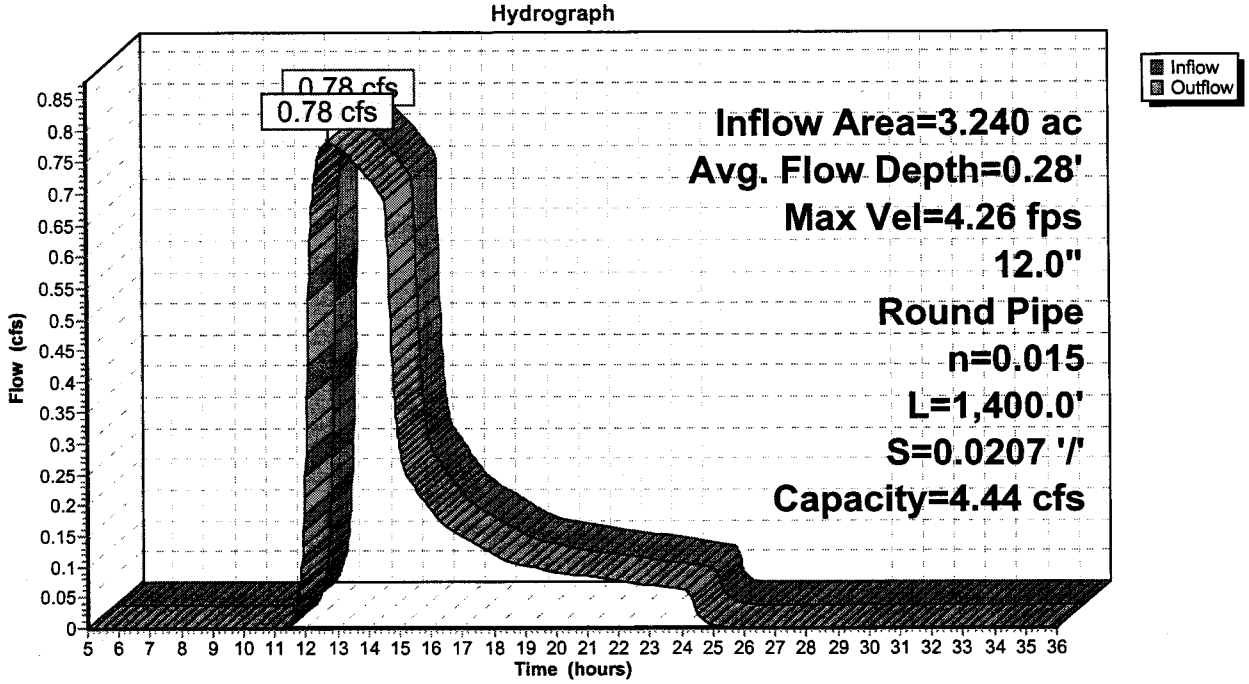
Routing by Stor-Ind+Trans method, Time Span= 5.00-36.00 hrs, dt= 0.02 hrs
Max. Velocity= 4.26 fps, Min. Travel Time= 5.5 min
Avg. Velocity = 2.30 fps, Avg. Travel Time= 10.1 min

Peak Storage= 257 cf @ 12.68 hrs
Average Depth at Peak Storage= 0.28'
Bank-Full Depth= 1.00', Capacity at Bank-Full= 4.44 cfs

12.0" Round Pipe
n= 0.015 Concrete sewer w/manholes & inlets
Length= 1,400.0' Slope= 0.0207 '/'
Inlet Invert= 289.00', Outlet Invert= 260.00'



Reach 6R: VIRTUAL REACH



Summary for Reach 11R: REACH

Allows for pipe travel time

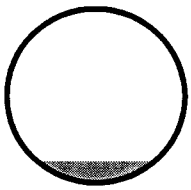
[52] Hint: Inlet/Outlet conditions not evaluated

Inflow Area = 2.050 ac, 0.00% Impervious, Inflow Depth = 0.54"
Inflow = 0.82 cfs @ 12.15 hrs, Volume= 0.093 af
Outflow = 0.81 cfs @ 12.19 hrs, Volume= 0.093 af, Atten= 1%, Lag= 2.3 min

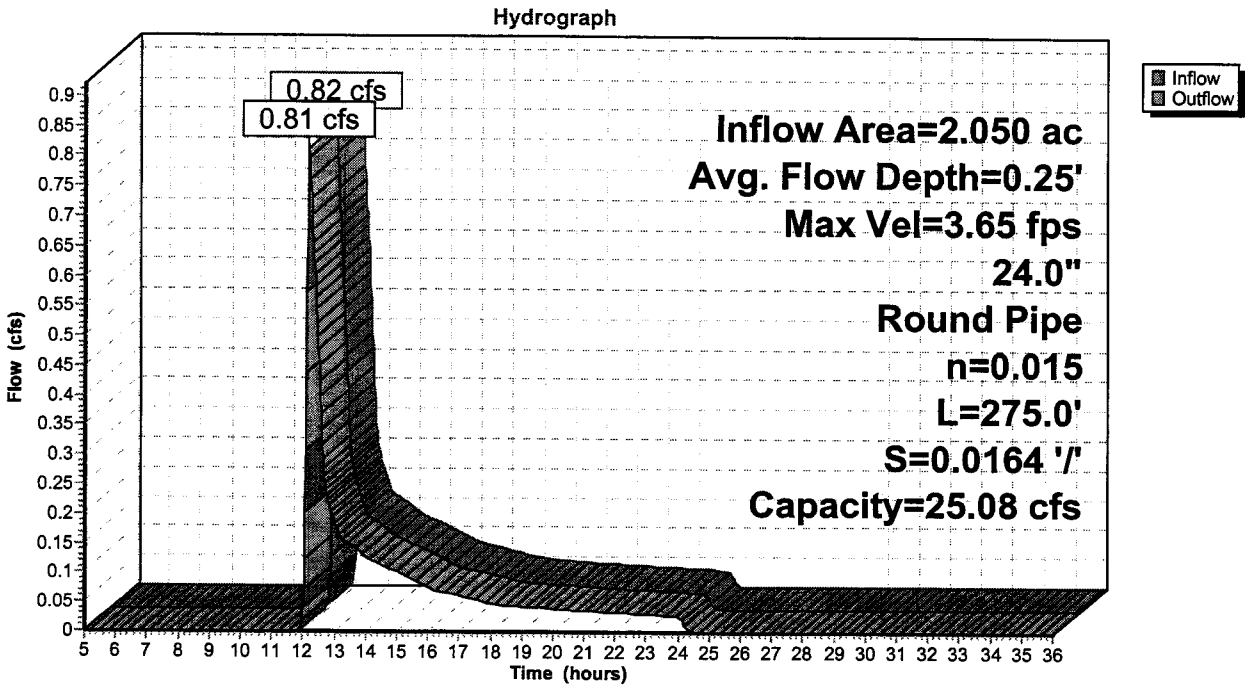
Routing by Stor-Ind+Trans method, Time Span= 5.00-36.00 hrs, dt= 0.02 hrs
Max. Velocity= 3.65 fps, Min. Travel Time= 1.3 min
Avg. Velocity = 1.70 fps, Avg. Travel Time= 2.7 min

Peak Storage= 61 cf @ 12.17 hrs
Average Depth at Peak Storage= 0.25'
Bank-Full Depth= 2.00', Capacity at Bank-Full= 25.08 cfs

24.0" Round Pipe
n= 0.015 Concrete sewer w/manholes & inlets
Length= 275.0' Slope= 0.0164 '/'
Inlet Invert= 249.50', Outlet Invert= 245.00'



Reach 11R: REACH



Summary for Pond 2P: RP4-MAIN

Inflow Area = 13.610 ac, 0.00% Impervious, Inflow Depth = 1.44"
Inflow = 15.41 cfs @ 12.20 hrs, Volume= 1.636 af
Outflow = 2.37 cfs @ 13.65 hrs, Volume= 1.636 af, Atten= 85%, Lag= 87.0 min
Primary = 2.37 cfs @ 13.65 hrs, Volume= 1.636 af

Routing by Stor-Ind method, Time Span= 5.00-36.00 hrs, dt= 0.02 hrs
Peak Elev= 248.53' @ 13.65 hrs Surf.Area= 0.114 ac Storage= 0.572 af

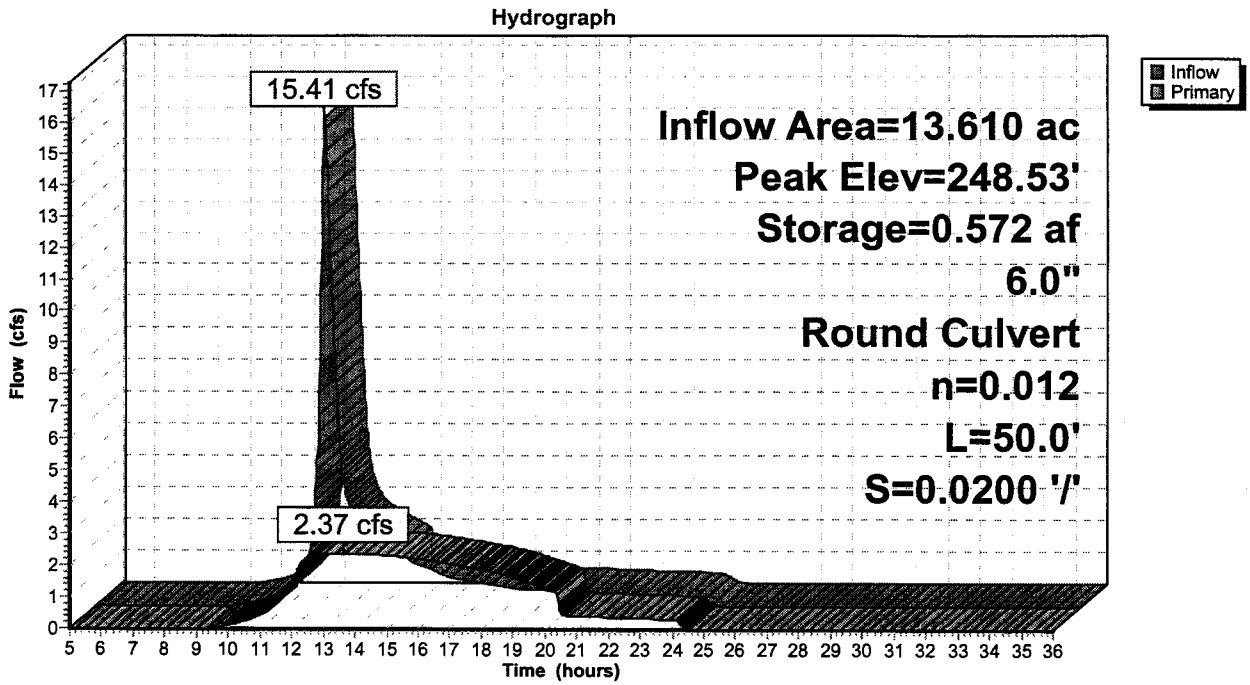
Plug-Flow detention time= 106.7 min calculated for 1.635 af (100% of inflow)
Center-of-Mass det. time= 106.6 min (965.3 - 858.7)

Volume	Invert	Avail.Storage	Storage Description
#1	240.00'	2.931 af	**25.00'W x 50.00'L x 20.00'H Prismatoid Z=2.0**

Device	Routing	Invert	Outlet Devices
#1	Primary	238.00'	**6.0" Round Culvert - 5 Yr** L= 50.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 238.00' / 237.00' S= 0.0200 '/' Cc= 0.900 n= 0.012 Steel, smooth

Primary OutFlow Max=2.37 cfs @ 13.65 hrs HW=248.53' (Free Discharge)
└**1=Culvert - 5 Yr** (Barrel Controls 2.37 cfs @ 12.08 fps)

Pond 2P: RP4-MAIN



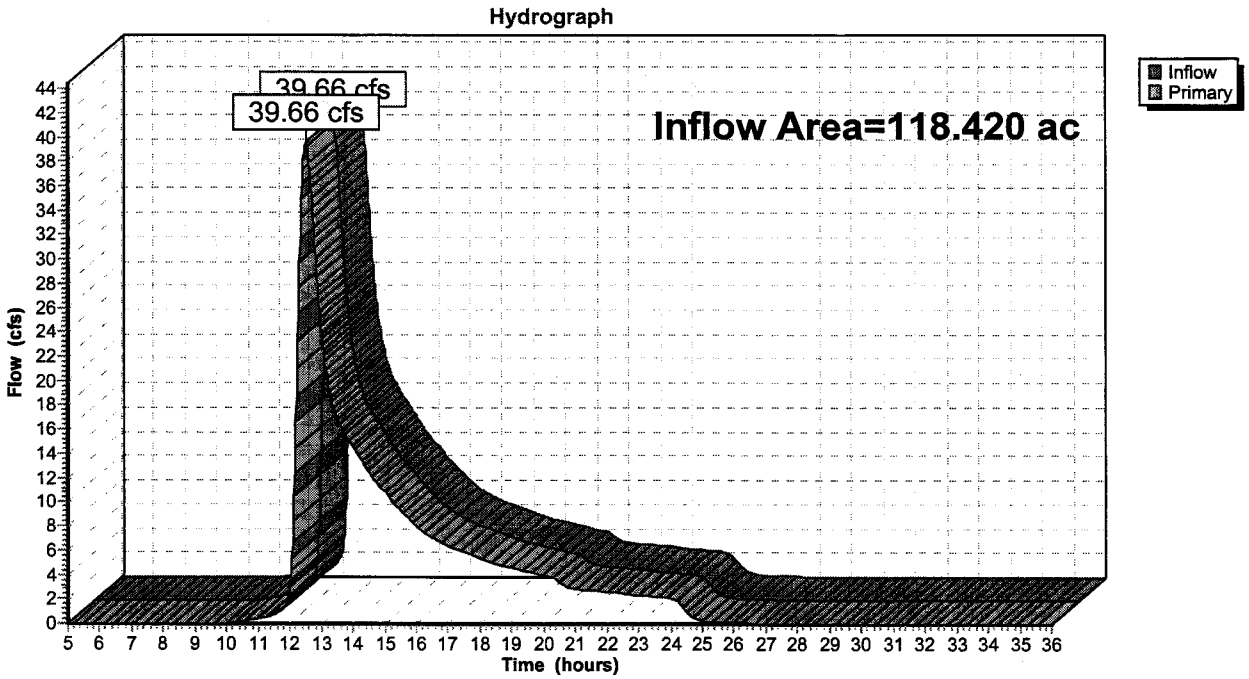
Summary for Pond 4P: DISCHARGE POINT AT A (ZERO VOLUME POND)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 118.420 ac, 0.00% Impervious, Inflow Depth = 0.86"
Inflow = 39.66 cfs @ 12.52 hrs, Volume= 8.469 af
Primary = 39.66 cfs @ 12.52 hrs, Volume= 8.469 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 5.00-36.00 hrs, dt= 0.02 hrs

Pond 4P: DISCHARGE POINT AT A (ZERO VOLUME POND)



Summary for Pond 5P: RP4-2

Backyard private retention pond formed by construction of road.

Inflow Area =	3.240 ac,	0.00% Impervious,	Inflow Depth =	0.97"
Inflow =	3.12 cfs @	12.13 hrs, Volume=	0.262 af	
Outflow =	0.78 cfs @	12.60 hrs, Volume=	0.262 af,	Atten= 75%, Lag= 28.1 min
Primary =	0.78 cfs @	12.60 hrs, Volume=	0.262 af	

Routing by Stor-Ind method, Time Span= 5.00-36.00 hrs, dt= 0.02 hrs
Peak Elev= 298.03' @ 12.60 hrs Surf.Area= 0.122 ac Storage= 0.063 af

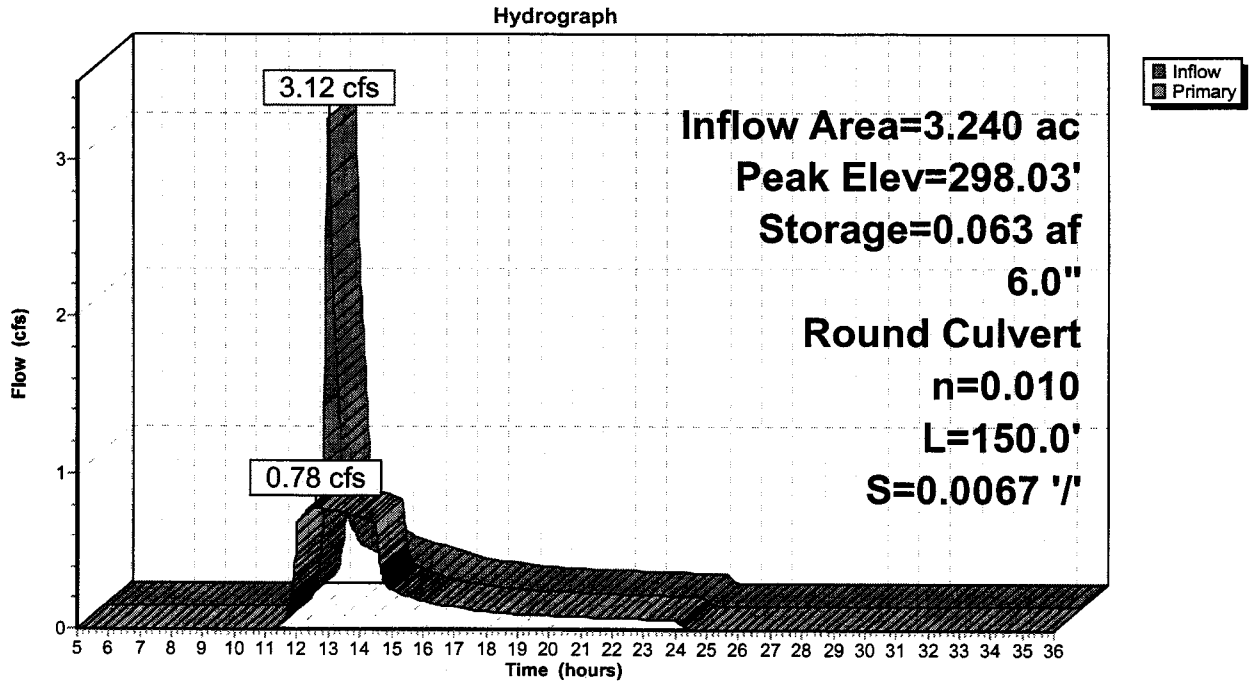
Plug-Flow detention time= 25.5 min calculated for 0.262 af (100% of inflow)
Center-of-Mass det. time= 25.5 min (899.3 - 873.8)

Volume	Invert	Avail.Storage	Storage Description
#1	297.50'	0.963 af	**50.00'W x 100.00'L x 6.00'H Prismatoid Z=2.0**

Device	Routing	Invert	Outlet Devices
#1	Primary	296.50'	**6.0" Round Culvert** L= 150.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 296.50' / 295.50' S= 0.0067 '/' Cc= 0.900 n= 0.010 PVC, smooth interior

Primary OutFlow Max=0.78 cfs @ 12.60 hrs HW=298.03' (Free Discharge)
↑**1=Culvert** (Barrel Controls 0.78 cfs @ 3.99 fps)

Pond 5P: RP4-2



Summary for Pond 7P: RP5-MAIN

Inflow Area = 38.400 ac, 0.00% Impervious, Inflow Depth = 0.88"
Inflow = 25.54 cfs @ 12.24 hrs, Volume= 2.815 af
Outflow = 8.07 cfs @ 12.73 hrs, Volume= 2.556 af, Atten= 68%, Lag= 29.6 min
Primary = 8.07 cfs @ 12.73 hrs, Volume= 2.556 af

Routing by Stor-Ind method, Time Span= 5.00-36.00 hrs, dt= 0.02 hrs
Peak Elev= 239.81' @ 12.73 hrs Surf.Area= 0.207 ac Storage= 0.923 af

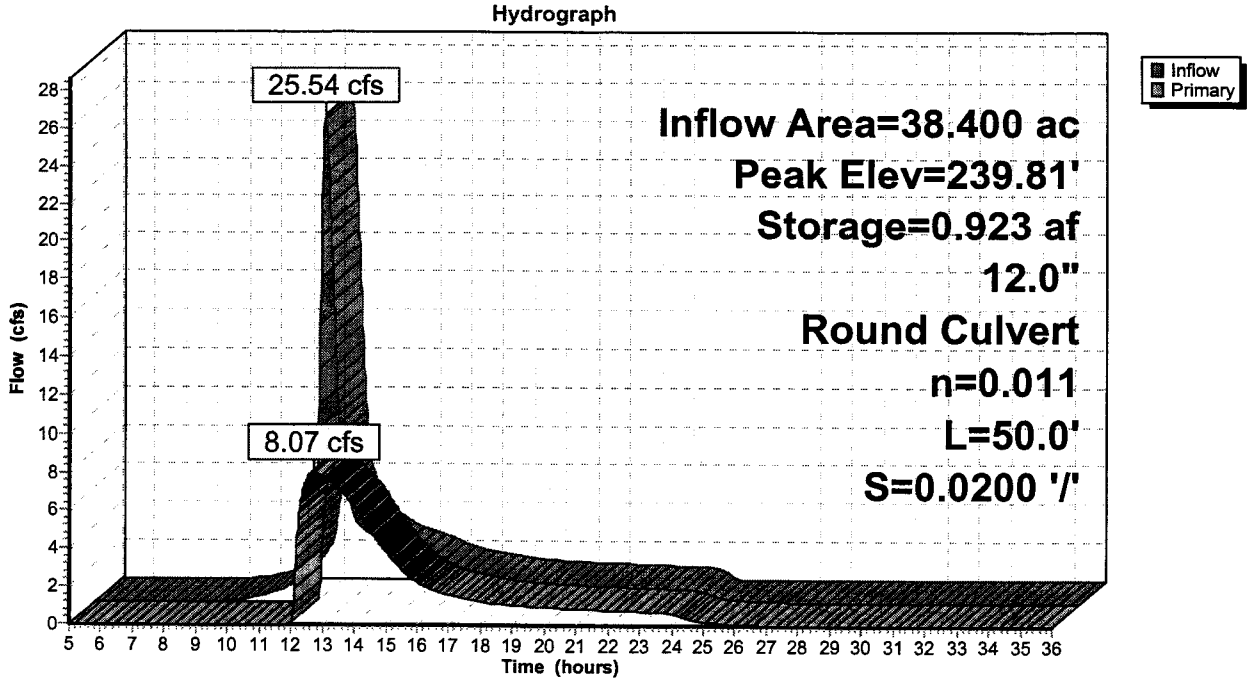
Plug-Flow detention time= 110.8 min calculated for 2.554 af (91% of inflow)
Center-of-Mass det. time= 65.6 min (934.5 - 868.9)

Volume	Invert	Avail.Storage	Storage Description
#1	234.00'	1.422 af	**50.00'W x 100.00'L x 8.00'H Prismatoid Z=2.0**

Device	Routing	Invert	Outlet Devices
#1	Primary	236.00'	**12.0" Round Culvert** L= 50.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 236.00' / 235.00' S= 0.0200 '/' Cc= 0.900 n= 0.011 Concrete pipe, straight & clean

Primary OutFlow Max=8.07 cfs @ 12.73 hrs HW=239.81' (Free Discharge)
↑—**1=Culvert** (Barrel Controls 8.07 cfs @ 10.27 fps)

Pond 7P: RP5-MAIN



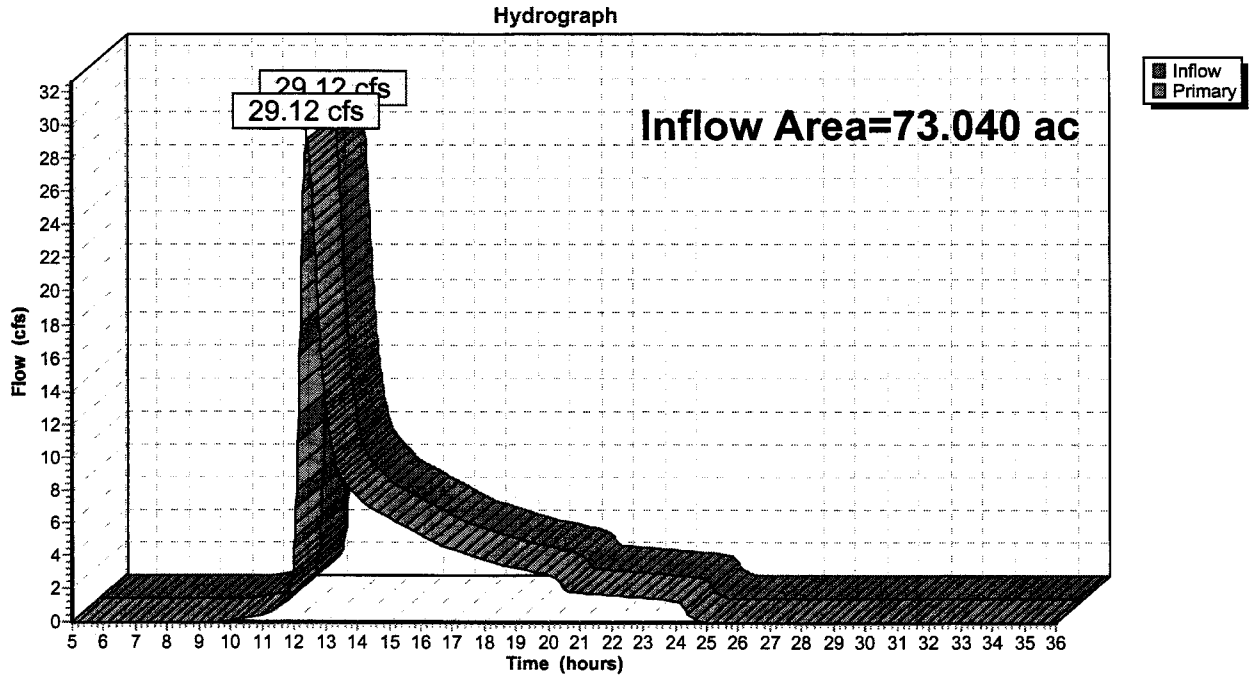
Summary for Pond 8P: DISCHARGE POINT AT B (ZERO VOLUME POND)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 73.040 ac, 0.00% Impervious, Inflow Depth = 0.89"
Inflow = 29.12 cfs @ 12.44 hrs, Volume= 5.438 af
Primary = 29.12 cfs @ 12.44 hrs, Volume= 5.438 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 5.00-36.00 hrs, dt= 0.02 hrs

Pond 8P: DISCHARGE POINT AT B (ZERO VOLUME POND)



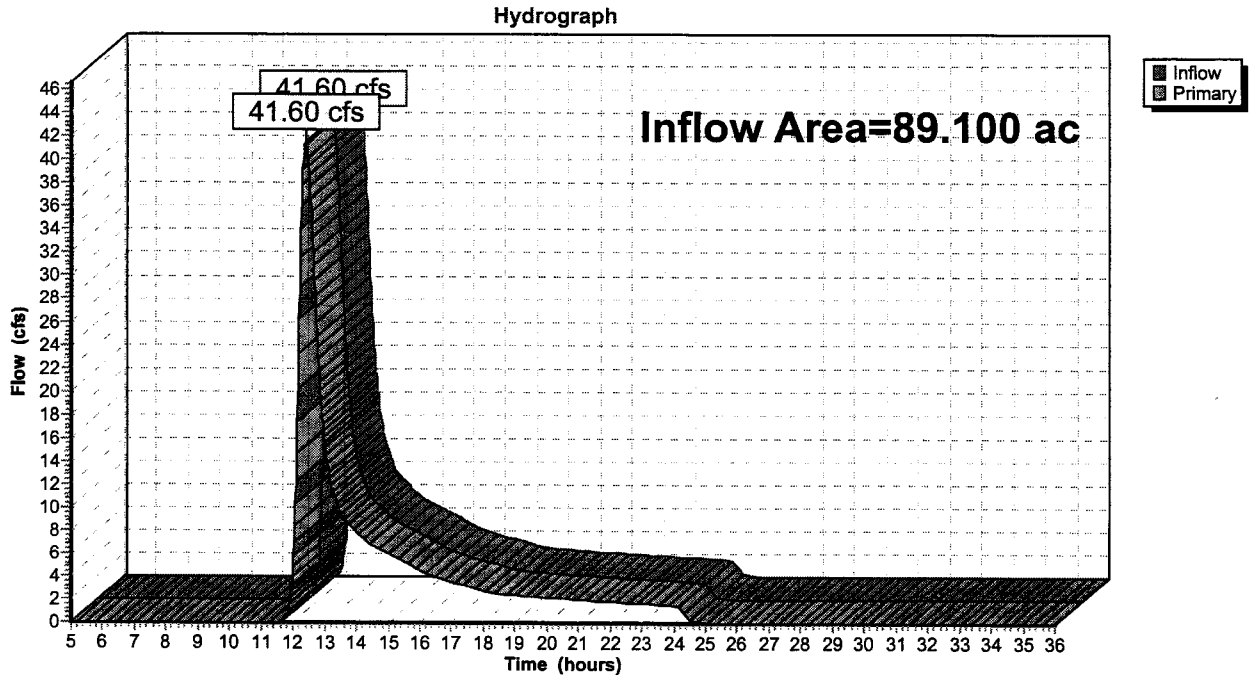
Summary for Pond 9P: A+B at B (Zero Volume Pond)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 89.100 ac, 0.00% Impervious, Inflow Depth = 0.78"
Inflow = 41.60 cfs @ 12.40 hrs, Volume= 5.793 af
Primary = 41.60 cfs @ 12.40 hrs, Volume= 5.793 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 5.00-36.00 hrs, dt= 0.02 hrs

Pond 9P: A+B at B (Zero Volume Pond)



Summary for Pond 12P: RP5-SUB-2

RP5-SUB-2 retention pond holds the 100 year precipitation event while releasing a 5 year rainfall flow rate. It is a back yard private retention pond.

Inflow Area =	2.050 ac,	0.00% Impervious,	Inflow Depth =	0.54"
Inflow =	0.91 cfs @	12.11 hrs, Volume=	0.093 af	
Outflow =	0.82 cfs @	12.15 hrs, Volume=	0.093 af,	Atten= 9%, Lag= 2.5 min
Primary =	0.82 cfs @	12.15 hrs, Volume=	0.093 af	

Routing by Stor-Ind method, Time Span= 5.00-36.00 hrs, dt= 0.02 hrs
Peak Elev= 258.58' @ 12.15 hrs Surf.Area= 0.036 ac Storage= 0.003 af

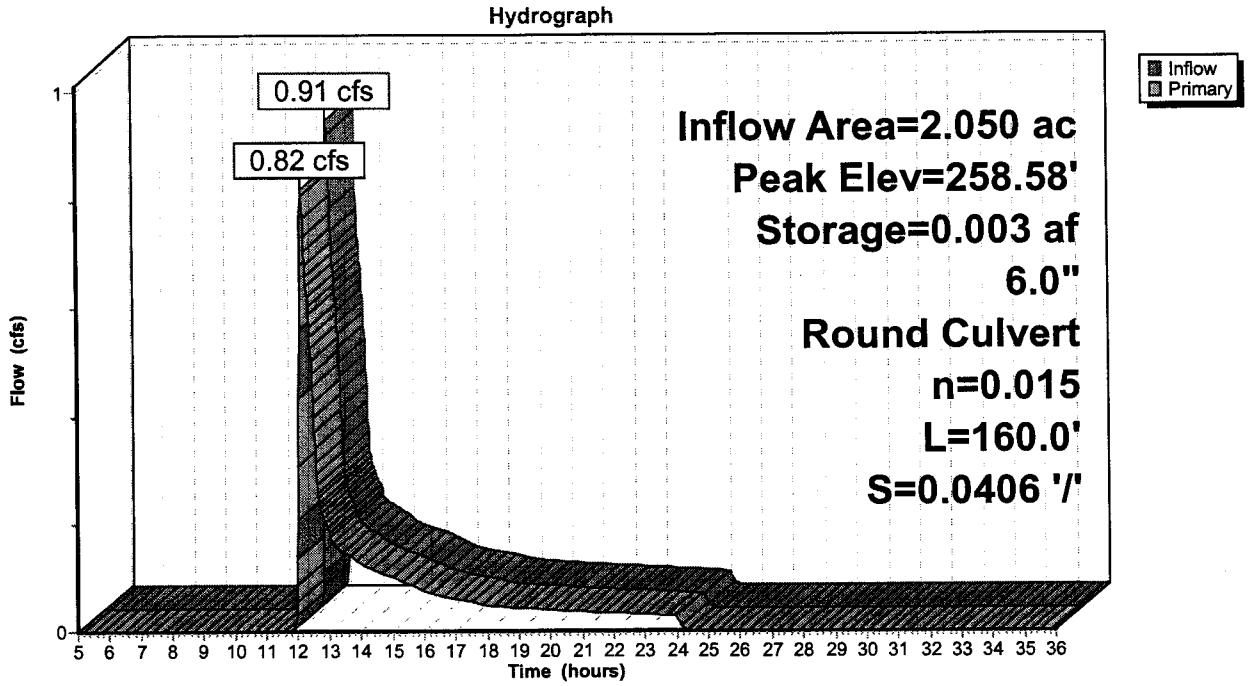
Plug-Flow detention time= 2.4 min calculated for 0.093 af (100% of inflow)
Center-of-Mass det. time= 2.4 min (910.0 - 907.5)

Volume	Invert	Avail.Storage	Storage Description
#1	258.50'	1.201 af	**150.00'W x 10.00'L x 10.00'H Prismatoid Z=2.0**

Device	Routing	Invert	Outlet Devices
#1	Primary	256.50'	**6.0" Round Culvert** L= 160.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 256.50' / 250.00' S= 0.0406 '/' Cc= 0.900 n= 0.015 Concrete sewer w/manholes & inlets

Primary OutFlow Max=1.05 cfs @ 12.15 hrs HW=258.58' (Free Discharge)
↑**1=Culvert** (Barrel Controls 1.05 cfs @ 5.37 fps)

Pond 12P: RP5-SUB-2

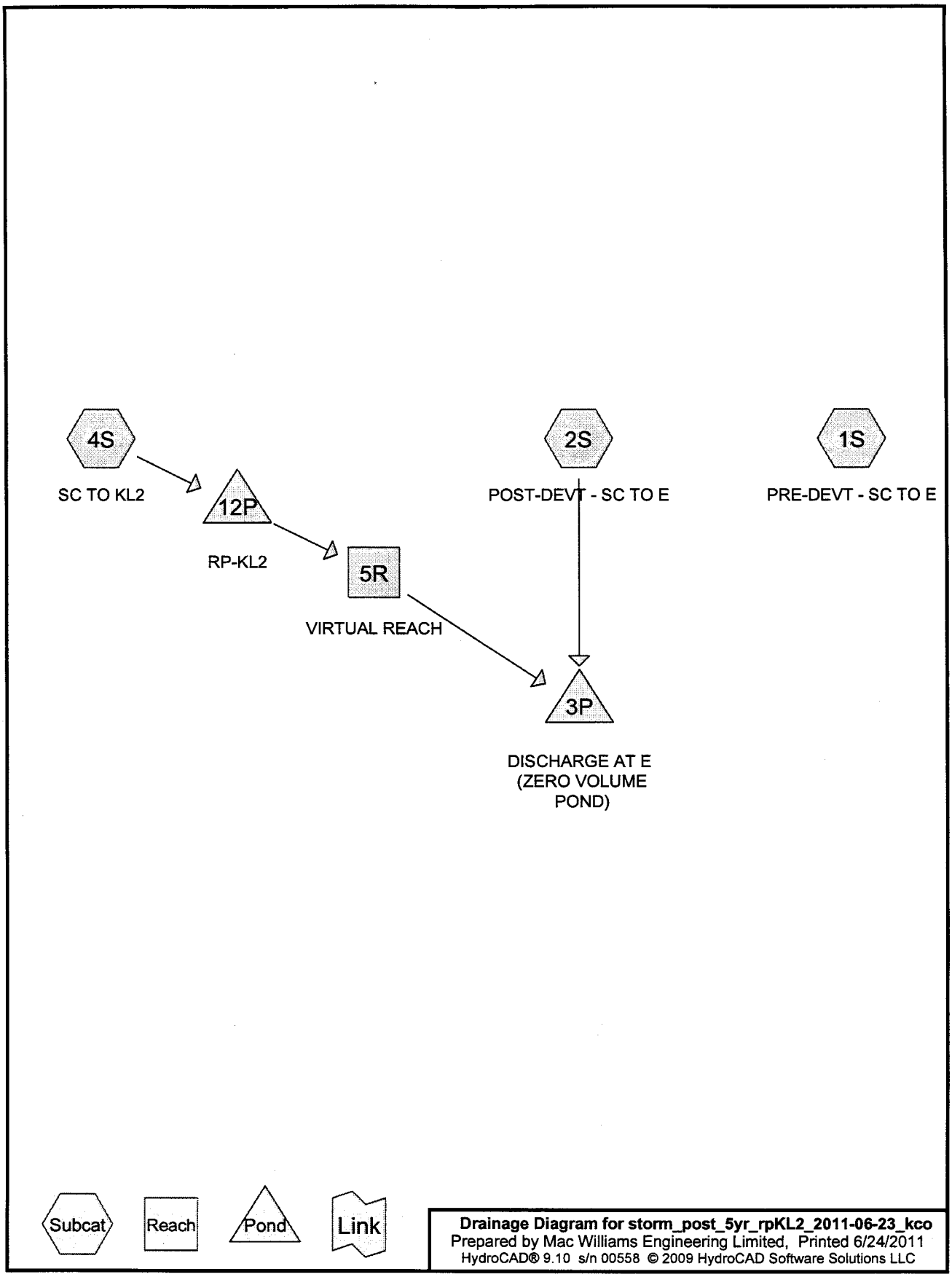


APPENDIX D-2

5 YEAR KL2

PRE-DEVELOPMENT AND POST-DEVELOPMENT

MODELING RESULTS FOR DESIGN STORM EVENTS



Drainage Diagram for storm_post_5yr_rpKL2_2011-06-23_kco
Prepared by Mac Williams Engineering Limited, Printed 6/24/2011

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
35.680	66	(1S, 2S)
30.200	70	(4S)
65.880		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
65.880	Other	1S, 2S, 4S
65.880		**TOTAL AREA**

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Fill (inches)
1	5R	240.00	200.00	1,050.0	0.0381	0.070	192.0	0.0	0.0
2	12P	250.00	249.00	50.0	0.0200	0.011	18.0	0.0	0.0
3	12P	253.00	249.00	50.0	0.0800	0.011	12.0	0.0	0.0

Time span=5.00-36.00 hrs, dt=0.05 hrs, 621 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: PRE-DEVT - SC TO E Runoff Area=26.400 ac 0.00% Impervious Runoff Depth=0.82"
Tc=23.5 min CN=66 Runoff=13.63 cfs 1.797 af

Subcatchment 2S: POST-DEVT - SC TO E Runoff Area=9.280 ac 0.00% Impervious Runoff Depth=0.82"
Tc=23.5 min CN=66 Runoff=4.79 cfs 0.632 af

Subcatchment 4S: SC TO KL2 Runoff Area=30.200 ac 0.00% Impervious Runoff Depth=1.03"
Tc=34.0 min CN=70 Runoff=17.88 cfs 2.584 af

Reach 5R: VIRTUAL REACH Avg. Flow Depth=0.82' Max Vel=2.74 fps Inflow=10.78 cfs 2.582 af
192.0" Round Pipe n=0.070 L=1,050.0' S=0.0381 '/' Capacity=2,099.23 cfs Outflow=10.71 cfs 2.581 af

Pond 3P: DISCHARGE AT E (ZERO VOLUME POND) Inflow=12.22 cfs 3.213 af
Primary=12.22 cfs 3.213 af

Pond 12P: RP-KL2 Peak Elev=252.81' Storage=0.498 af Inflow=17.88 cfs 2.584 af
Outflow=10.78 cfs 2.582 af

Total Runoff Area = 65.880 ac Runoff Volume = 5.012 af Average Runoff Depth = 0.91"
100.00% Pervious = 65.880 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: PRE-DEVT - SC TO E

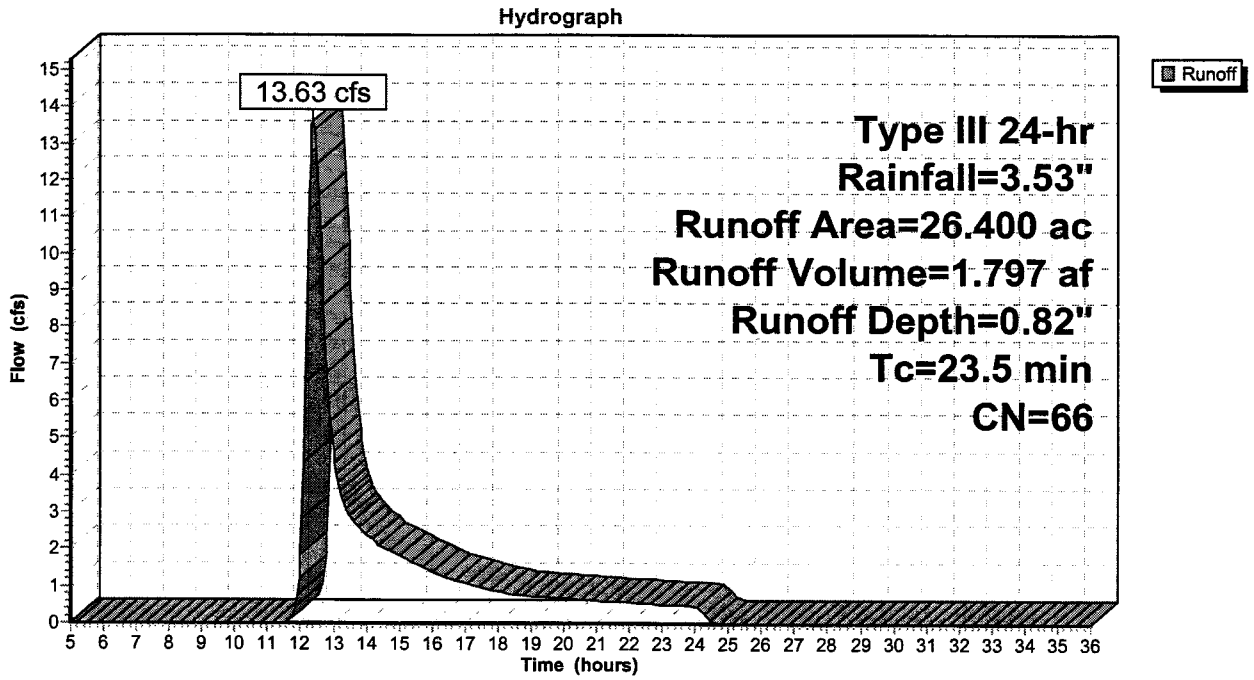
Runoff = 13.63 cfs @ 12.38 hrs, Volume= 1.797 af, Depth= 0.82"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr Rainfall=3.53"

	Area (ac)	CN	Description
*	26.400	66	
	26.400		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.5					**Direct Entry,**

Subcatchment 1S: PRE-DEVT - SC TO E



Summary for Subcatchment 2S: POST-DEVT - SC TO E

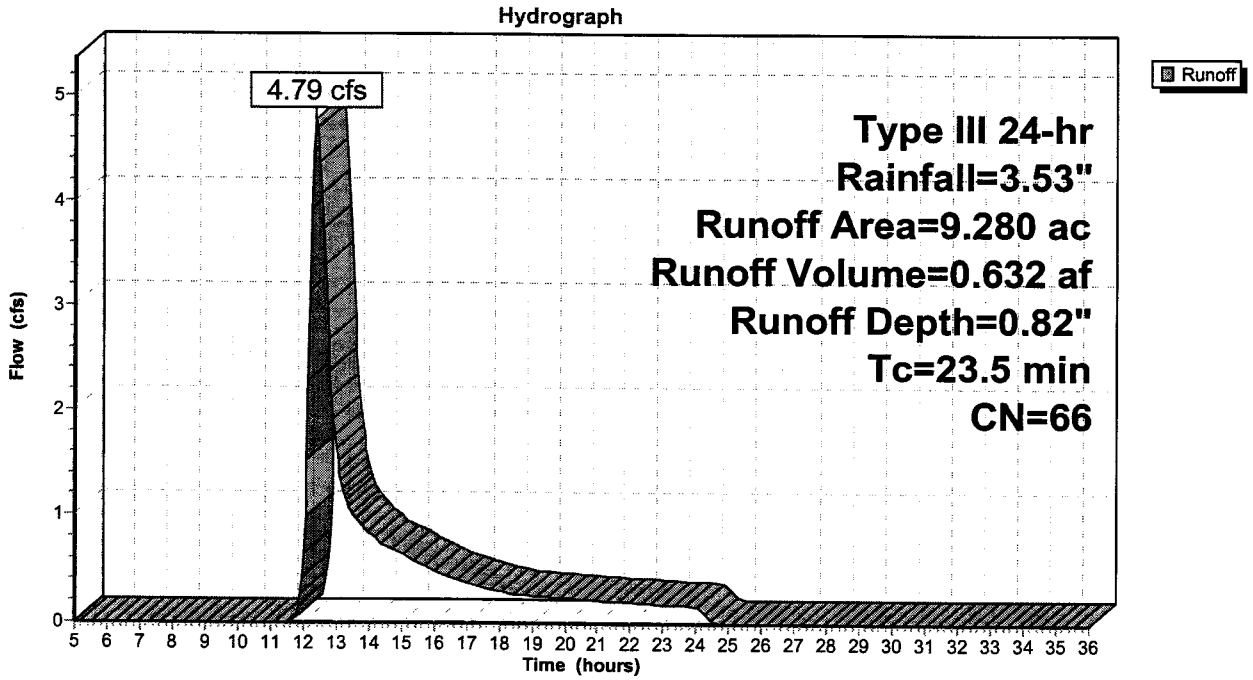
Runoff = 4.79 cfs @ 12.38 hrs, Volume= 0.632 af, Depth= 0.82"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr Rainfall=3.53"

	Area (ac)	CN	Description
*	9.280	66	
	9.280		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.5					**Direct Entry,**

Subcatchment 2S: POST-DEVT - SC TO E



Summary for Subcatchment 4S: SC TO KL2

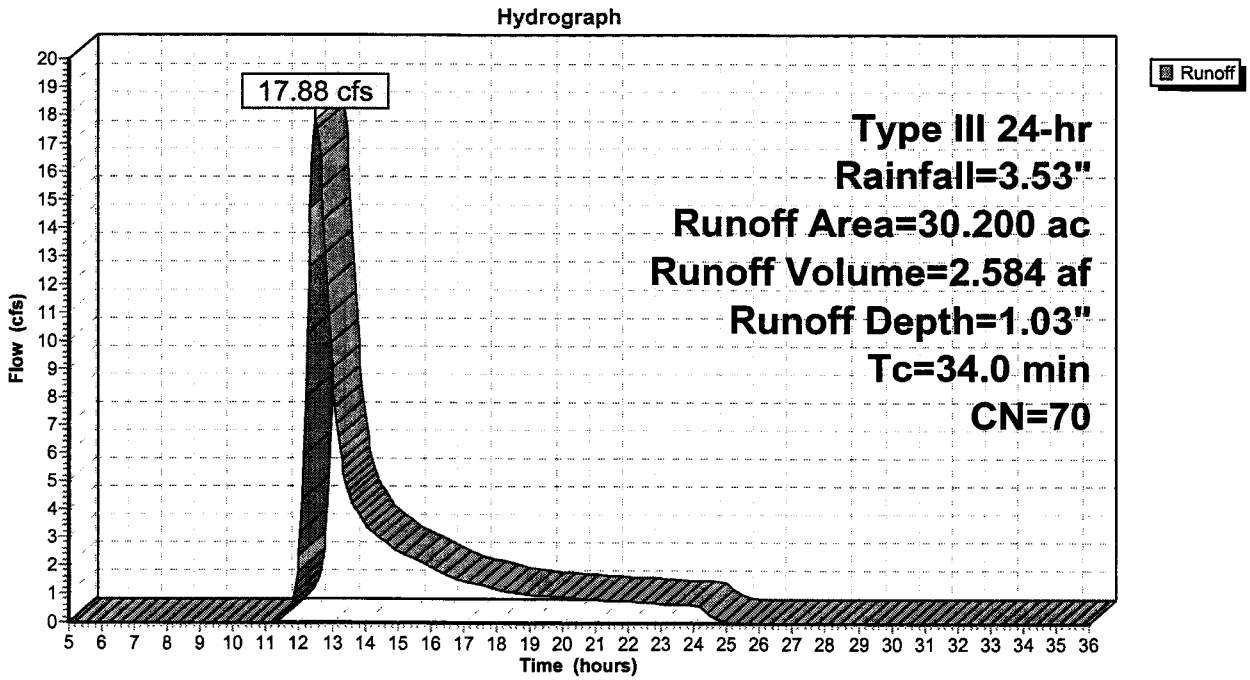
Runoff = 17.88 cfs @ 12.52 hrs, Volume= 2.584 af, Depth= 1.03"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr Rainfall=3.53"

	Area (ac)	CN	Description
*	30.200	70	
	30.200		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
34.0					**Direct Entry,**

Subcatchment 4S: SC TO KL2



Summary for Reach 5R: VIRTUAL REACH

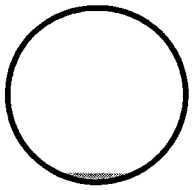
[52] Hint: Inlet/Outlet conditions not evaluated

Inflow Area = 30.200 ac, 0.00% Impervious, Inflow Depth > 1.03"
Inflow = 10.78 cfs @ 12.91 hrs, Volume= 2.582 af
Outflow = 10.71 cfs @ 13.10 hrs, Volume= 2.581 af, Atten= 1%, Lag= 11.4 min

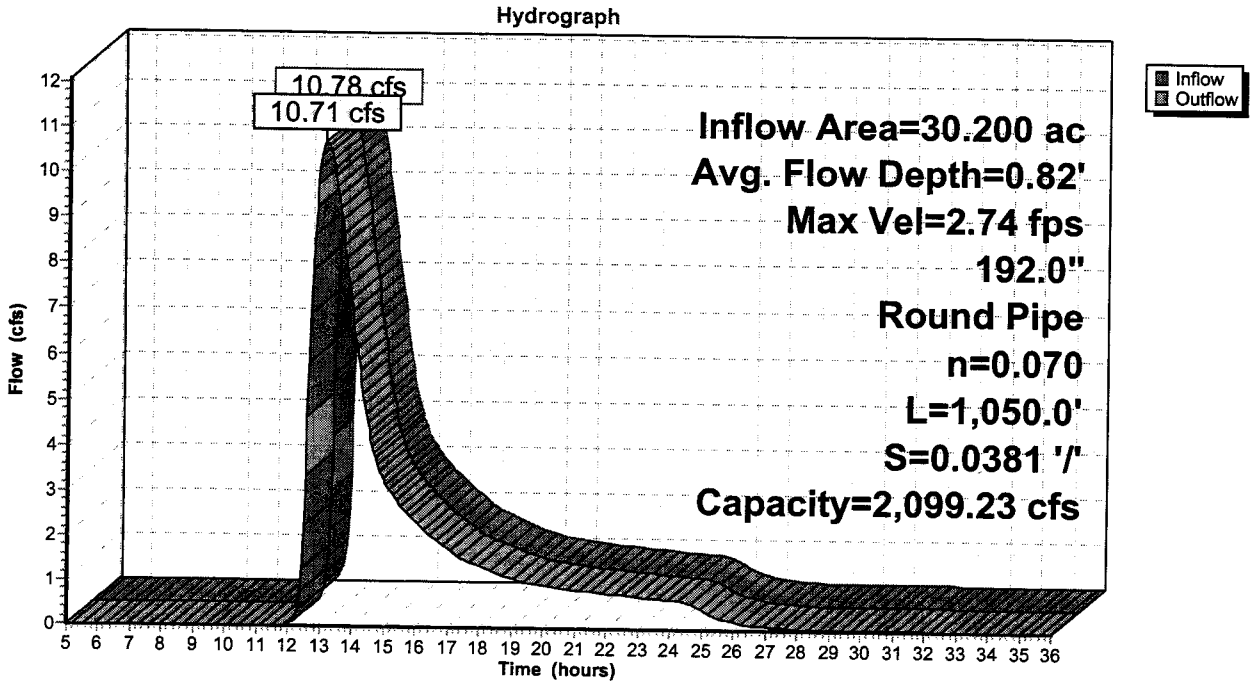
Routing by Stor-Ind+Trans method, Time Span= 5.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.74 fps, Min. Travel Time= 6.4 min
Avg. Velocity = 1.28 fps, Avg. Travel Time= 13.7 min

Peak Storage= 4,108 cf @ 12.99 hrs
Average Depth at Peak Storage= 0.82'
Bank-Full Depth= 16.00', Capacity at Bank-Full= 2,099.23 cfs

192.0" Round Pipe
n= 0.070 Sluggish weedy reaches w/pools
Length= 1,050.0' Slope= 0.0381 '/'
Inlet Invert= 240.00', Outlet Invert= 200.00'



Reach 5R: VIRTUAL REACH



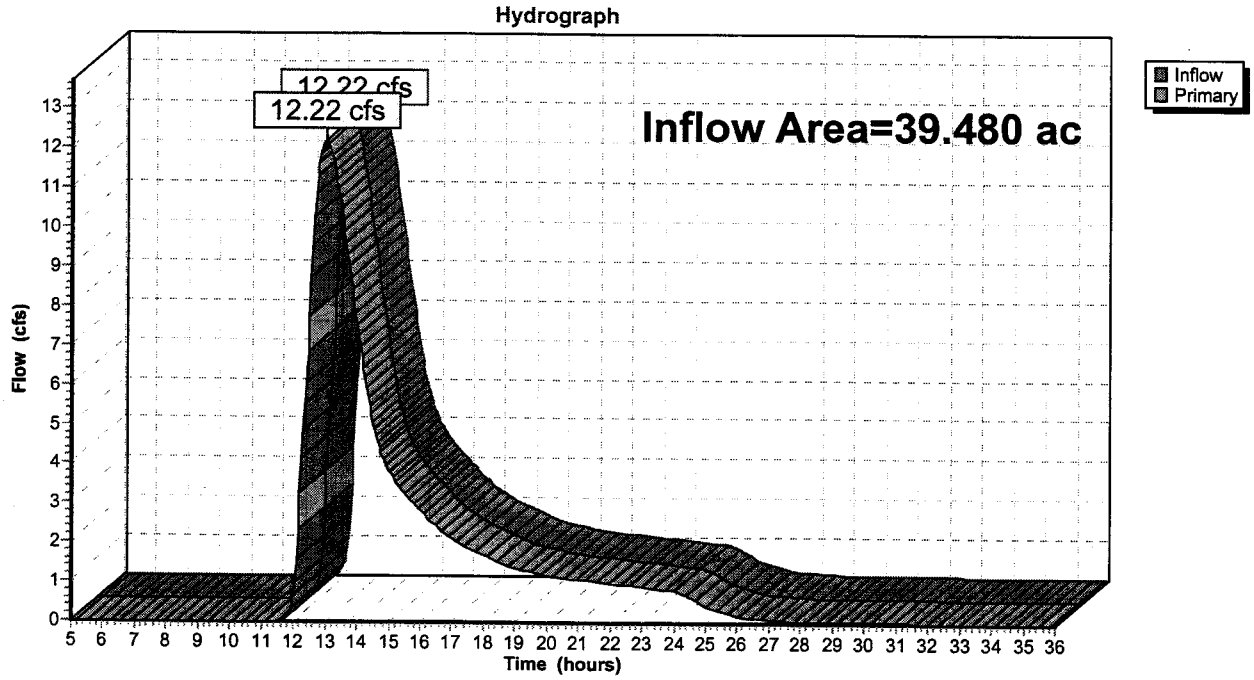
Summary for Pond 3P: DISCHARGE AT E (ZERO VOLUME POND)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 39.480 ac, 0.00% Impervious, Inflow Depth > 0.98"
Inflow = 12.22 cfs @ 13.01 hrs, Volume= 3.213 af
Primary = 12.22 cfs @ 13.01 hrs, Volume= 3.213 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 5.00-36.00 hrs, dt= 0.05 hrs

Pond 3P: DISCHARGE AT E (ZERO VOLUME POND)



Summary for Pond 12P: RP-KL2

Inflow Area = 30.200 ac, 0.00% Impervious, Inflow Depth = 1.03"
Inflow = 17.88 cfs @ 12.52 hrs, Volume= 2.584 af
Outflow = 10.78 cfs @ 12.91 hrs, Volume= 2.582 af, Atten= 40%, Lag= 23.1 min
Primary = 10.78 cfs @ 12.91 hrs, Volume= 2.582 af

Routing by Stor-Ind method, Time Span= 5.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 252.81' @ 12.91 hrs Surf.Area= 0.189 ac Storage= 0.498 af

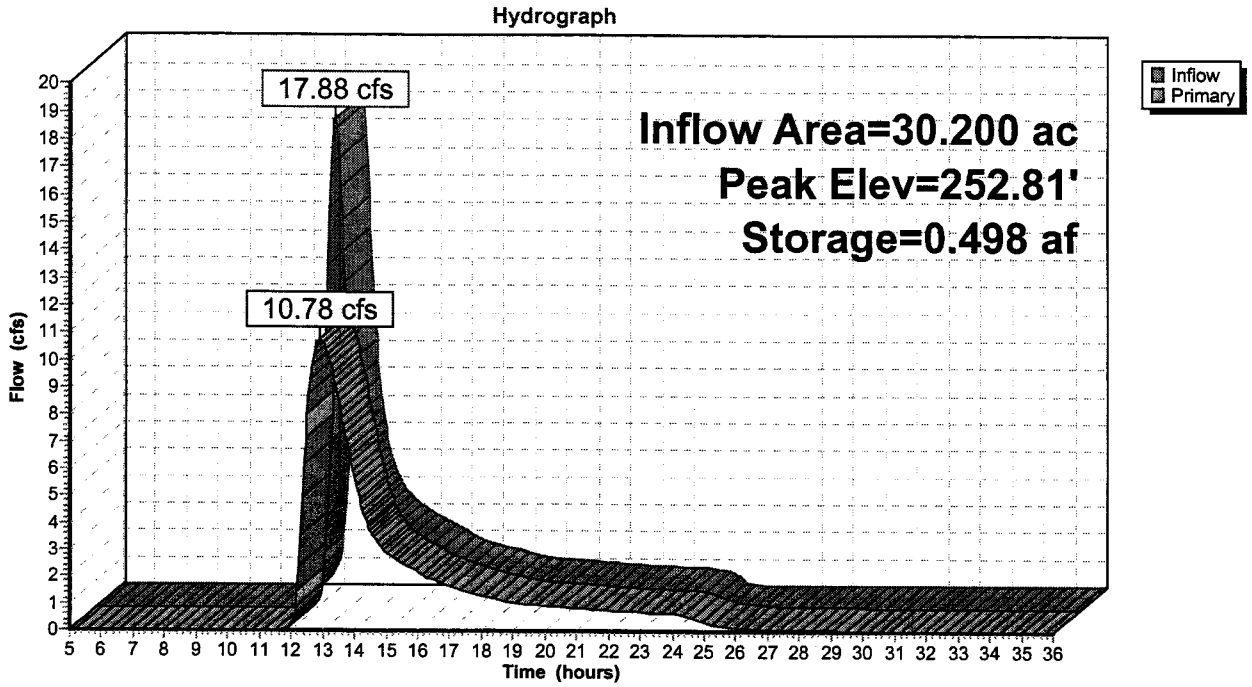
Plug-Flow detention time= 41.5 min calculated for 2.582 af (100% of inflow)
Center-of-Mass det. time= 41.0 min (935.6 - 894.7)

Volume	Invert	Avail.Storage	Storage Description
#1	250.00'	2.097 af	**60.00'W x 120.00'L x 10.00'H Prismatoid Z=1.0**

Device	Routing	Invert	Outlet Devices
#1	Primary	250.00'	**18.0" Round Culvert** L= 50.0' RCP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 250.00' / 249.00' S= 0.0200 '/' Cc= 0.900 n= 0.011 Concrete pipe, straight & clean
#2	Primary	253.00'	**12.0" Round Culvert** L= 50.0' RCP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 253.00' / 249.00' S= 0.0800 '/' Cc= 0.900 n= 0.011 Concrete pipe, straight & clean

Primary OutFlow Max=10.78 cfs @ 12.91 hrs HW=252.81' (Free Discharge)
↑—**1=Culvert** (Inlet Controls 10.78 cfs @ 6.10 fps)
└—**2=Culvert** (Controls 0.00 cfs)

Pond 12P: RP-KL2

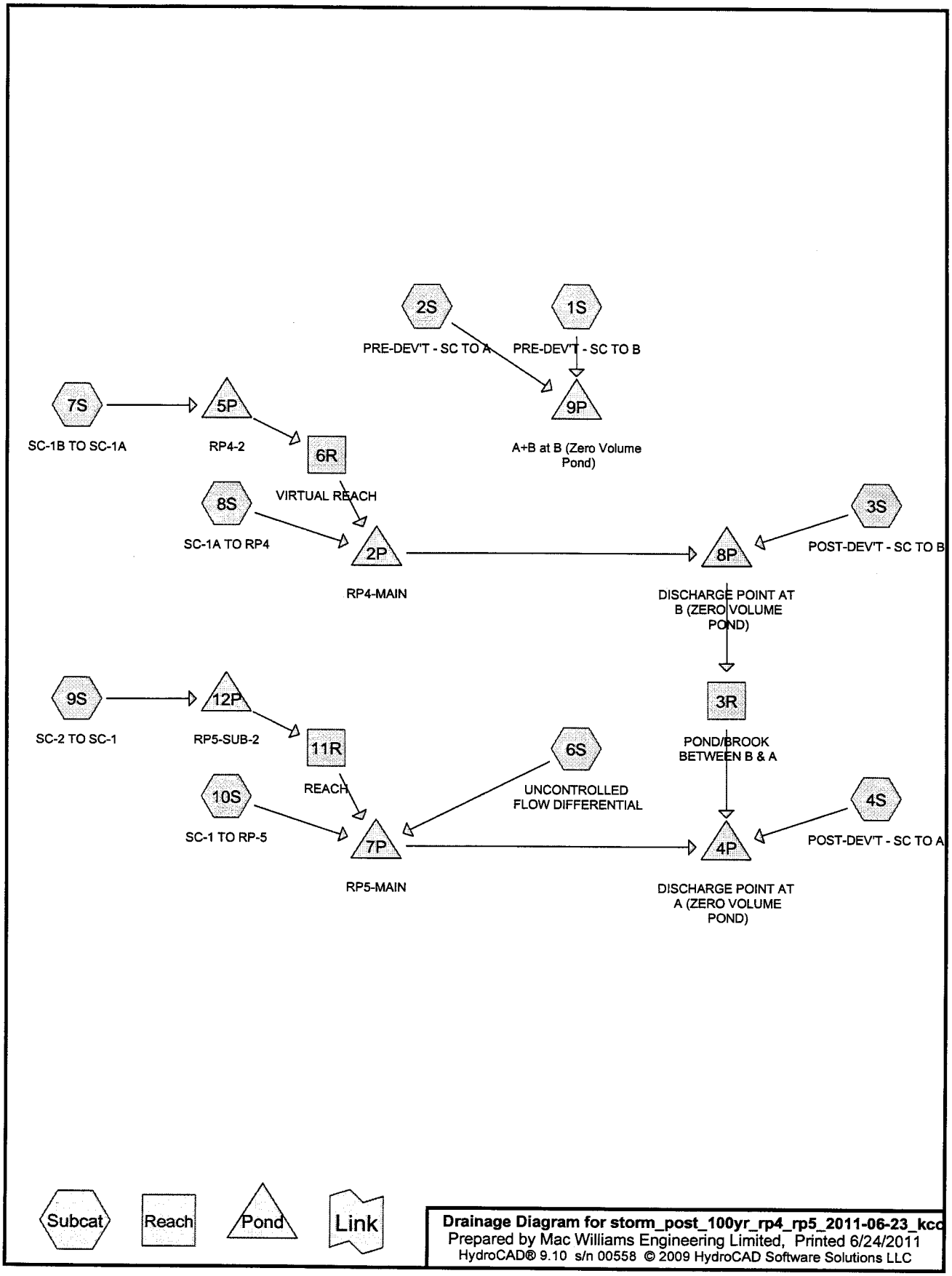


APPENDIX D-3

100 YEAR RP4 AND RP5

PRE-DEVELOPMENT AND POST-DEVELOPMENT

MODELING RESULTS FOR DESIGN STORM EVENTS



Drainage Diagram for storm_post_100yr_rp4_rp5_2011-06-23_kcc
Prepared by Mac Williams Engineering Limited, Printed 6/24/2011

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
20.690	42	(6S)
125.830	60	(1S, 3S)
29.680	61	(2S, 4S)
3.240	65	(7S)
15.660	68	(10S)
2.050	74	(9S)
10.370	84	(8S)
207.520		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
207.520	Other	1S, 2S, 3S, 4S, 6S, 7S, 8S, 9S, 10S
207.520		**TOTAL AREA**

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Fill (inches)
1	3R	236.50	217.00	650.0	0.0300	0.070	108.0	0.0	0.0
2	6R	289.00	260.00	1,400.0	0.0207	0.015	12.0	0.0	0.0
3	11R	249.50	245.00	275.0	0.0164	0.015	24.0	0.0	0.0
4	2P	238.00	237.00	50.0	0.0200	0.012	6.0	0.0	0.0
5	2P	242.00	237.00	50.0	0.1000	0.012	8.0	0.0	0.0
6	5P	296.50	295.50	150.0	0.0067	0.010	6.0	0.0	0.0
7	7P	232.00	231.00	50.0	0.0200	0.011	10.0	0.0	0.0
8	7P	236.00	231.00	50.0	0.1000	0.011	15.0	0.0	0.0
9	12P	256.50	250.00	160.0	0.0406	0.015	6.0	0.0	0.0

Time span=5.00-48.00 hrs, dt=0.02 hrs, 2151 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: PRE-DEV'T - SC TO B Runoff Area=66.400 ac 0.00% Impervious Runoff Depth=1.90"
Tc=26.5 min CN=60 Runoff=82.92 cfs 10.488 af

Subcatchment 2S: PRE-DEV'T - SC TO A Runoff Area=22.700 ac 0.00% Impervious Runoff Depth=1.98"
Tc=19.6 min CN=61 Runoff=33.82 cfs 3.743 af

Subcatchment 3S: POST-DEV'T - SC TO B Runoff Area=59.430 ac 0.00% Impervious Runoff Depth=1.90"
Tc=26.5 min CN=60 Runoff=74.21 cfs 9.387 af

Subcatchment 4S: POST-DEV'T - SC TO A Runoff Area=6.980 ac 0.00% Impervious Runoff Depth=1.98"
Tc=19.6 min CN=61 Runoff=10.40 cfs 1.151 af

Subcatchment 6S: UNCONTROLLED FLOW Runoff Area=20.690 ac 0.00% Impervious Runoff Depth=0.60"
Tc=5.0 min CN=42 Runoff=6.38 cfs 1.037 af

Subcatchment 7S: SC-1B TO SC-1A Runoff Area=3.240 ac 0.00% Impervious Runoff Depth=2.32"
Tc=8.0 min CN=65 Runoff=8.02 cfs 0.627 af

Subcatchment 8S: SC-1A TO RP4 Runoff Area=10.370 ac 0.00% Impervious Runoff Depth=4.16"
Tc=14.2 min CN=84 Runoff=38.61 cfs 3.594 af

Subcatchment 9S: SC-2 TO SC-1 Runoff Area=2.050 ac 0.00% Impervious Runoff Depth=3.15"
Tc=5.7 min CN=74 Runoff=7.64 cfs 0.538 af

Subcatchment 10S: SC-1 TO RP-5 Runoff Area=15.660 ac 0.00% Impervious Runoff Depth=2.59"
Tc=17.0 min CN=68 Runoff=33.70 cfs 3.380 af

Reach 3R: POND/BROOK BETWEEN Avg. Flow Depth=2.76' Max Vel=4.95 fps Inflow=82.30 cfs 13.608 af
108.0" Round Pipe n=0.070 L=650.0' S=0.0300 '/' Capacity=401.65 cfs Outflow=81.79 cfs 13.608 af

Reach 6R: VIRTUAL REACH Avg. Flow Depth=0.32' Max Vel=4.56 fps Inflow=1.00 cfs 0.627 af
12.0" Round Pipe n=0.015 L=1,400.0' S=0.0207 '/' Capacity=4.44 cfs Outflow=1.00 cfs 0.627 af

Reach 11R: REACH Avg. Flow Depth=0.30' Max Vel=4.13 fps Inflow=1.22 cfs 0.538 af
24.0" Round Pipe n=0.015 L=275.0' S=0.0164 '/' Capacity=25.08 cfs Outflow=1.22 cfs 0.538 af

Pond 2P: RP4-MAIN Peak Elev=253.51' Storage=1.317 af Inflow=39.37 cfs 4.221 af
Outflow=8.47 cfs 4.221 af

Pond 4P: DISCHARGE POINT AT A (ZERO VOLUME POND) Inflow=112.28 cfs 19.715 af
Primary=112.28 cfs 19.715 af

Pond 5P: RP4-2 Peak Elev=299.29' Storage=0.229 af Inflow=8.02 cfs 0.627 af
6.0" Round Culvert n=0.010 L=150.0' S=0.0067 '/' Outflow=1.00 cfs 0.627 af

Pond 7P: RP5-MAIN Peak Elev=240.51' Storage=0.786 af Inflow=40.93 cfs 4.955 af
Outflow=22.51 cfs 4.955 af

Pond 8P: DISCHARGE POINT AT B (ZERO VOLUME POND) Inflow=82.30 cfs 13.608 af
Primary=82.30 cfs 13.608 af

Pond 9P: A+B at B (Zero Volume Pond) Inflow=113.73 cfs 14.231 af
Primary=113.73 cfs 14.231 af

Pond 12P: RP5-SUB-2 Peak Elev=261.38' Storage=0.163 af Inflow=7.64 cfs 0.538 af
6.0" Round Culvert n=0.015 L=160.0' S=0.0406 '/' Outflow=1.22 cfs 0.538 af

Total Runoff Area = 207.520 ac Runoff Volume = 33.946 af Average Runoff Depth = 1.96"
100.00% Pervious = 207.520 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: PRE-DEV'T - SC TO B

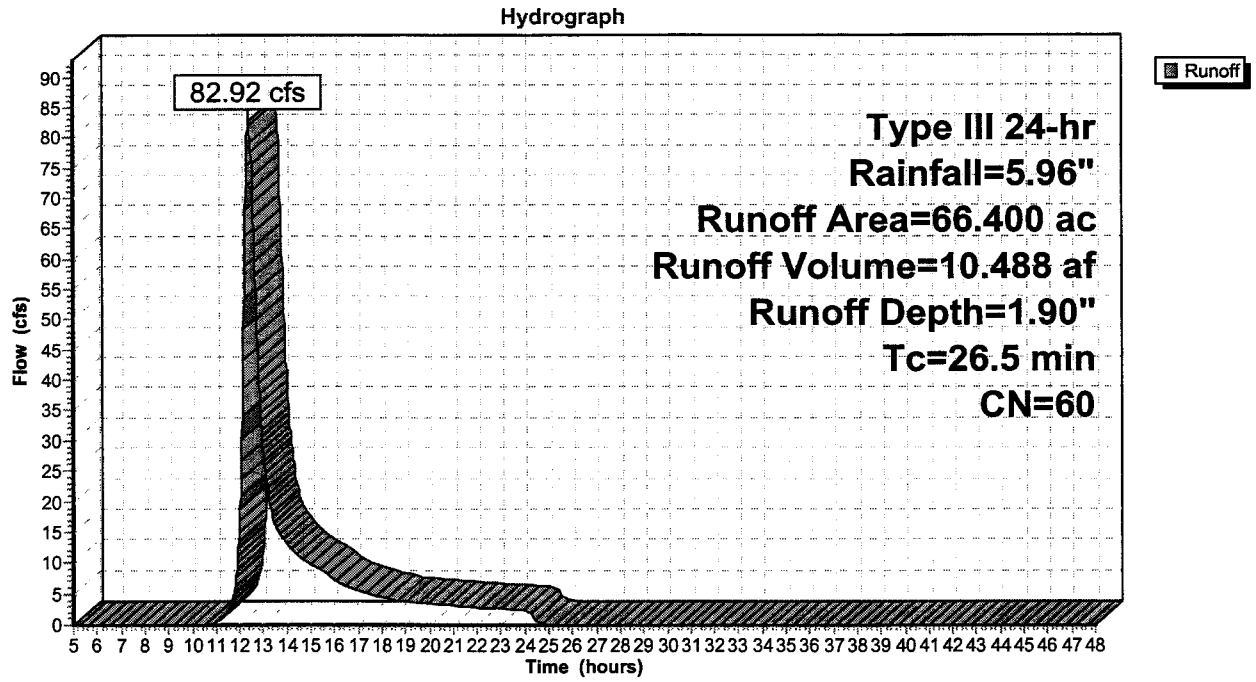
Runoff = 82.92 cfs @ 12.40 hrs, Volume= 10.488 af, Depth= 1.90"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr Rainfall=5.96"

	Area (ac)	CN	Description
*	66.400	60	
	66.400		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.5					**Direct Entry,**

Subcatchment 1S: PRE-DEV'T - SC TO B



Summary for Subcatchment 2S: PRE-DEV'T - SC TO A

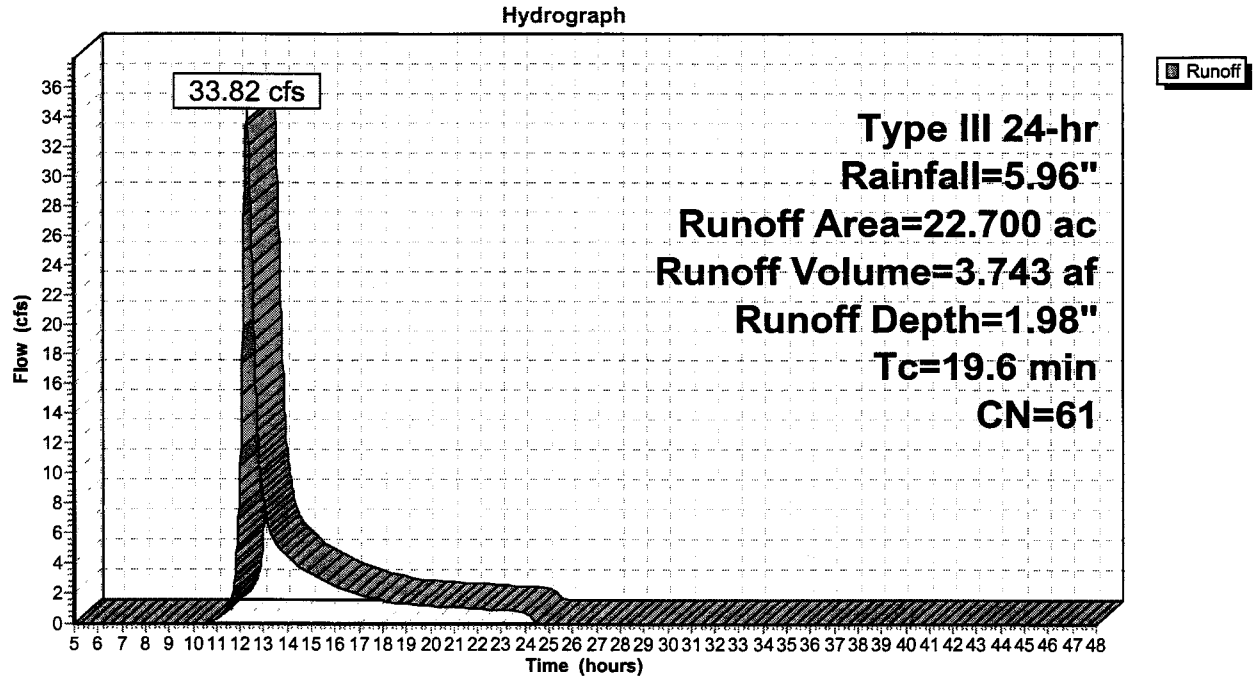
Runoff = 33.82 cfs @ 12.29 hrs, Volume= 3.743 af, Depth= 1.98"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr Rainfall=5.96"

	Area (ac)	CN	Description
*	22.700	61	
	22.700		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
19.6					**Direct Entry,**

Subcatchment 2S: PRE-DEV'T - SC TO A



Summary for Subcatchment 3S: POST-DEV'T - SC TO B

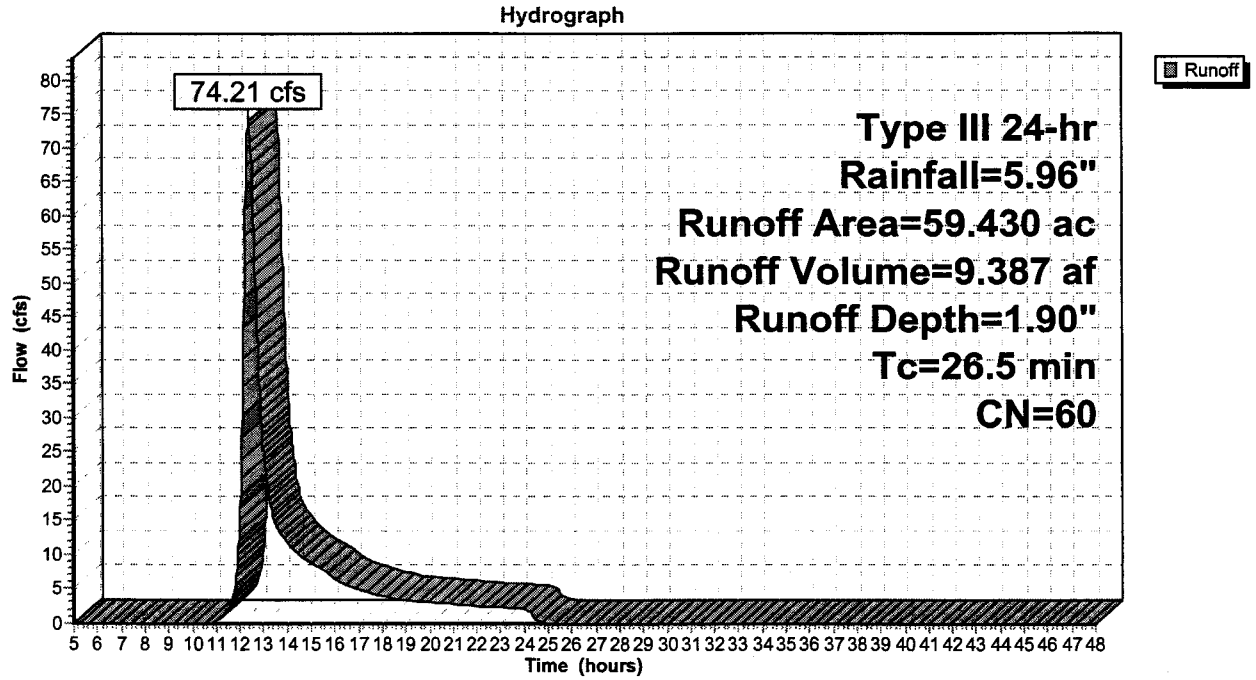
Runoff = 74.21 cfs @ 12.40 hrs, Volume= 9.387 af, Depth= 1.90"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr Rainfall=5.96"

	Area (ac)	CN	Description
*	59.430	60	
	59.430		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.5					**Direct Entry,**

Subcatchment 3S: POST-DEV'T - SC TO B



Summary for Subcatchment 4S: POST-DEV'T - SC TO A

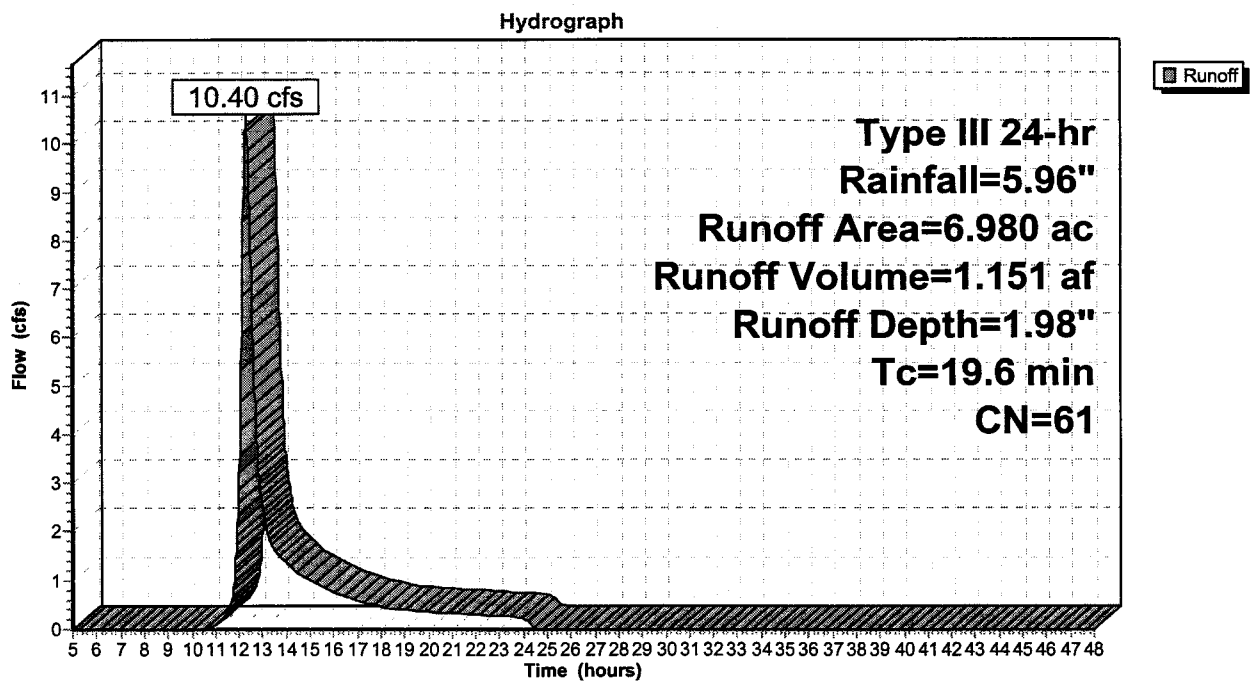
Runoff = 10.40 cfs @ 12.29 hrs, Volume= 1.151 af, Depth= 1.98"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr Rainfall=5.96"

	Area (ac)	CN	Description
*	6.980	61	
	6.980		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
19.6					**Direct Entry,**

Subcatchment 4S: POST-DEV'T - SC TO A



Summary for Subcatchment 6S: UNCONTROLLED FLOW DIFFERENTIAL

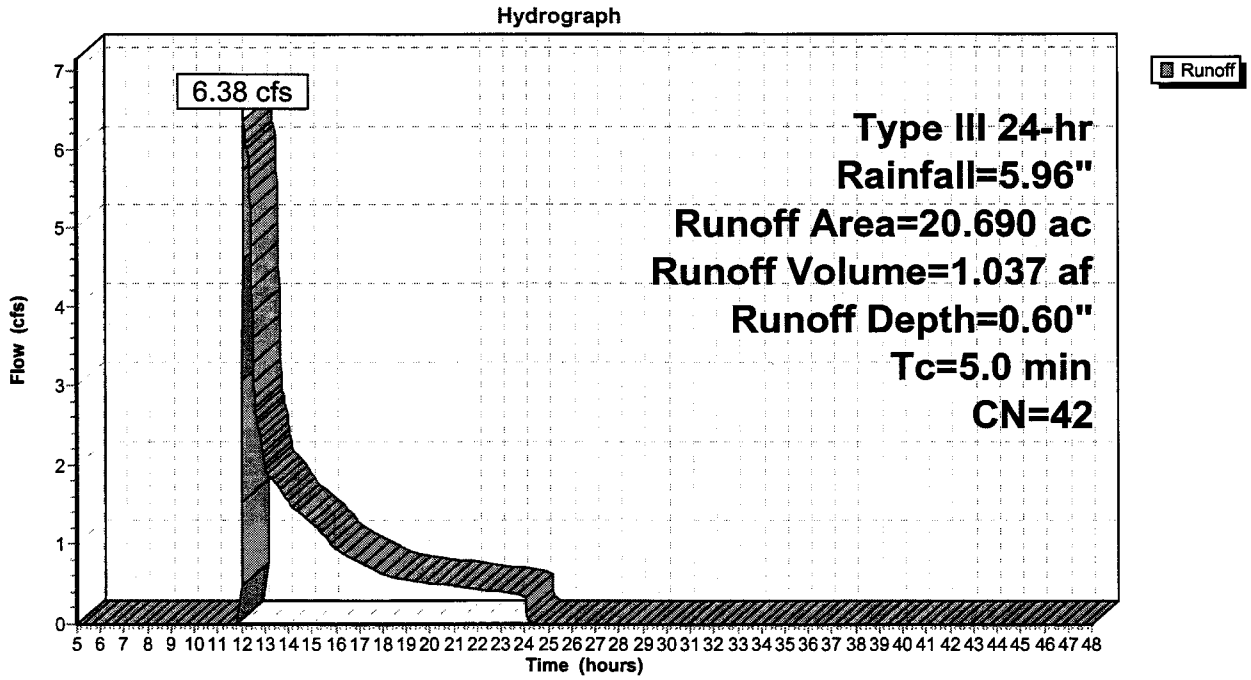
Runoff = 6.38 cfs @ 12.14 hrs, Volume= 1.037 af, Depth= 0.60"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr Rainfall=5.96"

	Area (ac)	CN	Description
*	20.690	42	
	20.690		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 6S: UNCONTROLLED FLOW DIFFERENTIAL



Summary for Subcatchment 7S: SC-1B TO SC-1A

This area backs onto the rear lots on unnamed street C-3. 5 year storm to be passed. 100 yr storm to be stored and released at ~5 year rate

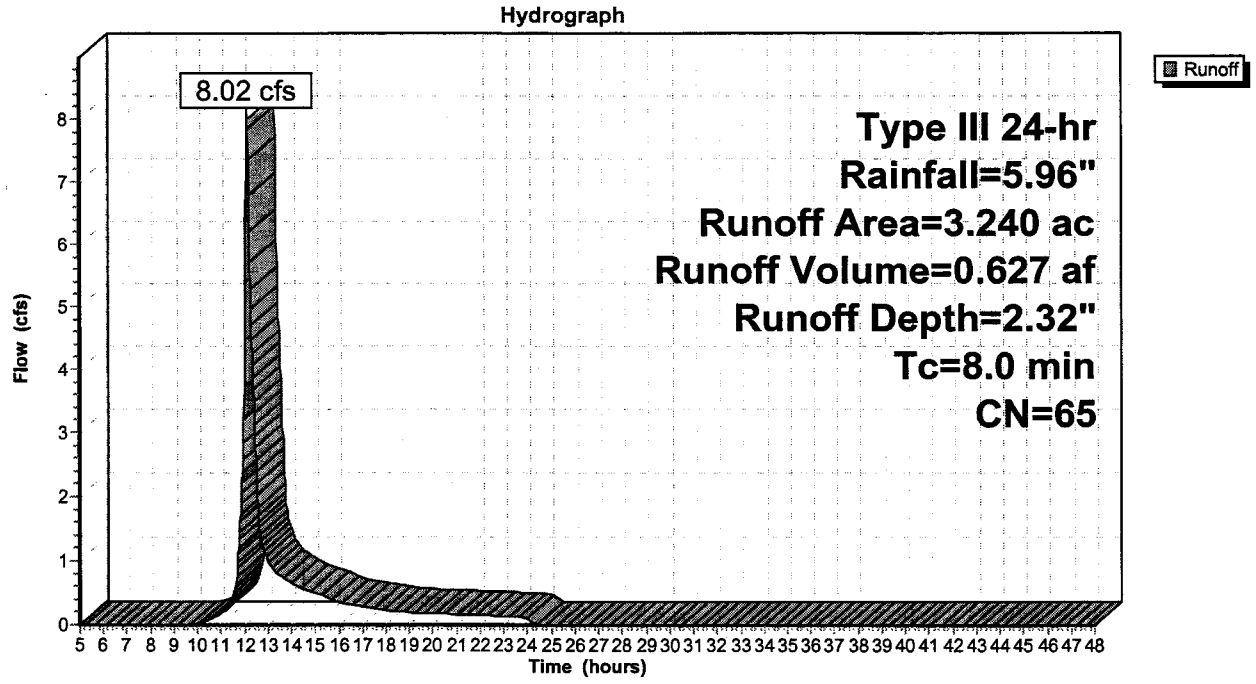
Runoff = 8.02 cfs @ 12.12 hrs, Volume= 0.627 af, Depth= 2.32"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr Rainfall=5.96"

	Area (ac)	CN	Description
*	3.240	65	
	3.240		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.0					**Direct Entry,**

Subcatchment 7S: SC-1B TO SC-1A



Summary for Subcatchment 8S: SC-1A TO RP4

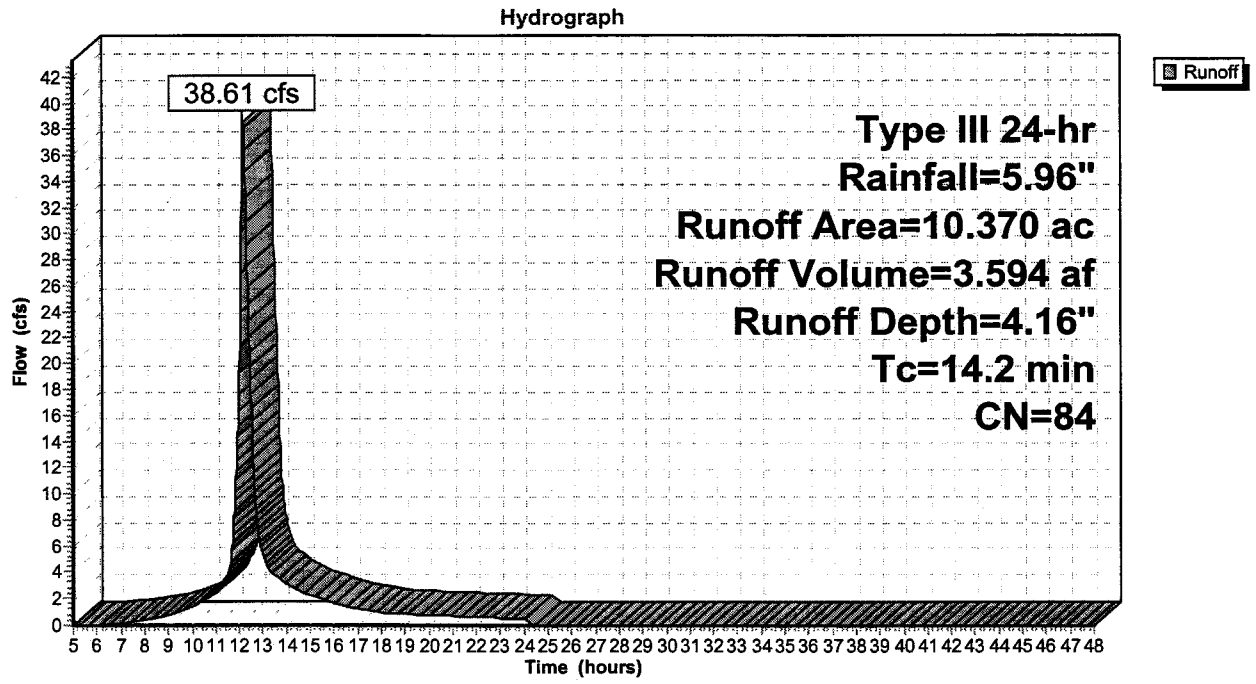
Runoff = 38.61 cfs @ 12.19 hrs, Volume= 3.594 af, Depth= 4.16"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr Rainfall=5.96"

	Area (ac)	CN	Description
*	10.370	84	
	10.370		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.2					**Direct Entry,**

Subcatchment 8S: SC-1A TO RP4



Summary for Subcatchment 9S: SC-2 TO SC-1

SC-2 to SC-1 drains SC-2 into SC-1. The 100 year flood is retained and released at the equivalent 5 year flow rate.

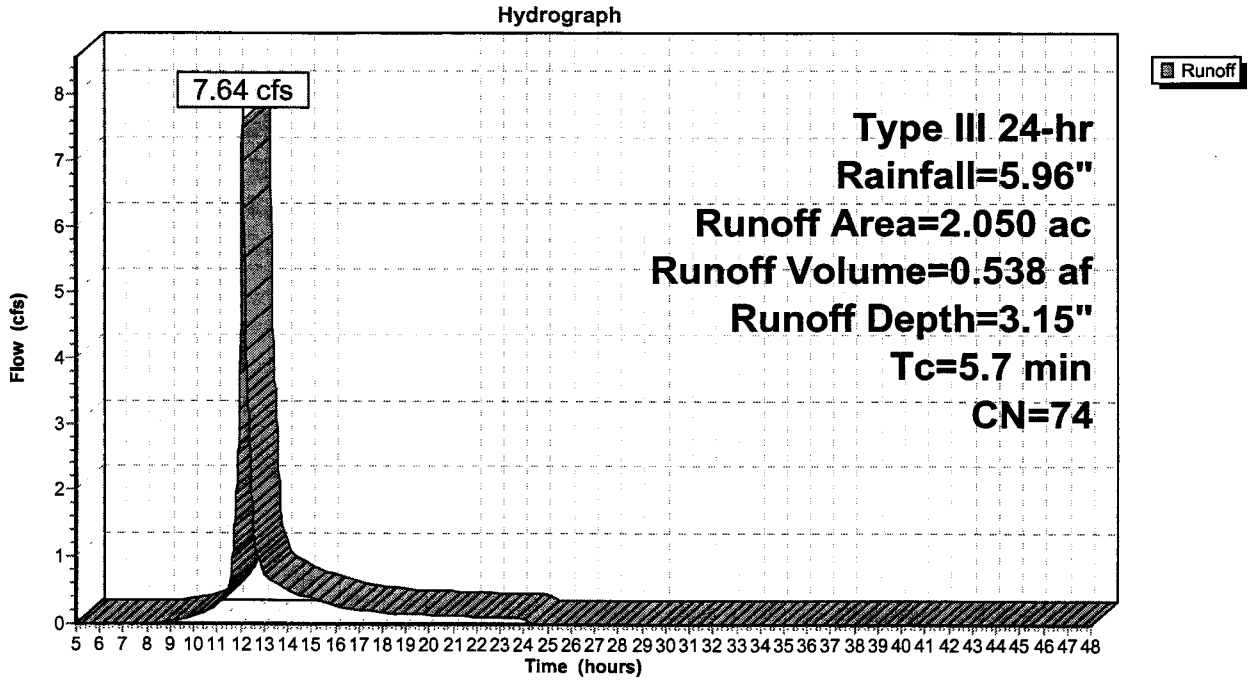
Runoff = 7.64 cfs @ 12.09 hrs, Volume= 0.538 af, Depth= 3.15"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr Rainfall=5.96"

	Area (ac)	CN	Description
*	2.050	74	
	2.050		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.7					**Direct Entry,**

Subcatchment 9S: SC-2 TO SC-1



Summary for Subcatchment 10S: SC-1 TO RP-5

SC-1 to RP-5 drains directly to RP-5

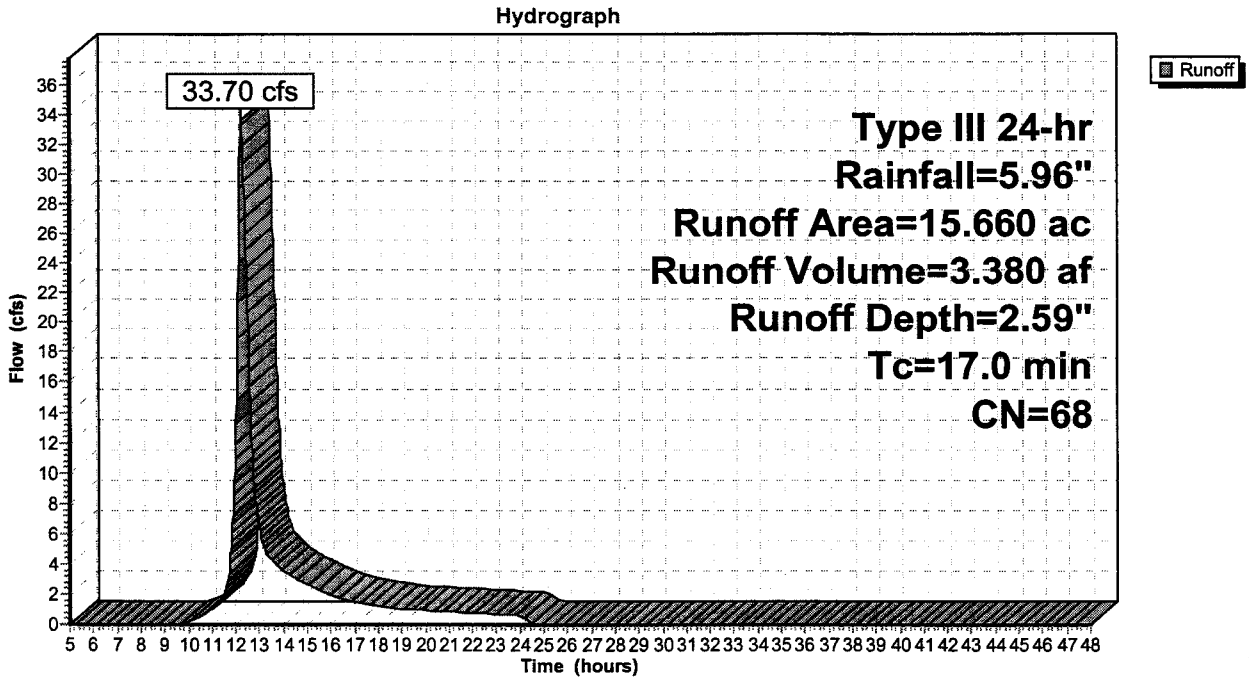
Runoff = 33.70 cfs @ 12.24 hrs, Volume= 3.380 af, Depth= 2.59"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr Rainfall=5.96"

	Area (ac)	CN	Description
*	15.660	68	
	15.660		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.0					**Direct Entry,**

Subcatchment 10S: SC-1 TO RP-5



Summary for Reach 3R: POND/BROOK BETWEEN B & A

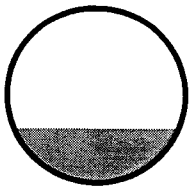
[52] Hint: Inlet/Outlet conditions not evaluated

Inflow Area = 73.040 ac, 0.00% Impervious, Inflow Depth = 2.24"
Inflow = 82.30 cfs @ 12.40 hrs, Volume= 13.608 af
Outflow = 81.79 cfs @ 12.47 hrs, Volume= 13.608 af, Atten= 1%, Lag= 3.9 min

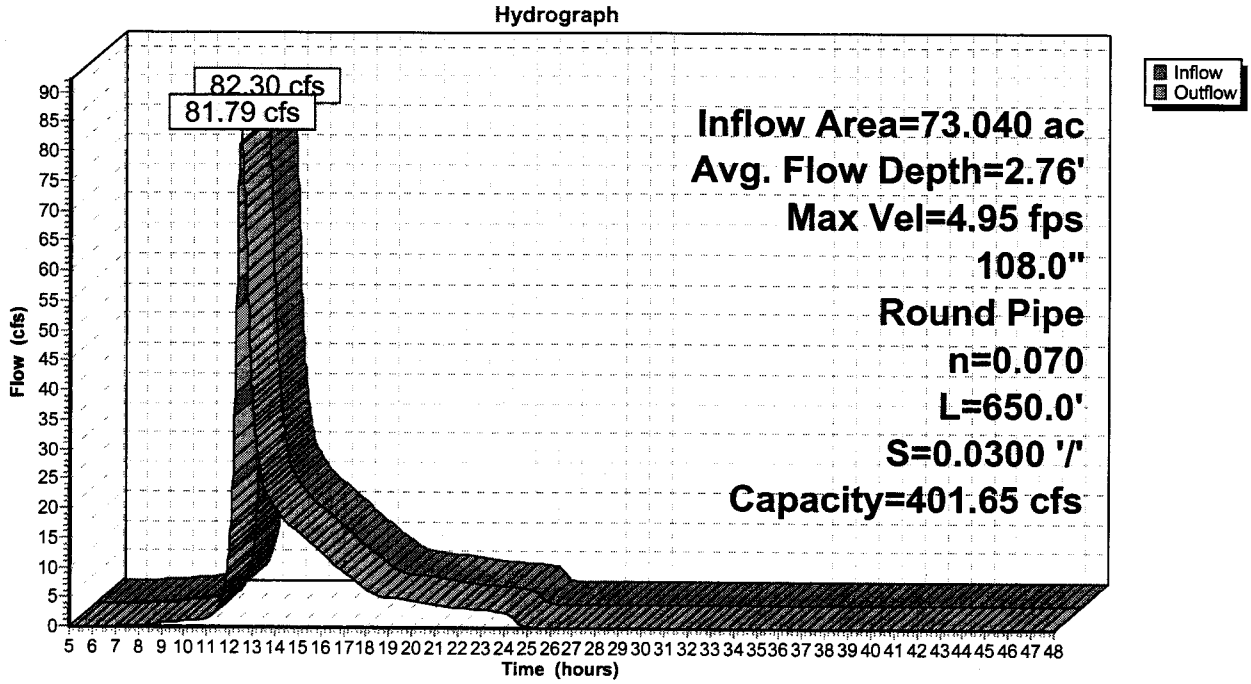
Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.02 hrs
Max. Velocity= 4.95 fps, Min. Travel Time= 2.2 min
Avg. Velocity = 1.86 fps, Avg. Travel Time= 5.8 min

Peak Storage= 10,731 cf @ 12.43 hrs
Average Depth at Peak Storage= 2.76'
Bank-Full Depth= 9.00', Capacity at Bank-Full= 401.65 cfs

108.0" Round Pipe
n= 0.070 Sluggish weedy reaches w/pools
Length= 650.0' Slope= 0.0300 '/'
Inlet Invert= 236.50', Outlet Invert= 217.00'



Reach 3R: POND/BROOK BETWEEN B & A



Summary for Reach 6R: VIRTUAL REACH

Used virtual reach to allow travel time to RP4

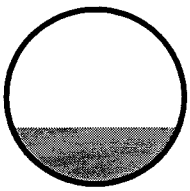
[52] Hint: Inlet/Outlet conditions not evaluated

Inflow Area = 3.240 ac, 0.00% Impervious, Inflow Depth = 2.32"
Inflow = 1.00 cfs @ 13.02 hrs, Volume= 0.627 af
Outflow = 1.00 cfs @ 13.17 hrs, Volume= 0.627 af, Atten= 0%, Lag= 8.9 min

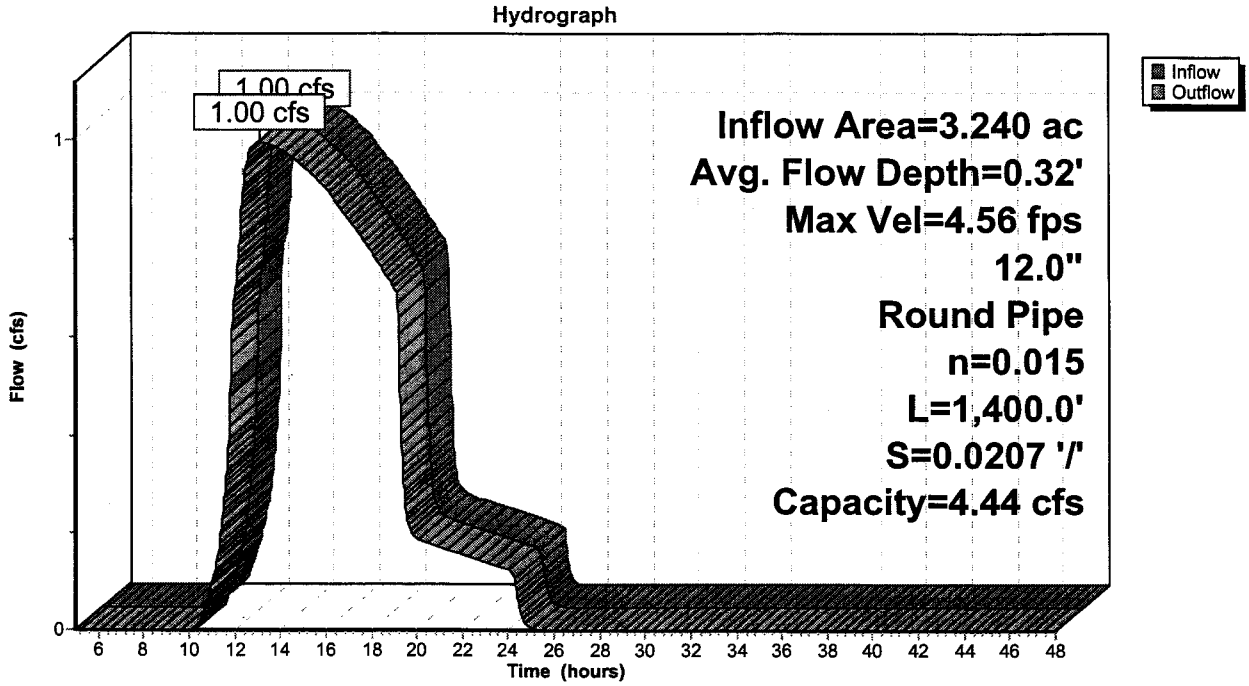
Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.02 hrs
Max. Velocity= 4.56 fps, Min. Travel Time= 5.1 min
Avg. Velocity = 2.97 fps, Avg. Travel Time= 7.9 min

Peak Storage= 306 cf @ 13.08 hrs
Average Depth at Peak Storage= 0.32'
Bank-Full Depth= 1.00', Capacity at Bank-Full= 4.44 cfs

12.0" Round Pipe
n= 0.015 Concrete sewer w/manholes & inlets
Length= 1,400.0' Slope= 0.0207 '/'
Inlet Invert= 289.00', Outlet Invert= 260.00'



Reach 6R: VIRTUAL REACH



Summary for Reach 11R: REACH

Allows for pipe travel time

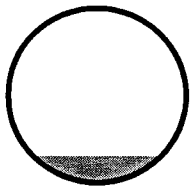
[52] Hint: Inlet/Outlet conditions not evaluated

Inflow Area = 2.050 ac, 0.00% Impervious, Inflow Depth = 3.15"
Inflow = 1.22 cfs @ 12.59 hrs, Volume= 0.538 af
Outflow = 1.22 cfs @ 12.62 hrs, Volume= 0.538 af, Atten= 0%, Lag= 2.0 min

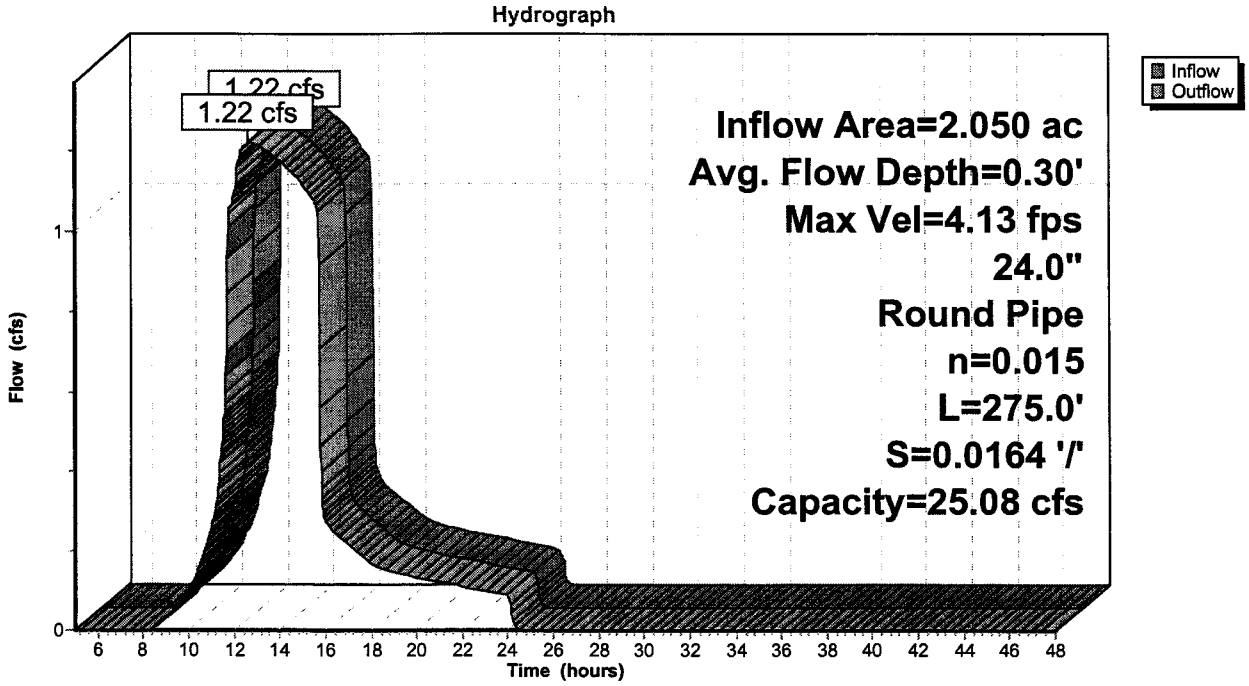
Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.02 hrs
Max. Velocity= 4.13 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 2.55 fps, Avg. Travel Time= 1.8 min

Peak Storage= 81 cf @ 12.60 hrs
Average Depth at Peak Storage= 0.30'
Bank-Full Depth= 2.00', Capacity at Bank-Full= 25.08 cfs

24.0" Round Pipe
n= 0.015 Concrete sewer w/manholes & inlets
Length= 275.0' Slope= 0.0164 '/'
Inlet Invert= 249.50', Outlet Invert= 245.00'



Reach 11R: REACH



Summary for Pond 2P: RP4-MAIN

Inflow Area = 13.610 ac, 0.00% Impervious, Inflow Depth = 3.72"
Inflow = 39.37 cfs @ 12.19 hrs, Volume= 4.221 af
Outflow = 8.47 cfs @ 12.76 hrs, Volume= 4.221 af, Atten= 78%, Lag= 34.3 min
Primary = 8.47 cfs @ 12.76 hrs, Volume= 4.221 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 253.51' @ 12.76 hrs Surf.Area= 0.189 ac Storage= 1.317 af

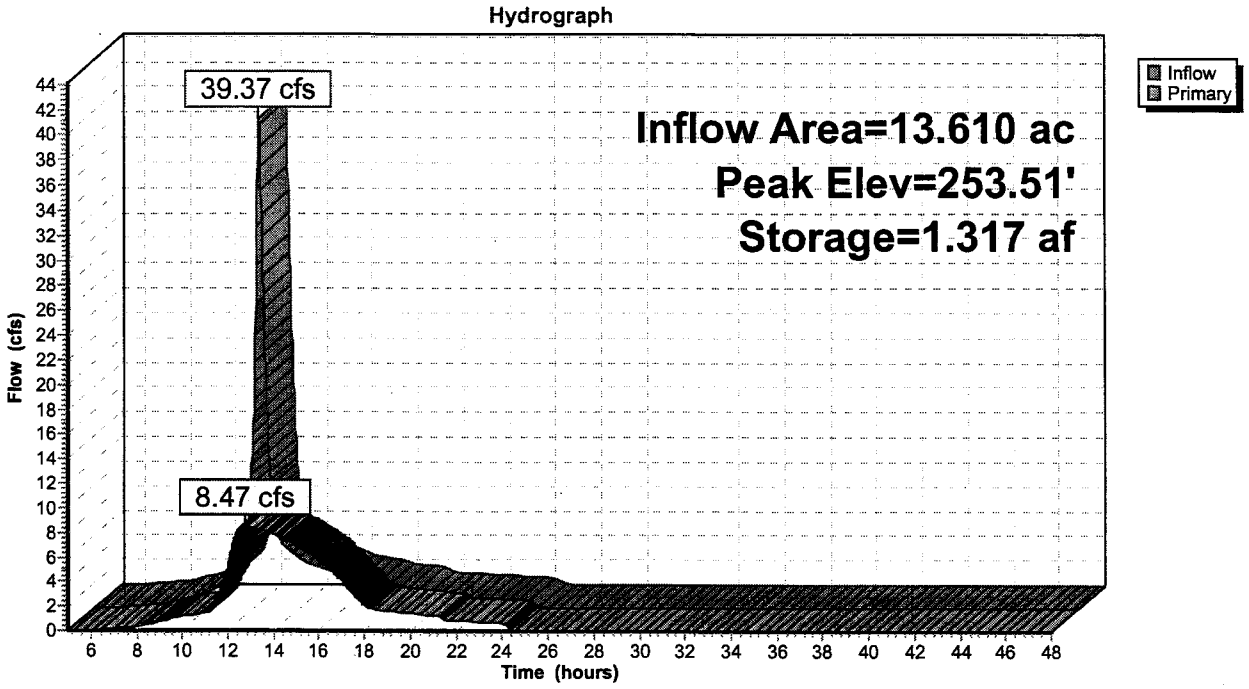
Plug-Flow detention time= 62.4 min calculated for 4.219 af (100% of inflow)
Center-of-Mass det. time= 62.4 min (895.7 - 833.3)

Volume	Invert	Avail.Storage	Storage Description
#1	240.00'	2.931 af	**25.00'W x 50.00'L x 20.00'H Prismatoid Z=2.0**

Device	Routing	Invert	Outlet Devices
#1	Primary	238.00'	**6.0" Round Culvert - 5 Yr** L= 50.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 238.00' / 237.00' S= 0.0200 '/' Cc= 0.900 n= 0.012 Steel, smooth
#2	Primary	242.00'	**8.0" Round Culvert - 5 Yr** L= 50.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 242.00' / 237.00' S= 0.1000 '/' Cc= 0.900 n= 0.012 Steel, smooth

Primary OutFlow Max=8.47 cfs @ 12.76 hrs HW=253.51' (Free Discharge)
↑—**1=Culvert - 5 Yr** (Barrel Controls 2.86 cfs @ 14.55 fps)
└—**2=Culvert - 5 Yr** (Inlet Controls 5.62 cfs @ 16.09 fps)

Pond 2P: RP4-MAIN



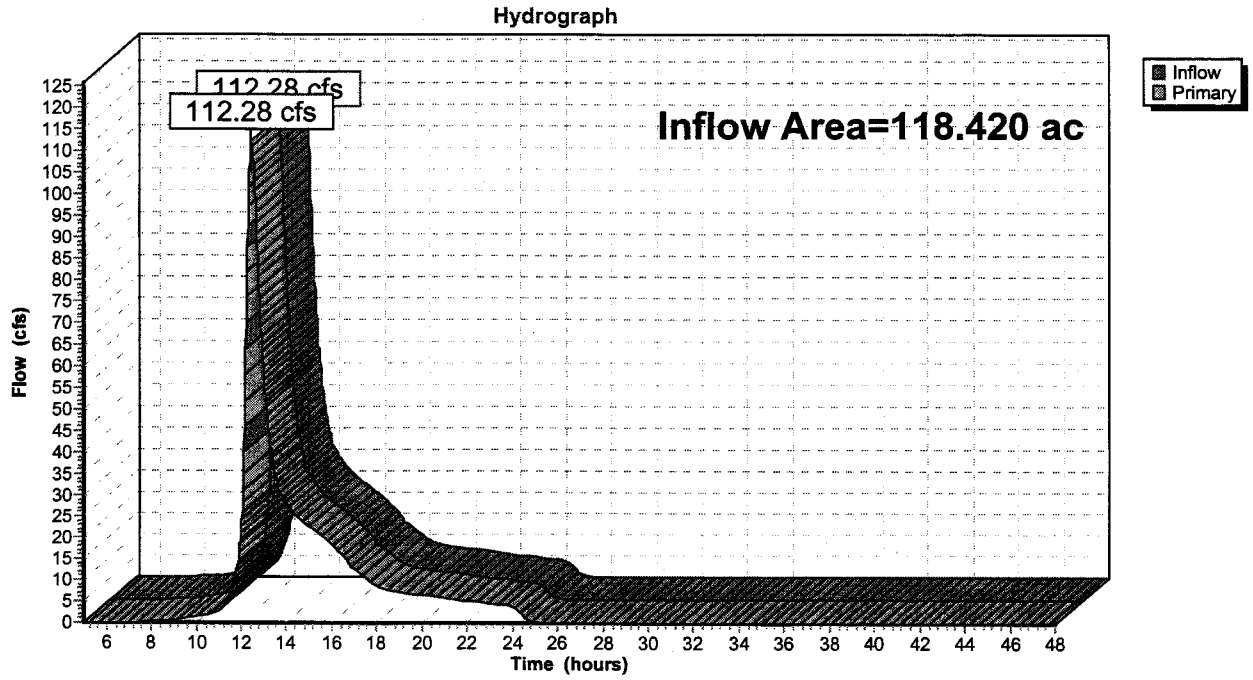
Summary for Pond 4P: DISCHARGE POINT AT A (ZERO VOLUME POND)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 118.420 ac, 0.00% Impervious, Inflow Depth = 2.00"
Inflow = 112.28 cfs @ 12.46 hrs, Volume= 19.715 af
Primary = 112.28 cfs @ 12.46 hrs, Volume= 19.715 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.02 hrs

Pond 4P: DISCHARGE POINT AT A (ZERO VOLUME POND)



Summary for Pond 5P: RP4-2

Backyard private retention pond formed by construction of road.

Inflow Area = 3.240 ac, 0.00% Impervious, Inflow Depth = 2.32"
Inflow = 8.02 cfs @ 12.12 hrs, Volume= 0.627 af
Outflow = 1.00 cfs @ 13.02 hrs, Volume= 0.627 af, Atten= 88%, Lag= 53.9 min
Primary = 1.00 cfs @ 13.02 hrs, Volume= 0.627 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 299.29' @ 13.02 hrs Surf.Area= 0.141 ac Storage= 0.229 af

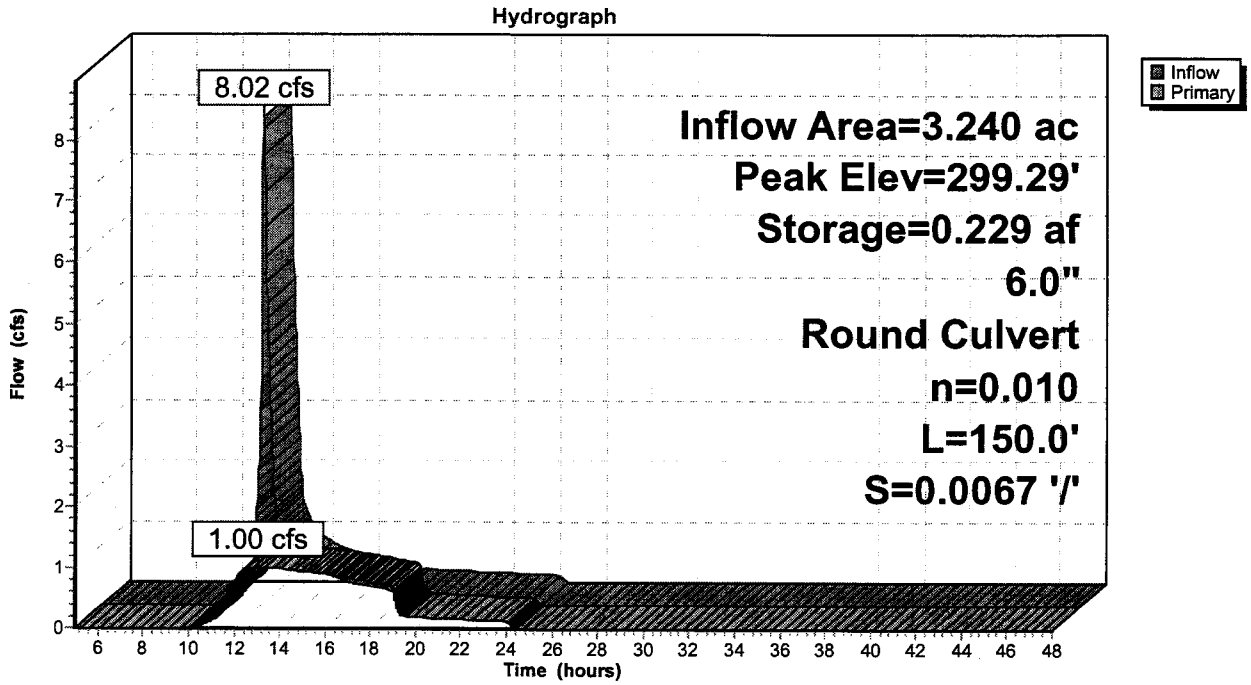
Plug-Flow detention time= 95.9 min calculated for 0.627 af (100% of inflow)
Center-of-Mass det. time= 95.9 min (948.3 - 852.4)

Volume	Invert	Avail.Storage	Storage Description
#1	297.50'	0.963 af	**50.00'W x 100.00'L x 6.00'H Prismatoid Z=2.0**

Device	Routing	Invert	Outlet Devices
#1	Primary	296.50'	**6.0" Round Culvert** L= 150.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 296.50' / 295.50' S= 0.0067 '/' Cc= 0.900 n= 0.010 PVC, smooth interior

Primary OutFlow Max=1.00 cfs @ 13.02 hrs HW=299.29' (Free Discharge)
1=Culvert (Barrel Controls 1.00 cfs @ 5.08 fps)

Pond 5P: RP4-2



Summary for Pond 7P: RP5-MAIN

Inflow Area = 38.400 ac, 0.00% Impervious, Inflow Depth = 1.55"
Inflow = 40.93 cfs @ 12.24 hrs, Volume= 4.955 af
Outflow = 22.51 cfs @ 12.55 hrs, Volume= 4.955 af, Atten= 45%, Lag= 18.6 min
Primary = 22.51 cfs @ 12.55 hrs, Volume= 4.955 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 240.51' @ 12.55 hrs Surf.Area= 0.171 ac Storage= 0.786 af

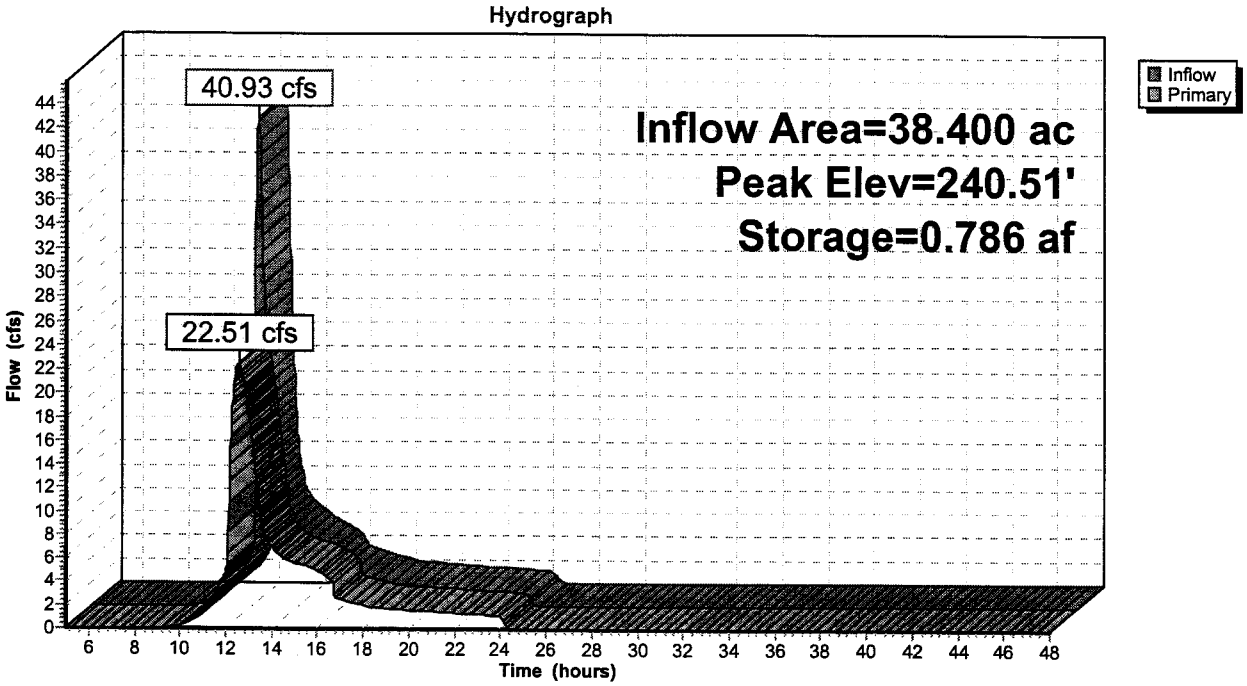
Plug-Flow detention time= 16.1 min calculated for 4.953 af (100% of inflow)
Center-of-Mass det. time= 16.1 min (888.9 - 872.8)

Volume	Invert	Avail.Storage	Storage Description
#1	234.00'	1.491 af	**33.00'W x 100.00'L x 10.00'H Prismatoid Z=2.0**

Device	Routing	Invert	Outlet Devices
#1	Primary	232.00'	**10.0" Round Culvert** L= 50.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 232.00' / 231.00' S= 0.0200 '/' Cc= 0.900 n= 0.011 Concrete pipe, straight & clean
#2	Primary	236.00'	**15.0" Round Culvert** L= 50.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 236.00' / 231.00' S= 0.1000 '/' Cc= 0.900 n= 0.011 Concrete pipe, straight & clean

Primary OutFlow Max=22.50 cfs @ 12.55 hrs HW=240.51' (Free Discharge)
└**1=Culvert** (Barrel Controls 7.95 cfs @ 14.57 fps)
└**2=Culvert** (Inlet Controls 14.56 cfs @ 11.86 fps)

Pond 7P: RP5-MAIN



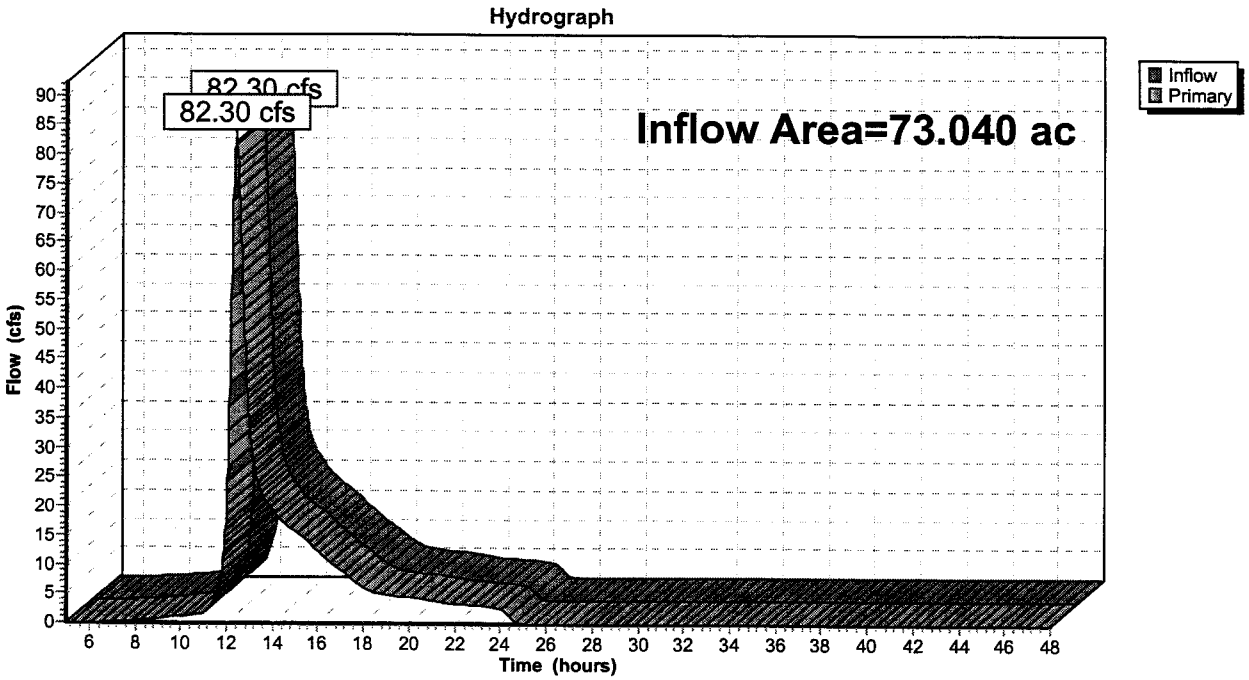
Summary for Pond 8P: DISCHARGE POINT AT B (ZERO VOLUME POND)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 73.040 ac, 0.00% Impervious, Inflow Depth = 2.24"
Inflow = 82.30 cfs @ 12.40 hrs, Volume= 13.608 af
Primary = 82.30 cfs @ 12.40 hrs, Volume= 13.608 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.02 hrs

Pond 8P: DISCHARGE POINT AT B (ZERO VOLUME POND)



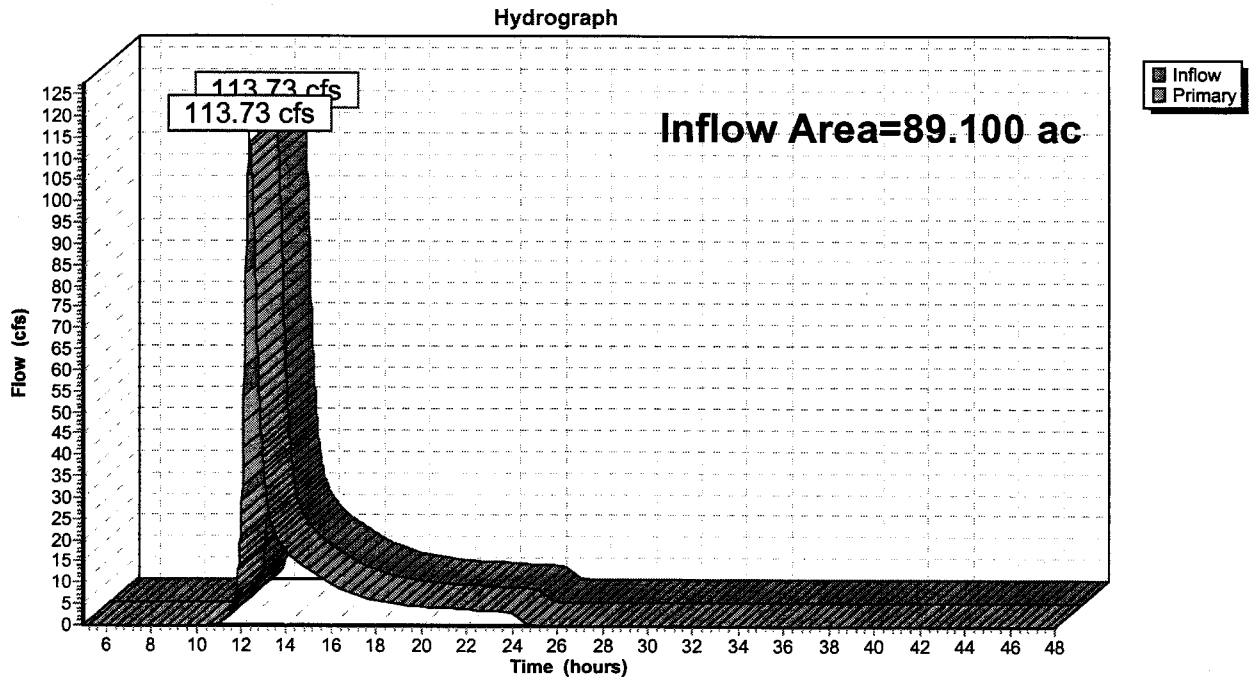
Summary for Pond 9P: A+B at B (Zero Volume Pond)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 89.100 ac, 0.00% Impervious, Inflow Depth = 1.92"
Inflow = 113.73 cfs @ 12.37 hrs, Volume= 14.231 af
Primary = 113.73 cfs @ 12.37 hrs, Volume= 14.231 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.02 hrs

Pond 9P: A+B at B (Zero Volume Pond)



Summary for Pond 12P: RP5-SUB-2

RP5-SUB-2 retention pond holds the 100 year precipitation event while releasing a 5 year rainfall flow rate. It is a back yard private retention pond.

Inflow Area =	2.050 ac,	0.00% Impervious,	Inflow Depth =	3.15"
Inflow =	7.64 cfs @	12.09 hrs, Volume=	0.538 af	
Outflow =	1.22 cfs @	12.59 hrs, Volume=	0.538 af,	Atten= 84%, Lag= 30.1 min
Primary =	1.22 cfs @	12.59 hrs, Volume=	0.538 af	

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 261.38' @ 12.59 hrs Surf.Area= 0.080 ac Storage= 0.163 af

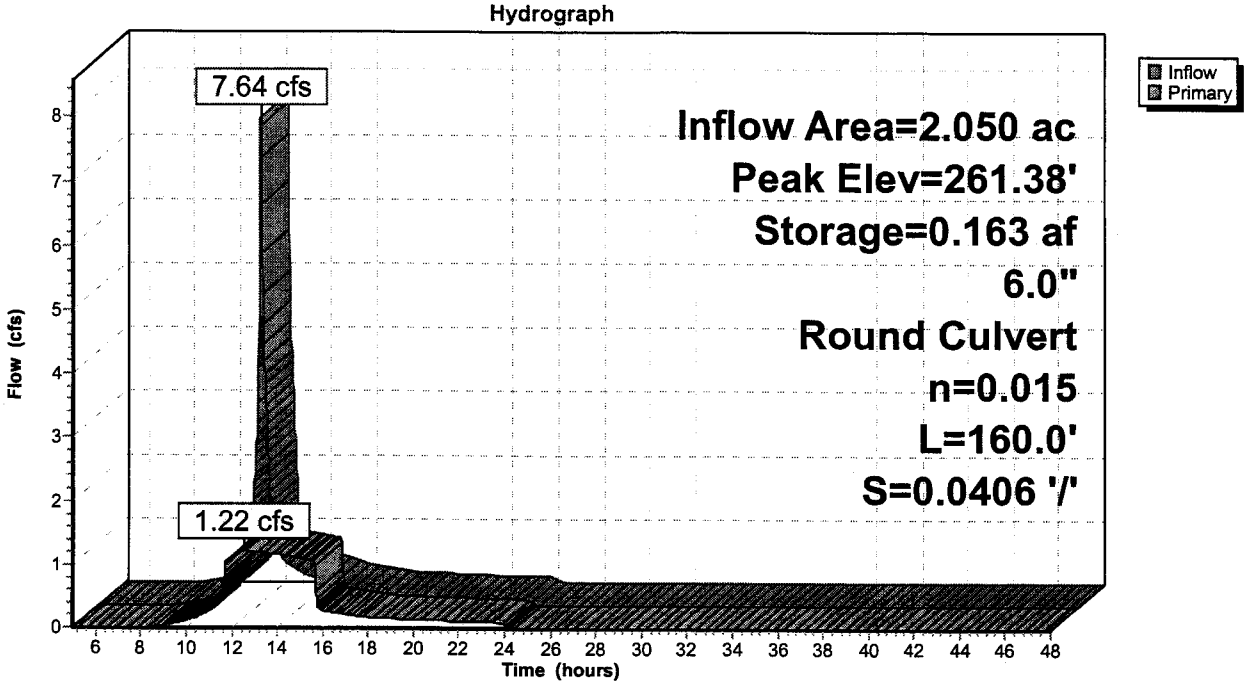
Plug-Flow detention time= 41.4 min calculated for 0.538 af (100% of inflow)
Center-of-Mass det. time= 41.4 min (870.2 - 828.8)

Volume	Invert	Avail.Storage	Storage Description
#1	258.50'	1.201 af	**150.00'W x 10.00'L x 10.00'H Prismatoid Z=2.0**

Device	Routing	Invert	Outlet Devices
#1	Primary	256.50'	**6.0" Round Culvert** L= 160.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 256.50' / 250.00' S= 0.0406 '/' Cc= 0.900 n= 0.015 Concrete sewer w/manholes & inlets

Primary OutFlow Max=1.22 cfs @ 12.59 hrs HW=261.38' (Free Discharge)
↑**1=Culvert** (Barrel Controls 1.22 cfs @ 6.23 fps)

Pond 12P: RP5-SUB-2

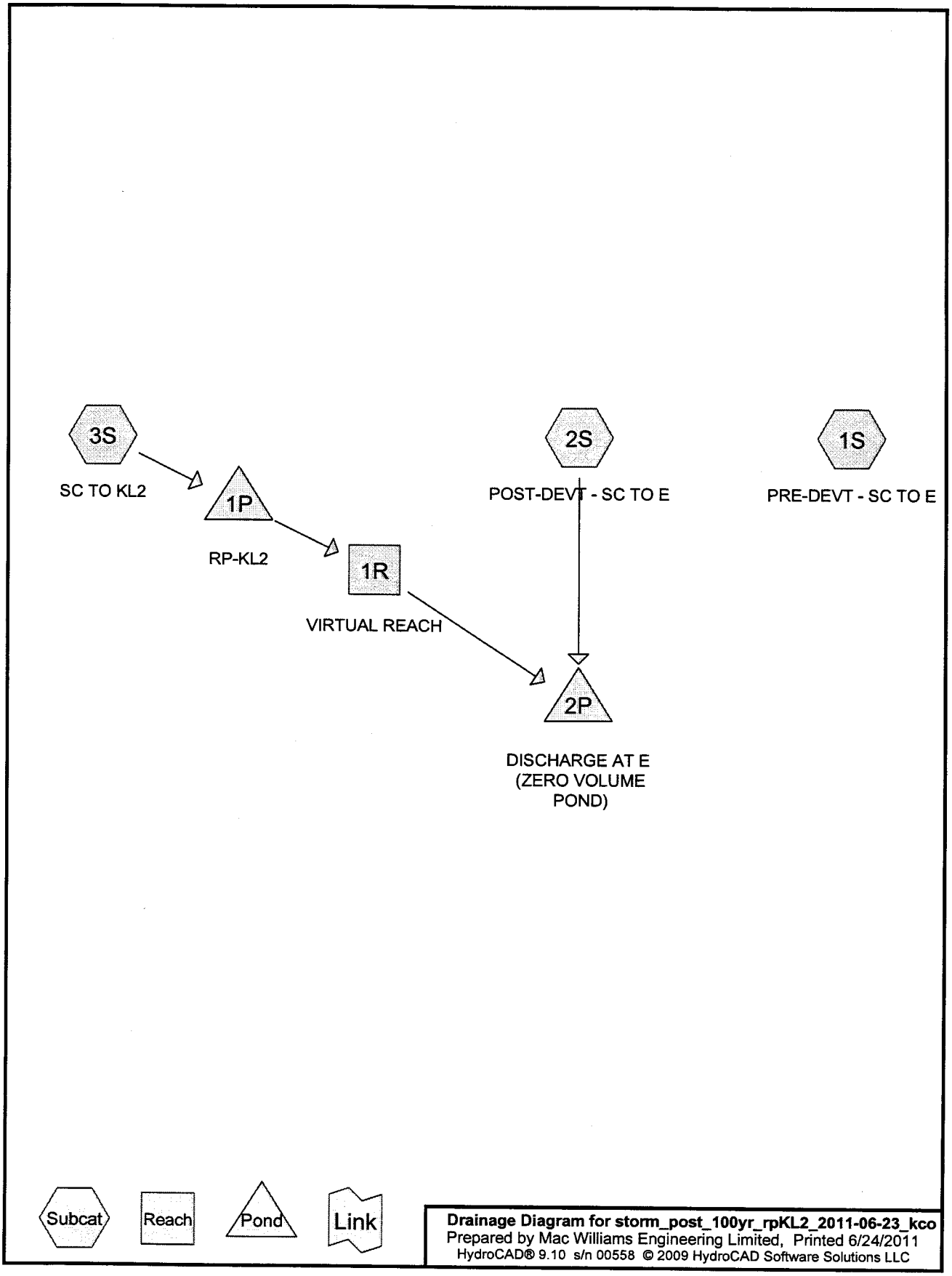


APPENDIX D-4

100 YEAR KL2

PRE-DEVELOPMENT AND POST-DEVELOPMENT

MODELING RESULTS FOR DESIGN STORM EVENTS



Drainage Diagram for storm_post_100yr_rpKL2_2011-06-23_kco
Prepared by Mac Williams Engineering Limited, Printed 6/24/2011

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
35.680	61	(1S, 2S)
30.200	68	(3S)
65.880		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
65.880	Other	1S, 2S, 3S
65.880		**TOTAL AREA**

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Fill (inches)
1	1R	240.00	200.00	1,050.0	0.0381	0.070	192.0	0.0	0.0
2	1P	248.00	247.00	50.0	0.0200	0.011	15.0	0.0	0.0
3	1P	250.00	249.00	50.0	0.0200	0.011	15.0	0.0	0.0

Time span=5.00-36.00 hrs, dt=0.05 hrs, 621 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: PRE-DEVT - SC TO E Runoff Area=26.400 ac 0.00% Impervious Runoff Depth=1.98"
Tc=23.5 min CN=61 Runoff=36.44 cfs 4.353 af

Subcatchment2S: POST-DEVT - SC TO E Runoff Area=9.280 ac 0.00% Impervious Runoff Depth=1.98"
Tc=23.5 min CN=61 Runoff=12.81 cfs 1.530 af

Subcatchment3S: SC TO KL2 Runoff Area=30.200 ac 0.00% Impervious Runoff Depth=2.59"
Tc=34.0 min CN=68 Runoff=48.17 cfs 6.519 af

Reach 1R: VIRTUAL REACH Avg. Flow Depth=1.32' Max Vel=3.71 fps Inflow=29.21 cfs 6.519 af
192.0" Round Pipe n=0.070 L=1,050.0' S=0.0381 '/' Capacity=2,099.23 cfs Outflow=29.11 cfs 6.519 af

Pond 1P: RP-KL2 Peak Elev=257.50' Storage=1.046 af Inflow=48.17 cfs 6.519 af
Outflow=29.21 cfs 6.519 af

Pond 2P: DISCHARGE AT E (ZERO VOLUME POND) Inflow=33.47 cfs 8.049 af
Primary=33.47 cfs 8.049 af

Total Runoff Area = 65.880 ac Runoff Volume = 12.402 af Average Runoff Depth = 2.26"
100.00% Pervious = 65.880 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: PRE-DEVT - SC TO E

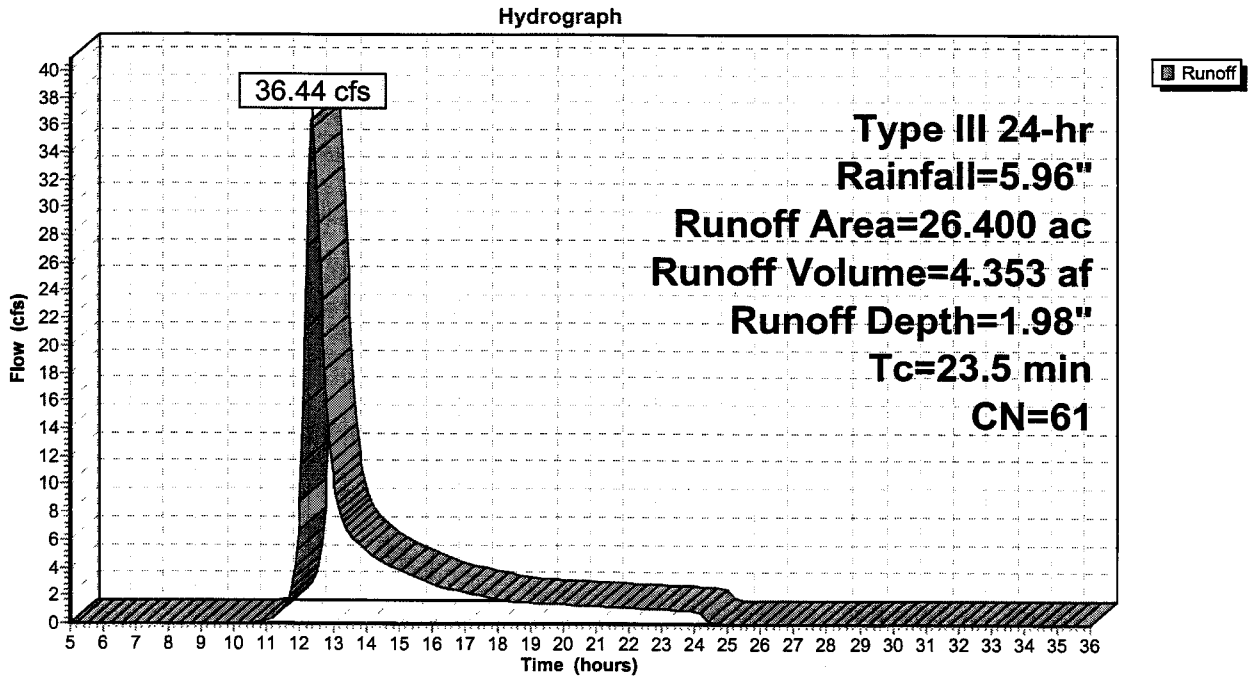
Runoff = 36.44 cfs @ 12.35 hrs, Volume= 4.353 af, Depth= 1.98"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr Rainfall=5.96"

	Area (ac)	CN	Description
*	26.400	61	
	26.400		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.5					**Direct Entry,**

Subcatchment 1S: PRE-DEVT - SC TO E



Summary for Subcatchment 2S: POST-DEVT - SC TO E

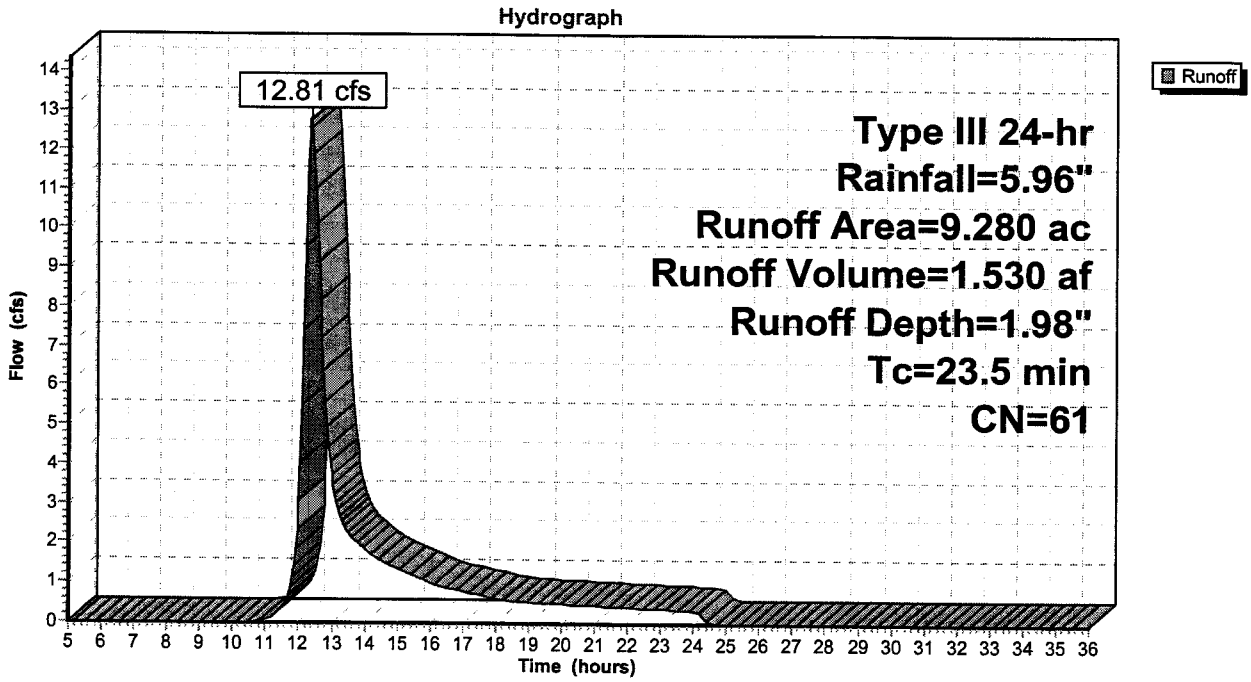
Runoff = 12.81 cfs @ 12.35 hrs, Volume= 1.530 af, Depth= 1.98"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr Rainfall=5.96"

	Area (ac)	CN	Description
*	9.280	61	
	9.280		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.5					**Direct Entry,**

Subcatchment 2S: POST-DEVT - SC TO E



Summary for Subcatchment 3S: SC TO KL2

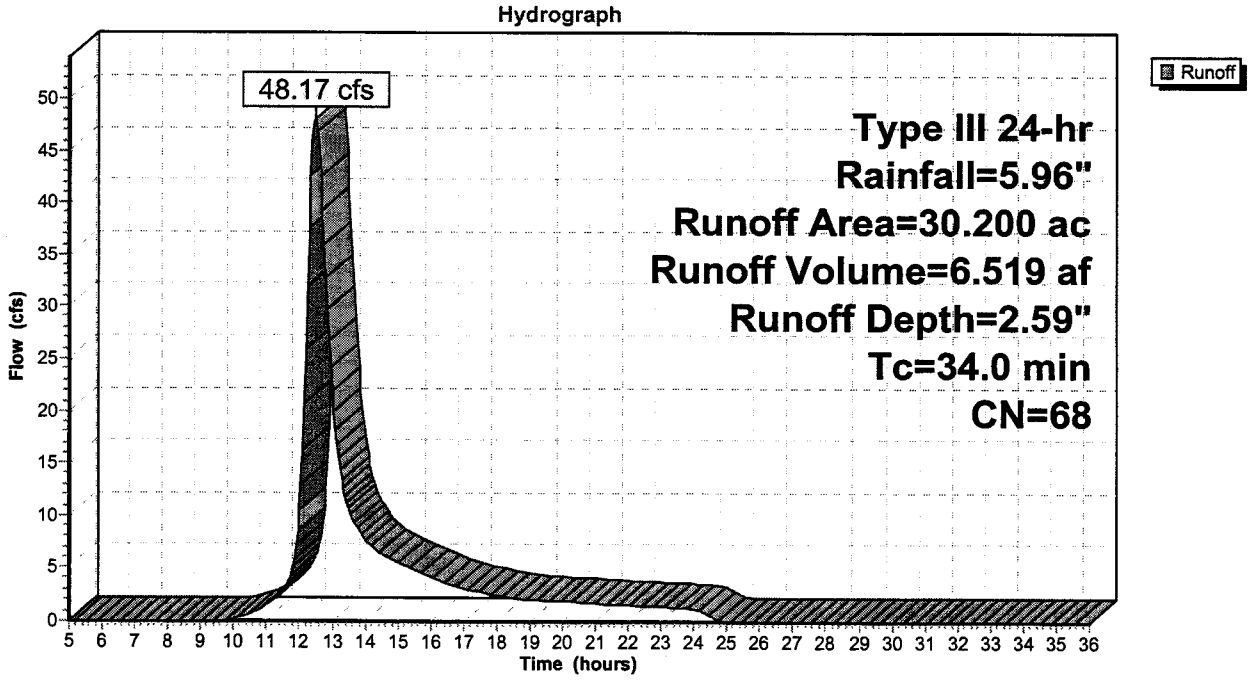
Runoff = 48.17 cfs @ 12.49 hrs, Volume= 6.519 af, Depth= 2.59"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr Rainfall=5.96"

	Area (ac)	CN	Description
*	30.200	68	
	30.200		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
34.0					**Direct Entry,**

Subcatchment 3S: SC TO KL2



Summary for Reach 1R: VIRTUAL REACH

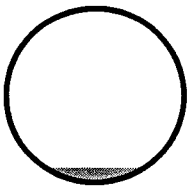
[52] Hint: Inlet/Outlet conditions not evaluated

Inflow Area = 30.200 ac, 0.00% Impervious, Inflow Depth = 2.59"
Inflow = 29.21 cfs @ 12.86 hrs, Volume= 6.519 af
Outflow = 29.11 cfs @ 13.00 hrs, Volume= 6.519 af, Atten= 0%, Lag= 8.3 min

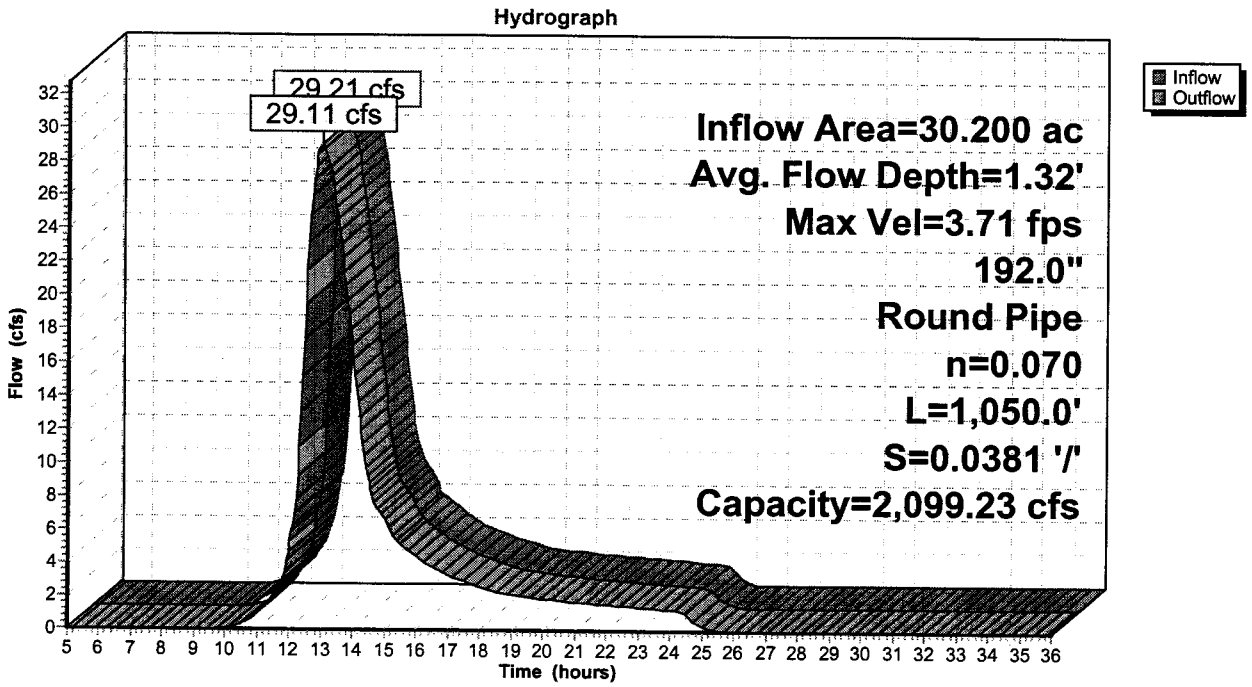
Routing by Stor-Ind+Trans method, Time Span= 5.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.71 fps, Min. Travel Time= 4.7 min
Avg. Velocity = 1.76 fps, Avg. Travel Time= 9.9 min

Peak Storage= 8,251 cf @ 12.92 hrs
Average Depth at Peak Storage= 1.32'
Bank-Full Depth= 16.00', Capacity at Bank-Full= 2,099.23 cfs

192.0" Round Pipe
n= 0.070 Sluggish weedy reaches w/pools
Length= 1,050.0' Slope= 0.0381 '/'
Inlet Invert= 240.00', Outlet Invert= 200.00'



Reach 1R: VIRTUAL REACH



Summary for Pond 1P: RP-KL2

Inflow Area = 30.200 ac, 0.00% Impervious, Inflow Depth = 2.59"
Inflow = 48.17 cfs @ 12.49 hrs, Volume= 6.519 af
Outflow = 29.21 cfs @ 12.86 hrs, Volume= 6.519 af, Atten= 39%, Lag= 22.1 min
Primary = 29.21 cfs @ 12.86 hrs, Volume= 6.519 af

Routing by Stor-Ind method, Time Span= 5.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 257.50' @ 12.86 hrs Surf.Area= 0.170 ac Storage= 1.046 af

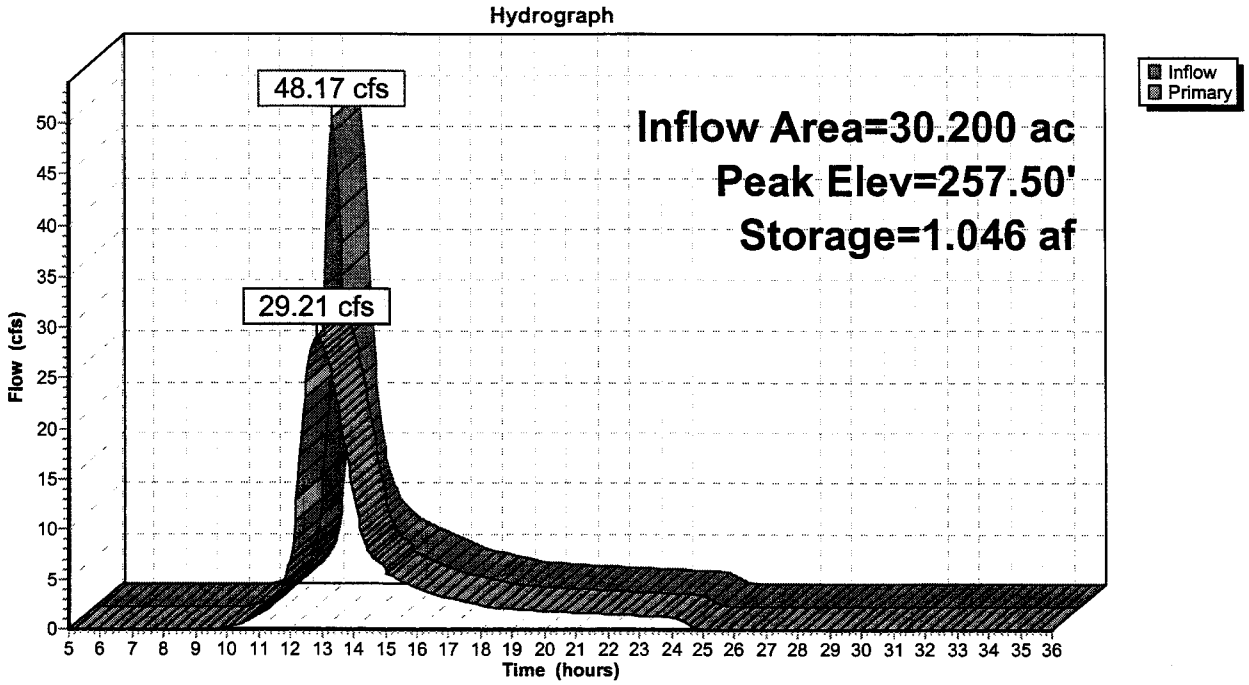
Plug-Flow detention time= 11.9 min calculated for 6.508 af (100% of inflow)
Center-of-Mass det. time= 11.8 min (881.1 - 869.3)

Volume	Invert	Avail.Storage	Storage Description
#1	250.00'	1.500 af	**40.00'W x 120.00'L x 10.00'H Prismatoid Z=1.0**

Device	Routing	Invert	Outlet Devices
#1	Primary	248.00'	**15.0" Round Culvert** L= 50.0' RCP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 248.00' / 247.00' S= 0.0200 '/' Cc= 0.900 n= 0.011 Concrete pipe, straight & clean
#2	Primary	250.00'	**15.0" Round Culvert** L= 50.0' RCP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 250.00' / 249.00' S= 0.0200 '/' Cc= 0.900 n= 0.011 Concrete pipe, straight & clean

Primary OutFlow Max=29.20 cfs @ 12.86 hrs HW=257.50' (Free Discharge)
↑—**1=Culvert** (Inlet Controls 15.53 cfs @ 12.65 fps)
└—**2=Culvert** (Inlet Controls 13.67 cfs @ 11.14 fps)

Pond 1P: RP-KL2



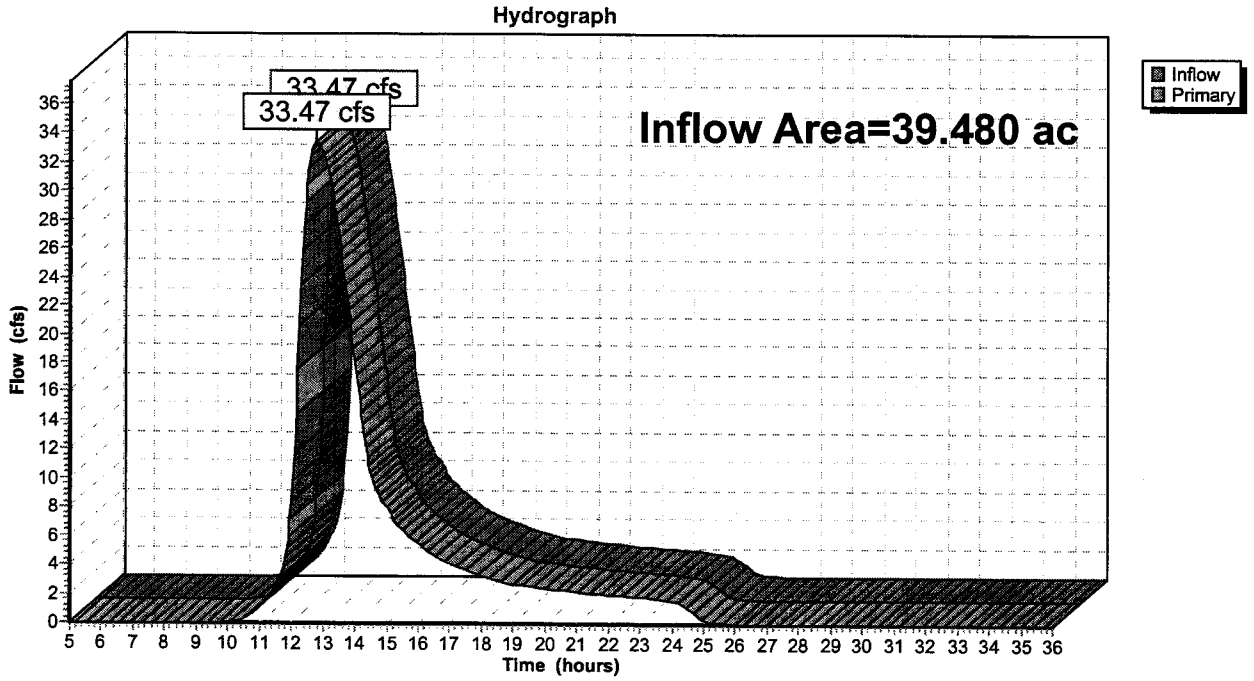
Summary for Pond 2P: DISCHARGE AT E (ZERO VOLUME POND)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 39.480 ac, 0.00% Impervious, Inflow Depth = 2.45"
Inflow = 33.47 cfs @ 12.80 hrs, Volume= 8.049 af
Primary = 33.47 cfs @ 12.80 hrs, Volume= 8.049 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 5.00-36.00 hrs, dt= 0.05 hrs

Pond 2P: DISCHARGE AT E (ZERO VOLUME POND)



APPENDIX D-5

HAND CALCULATIONS

PRE-DEVELOPMENT AND POST-DEVELOPMENT

MODELING RESULTS FOR DESIGN STORM EVENTS

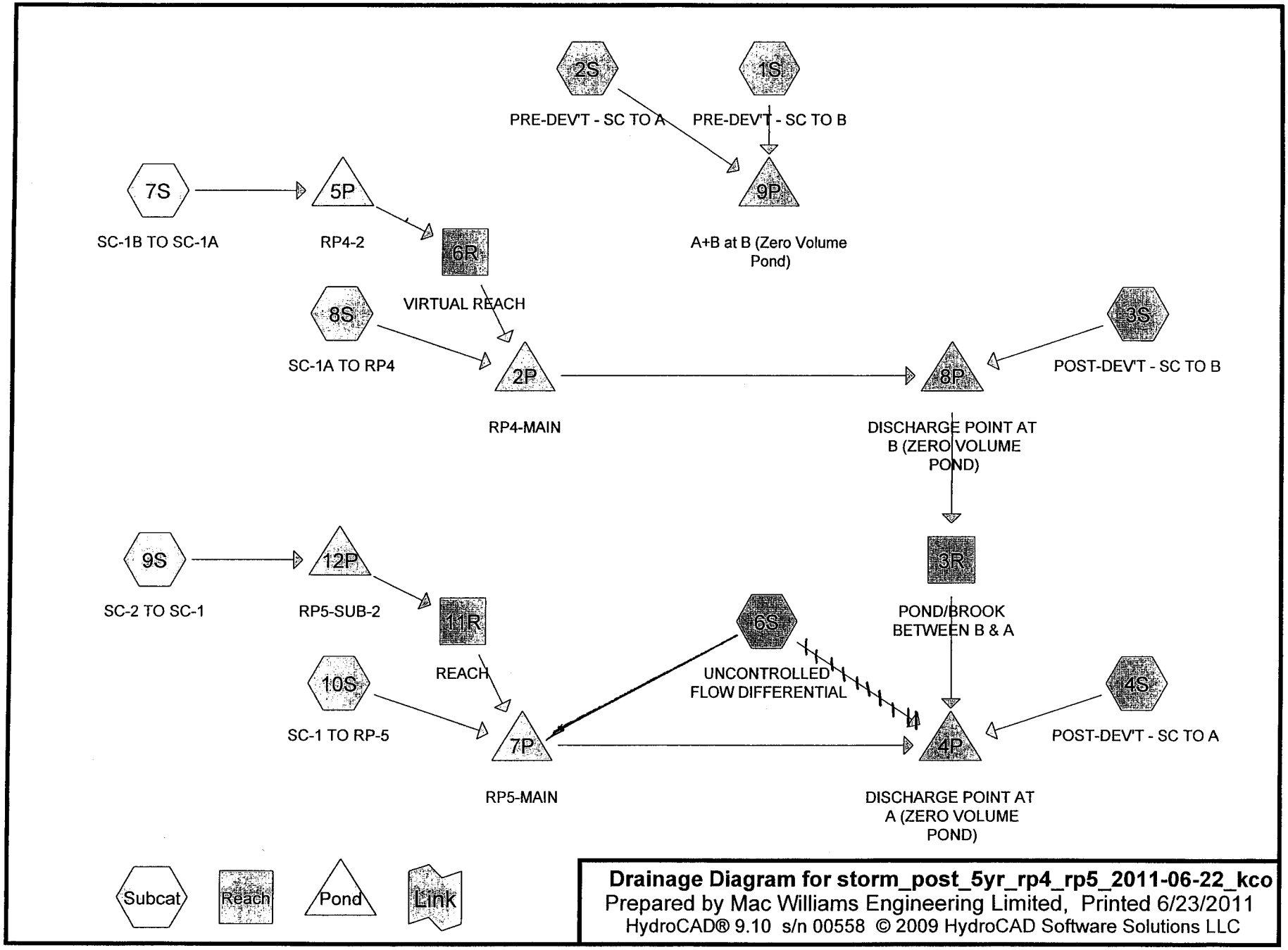
PRELIMINARY DESIGN

STORMWATER RETENTION PONDS

PN: 10575

2011-06-20

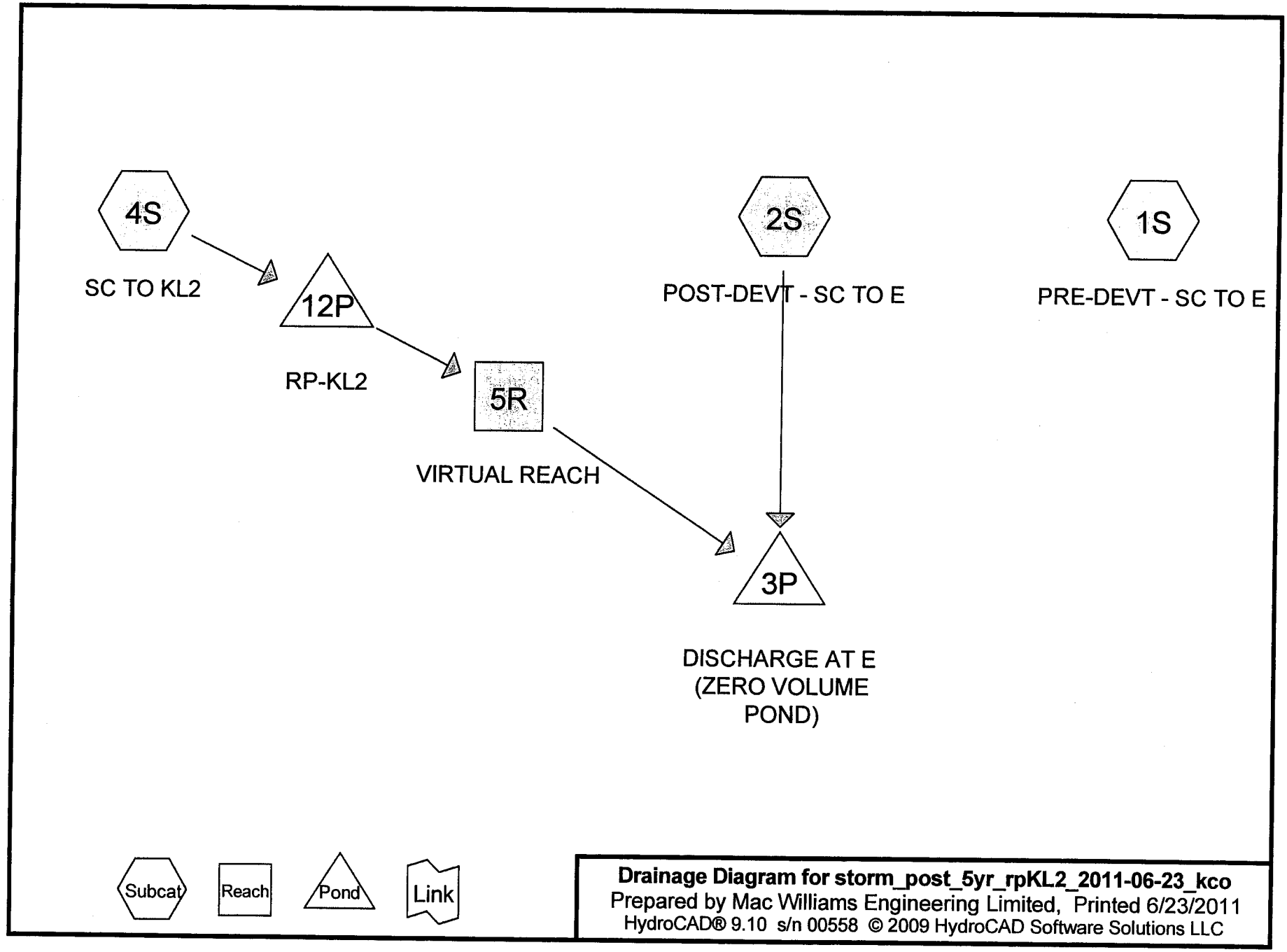
Keo.



PN 10575
EMSCOTE

STORMWATER SCHEMATIC

2011/06/23
KCO.



RJ: 10595
EMSCOTE

STORMWATER
SCHEMATIC

2011/06/23
KCO

PN 10575
EMSCOTE

2011/06/23
KZ.

Environment Canada/Environnement Canada

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2010/04/13

SHEARWATER A NS 8205090

Latitude: 44 38'N Longitude: 63 30'W Elevation/Altitude: 50 m

Years/Années : 1955 - 2006 # Years/Années : 51

Table 1 : Annual Maximum (mm)/Maximum annuel (mm)

Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
1955	5.1	7.1	8.9	13.7	19.3	23.4	27.7	30.7	45.0
1956	4.3	5.6	6.6	8.6	13.5	19.0	35.1	35.1	41.1
1958	3.8	5.1	6.9	10.4	17.3	25.1	43.7	47.5	47.8
1959	5.8	9.7	12.4	17.0	25.4	30.2	59.9	67.6	68.1
1960	5.3	8.1	10.9	16.0	18.3	19.8	25.1	35.3	38.1
1961	4.1	6.1	8.1	8.6	14.5	19.6	37.1	54.1	70.9
1962	3.6	5.6	7.1	10.9	15.7	27.7	42.7	55.9	71.6
1963	5.3	7.1	8.4	9.7	16.0	23.1	46.7	64.0	67.6
1964	11.2	13.0	15.0	17.5	17.8	31.5	68.8	75.2	75.2
1965	5.3	9.7	11.7	14.0	20.6	28.2	55.6	58.9	61.2
1966	8.1	9.9	10.7	11.7	13.0	18.0	33.5	42.9	43.2
1967	8.4	15.0	16.8	21.3	25.9	30.5	59.4	60.5	87.4
1968	5.6	9.7	13.5	17.0	24.1	32.3	38.9	55.6	68.3
1969	5.3	9.9	13.5	17.8	30.2	50.5	65.8	65.8	66.8
1970	6.6	9.4	10.7	16.5	20.1	25.4	51.8	72.9	77.5
1971	12.7	17.0	18.5	20.8	24.6	44.2	81.0	116.1	199.1
1972	5.6	8.6	11.2	16.0	19.8	24.1	45.0	66.3	72.4
1973	10.2	10.9	11.2	12.2	17.3	22.1	42.7	54.9	62.7
1974	5.6	7.9	8.9	13.2	18.0	23.4	33.3	48.5	49.8
1975	4.8	7.6	8.6	12.2	19.0	37.1	66.8	67.1	70.6
1976	6.6	10.9	14.0	17.8	29.5	58.9	84.6	84.6	84.6
1977	11.4	13.0	13.2	17.3	28.4	39.9	50.0	50.0	51.3
1978	4.2	7.5	8.0	9.3	16.1	26.2	52.2	56.4	57.1
1979	5.7	9.0	11.6	17.4	26.1	42.8	72.1	75.7	76.1
1980	4.1	4.9	7.1	9.9	15.6	23.4	36.8	48.9	50.3
1981	7.5	13.0	14.1	25.5	28.4	37.4	52.4	65.4	66.7
1982	6.3	10.2	13.5	23.9	31.2	39.8	52.5	66.6	98.9
1983	2.5	4.9	6.9	13.6	27.1	49.6	94.7	113.0	113.0
1984	5.3	7.3	9.7	17.7	27.8	41.6	61.2	62.7	68.7
1985	8.7	15.6	18.3	24.3	30.3	33.6	52.6	59.3	63.2
1986	10.6	13.7	15.1	17.8	22.2	29.2	38.3	45.0	46.6
1987	4.8	6.5	8.8	12.1	14.0	21.8	32.8	38.2	41.0
1988	4.3	8.3	11.1	14.4	24.2	27.1	45.1	60.5	79.8
1989	7.8	13.1	15.9	20.8	20.9	30.7	47.2	60.6	60.6
1990	5.1	7.5	9.7	13.0	16.2	24.2	62.8	86.7	100.0
1991	6.6	7.7	11.0	20.7	22.0	25.6	42.2	59.0	87.1
1992	3.7	5.0	5.4	7.5	12.1	16.0	32.3	38.3	49.0
1993	6.0	10.7	16.0	18.8	21.3	27.7	40.8	51.3	71.5
1994	4.6	6.5	8.3	11.9	19.4	34.3	49.0	64.3	68.8
1995	5.9	9.4	13.7	15.5	26.5	49.0	82.9	94.2	94.2
1996	6.0	8.4	9.3	13.0	23.4	39.4	69.4	70.2	91.2
1997	4.7	8.6	11.8	18.0	21.4	28.8	45.0	48.6	48.6
1998	7.1	11.0	13.3	19.0	26.5	36.4	67.9	76.8	87.4
1999	7.2	11.0	16.4	24.3	27.4	28.7	43.0	56.9	66.5
2000	5.7	9.3	10.9	13.8	18.8	25.9	58.0	72.0	72.2
2001	6.8	10.7	13.7	17.7	22.2	24.8	39.1	57.8	88.6
2002	4.3	5.9	8.6	13.5	18.0	27.2	43.3	47.9	56.7
2003	5.6	8.3	12.3	15.0	24.1	31.0	59.1	92.3	103.7
2004	5.2	8.6	12.7	15.0	15.6	20.3	37.6	39.8	52.6
2005	4.0	6.7	9.2	17.1	22.1	26.4	44.8	64.1	91.3
2006	5.3	9.6	12.2	17.7	23.1	32.7	53.6	57.6	57.6
# Yrs. Années	51	51	51	51	51	51	51	51	51
Mean Moyenne	6.1	9.1	11.4	15.7	21.4	30.5	51.1	61.6	71.2
Std. Dev. Écart-type	2.1	2.8	3.2	4.3	5.1	9.2	15.4	17.8	25.6
Skew. Dissymétrie	1.33	0.72	0.29	0.28	0.12	1.02	0.81	1.02	2.57
Kurtosis	4.76	3.46	2.62	2.86	2.19	3.97	3.50	4.82	14.46

*-99.9 Indicates Missing Data/Données manquantes

Warning: annual maximum amount greater than 100-yr return period amount
Avertissement : la quantité maximale annuelle excède la quantité pour une période de retour de 100 ans

Year/Année	Duration/Durée	Data/Données	100-yr/ans
1971	24 h	199.1	151.4

PN 10595
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2011/06/23
Kw.

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Table 2a : Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	5.7	7.6	8.9	10.5	11.7	12.8	51
10 min	8.7	11.2	12.8	14.9	16.5	18.0	51
15 min	10.9	13.7	15.5	17.9	19.6	21.3	51
30 min	14.9	18.8	21.3	24.5	26.8	29.2	51
1 h	20.6	25.1	28.0	31.8	34.6	37.3	51
2 h	29.0	37.2	42.6	49.4	54.5	59.5	51
6 h	48.5	62.1	71.1	82.5	90.9	99.3	51
12 h	58.6	74.4	84.8	97.9	107.7	117.3	51
24 h	67.0	89.6	104.5	123.5	137.5	151.4	51

3.53 in/h

5.96 in/h

****

Table 2b :

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	68.8	91.6	106.6	125.7	139.8	153.9	51
	+/- 6.5	+/- 10.9	+/- 14.8	+/- 19.9	+/- 23.8	+/- 27.8	51
10 min	52.0	67.0	77.0	89.6	98.9	108.1	51
	+/- 4.3	+/- 7.2	+/- 9.7	+/- 13.1	+/- 15.7	+/- 18.3	51
15 min	43.5	54.7	62.1	71.4	78.3	85.2	51
	+/- 3.2	+/- 5.4	+/- 7.2	+/- 9.8	+/- 11.7	+/- 13.6	51
30 min	29.9	37.5	42.5	48.9	53.6	58.3	51
	+/- 2.2	+/- 3.7	+/- 4.9	+/- 6.7	+/- 8.0	+/- 9.3	51
1 h	20.6	25.1	28.0	31.8	34.6	37.3	51
	+/- 1.3	+/- 2.2	+/- 2.9	+/- 3.9	+/- 4.7	+/- 5.5	51
2 h	14.5	18.6	21.3	24.7	27.2	29.8	51
	+/- 1.2	+/- 2.0	+/- 2.7	+/- 3.6	+/- 4.3	+/- 5.0	51
6 h	8.1	10.4	11.9	13.7	15.2	16.5	51
	+/- 0.6	+/- 1.1	+/- 1.5	+/- 2.0	+/- 2.4	+/- 2.8	51
12 h	4.9	6.2	7.1	8.2	9.0	9.8	51
	+/- 0.4	+/- 0.6	+/- 0.8	+/- 1.1	+/- 1.4	+/- 1.6	51
24 h	2.8	3.7	4.4	5.1	5.7	6.3	51
	+/- 0.3	+/- 0.5	+/- 0.6	+/- 0.8	+/- 1.0	+/- 1.1	51

****

Table 3 : Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

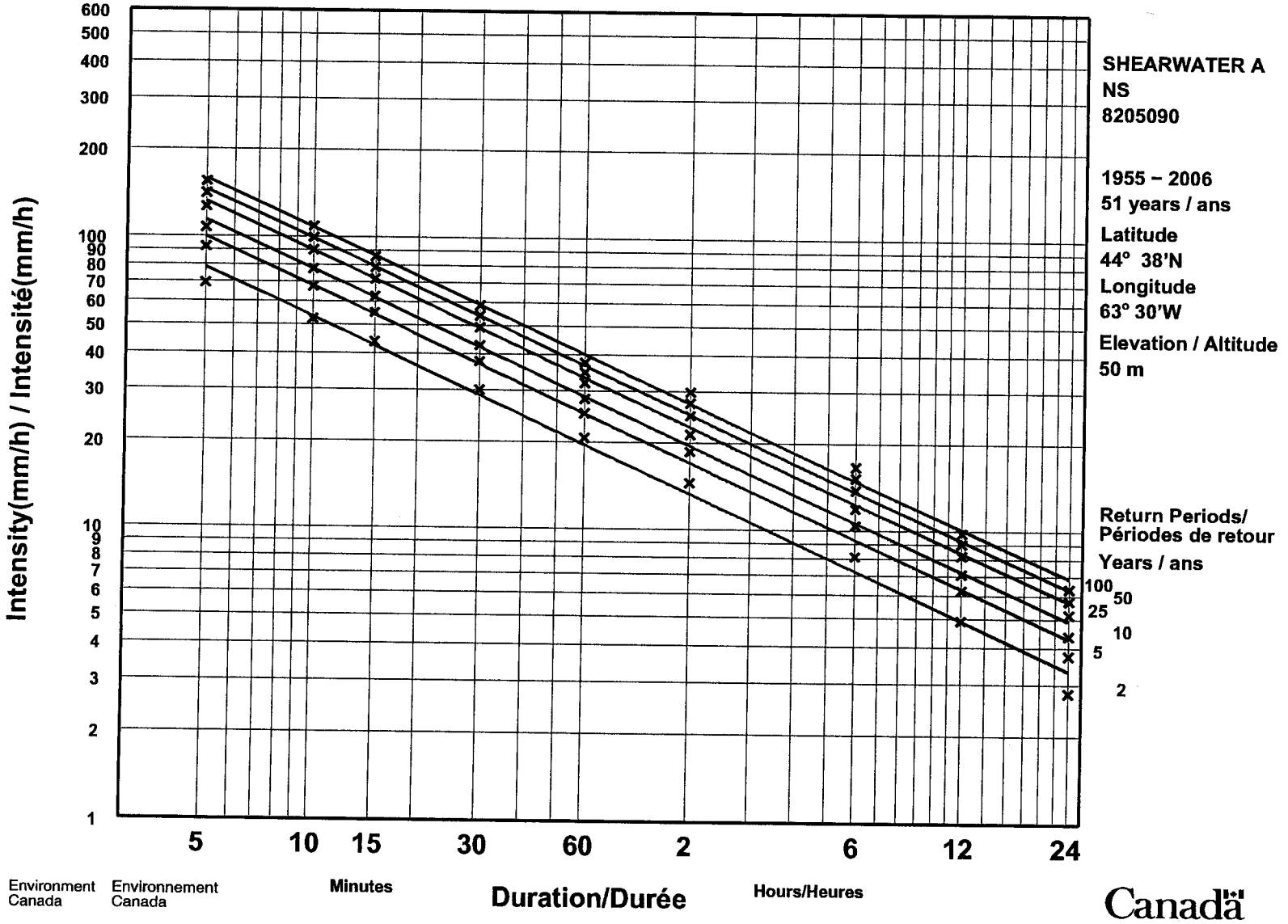
****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	27.2	35.0	40.1	46.6	51.4	56.1
Std. Dev. /Écart-type (RR)	23.1	30.4	35.3	41.4	45.9	50.4
Std. Error/Erreur-type	3.7	3.1	2.8	2.5	2.3	2.2
Coefficient (A)	19.5	25.0	28.6	33.1	36.5	39.8
Exponent/Exposant (B)	-0.558	-0.556	-0.555	-0.555	-0.554	-0.554
Mean % Error/% erreur moyenne	7.3	5.4	4.9	4.6	4.6	4.7

Short Duration Rainfall Intensity–Duration–Frequency Data

2010/04/13

Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée



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Canada

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PN: 10575 STORMWATER GENERATION 2011/06/28
EMSCOTE PRE DEVT FLOWS KGO

PRE DEVT TO (A) ALL FLOW FROM DRAINAGE BASIN FLOWING TO BALANCE PT. (A) BELOW BALANCE PT. (B)

t_o = 8.7 min AS IN (B) L_o = 2300 ft

$t_{CH} = (0.0078)(2300)^{0.77}(0.0354)^{-0.385}$ $S_o = \frac{300\text{ ft} - 218.5\text{ ft}}{2300} = 0.0354$

= 10.9 min

t_c = 19.6 min

5 YR $i = (25.0)\left(\frac{19.6}{60}\right)^{-0.556}$ = 46.6 mm/hr = 1.83 in/hr

100 YR $i = (39.8)\left(\frac{19.6}{60}\right)^{-0.554}$ = 74.0 mm/hr = 2.91 in/hr

AREA = 22.7 Ac
C = 0.3 PARK/UNDEV.

$Q_5 = (0.30)(1.83)(22.7)$ = 12.5 CFS = 0.353 m^3/sec

$Q_{100} = (0.50)(2.91)(22.7)$ = 33.0 CFS = 0.934 m^3/sec

PN: 10575 STORMWATER GENERATION 2011/06/22
EMSCOTE PRE-DEVT FLOWS

PRE-DEVT TO (B)

$$t_o = \left[\frac{(0.67)(n)(L_o)}{\sqrt{S_o}}\right]^{0.467}$$

$n = 0.10$
$L_o = 300\ ft$

$$S_o = \frac{305.7\ ft - 294.4\ ft}{300\ ft} = 0.0377$$

$$= \left[\frac{(0.67)(0.10)(300)}{\sqrt{0.0377}}\right]^{0.467}$$

$= 8.7\ min$

$$t_{CH} = (0.0078)(L^{0.77})(S^{-0.385})$$

$L \cong 3600\ ft$

$$S = \frac{305.7\ ft - 217.5\ ft}{3600\ ft} = 0.0245$$

$$= (0.0078)(3600^{0.77})(0.0245^{-0.385})$$

$= 17.8\ min$

$t_c = 26.5\ min$

5YR : $A = 25.0$ $B = -0.556$
100YR $A = 39.8$ $B = -0.554$

5YR $i = (25.0)\left(\frac{26.5}{60}\right)^{-0.556} = 39.4\ mm/hr = 1.55\ in/hr$

100YR $i = (39.8)\left(\frac{26.5}{60}\right)^{-0.554} = 62.6\ mm/hr = 2.46\ in/hr$

AREA = 66.41 Ac
C = 0.3 PARK/UNDEV

$Q_5 = (0.30)(1.55)(66.41) = 30.9\ CFS = 0.874\ m^3/sec$

$Q_{100} = (0.30)(2.46)(66.41) = 81.7\ CFS = 2.31\ m^3/sec$

PN: 10575 STORMWATER 2011/06/23
EMSCOTE DRAINAGE AREAS Kco.

POST SUB CATCHMENT TO (A)

SC TO (A) A= 22.7 AC

SUBTRACT AREA GOING TO RETENTION POND

REMAINING AREA = 6.98 AC

POST SUB CATCHMENT TO (B)

SC TO (B) A= 66.4 AC

REMAINING AREA = 59.43 AC

PN: 10575 STORMWATER GENERATION 2011-06-16
EMSCOTE KLO.

PRE DEVT → RP4

$$t_o = \left[\frac{(0.67)(n)(L_o)}{(S_o)^{1/2}}\right]^{0.467}$$

$n = 0.10$
$L_o = 300\,ft$
$S_o = \frac{316.5\,ft - 292.5\,ft}{300\,ft} = 0.08$

$$= \left[\frac{(0.67)(0.10)(300)}{\sqrt{0.08}}\right]^{0.467}$$

$= 7.3$ min

$$t_{ch} = (0.0078)(L^{0.77})(S^{-0.385})$$

$$= (0.0078)(976^{0.77})(0.056^{-0.385})$$

$L = 976$ ft
$S = \frac{292.5\,ft - 238\,ft}{976\,ft} = 0.056$

$= 4.7$ min

$t_c = 12$ min

5 YR $i = 61\ mm/hr = 2.4\ in/hr$
100 YR $i = 102\ mm/hr = 4.0\ in/hr$

$A = 284000\,SF = 6.5\,AC = 2.6\,ha$
$C = 0.3$ PARK/UNDEV.

$CA = 1.96$

$C_{100} = (C_5)(1.25)$

$Q_5 = (2.4)(1.96) = 4.7\ CFS = 0.13\ m^3/sec$

$Q_{100} = (4.0)(1.96)\left(\frac{0.5}{0.3}\right) = 13.1\ CFS = 0.37\ m^3/sec$

PN: 10575 STORM WATER 2011-06-17
EMSCOTE GENERATION KP

POST DEVT 5YR : 100 YR STORED TO RP4 WEST EDGE OF PROP

$$t_o = \left[\frac{(0.67)(n)(L_o)}{\sqrt{S_o}}\right]^{0.467}$$

$n = 0.10$

$L_o = 230\ ft$

$S_o = \frac{333\ ft - 295.5\ ft}{230\ ft} = 0.16$

$$= \left[\frac{(0.67)(0.10)(230)}{\sqrt{0.16}}\right]^{0.467}$$

$= 5.5\ min$

$t_{ch} = (0.0078)(L^{0.77})(S^{-0.385})$ $L = 217\ ft$

$= (0.0078)(217^{0.77})(0.021^{-0.385})$ $S = \frac{300\ ft - 295.5\ ft}{217} = 0.021$

$= 2.5\ min$

$t_c = 8.0\ min$ 5 YR $R = AT^B$ $A = 25.0$ $B = -0.556$

100 YR $A = 39.8$ $B = -0.554$

$R_5 = (25.0)\left(\frac{7.5}{60}\right)^{-0.556} = 79.4\ mm/hr = 3.13\ in/hr$

$R_{100} = (39.8)\left(\frac{7.5}{60}\right)^{-0.554} = 125.9\ mm/hr = 4.96\ in/hr$

$A = 141000\ SF = 3.24\ Ac$

$CA = (0.3)(3.24) = 0.97$ $C_{100} = (C_5)(1.25)$

$Q_5 = (3.13)(0.97) = 3.03\ CFS = 0.086\ m^3/sec$

$Q_{100} = (4.96)(0.97)\left(\frac{0.5}{0.3}\right) = 7.77\ CFS = 0.22\ m^3/sec$

POST DEVT RP4

① MF-A $A = 353900\ SF = 8.12\ AC$ $C = 0.70$

② SF $A = 71500\ SF = 1.64\ AC$ $C = 0.45$

③ UND $A = 26500\ SF = 0.61\ AC$ $C = 0.30$

$$t_o = \left[\frac{(0.67)(n)(L_o)}{\sqrt{S_o}}\right]^{0.467}$$

$L_o = 125\ ft$

$S = \frac{316\ ft - 301\ ft}{125\ ft} = 0.12$

$n = 0.10$

$$= \left[\frac{(0.67)(0.10)(125)}{\sqrt{0.12}}\right]^{0.467}$$

$= 4.4\ min$

$$t_{LC} = \frac{L_{LC}}{\frac{89.4}{n} R^{0.67} S_{LC}^{0.5}}$$

$L_{LC} = 1390\ ft$

$S_{LC} \cong \frac{305.9\ ft - 262.5\ ft}{1390\ ft} = 0.03$

$R = (0.25)(2.5\ ft) = 0.625$

$$= \frac{1390}{\left(\frac{89.4}{0.08}\right)(0.625^{0.67})(\sqrt{0.03})}$$

$= 9.8\ min$

$t_c = 14.2\ min$ 5 YR $A = 25.0$ $B = -0.556$ $R = AT^B$

100 YR $A = 39.8$ $B = -0.554$

$$i_5 = (25.0)\left(\frac{14.2}{60}\right)^{-0.556} = 55.7\ mm/hr = 2.19\ in/hr$$

$$i_{100} = (39.8)\left(\frac{14.2}{60}\right)^{-0.554} = 88.4\ mm/hr = 3.48\ in/hr$$

$$C_{COMP} = \left(\frac{8.12}{10.37}\right)(0.70) + \left(\frac{1.64}{10.37}\right)(0.45) + \left(\frac{0.61}{10.37}\right)(0.30) = 0.64$$

POST DEVT RP4

$CA = (0.64)(10.37) = 6.63$ $\quad C_{100} = (C_5)(1.25)$

$Q_5 = (2.19)(6.63) = 14.52$ CFS $= 0.411$ m^3/sec

$Q_{100} = (3.48)(6.63)(\frac{0.5}{0.3}) = 38.5$ CFS $= 1.089$ m^3/sec

$\uparrow 0.95$

NOTE: NEED TO ADD FLOW FROM "DAMMED" AREA

PRE-DEVT → RP5

$$t_o = \left[\frac{(0.67)(n)(L_o)}{\sqrt{S_o}}\right]^{0.467}$$

$n = 0.10$

$L_o = 300\ ft$

$S_o = \frac{315.5\ ft - 287\ ft}{300\ ft} = 0.095$

$$= \left[\frac{(0.67)(0.10)(300)}{\sqrt{0.095}}\right]^{0.467}$$

$= 7.0\ min$

$$t_{CH} = (0.0078)(L^{0.77})(S^{-0.385})$$

$L = 855\ ft$

$S = \frac{287\ ft - 231.7\ ft}{855\ ft} = 0.065$

$$= (0.0078)(855^{0.77})(0.065^{-0.385})$$

$= 4.0\ min$

$t_c = 11.0\ min$

$R = AT^B$

5YR $A = 25.0$ $B = -0.556$

100YR $A = 39.8$ $B = -0.554$

$$R_5 = (25.0)\left(\frac{11}{60}\right)^{-0.556}$$

$= 64\ mm/hr = 2.53\ in/hr$

$$R_{100} = (39.8)\left(\frac{11}{60}\right)^{-0.554}$$

$= 101.9\ mm/hr = 4.01\ in/hr$

$A = 206000\ ft^2 = 4.75\ AC$ $C = 0.3$ PARK/UNDEV

$CA = (0.3)(4.75) = 1.42$ $C_{100} = (C_5)(1.25)$

$Q_5 = (2.53)(1.42) = 3.59\ CFS = 0.102\ m^3/sec$

$Q_{100} = (4.01)(1.42)\left(\frac{0.5}{0.3}\right) = 9.49\ CFS = 0.269\ m^3/sec$

POST DEVT 5 YR → RP5 100 YR STORED @ INT^N BOSUN & FLEETVIEW

ASSUME OVERLAND FLOW TO EX. POND

$$t_o = \left[\frac{(0.67)(n)(L_o)}{\sqrt{S_o}}\right]^{0.467}$$

$L_o = 240$ ft

$n = 0.10$

$S_o = \frac{292.5\text{ ft} - 259\text{ ft}}{240\text{ ft}} = 0.14$

$$= \left[\frac{(0.67)(0.10)(240)}{\sqrt{0.14}}\right]^{0.467}$$

$= 5.7$ min

$t_c = 5.7$ min 5 YR $R = AT^B$ $A = 25.0$ $B = -0.556$

100 YR $A = 39.8$ $B = -0.554$

$R_5 = (25.0)\left(\frac{5.7}{60}\right)^{-0.556} = 92.5\ mm/hr = 3.64\ in/hr$

$R_{100} = (39.8)\left(\frac{5.7}{60}\right)^{-0.554} = 146.6\ mm/hr = 5.77\ in/hr$

$A = 89200$ SF $= 2.05$ AC 50/50 SPLIT B/W UNDEV & SF

$C = \frac{0.45 + 0.3}{2} = 0.375$

$CA = 0.77$

$Q_5 = (3.64)(0.77) = 2.8$ CFS $= 0.079\ m^3/sec$

$Q_{100} = (5.7)(0.77)\left(\frac{0.5}{0.3}\right) = 7.32$ CFS $= 0.207\ m^3/sec$

POST DEVT RP5

① MU-A A= 103700 SF = 2.38 Ac C= 0.70

② SF A= 159700 SF = 3.67 Ac C= 0.45

③ UND A= 418400 SF = 9.61 Ac C= 0.30

$$t_o = \left[\frac{(0.67)(n)(L_o)}{\sqrt{S}}\right]^{0.467}$$

$L_o = 300$

$S = \frac{331.25\,ft - 309\,ft}{300\,ft} = 0.074$

$= 7.5\,min$

$$t_{CH} = (0.0078)(L^{0.77})(S^{-0.385})$$

$L = 550\,ft$

$S = \frac{309\,ft - 275\,ft}{550\,ft} = 0.062$

$= (0.0078)(550^{0.77})(0.062^{-0.385})$

$= 7.1\,min$

$$t_{LC} = \frac{L_{LC}}{\frac{89.4}{n} R^{0.67} \sqrt{S_{LC}}}$$

$L_{LC} = 365\,ft$

$R = (0.25)(2\,ft) = 0.5\,ft$

$n = 0.08$

$S_{LC} = \frac{275\,ft - 258\,ft}{365\,ft} = 0.047$

$$= \frac{365}{\left(\frac{89.4}{0.08}\right)(0.5^{0.67})\left(\sqrt{0.047}\right)}$$

$= 2.4\,min$

$R_5 = (25)\left(\frac{17}{60}\right)^{-0.556} = 50.4\ mm/hr = 1.98\ in/hr$

$R_{100} = (39.8)\left(\frac{17}{60}\right)^{-0.554} = 80.0\ mm/hr = 3.15\ in/hr$

$t_c = 17\,min$ 5 YR $R = AT^B$ $A = 25.0$ $B = -0.556$

100 YR $A = 39.8$ $B = -0.554$

$$C_{COMP} = \left(\frac{2.38}{15.66}\right)0.70 + \left(\frac{3.67}{15.66}\right)0.45 + \left(\frac{9.61}{15.66}\right)0.30 = 0.40$$

POST DEVT RP5

$CA = (15.66)(0.40) = 6.26$ $C_{100} = C_5 (1.25)$

$Q_5 = (6.26)(1.98) = 12.4 \text{ CFS} = 0.25 \text{ m}^3/\text{sec}$

$Q_{100} = (6.26)\left(\frac{0.5}{0.3}\right)(3.15) = 32.9 \text{ CFS} = 0.931 \text{ m}^3/\text{sec}$

NOTE: NEED TO ADD POND FLOW CREATED BY HOUSES @ INT^N OF BOSUN & FLEETVIEW

TWO AREAS UNCONTROLLED

TO RP KL2 $A = 638400$ SF $= 14.7$ Ac $CA = 4.39$
DRAINAGE DISCHARGE

TO RP4 $A = 269900$ SF $= 6.2$ Ac $CA = 1.85$

@ $C = 0.30$ UND
$C = 0.70$ MU
$C = 0.45$ SF

TO RP4 SF: $A = 75800 = 1.74$ Ac $CA = (0.45)(1.74) = 0.78$
MU $A = 18000 = 0.41$ Ac $CA = (0.41)(0.70) = 0.281$

TO KL2 AREA SF $A = 138900 = 3.19$ Ac $CA = (0.45)(3.19) = 1.43$

Δ TOTAL TO RP4 $= (0.45 - 0.30)(1.74) + (0.70 - 0.30)(0.41)$

$CA = 0.427$

Δ TOTAL TO KL2 $= (0.45 - 0.30)(3.19) = 0.478$

$CA = 0.478$

ASSUME $t_c = 5.0$ min (SMALL AREAS) $i = 3.59$ in/hr 5 YR
$i = 6.05$ in/hr 100 YR

RP4 $Q_5 = (0.427)(3.59) = 1.53$ CFS $= 0.0434$ m³/sec
KL2 $Q_5 = (0.478)(3.59) = 1.72$ CFS $= 0.0486$ m³/sec

RP4 $Q_{100} = \frac{0.5}{0.3}(0.427)(6.05) = 430$ CFS $= 0.122$ m³/sec
KL2 $Q_{100} = \frac{0.5}{0.3}(0.478)(6.05) = 481$ CFS $= 0.136$ m³/sec

PN 10575 STORMWATER 2011/06/23
EMSCOTE UNCONTROLLED FLOW Kco.

RP5

DEVELOPED AREA A = 1.73 AC ← SF C = 0.45

TOTAL = 5.69 AC A = 3.96 AC ← SF C = 0.45

UND AREA (POST-DEV.) A = 10.69 AC ← UND/PARK C = 0.30

TOTAL = 15 AC A = 4.31 AC ← UND/PARK C = 0.30

ASSUME 5 min t_c

5 YR i = 91.2 mm/hr = 3.59 in/hr

100 YR i = 153.6 mm/hr = 6.05 in/hr

$$Q_5 = (0.45)(3.59)(5.69) + (0.30)(3.59)(15) - (0.30)(3.59)(15+5.69)$$
$$= 3.06 \text{ CFS} = 0.0868 \text{ m}^3/\text{sec}$$

$$Q_{100} = (Q_5)\left(\frac{0.5}{0.3}\right) = 6.38 \text{ CFS} = 0.180 \text{ m}^3/\text{sec}.$$

PRE DEVT TO (E)

$$t_o = \left[\frac{(0.67)(n)(L_o)}{\sqrt{S_o}}\right]^{0.467}$$

$n = 0.10$

$L_o = 300\ ft$

$S_o = \frac{303.5\ ft - 298.5\ ft}{300\ ft} = 0.0833$

$$= \left[\frac{(0.67)(0.1)(300)}{\sqrt{0.0833}}\right]^{0.467}$$

$= 7.25\ min$

$$t_{CH} = (0.0078)(L^{0.77})(S^{-0.385})$$

$L = 2290\ ft$

$$= (0.0078)(2290^{0.77})(0.0129^{-0.385})$$

$S = \frac{278.5 - 249\ ft}{2290\ ft} = 0.0129$

$= 16.1\ min$

$t_c = 23.5\ min$

5 YR A = 25.0 B = -0.556

100 YR A = 39.8 B = -0.554

5 YR $i = (25)\left(\frac{23.5}{60}\right)^{-0.556} = 42.1\ mm/hr = 1.66\ in/hr$

100 YR $i = (39.8)\left(\frac{23.5}{60}\right)^{-0.554} = 66.9\ mm/hr = 2.63\ in/hr$

AREA = 26.4 Ac

$Q_5 = (0.30)(1.66)(26.4) = 13.1\ CFS = 0.37\ m^3/sec$

$Q_{100} = (0.50)(2.63)(26.4) = 34.7\ CFS = 0.983\ m^3/sec$

PRE DEVT RP KL2

$$t_o = \left[\frac{(0.67)(n)(L_o)}{\sqrt{S_o}}\right]^{0.467}$$

$n = 0.10$

$L_o = 300\,ft$

$$S_o = \frac{327ft - 304ft}{300\,ft} = 0.077$$

$$= \left[\frac{(0.67)(0.10)(300)}{\sqrt{0.077}}\right]^{0.467}$$

$= 7.4\,min$

$$t_{CH} = (0.0078)(L^{0.77})(S^{-0.385})$$

$L = 1341\,ft$

$$= (0.0078)(1341^{0.77})(0.04^{-0.385})$$

$$S = \frac{3035ft - 2501ft}{1341\,ft} = 0.04$$

$= 7.0\,min$

$t_c = 14.4\,min$

$R = AT^B$ 5 YR $A = 25.0$ $B = -0.556$

100 YR $A = 39.8$ $B = -0.554$

$$R_5 = (25)\left(\frac{14.4}{60}\right)^{-0.556} = 55.3\ mm/hr = 2.18\ in/hr$$

$$R_{100} = (39.8)\left(\frac{14.4}{60}\right)^{-0.554} = 87.7\ mm/hr = 3.45\ in/hr$$

$A = 751200\ ft^2 = 17.2\ AC$

$C = 0.30$ PARK/UNDEV

$C_{100} = (C_5)(1.25)$

$CA = 5.17$

$Q_5 = (28)(5.17) = 11.3\ CFS = 0.319\ m^3/min$

$$Q_{100} = (3.45)(5.17)\left(\frac{0.5}{0.3}\right) = 29.7\ CFS = 0.842\ m^3/min$$

POST-DEV'T RP KL2

① APT/COMM $A = 138200\ SF = 3.17\ Ac$ $C = 0.55$

② PARK/UND $A = 282500\ SF - 138200\ SF + 27900\ SF$ $C = 0.30$
$= 172200\ SF = 3.95\ Ac$

③ $SF = 30.2\ AC - 3.17 - 3.95 = 23.1\ AC$ $C = 0.45$

$$t_o = \left[\frac{(0.67)(n)(L_o)}{\sqrt{S_o}}\right]^{0.467}$$

$L_o = 125\ ft$ ← ASSUMED JUST LENGTH OF LOT

$S_o = 5\%$ ← ASSUMED

$n = 0.10$

$$= \left[\frac{(0.67)(0.10)(125)}{\sqrt{0.05}}\right]^{0.467}$$

$= 5.5\ min$

$$t_{Lc} = \frac{L_{Lc}}{\frac{89.4}{n} R^{0.67} S_{Lc}^{0.5}}$$

PIPE FLOW

$L_{Lc} \cong 1550\ ft$

$S_{Lc} \cong \frac{299\ ft - 290\ ft}{1550\ ft} = 0.006$

$R = (0.25)(2\ ft) = 0.5\ ft$

$n = 0.08$

$$= \frac{1550}{\left(\frac{89.4}{0.08}\right)\left(0.5^{0.67}\right)\left(\sqrt{0.006}\right)}$$

$= 28.5\ min$

$t_c = 34\ min$ 5 YR 100 YR $R = AT^B$ $A = 25.0$ $B = -0.556$ $A = 39.8$ $B = -0.554$

$$R_5 = (25.0)\left(\frac{34}{60}\right)^{-0.556} = 34.3\ \frac{mm}{hr} = 1.35\ in/hr$$

$$R_{100} = (39.8)\left(\frac{34}{60}\right)^{-0.554} = 54.6\ \frac{mm}{hr} = 2.14\ in/hr$$

$$C_{COMP} = \left(\frac{3.17}{30.2}\right)(0.55) + \left(\frac{3.95}{30.2}\right)(0.30) + \left(\frac{23.1}{30.2}\right)(0.45) = 0.44$$

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POST DEVT RP KL2

$CA = (0.44)(30.2) = 13.3$ $\qquad C_{100} = (C_5)(1.25)$

$Q_5 = (1.35)(13.3) = 18.0 \text{ CFS} = 0.508 \text{ m}^3/\text{sec}$

$Q_{100} = (2.14)(13.3)\left(\frac{0.5}{0.3}\right) = 47.4 \text{ CFS} = 1.34 \text{ m}^3/\text{sec}$

POST DEVT SPLIT = 40% ← FROM TOM