EWB

New Bedford Regional Airport

RECONSTRUCT, MARK, LIGHT AND GROOVE RUNWAY 14-32 STORMWATER MANAGEMENT REPORT













Airport Solutions Group 390 Main Street, Suite 100 Woburn, MA 01801

October 2016

TABLE OF CONTENTS

DRAII	NAGE REPORT	1
1.	INTRODUCTION	1
2.	METHODOLOGY	1
3.	EXISTING CONDITIONS	2
4.	FINAL DESIGN: PROPOSED CONDITIONS	6
5.	COMPLIANCE WITH MASSDEP STORMWATER STANDARDS:	7
6.	DRAINAGE SUMMARY	10

APPENDICES

- A EXISTING DRAINAGE CALCULATIONS
- B PROPOSED DRAINAGE CALCULATIONS
- C TSS REMOVAL CALCULATIONS
- D EXHIBITS

EXISTING AND PROPOSED DRAINAGE PLANS
TEST PIT AND BORING LOCATIONS
UPDATED STORMWATER OPERATIONS AND MAINTENANCE PLAN
CHECKLIST FOR STORMWATER REPORT

STORMWATER MANAGEMENT REPORT

1. INTRODUCTION

The New Bedford Regional Airport, located in New Bedford, MA seeks to reconstruct Runway 14-32 and all associated taxiway stubs that serve this runway. The width of the runway will be reduced from 150 feet to 75 feet wide and the existing drainage system that currently serves the runway will be reused. The runway will be redesigned according to the following FAA regulations:

- FAA Advisory Circular 150/5300-13 (Airport Design), and
- MassDOT Aeronautics approved aeronautical rules and regulations for public use airports (pursuant to 702 CMR, as amended; for airports subject to MassDOT Aeronautics certification pursuant to M.G.L. c.90, Section 39B).

The proposed stormwater management system described herein has been designed to comply with MASS DEP's stormwater management standards that were incorporated into the Wetlands Protection Act Regulations on January 2, 2008 (see 310 CMR 10.05(6)(k)).

As explained in further detail below and in the accompanying Notice of Intent prepared by Epsilon Associates, Inc., work associated with reconstructing Runway 14-32 is characterized as a redevelopment project relative to collecting and treating stormwater runoff. More specifically, according to MASS DEP Stormwater Standard 7:

A redevelopment project is required to meet the following Stormwater Management Standard only to the maximum extent practicable: Standard 2, Standard 3, and the pretreatment and structural best management practice requirements of Standards 4, 5 and 6. Existing stormwater discharges shall comply with Standard 1 only to the maximum extent practicable. A redevelopment project shall also comply with all other requirements of the Stormwater Management Standards and improve existing conditions.

The Regulations require documentation demonstrating that runoff from the existing developed portion of Runway 14-32 meets the Stormwater Standards to the maximum extent practicable and improves existing conditions. Maximum extent practicable is defined at 310 CMR 10.05(6)(0) and is summarized as follows: all reasonable efforts have been made to meet each of the Standards; a complete evaluation has been conducted of possible stormwater management measures including (in part) environmentally sensitive site design and low impact development techniques that minimize land disturbance and impervious surfaces, structural stormwater best management practices, pollution prevention, erosion and sedimentation control and proper operation and maintenance; and if full compliance with the Standards cannot be achieved, the highest practicable level of stormwater management is implemented. The measures described herein comply with the Standards to the maximum extent practicable and will improve existing stormwater runoff conditions consistent with the requirements of Standard 7. Additional detail describing existing and proposed conditions is provided below.

2. METHODOLOGY

The existing and proposed watersheds were modeled utilizing HydroCad stormwater software, version 9.10. The watersheds were analyzed utilizing the SCS TR-20 methodology for hydrograph development and the TR-55 methodology for Time of Concentration (Tc) determination. Type III, 24-hour hydrographs were developed for the 2-year, 10-year, and 100-year storm events corresponding to 3.4", 4.8", and 7.0" rainfall storm events respectively as directed by the SCS *Technical Paper 40* (TP-40) and the MASS DEP *Hydrology Handbook for Conservation Commissioners*.

Existing topography and site features were obtained through a combination of aerial topography, on-ground topography, the MASS GIS system, and USGS Topographical Maps. Existing soil conditions were derived from a combination of geotechnical investigation performed by R.W. Gillespie & Associates, test pits performed by ASG, MASS GIS soils, and the Natural Resources Conservation Services (NRCS) Web Soil Service Mapping Tool. The wetland resource area boundaries depicted on the enclosed drawings were reviewed and approved under MASS DEP File No. 049-0635 and remain valid.

3. EXISTING CONDITIONS

The existing airport site consists of approximately 825+ acres located in the north-east corner of the Apponagansett Swamp, between I-195 and New Plainville Road, New Bedford, MA. The airport watershed is located north-east of and includes portions of the Paskamanset River between Turner Pond to the north and the Smith Mills Dam to the south. The existing airport watershed contains a mixture of forest, brushy areas associated with immature woods, maintained grassed areas, paved areas, and buildings. Watershed soils were determined to be a mixture of Hydrologic Soil Group (HSG) "A", "B", "C", & "D". All wetlands were classified hydrologic soil group "D". Runoff curve numbers associated with developed areas are based upon land usage.

Stormwater runoff generated by Runway 14 is captured in two separate closed drainage systems. Runoff from the Runway 14 end, between Taxiway C and the end taxiway serving Runway 14, is captured in an existing system and discharged into the West Ditch North. Runoff from Taxiway C to the intersection of Runway 5-23 is captured in Existing Drainage System "A" and discharged into the West Ditch North at a different outfall.

Stormwater runoff generated by Runway 32 is captured in two separate closed drainage systems, Existing Drainage Systems "B" and "C", and discharged into the East Ditch.

Existing Drainage Areas and Analysis Points are depicted on Sheet D-1.1.

This drainage study utilizes two Analysis Points (AP-1 and AP-2) in the calculations.

- Analysis Point #1 (AP-1) is defined as the point the Paskamansett River exits the study area. This point coincides with the southern edge of the airport property and the end of proposed work.
- Analysis Point #2 (AP-2) is defined as the north-western edge of watersheds "EX-NW1", "EX-NW3", and "EX-NORTH".

For analysis purposes, the 1,791 acre airport watershed was divided into twenty-eight (28) subwatersheds.

- "EX-WEST1" contains 286.694 acres located to the extreme west of the airport watershed and contains a portion of the Paskamansett River directly south of Turner Pond. This sub-watershed is bounded to the north by New Plainville Road and to the south by the Airport ILS road. Drainage from this watershed is directed through the Paskamansett River to Analysis Point #1.
- "EX-WEST2" contains 141.341 acres. This watershed is collected in the West Ditch and is discharged to AP-1.
- "EX-RW5-W1" contains 10.668 acres along the west side of Runway 5. Runoff from this
 watershed is collected within Infiltration Trench "5-A" with overflow being directed to a
 vegetated drainage channel and subsequently into Proposed Drainage System "A".
 Discharge through the proposed drainage system is directed to the West Ditch and
 ultimately to AP-1.
- "EX-RW5-W2" contains 1.446 acres on the west side of Runway 5 between Taxiway "B" and Runway 14-32. Runoff from this watershed is collected in a vegetated drainage channel and conveyed to the Proposed Drainage System "A". Discharge through the proposed drainage system is directed to the West Ditch and ultimately to AP-1.
- "EX-RW5-E1" contains 21.912 acres along the east side of Runway 5. Runoff from this watershed is collected in the infield storage area located between Runway 5 and Taxiway "A, is collected in the Existing Drainage System "B" and is discharged to the East Ditch via a swale.
- "EX-RW5-E2" contains 3.285 acres on the east side of Runway 5 near Taxiway "B". Runoff is collected in Infiltration Trench "5-B". Overflow is collected in a vegetated swale and conveyed to the Proposed Drainage System "A". Discharge through the proposed drainage system is directed to the West Ditch and ultimately to AP-1.
- "EX-RW5-E3" contains 3.245 acres located on the east side of Runway 5 between
 Taxiway "B" and Runway 14-32. Runoff is collected in Infiltration Trench "5-C".

 Overflow is collected in a vegetated swale and conveyed to the Proposed Drainage
 System "A". Discharge through the proposed drainage system is directed to the West
 Ditch and ultimately to AP-1.
- "EX-RW5-E5" contains 2.132 acres located on the east side of Runway 5 between Taxiway "B" and Runway 14-32. Runoff is collected in a vegetated drainage channel and conveyed to the Proposed Drainage System "A". Discharge through the proposed drainage system is directed to the West Ditch and ultimately AP-1.
- "EX-SOUTH" contains 662.283 acres south-east of the existing airport. This watershed is collected in the East Ditch and is conveyed to AP-1.
- "EX-EAST" contains 243.444 acres located at the east end of runway 14-32 and contains portions of runway 14-32 and airport buildings south-east of the runway. This watershed is bounded to the south by Shawmut Avenue and to the east by Route 140. Drainage from this watershed is collected in the East Ditch and is directed through the East Ditch to the Combined Ditch and ultimately to AP-1.
- "EX-NW3" contains 23.363 acres located north of New Plainville Road. This watershed is bounded by New Plainville Road to the south and the airport easement to the west.

- Drainage from this watershed is directed through an existing wetland complex and is discharged to AP-2.
- "EX-NW2" contains 29.472 acres located along the north edge of Runway 14. This watershed drains to the N.W. Storage Area where it enters the Proposed Drainage System "A". Discharge through the proposed drainage system is directed to the West Ditch and ultimately AP-1.
- "EX-RW23-W1" contains 11.251 acres located along the west side of Runway 23. This
 watershed drains to the proposed Infiltration Trench "23-A". Overflow is collected in a
 vegetated drainage channel and conveyed to the Proposed Drainage System "A".
 Discharge through the proposed drainage system is directed to the West Ditch and
 ultimately to AP-1.
- "EX-RW23-W3 contains 20.185 acres located along the west side of Runway 23. This watershed drains to vegetated drainage channel and is conveyed to the Proposed Drainage System "A". Discharge through the proposed drainage system is directed to the West Ditch and ultimately to AP-1.
- "EX-NW1" contains 23.135 acres. Discharge from the detention area is directed through the existing wetland complex to AP-2.
- "EX-RW23-W2" contains 3.107 acres within the re-graded RSA for Runway 23. Drainage from this watershed drains to the proposed Infiltration Trench "23-B". Overflow is directed to the existing wetlands and is discharged to AP-2.
- "EX-RW23-E2" contains 22.469 acres within the re-graded RSA for Runway 23. Drainage from this watershed drains to the proposed Infiltration Trench "23-C". Overflow is discharged to the existing Wetland "H", through the existing drainage system, and ultimately to AP-1.
- "EX-NORTH" contains 64.926 acres located between Route 140 and New Plainville Road to the far north of the airport proper. Drainage from this watershed is conveyed north along a wetland complex associated with Route 140 and discharges to the Acushnet Cedar Swamp at AP-2.
- "EX-NEAST" contains 121.656 acres located to the north-east of the runways 5-23 and 14-32 centerlines and southwest of Route 140. This watershed contains developed areas as well as undeveloped areas associated with the Airport. Drainage from this watershed is collected in the existing wetland complex and is directed south to the East Ditch. It is then conveyed by the East Ditch to the Combined Ditch and is discharged to AP-1.
- "EX-32N-1" contains 9.743 acres located on the north side of Runway 32. This runoff is collect in the runway edge drainage system annotated Drainage System "C". Runoff from this watershed is directed to the East Ditch N2 through Drainage System "C" and is ultimately discharged through the East Ditch, Combined Ditch and the Paskamansett River to AP-1.
- "EX-RW23-E1" contains 48.890 acres. Runoff from this watershed is collected in Wetland "H", is conveyed across the airport through existing drainage system "B", and is discharged to AP-1 through the East Ditch and Paskamansett River.
- "EX-RW23-E3" contains 9.450 acres. Runoff from this watershed is collected in a vegetated drainage channel and conveyed to the Proposed Drainage System "A".
 Discharge through the proposed drainage system is directed to the West Ditch and ultimately to AP-1.

- "EX-RW23-E4" contains 10.361 acres east of Runway 23. Runoff from this watershed is conveyed to an existing culvert and is then discharged into a drainage ditch at Existing Outfall #2 located in Wetland "H" and ultimately to AP-1.
- "EX-RW23-E5" contains 4.091 acres east of Runway 23. Runoff is collected in a vegetated drainage channel and conveyed to the Proposed Drainage System "A". Discharge through the proposed drainage system is directed to the West Ditch and ultimately AP-1.
- "EX-RW23-E6" contains 3.464 acres east of Runway 14-32 between Taxiway "A" and Taxiway "F". Runoff from this watershed is conveyed to an existing culvert and is then discharged into a drainage ditch at Existing Outfall #1 located in Wetland "H" and ultimately to AP-1.
- "EX-TWA-E1" contains 2.423 acres south of Taxiway A and between the Taxiway and the Aircraft Parking Ramp. Runoff from this watershed is conveyed to Drainage System B through Proposed Drainage System A. Discharge is from Drainage System B directed to the East Ditch South and ultimately AP-1.
- "EX-TWA-E2" contains 1.194 acres north of Taxiway A near the glideslope. Runoff from this watershed is conveyed to Drainage System B through Proposed Drainage System A. Discharge is from Drainage System B directed to the East Ditch South and ultimately AP-1.
- "EX-TWA-W1" contains 4.726 acres. Runoff from this watershed is conveyed to Proposed Drainage B which connects to Existing Outfall #1 located in Wetland "H" and ultimately to AP-1.

EXISTING DRAINAGE SUMMARY				
	(Pre-de	evelopment)		
		RETURN PERIOD		
	2-YR	10-YR	100 YR	
ANALYSIS POINT	EXISTING PEAK DISCHARGE	EXISTING PEAK DISCHARGE	EXISTING PEAK DISCHARGE	
	(CFS)	(CFS)	(CFS)	
AP-1	220.26	399.51	712.61	
AP-2	53.56	103.63	193.82	

4. PROPOSED CONDITIONS

The proposed analysis points are as indicated in the Existing Conditions Section. The control points have not been modified under the Proposed Conditions scenario.

Proposed Drainage Areas and Analysis Points are depicted on Sheet D2.1.

As part of the runway reconstruction effort, the Runway 14-32 Safety Areas (RSA) and Object Free Areas (OFA) will be reconstructed to conform to the current FAA standards. The current RSAs and OFAs are sub-standard at 200 feet long. They will be lengthened to 300 feet. On the Runway 32 end there will be no environmental impacts, as all regrading will be done outside of the wetland buffer zones. In order to comply with RSA and OFA grading criteria on the Runway 14 end approximately 1,280 SF of wetlands will be filled and mitigated elsewhere on site. RSAs and OFAs are typically turf areas surrounding the runway prepared or suitable for reducing the risk of damage to aircraft in the event of an undershoot, overshoot or excursion from the runway.

The reconstruction of the runway includes a reduction in the width of the runway from 150 feet to 75 feet wide, as well as the reduction in the widths of the taxiways serving the runway. This reduction in width will eliminate approximately 10 acres of impervious surfaces. These former impervious surfaces will be converted to turf and provide a grass filter strip before entering a grass channel. The proposed vegetated filter strips have been designed to slow runoff velocities, trap sediment, and promote infiltration, thereby reducing runoff volumes. Stormwater runoff will enter grass channels and be conveyed to the existing closed drainage systems and be discharged to the existing outfalls.

Collectively, these proposed measures will improve existing stormwater runoff conditions consistent with the requirements of Standard 7.

For analysis purposes, the 1,791 acre airport watershed was reanalyzed for the proposed conditions and contains the same twenty-eight (28) sub-watersheds as listed in the Existing Conditions Section.

PROPOSED DRAINAGE SUMMARY					
	(Post-development)				
		RETURN PERIOD			
	100 YR				
ANALYSIS POINT	PEAK DISCHARGE (CFS)	PEAK DISCHARGE (CFS)	PEAK DISCHARGE (CFS)		
AP-1	219.32	398.01	710.66		
AP-2	53.56	103.63	193.82		

5. COMPLIANCE WITH MASSDEP STORMWATER STANDARDS:

Standard #1: No new stormwater conveyance (e.g. outfalls) may discharge untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth.

No new outfalls are being proposed as part of this project. The existing closed drainage systems will be used to collect and discharge stormwater runoff.

All stormwater runoff associated with the proposed reconstruction will be treated using a combination of the following BMPs: vegetated filter strips and grass channels.

Standard #2: Stormwater management systems shall be designed so that post-development peak discharge rates do not exceed pre-development peak discharge rates.

As detailed in the following table, the post-development peak discharge rates have been decreased for Analysis Point #1 and remain the same for Analysis Point #2. No work is being performed that would affect stormwater runoff rates at Analysis Point #2. The reduction in peak discharge rates is a result of the removal of approximately 10 acres of pavement and the addition of vegetated filter strips and grass channels.

The following is a comparison of the Pre-development versus the Post-development peak stormwater discharge rates for the 2, 10 and 100 year storm events.

		RETURN PERIOD				
	2-	YR	10-	-YR	100) YR
ANALYSIS POINT	PRE	POST	PRE	POST	PRE	POST
AP-1	220.26	219.32	399.51	398.01	712.61	710.66
AP-2	53.56	53.56	103.63	103.63	193.82	193.82

Standard #3: Loss of annual recharge to groundwater shall be eliminated or minimized through the use of infiltration measures including environmentally sensitive site design, low impact development techniques, stormwater best management practices and good operation and maintenance. At a minimum, the annual recharge from the post development site shall approximate the annual recharge from the pre-development conditions based on soil type. This Standard is met when the stormwater management system is designed to infiltrate the required recharge volume as determined in accordance with the Massachusetts Stormwater Handbook.

Infiltration trenches were considered for use along Runway 14-32 to recharge groundwater, but seasonal high groundwater levels near the ground surface will not allow for stormwater infiltration. Wet and dry water quality swales were looked at as possible solutions as well where infiltration trenches could not be constructed. Dry water quality swales were dismissed due to high groundwater and the lack of the necessary separation of 2 – 4 feet between groundwater and the bottom of the engineered soil. Wet water quality swales were considered, but ultimately ruled out due to the potential for standing water. Similarly, extended detention basins were ruled out due to potential issues with standing water. Standing water could attract birds which could become hazards for Airport operations especially this close to the taxiway surfaces. The removal of approximately 10 acres of impervious surfaces and the conversion of these areas to turf will improve stormwater infiltration from the existing condition. The sub-

watersheds affected by the Runway 14-32 reconstruction are mostly grassed areas and additional infiltration should occur.

The annual recharge from the post-development condition should approximate the annual recharge from the pre-development conditions to the maximum extent practicable. This project will reduce the amount of impervious surfaces and all fill required to adjust existing grade will be HSG "A".

Standard #4: Stormwater management systems shall be designed to remove 80% of the average annual post-construction load of Total Suspended Solids (TSS). This Standard is met when (a) Suitable practices for source control and pollution prevention are identified in a long-term pollution prevention plan and thereafter are implemented and maintained; (b) Structural stormwater best management practices are sized to capture the required water quality volume determined in accordance with Massachusetts Stormwater Handbook; and (c) Pretreatment is provided in accordance with the Massachusetts Stormwater Handbook.

This project proposes to reuse the existing closed drainage system which is comprised of catch basins with sumps, manholes and drainage pipe of various sizes and types. In order to treat the stormwater runoff being generated by the runway, grass filter strips and grass channels will be used. The combination of a 50 foot wide grass filter strip and grass channel will remove 73% of TSS for the 9 sub-watersheds affected by the reconstruction of Runway 14-32.

TSS removal calculations are included in Appendix A.

Standard #5: Stormwater discharges from areas with higher potential pollutant loads require the use of specific stormwater management BMPs. The use of infiltration practices without pretreatment is prohibited.

Typical airports include land that is considered Land Use with Higher Potential Pollutant Loads (LUHPPL). These areas are defined as apron and plane storage and maintenance areas. Under this definition Runway 14-32 is not considered LUHPPL.

Standard #6: Stormwater discharges to critical areas must utilize certain stormwater BMPs approved for critical areas. Critical areas are Oustanding Resource Waters (ORWs), shellfish beds, swimming beaches, cold water fisheries, and recharge areas for public water supplies.

This Standard is not applicable.

Standard #7: A redevelopment project is required to meet the following Stormwater Management Standards only to the maximum extent practicable: Standard 2, Standard 3, and the pretreatment and structural stormwater best management practice requirements of Standards 4, 5 and 6. Existing stormwater discharges shall comply with Standard 1 only to the maximum extent practicable. A redevelopment project shall also comply with all other requirements of the Stormwater Management Standards and improve existing conditions.

As described above, work associated with reconstructing Runway 14-32 is considered to be a redevelopment and meets Stormwater Management Standards 2 and 3, and the pre-treatment

and structural BMP requirements of Standards 4, 5 and 6 to the maximum extent practicable as follows:

Standard #2: The post-development stormwater discharge rate does not exceed the predevelopment discharge rate. This project will reduce impervious surfaces and use vegetated filter strips, infiltration trenches, and grass channels to reduce the discharge rate in the postdevelopment scenario.

Standard #3: Due to high seasonal groundwater infiltration measures cannot be constructed to infiltrate the required volume of stormwater. This project will remove approximately 10 acres of impervious surfaces and convert these areas to turf. Water will be allowed to infiltrate in the large grassed areas in the Airport Watershed

Standard #4: 73% TSS removal has been achieved for the nine sub-watersheds affected by the reconstruction of Runway 14-32 by using vegetated filter strips and grass channels.

Standard #5: Runway 14-32 is not considered LUHPPL because Aircraft will not be parked, stored or maintained on the Runway. Please see the discussion in **Standard #5**.

Standard #6: This Standard is not applicable.

The project complies with all other standards and improves existing conditions.

Standard #8: A plan to control construction-related impacts including erosion, sedimentation and other pollutant sources during construction and land disturbance activities (construction period erosion, sedimentation, and pollution prevention plan) shall be developed and implemented.

Erosion control has been incorporated into the construction plan set. A General Permit Construction Phase SWPPP will be developed by the Contractor for this construction project. A construction SWPPP will be prepared prior to the start of construction.

Standard #9: A long-term operation and maintenance plan shall be developed and implemented to ensure that stormwater management systems function as designed.

ASG has prepared a long-term operation and maintenance plan titled "New Bedford Regional Airport – Storm Water Operations and Maintenance Plan" for the New Bedford Regional Airport. This Operations and Maintenance plan has been updated and a copy of the Plan is attached.

Standard #10: All illicit discharges to the stormwater management system are prohibited.

All existing illicit discharges associated with the Airport were removed / eliminated as part of the Variance Order issued by MASS DEP (e.g., floor drains at various hangar facilities).

6. DRAINAGE SUMMARY

Watershed Area Comparison				
Pre-dev Co	nditions	Post-dev Conditions		
Watershed	Area (AC)	Watershed	Area (AC)	
EX-WEST1	286.694	PROP-WEST1	286.694	
EX-WEST2	141.341	PROP-WEST2	141.341	
EX-RW5-W1	10.668	PROP-RW5-W1	10.668	
EX-RW5-W2	1.446	PROP-RW5-W2	1.446	
EX-RW5-E1	21.912	PROP-RW5-E1	21.912	
EX-RW5-E2	3.285	PROP-RW5-E2	3.285	
EX-RW5-E3	3.245	PROP-RW5-E3	3.245	
EX-RW5-E5	2.132	PROP-RW5-E5	2.132	
EX-SOUTH	662.283	PROP-SOUTH	662.283	
EX-EAST	243.444	PROP-EAST	243.444	
EX-NW3	23.363	PROP-NW3	23.363	
EX-NW2	29.472	PROP-NW2	29.472	
EX-RW23-W1	11.251	PROP-RW23-W1	11.251	
EX-RW23-W2	3.107	PROP-RW23-W2	3.107	
EX-RW23-W3	20.185	PROP-RW23-W3	20.185	
EX-NW1	23.135	PROP-NW1	23.135	
EX-RW23-E2	22.469	PROP-RW23-E2	22.469	
EX-NORTH	64.926	PROP-NORTH	64.926	
EX-NEAST	121.656	PROP-NEAST	121.656	
EX-32N-1	9.743	PROP-32N-1	9.743	
EX-RW23-E1	48.890	PROP-RW23-E1	48.890	
EX-RW23-E3	9.450	PROP-RW23-E3	9.450	
EX-RW23-E4	10.361	PROP-RW23-E4	10.361	
EX-RW23-E5	4.091	PROP-RW23-E5	4.091	
EX-RW23-E6	3.464	PROP-RW23-E6	3.464	
EX-TWA-E1	2.423	PROP-TWA-E1	2.423	
EX-TWA-E2	1.194	PROP-TWA-E2	1.194	
EX-TWA-W1	4.726	PROP-TWA-W1	4.726	
Total	1,790.356		1,790.356	

Soils Comparison				
HSG	Pre-dev Area (AC)	Post-dev Area (AC)		
Α	433.784	433.784		
В	20.165	20.165		
С	399.193	399.193		
D	937.214	937.214		
Total	1,790.356	1,790.356		

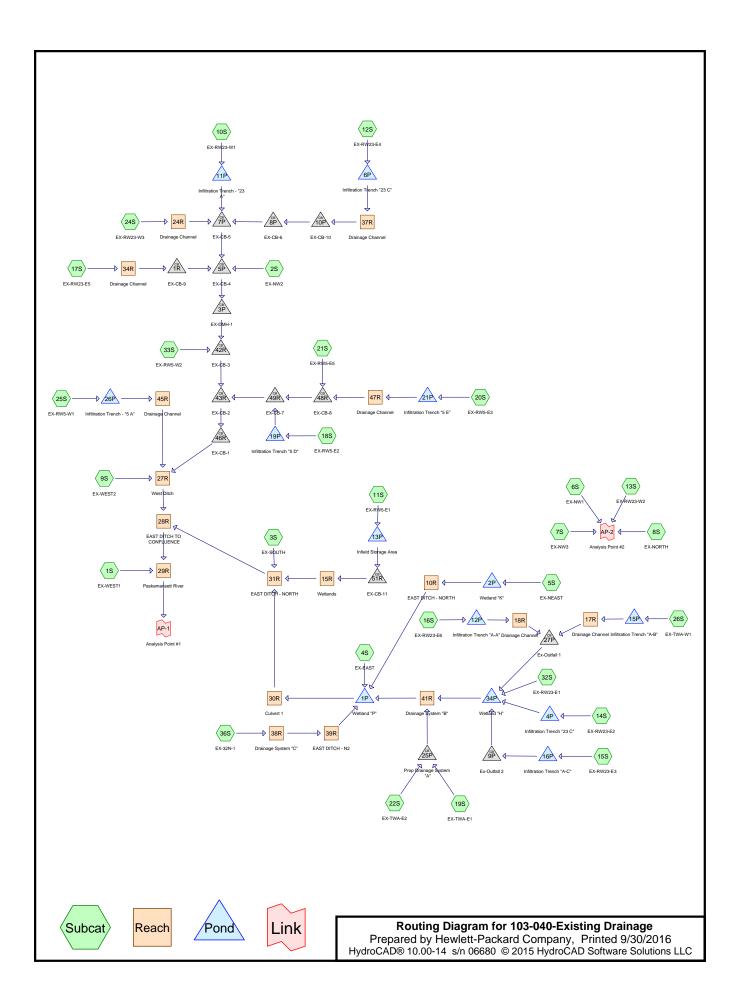
Peak Discharge Comparison (cfs)						
	2 YR		10 YR		100 YR	
	PRE	POST	PRE	POST	PRE	POST
AP-1	220.26	219.32	399.51	398.01	712.61	710.66
AP-2	53.56	53.56	103.63	103.63	193.82	193.82

This Page Intentionally Left Blank

APPENDIX A

EXISTING DRAINAGE CALCULATIONS

This Page Intentionally Left Blank



Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
17.726	61	1/4 acre lots, 38% imp, HSG A (1S, 2S, 9S, 24S)
51.376	83	1/4 acre lots, 38% imp, HSG C (4S, 5S, 32S)
7.815	87	1/4 acre lots, 38% imp, HSG D (4S, 5S, 32S)
111.957	39	>75% Grass cover, Good, HSG A (1S, 4S, 10S, 11S, 12S, 13S, 14S, 15S, 16S,
		17S, 18S, 19S, 20S, 21S, 22S, 24S, 25S, 26S, 32S, 33S, 36S)
25.423	74	>75% Grass cover, Good, HSG C (4S, 8S, 13S, 14S, 32S)
28.069	80	>75% Grass cover, Good, HSG D (1S, 4S, 8S, 14S, 25S, 32S)
29.258	30	Brush, Good, HSG A (2S, 3S, 5S, 6S, 9S, 24S, 32S)
1.916	48	Brush, Good, HSG B (1S, 9S)
21.620	65	Brush, Good, HSG C (1S, 3S, 6S, 14S)
196.069	73	Brush, Good, HSG D (1S, 3S, 5S, 6S, 9S, 32S)
4.941	76	Gravel roads, HSG A (3S, 4S, 5S, 9S, 11S, 14S, 32S)
5.666	89	Gravel roads, HSG C (4S, 6S, 7S, 8S)
10.360	91	Gravel roads, HSG D (3S, 4S, 5S, 6S, 7S, 8S, 9S)
102.506	39	Pasture/grassland/range, Good, HSG A (2S, 3S, 4S, 5S, 6S, 9S)
5.802	61	Pasture/grassland/range, Good, HSG B (3S)
19.236	74	Pasture/grassland/range, Good, HSG C (3S, 4S, 5S, 6S)
152.250	80	Pasture/grassland/range, Good, HSG D (3S, 4S, 5S, 6S, 9S)
68.280	98	Paved parking, HSG A (2S, 3S, 4S, 5S, 6S, 9S, 10S, 11S, 12S, 13S, 14S, 15S, 16S,
		17S, 18S, 19S, 20S, 21S, 22S, 24S, 25S, 26S, 32S, 33S, 36S)
1.637	98	Paved parking, HSG B (3S)
26.639	98	Paved parking, HSG C (3S, 4S, 6S, 8S)
44.125	98	Paved parking, HSG D (1S, 3S, 4S, 5S, 6S, 8S)
15.997	98	Water Surface, HSG D (1S, 3S, 4S, 5S, 6S, 7S, 8S, 9S)
66.941	30	Woods, Good, HSG A (1S, 3S, 4S, 5S, 6S, 9S, 32S)
10.810	55	Woods, Good, HSG B (1S, 9S)
125.260	70	Woods, Good, HSG C (1S, 3S, 4S, 5S, 6S, 7S, 8S, 14S, 32S)
409.934	77	Woods, Good, HSG D (1S, 3S, 4S, 5S, 6S, 7S, 8S, 9S, 14S, 32S)
32.175	32	Woods/grass comb., Good, HSG A (3S)
123.973	72	Woods/grass comb., Good, HSG C (3S)
72.595	79	Woods/grass comb., Good, HSG D (3S)
1,790.356	70	TOTAL AREA

103-040-Existing Drainage
Prepared by Hewlett-Packard Company
HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Printed 9/30/2016 Page 3

Soil Listing (all nodes)

Area	Soil	Subcatchment
(acres)	Group	Numbers
433.784	HSG A	1S, 2S, 3S, 4S, 5S, 6S, 9S, 10S, 11S, 12S, 13S, 14S, 15S, 16S, 17S, 18S, 19S,
		20S, 21S, 22S, 24S, 25S, 26S, 32S, 33S, 36S
20.165	HSG B	1S, 3S, 9S
399.193	HSG C	1S, 3S, 4S, 5S, 6S, 7S, 8S, 13S, 14S, 32S
937.214	HSG D	1S, 3S, 4S, 5S, 6S, 7S, 8S, 9S, 14S, 25S, 32S
0.000	Other	
1,790.356		TOTAL AREA

Pre-development Type III 24-hr 2-Year Rainfall=3.40" Printed 9/30/2016

Prepared by Hewlett-Packard Company
HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 4

Time span=5.00-48.00 hrs, dt=0.05 hrs, 861 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

3 ,	3 ,
Subcatchment1S: EX-WEST1	Runoff Area=286.694 ac 2.76% Impervious Runoff Depth=0.75" Flow Length=6,115' Tc=90.6 min CN=66 Runoff=63.29 cfs 17.838 af
Subcatchment 2S: EX-NW2	Runoff Area=29.472 ac 13.14% Impervious Runoff Depth=0.09" Flow Length=2,730' Tc=56.3 min CN=46 Runoff=0.34 cfs 0.213 af
Subcatchment 3S: EX-SOUTH	Runoff Area=662.283 ac 5.89% Impervious Runoff Depth=1.17" Flow Length=10,096' Tc=125.9 min CN=74 Runoff=205.76 cfs 64.650 af
Subcatchment 4S: EX-EAST	Runoff Area=243.444 ac 21.04% Impervious Runoff Depth=1.36" Flow Length=5,766' Tc=94.7 min CN=77 Runoff=110.09 cfs 27.523 af
Subcatchment 5S: EX-NEAST	Runoff Area=121.656 ac 18.34% Impervious Runoff Depth=1.29" Flow Length=4,620' Tc=50.7 min CN=76 Runoff=77.35 cfs 13.111 af
Subcatchment 6S: EX-NW1	Runoff Area=23.135 ac 5.60% Impervious Runoff Depth=0.89" Flow Length=1,415' Tc=26.5 min CN=69 Runoff=12.99 cfs 1.725 af
Subcatchment7S: EX-NW3	Runoff Area=23.363 ac 2.88% Impervious Runoff Depth=1.17" Flow Length=1,310' Tc=24.4 min CN=74 Runoff=18.94 cfs 2.281 af
Subcatchment8S: EX-NORTH	Runoff Area=64.926 ac 7.58% Impervious Runoff Depth=1.42" Flow Length=2,892' Tc=69.3 min CN=78 Runoff=38.03 cfs 7.693 af
Subcatchment9S: EX-WEST2	Runoff Area=141.341 ac 12.96% Impervious Runoff Depth=0.57" Flow Length=4,198' Tc=55.7 min CN=62 Runoff=29.14 cfs 6.706 af
Subcatchment 10S: EX-RW23-W1	Runoff Area=11.251 ac 38.77% Impervious Runoff Depth=0.57" Flow Length=336' Tc=31.7 min CN=62 Runoff=3.13 cfs 0.534 af
Subcatchment11S: EX-RW5-E1	Runoff Area=21.912 ac 22.13% Impervious Runoff Depth=0.22" Flow Length=1,467' Tc=45.1 min CN=52 Runoff=1.06 cfs 0.409 af
Subcatchment 12S: EX-RW23-E4	Runoff Area=10.361 ac 36.22% Impervious Runoff Depth=0.49" Flow Length=336' Tc=28.6 min CN=60 Runoff=2.38 cfs 0.422 af
Subcatchment 13S: EX-RW23-W2	Runoff Area=3.107 ac 13.45% Impervious Runoff Depth=0.70" Flow Length=431' Tc=26.1 min CN=65 Runoff=1.26 cfs 0.181 af
Subcatchment14S: EX-RW23-E2	Runoff Area=22.469 ac 9.29% Impervious Runoff Depth=0.57" Flow Length=1,209' Tc=18.8 min CN=62 Runoff=7.56 cfs 1.066 af
Subcatchment 15S: EX-RW23-E3	Runoff Area=9.450 ac 11.30% Impervious Runoff Depth=0.09" Flow Length=1,277' Tc=70.0 min CN=46 Runoff=0.11 cfs 0.068 af
Subcatchment16S: EX-RW23-E6	Runoff Area=3.464 ac 28.29% Impervious Runoff Depth=0.35" Flow Length=353' Tc=10.0 min CN=56 Runoff=0.57 cfs 0.100 af

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 5

 Subcatchment 17S: EX-RW23-E5
 Runoff Area=4.091 ac 39.21% Impervious Runoff Depth=0.57" Flow Length=2,359' Tc=34.9 min CN=62 Runoff=1.09 cfs 0.194 af

 Subcatchment 18S: EX-RW5-E2
 Runoff Area=3.285 ac 34.03% Impervious Runoff Depth=0.45" Flow Length=387' Tc=42.5 min CN=59 Runoff=0.55 cfs 0.123 af

 Subcatchment 19S: EX-TWA-E1
 Runoff Area=2.423 ac 46.35% Impervious Runoff Depth=0.75" Flow Length=322' Tc=21.8 min CN=66 Runoff=1.16 cfs 0.151 af

 Subcatchment 20S: EX-RW5-E3
 Runoff Area=3.245 ac 41.11% Impervious Runoff Depth=0.61" Slope=0.0133 '/' Tc=20.8 min CN=63 Runoff=1.18 cfs 0.165 af

Subcatchment 21S: EX-RW5-E5 Runoff Area=2.132 ac 29.83% Impervious Runoff Depth=0.38" Flow Length=1,056' Tc=46.6 min CN=57 Runoff=0.26 cfs 0.067 af

Subcatchment 22S: EX-TWA-E2

Runoff Area=1.194 ac 1.93% Impervious Runoff Depth=0.01"

Flow Length=338' Tc=21.4 min CN=40 Runoff=0.00 cfs 0.001 af

Subcatchment 24S: EX-RW23-W3

Runoff Area=20.185 ac 4.44% Impervious Runoff Depth=0.02"

Flow Length=2,853' Tc=57.2 min CN=41 Runoff=0.05 cfs 0.031 af

Subcatchment 25S: EX-RW5-W1 Runoff Area=10.668 ac 37.32% Impervious Runoff Depth=0.57" Flow Length=210' Tc=21.1 min CN=62 Runoff=3.45 cfs 0.506 af

Subcatchment 26S: EX-TWA-W1 Runoff Area=4.726 ac 14.47% Impervious Runoff Depth=0.13" Flow Length=595' Tc=17.6 min CN=48 Runoff=0.08 cfs 0.050 af

Subcatchment 32S: EX-RW23-E1 Runoff Area=48.890 ac 8.03% Impervious Runoff Depth=0.35" Flow Length=2,965' Tc=67.6 min CN=56 Runoff=4.16 cfs 1.406 af

Subcatchment 33S: EX-RW5-W2

Runoff Area=1.446 ac 46.96% Impervious Runoff Depth=0.79"
Flow Length=1,182' Tc=35.4 min CN=67 Runoff=0.61 cfs 0.096 af

Subcatchment 36S: EX-32N-1Runoff Area=9.743 ac 29.17% Impervious Runoff Depth=0.35"
Flow Length=1,616' Slope=0.0100 '/' Tc=19.2 min CN=56 Runoff=1.43 cfs 0.280 af

Reach 10R: EAST DITCH - NORTH Avg. Flow Depth=1.15' Max Vel=1.74 fps Inflow=31.90 cfs 13.111 af n=0.025 L=3,667.0' S=0.0009 '/' Capacity=291.82 cfs Outflow=30.58 cfs 13.109 af

Reach 15R: WetlandsAvg. Flow Depth=0.38' Max Vel=1.15 fps Inflow=1.05 cfs 0.409 af n=0.050 L=413.0' S=0.0097 '/' Capacity=82.03 cfs Outflow=1.04 cfs 0.409 af

Reach 18R: Drainage ChannelAvg. Flow Depth=0.18' Max Vel=1.05 fps Inflow=0.87 cfs 0.072 af n=0.030 L=281.0' S=0.0061 '/' Capacity=81.66 cfs Outflow=0.52 cfs 0.072 af

Reach 24R: Drainage ChannelAvg. Flow Depth=0.03' Max Vel=0.34 fps Inflow=0.05 cfs 0.031 af n=0.025 L=2,354.0' S=0.0032 '/' Capacity=20.34 cfs Outflow=0.04 cfs 0.031 af

Reach 27R: West Ditch

Avg. Flow Depth=3.11' Max Vel=0.78 fps Inflow=33.88 cfs 7.932 af

n=0.050 L=531.0' S=0.0003'/' Capacity=53.46 cfs Outflow=31.38 cfs 7.931 af

Reach 28R: EAST DITCH TOAvg. Flow Depth=4.35' Max Vel=3.14 fps Inflow=212.52 cfs 116.563 af n=0.050 L=1,705.0' S=0.0030 '/' Capacity=284.51 cfs Outflow=212.22 cfs 116.549 af

Reach 29R: Paskamansett River Avg. Flow Depth=9.21' Max Vel=0.87 fps Inflow=228.04 cfs 134.386 af n=0.035 L=1,905.0' S=0.0001 '/' Capacity=103.50 cfs Outflow=220.26 cfs 134.302 af

Reach 30R: Culvert 1 Avg. Flow Depth=1.72' Max Vel=6.96 fps Inflow=89.95 cfs 43.642 af 90.0" x 45.0" Box Pipe n=0.015 L=48.0' S=0.0040 '/' Capacity=203.41 cfs Outflow=89.95 cfs 43.642 af

Reach 31R: EAST DITCH - NORTH Avg. Flow Depth=23.25' Max Vel=0.47 fps Inflow=293.53 cfs 108.701 af n=0.050 L=2,413.0' S=0.0000 '/' Capacity=18.43 cfs Outflow=204.66 cfs 108.631 af

Reach 34R: Drainage ChannelAvg. Flow Depth=0.12' Max Vel=2.03 fps Inflow=1.09 cfs 0.194 af n=0.025 L=331.0' S=0.0230 '/' Capacity=240.18 cfs Outflow=1.08 cfs 0.194 af

Reach 37R: Drainage ChannelAvg. Flow Depth=0.14' Max Vel=0.28 fps Inflow=0.87 cfs 0.051 af n=0.080 L=1,795.0' S=0.0035 '/' Capacity=6.58 cfs Outflow=0.18 cfs 0.051 af

Reach 38R: Drainage System "C"Avg. Flow Depth=0.69' Max Vel=2.38 fps Inflow=1.43 cfs 0.280 af 12.0" Round Pipe n=0.012 L=796.0' S=0.0019 '/' Capacity=1.68 cfs Outflow=1.37 cfs 0.280 af

Reach 39R: EAST DITCH - N2Avg. Flow Depth=0.40' Max Vel=0.40 fps Inflow=1.37 cfs 0.280 af n=0.050 L=2,017.0' S=0.0011 '/' Capacity=68.77 cfs Outflow=0.50 cfs 0.280 af

Reach 41R: Drainage System "B"Avg. Flow Depth=0.62' Max Vel=4.06 fps Inflow=4.33 cfs 2.730 af 36.0" Round Pipe n=0.012 L=1,593.0' S=0.0040 '/' Capacity=45.62 cfs Outflow=4.33 cfs 2.730 af

Reach 45R: Drainage ChannelAvg. Flow Depth=0.26' Max Vel=1.16 fps Inflow=5.81 cfs 0.255 af n=0.025 L=2,480.0' S=0.0030 '/' Capacity=86.58 cfs Outflow=1.52 cfs 0.255 af

Reach 47R: Drainage ChannelAvg. Flow Depth=0.19' Max Vel=1.21 fps Inflow=1.51 cfs 0.098 af n=0.025 L=170.0' S=0.0047 '/' Capacity=108.73 cfs Outflow=1.08 cfs 0.098 af

Pond 1P: Wetland "P" Peak Elev=58.41' Storage=213,653 cf Inflow=126.14 cfs 43.642 af 90.0" x 45.0" Box Culvert n=0.015 L=1.0' S=0.0000 '/' Outflow=89.95 cfs 43.642 af

Pond 1R: EX-CB-9

Peak Elev=62.42' Inflow=1.08 cfs 0.194 af
18.0" Round Culvert n=0.012 L=425.0' S=0.0022 '/' Outflow=1.08 cfs 0.194 af

Pond 2P: Wetland "K" Peak Elev=61.44' Storage=158,458 cf Inflow=77.35 cfs 13.111 af

Outflow=31.90 cfs 13.111 af

Pond 3P: EX-DMH-1 Peak Elev=61.08' Inflow=4.26 cfs 0.649 af 24.0" Round Culvert n=0.012 L=293.0' S=0.0018 '/' Outflow=4.26 cfs 0.649 af

Pond 4P: Infiltration Trench "23 C" Peak Elev=78.09' Storage=1 cf Inflow=7.56 cfs 1.066 af Discarded=0.00 cfs 0.001 af Primary=7.56 cfs 1.065 af Outflow=7.56 cfs 1.066 af

Type III 24-hr 2-Year Rainfall=3.40"

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC Page 7

Peak Elev=61.62' Inflow=4.26 cfs 0.649 af Pond 5P: EX-CB-4 24.0" Round Culvert n=0.012 L=308.0' S=0.0018 '/' Outflow=4.26 cfs 0.649 af

Pond 6P: Infiltration Trench "23 C" Peak Elev=70.75' Storage=4,442 cf Inflow=2.38 cfs 0.422 af

Discarded=0.41 cfs 0.372 af Primary=0.87 cfs 0.051 af Outflow=1.27 cfs 0.423 af

Peak Elev=62.56' Inflow=3.21 cfs 0.243 af Pond 7P: EX-CB-5

18.0" Round Culvert n=0.012 L=250.0' S=0.0022 '/' Outflow=3.21 cfs 0.243 af

Pond 8P: EX-CB-6 Peak Elev=62.33' Inflow=0.18 cfs 0.051 af

18.0" Round Culvert n=0.012 L=250.0' S=0.0022 '/' Outflow=0.18 cfs 0.051 af

Peak Elev=70.39' Inflow=0.07 cfs 0.015 af Pond 9P: Ex-Outfall 2

12.0" Round Culvert n=0.012 L=107.0' S=0.0140 '/' Outflow=0.07 cfs 0.015 af

Peak Elev=63.37' Inflow=0.18 cfs 0.051 af Pond 10P: EX-CB-10

18.0" Round Culvert n=0.012 L=425.0' S=0.0022 '/' Outflow=0.18 cfs 0.051 af

Pond 11P: Infiltration Trench - "23 A" Peak Elev=71.00' Storage=4,479 cf Inflow=3.13 cfs 0.534 af

Discarded=0.35 cfs 0.381 af Primary=3.21 cfs 0.161 af Outflow=3.56 cfs 0.542 af

Pond 12P: Infiltration Trench "A-A" Peak Elev=67.27' Storage=139 cf Inflow=0.57 cfs 0.100 af

Discarded=0.02 cfs 0.028 af Primary=0.87 cfs 0.072 af Outflow=0.90 cfs 0.100 af

Pond 13P: Infield Storage Area Peak Elev=59.45' Storage=173 cf Inflow=1.06 cfs 0.409 af

Outflow=1.05 cfs 0.409 af

Pond 15P: Infiltration Trench "A-B" Peak Elev=68.23' Storage=120 cf Inflow=0.08 cfs 0.050 af

Discarded=0.03 cfs 0.030 af Primary=0.10 cfs 0.020 af Outflow=0.13 cfs 0.050 af

Pond 16P: Infiltration Trench "A-C" Peak Elev=73.98' Storage=240 cf Inflow=0.11 cfs 0.068 af

Discarded=0.05 cfs 0.053 af Primary=0.07 cfs 0.015 af Outflow=0.12 cfs 0.068 af

Pond 19P: Infiltration Trench "5 D" Peak Elev=71.01' Storage=653 cf Inflow=0.55 cfs 0.123 af

Discarded=0.05 cfs 0.063 af Primary=0.82 cfs 0.061 af Outflow=0.87 cfs 0.123 af

Pond 21P: Infiltration Trench "5 E" Peak Elev=71.02' Storage=700 cf Inflow=1.18 cfs 0.165 af

Discarded=0.05 cfs 0.067 af Primary=1.51 cfs 0.098 af Outflow=1.56 cfs 0.165 af

Peak Elev=59.86' Inflow=1.16 cfs 0.152 af Pond 25P: Prop Drainage System "A"

12.0" Round Culvert n=0.012 L=170.0' S=0.0026 '/' Outflow=1.16 cfs 0.152 af

Pond 26P: Infiltration Trench - "5 A" Peak Elev=59.26' Storage=2,938 cf Inflow=3.45 cfs 0.506 af

Discarded=0.23 cfs 0.283 af Primary=5.81 cfs 0.255 af Outflow=6.05 cfs 0.537 af

Peak Elev=64.68' Inflow=0.52 cfs 0.092 af Pond 27P: Ex-Outfall 1

12.0" Round Culvert n=0.012 L=124.0' S=0.0022 '/' Outflow=0.52 cfs 0.092 af

Pond 34P: Wetland "H" Peak Elev=65.42' Storage=22,024 cf Inflow=8.24 cfs 2.579 af

12.0" Round Culvert n=0.012 L=70.0' S=0.0020 '/' Outflow=4.14 cfs 2.579 af

Link AP-2: Analysis Point #2

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 8

Inflow=53.56 cfs 11.879 af Primary=53.56 cfs 11.879 af

Pond 42R: EX-CB-3	Peak Elev=60.56' Inflow=4.77 cfs 0.745 af 24.0" Round Culvert n=0.012 L=354.0' S=0.0016 '/' Outflow=4.77 cfs 0.745 af
Pond 43R: EX-CB-2	Peak Elev=60.44' Inflow=5.73 cfs 0.971 af 24.0" Round Culvert n=0.012 L=409.0' S=0.0001'/' Outflow=5.73 cfs 0.971 af
Pond 46R: EX-CB-1	Peak Elev=59.93' Inflow=5.73 cfs 0.971 af 24.0" Round Culvert n=0.012 L=36.0' S=0.0003 '/' Outflow=5.73 cfs 0.971 af
Pond 48R: EX-CB-8	Peak Elev=60.50' Inflow=1.22 cfs 0.166 af 18.0" Round Culvert n=0.012 L=364.0' S=0.0022 '/' Outflow=1.22 cfs 0.166 af
Pond 49R: EX-CB-7	Peak Elev=59.93' Inflow=1.63 cfs 0.226 af 18.0" Round Culvert n=0.012 L=425.0' S=0.0005 '/' Outflow=1.63 cfs 0.226 af
Pond 51R: EX-CB-11	Peak Elev=57.52' Inflow=1.05 cfs 0.409 af 18.0" Round Culvert n=0.012 L=307.0' S=0.0010 '/' Outflow=1.05 cfs 0.409 af
Link AP-1: Analysis Point #1	Inflow=220.26 cfs 134.302 af Primary=220.26 cfs 134.302 af

Total Runoff Area = 1,790.356 ac Runoff Volume = 147.589 af Average Runoff Depth = 0.99" 89.62% Pervious = 1,604.450 ac 10.38% Impervious = 185.906 ac

Pre-development Type III 24-hr 10-Year Rainfall=4.80" Printed 9/30/2016

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 1

Time span=5.00-48.00 hrs, dt=0.05 hrs, 861 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

readin routing by Gior	mar trane method in one reating by eter ma method
Subcatchment1S: EX-WEST1	Runoff Area=286.694 ac 2.76% Impervious Runoff Depth=1.59" Flow Length=6,115' Tc=90.6 min CN=66 Runoff=151.30 cfs 38.056 af
Subcatchment 2S: EX-NW2	Runoff Area=29.472 ac 13.14% Impervious Runoff Depth=0.42" Flow Length=2,730' Tc=56.3 min CN=46 Runoff=3.09 cfs 1.041 af
Subcatchment 3S: EX-SOUTH	Runoff Area=662.283 ac 5.89% Impervious Runoff Depth=2.21" bw Length=10,096' Tc=125.9 min CN=74 Runoff=404.55 cfs 121.738 af
Subcatchment 4S: EX-EAST	Runoff Area=243.444 ac 21.04% Impervious Runoff Depth=2.46" Flow Length=5,766' Tc=94.7 min CN=77 Runoff=204.32 cfs 49.837 af
Subcatchment 5S: EX-NEAST	Runoff Area=121.656 ac 18.34% Impervious Runoff Depth=2.37" Flow Length=4,620' Tc=50.7 min CN=76 Runoff=145.95 cfs 24.044 af
Subcatchment 6S: EX-NW1	Runoff Area=23.135 ac 5.60% Impervious Runoff Depth=1.81" Flow Length=1,415' Tc=26.5 min CN=69 Runoff=28.42 cfs 3.496 af
Subcatchment7S: EX-NW3	Runoff Area=23.363 ac 2.88% Impervious Runoff Depth=2.21" Flow Length=1,310' Tc=24.4 min CN=74 Runoff=37.03 cfs 4.294 af
Subcatchment8S: EX-NORTH	Runoff Area=64.926 ac 7.58% Impervious Runoff Depth=2.54" Flow Length=2,892' Tc=69.3 min CN=78 Runoff=69.34 cfs 13.758 af
Subcatchment 9S: EX-WEST2	Runoff Area=141.341 ac 12.96% Impervious Runoff Depth=1.32" Flow Length=4,198' Tc=55.7 min CN=62 Runoff=80.90 cfs 15.507 af
Subcatchment 10S: EX-RW23-W1	Runoff Area=11.251 ac 38.77% Impervious Runoff Depth=1.32" Flow Length=336' Tc=31.7 min CN=62 Runoff=8.70 cfs 1.234 af
Subcatchment11S: EX-RW5-E1	Runoff Area=21.912 ac 22.13% Impervious Runoff Depth=0.72" Flow Length=1,467' Tc=45.1 min CN=52 Runoff=6.06 cfs 1.308 af
Subcatchment12S: EX-RW23-E4	Runoff Area=10.361 ac 36.22% Impervious Runoff Depth=1.19" Flow Length=336' Tc=28.6 min CN=60 Runoff=7.33 cfs 1.024 af
Subcatchment 13S: EX-RW23-W2	Runoff Area=3.107 ac 13.45% Impervious Runoff Depth=1.52" Flow Length=431' Tc=26.1 min CN=65 Runoff=3.13 cfs 0.394 af
Subcatchment14S: EX-RW23-E2	Runoff Area=22.469 ac 9.29% Impervious Runoff Depth=1.32" Flow Length=1,209' Tc=18.8 min CN=62 Runoff=21.55 cfs 2.465 af
Subcatchment15S: EX-RW23-E3	Runoff Area=9.450 ac 11.30% Impervious Runoff Depth=0.42" Flow Length=1,277' Tc=70.0 min CN=46 Runoff=0.89 cfs 0.334 af
Subcatchment16S: EX-RW23-E6	Runoff Area=3.464 ac 28.29% Impervious Runoff Depth=0.94" Flow Length=353' Tc=10.0 min CN=56 Runoff=2.62 cfs 0.271 af

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 2

Subcatchment 17S: EX-RW23-E5

Runoff Area=4.091 ac 39.21% Impervious Runoff Depth=1.32"
Flow Length=2,359' Tc=34.9 min CN=62 Runoff=3.02 cfs 0.449 af

Subcatchment 18S: EX-RW5-E2

Runoff Area=3.285 ac 34.03% Impervious Runoff Depth=1.12"
Flow Length=387' Tc=42.5 min CN=59 Runoff=1.79 cfs 0.307 af

Subcatchment 19S: EX-TWA-E1

Runoff Area=2.423 ac 46.35% Impervious Runoff Depth=1.59"
Flow Length=322' Tc=21.8 min CN=66 Runoff=2.77 cfs 0.322 af

Subcatchment 20S: EX-RW5-E3 Runoff Area=3.245 ac 41.11% Impervious Runoff Depth=1.38" Flow Length=203' Slope=0.0133 '/' Tc=20.8 min CN=63 Runoff=3.19 cfs 0.374 af

Subcatchment 21S: EX-RW5-E5

Runoff Area=2.132 ac 29.83% Impervious Runoff Depth=1.00"
Flow Length=1,056' Tc=46.6 min CN=57 Runoff=0.94 cfs 0.178 af

Subcatchment 22S: EX-TWA-E2

Runoff Area=1.194 ac 1.93% Impervious Runoff Depth=0.19"
Flow Length=338' Tc=21.4 min CN=40 Runoff=0.03 cfs 0.019 af

Subcatchment 24S: EX-RW23-W3

Runoff Area=20.185 ac 4.44% Impervious Runoff Depth=0.23"

Flow Length=2,853' Tc=57.2 min CN=41 Runoff=0.68 cfs 0.381 af

Subcatchment 25S: EX-RW5-W1 Runoff Area=10.668 ac 37.32% Impervious Runoff Depth=1.32" Flow Length=210' Tc=21.1 min CN=62 Runoff=9.77 cfs 1.170 af

Subcatchment 26S: EX-TWA-W1 Runoff Area=4.726 ac 14.47% Impervious Runoff Depth=0.51" Flow Length=595' Tc=17.6 min CN=48 Runoff=1.10 cfs 0.203 af

Subcatchment 32S: EX-RW23-E1Runoff Area=48.890 ac 8.03% Impervious Runoff Depth=0.94"

Flow Length=2,965' Tc=67.6 min CN=56 Runoff=15.78 cfs 3.831 af

Subcatchment 33S: EX-RW5-W2

Runoff Area=1.446 ac 46.96% Impervious Runoff Depth=1.67"

Flow Length=1,182' Tc=35.4 min CN=67 Runoff=1.41 cfs 0.201 af

Subcatchment 36S: EX-32N-1 Runoff Area=9.743 ac 29.17% Impervious Runoff Depth=0.94" Flow Length=1,616' Slope=0.0100 '/' Tc=19.2 min CN=56 Runoff=5.83 cfs 0.763 af

Reach 10R: EAST DITCH - NORTH Avg. Flow Depth=1.97' Max Vel=2.37 fps Inflow=93.47 cfs 24.044 af n=0.025 L=3,667.0' S=0.0009 '/' Capacity=291.82 cfs Outflow=79.21 cfs 24.042 af

Reach 15R: WetlandsAvg. Flow Depth=0.82' Max Vel=1.88 fps Inflow=5.44 cfs 1.308 af n=0.050 L=413.0' S=0.0097'/' Capacity=82.03 cfs Outflow=5.42 cfs 1.308 af

Reach 17R: Drainage ChannelAvg. Flow Depth=0.27' Max Vel=1.30 fps Inflow=1.46 cfs 0.171 af n=0.030 L=281.0' S=0.0061 '/' Capacity=81.66 cfs Outflow=1.05 cfs 0.171 af

Reach 18R: Drainage ChannelAvg. Flow Depth=0.41' Max Vel=1.65 fps Inflow=2.70 cfs 0.243 af n=0.030 L=281.0' S=0.0061 '/' Capacity=81.66 cfs Outflow=2.47 cfs 0.243 af

Reach 24R: Drainage ChannelAvg. Flow Depth=0.15' Max Vel=0.89 fps Inflow=0.68 cfs 0.381 af n=0.025 L=2,354.0' S=0.0032 '/' Capacity=20.34 cfs Outflow=0.63 cfs 0.381 af

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 3

Reach 27R: West DitchAvg. Flow Depth=5.51' Max Vel=1.05 fps Inflow=100.01 cfs 20.443 af n=0.050 L=531.0' S=0.0003 '/' Capacity=53.46 cfs Outflow=95.98 cfs 20.443 af

Reach 28R: EAST DITCH TOAvg. Flow Depth=5.82' Max Vel=3.69 fps Inflow=383.00 cfs 225.375 af n=0.050 L=1,705.0' S=0.0030 '/' Capacity=284.51 cfs Outflow=382.43 cfs 225.360 af

Reach 29R: Paskamansett River Avg. Flow Depth=14.13' Max Vel=0.94 fps Inflow=414.44 cfs 263.416 af n=0.035 L=1,905.0' S=0.0001 '/' Capacity=103.50 cfs Outflow=399.51 cfs 263.324 af

Reach 30R: Culvert 1 Avg. Flow Depth=2.22' Max Vel=7.77 fps Inflow=129.13 cfs 81.963 af 90.0" x 45.0" Box Pipe n=0.015 L=48.0' S=0.0040 '/' Capacity=203.41 cfs Outflow=129.13 cfs 81.963 af

Reach 31R: EAST DITCH - NORTH Avg. Flow Depth=39.78' Max Vel=0.48 fps Inflow=522.63 cfs 205.009 af n=0.050 L=2,413.0' S=0.0000 '/' Capacity=18.43 cfs Outflow=364.62 cfs 204.933 af

Reach 34R: Drainage ChannelAvg. Flow Depth=0.22' Max Vel=2.88 fps Inflow=3.02 cfs 0.449 af n=0.025 L=331.0' S=0.0230 '/' Capacity=240.18 cfs Outflow=3.01 cfs 0.449 af

Reach 37R: Drainage ChannelAvg. Flow Depth=0.64' Max Vel=0.64 fps Inflow=7.33 cfs 0.528 af n=0.080 L=1,795.0' S=0.0035 '/' Capacity=6.58 cfs Outflow=2.70 cfs 0.528 af

Reach 38R: Drainage System "C"Avg. Flow Depth=1.00' Max Vel=2.43 fps Inflow=5.83 cfs 0.763 af 12.0" Round Pipe n=0.012 L=796.0' S=0.0019 '/' Capacity=1.68 cfs Outflow=1.82 cfs 0.763 af

Reach 39R: EAST DITCH - N2Avg. Flow Depth=0.69' Max Vel=0.58 fps Inflow=1.82 cfs 0.763 af n=0.050 L=2,017.0' S=0.0011 '/' Capacity=68.77 cfs Outflow=1.66 cfs 0.763 af

Reach 41R: Drainage System "B"Avg. Flow Depth=0.80' Max Vel=4.69 fps Inflow=7.19 cfs 7.321 af 36.0" Round Pipe n=0.012 L=1,593.0' S=0.0040'/ Capacity=45.62 cfs Outflow=7.10 cfs 7.321 af

Reach 45R: Drainage ChannelAvg. Flow Depth=0.51' Max Vel=1.68 fps Inflow=8.63 cfs 0.819 af n=0.025 L=2,480.0' S=0.0030 '/' Capacity=86.58 cfs Outflow=5.15 cfs 0.819 af

Reach 47R: Drainage ChannelAvg. Flow Depth=0.34' Max Vel=1.70 fps Inflow=4.32 cfs 0.304 af n=0.025 L=170.0' S=0.0047 '/' Capacity=108.73 cfs Outflow=3.11 cfs 0.304 af

Pond 1P: Wetland "P"Peak Elev=59.19' Storage=811,628 cf Inflow=258.44 cfs 81.963 af 90.0" x 45.0" Box Culvert n=0.015 L=1.0' S=0.0000 '/' Outflow=129.13 cfs 81.963 af

Pond 1R: EX-CB-9 Peak Elev=62.87' Inflow=3.01 cfs 0.449 af 18.0" Round Culvert n=0.012 L=425.0' S=0.0022 '/' Outflow=3.01 cfs 0.449 af

Pond 2P: Wetland "K"Peak Elev=61.84' Storage=268,326 cf Inflow=145.95 cfs 24.044 af Outflow=93.47 cfs 24.044 af

Pond 3P: EX-DMH-1 Peak Elev=62.15' Inflow=12.35 cfs 3.192 af

24.0" Round Culvert n=0.012 L=293.0' S=0.0018 '/' Outflow=12.35 cfs 3.192 af

Pond 4P: Infiltration Trench "23 C" Peak Elev=78.18' Storage=5 cf Inflow=21.55 cfs 2.465 af Discarded=0.01 cfs 0.001 af Primary=21.55 cfs 2.464 af Outflow=21.55 cfs 2.465 af

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 4

Pond 5P: EX-CB-4 Peak Elev=62.71' Inflow=12.35 cfs 3.192 af

24.0" Round Culvert n=0.012 L=308.0' S=0.0018 '/' Outflow=12.35 cfs 3.192 af

Pond 6P: Infiltration Trench "23 C" Peak Elev=70.76' Storage=4,461 cf Inflow=7.33 cfs 1.024 af

Discarded=0.41 cfs 0.483 af Primary=7.33 cfs 0.528 af Outflow=7.74 cfs 1.011 af

Pond 7P: EX-CB-5 Peak Elev=64.94' Inflow=10.40 cfs 1.703 af

18.0" Round Culvert n=0.012 L=250.0' S=0.0022 '/' Outflow=10.40 cfs 1.703 af

Pond 8P: EX-CB-6 Peak Elev=63.06' Inflow=2.70 cfs 0.528 af

18.0" Round Culvert n=0.012 L=250.0' S=0.0022 '/' Outflow=2.70 cfs 0.528 af

Pond 9P: Ex-Outfall 2 Peak Elev=70.71' Inflow=0.90 cfs 0.272 af

12.0" Round Culvert n=0.012 L=107.0' S=0.0140 '/' Outflow=0.90 cfs 0.272 af

Pond 10P: EX-CB-10 Peak Elev=64.11' Inflow=2.70 cfs 0.528 af

18.0" Round Culvert n=0.012 L=425.0' S=0.0022 '/' Outflow=2.70 cfs 0.528 af

Pond 11P: Infiltration Trench - "23 A" Peak Elev=71.01' Storage=4,495 cf Inflow=8.70 cfs 1.234 af

Discarded=0.35 cfs 0.462 af Primary=10.40 cfs 0.794 af Outflow=10.75 cfs 1.256 af

Pond 12P: Infiltration Trench "A-A" Peak Elev=67.28' Storage=141 cf Inflow=2.62 cfs 0.271 af

Discarded=0.02 cfs 0.029 af Primary=2.70 cfs 0.243 af Outflow=2.72 cfs 0.271 af

Pond 13P: Infield Storage Area Peak Elev=59.74' Storage=1,875 cf Inflow=6.06 cfs 1.308 af

Outflow=5.44 cfs 1.308 af

Pond 15P: Infiltration Trench "A-B" Peak Elev=68.24' Storage=122 cf Inflow=1.10 cfs 0.203 af

Discarded=0.03 cfs 0.031 af Primary=1.46 cfs 0.171 af Outflow=1.49 cfs 0.203 af

Pond 16P: Infiltration Trench "A-C" Peak Elev=73.99' Storage=242 cf Inflow=0.89 cfs 0.334 af

Discarded=0.05 cfs 0.062 af Primary=0.90 cfs 0.272 af Outflow=0.95 cfs 0.334 af

Pond 19P: Infiltration Trench "5 D" Peak Elev=71.02' Storage=653 cf Inflow=1.79 cfs 0.307 af

Discarded=0.05 cfs 0.065 af Primary=2.57 cfs 0.242 af Outflow=2.62 cfs 0.307 af

Pond 21P: Infiltration Trench "5 E" Peak Elev=71.04' Storage=700 cf Inflow=3.19 cfs 0.374 af

Discarded=0.05 cfs 0.070 af Primary=4.32 cfs 0.304 af Outflow=4.37 cfs 0.374 af

Pond 25P: Prop Drainage System "A" Peak Elev=60.81' Inflow=2.77 cfs 0.341 af

12.0" Round Culvert n=0.012 L=170.0' S=0.0026 '/' Outflow=2.77 cfs 0.341 af

Pond 26P: Infiltration Trench - "5 A" Peak Elev=59.27' Storage=2,949 cf Inflow=9.77 cfs 1.170 af

Discarded=0.23 cfs 0.312 af Primary=8.63 cfs 0.819 af Outflow=8.86 cfs 1.131 af

Pond 27P: Ex-Outfall 1 Peak Elev=65.82' Inflow=2.78 cfs 0.414 af

12.0" Round Culvert n=0.012 L=124.0' S=0.0022 '/' Outflow=2.78 cfs 0.414 af

Pond 34P: Wetland "H"Peak Elev=66.77' Storage=129,724 cf Inflow=26.30 cfs 6.981 af

12.0" Round Culvert n=0.012 L=70.0' S=0.0020 '/' Outflow=5.89 cfs 6.981 af

Pre-development Type III 24-hr 10-Year Rainfall=4.80"

Inflow=103.63 cfs 21.942 af Primary=103.63 cfs 21.942 af

103-040-Existing Drainage

Link AP-2: Analysis Point #2

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 5

Pond 42R: EX-CB-3	Peak Elev=62.23' Inflow=13.75 cfs 3.393 af
	24.0" Round Culvert n=0.012 L=354.0' S=0.0016 '/' Outflow=13.75 cfs 3.393 af
Pond 43R: EX-CB-2	Peak Elev=63.93' Inflow=19.52 cfs 4.117 af
	24.0" Round Culvert n=0.012 L=409.0' S=0.0001 '/' Outflow=19.52 cfs 4.117 af
Pond 46R: EX-CB-1	Peak Elev=61.55' Inflow=19.52 cfs 4.117 af
	24.0" Round Culvert n=0.012 L=36.0' S=0.0003 '/' Outflow=19.52 cfs 4.117 af
Pond 48R: EX-CB-8	Peak Elev=61.03' Inflow=3.60 cfs 0.482 af
	18.0" Round Culvert n=0.012 L=364.0' S=0.0022 '/' Outflow=3.60 cfs 0.482 af
Pond 49R: EX-CB-7	Peak Elev=61.54' Inflow=5.77 cfs 0.724 af
	18.0" Round Culvert n=0.012 L=425.0' S=0.0005 '/' Outflow=5.77 cfs 0.724 af
Pond 51R: EX-CB-11	Peak Elev=58.91' Inflow=5.44 cfs 1.308 af
	18.0" Round Culvert n=0.012 L=307.0' S=0.0010 '/' Outflow=5.44 cfs 1.308 af
Link AP-1: Analysis Point #1	Inflow=399.51 cfs 263.324 af
	Primary=399.51 cfs 263.324 af

Total Runoff Area = 1,790.356 ac Runoff Volume = 286.999 af Average Runoff Depth = 1.92" 89.62% Pervious = 1,604.450 ac 10.38% Impervious = 185.906 ac

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 6

Summary for Subcatchment 1S: EX-WEST1

Runoff = 151.30 cfs @ 13.29 hrs, Volume= 38.056 af, Depth= 1.59"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Type III 24-hr 10-Year Rainfall=4.80"

	Area	(ac) C	N Des	I Description			Land Use
_	0.128 98 Paved parking, HSG D				, HSG D	Pavement	
	8.	.191			88% imp, H	SG A	Residential
	4.	.903	39 >75	% Grass c	over, Good	, HSG A	Open Space
	0.	.096	80 >75	% Grass c	over, Good	, HSG D	Open Space
	0.	.263	48 Brus	sh, Good, I	HSG B		Brush
	6.	.206	65 Brus	sh, Good, I	HSG C		Brush
	57.	.636	73 Brus	sh, Good, I	HSG D		Brush
	40.	.591	30 Woo	ds, Good,	HSG A		Woods
	9.	.063	55 Woo	ds, Good,	HSG B		Woods
	69.	.648		ds, Good,			Woods
	85.302 77			Woods, Good, HSG D			Woods
_	4.	.667	98 Wat	er Surface	, HSG D		Open Water
	286.	694	66 Wei	ghted Avei	rage		
	278.	786	97.2	4% Pervio	us Area		
	7.	.908	2.76	% Impervi	ous Area		
	Tc	Length	Slope	Velocity	Capacity	Descripti	on
_	(min)	(feet)	(ft/ft)	(ft/sec)	(cfs)		
	13.8	100	0.0200	0.12		Sheet FI	ow,
						Grass: D	ense n= 0.240 P2= 3.40"
	50.2	3,067	0.0040	1.02		Shallow	Concentrated Flow,
						Unpaved	I Kv= 16.1 fps
	26.6	2,948	0.0020	1.85	66.44	Channel	•
_						Area= 36	3.0 sf Perim= 22.0' r= 1.64' n= 0.050
	90.6	6,115	Total				

Summary for Subcatchment 2S: EX-NW2

Runoff = 3.09 cfs @ 13.08 hrs, Volume= 1.041 af, Depth= 0.42"

_	Area (ac)	CN	Description	Land Use
	1.449	98	Paved parking, HSG A	Pavement
	6.381	61	1/4 acre lots, 38% imp, HSG A	Residential
	18.809	39	Pasture/grassland/range, Good, HSG A	Pasture
	2.833	30	Brush, Good, HSG A	Brush
	29.472	46	Weighted Average	
	25.598		86.86% Pervious Area	
	3.874		13.14% Impervious Area	

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 7

	Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
_	15.5	100	0.0150	0.11		Sheet Flow, Sheet over Grass
	39.8	1,280	0.0080	0.54		Grass: Dense n= 0.240 P2= 3.40" Shallow Concentrated Flow, Shallow through Brush Kv= 6.0 fps
	1.0	1,350	0.2200	23.05	18.10	Pipe Channel,
						12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.012 Concrete pipe, finished
	56.3	2,730	Total			

Summary for Subcatchment 3S: EX-SOUTH

Runoff = 404.55 cfs @ 13.71 hrs, Volume= 121.738 af, Depth= 2.21"

Area (ac)	CN	Description	Land Use
1.656	98	Paved parking, HSG A	Pavement
1.637	98	Paved parking, HSG B	Pavement
15.087	98	Paved parking, HSG C	Pavement
16.567	98	Paved parking, HSG D	Pavement
0.105	76	Gravel roads, HSG A	Roadway
0.314	91	Gravel roads, HSG D	Roadway
2.577	39	Pasture/grassland/range, Good, HSG A	Pasture
5.802	61	Pasture/grassland/range, Good, HSG B	Pasture
8.309	74	Pasture/grassland/range, Good, HSG C	Pasture
105.146	80	Pasture/grassland/range, Good, HSG D	Pasture
3.438	30	Brush, Good, HSG A	Brush
7.422	65	Brush, Good, HSG C	Brush
99.858	73	Brush, Good, HSG D	Brush
32.175	32	Woods/grass comb., Good, HSG A	Woods
123.973	72	Woods/grass comb., Good, HSG C	Woods
72.595	79	Woods/grass comb., Good, HSG D	Woods
10.801	30	Woods, Good, HSG A	Woods
8.266	70	Woods, Good, HSG C	Woods
142.466	77	Woods, Good, HSG D	Woods
4.089	98	Water Surface, HSG D	Open Water
662.283	74	Weighted Average	
623.247		94.11% Pervious Area	
39.036		5.89% Impervious Area	

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 8

Printed 9/30/2016

	Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
	1.2	100	0.0200	1.42		Sheet Flow,
	0.7	120	0.0200	2.87		Smooth surfaces n= 0.011 P2= 3.40" Shallow Concentrated Flow, Shallow 1 Paved Kv= 20.3 fps
	16.4	2,401	0.0230	2.44		Shallow Concentrated Flow, Shallow 2
	96.5	4,169	0.0020	0.72		Unpaved Kv= 16.1 fps Shallow Concentrated Flow, Shallow 3 Unpaved Kv= 16.1 fps
	11.1	3,306	0.0015	4.95	217.93	Channel Flow,
_						Area= 44.0 sf Perim= 30.0' r= 1.47' n= 0.015
	125.9	10,096	Total			

Summary for Subcatchment 4S: EX-EAST

Runoff = 204.32 cfs @ 13.29 hrs, Volume= 49.837 af, Depth= 2.46"

Area (ac)	CN	Description	Land Use
14.542	98	Paved parking, HSG A	Pavement
10.294	98	Paved parking, HSG C	Pavement
23.992	98	Paved parking, HSG D	Pavement
0.413	39	>75% Grass cover, Good, HSG A	Open Space
19.146	74	>75% Grass cover, Good, HSG C	Open Space
21.773	80	>75% Grass cover, Good, HSG D	Open Space
0.231	76	Gravel roads, HSG A	Roadway
4.397	89	Gravel roads, HSG C	Roadway
8.807	91	Gravel roads, HSG D	Roadway
29.003	39	Pasture/grassland/range, Good, HSG A	Pasture
9.124	74	Pasture/grassland/range, Good, HSG C	Pasture
21.148	80	Pasture/grassland/range, Good, HSG D	Pasture
0.807	30	Woods, Good, HSG A	Woods
11.715	70	Woods, Good, HSG C	Woods
64.446	77	Woods, Good, HSG D	Woods
1.642	98	Water Surface, HSG D	Open Water
1.126	83	1/4 acre lots, 38% imp, HSG C	Residential
0.838	87	1/4 acre lots, 38% imp, HSG D	Residential
243.444	77	Weighted Average	
192.228		78.96% Pervious Area	
51.216		21.04% Impervious Area	

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 9

Printed 9/30/2016

_	Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
	1.2	100	0.0200	1.42		Sheet Flow,
						Smooth surfaces n= 0.011 P2= 3.40"
	2.5	540	0.0518	3.66		Shallow Concentrated Flow, Shallow 1
						Unpaved Kv= 16.1 fps
	35.1	2,250	0.0044	1.07		Shallow Concentrated Flow, Shallow 2
						Unpaved Kv= 16.1 fps
	55.9	2,876	0.0001	0.86	22.30	Channel Flow,
						Area= 26.0 sf Perim= 15.0' r= 1.73' n= 0.025
	94.7	5,766	Total			

Summary for Subcatchment 5S: EX-NEAST

Runoff = 145.95 cfs @ 12.70 hrs, Volume= 24.044 af, Depth= 2.37"

Area (ac) C	CN	Description	Land Use
1.0	040	98	Paved parking, HSG A	Pavement
0.1	101	98	Paved parking, HSG D	Pavement
0.9	906	76	Gravel roads, HSG A	Roadway
0.0	032	91	Gravel roads, HSG D	Roadway
45.4	433	83	1/4 acre lots, 38% imp, HSG C	Residential
6.9	904	87	1/4 acre lots, 38% imp, HSG D	Residential
8.5	537	39	Pasture/grassland/range, Good, HSG A	Pasture
0.1	133	74	Pasture/grassland/range, Good, HSG C	Pasture
6.8	370	80	Pasture/grassland/range, Good, HSG D	Pasture
1.5	589	30	Brush, Good, HSG A	Brush
4.9	903	73	Brush, Good, HSG D	Brush
2.8	334	30	Woods, Good, HSG A	Woods
4.7	714	70	Woods, Good, HSG C	Woods
36.3	383	77	Woods, Good, HSG D	Woods
1.2	277	98	Water Surface, HSG D	Open Water
121.6	656	76	Weighted Average	
99.3	350		81.66% Pervious Area	
22.3	306		18.34% Impervious Area	

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 10

Printed 9/30/2016

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.5	100	0.0100	0.13		Sheet Flow,
					Grass: Short n= 0.150 P2= 3.40"
4.4	782	0.0345	2.99		Shallow Concentrated Flow, Shallow 1
00.0	4 000	0.0040	4.00		Unpaved Kv= 16.1 fps
28.9	1,833	0.0043	1.06		Shallow Concentrated Flow, Shallow 2
0.7	506	0.0040	12.05	385.56	Unpaved Kv= 16.1 fps Channel Flow, Channel 1
0.7	300	0.0040	12.03	303.30	Area= 32.0 sf Perim= 12.0' r= 2.67' n= 0.015
4.2	1,399	0.0040	5.56	200.26	Channel Flow, Channel 2
7.2	1,000	0.0040	0.00	200.20	Area= 36.0 sf Perim= 20.0' r= 1.80' n= 0.025
50.7	4,620	Total			

Summary for Subcatchment 6S: EX-NW1

Runoff = 28.42 cfs @ 12.39 hrs, Volume= 3.496 af, Depth= 1.81"

Area (ac)	Area (ac) CN		cription			Land Use
0.080 98		8 Pave	ed parking	, HSG A		Pavement
0.411 98			ed parking			Pavement
0.391	8 Pave	Paved parking, HSG D			Pavement	
0.374 89		9 Grav	el roads, l	HSG C		Roadway
0.008 91		1 Grav	el roads, l	HSG D		Roadway
0.947 39		9 Past	Pasture/grassland/range, Good, HSG A			Pasture
1.670 74		4 Past	Pasture/grassland/range, Good, HSG C			Pasture
3.516 80		0 Past	Pasture/grassland/range, Good, HSG D			Pasture
1.414 30		0 Brus	Brush, Good, HSG A			Brush
2.700 65			Brush, Good, HSG C			Brush
7.628 73		3 Brus	Brush, Good, HSG D			Brush
0.828 30			Woods, Good, HSG A			Woods
2.493 70			Woods, Good, HSG C			Woods
0.261 77			Woods, Good, HSG D			Woods
0.414 9		8 Wate	Water Surface, HSG D			Open Water
23.135 69 Weighted Average						
21.839		94.4	0% Pervio	us Area		
1.296		5.60	% Impervi	ous Area		
	ngth	Slope	Velocity	Capacity	Description	
	eet)	(ft/ft)	(ft/sec)	(cfs)		
11.1	100	0.0350	0.15			hrough Grass
						n= 0.240 P2= 3.40"
8.5	506	0.0200	0.99			entrated Flow, Through Grass
						asture Kv= 7.0 fps
6.9	809	0.0020	1.97	70.80		, Through Wetlands
					Area= 36.0 sf	Perim= 20.0' r= 1.80' n= 0.050
26.5 1,	415	Total				

Page 11

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Summary for Subcatchment 7S: EX-NW3

Runoff = 37.03 cfs @ 12.35 hrs, Volume= 4.294 af, Depth= 2.21"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Type III 24-hr 10-Year Rainfall=4.80"

Area (ac) CN		CN D	escr	iption		Land Use	
0.598 89				rave	l roads, F	HSG C	Roadway
	0.	192	91 G	rave	l roads, F	HSG D	Roadway
	14.	227	70 W	lood/	s, Good,	HSG C	Woods
	7.	672	77 V	lood/	s, Good,	HSG D	Woods
_	0.	674	98 V	Water Surface, HSG D			Open Water
	23.363 74 Weighted Average					age	
	22.	689	9	7.129	% Pervio	us Area	
	0.	674	2	2.88% Impervious Area			
	Tc	Length			Velocity	Capacity	Description
_	(min)	(feet)	(ft/	ft)	(ft/sec)	(cfs)	
	16.5	100	0.005	50	0.10		Sheet Flow,
							Grass: Short n= 0.150 P2= 3.40"
	7.9	1,210	0.025	50	2.55		Shallow Concentrated Flow,
							Unpaved Kv= 16.1 fps
	24.4	1,310	Total				

Summary for Subcatchment 8S: EX-NORTH

Runoff = 69.34 cfs @ 12.95 hrs, Volume= 13.758 af, Depth= 2.54"

 Area (ac)	CN	Description	Land Use
0.847	98	Paved parking, HSG C	Pavement
2.946	98	Paved parking, HSG D	Pavement
0.297	89	Gravel roads, HSG C	Roadway
0.125	91	Gravel roads, HSG D	Roadway
0.567	74	>75% Grass cover, Good, HSG C	Open Space
3.489	80	>75% Grass cover, Good, HSG D	Open Space
12.020	70	Woods, Good, HSG C	Woods
43.507	77	Woods, Good, HSG D	Woods
 1.128	98	Water Surface, HSG D	Open Water
64.926	78	Weighted Average	
60.005		92.42% Pervious Area	
4.921		7.58% Impervious Area	

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page	1	2
------	---	---

	Tc	Length	Slope	Velocity	Capacity	Description
_	(min)	(feet)	(ft/ft)	(ft/sec)	(cfs)	
Ī	1.2	100	0.0200	1.42		Sheet Flow,
						Smooth surfaces n= 0.011 P2= 3.40"
	68.1	2,792	0.0018	0.68		Shallow Concentrated Flow,
_						Unpaved Kv= 16.1 fps
	69.3	2 892	Total			

Summary for Subcatchment 9S: EX-WEST2

Runoff = 80.90 cfs @ 12.83 hrs, Volume= 15.507 af, Depth= 1.32"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Type III 24-hr 10-Year Rainfall=4.80"

Area ((ac) (CN	Desc	cription			Land Use
15.3	388	98	Pave	ed parking	, HSG A		Pavement
1.703 76 Gravel roads, HSG A							Roadway
0.8	882	91	Grav	el roads, l	HSG D		Roadway
2.	150	61	1/4 a	icre lots, 3	8% imp, H	SG A	Residential
42.0	633	39	Past	ure/grassla	and/range,	Good, HSG A	Pasture
15.	570	80	Past	ure/grassla	and/range,	Good, HSG D	Pasture
5.0	034	30	Brus	h, Good, F	HSG A		Brush
1.0	653	48	Brus	h, Good, F	HSG B		Brush
18.9	983	73	Brus	h, Good, F	HSG D		Brush
10.4	479	30	Woo	ds, Good,	HSG A		Woods
1.7	747	55	Woods, Good, HSG B Woods				Woods
23.0	23.013 77			ds, Good,	HSG D		Woods
2.	106	98	Wate	er Surface	, HSG D		Open Water
141.3	341	62	Weig	hted Aver	age		
123.0	030		87.0	4% Pervio	us Area		
18.3	311		12.9	6% Imperv	ious Area		
Tc	Length	SI	ope	Velocity	Capacity	Description	
(min)	(feet)	(1	ft/ft)	(ft/sec)	(cfs)		
16.5	100	0.0	050	0.10		Sheet Flow,	
						Grass: Short	n= 0.150 P2= 3.40"
33.3	2,691	0.0	070	1.35		Shallow Cond	entrated Flow,
						Unpaved Kv=	= 16.1 fps
5.9	1,407	0.0	025	3.97	135.07	Channel Flow	',
						Area= 34.0 sf	Perim= 22.0' r= 1.55' n= 0.025
55.7	4,198	Tot	al				

Summary for Subcatchment 10S: EX-RW23-W1

Runoff = 8.70 cfs @ 12.50 hrs, Volume= 1.234 af, Depth= 1.32"

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

<u>Ра</u>	qε) 1	3

Area	a (ac)	CI	N Desc	cription		Land Use
	4.362	9		ed parking,		Pavement
	6.889	3	9 >75%	6 Grass co	over, Good,	, HSG A Residential
1	1.251	6	2 Weig	hted Aver	age	
	6.889		61.2	3% Pervio	us Area	
	4.362		38.7	7% Imperv	vious Area	
To	: Leng	jth	Slope	Velocity	Capacity	Description
(min) (fe	et)	(ft/ft)	(ft/sec)	(cfs)	
1.9) 1:	26	0.0100	1.13		Sheet Flow, Over Pavement
						Smooth surfaces n= 0.011 P2= 3.40"
29.8	3 2	10	0.0130	0.12		Sheet Flow, Over Grass
						Grass: Dense n= 0.240 P2= 3.40"
31.7	3	36	Total			

Summary for Subcatchment 11S: EX-RW5-E1

Runoff = 6.06 cfs @ 12.77 hrs, Volume= 1.308 af, Depth= 0.72"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Type III 24-hr 10-Year Rainfall=4.80"

Area (ac) CN			CN Des	cription		Land Use		
	4.	850	98 Pav	Paved parking, HSG A Pavement				
16.936 39		39 >75	% Ġrass c	over, Good	, HSG A Open Space			
_	0.	126	76 Gra	vel roads, l	HSG A	Roadway		
	21.	912		ghted Aver				
	17.	062	77.8	37% Pervio	us Area			
	4.850		22.1	3% Imper	vious Area			
	_							
	Tc	Length		Velocity	Capacity	Description		
_	(min)	(feet)	(ft/ft)	(ft/sec)	(cfs)			
	1.1	78	0.0143	1.18		Sheet Flow, Over Pavement		
						Smooth surfaces n= 0.011 P2= 3.40"		
	39.3	1,081	0.0043	0.46		Shallow Concentrated Flow, Over Grass		
						Short Grass Pasture Kv= 7.0 fps		
	4.7	308	0.0005	1.10	0.86	Pipe Channel, Pipe Reach		
						12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25'		
_						n= 0.012		
	45.1	1,467	Total					

Summary for Subcatchment 12S: EX-RW23-E4

Runoff = 7.33 cfs @ 12.46 hrs, Volume= 1.024 af, Depth= 1.19"

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016 Page 14

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Area	(ac)	CN	Desc	ription		Land Use
3	3.753	98	Pave	d parking,	HSG A	Pavement
6	3.608	39	>75%	6 Grass co	over, Good,	, HSG A Open Space
10	.361	60	Weig	hted Aver	age	
6	3.608		63.78	3% Pervio	us Area	
3	3.753		36.22	2% Imperv	rious Area	
Tc	- 3		Slope	Velocity	Capacity	Description
(min)	(fee	t)	(ft/ft)	(ft/sec)	(cfs)	
1.9	12	6 0	0.0100	1.13		Sheet Flow, Over Pavement
						Smooth surfaces n= 0.011 P2= 3.40"
26.7	21	0 0	0.0171	0.13		Sheet Flow, Over Grass
						Grass: Dense n= 0.240 P2= 3.40"
28.6	33	6 T	otal			

Summary for Subcatchment 13S: EX-RW23-W2

Runoff = 3.13 cfs @ 12.40 hrs, Volume= 0.394 af, Depth= 1.52"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Type III 24-hr 10-Year Rainfall=4.80"

Area (ac) CN			Desc	ription		Land Use	
	1.	107	39	>75%	6 Grass co	over, Good	, HSG A Open Space
	0.	418	98	Pave	ed parking,	, HSG A	Pavement
	1.	582	74	>75%	√ Grass co	over, Good,	, HSG C Open Space
3.107 65 Weighted Average							
	2.	689		86.5	5% Pervio	us Area	
	0.	418		13.4	5% Imperv	ious Area	
	Tc	Lengt	:h	Slope	Velocity	Capacity	Description
_	(min)	(fee	t)	(ft/ft)	(ft/sec)	(cfs)	
	21.0	30	0 0	0.0638	0.24		Sheet Flow, Over Grass
							Grass: Dense n= 0.240 P2= 3.40"
	5.1	13	1 0	0.0271	0.43		Shallow Concentrated Flow, Through Grass
							Kv= 2.6 fps
	26.1	43	1 T	otal			

Summary for Subcatchment 14S: EX-RW23-E2

Runoff = 21.55 cfs @ 12.29 hrs, Volume= 2.465 af, Depth= 1.32"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 15

	Area ((ac)	CN	Desc	ription			Land Use
2.088 98 Paved parking, HSG A								Pavement
	0.0	049	76	Grav	el roads, l	HSG A		Roadway
	8.2	257	39	>75%	6 Grass co	over, Good,	HSG A	Open Space
	5.2	292	65	Brus	h, Good, F	HSG C		Brush
	3.	510	74	>75%	6 Grass co	over, Good,	HSG C	Open Space
	0.	194	70	Woo	ds, Good,	HSG C		Woods
	1.0	637	80	>75%	6 Grass co	over, Good,	HSG D	Open Space
	1.4	442	77	Woo	ds, Good,	HSG D		Woods
	22.4	469	62	Weig	hted Aver	age		
	20.3	381		90.7	1% Pervio	us Area		
	2.0	880		9.29	% Impervi	ous Area		
	Tc	Length	1 5	Slope	Velocity	Capacity	Description	on
	(min)	(feet))	(ft/ft)	(ft/sec)	(cfs)		
	4.9	300	0.	0050	1.01		Sheet Flo	ow, Over Grass
							Smooth s	surfaces n= 0.011 P2= 3.40"
	13.7	811	0.	0200	0.99		Shallow	Concentrated Flow, Shallow through grass
							Short Gra	ass Pasture Kv= 7.0 fps
	0.2	98	8 0.	0100	8.85	53.11		Flow, Through ditch
							Area= 6.0) sf Perim= 4.0' r= 1.50'
							n= 0.022	Earth, clean & straight
	18.8	1,209) To	otal				

Summary for Subcatchment 15S: EX-RW23-E3

Runoff = 0.89 cfs @ 13.31 hrs, Volume= 0.334 af, Depth= 0.42"

	Area (ac) CN		N Des	cription		Land Use
				Paved parking, HSG A		Pasture
	8.	382 3	39 >75°	% Grass co	over, Good,	HSG A Pasture
	9.	450 4	46 Wei	ghted Aver	age	
	8.	382	88.7	0% Pervio	us Area	
	1.	068	11.3	0% Imper	∕ious Area	
	Tc	Length	Slope	Velocity	Capacity	Description
<u>(r</u>	nin)	(feet)	(ft/ft)	(ft/sec)	(cfs)	
	0.7	37	0.0100	0.88		Sheet Flow, Over Taxiway
						Smooth surfaces n= 0.011 P2= 3.40"
5	54.7	300	0.0058	0.09		Sheet Flow, Over Land
						Grass: Dense n= 0.240 P2= 3.40"
1	3.7	828	0.0045	1.01		Shallow Concentrated Flow, Shallow Concentrated Flow
						Grassed Waterway Kv= 15.0 fps
	0.9	112	0.0025	2.18	1.19	Pipe Channel, Pipe to Existing Outfall
						10.0" Round Area= 0.5 sf Perim= 2.6' r= 0.21'
						n= 0.012 Concrete pipe, finished
7	70.0	1,277	Total			

Prepared by Hewlett-Packard Company

Printed 9/30/2016 Page 16

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Runoff = 2.62 cfs @ 12.17 hrs, Volume= 0.271 af, Depth= 0.94"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Type III 24-hr 10-Year Rainfall=4.80"

Summary for Subcatchment 16S: EX-RW23-E6

	Area ((ac)	CN	Des	scription		Land Use
	0.9	980	98	Pav	ed parking,	, HSG A	Pavement
	2.	484	39	>75	% Grass co	over, Good,	I, HSG A Open Space
	3.4	464	56	We	ighted Aver	age	
	2.	484		71.	71% Pervio	us Area	
	0.9	980		28.2	29% Imperv	vious Area	
	Tc (min)	Length (feet		ope ft/ft)	•	Capacity (cfs)	Description
_	2.5	19	, ,		, ,	(010)	Sheet Flow, Overland thru Grass
	2.0	1	0.0	02 0	0.10		Grass: Dense n= 0.240 P2= 3.40"
	2.1	210	0.0	125	1.68		Shallow Concentrated Flow, Shallow Concentrated Flow
							Grassed Waterway Kv= 15.0 fps
	1.5	124	4 0.0	010	1.38	0.75	, , , , , , , , , , , , , , , , , , ,
							10.0" Round Area= 0.5 sf Perim= 2.6' r= 0.21'
							n= 0.012 Concrete pipe, finished
	6.1	353	3 Tot	al,	Increased t	o minimum	n Tc = 10.0 min

Summary for Subcatchment 17S: EX-RW23-E5

Runoff = 3.02 cfs @ 12.54 hrs, Volume= 0.449 af, Depth= 1.32"

 Area (ac)	CN	Description	Land Use
1.604	98	Paved parking, HSG A	Pavement
 2.487	39	>75% Grass cover, Good, HSG A	Open Space
4.091	62	Weighted Average	
2.487		60.79% Pervious Area	
1.604		39.21% Impervious Area	

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 17

Tc	Length	Slope	Velocity	Capacity	Description
(min)	(feet)	(ft/ft)	(ft/sec)	(cfs)	
1.3	83	0.0100	1.04		Sheet Flow, Through Grass
					Smooth surfaces n= 0.011 P2= 3.40"
18.9	131	0.0157	0.12		Sheet Flow, Over Grass
					Grass: Dense n= 0.240 P2= 3.40"
1.7	324	0.0043	3.12	49.91	Channel Flow, Drainage Channel
					Area= 16.0 sf Perim= 17.0' r= 0.94'
					n= 0.030 Earth, grassed & winding
2.5	425	0.0032	2.78	2.18	Pipe Channel, Pipe Reach
					12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25'
					n= 0.012
5.6	966	0.0020	2.88	5.09	Pipe Channel, Pipe Reach
					18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38'
				0 = 4	n= 0.012 Concrete pipe, finished
4.5	385	0.0005	1.44	2.54	Pipe Channel, Pipe Reach
					18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38'
0.4	4.5	0.0005	4 - 4	5 40	n= 0.012
0.4	45	0.0005	1.74	5.48	Pipe Channel, Pipe Reach
					24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50'
					n= 0.012
34.9	2,359	Total			

Summary for Subcatchment 18S: EX-RW5-E2

Runoff = 1.79 cfs @ 12.67 hrs, Volume= 0.307 af, Depth= 1.12"

	Area ((ac) C	N Des	cription			Land Use
	1.	118 9	98 Pav	ed parking	, HSG A		Pavement
_	2.	167	39 >75	% Grass c	over, Good	, HSG A	Open Space
	3.2	285	59 Wei	ghted Avei	age		
		167		97% Pervio			
	1.	118	34.0	03% Imper	vious Area		
	Tc (min)	Length (feet)	Slope (ft/ft)		Capacity (cfs)	Descripti	on
_	0.9	48	0.0079	0.84	(613)	Shoot Fl	ow, Over Taxiway B
	0.5	70	0.0073	0.04			surfaces n= 0.011 P2= 3.40"
	41.3	300	0.0117	0.12			ow, Over Grass
							ense n= 0.240 P2= 3.40"
	0.3	39	0.0228	2.26			Concentrated Flow, Shallow to Existing Drainage Syste
_						Grassed	Waterway Kv= 15.0 fps
	42.5	387	Total				

Type III 24-hr 10-Year Rainfall=4.80" Printed 9/30/2016

Prepared by Hewlett-Packard Company

Page 18

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Summary for Subcatchment 19S: EX-TWA-E1

Runoff = 2.77 cfs @ 12.33 hrs, Volume= 0.322 af, Depth= 1.59"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Type III 24-hr 10-Year Rainfall=4.80"

_	Area	(ac) (CN Des	scription		Land Use
1.123 98			98 Pav	ed parking	, HSG A	Pavement
_	1.	300	39 >75	5% Grass c	over, Good,	HSG A Open Space
	2.	423		ighted Avei		
		300	53.0	65% Pervio	us Area	
	1.	123	46.3	35% Imper	vious Area	
	Tc (min)	Length (feet)	•	•	Capacity (cfs)	Description
-	1.2	66		, ,	(515)	Sheet Flow, Over Pavement Smooth surfaces n= 0.011 P2= 3.40"
	18.7	81	0.0062	0.07		Sheet Flow, Sheet thru Island Grass: Dense n= 0.240 P2= 3.40"
	1.9	175	0.0010	1.55	1.22	Pipe Channel, Pipe to Existing Drainage System 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.012 Concrete pipe, finished
	21.8	322	Total			

Summary for Subcatchment 20S: EX-RW5-E3

Runoff = 3.19 cfs @ 12.32 hrs, Volume= 0.374 af, Depth= 1.38"

	Area	(ac) C	N Des	cription		Land Use
1.334 98 Paved parking, HSG A					, HSG A	Pavement
_	1.	911 :	39 >759	% Grass co	over, Good	, HSG A Open Space
	3.	245	3 Weig	ghted Aver	age	
	1.	911	58.8	9% Pervio	us Area	
	1.	334	41.1	1% Imperv	∕ious Area	
	Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
	1.1	76	0.0133	1.14		Sheet Flow, Sheet over Pavement
_	19.7	127	0.0133	0.11		Smooth surfaces n= 0.011 P2= 3.40" Sheet Flow, Over Grass Grass: Dense n= 0.240 P2= 3.40"
	20.8	203	Total			

Printed 9/30/2016 Page 19

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Summary for Subcatchment 21S: EX-RW5-E5

Runoff = 0.94 cfs @ 12.74 hrs, Volume= 0.178 af, Depth= 1.00"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Type III 24-hr 10-Year Rainfall=4.80"

Area	(ac) C	N Desc	cription		Land Use
0.	636	98 Pave	ed parking	, HSG A	Pavement
1.	496 3	39 >759	% Grass co	over, Good	, HSG A Open Space
2.	132 5	57 Weig	ghted Aver	age	
1.	496	70.1	7% Pervio	us Area	
0.	636	29.8	3% Imperv	vious Area	
Tc	Length	Slope	Velocity	Capacity	Description
(min)	(feet)	(ft/ft)	(ft/sec)	(cfs)	
1.1	77	0.0129	1.13		Sheet Flow, Over Pavement
					Smooth surfaces n= 0.011 P2= 3.40"
35.9	179	0.0059	0.08		Sheet Flow, Over Grass
					Grass: Dense n= 0.240 P2= 3.40"
9.6	800	0.0020	1.38	0.27	Pipe Channel, Pipe to Drainage System B
					6.0" Round Area= 0.2 sf Perim= 1.6' r= 0.13'
					n= 0.012 Concrete pipe, finished
46.6	1,056	Total			

Summary for Subcatchment 22S: EX-TWA-E2

Runoff = 0.03 cfs @ 13.00 hrs, Volume= 0.019 af, Depth= 0.19"

_	Area	(ac) C	N Des	cription		Land Use		
	0.	023	98 Pave	ed parking	HSG A	Pavement		
	1.	171 :	39 >759	% Grass co	over, Good,	, HSG A Open Space		
1.194 40 Weighted Average								
	1.	171	98.0	7% Pervio	us Area			
	0.	023	1.93	% Impervi	ous Area			
	Tc	Length	Slope	Velocity	Capacity	Description		
_	(min)	(feet)	(ft/ft)	(ft/sec)	(cfs)			
	16.8	75	0.0069	0.07		Sheet Flow, Flow Over Grass		
						Grass: Dense n= 0.240 P2= 3.40"		
	3.8	163	0.0023	0.72		Shallow Concentrated Flow,		
						Grassed Waterway Kv= 15.0 fps		
	0.8	100	0.0022	2.08	1.56	Pipe Channel, Flow through Pipe		
						18.0" x 6.0" Box Area= 0.8 sf Perim= 4.0' r= 0.19'		
_						n= 0.011 Concrete pipe, straight & clean		
	21.4	338	Total					

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 20

Printed 9/30/2016

Summary for Subcatchment 24S: EX-RW23-W3

Runoff = 0.68 cfs @ 13.66 hrs, Volume= 0.381 af, Depth= 0.23"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Type III 24-hr 10-Year Rainfall=4.80"

Area	(ac) C	N Desc	cription		Land Use
			ed parking		Pavement
			sh, Good, F		Open Space
				8% imp, H	
17.	.972 3	39 >75°	<u>% Grass co</u>	over, Good,	, HSG A Open Space
			ghted Aver		
	.288		6% Pervio		
0.	.897	4.44	% Impervi	ous Area	
То	Longth	Clana	\/alaaitı	Consoitu	Description
Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.5	100	0.0150	0.11	(010)	Sheet Flow, Over Grass
10.0	100	0.0100	0.11		Grass: Dense n= 0.240 P2= 3.40"
29.8	1,118	0.0080	0.63		Shallow Concentrated Flow, Concentrated Flow through Brush
	,				Short Grass Pasture Kv= 7.0 fps
1.4	239	0.0032	2.78	2.18	Pipe Channel, Pipe Reach
					12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25'
					n= 0.012 Concrete pipe, finished
5.6	966	0.0020	2.88	5.09	• • • • • • • • • • • • • • • • • • • •
					18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38'
4.5	005	0.0005	4 4 4	0.54	n= 0.012
4.5	385	0.0005	1.44	2.54	· · · · · · · · · · · · · · · · · · ·
					18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38'
0.4	45	0.0005	1.74	5.48	n= 0.012 Concrete pipe, finished Pipe Channel, Pipe Reach
0.4	45	0.0005	1.74	5.40	24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50'
					n= 0.012 Concrete pipe, finished
57.2	2,853	Total			11- 0.012 Controlo pipo, ililionou
51.2	2,000	i Otai			

Summary for Subcatchment 25S: EX-RW5-W1

Runoff = 9.77 cfs @ 12.33 hrs, Volume= 1.170 af, Depth= 1.32"

 Area (ac)	CN	Description	Land Use				
3.981	98	Paved parking, HSG A	Pavement				
6.393	39	>75% Grass cover, Good, HSG A	Open Space				
 0.294	80	>75% Grass cover, Good, HSG D	Open Space				
10.668	62	Weighted Average					
6.687		62.68% Pervious Area					
3.981		37.32% Impervious Area					

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Printed 9/30/2016 Page 21

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.2	79	0.0129	1.13		Sheet Flow, Sheet over Pavement
19.9	131	0.0138	0.11		Smooth surfaces n= 0.011 P2= 3.40" Sheet Flow, Sheet through Grass Grass: Dense n= 0.240 P2= 3.40"
21.1	210	Total			

Summary for Subcatchment 26S: EX-TWA-W1

Runoff = 1.10 cfs @ 12.44 hrs, Volume= 0.203 af, Depth= 0.51"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Type III 24-hr 10-Year Rainfall=4.80"

	Aroo	(00)	CN	Door	orintion		Land Use
_							Land USE
0.684 98			Pave	ed parking	, HSG A	Pavement	
	4.	042	39	>759	% Grass co	over, Good,	HSG A Open Space
_	4.	726	48	Weig	hted Aver	age	· · ·
	4.	042			3% Pervio		
		684				ious Area	
					. ,		
	Tc	Lengtl	h S	Slope	Velocity	Capacity	Description
	(min)	(feet		(ft/ft)	(ft/sec)	(cfs)	'
_	12.5	123	3 0.	0390	0.16		Sheet Flow, Sheet Flow
							Grass: Dense n= 0.240 P2= 3.40"
	3.6	26	1 0.	0066	1.22		Shallow Concentrated Flow, Shallow Concentrated Flow
							Grassed Waterway Kv= 15.0 fps
	1.5	21	1 0.	0022	2.31	1.81	Pipe Channel, Pipe Flow
							12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25'
							n= 0.012 Concrete pipe, finished
Ī	17.6	59	5 To	otal			

Summary for Subcatchment 32S: EX-RW23-E1

Runoff = 15.78 cfs @ 13.05 hrs, Volume= 3.831 af, Depth= 0.94"

Prepared by Hewlett-Packard Company

Type III 24-hr 10-Year Rainfall=4.80" Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 22

Area (ac) CN Description		Land Use				
2.067 98 Paved parking, HSG A			, HSG A	Pavement		
14.	256	30 Brus	h, Good, F	HSG A		Brush
9.	371 3	39 >759	% Grass co	over, Good	, HSG A	Open Space
1.	821	76 Grav	el roads, l	HSG A		Roadway
0.	601 3	30 Woo	ds, Good,	HSG A		Woods
4.	817 8	33 1/4 a	acre lots, 3	8% imp, H	SG C	Residential
0.	618	74 >759	% Grass co	over, Good	, HSG C	Open Space
1.	983	70 Woo	ds, Good,	HSG C		Woods
0.	073 8	37 1/4 a	acre lots, 3	8% imp, H	SG D	Residential
7.	061	73 Brus	h, Good, F	HSG D		Brush
0.	780 8			over, Good	, HSG D	Open Space
5.	442	77 Woo	ds, Good,	HSG D		Woods
48.	890	56 Weig	ghted Aver	age		
44.	965	91.9	91.97% Pervious Area			
3.	925	8.03	% Impervi	ous Area		
Tc	Length	Slope	Velocity	Capacity	Descripti	ion
(min)	(feet)	(ft/ft)	(ft/sec)	(cfs)		
20.8	100	0.0200	0.08		Sheet Fl	low, Through Woods
					Woods: I	Light underbrush n= 0.400 P2= 3.40"
37.8	1,280	0.0065	0.56		Shallow	Concentrated Flow, Through Wetlands
					Short Gr	ass Pasture Kv= 7.0 fps
9.0	1,585	0.0036	2.92	122.82		l Flow, Through Wetlands
						2.0 sf Perim= 20.0' r= 2.10'
					n= 0.050	Scattered brush, heavy weeds
67.6	2,965	Total				

Summary for Subcatchment 33S: EX-RW5-W2

Runoff = 1.41 cfs @ 12.53 hrs, Volume= 0.201 af, Depth= 1.67"

 Area (ac)	CN	Description	Land Use
0.679	98	Paved parking, HSG A	Pavement
 0.767	39	>75% Grass cover, Good, HSG A	Open Space
1.446	67	Weighted Average	
0.767		53.04% Pervious Area	
0.679		46.96% Impervious Area	

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 23

(mi	Гс n)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1	.3	78	0.0100	1.02		Sheet Flow, Sheet over Pavement
26	.4	183	0.0133	0.12		Smooth surfaces n= 0.011 P2= 3.40" Sheet Flow, Sheet Flow Grass: Dense n= 0.240 P2= 3.40"
0	.1	25	0.0045	3.19	51.06	
						Area= 16.0 sf Perim= 17.0' r= 0.94'
2	.7	466	0.0020	2.88	5.09	n= 0.030 Earth, grassed & winding Pipe Channel, Pipe Reach
	.,	400	0.0020	2.00	0.00	18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38'
						n= 0.012
4	.5	385	0.0005	1.44	2.54	Pipe Channel, Pipe Reach
						18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.012
0	.4	45	0.0005	1.74	5.48	Pipe Channel, Pipe Reach
Ū			0.0000		00	24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50'
						n= 0.012
35	.4	1,182	Total			

Summary for Subcatchment 36S: EX-32N-1

Runoff = 5.83 cfs @ 12.33 hrs, Volume= 0.763 af, Depth= 0.94"

	Area ((ac) C	N Des	cription		Land Use
	2.842 98		98 Pave	Paved parking, HSG A		Pavement
_	6.9	901 :			over, Good,	, HSG A Open Space
	9.743 56 Weighted Average			ghted Aver	age	
	6.9	901	70.8	3% Pervio	us Area	
	2.8	842	29.1	7% Imperv	vious Area	
	_					
	Tc	Length	Slope	Velocity	Capacity	Description
_	(min)	(feet)	(ft/ft)	(ft/sec)	(cfs)	
	12.5	100	0.0100	0.13		Sheet Flow, Over Grass
						Grass: Short n= 0.150 P2= 3.40"
	1.9	100	0.0100	0.90		Shallow Concentrated Flow, Over Grass
						Cultivated Straight Rows Kv= 9.0 fps
	4.8	1,416	0.0100	4.91	3.86	Pipe Channel, Drainage System
						12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25'
_						n= 0.012
	19.2	1.616	Total			

Printed 9/30/2016

103-040-Existing Drainage

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 24

Summary for Reach 10R: EAST DITCH - NORTH

Inflow Area = 121.656 ac, 18.34% Impervious, Inflow Depth = 2.37" for 10-Year event

Inflow = 93.47 cfs @ 13.15 hrs, Volume= 24.044 af

Outflow = 79.21 cfs @ 13.92 hrs, Volume= 24.042 af, Atten= 15%, Lag= 46.5 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 2.37 fps, Min. Travel Time= 25.8 min Avg. Velocity = 0.66 fps, Avg. Travel Time= 92.2 min

Peak Storage= 122,642 cf @ 13.49 hrs Average Depth at Peak Storage= 1.97'

Bank-Full Depth= 4.00' Flow Area= 84.0 sf, Capacity= 291.82 cfs

13.00' x 4.00' deep channel, n= 0.025 Side Slope Z-value= 2.0 '/' Top Width= 29.00'

Length= 3,667.0' Slope= 0.0009 '/'

Inlet Invert= 55.86', Outlet Invert= 52.56'



Summary for Reach 15R: Wetlands

[81] Warning: Exceeded Pond 51R by 0.19' @ 26.55 hrs

Inflow Area = 21.912 ac, 22.13% Impervious, Inflow Depth = 0.72" for 10-Year event

Inflow = 5.44 cfs @ 12.96 hrs, Volume= 1.308 af

Outflow = 5.42 cfs @ 13.07 hrs, Volume= 1.308 af, Atten= 0%, Lag= 6.3 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 1.88 fps, Min. Travel Time= 3.7 min Avg. Velocity = 0.91 fps, Avg. Travel Time= 7.6 min

Peak Storage= 1,189 cf @ 13.01 hrs Average Depth at Peak Storage= 0.82'

Bank-Full Depth= 3.00' Flow Area= 20.0 sf, Capacity= 82.03 cfs

10.00' x 3.00' deep Parabolic Channel, n= 0.050

Length= 413.0' Slope= 0.0097 '/'

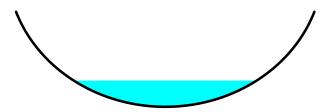
Inlet Invert= 57.00', Outlet Invert= 53.00'

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016 Page 25

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC



Summary for Reach 17R: Drainage Channel

[81] Warning: Exceeded Pond 15P by 0.03' @ 12.50 hrs

Inflow Area = 4.726 ac, 14.47% Impervious, Inflow Depth = 0.44" for 10-Year event

Inflow = 1.46 cfs @ 12.45 hrs, Volume= 0.171 af

Outflow = 1.05 cfs @ 12.55 hrs, Volume= 0.171 af, Atten= 28%, Lag= 6.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 1.30 fps, Min. Travel Time= 3.6 min Avg. Velocity = 0.62 fps, Avg. Travel Time= 7.5 min

Peak Storage= 229 cf @ 12.49 hrs Average Depth at Peak Storage= 0.27'

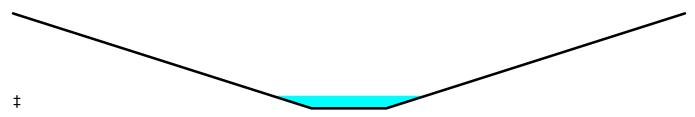
Bank-Full Depth= 2.00' Flow Area= 20.0 sf, Capacity= 81.66 cfs

2.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding

Side Slope Z-value= 4.0 '/' Top Width= 18.00'

Length= 281.0' Slope= 0.0061 '/'

Inlet Invert= 68.00', Outlet Invert= 66.28'



Summary for Reach 18R: Drainage Channel

[81] Warning: Exceeded Pond 12P by 1.99' @ 26.65 hrs

Inflow Area = 3.464 ac, 28.29% Impervious, Inflow Depth = 0.84" for 10-Year event

Inflow = 2.70 cfs @ 12.16 hrs, Volume= 0.243 af

Outflow = 2.47 cfs @ 12.26 hrs, Volume= 0.243 af, Atten= 8%, Lag= 6.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 1.65 fps, Min. Travel Time= 2.8 min Avg. Velocity = 0.66 fps, Avg. Travel Time= 7.1 min

Peak Storage= 422 cf @ 12.22 hrs

Average Depth at Peak Storage= 0.41'

Bank-Full Depth= 2.00' Flow Area= 20.0 sf, Capacity= 81.66 cfs

Pre-development

103-040-Existing Drainage

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 26

2.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding Side Slope Z-value= 4.0 '/' Top Width= 18.00' Length= 281.0' Slope= 0.0061 '/' Inlet Invert= 68.00', Outlet Invert= 66.28'



Summary for Reach 24R: Drainage Channel

Inflow Area = 20.185 ac, 4.44% Impervious, Inflow Depth = 0.23" for 10-Year event

Inflow = 0.68 cfs @ 13.66 hrs, Volume= 0.381 af

Outflow = 0.63 cfs @ 15.50 hrs, Volume= 0.381 af, Atten= 8%, Lag= 110.4 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 0.89 fps, Min. Travel Time= 44.2 min Avg. Velocity = 0.36 fps, Avg. Travel Time= 107.9 min

Peak Storage= 1,670 cf @ 14.76 hrs Average Depth at Peak Storage= 0.15'

Bank-Full Depth= 1.00' Flow Area= 8.0 sf, Capacity= 20.34 cfs

4.00' x 1.00' deep channel, n= 0.025 Earth, clean & winding Side Slope Z-value= 4.0 '/' Top Width= 12.00' Length= 2,354.0' Slope= 0.0032 '/' Inlet Invert= 73.80', Outlet Invert= 66.20'



Summary for Reach 27R: West Ditch

[91] Warning: Storage range exceeded by 1.51'

[55] Hint: Peak inflow is 187% of Manning's capacity

[62] Hint: Exceeded Reach 45R OUTLET depth by 4.81' @ 12.95 hrs

[81] Warning: Exceeded Pond 46R by 0.49' @ 13.00 hrs

Inflow Area = 237.477 ac, 17.07% Impervious, Inflow Depth = 1.03" for 10-Year event

Inflow = 100.01 cfs @ 12.84 hrs, Volume= 20.443 af

Outflow = 95.98 cfs @ 13.09 hrs, Volume= 20.443 af, Atten= 4%, Lag= 14.6 min

Pre-development Type III 24-hr 10-Year Rainfall=4.80"

103-040-Existing Drainage

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

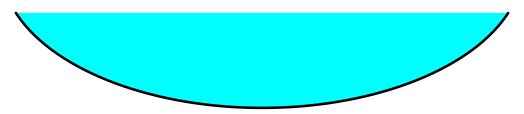
Page 27

Printed 9/30/2016

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Max. Velocity= 1.05 fps, Min. Travel Time= 8.5 min Avg. Velocity = 0.26 fps, Avg. Travel Time= 33.6 min

Peak Storage= 48,778 cf @ 12.94 hrs Average Depth at Peak Storage= 5.51' Bank-Full Depth= 4.00' Flow Area= 58.7 sf, Capacity= 53.46 cfs

22.00' x 4.00' deep Parabolic Channel, n= 0.050 Scattered brush, heavy weeds Length= 531.0' Slope= 0.0003 '/' Inlet Invert= 55.55', Outlet Invert= 55.40'



Summary for Reach 28R: EAST DITCH TO CONFLUENCE

[91] Warning: Storage range exceeded by 0.82'

[55] Hint: Peak inflow is 135% of Manning's capacity

[63] Warning: Exceeded Reach 27R INLET depth by 3.40' @ 16.90 hrs

[63] Warning: Exceeded Reach 31R INLET depth by 0.06' @ 5.00 hrs

Inflow Area = 1,389.131 ac, 12.29% Impervious, Inflow Depth > 1.95" for 10-Year event

Inflow = 383.00 cfs @ 16.29 hrs, Volume= 225.375 af

Outflow = 382.43 cfs @ 16.52 hrs, Volume= 225.360 af, Atten= 0%, Lag= 14.1 min

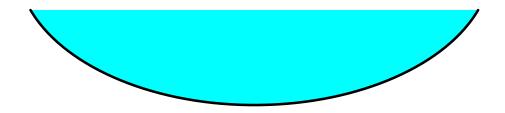
Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 3.69 fps, Min. Travel Time= 7.7 min Avg. Velocity = 1.55 fps, Avg. Travel Time= 18.3 min

Peak Storage= 176,939 cf @ 16.40 hrs Average Depth at Peak Storage= 5.82'

Bank-Full Depth= 5.00' Flow Area= 83.3 sf, Capacity= 284.51 cfs

25.00' x 5.00' deep Parabolic Channel, n= 0.050 Length= 1,705.0' Slope= 0.0030 '/' Inlet Invert= 55.40', Outlet Invert= 50.28'



Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Printed 9/30/2016 Page 28

Summary for Reach 29R: Paskamansett River

[91] Warning: Storage range exceeded by 8.13'

[55] Hint: Peak inflow is 400% of Manning's capacity

[63] Warning: Exceeded Reach 28R INLET depth by 8.56' @ 17.20 hrs

Inflow Area = 1,675.825 ac, 10.66% Impervious, Inflow Depth > 1.89" for 10-Year event

Inflow 414.44 cfs @ 16.42 hrs, Volume= 263.416 af

399.51 cfs @ 17.58 hrs. Volume= Outflow 263.324 af, Atten= 4%, Lag= 69.3 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

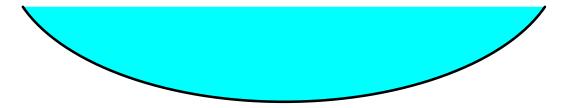
Max. Velocity= 0.94 fps, Min. Travel Time= 33.7 min Avg. Velocity = 0.47 fps, Avg. Travel Time= 67.2 min

Peak Storage= 807,167 cf @ 17.02 hrs Average Depth at Peak Storage= 14.13'

Bank-Full Depth= 6.00' Flow Area= 140.0 sf, Capacity= 103.50 cfs

35.00' x 6.00' deep Parabolic Channel, n= 0.035

Length= 1,905.0' Slope= 0.0001 '/' Inlet Invert= 55.50', Outlet Invert= 55.40'



Summary for Reach 30R: Culvert 1

[52] Hint: Inlet/Outlet conditions not evaluated

[79] Warning: Submerged Pond 1P Primary device # 1 by 2.22'

Inflow Area = 467.459 ac, 18.45% Impervious, Inflow Depth = 2.10" for 10-Year event

Inflow 129.13 cfs @ 14.88 hrs, Volume= 81.963 af

Outflow 129.13 cfs @ 14.89 hrs, Volume= 81.963 af, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 7.77 fps, Min. Travel Time= 0.1 min Avg. Velocity = 2.82 fps, Avg. Travel Time= 0.3 min

Peak Storage= 797 cf @ 14.89 hrs Average Depth at Peak Storage= 2.22'

Bank-Full Depth= 3.75' Flow Area= 28.1 sf, Capacity= 203.41 cfs

90.0" W x 45.0" H Box Pipe

n = 0.015

Length= 48.0' Slope= 0.0040 '/'

Inlet Invert= 55.53', Outlet Invert= 55.34'

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 29

Printed 9/30/2016



Summary for Reach 31R: EAST DITCH - NORTH

[91] Warning: Storage range exceeded by 35.78'

[55] Hint: Peak inflow is 2835% of Manning's capacity

[63] Warning: Exceeded Reach 15R INLET depth by 37.64' @ 14.95 hrs [63] Warning: Exceeded Reach 30R INLET depth by 37.37' @ 14.95 hrs

Inflow Area = 1,151.654 ac, 11.30% Impervious, Inflow Depth = 2.14" for 10-Year event

Inflow = 522.63 cfs @ 13.79 hrs, Volume= 205.009 af

Outflow = 364.62 cfs @ 16.35 hrs, Volume= 204.933 af, Atten= 30%, Lag= 153.1 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 0.48 fps, Min. Travel Time= 84.6 min

Avg. Velocity = 0.26 fps, Avg. Travel Time= 155.2 min

Peak Storage= 1,850,939 cf @ 14.94 hrs

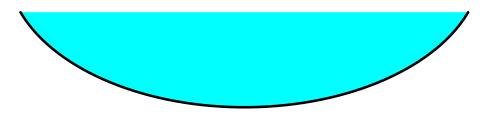
Average Depth at Peak Storage= 39.78'

Bank-Full Depth= 4.00' Flow Area= 53.3 sf, Capacity= 18.43 cfs

20.00' x 4.00' deep Parabolic Channel, n= 0.050

Length= 2,413.0' Slope= 0.0000 '/'

Inlet Invert= 55.34', Outlet Invert= 55.24'



Summary for Reach 34R: Drainage Channel

Inflow Area = 4.091 ac, 39.21% Impervious, Inflow Depth = 1.32" for 10-Year event

Inflow = 3.02 cfs @ 12.54 hrs, Volume= 0.449 af

Outflow = 3.01 cfs @ 12.60 hrs, Volume= 0.449 af, Atten= 1%, Lag= 3.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 2.88 fps, Min. Travel Time= 1.9 min Avg. Velocity = 1.20 fps, Avg. Travel Time= 4.6 min

Peak Storage= 346 cf @ 12.57 hrs

Average Depth at Peak Storage= 0.22'

Bank-Full Depth= 2.00' Flow Area= 24.0 sf, Capacity= 240.18 cfs

Pre-development

103-040-Existing Drainage

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 30

4.00' x 2.00' deep channel, n= 0.025 Earth, clean & winding Side Slope Z-value= 4.0 '/' Top Width= 20.00' Length= 331.0' Slope= 0.0230 '/' Inlet Invert= 73.80', Outlet Invert= 66.20'



Summary for Reach 37R: Drainage Channel

[55] Hint: Peak inflow is 111% of Manning's capacity [81] Warning: Exceeded Pond 6P by 5.87' @ 27.40 hrs

Inflow Area = 10.361 ac, 36.22% Impervious, Inflow Depth = 0.61" for 10-Year event

Inflow = 7.33 cfs @ 12.47 hrs, Volume= 0.528 af

Outflow = 2.70 cfs @ 13.77 hrs, Volume= 0.528 af, Atten= 63%, Lag= 78.5 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 0.64 fps, Min. Travel Time= 46.5 min Avg. Velocity = 0.14 fps, Avg. Travel Time= 215.5 min

Peak Storage= 7,530 cf @ 13.00 hrs Average Depth at Peak Storage= 0.64' Bank-Full Depth= 1.00' Flow Area= 8.0 sf, Capacity= 6.58 cfs

4.00' x 1.00' deep channel, n= 0.080 Earth, long dense weeds Side Slope Z-value= 4.0 '/' Top Width= 12.00' Length= 1,795.0' Slope= 0.0035 '/' Inlet Invert= 74.60', Outlet Invert= 68.40'



Summary for Reach 38R: Drainage System "C"

[52] Hint: Inlet/Outlet conditions not evaluated

[55] Hint: Peak inflow is 348% of Manning's capacity

[76] Warning: Detained 0.159 af (Pond w/culvert advised)

Inflow Area = 9.743 ac, 29.17% Impervious, Inflow Depth = 0.94" for 10-Year event

Inflow = 5.83 cfs @ 12.33 hrs, Volume= 0.763 af

Outflow = 1.82 cfs @ 12.27 hrs, Volume= 0.763 af, Atten= 69%, Lag= 0.0 min

Pre-development

103-040-Existing Drainage

Type III 24-hr 10-Year Rainfall=4.80" Printed 9/30/2016

Prepared by Hewlett-Packard Company

Dama 04

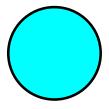
HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 31

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Max. Velocity= 2.43 fps, Min. Travel Time= 5.5 min Avg. Velocity = 1.34 fps, Avg. Travel Time= 9.9 min

Peak Storage= 625 cf @ 12.20 hrs Average Depth at Peak Storage= 1.00' Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 1.68 cfs

12.0" Round Pipe n= 0.012 Length= 796.0' Slope= 0.0019 '/' Inlet Invert= 59.27', Outlet Invert= 57.77'



Summary for Reach 39R: EAST DITCH - N2

[62] Hint: Exceeded Reach 38R OUTLET depth by 0.23' @ 16.05 hrs

Inflow Area = 9.743 ac, 29.17% Impervious, Inflow Depth = 0.94" for 10-Year event

Inflow = 1.82 cfs @ 12.27 hrs, Volume= 0.763 af

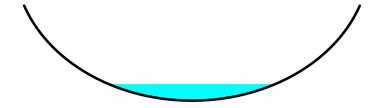
Outflow = 1.66 cfs @ 16.79 hrs, Volume= 0.763 af, Atten= 8%, Lag= 271.6 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 0.58 fps, Min. Travel Time= 58.1 min Avg. Velocity = 0.22 fps, Avg. Travel Time= 150.1 min

Peak Storage= 5,796 cf @ 15.84 hrs Average Depth at Peak Storage= 0.69' Bank-Full Depth= 4.00' Flow Area= 40.0 sf, Capacity= 68.77 cfs

15.00' x 4.00' deep Parabolic Channel, n= 0.050 Length= 2,017.0' Slope= 0.0011 '/' Inlet Invert= 57.77', Outlet Invert= 55.53'



Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Printed 9/30/2016 Page 32

Summary for Reach 41R: Drainage System "B"

[52] Hint: Inlet/Outlet conditions not evaluated

[81] Warning: Exceeded Pond 25P by 3.79' @ 25.20 hrs

Inflow Area = 92.616 ac, 10.68% Impervious, Inflow Depth = 0.95" for 10-Year event

Inflow = 7.19 cfs @ 12.50 hrs, Volume= 7.321 af

Outflow = 7.10 cfs @ 12.67 hrs, Volume= 7.321 af, Atten= 1%, Lag= 10.2 min

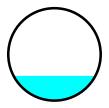
Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 4.69 fps, Min. Travel Time= 5.7 min Avg. Velocity = 2.31 fps, Avg. Travel Time= 11.5 min

Peak Storage= 2,412 cf @ 12.57 hrs Average Depth at Peak Storage= 0.80'

Bank-Full Depth= 3.00' Flow Area= 7.1 sf, Capacity= 45.62 cfs

36.0" Round Pipe n= 0.012 Length= 1,593.0' Slope= 0.0040 '/' Inlet Invert= 62.26', Outlet Invert= 55.91'



Summary for Reach 45R: Drainage Channel

[81] Warning: Exceeded Pond 26P by 5.96' @ 28.40 hrs

Inflow Area = 10.668 ac, 37.32% Impervious, Inflow Depth = 0.92" for 10-Year event

Inflow = 8.63 cfs @ 12.35 hrs, Volume= 0.819 af

Outflow = 5.15 cfs @ 13.08 hrs, Volume= 0.819 af, Atten= 40%, Lag= 44.3 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 1.68 fps, Min. Travel Time= 24.5 min Avg. Velocity = 0.44 fps, Avg. Travel Time= 93.5 min

Peak Storage= 7,598 cf @ 12.67 hrs Average Depth at Peak Storage= 0.51'

Bank-Full Depth= 2.00' Flow Area= 24.0 sf, Capacity= 86.58 cfs

4.00' x 2.00' deep channel, n= 0.025 Earth, clean & winding Side Slope Z-value= 4.0 '/' Top Width= 20.00' Length= 2,480.0' Slope= 0.0030 '/' Inlet Invert= 63.20', Outlet Invert= 55.80'

Type III 24-hr 10-Year Rainfall=4.80" Printed 9/30/2016

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 33



Summary for Reach 47R: Drainage Channel

Inflow Area = 3.245 ac, 41.11% Impervious, Inflow Depth = 1.12" for 10-Year event

Inflow = 4.32 cfs @ 12.35 hrs, Volume= 0.304 af

Outflow = 3.11 cfs @ 12.37 hrs, Volume= 0.304 af, Atten= 28%, Lag= 1.3 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 1.70 fps, Min. Travel Time= 1.7 min Avg. Velocity = 0.61 fps, Avg. Travel Time= 4.6 min

Peak Storage= 312 cf @ 12.34 hrs Average Depth at Peak Storage= 0.34'

Bank-Full Depth= 2.00' Flow Area= 24.0 sf, Capacity= 108.73 cfs

4.00' x 2.00' deep channel, n= 0.025 Earth, clean & winding

Side Slope Z-value= 4.0 '/' Top Width= 20.00'

Length= 170.0' Slope= 0.0047 '/'

Inlet Invert= 64.80', Outlet Invert= 64.00'



Summary for Pond 1P: Wetland "P"

[63] Warning: Exceeded Reach 10R INLET depth by 2.10' @ 15.50 hrs

[63] Warning: Exceeded Reach 39R INLET depth by 0.74' @ 14.80 hrs

[62] Hint: Exceeded Reach 41R OUTLET depth by 2.54' @ 14.90 hrs

Inflow Area = 467.459 ac, 18.45% Impervious, Inflow Depth = 2.10" for 10-Year event

Inflow = 258.44 cfs @ 13.57 hrs, Volume= 81.963 af

Outflow = 129.13 cfs @ 14.88 hrs, Volume= 81.963 af, Atten= 50%, Lag= 79.1 min

Primary = 129.13 cfs @ 14.88 hrs, Volume= 81.963 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Peak Elev= 59.19' @ 14.88 hrs Surf.Area= 983,952 sf Storage= 811,628 cf

Plug-Flow detention time= 60.3 min calculated for 81.868 af (100% of inflow)

Center-of-Mass det. time= 60.3 min (1,023.7 - 963.4)

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 34

Volume	Inve	ert Avail.Sto	rage	Storage	Description	
#1	55.5	2,990,7	64 cf	Custom	Stage Data (Pr	rismatic)Listed below (Recalc)
Elevation (feet)	=	Surf.Area (sq-ft)		.Store c-feet)	Cum.Store (cubic-feet)	
55.53	}	144		0	0	
56.00)	7,755		1,856	1,856	
57.00)	11,838		9,797	11,653	
58.00)	142,731	7	7,285	88,937	
59.00)	929,931	53	6,331	625,268	
60.00)	1,207,326	1,06	8,629	1,693,897	
61.00)	1,386,408	1,29	6,867	2,990,764	
	Routing	Invert		et Devices		
#1 I	Primary	55.53'	L= 1 Inlet	.0' Box, / Outlet In		uare edges, Ke= 0.500 5.53' S= 0.0000 '/' Cc= 0.900

Primary OutFlow Max=129.13 cfs @ 14.88 hrs HW=59.19' (Free Discharge) 1=Culvert (Barrel Controls 129.13 cfs @ 6.26 fps)

Summary for Pond 1R: EX-CB-9

[57] Hint: Peaked at 62.87' (Flood elevation advised)

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 62.87' @ 12.60 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary		18.0" Round Culvert L= 425.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 61.82' / 60.88' S= 0.0022 '/' Cc= 0.900 n= 0.012, Flow Area= 1.77 sf

Primary OutFlow Max=3.00 cfs @ 12.60 hrs HW=62.87' (Free Discharge) 1=Culvert (Barrel Controls 3.00 cfs @ 3.20 fps)

Summary for Pond 2P: Wetland "K"

Inflow Area =	121.656 ac, 18.34% Impervious, Inflo	w Depth = 2.37" for 10-Year event
Inflow =	145.95 cfs @ 12.70 hrs, Volume=	24.044 af
Outflow =	93.47 cfs @ 13.15 hrs, Volume=	24.044 af, Atten= 36%, Lag= 26.7 min
Primary =	93.47 cfs @ 13.15 hrs, Volume=	24.044 af

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016 Page 35

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 61.84' @ 13.15 hrs Surf.Area= 324,222 sf Storage= 268,326 cf

Plug-Flow detention time= 57.4 min calculated for 24.044 af (100% of inflow)

Center-of-Mass det. time= 56.9 min (932.6 - 875.7)

Volume	Inv	ert Avail.Sto	rage Storage	Description	
#1	58.	92' 766,46	69 cf Custon	n Stage Data (Pi	rismatic)Listed below (Recalc)
-		0 ()	. 0	0 0	
Elevation		Surf.Area	Inc.Store	Cum.Store	
(fee	et)	(sq-ft)	(cubic-feet)	(cubic-feet)	
58.9	92	4,355	0	0	
60.0	00	23,907	15,261	15,261	
61.0	00	113,475	68,691	83,952	
62.0	00	363,629	238,552	322,504	
63.0	00	524,301	443,965	766,469	
Device	Routing	Invert	Outlet Device	es	
#1	Primary	58.92'	24.0" Round	d Culvert X 2.00	
	,		L= 1.0' RCF	, square edge he	eadwall, Ke= 0.500
					8.92' S= 0.0000 '/' Cc= 0.900
			n= 0.012, Flo	ow Area= 3.14 sf	:
#2	Primary	61.50'	100.0' long	x 20.0' breadth l	Broad-Crested Rectangular Weir
	-		Head (feet)	0.20 0.40 0.60	0.80 1.00 1.20 1.40 1.60
			Coef. (Englis	h) 2.68 2.70 2.	70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=93.38 cfs @ 13.15 hrs HW=61.84' (Free Discharge)

1=Culvert (Barrel Controls 39.40 cfs @ 6.27 fps)

—2=Broad-Crested Rectangular Weir (Weir Controls 53.98 cfs @ 1.58 fps)

Summary for Pond 3P: EX-DMH-1

[57] Hint: Peaked at 62.15' (Flood elevation advised)

[79] Warning: Submerged Pond 5P Primary device # 1 INLET by 1.69'

Inflow Area = 75.360 ac, 19.23% Impervious, Inflow Depth = 0.51" for 10-Year event

Inflow = 12.35 cfs @ 12.56 hrs, Volume= 3.192 af

Outflow = 12.35 cfs @ 12.56 hrs, Volume= 3.192 af, Atten= 0%, Lag= 0.0 min

Primary = 12.35 cfs @ 12.56 hrs, Volume= 3.192 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Peak Elev= 62.15' @ 12.56 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	59.92'	24.0" Round Culvert
	-		L= 293.0' RCP, groove end projecting, Ke= 0.200
			Inlet / Outlet Invert= 59.92' / 59.40' S= 0.0018 '/' Cc= 0.900
			n= 0.012 Concrete pipe, finished. Flow Area= 3.14 sf

Primary OutFlow Max=12.33 cfs @ 12.56 hrs HW=62.15' (Free Discharge)

1=Culvert (Barrel Controls 12.33 cfs @ 4.39 fps)

#2

Primary

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 36

Summary for Pond 4P: Infiltration Trench "23 C"

Inflow Area = 22.469 ac, 9.29% Impervious, Inflow Depth = 1.32" for 10-Year event
Inflow = 21.55 cfs @ 12.29 hrs, Volume= 2.465 af
Outflow = 21.55 cfs @ 12.29 hrs, Volume= 2.465 af, Atten= 0%, Lag= 0.0 min
Discarded = 0.01 cfs @ 12.29 hrs, Volume= 0.001 af
Primary = 21.55 cfs @ 12.29 hrs, Volume= 2.464 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 78.18' @ 12.29 hrs Surf.Area= 127 sf Storage= 5 cf

Plug-Flow detention time= 0.0 min calculated for 2.462 af (100% of inflow) Center-of-Mass det. time= 0.0 min (884.1 - 884.1)

Volume	Invert	Avail.Stora	age Storage Description
#1	78.00'	340	O cf 60.0" W x 24.0" H Box Pipe Storage L= 85.0' S= 0.0071 '/' 850 cf Overall x 40.0% Voids
Device	Routing	Invert	Outlet Devices
#1	Discarded		2.410 in/hr Exfiltration over Surface area Conductivity to Groundwater Elevation = 0.00'

85.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s)

Discarded OutFlow Max=0.01 cfs @ 12.29 hrs HW=78.18' (Free Discharge) 1=Exfiltration (Controls 0.01 cfs)

2.2' Crest Height

Primary OutFlow Max=21.46 cfs @ 12.29 hrs HW=78.18' (Free Discharge) 2=Sharp-Crested Rectangular Weir (Weir Controls 21.46 cfs @ 1.40 fps)

Summary for Pond 5P: EX-CB-4

[57] Hint: Peaked at 62.71' (Flood elevation advised)

78.00'

[79] Warning: Submerged Pond 1R Primary device # 1 INLET by 0.89' [79] Warning: Submerged Pond 7P Primary device # 1 INLET by 1.28'

Inflow Area = 75.360 ac, 19.23% Impervious, Inflow Depth = 0.51" for 10-Year event

Inflow = 12.35 cfs @ 12.56 hrs, Volume= 3.192 af

Outflow = 12.35 cfs @ 12.56 hrs, Volume= 3.192 af, Atten= 0%, Lag= 0.0 min

Primary = 12.35 cfs @ 12.56 hrs, Volume= 3.192 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 62.71' @ 12.56 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	60.46'	24.0" Round Culvert
			L= 308.0' RCP, groove end projecting, Ke= 0.200
			Inlet / Outlet Invert= 60.46' / 59.92' S= 0.0018 '/' Cc= 0.900
			n= 0.012 Concrete pipe, finished, Flow Area= 3.14 sf

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 37

Primary OutFlow Max=12.33 cfs @ 12.56 hrs HW=62.71' (Free Discharge) 1=Culvert (Barrel Controls 12.33 cfs @ 4.37 fps)

Summary for Pond 6P: Infiltration Trench "23 C"

[88] Warning: Qout>Qin may require smaller dt or Finer Routing

Inflow Area =	10.361 ac, 36.22% Impervious, Inflow D	Depth = 1.19" for 10-Year event
Inflow =	7.33 cfs @ 12.46 hrs, Volume=	1.024 af
Outflow =	7.74 cfs @ 12.47 hrs, Volume=	1.011 af, Atten= 0%, Lag= 0.5 min
Discarded =	0.41 cfs @ 12.45 hrs, Volume=	0.483 af
Primary =	7.33 cfs @ 12.47 hrs, Volume=	0.528 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs / 5 Peak Elev= 70.76' @ 12.45 hrs Surf.Area= 7,144 sf Storage= 4,461 cf

Plug-Flow detention time= 82.7 min calculated for 1.011 af (99% of inflow) Center-of-Mass det. time= 75.8 min (975.2 - 899.5)

Volume	Invert	Avail.Storage	Storage Description
#1	68.75'	5,715 cf	48.0" W x 24.0" H Box Pipe Storage L= 1,786.0' S= 0.0005 '/' 14,288 cf Overall x 40.0% Voids
Device	Routing	Invert Out	let Devices
#1	Discarded		10 in/hr Exfiltration over Surface area nductivity to Groundwater Elevation = 0.00'

1,786.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s)

Discarded OutFlow Max=0.41 cfs @ 12.45 hrs HW=70.76' (Free Discharge)
1=Exfiltration (Controls 0.41 cfs)

Primary OutFlow Max=3.89 cfs @ 12.47 hrs HW=70.76' (Free Discharge) 2=Sharp-Crested Rectangular Weir (Weir Controls 3.89 cfs @ 0.29 fps)

Summary for Pond 7P: EX-CB-5

[57] Hint: Peaked at 64.94' (Flood elevation advised) [81] Warning: Exceeded Pond 8P by 2.56' @ 12.35 hrs

70.75'

#2

Primary

Inflow Area	a =	41.797 ac, 21.56% Impervious, Inflow Depth = 0.49" for 10-Ye	ear event
Inflow	=	10.40 cfs @ 12.37 hrs, Volume= 1.703 af	
Outflow	=	10.40 cfs @ 12.37 hrs, Volume= 1.703 af, Atten= 0%, Land	ag= 0.0 min
Primary	=	10.40 cfs @ 12.37 hrs, Volume= 1.703 af	-

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 64.94' @ 12.37 hrs

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 38

#1 Primary 61.43' 18.0" Round Culvert L= 250.0' RCP, groove end projecting, Ke= 0.200	Device	Routing	Invert	Outlet Devices		
n= 0.012 Concrete pipe, finished, Flow Area= 1.77 sf			61.43'	L= 250.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 61.43' / 60.88' S= 0.0022 '/' Cc= 0.900		

Primary OutFlow Max=9.17 cfs @ 12.37 hrs HW=64.51' (Free Discharge) 1=Culvert (Barrel Controls 9.17 cfs @ 5.19 fps)

Summary for Pond 8P: EX-CB-6

[57] Hint: Peaked at 63.06' (Flood elevation advised)

[79] Warning: Submerged Pond 10P Primary device # 1 OUTLET by 0.88'

Inflow Area =	10.361 ac, 36.22% Impe	ervious, Inflow Depth >	0.61" for 10-Year event
Inflow =	2.70 cfs @ 13.77 hrs,	Volume= 0.528	af
Outflow =	2.70 cfs @ 13.77 hrs,	Volume= 0.528	af, Atten= 0%, Lag= 0.0 min
Primary =	2.70 cfs @ 13.77 hrs,	Volume= 0.528	af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 63.06' @ 13.77 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	62.08'	18.0" Round Culvert L= 250.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 62.08' / 61.53' S= 0.0022 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 1.77 sf

Primary OutFlow Max=2.69 cfs @ 13.77 hrs HW=63.06' (Free Discharge) 1=Culvert (Barrel Controls 2.69 cfs @ 3.14 fps)

Summary for Pond 9P: Ex-Outfall 2

[57] Hint: Peaked at 70.71' (Flood elevation advised)

Inflow Area	a =	9.450 ac, 1	l 1.30% Impervious	, Inflow Depth = 0	.35" for 10-	Year event
Inflow	=	0.90 cfs @	13.30 hrs, Volum	e= 0.272 af		
Outflow	=	0.90 cfs @	13.30 hrs, Volum	e= 0.272 af	, Atten= 0%,	Lag= 0.0 min
Primary	=	0.90 cfs @	13.30 hrs, Volum	e= 0.272 af		-

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 70.71' @ 13.30 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	70.28'	12.0" Round Culvert
	-		L= 107.0' RCP, groove end projecting, Ke= 0.200
			Inlet / Outlet Invert= 70.28' / 68.78' S= 0.0140 '/' Cc= 0.900
			n= 0.012 Concrete pipe, finished, Flow Area= 0.79 sf

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Printed 9/30/2016

Page 39

Primary OutFlow Max=0.90 cfs @ 13.30 hrs HW=70.71' (Free Discharge) 1=Culvert (Inlet Controls 0.90 cfs @ 2.79 fps)

Summary for Pond 10P: EX-CB-10

[57] Hint: Peaked at 64.11' (Flood elevation advised)

Inflow Area = 10.361 ac, 36.22% Impervious, Inflow Depth > 0.61" for 10-Year event

Inflow = 2.70 cfs @ 13.77 hrs, Volume= 0.528 af

Outflow = 2.70 cfs @ 13.77 hrs, Volume= 0.528 af, Atten= 0%, Lag= 0.0 min

Primary = 2.70 cfs @ 13.77 hrs, Volume= 0.528 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Peak Elev= 64.11' @ 13.77 hrs

Device	Routing	Invert	Outlet Devices		
#1	Primary	63.12'	18.0" Round Culvert		
			L= 425.0' RCP, groove end projecting, Ke= 0.200		
			Inlet / Outlet Invert= 63.12' / 62.18' S= 0.0022 '/' Cc= 0.900		
			n= 0.012 Concrete pipe, finished, Flow Area= 1.77 sf		

Primary OutFlow Max=2.69 cfs @ 13.77 hrs HW=64.10' (Free Discharge)
1=Culvert (Barrel Controls 2.69 cfs @ 3.11 fps)

Summary for Pond 11P: Infiltration Trench - "23 A"

[88] Warning: Qout>Qin may require smaller dt or Finer Routing

Inflow Area = 11.251 ac, 38.77% Impervious, Inflow Depth = 1.32" for 10-Year event

Inflow = 8.70 cfs @ 12.50 hrs, Volume= 1.234 af

Outflow = 10.75 cfs @ 12.37 hrs, Volume= 1.256 af, Atten= 0%, Lag= 0.0 min

Discarded = 0.35 cfs @ 12.35 hrs, Volume= 0.462 af Primary = 10.40 cfs @ 12.37 hrs, Volume= 0.794 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs / 4 Peak Elev= 71.01' @ 12.35 hrs Surf.Area= 6,120 sf Storage= 4,495 cf

Plug-Flow detention time= 53.0 min calculated for 1.234 af (100% of inflow)

Center-of-Mass det. time= 65.3 min (961.4 - 896.1)

Volume	Invert	Avail.Storage	Storage Description
#1	68.75'	4,896 cf	48.0" W x 24.0" H Box Pipe Storage L= 1,530.0' S= 0.0005 '/' 12,240 cf Overall x 40.0% Voids

#1 Discarded 68.75' 2.410 in/hr Exfiltration over Surface area	
#1 Discarded 00.75 2.410 in/iii Exhittation Over Surface area	
Conductivity to Groundwater Elevation = 0.00'	
#2 Primary 71.00' 1,530.0' long Sharp-Crested Rectangular Weir 2 End Contract	on(s)

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 40

2.2' Crest Height

Discarded OutFlow Max=0.35 cfs @ 12.35 hrs HW=71.01' (Free Discharge) 1=Exfiltration (Controls 0.35 cfs)

Primary OutFlow Max=8.21 cfs @ 12.37 hrs HW=71.01' (Free Discharge) 2=Sharp-Crested Rectangular Weir (Weir Controls 8.21 cfs @ 0.39 fps)

Summary for Pond 12P: Infiltration Trench "A-A"

[88] Warning: Qout>Qin may require smaller dt or Finer Routing

[85] Warning: Oscillations may require smaller dt or Finer Routing (severity=39)

Inflow Area = 3.464 ac, 28.29% Impervious, Inflow Depth = 0.94" for 10-Year event Inflow = 2.62 cfs @ 12.17 hrs, Volume= 0.271 af

Outflow = 2.72 cfs @ 12.16 hrs, Volume= 0.271 af, Atten= 0%, Lag= 0.0 min Discarded = 0.02 cfs @ 12.16 hrs, Volume= 0.029 af

Primary = 2.70 cfs @ 12.16 hrs, Volume= 0.243 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 67.28' @ 12.16 hrs Surf.Area= 440 sf Storage= 141 cf

Plug-Flow detention time= 9.1 min calculated for 0.271 af (100% of inflow) Center-of-Mass det. time= 9.2 min (905.6 - 896.4)

<u>Volume</u>	Invert	Avail.Storage	Storage Description
#1	66.01'	176 cf	24.0" W x 12.0" H Box Pipe Storage L= 220.0' S= 0.0039 '/' 440 cf Overall x 40.0% Voids
Device	Routing	Invert Out	let Devices
#1	Discarded		10 in/hr Exfiltration over Surface area nductivity to Groundwater Elevation = 0.00' Phase-In= 0.01'
#2	Primary		.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s)

Discarded OutFlow Max=0.02 cfs @ 12.16 hrs HW=67.28' (Free Discharge) 1=Exfiltration (Controls 0.02 cfs)

1.2' Crest Height

Primary OutFlow Max=2.45 cfs @ 12.16 hrs HW=67.28' (Free Discharge) 2=Sharp-Crested Rectangular Weir (Weir Controls 2.45 cfs @ 0.49 fps)

Summary for Pond 13P: Infield Storage Area

Inflow Area = 21.912 ac, 22.13% Impervious, Inflow Depth = 0.72" for 10-Year event Inflow = 6.06 cfs @ 12.77 hrs, Volume= 1.308 af

Outflow = 5.44 cfs @ 12.96 hrs, Volume= 1.308 af

Primary = 5.44 cfs @ 12.96 hrs, Volume= 1.308 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Invort

Volume

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 41

Peak Elev= 59.74' @ 12.96 hrs Surf.Area= 8,898 sf Storage= 1,875 cf

Plug-Flow detention time= 3.4 min calculated for 1.306 af (100% of inflow)

Avail Storage Storage Description

Center-of-Mass det. time= 3.4 min (949.7 - 946.2)

volume	inve	rt Avaii.Stoi	rage Storage L	rescription		
#1	59.3	3' 56,39	22 cf Custom	Stage Data (Pi	rismatic)Listed below (Recalc)	
Elevation (fee		Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)		
59.3 60.0	_	290 14,422	0 4,929	0 4,929		
60.8		114,236	51,463	56,392		
Device	Routing	Invert	Outlet Devices			
#1	Device 2	56.83'	18.0" Round 18" Round Culvert L= 1.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 56.83' / 56.82' S= 0.0100 '/' Cc= 0.900 n= 0.012, Flow Area= 1.77 sf			
#2	Primary	59.33'	8.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s) 0.5' Crest Height			

Primary OutFlow Max=5.43 cfs @ 12.96 hrs HW=59.74' (Free Discharge)

2=Sharp-Crested Rectangular Weir (Passes 5.43 cfs of 7.41 cfs potential flow)

1=18" Round Culvert (Inlet Controls 5.43 cfs @ 3.07 fps)

Summary for Pond 15P: Infiltration Trench "A-B"

[88] Warning: Qout>Qin may require smaller dt or Finer Routing

[85] Warning: Oscillations may require smaller dt or Finer Routing (severity=77)

Inflow Area = 4.726 ac, 14.47% Impervious, Inflow Depth = 0.51" for 10-Year event
Inflow = 1.10 cfs @ 12.44 hrs, Volume= 0.203 af
Outflow = 1.49 cfs @ 12.45 hrs, Volume= 0.203 af, Atten= 0%, Lag= 0.7 min
Discarded = 0.03 cfs @ 12.45 hrs, Volume= 0.031 af
Primary = 1.46 cfs @ 12.45 hrs, Volume= 0.171 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 68.24' @ 12.45 hrs Surf.Area= 505 sf Storage= 122 cf

Plug-Flow detention time= 10.5 min calculated for 0.203 af (100% of inflow) Center-of-Mass det. time= 10.6 min (953.8 - 943.1)

Volume	Invert	Avail.Storage	Storage Description
#1	66.98'	230 cf	24.0" W x 12.0" H Box Pipe Storage L= 287.0' S= 0.0050 '/' 574 cf Overall x 40.0% Voids
Device	Routing	Invert Out	let Devices
#1	Discarded	66.98' 2.4 1	0 in/hr Exfiltration over Surface area

Conductivity to Groundwater Elevation = 0.00'

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 42

#2 Primary 68.23' **287.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s) 1.2' Crest Height

Discarded OutFlow Max=0.03 cfs @ 12.45 hrs HW=68.24' (Free Discharge) 1=Exfiltration (Controls 0.03 cfs)

Primary OutFlow Max=1.27 cfs @ 12.45 hrs HW=68.24' (Free Discharge) 2=Sharp-Crested Rectangular Weir (Weir Controls 1.27 cfs @ 0.36 fps)

Summary for Pond 16P: Infiltration Trench "A-C"

[88] Warning: Qout>Qin may require smaller dt or Finer Routing

[85] Warning: Oscillations may require smaller dt or Finer Routing (severity=34)

Inflow Area = 9.450 ac, 11.30% Impervious, Inflow Depth = 0.42" for 10-Year event

Inflow = 0.89 cfs @ 13.31 hrs, Volume= 0.334 af

Outflow = 0.95 cfs @ 13.30 hrs, Volume= 0.334 af, Atten= 0%, Lag= 0.0 min

Discarded = 0.90 cfs @ 13.30 hrs, Volume= 0.062 af

Primary = 0.90 cfs @ 13.30 hrs, Volume= 0.272 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 73.99' @ 13.30 hrs Surf.Area= 704 sf Storage= 242 cf

Plug-Flow detention time= 13.8 min calculated for 0.334 af (100% of inflow) Center-of-Mass det. time= 13.8 min (1,019.6 - 1,005.8)

Volume	Invert	Avail.Storage	Storage Description
#1	72.23'	620 cf	24.0" W x 18.0" H Box Pipe Storage
			L= 517.0' S= 0.0050 '/'
			1,551 cf Overall x 40.0% Voids

Device	Routing	Invert	Outlet Devices
#1	Discarded	72.23'	2.410 in/hr Exfiltration over Surface area
			Conductivity to Groundwater Elevation = 70.23'
#2	Primary	73.98'	220.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s)
	-		1.7' Crest Height

Discarded OutFlow Max=0.05 cfs @ 13.30 hrs HW=73.99' (Free Discharge) 1=Exfiltration (Controls 0.05 cfs)

Primary OutFlow Max=0.67 cfs @ 13.30 hrs HW=73.99' (Free Discharge) 2=Sharp-Crested Rectangular Weir (Weir Controls 0.67 cfs @ 0.32 fps)

Summary for Pond 19P: Infiltration Trench "5 D"

[93] Warning: Storage range exceeded by 0.17'

[88] Warning: Qout>Qin may require smaller dt or Finer Routing

[85] Warning: Oscillations may require smaller dt or Finer Routing (severity=118)

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 43

Inflow Area =	3.285 ac, 34.03% Impervious, I	nflow Depth = 1.12"	for 10-Year event
Inflow =	1.79 cfs @ 12.67 hrs, Volume=	0.307 af	
O 40	0.00 (0 (0.07)	0.00= (4	00/ 1 00 1

Outflow = 2.62 cfs @ 12.65 hrs, Volume= 0.307 af, Atten= 0%, Lag= 0.0 min

Discarded = 0.05 cfs @ 12.65 hrs, Volume= 0.065 af Primary = 2.57 cfs @ 12.65 hrs, Volume= 0.242 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 71.02' @ 12.65 hrs Surf.Area= 816 sf Storage= 653 cf

Plug-Flow detention time= 42.2 min calculated for 0.307 af (100% of inflow) Center-of-Mass det. time= 42.4 min (958.1 - 915.7)

Volume	Invert	Avail.Storage	Storage Description
#1	68.75'	653 cf	48.0" W x 24.0" H Box Pipe Storage L= 204.0' S= 0.0005 '/'
			1,632 cf Overall x 40.0% Voids

Device	Routing	Invert	Outlet Devices
#1	Discarded	68.75'	2.410 in/hr Exfiltration over Surface area
			Conductivity to Groundwater Elevation = 0.00'
#2	Primary	71.00'	204.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s)
	-		2.2' Crest Height

Discarded OutFlow Max=0.05 cfs @ 12.65 hrs HW=71.02' (Free Discharge) 1=Exfiltration (Controls 0.05 cfs)

Primary OutFlow Max=2.51 cfs @ 12.65 hrs HW=71.02' (Free Discharge) 2=Sharp-Crested Rectangular Weir (Weir Controls 2.51 cfs @ 0.51 fps)

Summary for Pond 21P: Infiltration Trench "5 E"

[93] Warning: Storage range exceeded by 0.20'

[88] Warning: Qout>Qin may require smaller dt or Finer Routing

[85] Warning: Oscillations may require smaller dt or Finer Routing (severity=118)

Inflow Area	a =	3.245 ac, 4	11.11% Imp	ervious,	Inflow De	epth = 1	.38"	for 10-	Year event	
Inflow	=	3.19 cfs @	12.32 hrs,	Volume	=	0.374 at	•			
Outflow	=	4.37 cfs @	12.35 hrs,	Volume	=	0.374 at	, Atte	en= 0%,	Lag= 1.7 m	nin

Discarded = 0.05 cfs @ 12.35 hrs, Volume= 0.070 af Primary = 4.32 cfs @ 12.35 hrs, Volume= 0.304 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 71.04' @ 12.35 hrs Surf.Area= 875 sf Storage= 700 cf

Plug-Flow detention time= 36.9 min calculated for 0.374 af (100% of inflow) Center-of-Mass det. time= 37.1 min (920.1 - 882.9)

Volume	Invert	Avail.Storage	Storage Description
#1	68.75'	700 cf	60.0" W x 24.0" H Box Pipe Storage
			L= 175.0' S= 0.0005 '/'
			1,750 cf Overall x 40.0% Voids

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016 Page 44

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Device	Routing	Invert	Outlet Devices
#1	Discarded	68.75'	2.410 in/hr Exfiltration over Surface area
			Conductivity to Groundwater Elevation = 0.00'
#2	Primary	71.00'	175.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s)
	•		2.2' Crest Height

Discarded OutFlow Max=0.05 cfs @ 12.35 hrs HW=71.04' (Free Discharge) 1=Exfiltration (Controls 0.05 cfs)

Primary OutFlow Max=4.14 cfs @ 12.35 hrs HW=71.04' (Free Discharge) 2=Sharp-Crested Rectangular Weir (Weir Controls 4.14 cfs @ 0.63 fps)

Summary for Pond 25P: Prop Drainage System "A"

[57] Hint: Peaked at 60.81' (Flood elevation advised)

Inflow Area	1 =	3.617 ac, 3	31.68% lmp	ervious,	Inflow	Depth =	1.1	3" for	10-	Year ev	/ent
Inflow	=	2.77 cfs @	12.33 hrs,	Volume	=	0.341	af				
Outflow	=	2.77 cfs @	12.33 hrs,	Volume	=	0.341	af,	Atten=	0%,	Lag= 0).0 min
Primary	=	2.77 cfs @	12.33 hrs.	Volume	=	0.341	af			•	

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 60.81' @ 12.33 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	59.15'	12.0" Round Culvert
			L= 170.0' RCP, groove end projecting, Ke= 0.200
			Inlet / Outlet Invert= 59.15' / 58.70' S= 0.0026 '/' Cc= 0.900
			n= 0.012 Concrete pipe, finished, Flow Area= 0.79 sf

Primary OutFlow Max=2.76 cfs @ 12.33 hrs HW=60.80' (Free Discharge) 1=Culvert (Barrel Controls 2.76 cfs @ 3.51 fps)

Summary for Pond 26P: Infiltration Trench - "5 A"

Inflow Area =	10.668 ac, 3	37.32% Impervious, Inflo	w Depth = 1.32"	for 10-Year event
Inflow =	9.77 cfs @	12.33 hrs, Volume=	1.170 af	
Outflow =	8.86 cfs @	12.35 hrs, Volume=	1.131 af, Atte	en= 9%, Lag= 1.1 min
Discarded =	0.23 cfs @	12.35 hrs, Volume=	0.312 af	_
Primary =	8.63 cfs @	12.35 hrs, Volume=	0.819 af	

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs / 2 Peak Elev= 59.27' @ 12.35 hrs Surf.Area= 4,055 sf Storage= 2,949 cf

Plug-Flow detention time= 73.7 min calculated for 1.131 af (97% of inflow) Center-of-Mass det. time= 55.3 min (941.5 - 886.2)

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 45

Volume	Invert	Avail.Storage	Storage Description
#1	57.25'	3,244 cf	60.0" W x 24.0" H Box Pipe Storage L= 811.0' S= 0.0005 '/' 8,110 cf Overall x 40.0% Voids
Device	Routing	Invert Out	tlet Devices
#1	Discarded		10 in/hr Exfiltration over Surface area nductivity to Groundwater Elevation = 0.00'
#2	Primary		.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s) Crest Height

Discarded OutFlow Max=0.23 cfs @ 12.35 hrs HW=59.27' (Free Discharge) 1=Exfiltration (Controls 0.23 cfs)

Primary OutFlow Max=8.47 cfs @ 12.35 hrs HW=59.27' (Free Discharge) 2=Sharp-Crested Rectangular Weir (Weir Controls 8.47 cfs @ 0.48 fps)

Summary for Pond 27P: Ex-Outfall 1

[57] Hint: Peaked at 65.82' (Flood elevation advised)

Inflow Area = 8.190 ac, 20.32% Impervious, Inflow Depth = 0.61" for 10-Year event Inflow = 2.78 cfs @ 12.42 hrs. Volume= 0.414 af

Outflow = 2.78 cfs @ 12.42 hrs, Volume= 0.414 af, Atten= 0%, Lag= 0.0 min

Primary = 2.78 cfs @ 12.42 hrs, Volume= 0.414 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 65.82' @ 12.42 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	64.21'	12.0" Round Culvert
			L= 124.0' RCP, groove end projecting, Ke= 0.200
			Inlet / Outlet Invert= 64.21' / 63.94' S= 0.0022 '/' Cc= 0.900
			n= 0.012 Concrete pipe, finished, Flow Area= 0.79 sf

Primary OutFlow Max=2.77 cfs @ 12.42 hrs HW=65.81' (Free Discharge) 1=Culvert (Barrel Controls 2.77 cfs @ 3.53 fps)

Summary for Pond 34P: Wetland "H"

[81] Warning: Exceeded Pond 27P by 2.23' @ 18.25 hrs

Inflow Area = 88.999 ac, 9.83% Impervious, Inflow Depth = 0.94" for 10-Year event

Inflow = 26.30 cfs @ 12.34 hrs, Volume= 6.981 af

Outflow = 5.89 cfs @ 16.23 hrs, Volume= 6.981 af, Atten= 78%, Lag= 233.8 min

Primary = 5.89 cfs @ 16.23 hrs, Volume= 6.981 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 46

Peak Elev= 66.77' @ 16.23 hrs Surf.Area= 224,177 sf Storage= 129,724 cf

Plug-Flow detention time= 253.1 min calculated for 6.972 af (100% of inflow)

Center-of-Mass det. time= 253.3 min (1,178.5 - 925.2)

<u>Volume</u>	Inv	ert Avail.Sto	rage Storage	Description	
#1	63.2	23' 338,18	B1 cf Custon	n Stage Data (Pri	smatic)Listed below (Recalc)
	Elevation Surf.Area (feet) (sq-ft)		Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	
63.2	23	1,000	0	0	
64.00		8,186	3,537	3,537	
65.00		14,900	11,543	15,080	
66.0	00	23,207	19,054	34,133	
67.0	00	283,259	153,233	187,366	
67.5	50	320,000	150,815	338,181	
Device	Routing	Invert	Outlet Device	s	
#1	Primary	63.23'	Inlet / Outlet I	P, groove end w/h	neadwall, Ke= 0.200 .09' S= 0.0020 '/' Cc= 0.900

Primary OutFlow Max=5.89 cfs @ 16.23 hrs HW=66.77' (Free Discharge) 1=Culvert (Barrel Controls 5.89 cfs @ 7.50 fps)

Summary for Pond 42R: EX-CB-3

[57] Hint: Peaked at 62.23' (Flood elevation advised)

[81] Warning: Exceeded Pond 3P by 0.07' @ 12.55 hrs

Inflow Area = 76.806 ac, 19.75% Impervious, Inflow Depth = 0.53" for 10-Year event

Inflow = 13.75 cfs @ 12.55 hrs, Volume= 3.393 af

Outflow = 13.75 cfs @ 12.55 hrs, Volume= 3.393 af, Atten= 0%, Lag= 0.0 min

Primary = 13.75 cfs @ 12.55 hrs, Volume= 3.393 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Peak Elev= 62.23' @ 12.55 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	59.30'	24.0" Round Culvert
			L= 354.0' RCP, groove end projecting, Ke= 0.200
			Inlet / Outlet Invert= 59.30' / 58.75' S= 0.0016 '/' Cc= 0.900
			n= 0.012 Concrete pipe, finished, Flow Area= 3.14 sf

Primary OutFlow Max=13.74 cfs @ 12.55 hrs HW=62.22' (Free Discharge) 1=Culvert (Barrel Controls 13.74 cfs @ 4.38 fps)

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 47

Summary for Pond 43R: EX-CB-2

[57] Hint: Peaked at 63.93' (Flood elevation advised)

[81] Warning: Exceeded Pond 42R by 1.71' @ 12.55 hrs

[81] Warning: Exceeded Pond 49R by 2.69' @ 12.60 hrs

Inflow Area = 85.468 ac, 21.36% Impervious, Inflow Depth = 0.58" for 10-Year event

Inflow = 19.52 cfs @ 12.55 hrs, Volume= 4.117 af

Outflow = 19.52 cfs @ 12.55 hrs, Volume= 4.117 af, Atten= 0%, Lag= 0.0 min

Primary = 19.52 cfs @ 12.55 hrs, Volume= 4.117 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Peak Elev= 63.93' @ 12.55 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	58.65'	24.0" Round Culvert
	_		L= 409.0' RCP, groove end projecting, Ke= 0.200
			Inlet / Outlet Invert= 58.65' / 58.61' S= 0.0001 '/' Cc= 0.900
			n= 0.012 Concrete pipe, finished, Flow Area= 3.14 sf

Primary OutFlow Max=19.50 cfs @ 12.55 hrs HW=63.93' (Free Discharge)

1=Culvert (Barrel Controls 19.50 cfs @ 6.21 fps)

Summary for Pond 46R: EX-CB-1

[57] Hint: Peaked at 61.55' (Flood elevation advised)

[79] Warning: Submerged Pond 43R Primary device # 1 INLET by 2.90'

Inflow Area = 85.468 ac, 21.36% Impervious, Inflow Depth = 0.58" for 10-Year event

Inflow = 19.52 cfs @ 12.55 hrs, Volume= 4.117 af

Outflow = 19.52 cfs @ 12.55 hrs, Volume= 4.117 af, Atten= 0%, Lag= 0.0 min

Primary = 19.52 cfs @ 12.55 hrs, Volume= 4.117 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Peak Elev= 61.55' @ 12.55 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	58.61'	24.0" Round Culvert
	-		L= 36.0' RCP, groove end projecting, Ke= 0.200
			Inlet / Outlet Invert= 58.61' / 58.60' S= 0.0003 '/' Cc= 0.900
			n= 0.012 Concrete pipe, finished, Flow Area= 3.14 sf

Primary OutFlow Max=19.50 cfs @ 12.55 hrs HW=61.55' (Free Discharge) 1=Culvert (Barrel Controls 19.50 cfs @ 6.21 fps)

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Printed 9/30/2016 Page 48

Summary for Pond 48R: EX-CB-8

[57] Hint: Peaked at 61.03' (Flood elevation advised)

Inflow Area = 5.377 ac, 36.64% Impervious, Inflow Depth = 1.08" for 10-Year event

Inflow = 3.60 cfs @ 12.41 hrs, Volume= 0.482 af

Outflow = 3.60 cfs @ 12.41 hrs, Volume= 0.482 af, Atten= 0%, Lag= 0.0 min

Primary = 3.60 cfs @ 12.41 hrs, Volume= 0.482 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Peak Elev= 61.03' @ 12.41 hrs

Device	Routing	Invert	Outlet Devices	
#1	Primary	59.86'	18.0" Round Culvert	
			L= 364.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 59.86' / 59.06' S= 0.0022 '/' Cc= 0.900	
			n= 0.012 Concrete pipe, finished, Flow Area= 1.77 sf	

Primary OutFlow Max=3.59 cfs @ 12.41 hrs HW=61.03' (Free Discharge) 1=Culvert (Barrel Controls 3.59 cfs @ 3.36 fps)

Summary for Pond 49R: EX-CB-7

[57] Hint: Peaked at 61.54' (Flood elevation advised)

[81] Warning: Exceeded Pond 48R by 0.57' @ 12.55 hrs

Inflow Area = 8.662 ac, 35.65% Impervious, Inflow Depth = 1.00" for 10-Year event

Inflow = 5.77 cfs @ 12.55 hrs, Volume= 0.724 af

Outflow = 5.77 cfs @ 12.55 hrs, Volume= 0.724 af, Atten= 0%, Lag= 0.0 min

Primary = 5.77 cfs @ 12.55 hrs, Volume= 0.724 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Peak Elev= 61.54' @ 12.55 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	58.96'	18.0" Round Culvert
			L= 425.0' RCP, groove end projecting, Ke= 0.200
			Inlet / Outlet Invert= 58.96' / 58.75' S= 0.0005 '/' Cc= 0.900
			n= 0.012 Concrete pipe, finished, Flow Area= 1.77 sf

Primary OutFlow Max=5.73 cfs @ 12.55 hrs HW=61.53' (Free Discharge) 1=Culvert (Barrel Controls 5.73 cfs @ 3.24 fps)

Summary for Pond 51R: EX-CB-11

[57] Hint: Peaked at 58.91' (Flood elevation advised)

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 49

Inflow Area = 21.912 ac, 22.13% Impervious, Inflow Depth = 0.72" for 10-Year event

Inflow = 5.44 cfs @ 12.96 hrs, Volume= 1.308 af

Outflow = 5.44 cfs @ 12.96 hrs, Volume= 1.308 af, Atten= 0%, Lag= 0.0 min

Primary = 5.44 cfs @ 12.96 hrs, Volume= 1.308 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Peak Elev= 58.91' @ 12.96 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	56.83'	18.0" Round Culvert
	_		L= 307.0' RCP, groove end projecting, Ke= 0.200
			Inlet / Outlet Invert= 56.83' / 56.53' S= 0.0010 '/' Cc= 0.900
			n= 0.012 Concrete pipe, finished, Flow Area= 1.77 sf

Primary OutFlow Max=5.43 cfs @ 12.96 hrs HW=58.91' (Free Discharge) 1=Culvert (Barrel Controls 5.43 cfs @ 3.07 fps)

Summary for Link AP-1: Analysis Point #1

Inflow Area = 1,675.825 ac, 10.66% Impervious, Inflow Depth > 1.89" for 10-Year event

Inflow = 399.51 cfs @ 17.58 hrs, Volume= 263.324 af

Primary = 399.51 cfs @ 17.58 hrs, Volume= 263.324 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Summary for Link AP-2: Analysis Point #2

Inflow Area = 114.531 ac, 6.38% Impervious, Inflow Depth = 2.30" for 10-Year event

Inflow = 103.63 cfs @ 12.54 hrs, Volume= 21.942 af

Primary = 103.63 cfs @ 12.54 hrs, Volume= 21.942 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Pre-development Type III 24-hr 100-Year Rainfall=7.00" Printed 9/30/2016

103-040-Existing Drainage

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 1

Time span=5.00-48.00 hrs, dt=0.05 hrs, 861 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

3 ,	3 ,
Subcatchment 1S: EX-WEST1	Runoff Area=286.694 ac 2.76% Impervious Runoff Depth=3.20" Flow Length=6,115' Tc=90.6 min CN=66 Runoff=321.26 cfs 76.558 af
Subcatchment 2S: EX-NW2	Runoff Area=29.472 ac 13.14% Impervious Runoff Depth=1.32" Flow Length=2,730' Tc=56.3 min CN=46 Runoff=14.75 cfs 3.243 af
Subcatchment 3S: EX-SOUTH	Runoff Area=662.283 ac 5.89% Impervious Runoff Depth=4.04" ow Length=10,096' Tc=125.9 min CN=74 Runoff=754.33 cfs 223.083 af
Subcatchment 4S: EX-EAST	Runoff Area=243.444 ac 21.04% Impervious Runoff Depth=4.37" Flow Length=5,766' Tc=94.7 min CN=77 Runoff=365.65 cfs 88.569 af
Subcatchment 5S: EX-NEAST	Runoff Area=121.656 ac 18.34% Impervious Runoff Depth=4.26" Flow Length=4,620' Tc=50.7 min CN=76 Runoff=263.29 cfs 43.161 af
Subcatchment 6S: EX-NW1	Runoff Area=23.135 ac 5.60% Impervious Runoff Depth=3.51" Flow Length=1,415' Tc=26.5 min CN=69 Runoff=56.70 cfs 6.775 af
Subcatchment 7S: EX-NW3	Runoff Area=23.363 ac 2.88% Impervious Runoff Depth=4.04" Flow Length=1,310' Tc=24.4 min CN=74 Runoff=68.49 cfs 7.870 af
Subcatchment 8S: EX-NORTH	Runoff Area=64.926 ac 7.58% Impervious Runoff Depth=4.47" Flow Length=2,892' Tc=69.3 min CN=78 Runoff=122.24 cfs 24.211 af
Subcatchment9S: EX-WEST2	Runoff Area=141.341 ac 12.96% Impervious Runoff Depth=2.80" Flow Length=4,198' Tc=55.7 min CN=62 Runoff=185.68 cfs 32.992 af
Subcatchment 10S: EX-RW23-W1	Runoff Area=11.251 ac 38.77% Impervious Runoff Depth=2.80" Flow Length=336' Tc=31.7 min CN=62 Runoff=19.89 cfs 2.626 af
Subcatchment 11S: EX-RW5-E1	Runoff Area=21.912 ac 22.13% Impervious Runoff Depth=1.85" Flow Length=1,467' Tc=45.1 min CN=52 Runoff=19.68 cfs 3.372 af
Subcatchment 12S: EX-RW23-E4	Runoff Area=10.361 ac 36.22% Impervious Runoff Depth=2.60" Flow Length=336' Tc=28.6 min CN=60 Runoff=17.63 cfs 2.248 af
Subcatchment 13S: EX-RW23-W2	Runoff Area=3.107 ac 13.45% Impervious Runoff Depth=3.10" Flow Length=431' Tc=26.1 min CN=65 Runoff=6.70 cfs 0.803 af
Subcatchment14S: EX-RW23-E2	Runoff Area=22.469 ac 9.29% Impervious Runoff Depth=2.80" Flow Length=1,209' Tc=18.8 min CN=62 Runoff=49.66 cfs 5.245 af
Subcatchment 15S: EX-RW23-E3	Runoff Area=9.450 ac 11.30% Impervious Runoff Depth=1.32" Flow Length=1,277' Tc=70.0 min CN=46 Runoff=4.14 cfs 1.040 af
Subcatchment 16S: EX-RW23-E6	Runoff Area=3.464 ac 28.29% Impervious Runoff Depth=2.22" Flow Length=353' Tc=10.0 min CN=56 Runoff=7.32 cfs 0.640 af

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 2

Subcatchment 17S: EX-RW23-E5

Runoff Area=4.091 ac 39.21% Impervious Runoff Depth=2.80"
Flow Length=2,359' Tc=34.9 min CN=62 Runoff=6.90 cfs 0.955 af

Subcatchment 18S: EX-RW5-E2

Runoff Area=3.285 ac 34.03% Impervious Runoff Depth=2.51"

Flow Length=387' Tc=42.5 min CN=59 Runoff=4.43 cfs 0.686 af

Subcatchment 19S: EX-TWA-E1

Runoff Area=2.423 ac 46.35% Impervious Runoff Depth=3.20"
Flow Length=322' Tc=21.8 min CN=66 Runoff=5.85 cfs 0.647 af

Subcatchment 20S: EX-RW5-E3 Runoff Area=3.245 ac 41.11% Impervious Runoff Depth=2.90" Flow Length=203' Slope=0.0133 '/' Tc=20.8 min CN=63 Runoff=7.15 cfs 0.784 af

Subcatchment 21S: EX-RW5-E5

Runoff Area=2.132 ac 29.83% Impervious Runoff Depth=2.31"
Flow Length=1,056' Tc=46.6 min CN=57 Runoff=2.49 cfs 0.411 af

Subcatchment 22S: EX-TWA-E2

Runoff Area=1.194 ac 1.93% Impervious Runoff Depth=0.84"

Flow Length=338' Tc=21.4 min CN=40 Runoff=0.47 cfs 0.084 af

Subcatchment 24S: EX-RW23-W3

Runoff Area=20.185 ac 4.44% Impervious Runoff Depth=0.92"
Flow Length=2,853' Tc=57.2 min CN=41 Runoff=5.82 cfs 1.544 af

Subcatchment 25S: EX-RW5-W1

Runoff Area=10.668 ac 37.32% Impervious Runoff Depth=2.80"
Flow Length=210' Tc=21.1 min CN=62 Runoff=22.48 cfs 2.490 af

Subcatchment 26S: EX-TWA-W1 Runoff Area=4.726 ac 14.47% Impervious Runoff Depth=1.49" Flow Length=595' Tc=17.6 min CN=48 Runoff=4.81 cfs 0.587 af

Subcatchment 32S: EX-RW23-E1Runoff Area=48.890 ac 8.03% Impervious Runoff Depth=2.22"

Flow Length=2,965' Tc=67.6 min CN=56 Runoff=43.30 cfs 9.037 af

Subcatchment 33S: EX-RW5-W2

Runoff Area=1.446 ac 46.96% Impervious Runoff Depth=3.31"
Flow Length=1,182' Tc=35.4 min CN=67 Runoff=2.91 cfs 0.398 af

Subcatchment 36S: EX-32N-1 Runoff Area=9.743 ac 29.17% Impervious Runoff Depth=2.22" Flow Length=1,616' Slope=0.0100'/' Tc=19.2 min CN=56 Runoff=16.19 cfs 1.801 af

Reach 10R: EAST DITCH - NORTH Avg. Flow Depth=3.08' Max Vel=3.02 fps Inflow=202.34 cfs 43.161 af n=0.025 L=3,667.0' S=0.0009 '/' Capacity=291.82 cfs Outflow=178.52 cfs 43.158 af

Reach 15R: WetlandsAvg. Flow Depth=1.06' Max Vel=2.20 fps Inflow=9.18 cfs 3.372 af n=0.050 L=413.0' S=0.0097'/' Capacity=82.03 cfs Outflow=9.18 cfs 3.372 af

Reach 17R: Drainage ChannelAvg. Flow Depth=0.57' Max Vel=1.96 fps Inflow=5.09 cfs 0.555 af n=0.030 L=281.0' S=0.0061 '/' Capacity=81.66 cfs Outflow=4.72 cfs 0.555 af

Reach 18R: Drainage ChannelAvg. Flow Depth=0.68' Max Vel=2.18 fps Inflow=7.36 cfs 0.610 af n=0.030 L=281.0' S=0.0061 '/' Capacity=81.66 cfs Outflow=6.96 cfs 0.610 af

Reach 24R: Drainage ChannelAvg. Flow Depth=0.48' Max Vel=1.71 fps Inflow=5.82 cfs 1.544 af n=0.025 L=2,354.0' S=0.0032 '/' Capacity=20.34 cfs Outflow=4.89 cfs 1.544 af

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 3

Reach 27R: West Ditch

Avg. Flow Depth=10.59' Max Vel=1.18 fps Inflow=247.76 cfs 46.887 af

n=0.050 L=531.0' S=0.0003'/' Capacity=53.46 cfs Outflow=238.90 cfs 46.887 af

Reach 28R: EAST DITCH TOAvg. Flow Depth=8.31' Max Vel=4.10 fps Inflow=680.60 cfs 423.785 af n=0.050 L=1,705.0' S=0.0030 '/' Capacity=284.51 cfs Outflow=679.44 cfs 423.736 af

Reach 29R: Paskamansett River Avg. Flow Depth=22.72' Max Vel=0.98 fps Inflow=739.61 cfs 500.294 af n=0.035 L=1,905.0' S=0.0001 '/' Capacity=103.50 cfs Outflow=712.61 cfs 499.986 af

Reach 30R: Culvert 1 Avg. Flow Depth=2.94' Max Vel=8.70 fps Inflow=192.08 cfs 150.678 af 90.0" x 45.0" Box Pipe n=0.015 L=48.0' S=0.0040 '/' Capacity=203.41 cfs Outflow=192.08 cfs 150.678 af

Reach 31R: EAST DITCH - NORTH Avg. Flow Depth=68.56' Max Vel=0.48 fps Inflow=922.74 cfs 377.132 af n=0.050 L=2,413.0' S=0.0000 '/' Capacity=18.43 cfs Outflow=643.17 cfs 376.899 af

Reach 34R: Drainage ChannelAvg. Flow Depth=0.34' Max Vel=3.75 fps Inflow=6.90 cfs 0.955 af n=0.025 L=331.0' S=0.0230 '/' Capacity=240.18 cfs Outflow=6.87 cfs 0.955 af

Reach 37R: Drainage ChannelAvg. Flow Depth=1.26' Max Vel=0.91 fps Inflow=17.22 cfs 1.710 af n=0.080 L=1,795.0' S=0.0035 '/' Capacity=6.58 cfs Outflow=10.10 cfs 1.709 af

Reach 38R: Drainage System "C"Avg. Flow Depth=1.00' Max Vel=2.41 fps Inflow=16.19 cfs 1.801 af 12.0" Round Pipe n=0.012 L=796.0' S=0.0019 '/' Capacity=1.68 cfs Outflow=1.79 cfs 1.801 af

Reach 39R: EAST DITCH - N2Avg. Flow Depth=0.69' Max Vel=0.58 fps Inflow=1.79 cfs 1.801 af n=0.050 L=2,017.0' S=0.0011 '/' Capacity=68.77 cfs Outflow=1.68 cfs 1.801 af

Reach 41R: Drainage System "B"Avg. Flow Depth=1.67' Max Vel=6.73 fps Inflow=51.13 cfs 17.150 af 36.0" Round Pipe n=0.012 L=1,593.0' S=0.0040 '/' Capacity=45.62 cfs Outflow=27.02 cfs 17.150 af

Reach 45R: Drainage ChannelAvg. Flow Depth=0.92' Max Vel=2.34 fps Inflow=22.35 cfs 2.183 af n=0.025 L=2,480.0' S=0.0030 '/' Capacity=86.58 cfs Outflow=16.55 cfs 2.183 af

Reach 47R: Drainage ChannelAvg. Flow Depth=0.53' Max Vel=2.17 fps Inflow=7.24 cfs 0.709 af n=0.025 L=170.0' S=0.0047 '/' Capacity=108.73 cfs Outflow=7.02 cfs 0.709 af

Pond 1P: Wetland "P"Peak Elev=60.30' Storage=2,070,111 cf Inflow=529.25 cfs 150.678 af 90.0" x 45.0" Box Culvert n=0.015 L=1.0' S=0.0000 '/' Outflow=192.08 cfs 150.678 af

Pond 1R: EX-CB-9

Peak Elev=64.22' Inflow=6.87 cfs 0.955 af
18.0" Round Culvert n=0.012 L=425.0' S=0.0022 '/' Outflow=6.87 cfs 0.955 af

Pond 2P: Wetland "K"Peak Elev=62.20' Storage=398,747 cf Inflow=263.29 cfs 43.161 af

Outflow=202.34 cfs 43.161 af

Pond 3P: EX-DMH-1 Peak Elev=69.83' Inflow=35.25 cfs 9.577 af

24.0" Round Culvert n=0.012 L=293.0' S=0.0018 '/' Outflow=35.25 cfs 9.577 af

Pond 4P: Infiltration Trench "23 C"Peak Elev=78.31' Storage=14 cf Inflow=49.66 cfs 5.245 af Discarded=0.01 cfs 0.002 af Primary=49.65 cfs 5.242 af Outflow=49.66 cfs 5.245 af

Prepared by newlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC Page 4

Pond 5P: EX-CB-4 Peak Elev=70.66' Inflow=35.25 cfs 9.577 af

24.0" Round Culvert n=0.012 L=308.0' S=0.0018 '/' Outflow=35.25 cfs 9.577 af

Pond 6P: Infiltration Trench "23 C" Peak Elev=70.77' Storage=4,492 cf Inflow=17.63 cfs 2.248 af

Discarded=0.41 cfs 0.549 af Primary=17.22 cfs 1.710 af Outflow=17.63 cfs 2.259 af

Pond 7P: EX-CB-5 Peak Elev=72.05' Inflow=19.53 cfs 5.380 af

18.0" Round Culvert n=0.012 L=250.0' S=0.0022 '/' Outflow=19.53 cfs 5.380 af

Pond 8P: EX-CB-6 Peak Elev=65.61' Inflow=10.10 cfs 1.709 af

18.0" Round Culvert n=0.012 L=250.0' S=0.0022 '/' Outflow=10.10 cfs 1.709 af

Pond 9P: Ex-Outfall 2 Peak Elev=71.79' Inflow=4.44 cfs 0.975 af

12.0" Round Culvert n=0.012 L=107.0' S=0.0140 '/' Outflow=4.44 cfs 0.975 af

Pond 10P: EX-CB-10 Peak Elev=67.65' Inflow=10.10 cfs 1.709 af

18.0" Round Culvert n=0.012 L=425.0' S=0.0022 '/' Outflow=10.10 cfs 1.709 af

Pond 11P: Infiltration Trench - "23 A" Peak Elev=71.02' Storage=4,509 cf Inflow=19.89 cfs 2.626 af

Discarded=0.35 cfs 0.500 af Primary=19.53 cfs 2.127 af Outflow=19.88 cfs 2.627 af

Pond 12P: Infiltration Trench "A-A" Peak Elev=67.31' Storage=144 cf Inflow=7.32 cfs 0.640 af

Discarded=0.02 cfs 0.030 af Primary=7.36 cfs 0.610 af Outflow=7.39 cfs 0.640 af

Pond 13P: Infield Storage Area Peak Elev=60.49' Storage=27,236 cf Inflow=19.68 cfs 3.372 af

Outflow=9.18 cfs 3.372 af

Pond 15P: Infiltration Trench "A-B" Peak Elev=68.26' Storage=125 cf Inflow=4.81 cfs 0.587 af

Discarded=0.03 cfs 0.032 af Primary=5.09 cfs 0.555 af Outflow=5.12 cfs 0.587 af

Pond 16P: Infiltration Trench "A-C" Peak Elev=74.01' Storage=247 cf Inflow=4.14 cfs 1.040 af

Discarded=0.05 cfs 0.065 af Primary=4.44 cfs 0.975 af Outflow=4.49 cfs 1.040 af

Pond 19P: Infiltration Trench "5 D" Peak Elev=71.04' Storage=653 cf Inflow=4.43 cfs 0.686 af

Discarded=0.05 cfs 0.069 af Primary=5.00 cfs 0.617 af Outflow=5.05 cfs 0.686 af

Pond 21P: Infiltration Trench "5 E" Peak Elev=71.05' Storage=700 cf Inflow=7.15 cfs 0.784 af

Discarded=0.05 cfs 0.076 af Primary=7.24 cfs 0.709 af Outflow=7.29 cfs 0.784 af

Pond 25P: Prop Drainage System "A" Peak Elev=65.32' Inflow=6.23 cfs 0.731 af

12.0" Round Culvert n=0.012 L=170.0' S=0.0026 '/' Outflow=6.23 cfs 0.731 af

Pond 26P: Infiltration Trench - "5 A" Peak Elev=59.29' Storage=2,978 cf Inflow=22.48 cfs 2.490 af

Discarded=0.23 cfs 0.336 af Primary=22.35 cfs 2.183 af Outflow=22.58 cfs 2.519 af

Pond 27P: Ex-Outfall 1 Peak Elev=77.61' Inflow=10.56 cfs 1.165 af

12.0" Round Culvert n=0.012 L=124.0' S=0.0022 '/' Outflow=10.56 cfs 1.165 af

Pond 34P: Wetland "H" Peak Elev=259.84' Storage=338,181 cf Inflow=70.41 cfs 16.419 af

12.0" Round Culvert n=0.012 L=70.0' S=0.0020 '/' Outflow=50.31 cfs 16.419 af

Pond 49R: EX-CB-7

Type III 24-hr 100-Year Rainfall=7.00"

Peak Elev=66.44' Inflow=12.62 cfs 1.736 af

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 5

Pond 42R: EX-CB-3	Peak Elev=72	2.05' Inflow=38.06 cfs 9.976 af
	24.0" Round Culvert n=0.012 L=354.0' S=0.0016	'/' Outflow=38.06 cfs 9.976 af

Pond 43R: EX-CB-2 Peak Elev=82.55' Inflow=50.16 cfs 11.712 af

24.0" Round Culvert n=0.012 L=409.0' S=0.0001 '/' Outflow=50.16 cfs 11.712 af

Pond 46R: EX-CB-1 Peak Elev=66.86' Inflow=50.16 cfs 11.712 af

24.0" Round Culvert n=0.012 L=36.0' S=0.0003 '/' Outflow=50.16 cfs 11.712 af

Pond 48R: EX-CB-8 Peak Elev=63.03' Inflow=8.50 cfs 1.120 af 18.0" Round Culvert n=0.012 L=364.0' S=0.0022 '/' Outflow=8.50 cfs 1.120 af

18.0" Round Culvert n=0.012 L=425.0' S=0.0005 '/' Outflow=12.62 cfs 1.736 af

Pond 51R: EX-CB-11 Peak Elev=60.54' Inflow=9.18 cfs 3.372 af

18.0" Round Culvert n=0.012 L=307.0' S=0.0010 '/' Outflow=9.18 cfs 3.372 af

Link AP-1: Analysis Point #1 Inflow=712.61 cfs 499.986 af

Primary=712.61 cfs 499.986 af

Link AP-2: Analysis Point #2 Inflow=193.82 cfs 39.659 af

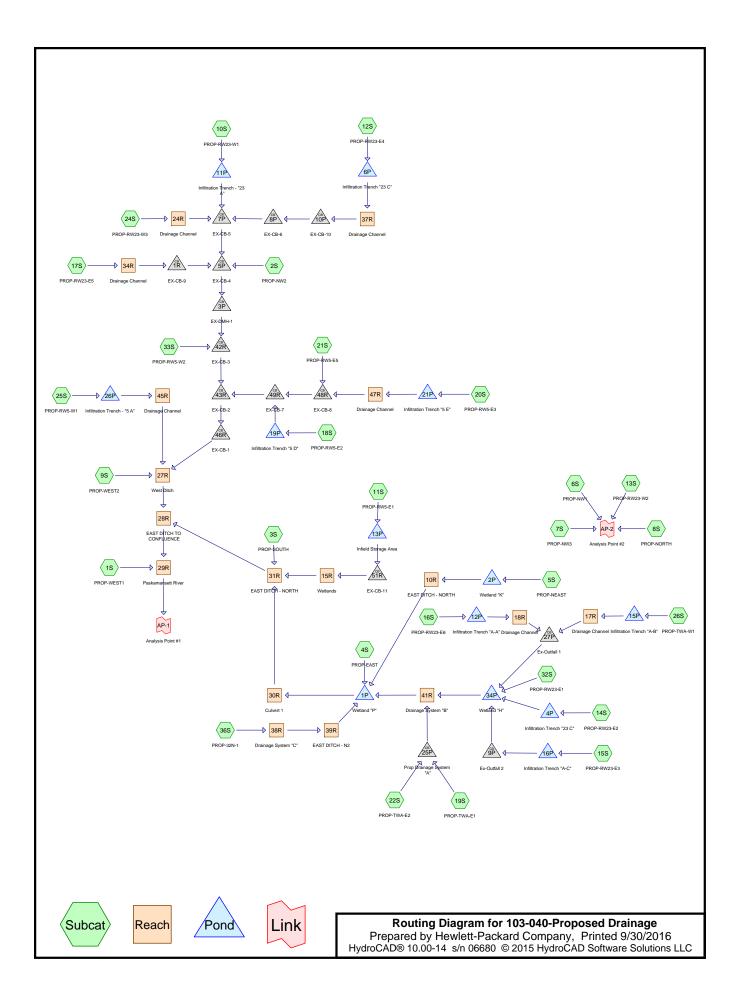
Primary=193.82 cfs 39.659 af

Total Runoff Area = 1,790.356 ac Runoff Volume = 541.859 af Average Runoff Depth = 3.63" 89.62% Pervious = 1,604.450 ac 10.38% Impervious = 185.906 ac

APPENDIX B

PROPOSED DRAINAGE CALCULATIONS

This Page Intentionally Left Blank



Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
17.726	61	1/4 acre lots, 38% imp, HSG A (1S, 2S, 9S, 24S)
51.376	83	1/4 acre lots, 38% imp, HSG C (4S, 5S, 32S)
7.815	87	1/4 acre lots, 38% imp, HSG D (4S, 5S, 32S)
121.477	39	>75% Grass cover, Good, HSG A (1S, 2S, 4S, 5S, 9S, 10S, 11S, 12S, 13S, 14S, 15S, 16S, 17S, 18S, 19S, 20S, 21S, 22S, 24S, 25S, 26S, 32S, 33S, 36S)
25.423	74	>75% Grass cover, Good, HSG C (4S, 8S, 13S, 14S, 32S)
28.069	80	>75% Grass cover, Good, HSG D (1S, 4S, 8S, 14S, 25S, 32S)
29.258	30	Brush, Good, HSG A (2S, 3S, 5S, 6S, 9S, 24S, 32S)
1.916	48	Brush, Good, HSG B (1S, 9S)
21.620	65	Brush, Good, HSG C (1S, 3S, 6S, 14S)
196.069	73	Brush, Good, HSG D (1S, 3S, 5S, 6S, 9S, 32S)
4.941	76	Gravel roads, HSG A (3S, 4S, 5S, 9S, 11S, 14S, 32S)
5.666	89	Gravel roads, HSG C (4S, 6S, 7S, 8S)
10.360	91	Gravel roads, HSG D (3S, 4S, 5S, 6S, 7S, 8S, 9S)
102.506	39	Pasture/grassland/range, Good, HSG A (2S, 3S, 4S, 5S, 6S, 9S)
5.802	61	Pasture/grassland/range, Good, HSG B (3S)
19.236	74	Pasture/grassland/range, Good, HSG C (3S, 4S, 5S, 6S)
152.250	80	Pasture/grassland/range, Good, HSG D (3S, 4S, 5S, 6S, 9S)
58.760	98	Paved parking, HSG A (2S, 3S, 4S, 5S, 6S, 9S, 10S, 11S, 12S, 13S, 14S, 15S, 16S, 17S, 18S, 19S, 20S, 21S, 22S, 24S, 25S, 26S, 32S, 33S, 36S)
1.637	98	Paved parking, HSG B (3S)
26.639	98	Paved parking, HSG C (3S, 4S, 6S, 8S)
44.125	98	Paved parking, HSG D (1S, 3S, 4S, 5S, 6S, 8S)
15.997	98	Water Surface, HSG D (1S, 3S, 4S, 5S, 6S, 7S, 8S, 9S)
66.941	30	Woods, Good, HSG A (1S, 3S, 4S, 5S, 6S, 9S, 32S)
10.810	55	Woods, Good, HSG B (1S, 9S)
125.260	70	Woods, Good, HSG C (1S, 3S, 4S, 5S, 6S, 7S, 8S, 14S, 32S)
409.934	77	Woods, Good, HSG D (1S, 3S, 4S, 5S, 6S, 7S, 8S, 9S, 14S, 32S)
32.175	32	Woods/grass comb., Good, HSG A (3S)
123.973	72	Woods/grass comb., Good, HSG C (3S)
72.595	79	Woods/grass comb., Good, HSG D (3S)
1,790.356	69	TOTAL AREA

103-040-Proposed Drainage
Prepared by Hewlett-Packard Company
HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Printed 9/30/2016 Page 3

Soil Listing (all nodes)

Area	Soil	Subcatchment
(acres)	Group	Numbers
433.784	HSG A	1S, 2S, 3S, 4S, 5S, 6S, 9S, 10S, 11S, 12S, 13S, 14S, 15S, 16S, 17S, 18S, 19S,
		20S, 21S, 22S, 24S, 25S, 26S, 32S, 33S, 36S
20.165	HSG B	1S, 3S, 9S
399.193	HSG C	1S, 3S, 4S, 5S, 6S, 7S, 8S, 13S, 14S, 32S
937.214	HSG D	1S, 3S, 4S, 5S, 6S, 7S, 8S, 9S, 14S, 25S, 32S
0.000	Other	
1,790.356		TOTAL AREA

Post-development Type III 24-hr 2-Year Rainfall=3.40" Printed 9/30/2016

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 4

Time span=5.00-48.00 hrs, dt=0.05 hrs, 861 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method			
Subcatchment1S: PROP-WEST1	Runoff Area=286.694 ac 2.76% Impervious Runoff Depth=0.75" Flow Length=6,115' Tc=90.6 min CN=66 Runoff=63.29 cfs 17.838 af		
Subcatchment 2S: PROP-NW2	Runoff Area=29.472 ac 10.76% Impervious Runoff Depth=0.05" Flow Length=2,730' Tc=56.3 min CN=44 Runoff=0.20 cfs 0.132 af		
Subcatchment3S: PROP-SOUTH Flow	Runoff Area=662.283 ac 5.89% Impervious Runoff Depth=1.17" w Length=10,096' Tc=125.9 min CN=74 Runoff=205.76 cfs 64.650 af		
Subcatchment 4S: PROP-EAST	Runoff Area=243.444 ac 19.98% Impervious Runoff Depth=1.36" Tow Length=5,766' Tc=94.7 min CN=77 Runoff=110.09 cfs 27.523 af		
Subcatchment 5S: PROP-NEAST	Runoff Area=121.656 ac 17.92% Impervious Runoff Depth=1.23" Flow Length=4,620' Tc=50.7 min CN=75 Runoff=73.09 cfs 12.485 af		
Subcatchment 6S: PROP-NW1	Runoff Area=23.135 ac 5.60% Impervious Runoff Depth=0.89" Flow Length=1,415' Tc=26.5 min CN=69 Runoff=12.99 cfs 1.725 af		
Subcatchment7S: PROP-NW3	Runoff Area=23.363 ac 2.88% Impervious Runoff Depth=1.17" Flow Length=1,310' Tc=24.4 min CN=74 Runoff=18.94 cfs 2.281 af		
Subcatchment8S: PROP-NORTH	Runoff Area=64.926 ac 7.58% Impervious Runoff Depth=1.42" Flow Length=2,892' Tc=69.3 min CN=78 Runoff=38.03 cfs 7.693 af		
Subcatchment9S: PROP-WEST2	Runoff Area=141.341 ac 10.61% Impervious Runoff Depth=0.53" Flow Length=4,198' Tc=55.7 min CN=61 Runoff=26.11 cfs 6.225 af		
Subcatchment 10S: PROP-RW23-W1	Runoff Area=11.251 ac 37.77% Impervious Runoff Depth=0.53" Flow Length=336' Tc=31.7 min CN=61 Runoff=2.79 cfs 0.496 af		
Subcatchment11S: PROP-RW5-E1	Runoff Area=21.912 ac 22.13% Impervious Runoff Depth=0.22" Flow Length=1,467' Tc=45.1 min CN=52 Runoff=1.06 cfs 0.409 af		
Subcatchment12S: PROP-RW23-E4	Runoff Area=10.361 ac 36.22% Impervious Runoff Depth=0.49" Flow Length=336' Tc=28.6 min CN=60 Runoff=2.38 cfs 0.422 af		
Subcatchment13S: PROP-RW23-W2	Runoff Area=3.107 ac 13.45% Impervious Runoff Depth=0.70" Flow Length=431' Tc=26.1 min CN=65 Runoff=1.26 cfs 0.181 af		
Subcatchment14S: PROP-RW23-E2	Runoff Area=22.469 ac 9.29% Impervious Runoff Depth=0.57" Flow Length=1,209' Tc=18.8 min CN=62 Runoff=7.56 cfs 1.066 af		
Subcatchment 15S: PROP-RW23-E3	Runoff Area=9.450 ac 11.30% Impervious Runoff Depth=0.09" Flow Length=1,277' Tc=70.0 min CN=46 Runoff=0.11 cfs 0.068 af		
Subcatchment16S: PROP-RW23-E6	Runoff Area=3.464 ac 23.70% Impervious Runoff Depth=0.25" Flow Length=353' Tc=10.0 min CN=53 Runoff=0.33 cfs 0.073 af		

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 5

Subcatchment 17S: PROP-RW23-E5

Runoff Area=4.091 ac 30.73% Impervious Runoff Depth=0.38"

Flow Length=2,359' Tc=34.9 min CN=57 Runoff=0.57 cfs 0.129 af

Subcatchment 18S: PROP-RW5-E2

Runoff Area=3.285 ac 34.03% Impervious Runoff Depth=0.45"

Flow Length=387' Tc=42.5 min CN=59 Runoff=0.55 cfs 0.123 af

Subcatchment 19S: PROP-TWA-E1

Runoff Area=2.423 ac 46.35% Impervious Runoff Depth=0.75"

Flow Length=322' Tc=21.8 min CN=66 Runoff=1.16 cfs 0.151 af

Subcatchment 20S: PROP-RW5-E3 Runoff Area=3.245 ac 41.11% Impervious Runoff Depth=0.61" Flow Length=203' Slope=0.0133 '/' Tc=20.8 min CN=63 Runoff=1.18 cfs 0.165 af

Subcatchment 21S: PROP-RW5-E5

Runoff Area=2.132 ac 29.83% Impervious Runoff Depth=0.38"

Flow Length=1,056' Tc=46.6 min CN=57 Runoff=0.26 cfs 0.067 af

Subcatchment 22S: PROP-TWA-E2

Runoff Area=1.194 ac 1.93% Impervious Runoff Depth=0.01"

Flow Length=338' Tc=21.4 min CN=40 Runoff=0.00 cfs 0.001 af

Subcatchment 24S: PROP-RW23-W3

Runoff Area=20.185 ac 4.44% Impervious Runoff Depth=0.02"
Flow Length=2,853' Tc=57.2 min CN=41 Runoff=0.05 cfs 0.031 af

Subcatchment 25S: PROP-RW5-W1 Runoff Area=10.668 ac 37.32% Impervious Runoff Depth=0.57" Flow Length=210' Tc=21.1 min CN=62 Runoff=3.45 cfs 0.506 af

Subcatchment 26S: PROP-TWA-W1

Runoff Area=4.726 ac 14.47% Impervious Runoff Depth=0.13"
Flow Length=595' Tc=17.6 min CN=48 Runoff=0.08 cfs 0.050 af

Subcatchment 32S: PROP-RW23-E1Runoff Area=48.890 ac 7.30% Impervious Runoff Depth=0.35"
Flow Length=2,965' Tc=67.6 min CN=56 Runoff=4.16 cfs 1.406 af

Subcatchment 33S: PROP-RW5-W2

Runoff Area=1.446 ac 46.96% Impervious Runoff Depth=0.79"

Flow Length=1,182' Tc=35.4 min CN=67 Runoff=0.61 cfs 0.096 af

Subcatchment 36S: PROP-32N-1Runoff Area=9.743 ac 14.47% Impervious Runoff Depth=0.13"
Flow Length=1,616' Slope=0.0100 '/' Tc=19.2 min CN=48 Runoff=0.17 cfs 0.102 af

Reach 10R: EAST DITCH - NORTH Avg. Flow Depth=1.13' Max Vel=1.73 fps Inflow=31.13 cfs 12.485 af n=0.025 L=3,667.0' S=0.0009 '/' Capacity=291.82 cfs Outflow=29.68 cfs 12.483 af

Reach 15R: WetlandsAvg. Flow Depth=0.38' Max Vel=1.15 fps Inflow=1.05 cfs 0.409 af n=0.050 L=413.0' S=0.0097 '/' Capacity=82.03 cfs Outflow=1.04 cfs 0.409 af

Reach 17R: Drainage ChannelAvg. Flow Depth=0.05' Max Vel=0.51 fps Inflow=0.10 cfs 0.020 af n=0.030 L=281.0' S=0.0061 '/' Capacity=81.66 cfs Outflow=0.06 cfs 0.020 af

Reach 18R: Drainage ChannelAvg. Flow Depth=0.13' Max Vel=0.85 fps Inflow=0.37 cfs 0.045 af n=0.030 L=281.0' S=0.0061 '/' Capacity=81.66 cfs Outflow=0.27 cfs 0.045 af

Reach 24R: Drainage ChannelAvg. Flow Depth=0.03' Max Vel=0.34 fps Inflow=0.05 cfs 0.031 af n=0.025 L=2,354.0' S=0.0032 '/' Capacity=20.34 cfs Outflow=0.04 cfs 0.031 af

Type III 24-hr 2-Year Rainfall=3.40"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 6

Reach 27R: West DitchAvg. Flow Depth=2.93' Max Vel=0.75 fps Inflow=29.94 cfs 7.266 af n=0.050 L=531.0' S=0.0003'/' Capacity=53.46 cfs Outflow=27.64 cfs 7.266 af

Reach 28R: EAST DITCH TOAvg. Flow Depth=4.34' Max Vel=3.13 fps Inflow=211.62 cfs 115.067 af n=0.050 L=1,705.0' S=0.0030 '/' Capacity=284.51 cfs Outflow=211.31 cfs 115.053 af

Reach 29R: Paskamansett River Avg. Flow Depth=9.18' Max Vel=0.87 fps Inflow=227.14 cfs 132.890 af n=0.035 L=1,905.0' S=0.0001 '/' Capacity=103.50 cfs Outflow=219.32 cfs 132.806 af

Reach 30R: Culvert 1 Avg. Flow Depth=1.72' Max Vel=6.95 fps Inflow=89.41 cfs 42.811 af 90.0" x 45.0" Box Pipe n=0.015 L=48.0' S=0.0040 '/' Capacity=203.41 cfs Outflow=89.41 cfs 42.811 af

Reach 31R: EAST DITCH - NORTH Avg. Flow Depth=23.20' Max Vel=0.47 fps Inflow=293.15 cfs 107.870 af n=0.050 L=2,413.0' S=0.0000 '/' Capacity=18.43 cfs Outflow=204.23 cfs 107.801 af

Reach 34R: Drainage ChannelAvg. Flow Depth=0.08' Max Vel=1.61 fps Inflow=0.57 cfs 0.129 af n=0.025 L=331.0' S=0.0230 '/' Capacity=240.18 cfs Outflow=0.57 cfs 0.129 af

Reach 37R: Drainage ChannelAvg. Flow Depth=0.14' Max Vel=0.28 fps Inflow=0.87 cfs 0.051 af n=0.080 L=1,795.0' S=0.0035 '/' Capacity=6.58 cfs Outflow=0.18 cfs 0.051 af

Reach 38R: Drainage System "C"Avg. Flow Depth=0.22' Max Vel=1.38 fps Inflow=0.17 cfs 0.102 af 12.0" Round Pipe n=0.012 L=796.0' S=0.0019 '/' Capacity=1.68 cfs Outflow=0.17 cfs 0.102 af

Reach 39R: EAST DITCH - N2Avg. Flow Depth=0.21' Max Vel=0.27 fps Inflow=0.17 cfs 0.102 af n=0.050 L=2,017.0' S=0.0011 '/' Capacity=68.77 cfs Outflow=0.13 cfs 0.102 af

Reach 41R: Drainage System "B"Avg. Flow Depth=0.62' Max Vel=4.05 fps Inflow=4.29 cfs 2.704 af 36.0" Round Pipe n=0.012 L=1,593.0' S=0.0040 '/' Capacity=45.62 cfs Outflow=4.29 cfs 2.704 af

Reach 45R: Drainage ChannelAvg. Flow Depth=0.26' Max Vel=1.16 fps Inflow=5.81 cfs 0.255 af n=0.025 L=2,480.0' S=0.0030 '/' Capacity=86.58 cfs Outflow=1.52 cfs 0.255 af

Reach 47R: Drainage ChannelAvg. Flow Depth=0.19' Max Vel=1.21 fps Inflow=1.51 cfs 0.098 af n=0.025 L=170.0' S=0.0047 '/' Capacity=108.73 cfs Outflow=1.08 cfs 0.098 af

Pond 1P: Wetland "P" Peak Elev=58.40' Storage=208,362 cf Inflow=124.75 cfs 42.811 af 90.0" x 45.0" Box Culvert n=0.015 L=1.0' S=0.0000 '/' Outflow=89.41 cfs 42.811 af

Pond 1R: EX-CB-9

Peak Elev=62.26' Inflow=0.57 cfs 0.129 af
18.0" Round Culvert n=0.012 L=425.0' S=0.0022 '/' Outflow=0.57 cfs 0.129 af

Pond 2P: Wetland "K"Peak Elev=61.39' Storage=146,413 cf Inflow=73.09 cfs 12.485 af

Outflow=31.13 cfs 12.485 af

Peak Elev=60.77' Inflow=2.37 cfs 0.465 af

Pond 3P: EX-DMH-1 Peak Elev=60.77' Inflow=2.37 cfs 0.465 af 24.0" Round Culvert n=0.012 L=293.0' S=0.0018 '/' Outflow=2.37 cfs 0.465 af

Pond 4P: Infiltration Trench "23 C" Peak Elev=78.09' Storage=1 cf Inflow=7.56 cfs 1.066 af Discarded=0.00 cfs 0.001 af Primary=7.56 cfs 1.065 af Outflow=7.56 cfs 1.066 af

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Peak Elev=61.32' Inflow=2.37 cfs 0.465 af Pond 5P: EX-CB-4

24.0" Round Culvert n=0.012 L=308.0' S=0.0018 '/' Outflow=2.37 cfs 0.465 af

Pond 6P: Infiltration Trench "23 C" Peak Elev=70.75' Storage=4,442 cf Inflow=2.38 cfs 0.422 af

Discarded=0.41 cfs 0.372 af Primary=0.87 cfs 0.051 af Outflow=1.27 cfs 0.423 af

Peak Elev=62.26' Inflow=1.83 cfs 0.203 af Pond 7P: EX-CB-5

18.0" Round Culvert n=0.012 L=250.0' S=0.0022 '/' Outflow=1.83 cfs 0.203 af

Pond 8P: EX-CB-6 Peak Elev=62.33' Inflow=0.18 cfs 0.051 af

18.0" Round Culvert n=0.012 L=250.0' S=0.0022 '/' Outflow=0.18 cfs 0.051 af

Peak Elev=70.39' Inflow=0.07 cfs 0.015 af Pond 9P: Ex-Outfall 2

12.0" Round Culvert n=0.012 L=107.0' S=0.0140 '/' Outflow=0.07 cfs 0.015 af

Peak Elev=63.37' Inflow=0.18 cfs 0.051 af Pond 10P: EX-CB-10

18.0" Round Culvert n=0.012 L=425.0' S=0.0022 '/' Outflow=0.18 cfs 0.051 af

Pond 11P: Infiltration Trench - "23 A" Peak Elev=71.00' Storage=4,476 cf Inflow=2.79 cfs 0.496 af

Discarded=0.35 cfs 0.374 af Primary=1.83 cfs 0.122 af Outflow=2.18 cfs 0.496 af

Pond 12P: Infiltration Trench "A-A" Peak Elev=67.26' Storage=139 cf Inflow=0.33 cfs 0.073 af

Discarded=0.02 cfs 0.028 af Primary=0.37 cfs 0.045 af Outflow=0.39 cfs 0.073 af

Pond 13P: Infield Storage Area Peak Elev=59.45' Storage=173 cf Inflow=1.06 cfs 0.409 af

Outflow=1.05 cfs 0.409 af

Pond 15P: Infiltration Trench "A-B" Peak Elev=68.23' Storage=120 cf Inflow=0.08 cfs 0.050 af

Discarded=0.03 cfs 0.030 af Primary=0.10 cfs 0.020 af Outflow=0.13 cfs 0.050 af

Pond 16P: Infiltration Trench "A-C" Peak Elev=73.98' Storage=240 cf Inflow=0.11 cfs 0.068 af

Discarded=0.05 cfs 0.053 af Primary=0.07 cfs 0.015 af Outflow=0.12 cfs 0.068 af

Pond 19P: Infiltration Trench "5 D" Peak Elev=71.01' Storage=653 cf Inflow=0.55 cfs 0.123 af

Discarded=0.05 cfs 0.063 af Primary=0.82 cfs 0.061 af Outflow=0.87 cfs 0.123 af

Pond 21P: Infiltration Trench "5 E" Peak Elev=71.02' Storage=700 cf Inflow=1.18 cfs 0.165 af

Discarded=0.05 cfs 0.067 af Primary=1.51 cfs 0.098 af Outflow=1.56 cfs 0.165 af

Peak Elev=59.86' Inflow=1.16 cfs 0.152 af Pond 25P: Prop Drainage System "A"

12.0" Round Culvert n=0.012 L=170.0' S=0.0026 '/' Outflow=1.16 cfs 0.152 af

Pond 26P: Infiltration Trench - "5 A" Peak Elev=59.26' Storage=2,938 cf Inflow=3.45 cfs 0.506 af

Discarded=0.23 cfs 0.283 af Primary=5.81 cfs 0.255 af Outflow=6.05 cfs 0.537 af

Peak Elev=64.55' Inflow=0.27 cfs 0.065 af Pond 27P: Ex-Outfall 1

12.0" Round Culvert n=0.012 L=124.0' S=0.0022 '/' Outflow=0.27 cfs 0.065 af

Pond 34P: Wetland "H" Peak Elev=65.39' Storage=21,609 cf Inflow=7.86 cfs 2.552 af

12.0" Round Culvert n=0.012 L=70.0' S=0.0020 '/' Outflow=4.11 cfs 2.552 af

400.040.0		Post-development
103-040-Proposed Drain		Type III 24-hr 2-Year Rainfall=3.40"
Prepared by Hewlett-Packa	ard Company	Printed 9/30/2016
HydroCAD® 10.00-14 s/n 0668	0 © 2015 HydroCAD Software Solution	ns LLC Page 8
Pond 42R: EX-CB-3		Peak Elev=60.25' Inflow=2.81 cfs 0.560 af
	24.0" Round Culvert n=0.012 L=35	4.0' S=0.0016 '/' Outflow=2.81 cfs 0.560 af
Pond 43R: EX-CB-2		Peak Elev=60.19' Inflow=4.36 cfs 0.787 af
	24.0" Round Culvert n=0.012 L=40	9.0' S=0.0001 '/' Outflow=4.36 cfs 0.787 af
Pond 46R: EX-CB-1		Peak Elev=59.75' Inflow=4.36 cfs 0.787 af
	24.0" Round Culvert n=0.012 L=3	6.0' S=0.0003 '/' Outflow=4.36 cfs 0.787 af
Pond 48R: EX-CB-8		Peak Elev=60.50' Inflow=1.22 cfs 0.166 af
	18.0" Round Culvert n=0.012 L=36	4.0' S=0.0022 '/' Outflow=1.22 cfs 0.166 af
Pond 49R: EX-CB-7		Peak Elev=59.93' Inflow=1.63 cfs 0.226 af
1 ond 1011. EX 02 1	18.0" Round Culvert n=0.012 L=42	5.0' S=0.0005 '/' Outflow=1.63 cfs 0.226 af
Pond 51R: EX-CB-11		Peak Elev=57.52' Inflow=1.05 cfs 0.409 af

Link AP-1: Analysis Point #1Inflow=219.32 cfs 132.806 af Primary=219.32 cfs 132.806 af

Link AP-2: Analysis Point #2Inflow=53.56 cfs 11.879 af Primary=53.56 cfs 11.879 af

Total Runoff Area = 1,790.356 ac Runoff Volume = 146.094 af Average Runoff Depth = 0.98" 90.15% Pervious = 1,613.970 ac 9.85% Impervious = 176.386 ac

18.0" Round Culvert n=0.012 L=307.0' S=0.0010 '/' Outflow=1.05 cfs 0.409 af

Subcatchment 16S: PROP-RW23-E6

Post-development Type III 24-hr 10-Year Rainfall=4.80" Printed 9/30/2016

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 1

Time span=5.00-48.00 hrs, dt=0.05 hrs, 861 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Reach routing by Stor-I	nd+Trans method - Pond routing by Stor-Ind method
Subcatchment 1S: PROP-WEST1	Runoff Area=286.694 ac 2.76% Impervious Runoff Depth=1.59" Flow Length=6,115' Tc=90.6 min CN=66 Runoff=151.30 cfs 38.056 af
Subcatchment 2S: PROP-NW2	Runoff Area=29.472 ac 10.76% Impervious Runoff Depth=0.34" Flow Length=2,730' Tc=56.3 min CN=44 Runoff=2.09 cfs 0.833 af
Subcatchment 3S: PROP-SOUTH Flow	Runoff Area=662.283 ac 5.89% Impervious Runoff Depth=2.21" w Length=10,096' Tc=125.9 min CN=74 Runoff=404.55 cfs 121.738 af
Subcatchment 4S: PROP-EAST	Runoff Area=243.444 ac 19.98% Impervious Runoff Depth=2.46" Flow Length=5,766' Tc=94.7 min CN=77 Runoff=204.32 cfs 49.837 af
Subcatchment5S: PROP-NEAST	Runoff Area=121.656 ac 17.92% Impervious Runoff Depth=2.29" Flow Length=4,620' Tc=50.7 min CN=75 Runoff=140.45 cfs 23.197 af
Subcatchment6S: PROP-NW1	Runoff Area=23.135 ac 5.60% Impervious Runoff Depth=1.81" Flow Length=1,415' Tc=26.5 min CN=69 Runoff=28.42 cfs 3.496 af
Subcatchment7S: PROP-NW3	Runoff Area=23.363 ac 2.88% Impervious Runoff Depth=2.21" Flow Length=1,310' Tc=24.4 min CN=74 Runoff=37.03 cfs 4.294 af
Subcatchment8S: PROP-NORTH	Runoff Area=64.926 ac 7.58% Impervious Runoff Depth=2.54" Flow Length=2,892' Tc=69.3 min CN=78 Runoff=69.34 cfs 13.758 af
Subcatchment9S: PROP-WEST2	Runoff Area=141.341 ac 10.61% Impervious Runoff Depth=1.25" Flow Length=4,198' Tc=55.7 min CN=61 Runoff=75.74 cfs 14.730 af
Subcatchment 10S: PROP-RW23-W	Runoff Area=11.251 ac 37.77% Impervious Runoff Depth=1.25" Flow Length=336' Tc=31.7 min CN=61 Runoff=8.15 cfs 1.173 af
Subcatchment11S: PROP-RW5-E1	Runoff Area=21.912 ac 22.13% Impervious Runoff Depth=0.72" Flow Length=1,467' Tc=45.1 min CN=52 Runoff=6.06 cfs 1.308 af
Subcatchment 12S: PROP-RW23-E4	Runoff Area=10.361 ac 36.22% Impervious Runoff Depth=1.19" Flow Length=336' Tc=28.6 min CN=60 Runoff=7.33 cfs 1.024 af
Subcatchment 13S: PROP-RW23-W2	Runoff Area=3.107 ac 13.45% Impervious Runoff Depth=1.52" Flow Length=431' Tc=26.1 min CN=65 Runoff=3.13 cfs 0.394 af
Subcatchment 14S: PROP-RW23-E2	Runoff Area=22.469 ac 9.29% Impervious Runoff Depth=1.32" Flow Length=1,209' Tc=18.8 min CN=62 Runoff=21.55 cfs 2.465 af
Subcatchment 15S: PROP-RW23-E3	Runoff Area=9.450 ac 11.30% Impervious Runoff Depth=0.42" Flow Length=1,277' Tc=70.0 min CN=46 Runoff=0.89 cfs 0.334 af
0 1 4 1 4400 PDOD PW00 F0	D = ((A = = 0 404 = = 00 700 / Le = = 'e = D = = ((D = + = 0.77

Runoff Area=3.464 ac 23.70% Impervious Runoff Depth=0.77" Flow Length=353' Tc=10.0 min CN=53 Runoff=1.87 cfs 0.222 af

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 2

Subcatchment 17S: PROP-RW23-E5

Runoff Area=4.091 ac 30.73% Impervious Runoff Depth=1.00"
Flow Length=2,359' Tc=34.9 min CN=57 Runoff=2.10 cfs 0.341 af

Subcatchment 18S: PROP-RW5-E2

Runoff Area=3.285 ac 34.03% Impervious Runoff Depth=1.12"

Flow Length=387' Tc=42.5 min CN=59 Runoff=1.79 cfs 0.307 af

Subcatchment 19S: PROP-TWA-E1

Runoff Area=2.423 ac 46.35% Impervious Runoff Depth=1.59"
Flow Length=322' Tc=21.8 min CN=66 Runoff=2.77 cfs 0.322 af

Subcatchment 20S: PROP-RW5-E3 Runoff Area=3.245 ac 41.11% Impervious Runoff Depth=1.38" Flow Length=203' Slope=0.0133'/' Tc=20.8 min CN=63 Runoff=3.19 cfs 0.374 af

Subcatchment 21S: PROP-RW5-E5

Runoff Area=2.132 ac 29.83% Impervious Runoff Depth=1.00"
Flow Length=1,056' Tc=46.6 min CN=57 Runoff=0.94 cfs 0.178 af

Subcatchment 22S: PROP-TWA-E2

Runoff Area=1.194 ac 1.93% Impervious Runoff Depth=0.19"
Flow Length=338' Tc=21.4 min CN=40 Runoff=0.03 cfs 0.019 af

Subcatchment 24S: PROP-RW23-W3

Runoff Area=20.185 ac 4.44% Impervious Runoff Depth=0.23"
Flow Length=2,853' Tc=57.2 min CN=41 Runoff=0.68 cfs 0.381 af

Subcatchment 25S: PROP-RW5-W1

Runoff Area=10.668 ac 37.32% Impervious Runoff Depth=1.32"
Flow Length=210' Tc=21.1 min CN=62 Runoff=9.77 cfs 1.170 af

Subcatchment 26S: PROP-TWA-W1

Runoff Area=4.726 ac 14.47% Impervious Runoff Depth=0.51"

Flow Length=595' Tc=17.6 min CN=48 Runoff=1.10 cfs 0.203 af

Subcatchment 32S: PROP-RW23-E1 Runoff Area=48.890 ac 7.30% Impervious Runoff Depth=0.94" Flow Length=2,965' Tc=67.6 min CN=56 Runoff=15.78 cfs 3.831 af

Subcatchment 33S: PROP-RW5-W2

Runoff Area=1.446 ac 46.96% Impervious Runoff Depth=1.67"

Flow Length=1,182' Tc=35.4 min CN=67 Runoff=1.41 cfs 0.201 af

Subcatchment 36S: PROP-32N-1Runoff Area=9.743 ac 14.47% Impervious Runoff Depth=0.51"

Flow Length=1,616' Slope=0.0100 '/' Tc=19.2 min CN=48 Runoff=2.22 cfs 0.418 af

Reach 10R: EAST DITCH - NORTH Avg. Flow Depth=1.91' Max Vel=2.33 fps Inflow=88.04 cfs 23.197 af n=0.025 L=3,667.0' S=0.0009 '/' Capacity=291.82 cfs Outflow=74.59 cfs 23.194 af

Reach 15R: WetlandsAvg. Flow Depth=0.82' Max Vel=1.88 fps Inflow=5.44 cfs 1.308 af n=0.050 L=413.0' S=0.0097'/' Capacity=82.03 cfs Outflow=5.42 cfs 1.308 af

Reach 17R: Drainage ChannelAvg. Flow Depth=0.27' Max Vel=1.30 fps Inflow=1.46 cfs 0.171 af n=0.030 L=281.0' S=0.0061 '/' Capacity=81.66 cfs Outflow=1.05 cfs 0.171 af

Reach 18R: Drainage ChannelAvg. Flow Depth=0.35' Max Vel=1.50 fps Inflow=2.45 cfs 0.194 af n=0.030 L=281.0' S=0.0061 '/' Capacity=81.66 cfs Outflow=1.75 cfs 0.194 af

Reach 24R: Drainage ChannelAvg. Flow Depth=0.15' Max Vel=0.89 fps Inflow=0.68 cfs 0.381 af n=0.025 L=2,354.0' S=0.0032 '/' Capacity=20.34 cfs Outflow=0.63 cfs 0.381 af

Pond 3P: EX-DMH-1

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 3

Reach 27R: West DitchAvg. Flow Depth=5.27' Max Vel=1.03 fps Inflow=92.95 cfs 19.263 af n=0.050 L=531.0' S=0.0003 '/' Capacity=53.46 cfs Outflow=89.06 cfs 19.263 af

Reach 28R: EAST DITCH TOAvg. Flow Depth=5.81' Max Vel=3.68 fps Inflow=381.51 cfs 222.954 af n=0.050 L=1,705.0' S=0.0030 '/' Capacity=284.51 cfs Outflow=380.95 cfs 222.939 af

Reach 29R: Paskamansett River Avg. Flow Depth=14.09' Max Vel=0.94 fps Inflow=412.96 cfs 260.995 af n=0.035 L=1,905.0' S=0.0001 '/' Capacity=103.50 cfs Outflow=398.01 cfs 260.904 af

Reach 30R: Culvert 1 Avg. Flow Depth=2.20' Max Vel=7.75 fps Inflow=127.92 cfs 80.721 af 90.0" x 45.0" Box Pipe n=0.015 L=48.0' S=0.0040 '/' Capacity=203.41 cfs Outflow=127.92 cfs 80.721 af

Reach 31R: EAST DITCH - NORTH Avg. Flow Depth=39.69' Max Vel=0.48 fps Inflow=521.83 cfs 203.767 af n=0.050 L=2,413.0' S=0.0000 '/' Capacity=18.43 cfs Outflow=363.82 cfs 203.691 af

Reach 34R: Drainage ChannelAvg. Flow Depth=0.17' Max Vel=2.55 fps Inflow=2.10 cfs 0.341 af n=0.025 L=331.0' S=0.0230 '/' Capacity=240.18 cfs Outflow=2.09 cfs 0.341 af

Reach 37R: Drainage ChannelAvg. Flow Depth=0.64' Max Vel=0.64 fps Inflow=7.33 cfs 0.528 af n=0.080 L=1,795.0' S=0.0035 '/' Capacity=6.58 cfs Outflow=2.70 cfs 0.528 af

Reach 38R: Drainage System "C"Avg. Flow Depth=1.00' Max Vel=2.42 fps Inflow=2.22 cfs 0.418 af 12.0" Round Pipe n=0.012 L=796.0' S=0.0019 '/' Capacity=1.68 cfs Outflow=1.75 cfs 0.418 af

Reach 39R: EAST DITCH - N2Avg. Flow Depth=0.51' Max Vel=0.48 fps Inflow=1.75 cfs 0.418 af n=0.050 L=2,017.0' S=0.0011 '/' Capacity=68.77 cfs Outflow=0.87 cfs 0.418 af

Reach 41R: Drainage System "B"Avg. Flow Depth=0.80' Max Vel=4.68 fps Inflow=7.14 cfs 7.272 af 36.0" Round Pipe n=0.012 L=1,593.0' S=0.0040 '/' Capacity=45.62 cfs Outflow=7.06 cfs 7.272 af

Reach 45R: Drainage ChannelAvg. Flow Depth=0.51' Max Vel=1.68 fps Inflow=8.63 cfs 0.819 af n=0.025 L=2,480.0' S=0.0030 '/' Capacity=86.58 cfs Outflow=5.15 cfs 0.819 af

Reach 47R: Drainage ChannelAvg. Flow Depth=0.34' Max Vel=1.70 fps Inflow=4.32 cfs 0.304 af n=0.025 L=170.0' S=0.0047 '/' Capacity=108.73 cfs Outflow=3.11 cfs 0.304 af

Pond 1P: Wetland "P"Peak Elev=59.17' Storage=789,030 cf Inflow=251.87 cfs 80.721 af 90.0" x 45.0" Box Culvert n=0.015 L=1.0' S=0.0000 '/' Outflow=127.92 cfs 80.721 af

Pond 1R: EX-CB-9 Peak Elev=62.67' Inflow=2.09 cfs 0.341 af 18.0" Round Culvert n=0.012 L=425.0' S=0.0022 '/' Outflow=2.09 cfs 0.341 af

Pond 2P: Wetland "K"Peak Elev=61.82' Storage=261,563 cf Inflow=140.45 cfs 23.197 af Outflow=88.04 cfs 23.197 af

Peak Elev=61.85' Inflow=10.27 cfs 2.789 af

24.0" Round Culvert n=0.012 L=293.0' S=0.0018 '/' Outflow=10.27 cfs 2.789 af

Pond 4P: Infiltration Trench "23 C" Peak Elev=78.18' Storage=5 cf Inflow=21.55 cfs 2.465 af Discarded=0.01 cfs 0.001 af Primary=21.55 cfs 2.464 af Outflow=21.55 cfs 2.465 af

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 4

Pond 5P: EX-CB-4 Peak Elev=62.40' Inflow=10.27 cfs 2.789 af

24.0" Round Culvert n=0.012 L=308.0' S=0.0018 '/' Outflow=10.27 cfs 2.789 af

Pond 6P: Infiltration Trench "23 C" Peak Elev=70.76' Storage=4,461 cf Inflow=7.33 cfs 1.024 af

Discarded=0.41 cfs 0.483 af Primary=7.33 cfs 0.528 af Outflow=7.74 cfs 1.011 af

Pond 7P: EX-CB-5 Peak Elev=63.95' Inflow=7.87 cfs 1.615 af

18.0" Round Culvert n=0.012 L=250.0' S=0.0022 '/' Outflow=7.87 cfs 1.615 af

Pond 8P: EX-CB-6 Peak Elev=63.06' Inflow=2.70 cfs 0.528 af

18.0" Round Culvert n=0.012 L=250.0' S=0.0022 '/' Outflow=2.70 cfs 0.528 af

Pond 9P: Ex-Outfall 2 Peak Elev=70.71' Inflow=0.90 cfs 0.272 af

12.0" Round Culvert n=0.012 L=107.0' S=0.0140 '/' Outflow=0.90 cfs 0.272 af

Pond 10P: EX-CB-10 Peak Elev=64.11' Inflow=2.70 cfs 0.528 af

18.0" Round Culvert n=0.012 L=425.0' S=0.0022 '/' Outflow=2.70 cfs 0.528 af

Pond 11P: Infiltration Trench - "23 A" Peak Elev=71.01' Storage=4,491 cf Inflow=8.15 cfs 1.173 af

Discarded=0.35 cfs 0.459 af Primary=7.87 cfs 0.707 af Outflow=8.22 cfs 1.165 af

Pond 12P: Infiltration Trench "A-A" Peak Elev=67.28' Storage=141 cf Inflow=1.87 cfs 0.222 af

Discarded=0.02 cfs 0.028 af Primary=2.45 cfs 0.194 af Outflow=2.48 cfs 0.222 af

Pond 13P: Infield Storage Area Peak Elev=59.74' Storage=1,875 cf Inflow=6.06 cfs 1.308 af

Outflow=5.44 cfs 1.308 af

Pond 15P: Infiltration Trench "A-B" Peak Elev=68.24' Storage=122 cf Inflow=1.10 cfs 0.203 af

Discarded=0.03 cfs 0.031 af Primary=1.46 cfs 0.171 af Outflow=1.49 cfs 0.203 af

Pond 16P: Infiltration Trench "A-C" Peak Elev=73.99' Storage=242 cf Inflow=0.89 cfs 0.334 af

Discarded=0.05 cfs 0.062 af Primary=0.90 cfs 0.272 af Outflow=0.95 cfs 0.334 af

Pond 19P: Infiltration Trench "5 D" Peak Elev=71.02' Storage=653 cf Inflow=1.79 cfs 0.307 af

Discarded=0.05 cfs 0.065 af Primary=2.57 cfs 0.242 af Outflow=2.62 cfs 0.307 af

Pond 21P: Infiltration Trench "5 E" Peak Elev=71.04' Storage=700 cf Inflow=3.19 cfs 0.374 af

Discarded=0.05 cfs 0.070 af Primary=4.32 cfs 0.304 af Outflow=4.37 cfs 0.374 af

Pond 25P: Prop Drainage System "A" Peak Elev=60.81' Inflow=2.77 cfs 0.341 af

12.0" Round Culvert n=0.012 L=170.0' S=0.0026 '/' Outflow=2.77 cfs 0.341 af

Pond 26P: Infiltration Trench - "5 A" Peak Elev=59.27' Storage=2,949 cf Inflow=9.77 cfs 1.170 af

Discarded=0.23 cfs 0.312 af Primary=8.63 cfs 0.819 af Outflow=8.86 cfs 1.131 af

Pond 27P: Ex-Outfall 1 Peak Elev=65.60' Inflow=2.40 cfs 0.365 af

12.0" Round Culvert n=0.012 L=124.0' S=0.0022 '/' Outflow=2.40 cfs 0.365 af

Pond 34P: Wetland "H"Peak Elev=66.77' Storage=128,144 cf Inflow=25.78 cfs 6.932 af

12.0" Round Culvert n=0.012 L=70.0' S=0.0020 '/' Outflow=5.88 cfs 6.932 af

103-040-Proposed Dra	inago	Post-development Type III 24-hr 10-Year Rainfall=4.80"
Prepared by Hewlett-Pac	•	Printed 9/30/2016
HydroCAD® 10.00-14 s/n 066	880 © 2015 HydroCAD Software Solut	tions LLC Page 5
Pond 42R: EX-CB-3		Peak Elev=61.52' Inflow=11.67 cfs 2.990 af
	24.0" Round Culvert n=0.012 L=3	54.0' S=0.0016 '/' Outflow=11.67 cfs 2.990 af
Pond 43R: EX-CB-2		Peak Elev=63.26' Inflow=17.44 cfs 3.714 af
	24.0" Round Culvert n=0.012 L=4	09.0' S=0.0001 '/' Outflow=17.44 cfs 3.714 af
Pond 46R: EX-CB-1		Peak Elev=61.36' Inflow=17.44 cfs 3.714 af
	24.0" Round Culvert n=0.012 L=	36.0' S=0.0003 '/' Outflow=17.44 cfs 3.714 af
Pond 48R: EX-CB-8		Peak Elev=61.03' Inflow=3.60 cfs 0.482 af
	18.0" Round Culvert n=0.012 L=	364.0' S=0.0022 '/' Outflow=3.60 cfs 0.482 af

18.0" Round Culvert n=0.012 L=307.0' S=0.0010 '/' Outflow=5.44 cfs 1.308 af

Pond 49R: EX-CB-7

Pond 51R: EX-CB-11

Link AP-1: Analysis Point #1Inflow=398.01 cfs 260.904 af Primary=398.01 cfs 260.904 af

Link AP-2: Analysis Point #2Inflow=103.63 cfs 21.942 af Primary=103.63 cfs 21.942 af

Total Runoff Area = 1,790.356 ac Runoff Volume = 284.603 af Average Runoff Depth = 1.91" 90.15% Pervious = 1,613.970 ac 9.85% Impervious = 176.386 ac

18.0" Round Culvert n=0.012 L=425.0' S=0.0005 '/' Outflow=5.77 cfs 0.724 af

Peak Elev=61.54' Inflow=5.77 cfs 0.724 af

Peak Elev=58.91' Inflow=5.44 cfs 1.308 af

Printed 9/30/2016 Page 6

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Summary for Subcatchment 1S: PROP-WEST1

Runoff = 151.30 cfs @ 13.29 hrs, Volume= 38.056 af, Depth= 1.59"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Type III 24-hr 10-Year Rainfall=4.80"

Area (ac) CN Description						Land Use
_	0.	128	98 Pav	ed parking	, HSG D	Pavement
	8.	191			88% imp, H	ISG A Residential
	4.	903	39 >75	% Grass c	over, Good	d, HSG A Open Space
	0.	096	80 >75	% Grass c	over, Good	d, HSG D Open Space
	0.	263	48 Brus	sh, Good, I	HSG B	Brush
	6.	206	65 Brus	sh, Good, I	HSG C	Brush
	57.	636	73 Brus	sh, Good, I	HSG D	Brush
	40.	591	30 Woo	ods, Good,	HSG A	Woods
	9.	063	55 Woo	ods, Good,	HSG B	Woods
	69.	648		ods, Good,		Woods
	85.302 77			ods, Good,	HSG D	Woods
_	4.	667	98 Wat	er Surface	, HSG D	Open Water
	286.	694	66 Wei	ghted Ave	rage	
	278.	786	97.2	24% Pervic	us Area	
	7.	908	2.76	3% Impervi	ous Area	
	Tc	Length		Velocity		•
_	(min)	(feet)	(ft/ft)	(ft/sec)	(cfs)	
	13.8	100	0.0200	0.12		Sheet Flow,
						Grass: Dense n= 0.240 P2= 3.40"
	50.2	3,067	0.0040	1.02		Shallow Concentrated Flow,
						Unpaved Kv= 16.1 fps
	26.6	2,948	0.0020	1.85	66.44	,
_						Area= 36.0 sf Perim= 22.0' r= 1.64' n= 0.050
	90.6	6,115	Total			

Summary for Subcatchment 2S: PROP-NW2

Runoff = 2.09 cfs @ 13.18 hrs, Volume= 0.833 af, Depth= 0.34"

 Area (ac)	CN	Description	Land Use
0.745	98	Paved parking, HSG A	Pavement
6.381	61	1/4 acre lots, 38% imp, HSG A	Residential
18.809	39	Pasture/grassland/range, Good, HSG A	Pasture
2.833	30	Brush, Good, HSG A	Brush
 0.704	39	>75% Grass cover, Good, HSG A	Open Space
29.472	44	Weighted Average	
26.302		89.24% Pervious Area	
3.170		10.76% Impervious Area	

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Printed 9/30/2016 Page 7

	Тс	Length	Slope	Velocity	Capacity	Description
_	(min)	(feet)	(ft/ft)	(ft/sec)	(cfs)	
	15.5	100	0.0150	0.11		Sheet Flow, Sheet over Grass
						Grass: Dense n= 0.240 P2= 3.40"
	39.8	1,280	0.0080	0.54		Shallow Concentrated Flow, Shallow through Brush
						Kv= 6.0 fps
	1.0	1,350	0.2200	23.05	18.10	Pipe Channel,
						12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25'
						n= 0.012 Concrete pipe, finished
	56.3	2.730	Total			

Summary for Subcatchment 3S: PROP-SOUTH

Runoff = 404.55 cfs @ 13.71 hrs, Volume= 121.738 af, Depth= 2.21"

Area (ac)	CN	Description	Land Use
1.656	98	Paved parking, HSG A	Pavement
1.637	98	Paved parking, HSG B	Pavement
15.087	98	Paved parking, HSG C	Pavement
16.567	98	Paved parking, HSG D	Pavement
0.105	76	Gravel roads, HSG A	Roadway
0.314	91	Gravel roads, HSG D	Roadway
2.577	39	Pasture/grassland/range, Good, HSG A	Pasture
5.802	61	Pasture/grassland/range, Good, HSG B	Pasture
8.309	74	Pasture/grassland/range, Good, HSG C	Pasture
105.146	80	Pasture/grassland/range, Good, HSG D	Pasture
3.438	30	Brush, Good, HSG A	Brush
7.422	65	Brush, Good, HSG C	Brush
99.858	73	Brush, Good, HSG D	Brush
32.175	32	Woods/grass comb., Good, HSG A	Woods
123.973	72	Woods/grass comb., Good, HSG C	Woods
72.595	79	Woods/grass comb., Good, HSG D	Woods
10.801	30	Woods, Good, HSG A	Woods
8.266	70	Woods, Good, HSG C	Woods
142.466	77	Woods, Good, HSG D	Woods
4.089	98	Water Surface, HSG D	Open Water
662.283	74	Weighted Average	
623.247		94.11% Pervious Area	
39.036		5.89% Impervious Area	

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 8

Printed 9/30/2016

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.2	100	0.0200	1.42	•	Sheet Flow,
0.7	120	0.0200	2.87		Smooth surfaces n= 0.011 P2= 3.40" Shallow Concentrated Flow, Shallow 1 Paved Kv= 20.3 fps
16.4	2,401	0.0230	2.44		Shallow Concentrated Flow, Shallow 2 Unpaved Kv= 16.1 fps
96.5	4,169	0.0020	0.72		Shallow Concentrated Flow, Shallow 3 Unpaved Kv= 16.1 fps
11.1	3,306	0.0015	4.95	217.93	Channel Flow, Area= 44.0 sf Perim= 30.0' r= 1.47' n= 0.015
125.9	10,096	Total			

Summary for Subcatchment 4S: PROP-EAST

Runoff = 204.32 cfs @ 13.29 hrs, Volume= 49.837 af, Depth= 2.46"

Area (ac)	CN	Description	Land Use
11.959	98	Paved parking, HSG A	Pavement
10.294	98	Paved parking, HSG C	Pavement
23.992	98	Paved parking, HSG D	Pavement
2.996	39	>75% Grass cover, Good, HSG A	Open Space
19.146	74	>75% Grass cover, Good, HSG C	Open Space
21.773	80	>75% Grass cover, Good, HSG D	Open Space
0.231	76	Gravel roads, HSG A	Roadway
4.397	89	Gravel roads, HSG C	Roadway
8.807	91	Gravel roads, HSG D	Roadway
29.003	39	Pasture/grassland/range, Good, HSG A	Pasture
9.124	74	Pasture/grassland/range, Good, HSG C	Pasture
21.148	80	Pasture/grassland/range, Good, HSG D	Pasture
0.807	30	Woods, Good, HSG A	Woods
11.715	70	Woods, Good, HSG C	Woods
64.446	77	Woods, Good, HSG D	Woods
1.642	98	Water Surface, HSG D	Open Water
1.126	83	1/4 acre lots, 38% imp, HSG C	Residential
0.838	87	1/4 acre lots, 38% imp, HSG D	Residential
243.444	77	Weighted Average	
194.811		80.02% Pervious Area	
48.633		19.98% Impervious Area	

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Printed 9/30/2016 Page 9

	Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
_					(013)	Chaot Flour
	1.2	100	0.0200	1.42		Sheet Flow,
						Smooth surfaces n= 0.011 P2= 3.40"
	2.5	540	0.0518	3.66		Shallow Concentrated Flow, Shallow 1
						Unpaved Kv= 16.1 fps
	35.1	2,250	0.0044	1.07		Shallow Concentrated Flow, Shallow 2
						Unpaved Kv= 16.1 fps
	55.9	2,876	0.0001	0.86	22.30	Channel Flow,
		,				Area= 26.0 sf Perim= 15.0' r= 1.73' n= 0.025
_	94.7	5,766	Total			

Summary for Subcatchment 5S: PROP-NEAST

Runoff = 140.45 cfs @ 12.71 hrs, Volume= 23.197 af, Depth= 2.29"

Area (ac)	CN	Description	Land Use
0.532	98	Paved parking, HSG A	Pavement
0.101	98	Paved parking, HSG D	Pavement
0.906	76	Gravel roads, HSG A	Roadway
0.032	91	Gravel roads, HSG D	Roadway
45.433	83	1/4 acre lots, 38% imp, HSG C	Residential
6.904	87	1/4 acre lots, 38% imp, HSG D	Residential
8.537	39	Pasture/grassland/range, Good, HSG A	Pasture
0.133	74	Pasture/grassland/range, Good, HSG C	Pasture
6.870	80	Pasture/grassland/range, Good, HSG D	Pasture
1.589	30	Brush, Good, HSG A	Brush
4.903	73	Brush, Good, HSG D	Brush
2.834	30	Woods, Good, HSG A	Woods
4.714	70	Woods, Good, HSG C	Woods
36.383	77	Woods, Good, HSG D	Woods
0.508	39	>75% Grass cover, Good, HSG A	Open Space
1.277	98	Water Surface, HSG D	Open Water
121.656	75	Weighted Average	
99.858		82.08% Pervious Area	
21.798		17.92% Impervious Area	

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 10

Tc	Length	Slope	Velocity	Capacity	Description
 (min)	(feet)	(ft/ft)	(ft/sec)	(cfs)	
12.5	100	0.0100	0.13		Sheet Flow,
					Grass: Short n= 0.150 P2= 3.40"
4.4	782	0.0345	2.99		Shallow Concentrated Flow, Shallow 1
					Unpaved Kv= 16.1 fps
28.9	1,833	0.0043	1.06		Shallow Concentrated Flow, Shallow 2
					Unpaved Kv= 16.1 fps
0.7	506	0.0040	12.05	385.56	Channel Flow, Channel 1
					Area= 32.0 sf Perim= 12.0' r= 2.67' n= 0.015
4.2	1,399	0.0040	5.56	200.26	Channel Flow, Channel 2
					Area= 36.0 sf Perim= 20.0' r= 1.80' n= 0.025
50.7	4.620	Total			

Summary for Subcatchment 6S: PROP-NW1

Runoff = 28.42 cfs @ 12.39 hrs, Volume= 3.496 af, Depth= 1.81"

Area	(ac)	CN	Desc	cription			Land Use
0.	.080	98	Pave	ed parking,	, HSG A		Pavement
0.	411	98	Pave	ed parking,	, HSG C		Pavement
0.	.391	98	Pave	ed parking,	, HSG D		Pavement
0.	.374	89	Grav	el roads, l	HSG C		Roadway
	.008	91		el roads, l			Roadway
	.947	39				Good, HSG A	Pasture
	.670	74				Good, HSG C	Pasture
	.516	80				Good, HSG D	Pasture
	414	30		h, Good, F			Brush
	700	65		h, Good, F			Brush
	628	73		h, Good, F			Brush
	.828	30		ds, Good,			Woods
	493	70		Woods, Good, HSG C Woods			
	.261	77		ds, Good,			Woods
	414	98		er Surface,			Open Water
	.135	69		ghted Aver			
	.839			0% Pervio			
1.	.296		5.60	% Impervi	ous Area		
_		_					
Tc	Length		Slope	Velocity	Capacity	Description	
(min)	(feet		(ft/ft)	(ft/sec)	(cfs)		
11.1	100	0.	0350	0.15			hrough Grass
							n= 0.240 P2= 3.40"
8.5	506	6 0.	0200	0.99			entrated Flow, Through Grass
		_					asture Kv= 7.0 fps
6.9	809	0.	0020	1.97	70.80		, Through Wetlands
						Area= 36.0 sf	Perim= 20.0' r= 1.80' n= 0.050
26.5	1,415	5 To	otal				

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 11

Summary for Subcatchment 7S: PROP-NW3

Runoff = 37.03 cfs @ 12.35 hrs, Volume= 4.294 af, Depth= 2.21"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Type III 24-hr 10-Year Rainfall=4.80"

Area (ac) CN De			Desc	cription		Land Use	
	0.	598	89	Grav	el roads, H	HSG C	Roadway
	0.	192	91	Grav	el roads, l	HSG D	Roadway
	14.	227	70	Woo	ds, Good,	HSG C	Woods
	7.	672	77	Woo	ds, Good,	HSG D	Woods
	0.	674	98	Wate	er Surface,	HSG D	Open Water
	23.	363	74	Weig	hted Aver	age	
	22.	689		97.1	2% Pervio	us Area	
	0.	674		2.88	% Impervi	ous Area	
	Tc	Length	n Sl	ope	Velocity	Capacity	Description
	(min)	(feet)) (1	ft/ft)	(ft/sec)	(cfs)	
	16.5	100	0.0	050	0.10		Sheet Flow,
							Grass: Short n= 0.150 P2= 3.40"
	7.9	1,210	0.0	250	2.55		Shallow Concentrated Flow,
		•					Unpaved Kv= 16.1 fps
	24.4	1,310) Tot	al			

Summary for Subcatchment 8S: PROP-NORTH

Runoff = 69.34 cfs @ 12.95 hrs, Volume= 13.758 af, Depth= 2.54"

Area (ac)	CN	Description	Land Use
0.847	98	Paved parking, HSG C	Pavement
2.946	98	Paved parking, HSG D	Pavement
0.297	89	Gravel roads, HSG C	Roadway
0.125	91	Gravel roads, HSG D	Roadway
0.567	74	>75% Grass cover, Good, HSG C	Open Space
3.489	80	>75% Grass cover, Good, HSG D	Open Space
12.020	70	Woods, Good, HSG C	Woods
43.507	77	Woods, Good, HSG D	Woods
1.128	98	Water Surface, HSG D	Open Water
64.926	78	Weighted Average	
60.005		92.42% Pervious Area	
4.921		7.58% Impervious Area	

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 12

	Tc	Length	Slope	Velocity	Capacity	Description
_	(min)	(feet)	(ft/ft)	(ft/sec)	(cfs)	
	1.2	100	0.0200	1.42		Sheet Flow,
						Smooth surfaces n= 0.011 P2= 3.40"
	68.1	2,792	0.0018	0.68		Shallow Concentrated Flow,
						Unpaved Kv= 16.1 fps
	69.3	2 892	Total			

Summary for Subcatchment 9S: PROP-WEST2

Runoff = 75.74 cfs @ 12.84 hrs, Volume= 14.730 af, Depth= 1.25"

Area	(ac) (ON D	esc	ription			Land Use
12.068 98 Paved parking, HSG A							Pavement
				el roads, l			Roadway
0.	.882			el roads, l			Roadway
2.	.150	61 1	/4 a	cre lots, 3	8% imp, H	SG A	Residential
42.	.633	39 F	ast	ure/grassla	and/range,	Good, HSG A	Pasture
15.	.570	80 F	ast	ure/grassla	and/range,	Good, HSG D	Pasture
5.	.034	30 E	Brus	h, Good, F	HSG A		Brush
1.	.653	48 E	Brus	h, Good, F	HSG B		Brush
18.	.983	73 B	Brus	h, Good, F	HSG D		Brush
10.	.479	30 V	Voo	ds, Good,	HSG A		Woods
1.	.747	55 V	Voo	ds, Good,	HSG B		Woods
23.	.013			ds, Good,			Woods
3.			75%	⟨ Grass co ⟨ ⟨ ⟨ ⟨ ⟨ ⟨ ⟨ ⟨ ⟩ ⟩ ⟩ ⟩ ⟩ ⟩ ⟩ ⟩ ⟩ ⟨ ⟨ ⟨ ⟨ ⟨ ⟩ ⟩ ⟩ ⟩ ⟩ ⟩ ⟨ ⟨ ⟨ ⟨ ⟩ ⟩ ⟩ ⟩ ⟩ ⟩ ⟩ ⟩ ⟩ ⟨ ⟨ ⟨ ⟨ ⟩ ⟩ ⟩ ⟩ ⟩ ⟩ ⟩ ⟩ ⟩ ⟩ ⟩ ⟨ ⟨ ⟨ ⟨ ⟩ ⟩ ⟩ ⟩ ⟩ ⟩ ⟩ ⟩ ⟩ ⟨ ⟨ ⟨ ⟩	over, Good	, HSG A	Open Space
2.	.106	98 V	Vate	r Surface	, HSG D		Open Water
141.	.341	61 V	Veig	hted Aver	age		
126.	.350	8	9.39	9% Pervio	us Area		
14.	.991	1	0.6	1% Imperv	ious Area		
Tc	Length			Velocity	Capacity	Description	
<u>(min)</u>	(feet)	(ft	/ft)	(ft/sec)	(cfs)		
16.5	100	0.00	50	0.10		Sheet Flow,	
						Grass: Short	n= 0.150 P2= 3.40"
33.3	2,691	0.00	70	1.35			centrated Flow,
						Unpaved Kv=	= 16.1 fps
5.9	1,407	0.00	25	3.97	135.07	Channel Flow	
						Area= 34.0 sf	Perim= 22.0' r= 1.55' n= 0.025
55.7	4,198	Tota	I				

Page 13

Summary for Subcatchment 10S: PROP-RW23-W1

Runoff = 8.15 cfs @ 12.50 hrs, Volume= 1.173 af, Depth= 1.25"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Type III 24-hr 10-Year Rainfall=4.80"

	Area	(ac) C	N Des	cription		Land Use		
4.250 98 Paved parking, HS				ed parking	, HSG A	Pavement		
7.001 39 >75% Grass cover, Good, H				% Grass co	over, Good	, HSG A Residential		
	11.251 61 Weighted Average							
7.001 62.23% Pervious Area								
4.250 37.77% Impervious					ious Area			
	Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description		
_	1.9	126	0.0100	1.13		Sheet Flow, Over Pavement		
						Smooth surfaces n= 0.011 P2= 3.40"		
	29.8	210	0.0130	0.12		Sheet Flow, Over Grass		
_						Grass: Dense n= 0.240 P2= 3.40"		
	31.7	336	Total					

Summary for Subcatchment 11S: PROP-RW5-E1

Runoff = 6.06 cfs @ 12.77 hrs, Volume= 1.308 af, Depth= 0.72"

Area	(ac) (CN Des	cription		Land Use
4.	4.850 98 Paved parking, HSG A				Pavement
16.	936	39 >759	% Ġrass c	over, Good	, HSG A Open Space
0.	0.126 76 Gravel roads, HSG A				Roadway
21.	912	52 Weig	ghted Aver	age	
17.	062	77.8	7% Pervio	us Area	
4.	850	22.1	3% Imperv	ious Area	
Tc	Length	Slope	Velocity	Capacity	Description
(min)	(feet)	(ft/ft)	(ft/sec)	(cfs)	
1.1	78	0.0143	1.18		Sheet Flow, Over Pavement
					Smooth surfaces n= 0.011 P2= 3.40"
39.3	1,081	0.0043	0.46		Shallow Concentrated Flow, Over Grass
					Short Grass Pasture Kv= 7.0 fps
4.7	308	0.0005	1.10	0.86	
					12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25'
					n= 0.012
45.1	1,467	Total			

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Summary for Subcatchment 12S: PROP-RW23-E4

Runoff = 7.33 cfs @ 12.46 hrs, Volume= 1.024 af, Depth= 1.19"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Type III 24-hr 10-Year Rainfall=4.80"

_	Area	(ac) (CN Des	cription		Land Use		
3.753 98 Paved parking, HSG A					, HSG A	Pavement		
6.608 39 >75% Grass cover, Good, H						, HSG A Open Space		
	10.361 60 Weighted Average							
	6.608 63.78% Pervious Area							
3.753 36.22% Impervious Area								
	Tc (min)	Length (feet)	•	Velocity (ft/sec)	Capacity (cfs)	Description		
	1.9	126	0.0100	1.13		Sheet Flow, Over Pavement		
						Smooth surfaces n= 0.011 P2= 3.40"		
	26.7	210	0.0171	0.13		Sheet Flow, Over Grass		
_						Grass: Dense n= 0.240 P2= 3.40"		
	28.6	336	Total					

Summary for Subcatchment 13S: PROP-RW23-W2

Runoff = 3.13 cfs @ 12.40 hrs, Volume= 0.394 af, Depth= 1.52"

	Δ	()	- N		ata et a la			Las dellas
Area (ac) CN Description								Land Use
	1.107 39 >75% Grass cover, Good, HSG A							Open Space
	0.418 98 Paved parking, HSG A							Pavement
	_	582				over, Good	, HSG C	Open Space
_	3.107 65 Weighted Average							
	2.	689			5% Pervio			
	0.	418		13.45	5% Imperv	vious Area		
	Tc	Length	Slo	ope	Velocity	Capacity	Descript	ion
	(min)	(feet)		t/ft)	(ft/sec)	(cfs)	•	
_	21.0	300	0.06	538	0.24	, ,	Sheet F	ow, Over Grass
								Pense n= 0.240 P2= 3.40"
	5.1	131	0.02	271	0.43			Concentrated Flow, Through Grass
	5.1	101	3.02	'	5.40		Kv= 2.	, and the second
_	26.1	/21	Tota				2.	o .po
	∠0.1	431	Tota	aı				

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Summary for Subcatchment 14S: PROP-RW23-E2

Runoff = 21.55 cfs @ 12.29 hrs, Volume= 2.465 af, Depth= 1.32"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Type III 24-hr 10-Year Rainfall=4.80"

	Area	(ac) (CN Des	cription		Land Use
-		· - /		ed parking	. HSG A	Pavement
				vel roads, l	•	Roadway
				% Grass c		
	5.	292	65 Brus	sh, Good, I	HSG [°] C	Brush
	3.	510	74 >75	% Grass c	over, Good	, HSG C Open Space
	0.	194	70 Woo	ods, Good,	HSG C	Woods
	1.	637	80 >75	% Grass c	over, Good	, HSG D Open Space
_	1.	442	77 Woo	ods, Good,	HSG D	Woods
				ghted Aver		
	20.	381	90.7	'1% Pervio	us Area	
	2.	880	9.29	% Impervi	ous Area	
	_		٥.			
	Tc	Length		Velocity	Capacity	Description
_	(min)	(feet)		(ft/sec)	(cfs)	
	4.9	300	0.0050	1.01		Sheet Flow, Over Grass
						Smooth surfaces n= 0.011 P2= 3.40"
	13.7	811	0.0200	0.99		Shallow Concentrated Flow, Shallow through grass
	0.0	00	0.0400	0.05	50.44	Short Grass Pasture Kv= 7.0 fps
	0.2	98	0.0100	8.85	53.11	Channel Flow, Through ditch
						Area= 6.0 sf Perim= 4.0' r= 1.50'
-	40.6	4 000	—			n= 0.022 Earth, clean & straight
	1Q Q	1 200	Total			

18.8 1,209 Total

Summary for Subcatchment 15S: PROP-RW23-E3

Runoff = 0.89 cfs @ 13.31 hrs, Volume= 0.334 af, Depth= 0.42"

_	Area (ac)	CN	Description	Land Use		
	1.068	98	Paved parking, HSG A	Pasture		
	8.382	39	>75% Grass cover, Good, HSG A	Pasture		
	9.450	46	Weighted Average			
	8.382		88.70% Pervious Area			
	1.068		11.30% Impervious Area			

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 16

	Tc	Length	Slope	Velocity	Capacity	Description
_	(min)	(feet)	(ft/ft)	(ft/sec)	(cfs)	
	0.7	37	0.0100	0.88		Sheet Flow, Over Taxiway
						Smooth surfaces n= 0.011 P2= 3.40"
	54.7	300	0.0058	0.09		Sheet Flow, Over Land
						Grass: Dense n= 0.240 P2= 3.40"
	13.7	828	0.0045	1.01		Shallow Concentrated Flow, Shallow Concentrated Flow
						Grassed Waterway Kv= 15.0 fps
	0.9	112	0.0025	2.18	1.19	Pipe Channel, Pipe to Existing Outfall
						10.0" Round Area= 0.5 sf Perim= 2.6' r= 0.21'
_						n= 0.012 Concrete pipe, finished
	70.0	1.277	Total			

Summary for Subcatchment 16S: PROP-RW23-E6

Runoff = 1.87 cfs @ 12.19 hrs, Volume= 0.222 af, Depth= 0.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Type III 24-hr 10-Year Rainfall=4.80"

Area	(ac)	CN De	scription		Land Use
0.821 98 Paved parking, HSG A			ved parking	, HSG A	Pavement
2	.643	39 >7	<u>5% Ġrass c</u>	over, Good	HSG A Open Space
3	.464	53 We	eighted Ave	rage	
2	.643	76	.30% Pervio	ous Area	
0	.821	23	.70% Imper	vious Area	
_					
Tc	Length	•	•	Capacity	Description
<u>(min)</u>	(feet) (ft/f1	(ft/sec)	(cfs)	
2.5	19	0.052	0.13		Sheet Flow, Overland thru Grass
					Grass: Dense n= 0.240 P2= 3.40"
2.1	210	0.012	5 1.68		Shallow Concentrated Flow, Shallow Concentrated Flow
					Grassed Waterway Kv= 15.0 fps
1.5	124	1 0.001	1.38	0.75	Pipe Channel, Pipe Flow to Existing Outfall
					10.0" Round Area= 0.5 sf Perim= 2.6' r= 0.21'
					n= 0.012 Concrete pipe, finished
6.1	353	3 Total,	Increased	to minimum	Tc = 10.0 min

Summary for Subcatchment 17S: PROP-RW23-E5

Runoff = 2.10 cfs @ 12.57 hrs, Volume= 0.341 af, Depth= 1.00"

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

Page 17

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

_	Area	(ac) C	N Desc	cription		Land Use
	1.3	257 9	8 Pave	ed parking	, HSG A	Pavement
	2.834 39 >75% Grass cover, Good,					, HSG A Open Space
	4.	091 5	7 Weig	ghted Aver	age	
	2.	834	69.2	7% Pervio	us Area	
	1.3	257	30.7	3% Imperv	vious Area	
	Tc	Length	Slope	Velocity	Capacity	Description
_	(min)	(feet)	(ft/ft)	(ft/sec)	(cfs)	
	1.3	83	0.0100	1.04		Sheet Flow, Through Grass
						Smooth surfaces n= 0.011 P2= 3.40"
	18.9	131	0.0157	0.12		Sheet Flow, Over Grass
						Grass: Dense n= 0.240 P2= 3.40"
	1.7	324	0.0043	3.12	49.91	, <u> </u>
						Area= 16.0 sf Perim= 17.0' r= 0.94'
						n= 0.030 Earth, grassed & winding
	2.5	425	0.0032	2.78	2.18	1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
						12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25'
						n= 0.012
	5.6	966	0.0020	2.88	5.09	1 ' 1
						18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38'
						n= 0.012 Concrete pipe, finished
	4.5	385	0.0005	1.44	2.54	1 ' 1
						18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38'
	0.4	4.5	0.0005	4 7 4	5 40	n= 0.012
	0.4	45	0.0005	1.74	5.48	Pipe Channel, Pipe Reach
						24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50'
_	0.4.6	0.050				n= 0.012
	34.9	2,359	Total			

Summary for Subcatchment 18S: PROP-RW5-E2

Runoff = 1.79 cfs @ 12.67 hrs, Volume= 0.307 af, Depth= 1.12"

 Area (ac)	CN	Description	Land Use	
1.118	98	Paved parking, HSG A	Pavement	
 2.167	39	>75% Grass cover, Good, HSG A	Open Space	
3.285	59	Weighted Average		
2.167		65.97% Pervious Area 34.03% Impervious Area		
1.118				

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 18

Printed 9/30/2016

Tc	Length	Slope	Velocity	Capacity	Description
(min)	(feet)	(ft/ft)	(ft/sec)	(cfs)	<u> </u>
0.9	48	0.0079	0.84		Sheet Flow, Over Taxiway B
					Smooth surfaces n= 0.011 P2= 3.40"
41.3	300	0.0117	0.12		Sheet Flow, Over Grass
					Grass: Dense n= 0.240 P2= 3.40"
0.3	39	0.0228	2.26		Shallow Concentrated Flow, Shallow to Existing Drainage Syst
					Grassed Waterway Kv= 15.0 fps
42.5	387	Total			

Summary for Subcatchment 19S: PROP-TWA-E1

Runoff = 2.77 cfs @ 12.33 hrs, Volume= 0.322 af, Depth= 1.59"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Type III 24-hr 10-Year Rainfall=4.80"

Area	(ac) (CN Des	cription		Land Use		
1.	123	98 Pav	ed parking	, HSG A	Pavement		
1.	300	39 >75	% Grass co	over, Good	, HSG A Open Space		
2.423 66 Weighted Average							
1.	300	53.6					
1.	1.123 46.35% Impervious Area			ious Area			
Tc	Length		Velocity	Capacity	Description		
<u>(min)</u>	(feet)	(ft/ft)	(ft/sec)	(cfs)			
1.2	66	0.0076	0.89		Sheet Flow, Over Pavement		
					Smooth surfaces n= 0.011 P2= 3.40"		
18.7	81	0.0062	0.07		Sheet Flow, Sheet thru Island		
					Grass: Dense n= 0.240 P2= 3.40"		
1.9	175	0.0010	1.55	1.22			
					12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25'		
					n= 0.012 Concrete pipe, finished		
21.8	322	Total					

Summary for Subcatchment 20S: PROP-RW5-E3

Runoff = 3.19 cfs @ 12.32 hrs, Volume= 0.374 af, Depth= 1.38"

Area (ac)	CN	Description	Land Use		
1.334	98	Paved parking, HSG A	Pavement		
1.911	39	>75% Grass cover, Good, HSG A	Open Space		
3.245	63	Weighted Average			
1.911		58.89% Pervious Area			
1.334		41.11% Impervious Area			
	1.334 1.911 3.245 1.911	1.334 98 1.911 39 3.245 63 1.911	1.334 98 Paved parking, HSG A 1.911 39 >75% Grass cover, Good, HSG A 3.245 63 Weighted Average 1.911 58.89% Pervious Area		

Prepared by Hewlett-Packard Company

Type III 24-hr 10-Year Rainfall=4.80" Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 19

	Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
	1.1	76	0.0133	1.14		Sheet Flow, Sheet over Pavement
						Smooth surfaces n= 0.011 P2= 3.40"
	19.7	127	0.0133	0.11		Sheet Flow, Over Grass
_						Grass: Dense n= 0.240 P2= 3.40"
	20.8	203	Total			

Summary for Subcatchment 21S: PROP-RW5-E5

Runoff = 0.94 cfs @ 12.74 hrs, Volume= 0.178 af, Depth= 1.00"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Type III 24-hr 10-Year Rainfall=4.80"

Area	(ac) C	N Des	cription		Land Use
0.636 98 Pa		98 Pave	ed parking	HSG A	Pavement
1.	1.496 39		% Grass co	over, Good,	HSG A Open Space
2.132 57 Weighted Average					
1.	496	70.1	7% Pervio	us Area	
0.	636	29.8	3% Imperv	ious Area	
Tc	Length	Slope	Velocity	Capacity	Description
<u>(min)</u>	(feet)	(ft/ft)	(ft/sec)	(cfs)	
1.1	77	0.0129	1.13		Sheet Flow, Over Pavement
					Smooth surfaces n= 0.011 P2= 3.40"
35.9	179	0.0059	0.08		Sheet Flow, Over Grass
					Grass: Dense n= 0.240 P2= 3.40"
9.6	800	0.0020	1.38	0.27	Pipe Channel, Pipe to Drainage System B
					6.0" Round Area= 0.2 sf Perim= 1.6' r= 0.13'
					n= 0.012 Concrete pipe, finished
46.6	1,056	Total			

Summary for Subcatchment 22S: PROP-TWA-E2

Runoff = 0.03 cfs @ 13.00 hrs, Volume= 0.019 af, Depth= 0.19"

 Area (ac)	CN	Description	Land Use
0.023	98	Paved parking, HSG A	Pavement
 1.171	39	>75% Grass cover, Good, HSG A	Open Space
1.194	40	Weighted Average	
1.171		98.07% Pervious Area	
0.023		1.93% Impervious Area	

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 20

	Tc	Length	Slope	Velocity	Capacity	Description
_	(min)	(feet)	(ft/ft)	(ft/sec)	(cfs)	
	16.8	75	0.0069	0.07		Sheet Flow, Flow Over Grass
						Grass: Dense n= 0.240 P2= 3.40"
	3.8	163	0.0023	0.72		Shallow Concentrated Flow,
						Grassed Waterway Kv= 15.0 fps
	8.0	100	0.0022	2.08	1.56	
						18.0" x 6.0" Box Area= 0.8 sf Perim= 4.0' r= 0.19'
						n= 0.011 Concrete pipe, straight & clean
	21.4	338	Total			

Summary for Subcatchment 24S: PROP-RW23-W3

Runoff = 0.68 cfs @ 13.66 hrs, Volume= 0.381 af, Depth= 0.23"

Area	(ac) C	N Des	cription		Land Use
			ed parking		Pavement
			h, Good, F		Open Space
				8% imp, H	
			<u>% Grass co</u>	over, Good,	, HSG A Open Space
			ghted Aver	•	
	288		6% Pervio		
0.	897	4.44	% Impervi	ous Area	
Тс	Length	Slope	Velocity	Capacity	Description
(min)	(feet)	(ft/ft)	(ft/sec)	(cfs)	·
15.5	100	0.0150	0.11		Sheet Flow, Over Grass
					Grass: Dense n= 0.240 P2= 3.40"
29.8	1,118	0.0080	0.63		Shallow Concentrated Flow, Concentrated Flow through Brush
4.4	000	0.0000	0.70	0.40	Short Grass Pasture Kv= 7.0 fps
1.4	239	0.0032	2.78	2.18	1 ' 1
					12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25'
5.6	966	0.0020	2.88	5.09	n= 0.012 Concrete pipe, finished Pipe Channel, Pipe Reach
5.0	300	0.0020	2.00	3.09	18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38'
					n= 0.012
4.5	385	0.0005	1.44	2.54	
					18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38'
					n= 0.012 Concrete pipe, finished
0.4	45	0.0005	1.74	5.48	
					24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50'
					n= 0.012 Concrete pipe, finished
57.2	2,853	Total			

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Summary for Subcatchment 25S: PROP-RW5-W1

Runoff = 9.77 cfs @ 12.33 hrs, Volume= 1.170 af, Depth= 1.32"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Type III 24-hr 10-Year Rainfall=4.80"

_	Area	(ac)	CN	Desc	ription			Land Use	
3.981 98 Paved parking, HSG A				Pavement					
6.393		393	39	>75% Grass cover, Good,			, HSG A	Open Space	
	0.	294	80	>75%	6 Grass co	over, Good	, HSG D	Open Space	
10.668 62 Weighted Average									
6.687 62.68% Pervious Area									
3.981 37.32% Impervious Area						ious Area			
	Tc (min)	Length (feet)		Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Descripti	on	
	1.2	79	0.0	0129	1.13		Sheet Fl	ow, Sheet over Pavement	
	19.9	131	I 0.0	0138	0.11		Sheet Fl	surfaces n= 0.011 P2= 3.40" ow, Sheet through Grass ense n= 0.240 P2= 3.40"	
	21.1	210) To	otal					

Summary for Subcatchment 26S: PROP-TWA-W1

Runoff = 1.10 cfs @ 12.44 hrs, Volume= 0.203 af, Depth= 0.51"

Area (ac) CN Description			cription		Land Use	
0.684 98		98 Pav	ed parking	, HSG A	Pavement	
4.042		042			over, Good,	HSG A Open Space
	4.	726	48 Wei	ghted Aver	age	
	4.	042	85.5	3% Pervio	us Area	
	0.	684	14.4	7% Imper	vious Area	
	_					
	Tc	Length	Slope	Velocity	Capacity	Description
_	(min)	(feet)	(ft/ft)	(ft/sec)	(cfs)	
	12.5	123	0.0390	0.16		Sheet Flow, Sheet Flow
						Grass: Dense n= 0.240 P2= 3.40"
	3.6	261	0.0066	1.22		Shallow Concentrated Flow, Shallow Concentrated Flow
						Grassed Waterway Kv= 15.0 fps
	1.5	211	0.0022	2.31	1.81	Pipe Channel, Pipe Flow
						12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25'
_						n= 0.012 Concrete pipe, finished
	17 6	595	Total			

Printed 9/30/2016 Page 22

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Summary for Subcatchment 32S: PROP-RW23-E1

Runoff = 15.78 cfs @ 13.05 hrs, Volume= 3.831 af, Depth= 0.94"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Type III 24-hr 10-Year Rainfall=4.80"

Area (ac) CN Description			Land Use			
1.712 98 Paved parking, HSG A			Pavement			
14.256 30 Brush, Good, HSG A						Brush
9.	726			over, Good	, HSG A	Open Space
1.	821		/el roads, l			Roadway
0.	601 :	30 Woo	ds, Good,	HSG A		Woods
4.	817	33 1/4 a	acre lots, 3	8% imp, H	SG C	Residential
0.	618	74 >759	% Grass co	over, Good	, HSG C	Open Space
1.	983	70 Woo	ds, Good,	HSG C		Woods
0.	073	37 1/4 a	acre lots, 3	8% imp, H	SG D	Residential
7.	061	73 Brus	sh, Good, F	HSG D		Brush
0.	780	30 >759	% Grass co	over, Good,	, HSG D	Open Space
5.	5.442 77 Woods, Good, HSG D					Woods
48.	890	56 Wei	ghted Aver	age		
45.	320	92.7	0% Pervio	us Area		
3.	570	7.30	% Impervi	ous Area		
Tc	Length	Slope	Velocity	Capacity	Descripti	on
(min)	(feet)	(ft/ft)	(ft/sec)	(cfs)		
20.8	100	0.0200	0.08		Sheet Fl	low, Through Woods
					Woods:	Light underbrush n= 0.400 P2= 3.40"
37.8	1,280	0.0065	0.56		Shallow	Concentrated Flow, Through Wetlands
						ass Pasture Kv= 7.0 fps
9.0				l Flow, Through Wetlands		
						2.0 sf Perim= 20.0' r= 2.10'
					n = 0.050	Scattered brush, heavy weeds
67.6	2,965	Total				

Summary for Subcatchment 33S: PROP-RW5-W2

Runoff = 1.41 cfs @ 12.53 hrs, Volume= 0.201 af, Depth= 1.67"

 Area (ac)	CN	Description	Land Use
0.679	98	Paved parking, HSG A	Pavement
0.767	39	>75% Grass cover, Good, HSG A	Open Space
1.446	67	Weighted Average	
0.767		53.04% Pervious Area	
0.679		46.96% Impervious Area	

103-040-Proposed DrainagePrepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 23

(mi	Гс n)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1	.3	78	0.0100	1.02		Sheet Flow, Sheet over Pavement
26	.4	183	0.0133	0.12		Smooth surfaces n= 0.011 P2= 3.40" Sheet Flow, Sheet Flow Grass: Dense n= 0.240 P2= 3.40"
0	.1	25	0.0045	3.19	51.06	
						Area= 16.0 sf Perim= 17.0' r= 0.94'
2	.7	466	0.0020	2.88	5.09	n= 0.030 Earth, grassed & winding Pipe Channel, Pipe Reach
	.,	400	0.0020	2.00	0.00	18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38'
						n= 0.012
4	.5	385	0.0005	1.44	2.54	Pipe Channel, Pipe Reach
						18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.012
0	.4	45	0.0005	1.74	5.48	Pipe Channel, Pipe Reach
Ū			0.0000		00	24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50'
						n= 0.012
35	.4	1,182	Total			

Summary for Subcatchment 36S: PROP-32N-1

Runoff = 2.22 cfs @ 12.46 hrs, Volume= 0.418 af, Depth= 0.51"

	Area (ac) CN Description					Land Use
	1.410 98 Paved parking, HSG A				HSG A	Pavement
8.333 39 >75% Grass cover, Good, H						HSG A Open Space
	9.	743	48 Weig	ghted Aver	age	
	8.	333	85.5	3% Pervio	us Area	
	1.	410	14.4	7% Imperv	vious Area	
	_					
	Tc	Length	Slope	Velocity	Capacity	Description
_	(min)	(feet)	(ft/ft)	(ft/sec)	(cfs)	
	12.5	100	0.0100	0.13		Sheet Flow, Over Grass
						Grass: Short n= 0.150 P2= 3.40"
	1.9	100	0.0100	0.90		Shallow Concentrated Flow, Over Grass
						Cultivated Straight Rows Kv= 9.0 fps
	4.8	1,416	0.0100	4.91	3.86	Pipe Channel, Drainage System
						12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25'
_						n= 0.012
	19.2	1.616	Total			

Printed 9/30/2016

103-040-Proposed Drainage

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 24

Summary for Reach 10R: EAST DITCH - NORTH

Inflow Area = 121.656 ac, 17.92% Impervious, Inflow Depth = 2.29" for 10-Year event

Inflow = 88.04 cfs @ 13.17 hrs, Volume= 23.197 af

Outflow = 74.59 cfs @ 13.96 hrs, Volume= 23.194 af, Atten= 15%, Lag= 47.4 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 2.33 fps, Min. Travel Time= 26.3 min Avg. Velocity = 0.66 fps, Avg. Travel Time= 93.0 min

Peak Storage= 117,650 cf @ 13.52 hrs Average Depth at Peak Storage= 1.91'

Bank-Full Depth= 4.00' Flow Area= 84.0 sf, Capacity= 291.82 cfs

13.00' x 4.00' deep channel, n= 0.025 Side Slope Z-value= 2.0 '/' Top Width= 29.00'

Length= 3,667.0' Slope= 0.0009 '/' Inlet Invert= 55.86', Outlet Invert= 52.56'



Summary for Reach 15R: Wetlands

[81] Warning: Exceeded Pond 51R by 0.19' @ 26.55 hrs

Inflow Area = 21.912 ac, 22.13% Impervious, Inflow Depth = 0.72" for 10-Year event

Inflow = 5.44 cfs @ 12.96 hrs, Volume= 1.308 af

Outflow = 5.42 cfs @ 13.07 hrs, Volume= 1.308 af, Atten= 0%, Lag= 6.3 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 1.88 fps, Min. Travel Time= 3.7 min Avg. Velocity = 0.91 fps, Avg. Travel Time= 7.6 min

Peak Storage= 1,189 cf @ 13.01 hrs Average Depth at Peak Storage= 0.82'

Bank-Full Depth= 3.00' Flow Area= 20.0 sf, Capacity= 82.03 cfs

10.00' x 3.00' deep Parabolic Channel, n= 0.050

Length= 413.0' Slope= 0.0097 '/'

Inlet Invert= 57.00', Outlet Invert= 53.00'

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Printed 9/30/2016 Page 25



Summary for Reach 17R: Drainage Channel

[81] Warning: Exceeded Pond 15P by 0.03' @ 12.50 hrs

Inflow Area = 4.726 ac, 14.47% Impervious, Inflow Depth = 0.44" for 10-Year event

Inflow = 1.46 cfs @ 12.45 hrs, Volume= 0.171 af

Outflow = 1.05 cfs @ 12.55 hrs, Volume= 0.171 af, Atten= 28%, Lag= 6.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 1.30 fps, Min. Travel Time= 3.6 min Avg. Velocity = 0.62 fps, Avg. Travel Time= 7.5 min

Peak Storage= 229 cf @ 12.49 hrs Average Depth at Peak Storage= 0.27'

Bank-Full Depth= 2.00' Flow Area= 20.0 sf, Capacity= 81.66 cfs

2.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding

Side Slope Z-value= 4.0 '/' Top Width= 18.00'

Length= 281.0' Slope= 0.0061 '/'

Inlet Invert= 68.00', Outlet Invert= 66.28'



Summary for Reach 18R: Drainage Channel

[81] Warning: Exceeded Pond 12P by 1.99' @ 26.65 hrs

Inflow Area = 3.464 ac, 23.70% Impervious, Inflow Depth = 0.67" for 10-Year event

Inflow = 2.45 cfs @ 12.20 hrs, Volume= 0.194 af

Outflow = 1.75 cfs @ 12.30 hrs, Volume= 0.194 af, Atten= 28%, Lag= 5.9 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 1.50 fps, Min. Travel Time= 3.1 min Avg. Velocity = 0.63 fps, Avg. Travel Time= 7.5 min

Peak Storage= 329 cf @ 12.24 hrs Average Depth at Peak Storage= 0.35'

Bank-Full Depth= 2.00' Flow Area= 20.0 sf, Capacity= 81.66 cfs

Post-development

103-040-Proposed Drainage

Type III 24-hr 10-Year Rainfall=4.80"

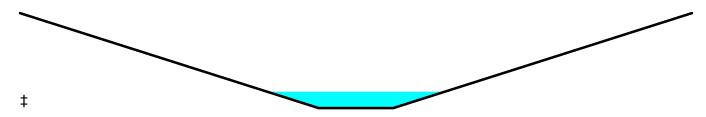
Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 26

2.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding Side Slope Z-value= 4.0 '/' Top Width= 18.00' Length= 281.0' Slope= 0.0061 '/' Inlet Invert= 68.00', Outlet Invert= 66.28'



Summary for Reach 24R: Drainage Channel

Inflow Area = 20.185 ac, 4.44% Impervious, Inflow Depth = 0.23" for 10-Year event

Inflow = 0.68 cfs @ 13.66 hrs, Volume= 0.381 af

Outflow = 0.63 cfs @ 15.50 hrs, Volume= 0.381 af, Atten= 8%, Lag= 110.4 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 0.89 fps, Min. Travel Time= 44.2 min Avg. Velocity = 0.36 fps, Avg. Travel Time= 107.9 min

Peak Storage= 1,670 cf @ 14.76 hrs Average Depth at Peak Storage= 0.15'

Bank-Full Depth= 1.00' Flow Area= 8.0 sf, Capacity= 20.34 cfs

4.00' x 1.00' deep channel, n= 0.025 Earth, clean & winding Side Slope Z-value= 4.0 '/' Top Width= 12.00' Length= 2,354.0' Slope= 0.0032 '/' Inlet Invert= 73.80', Outlet Invert= 66.20'



Summary for Reach 27R: West Ditch

[91] Warning: Storage range exceeded by 1.27'

[55] Hint: Peak inflow is 174% of Manning's capacity

[62] Hint: Exceeded Reach 45R OUTLET depth by 4.56' @ 12.95 hrs

[81] Warning: Exceeded Pond 46R by 0.43' @ 13.00 hrs

Inflow Area = 237.477 ac, 15.19% Impervious, Inflow Depth = 0.97" for 10-Year event

Inflow = 92.95 cfs @ 12.85 hrs, Volume= 19.263 af

Outflow = 89.06 cfs @ 13.10 hrs, Volume= 19.263 af, Atten= 4%, Lag= 15.1 min

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

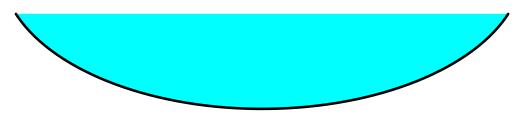
Page 27

Printed 9/30/2016

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Max. Velocity= 1.03 fps, Min. Travel Time= 8.6 min Avg. Velocity = 0.26 fps, Avg. Travel Time= 34.1 min

Peak Storage= 45,906 cf @ 12.95 hrs Average Depth at Peak Storage= 5.27' Bank-Full Depth= 4.00' Flow Area= 58.7 sf, Capacity= 53.46 cfs

22.00' x 4.00' deep Parabolic Channel, n= 0.050 Scattered brush, heavy weeds Length= 531.0' Slope= 0.0003 '/' Inlet Invert= 55.55', Outlet Invert= 55.40'



Summary for Reach 28R: EAST DITCH TO CONFLUENCE

[91] Warning: Storage range exceeded by 0.81'

[55] Hint: Peak inflow is 134% of Manning's capacity

[63] Warning: Exceeded Reach 27R INLET depth by 3.43' @ 16.90 hrs

[63] Warning: Exceeded Reach 31R INLET depth by 0.06' @ 5.00 hrs

Inflow Area = 1,389.131 ac, 11.60% Impervious, Inflow Depth > 1.93" for 10-Year event

Inflow = 381.51 cfs @ 16.29 hrs, Volume= 222.954 af

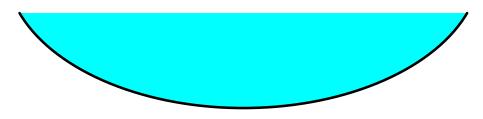
Outflow = 380.95 cfs @ 16.52 hrs, Volume= 222.939 af, Atten= 0%, Lag= 14.1 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 3.68 fps, Min. Travel Time= 7.7 min Avg. Velocity = 1.55 fps, Avg. Travel Time= 18.4 min

Peak Storage= 176,411 cf @ 16.40 hrs Average Depth at Peak Storage= 5.81' Bank-Full Depth= 5.00' Flow Area= 83.3 sf, Capacity= 284.51 cfs

25.00' x 5.00' deep Parabolic Channel, n= 0.050 Length= 1,705.0' Slope= 0.0030 '/' Inlet Invert= 55.40', Outlet Invert= 50.28'



HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 28

Printed 9/30/2016

Summary for Reach 29R: Paskamansett River

[91] Warning: Storage range exceeded by 8.09'

[55] Hint: Peak inflow is 399% of Manning's capacity

[63] Warning: Exceeded Reach 28R INLET depth by 8.53' @ 17.20 hrs

Inflow Area = 1,675.825 ac, 10.09% Impervious, Inflow Depth > 1.87" for 10-Year event

Inflow = 412.96 cfs @ 16.42 hrs, Volume= 260.995 af

Outflow = 398.01 cfs @ 17.58 hrs, Volume= 260.904 af, Atten= 4%, Lag= 69.3 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

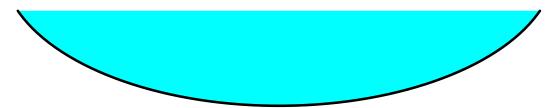
Max. Velocity= 0.94 fps, Min. Travel Time= 33.7 min Avg. Velocity = 0.47 fps, Avg. Travel Time= 67.3 min

Peak Storage= 804,422 cf @ 17.02 hrs Average Depth at Peak Storage= 14.09'

Bank-Full Depth= 6.00' Flow Area= 140.0 sf, Capacity= 103.50 cfs

35.00' x 6.00' deep Parabolic Channel, n= 0.035

Length= 1,905.0' Slope= 0.0001 '/' Inlet Invert= 55.50', Outlet Invert= 55.40'



Summary for Reach 30R: Culvert 1

[52] Hint: Inlet/Outlet conditions not evaluated

[79] Warning: Submerged Pond 1P Primary device # 1 by 2.20'

Inflow Area = 467,459 ac. 17,37% Impervious. Inflow Depth = 2.07" for 10-Year event

Inflow = 127.92 cfs @ 14.88 hrs, Volume= 80.721 af

Outflow = 127.92 cfs @ 14.88 hrs, Volume= 80.721 af, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 7.75 fps, Min. Travel Time= 0.1 min Avg. Velocity = 2.80 fps, Avg. Travel Time= 0.3 min

Peak Storage= 792 cf @ 14.88 hrs Average Depth at Peak Storage= 2.20'

Bank-Full Depth= 3.75' Flow Area= 28.1 sf, Capacity= 203.41 cfs

90.0" W x 45.0" H Box Pipe

n = 0.015

Length= 48.0' Slope= 0.0040 '/'

Inlet Invert= 55.53', Outlet Invert= 55.34'

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Printed 9/30/2016

Page 29



Summary for Reach 31R: EAST DITCH - NORTH

[91] Warning: Storage range exceeded by 35.69'

[55] Hint: Peak inflow is 2831% of Manning's capacity

[63] Warning: Exceeded Reach 15R INLET depth by 37.55' @ 14.95 hrs [63] Warning: Exceeded Reach 30R INLET depth by 37.30' @ 14.95 hrs

Inflow Area = 1,151.654 ac, 10.86% Impervious, Inflow Depth = 2.12" for 10-Year event

Inflow = 521.83 cfs @ 13.79 hrs, Volume= 203.767 af

Outflow = 363.82 cfs @ 16.34 hrs, Volume= 203.691 af, Atten= 30%, Lag= 153.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 0.48 fps, Min. Travel Time= 84.6 min

Avg. Velocity = 0.26 fps, Avg. Travel Time= 155.4 min

Peak Storage= 1,846,972 cf @ 14.93 hrs

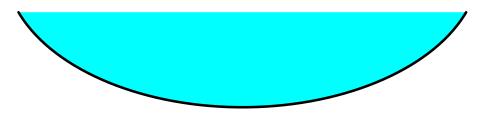
Average Depth at Peak Storage= 39.69'

Bank-Full Depth= 4.00' Flow Area= 53.3 sf, Capacity= 18.43 cfs

20.00' x 4.00' deep Parabolic Channel, n= 0.050

Length= 2,413.0' Slope= 0.0000 '/'

Inlet Invert= 55.34', Outlet Invert= 55.24'



Summary for Reach 34R: Drainage Channel

Inflow Area = 4.091 ac, 30.73% Impervious, Inflow Depth = 1.00" for 10-Year event

Inflow = 2.10 cfs @ 12.57 hrs, Volume= 0.341 af

Outflow = 2.09 cfs @ 12.64 hrs, Volume= 0.341 af, Atten= 1%, Lag= 3.7 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 2.55 fps, Min. Travel Time= 2.2 min Avg. Velocity = 1.13 fps, Avg. Travel Time= 4.9 min

Peak Storage= 271 cf @ 12.60 hrs

Average Depth at Peak Storage= 0.17'

Bank-Full Depth= 2.00' Flow Area= 24.0 sf, Capacity= 240.18 cfs

Post-development

103-040-Proposed Drainage

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 30

4.00' x 2.00' deep channel, n= 0.025 Earth, clean & winding Side Slope Z-value= 4.0 '/' Top Width= 20.00' Length= 331.0' Slope= 0.0230 '/' Inlet Invert= 73.80', Outlet Invert= 66.20'



Summary for Reach 37R: Drainage Channel

[55] Hint: Peak inflow is 111% of Manning's capacity [81] Warning: Exceeded Pond 6P by 5.87' @ 27.40 hrs

Inflow Area = 10.361 ac, 36.22% Impervious, Inflow Depth = 0.61" for 10-Year event

Inflow = 7.33 cfs @ 12.47 hrs, Volume= 0.528 af

Outflow = 2.70 cfs @ 13.77 hrs, Volume= 0.528 af, Atten= 63%, Lag= 78.5 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 0.64 fps, Min. Travel Time= 46.5 min Avg. Velocity = 0.14 fps, Avg. Travel Time= 215.5 min

Peak Storage= 7,530 cf @ 13.00 hrs Average Depth at Peak Storage= 0.64' Bank-Full Depth= 1.00' Flow Area= 8.0 sf, Capacity= 6.58 cfs

4.00' x 1.00' deep channel, n= 0.080 Earth, long dense weeds Side Slope Z-value= 4.0 '/' Top Width= 12.00' Length= 1,795.0' Slope= 0.0035 '/' Inlet Invert= 74.60', Outlet Invert= 68.40'



Summary for Reach 38R: Drainage System "C"

[52] Hint: Inlet/Outlet conditions not evaluated

[55] Hint: Peak inflow is 132% of Manning's capacity

[76] Warning: Detained 0.008 af (Pond w/culvert advised)

Inflow Area = 9.743 ac, 14.47% Impervious, Inflow Depth = 0.51" for 10-Year event

Inflow = 2.22 cfs @ 12.46 hrs, Volume= 0.418 af

Outflow = 1.75 cfs @ 12.51 hrs, Volume= 0.418 af, Atten= 21%, Lag= 2.9 min

Post-development

103-040-Proposed Drainage

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

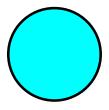
Printed 9/30/2016 Page 31

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Max. Velocity= 2.42 fps, Min. Travel Time= 5.5 min Avg. Velocity = 1.23 fps, Avg. Travel Time= 10.8 min

Peak Storage= 625 cf @ 12.45 hrs Average Depth at Peak Storage= 1.00' Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 1.68 cfs

12.0" Round Pipe n= 0.012 Length= 796.0' Slope= 0.0019 '/' Inlet Invert= 59.27', Outlet Invert= 57.77'



Summary for Reach 39R: EAST DITCH - N2

[62] Hint: Exceeded Reach 38R OUTLET depth by 0.16' @ 25.05 hrs

Inflow Area = 9.743 ac, 14.47% Impervious, Inflow Depth = 0.51" for 10-Year event

Inflow = 1.75 cfs @ 12.51 hrs, Volume= 0.418 af

Outflow = 0.87 cfs @ 14.54 hrs, Volume= 0.418 af, Atten= 50%, Lag= 121.7 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 0.48 fps, Min. Travel Time= 70.6 min Avg. Velocity = 0.20 fps, Avg. Travel Time= 169.0 min

Peak Storage= 3,685 cf @ 13.36 hrs Average Depth at Peak Storage= 0.51' Bank-Full Depth= 4.00' Flow Area= 40.0 sf, Capacity= 68.77 cfs

15.00' x 4.00' deep Parabolic Channel, n= 0.050 Length= 2,017.0' Slope= 0.0011 '/' Inlet Invert= 57.77', Outlet Invert= 55.53'



Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Printed 9/30/2016 Page 32

Summary for Reach 41R: Drainage System "B"

[52] Hint: Inlet/Outlet conditions not evaluated

[81] Warning: Exceeded Pond 25P by 3.79' @ 25.20 hrs

Inflow Area = 92.616 ac, 10.12% Impervious, Inflow Depth = 0.94" for 10-Year event

Inflow = 7.14 cfs @ 12.51 hrs, Volume= 7.272 af

Outflow = 7.06 cfs @ 12.67 hrs, Volume= 7.272 af, Atten= 1%, Lag= 10.0 min

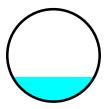
Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 4.68 fps, Min. Travel Time= 5.7 min Avg. Velocity = 2.30 fps, Avg. Travel Time= 11.6 min

Peak Storage= 2,402 cf @ 12.58 hrs Average Depth at Peak Storage= 0.80'

Bank-Full Depth= 3.00' Flow Area= 7.1 sf, Capacity= 45.62 cfs

36.0" Round Pipe n= 0.012 Length= 1,593.0' Slope= 0.0040 '/' Inlet Invert= 62.26', Outlet Invert= 55.91'



Summary for Reach 45R: Drainage Channel

[81] Warning: Exceeded Pond 26P by 5.96' @ 28.40 hrs

Inflow Area = 10.668 ac, 37.32% Impervious, Inflow Depth = 0.92" for 10-Year event

Inflow = 8.63 cfs @ 12.35 hrs, Volume= 0.819 af

Outflow = 5.15 cfs @ 13.08 hrs, Volume= 0.819 af, Atten= 40%, Lag= 44.3 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 1.68 fps, Min. Travel Time= 24.5 min Avg. Velocity = 0.44 fps, Avg. Travel Time= 93.5 min

Peak Storage= 7,598 cf @ 12.67 hrs Average Depth at Peak Storage= 0.51'

Bank-Full Depth= 2.00' Flow Area= 24.0 sf, Capacity= 86.58 cfs

4.00' x 2.00' deep channel, n= 0.025 Earth, clean & winding Side Slope Z-value= 4.0 '/' Top Width= 20.00' Length= 2,480.0' Slope= 0.0030 '/' Inlet Invert= 63.20', Outlet Invert= 55.80'

Post-development

103-040-Proposed Drainage

Type III 24-hr 10-Year Rainfall=4.80" Printed 9/30/2016

Prepared by Hewlett-Packard Company
HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 33



Summary for Reach 47R: Drainage Channel

Inflow Area = 3.245 ac, 41.11% Impervious, Inflow Depth = 1.12" for 10-Year event

Inflow = 4.32 cfs @ 12.35 hrs, Volume= 0.304 af

Outflow = 3.11 cfs @ 12.37 hrs, Volume= 0.304 af, Atten= 28%, Lag= 1.3 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Max. Velocity= 1.70 fps, Min. Travel Time= 1.7 min Avg. Velocity = 0.61 fps, Avg. Travel Time= 4.6 min

Peak Storage= 312 cf @ 12.34 hrs Average Depth at Peak Storage= 0.34'

Bank-Full Depth= 2.00' Flow Area= 24.0 sf, Capacity= 108.73 cfs

4.00' x 2.00' deep channel, n= 0.025 Earth, clean & winding

Side Slope Z-value= 4.0 '/' Top Width= 20.00'

Length= 170.0' Slope= 0.0047 '/'

Inlet Invert= 64.80', Outlet Invert= 64.00'



Summary for Pond 1P: Wetland "P"

[63] Warning: Exceeded Reach 10R INLET depth by 2.08' @ 15.45 hrs

[63] Warning: Exceeded Reach 39R INLET depth by 0.95' @ 15.05 hrs

[62] Hint: Exceeded Reach 41R OUTLET depth by 2.52' @ 14.90 hrs

Inflow Area = 467.459 ac, 17.37% Impervious, Inflow Depth = 2.07" for 10-Year event

Inflow = 251.87 cfs @ 13.56 hrs, Volume= 80.721 af

Outflow = 127.92 cfs @ 14.88 hrs, Volume= 80.721 af, Atten= 49%, Lag= 78.9 min

Primary = 127.92 cfs @ 14.88 hrs, Volume= 80.721 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Peak Elev= 59.17' @ 14.88 hrs Surf.Area= 977,561 sf Storage= 789,030 cf

Plug-Flow detention time= 59.0 min calculated for 80.627 af (100% of inflow)

Center-of-Mass det. time= 58.9 min (1,022.5 - 963.6)

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 34

Volume	In	vert Ava	ail.Storage	Storage	Description			
#1	55	.53' 2,	990,764 cf	Custon	Stage Data (Pr	rismatic)Listed below (Recalc)		
Elevatio		Surf.Area (sq-ft)		c.Store pic-feet)	Cum.Store (cubic-feet)			
55.5	53	144		0	0			
56.0	00	7,755		1,856	1,856			
57.0	00	11,838		9,797	11,653			
58.0	00	142,731		77,285	88,937			
59.0	00	929,931	5	36,331	625,268			
60.0	00	1,207,326	1,0	68,629	1,693,897			
61.0	00	1,386,408	1,2	296,867	2,990,764			
Device	Routing	j l	nvert Ou	tlet Device	S			
#1	Primary	, 5	5.53' 90.	0" W x 45	.0" H Box Culve	ert		
,				L= 1.0' Box, headwall w/3 square edges, Ke= 0.500 Inlet / Outlet Invert= 55.53' / 55.53' S= 0.0000 '/' Cc= 0.900 n= 0.015, Flow Area= 28.13 sf				

Primary OutFlow Max=127.91 cfs @ 14.88 hrs HW=59.17' (Free Discharge) 1=Culvert (Barrel Controls 127.91 cfs @ 6.24 fps)

Summary for Pond 1R: EX-CB-9

[57] Hint: Peaked at 62.67' (Flood elevation advised)

Inflow Area = 4.091 ac, 30.73% Impervious, Inflow Depth = 1.00" for 10-Year event
Inflow = 2.09 cfs @ 12.64 hrs, Volume= 0.341 af
Outflow = 2.09 cfs @ 12.64 hrs, Volume= 0.341 af, Atten= 0%, Lag= 0.0 min
Primary = 2.09 cfs @ 12.64 hrs, Volume= 0.341 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 62.67' @ 12.64 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary		18.0" Round Culvert L= 425.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 61.82' / 60.88' S= 0.0022 '/' Cc= 0.900 n= 0.012, Flow Area= 1.77 sf

Primary OutFlow Max=2.08 cfs @ 12.64 hrs HW=62.67' (Free Discharge) 1=Culvert (Barrel Controls 2.08 cfs @ 2.90 fps)

Summary for Pond 2P: Wetland "K"

Inflow Are	a =	121.656 ac, 1	l 7.92% Impervious, Ir	nflow Depth = 2.29"	for 10-Year event
Inflow	=	140.45 cfs @	12.71 hrs, Volume=	23.197 af	
Outflow	=	88.04 cfs @	13.17 hrs, Volume=	23.197 af, At	ten= 37%, Lag= 27.6 min
Primary	=	88.04 cfs @	13.17 hrs, Volume=	23.197 af	_

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016 Page 35

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 61.82' @ 13.17 hrs Surf.Area= 318.962 sf Storage= 261.563 cf

Plug-Flow detention time= 57.3 min calculated for 23.170 af (100% of inflow)

Center-of-Mass det. time= 57.5 min (935.8 - 878.3)

Volume	Inv	ert Avail.Sto	rage Storage	e Description	
#1	58.9	92' 766,46	69 cf Custon	n Stage Data (Pr	ismatic)Listed below (Recalc)
Elevation	าท	Surf.Area	Inc.Store	Cum.Store	
(fee		(sq-ft)	(cubic-feet)	(cubic-feet)	
58.9	92	4,355	0	0	
60.0	00	23,907	15,261	15,261	
61.0	00	113,475	68,691	83,952	
62.0	00	363,629	238,552	322,504	
63.0	00	524,301	443,965	766,469	
Device	Routing	Invert	Outlet Device	es	
#1	Primary	58.92'	24.0" Round	d Culvert X 2.00	
	-		L= 1.0' RCF	, square edge he	eadwall, Ke= 0.500
					8.92' S= 0.0000 '/' Cc= 0.900
			•	ow Area= 3.14 sf	
#2	Primary	61.50'			Broad-Crested Rectangular Weir
			` '		0.80 1.00 1.20 1.40 1.60
			Coet. (Englis	h) 2.68 2.70 2.7	70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=87.91 cfs @ 13.17 hrs HW=61.82' (Free Discharge)

-1=Culvert (Barrel Controls 38.94 cfs @ 6.20 fps)

-2=Broad-Crested Rectangular Weir (Weir Controls 48.96 cfs @ 1.53 fps)

Summary for Pond 3P: EX-DMH-1

[57] Hint: Peaked at 61.85' (Flood elevation advised)

[79] Warning: Submerged Pond 5P Primary device # 1 INLET by 1.39'

Inflow Area = 75.360 ac, 17.68% Impervious, Inflow Depth = 0.44" for 10-Year event

Inflow 10.27 cfs @ 12.56 hrs, Volume= 2.789 af

Outflow = 10.27 cfs @ 12.56 hrs, Volume= 2.789 af, Atten= 0%, Lag= 0.0 min

10.27 cfs @ 12.56 hrs, Volume= Primary 2.789 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Peak Elev= 61.85' @ 12.56 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	59.92'	24.0" Round Culvert
			L= 293.0' RCP, groove end projecting, Ke= 0.200
			Inlet / Outlet Invert= 59.92' / 59.40' S= 0.0018 '/' Cc= 0.900
			n= 0.012 Concrete pipe, finished, Flow Area= 3.14 sf

Primary OutFlow Max=10.26 cfs @ 12.56 hrs HW=61.85' (Free Discharge) 1=Culvert (Barrel Controls 10.26 cfs @ 4.21 fps)

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Type III 24-hr 10-Year Rainfall=4.80" Printed 9/30/2016

Page 36

Summary for Pond 4P: Infiltration Trench "23 C"

Inflow Area = 22.469 ac, 9.29% Impervious, Inflow Depth = 1.32" for 10-Year event
Inflow = 21.55 cfs @ 12.29 hrs, Volume= 2.465 af
Outflow = 21.55 cfs @ 12.29 hrs, Volume= 2.465 af, Atten= 0%, Lag= 0.0 min
Discarded = 0.01 cfs @ 12.29 hrs, Volume= 0.001 af
Primary = 21.55 cfs @ 12.29 hrs, Volume= 2.464 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 78.18' @ 12.29 hrs Surf.Area= 127 sf Storage= 5 cf

Plug-Flow detention time= 0.0 min calculated for 2.462 af (100% of inflow) Center-of-Mass det. time= 0.0 min (884.1 - 884.1)

volume	invert	Avaii.Storage	Storage Description
#1	78.00'	340 cf	60.0" W x 24.0" H Box Pipe Storage L= 85.0' S= 0.0071 '/' 850 cf Overall x 40.0% Voids
Device	Routing	Invert Ou	tlet Devices
#1	Discarded	78.00' 2.4	10 in/hr Exfiltration over Surface area
		Co	nductivity to Groundwater Elevation = 0.00'
#2	Primary	78.00' 85.	0' long Sharp-Crested Rectangular Weir 2 End Contraction(s)

Discarded OutFlow Max=0.01 cfs @ 12.29 hrs HW=78.18' (Free Discharge) 1=Exfiltration (Controls 0.01 cfs)

2.2' Crest Height

Primary OutFlow Max=21.46 cfs @ 12.29 hrs HW=78.18' (Free Discharge) 2=Sharp-Crested Rectangular Weir (Weir Controls 21.46 cfs @ 1.40 fps)

Summary for Pond 5P: EX-CB-4

[57] Hint: Peaked at 62.40' (Flood elevation advised)

[79] Warning: Submerged Pond 1R Primary device # 1 INLET by 0.58' [79] Warning: Submerged Pond 7P Primary device # 1 INLET by 0.97'

Inflow Area = 75.360 ac, 17.68% Impervious, Inflow Depth = 0.44" for 10-Year event

Inflow = 10.27 cfs @ 12.56 hrs, Volume= 2.789 af

Outflow = 10.27 cfs @ 12.56 hrs, Volume= 2.789 af, Atten= 0%, Lag= 0.0 min

Primary = 10.27 cfs @ 12.56 hrs, Volume= 2.789 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 62.40' @ 12.56 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	60.46'	24.0" Round Culvert
			L= 308.0' RCP, groove end projecting, Ke= 0.200
			Inlet / Outlet Invert= 60.46' / 59.92' S= 0.0018 '/' Cc= 0.900
			n= 0.012 Concrete pipe, finished, Flow Area= 3.14 sf

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016 Page 37

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Primary OutFlow Max=10.26 cfs @ 12.56 hrs HW=62.40' (Free Discharge) 1=Culvert (Barrel Controls 10.26 cfs @ 4.19 fps)

Summary for Pond 6P: Infiltration Trench "23 C"

[88] Warning: Qout>Qin may require smaller dt or Finer Routing

Inflow Area =	10.361 ac, 36.22% Impervious, Inflow D	epth = 1.19" for 10-Year event
Inflow =	7.33 cfs @ 12.46 hrs, Volume=	1.024 af
Outflow =	7.74 cfs @ 12.47 hrs, Volume=	1.011 af, Atten= 0%, Lag= 0.5 min
Discarded =	0.41 cfs @ 12.45 hrs, Volume=	0.483 af
Primary =	7.33 cfs @ 12.47 hrs, Volume=	0.528 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs / 5 Peak Elev= 70.76' @ 12.45 hrs Surf.Area= 7,144 sf Storage= 4,461 cf

Plug-Flow detention time= 82.6 min calculated for 1.010 af (99% of inflow) Center-of-Mass det. time= 75.8 min (975.2 - 899.5)

Volume	Invert	Avail.Storage	Storage Description
#1	68.75'	5,715 cf	48.0" W x 24.0" H Box Pipe Storage L= 1,786.0' S= 0.0005 '/' 14,288 cf Overall x 40.0% Voids
Device	Routing	Invert Out	let Devices
#1	Discarded		10 in/hr Exfiltration over Surface area aductivity to Groundwater Elevation = 0.00'

70.75' **1,786.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Discarded OutFlow Max=0.41 cfs @ 12.45 hrs HW=70.76' (Free Discharge) 1=Exfiltration (Controls 0.41 cfs)

Primary OutFlow Max=3.89 cfs @ 12.47 hrs HW=70.76' (Free Discharge) 2=Sharp-Crested Rectangular Weir (Weir Controls 3.89 cfs @ 0.29 fps)

Summary for Pond 7P: EX-CB-5

[57] Hint: Peaked at 63.95' (Flood elevation advised) [81] Warning: Exceeded Pond 8P by 1.87' @ 12.50 hrs

#2

Primary

Inflow Area = 41.797 ac, 21.29% Impervious, Inflow Depth = 0.46" for 10-Year event
Inflow = 7.87 cfs @ 12.48 hrs, Volume= 1.615 af
Outflow = 7.87 cfs @ 12.48 hrs, Volume= 1.615 af, Atten= 0%, Lag= 0.0 min
Primary = 7.87 cfs @ 12.48 hrs, Volume= 1.615 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 63.95' @ 12.48 hrs

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 38

Device	Routing	Invert	Outlet Devices
#1	Primary	61.43'	18.0" Round Culvert L= 250.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 61.43' / 60.88' S= 0.0022 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 1.77 sf

Primary OutFlow Max=7.85 cfs @ 12.48 hrs HW=63.94' (Free Discharge) 1=Culvert (Barrel Controls 7.85 cfs @ 4.44 fps)

Summary for Pond 8P: EX-CB-6

[57] Hint: Peaked at 63.06' (Flood elevation advised)

[79] Warning: Submerged Pond 10P Primary device # 1 OUTLET by 0.88'

Inflow Are	a =	10.361 ac, 36	.22% Impervious,	Inflow Depth > 0	0.61" for 10-	Year event
Inflow	=	2.70 cfs @ 1	3.77 hrs, Volume	e= 0.528 a	af	
Outflow	=	2.70 cfs @ 1	3.77 hrs, Volume	e= 0.528 a	af, Atten= 0%,	Lag= 0.0 min
Primary	=	2.70 cfs @ 1	3.77 hrs, Volume	e= 0.528 a	af	-

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 63.06' @ 13.77 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	62.08'	18.0" Round Culvert L= 250.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 62.08' / 61.53' S= 0.0022 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 1.77 sf

Primary OutFlow Max=2.69 cfs @ 13.77 hrs HW=63.06' (Free Discharge) 1=Culvert (Barrel Controls 2.69 cfs @ 3.14 fps)

Summary for Pond 9P: Ex-Outfall 2

[57] Hint: Peaked at 70.71' (Flood elevation advised)

Inflow Area =	9.450 ac, 11.30% Impervious, Inflow I	Depth = 0.35" for 10-Year event
Inflow =	0.90 cfs @ 13.30 hrs, Volume=	0.272 af
Outflow =	0.90 cfs @ 13.30 hrs, Volume=	0.272 af, Atten= 0%, Lag= 0.0 min
Primary =	0.90 cfs @ 13.30 hrs, Volume=	0.272 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 70.71' @ 13.30 hrs

Device	Routing	Invert	Outlet Devices	
#1	Primary	70.28'	12.0" Round Culvert	
	-		L= 107.0' RCP, groove end projecting, Ke= 0.200	
			Inlet / Outlet Invert= 70.28' / 68.78' S= 0.0140 '/' Cc= 0.900	
			n= 0.012 Concrete pipe, finished, Flow Area= 0.79 sf	

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Printed 9/30/2016 Page 39

Primary OutFlow Max=0.90 cfs @ 13.30 hrs HW=70.71' (Free Discharge) -1=Culvert (Inlet Controls 0.90 cfs @ 2.79 fps)

Summary for Pond 10P: EX-CB-10

[57] Hint: Peaked at 64.11' (Flood elevation advised)

10.361 ac, 36.22% Impervious, Inflow Depth > 0.61" for 10-Year event Inflow Area =

Inflow 2.70 cfs @ 13.77 hrs, Volume= 0.528 af

Outflow 2.70 cfs @ 13.77 hrs, Volume= 0.528 af, Atten= 0%, Lag= 0.0 min

Primary 2.70 cfs @ 13.77 hrs, Volume= 0.528 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Peak Elev= 64.11' @ 13.77 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	63.12'	18.0" Round Culvert
			L= 425.0' RCP, groove end projecting, Ke= 0.200
			Inlet / Outlet Invert= 63.12' / 62.18' S= 0.0022 '/' Cc= 0.900
			n= 0.012 Concrete pipe, finished, Flow Area= 1.77 sf

Primary OutFlow Max=2.69 cfs @ 13.77 hrs HW=64.10' (Free Discharge) 1=Culvert (Barrel Controls 2.69 cfs @ 3.11 fps)

Summary for Pond 11P: Infiltration Trench - "23 A"

[88] Warning: Qout>Qin may require smaller dt or Finer Routing

Inflow Area = 11.251 ac, 37.77% Impervious, Inflow Depth = 1.25" for 10-Year event Inflow 8.15 cfs @ 12.50 hrs, Volume= 1.173 af

Outflow 8.22 cfs @ 12.48 hrs, Volume= 1.165 af, Atten= 0%, Lag= 0.0 min

Discarded = 0.35 cfs @ 12.48 hrs, Volume= 0.459 af 7.87 cfs @ 12.48 hrs, Volume= 0.707 af Primary

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs / 4 Peak Elev= 71.01' @ 12.48 hrs Surf.Area= 6,120 sf Storage= 4,491 cf

Plug-Flow detention time= 77.3 min calculated for 1.165 af (99% of inflow)

Center-of-Mass det. time= 73.8 min (972.9 - 899.2)

Volume	Invert	Avail.Storage	Storage Description
#1	68.75'	4,896 cf	48.0" W x 24.0" H Box Pipe Storage L= 1,530.0' S= 0.0005 '/' 12,240 cf Overall x 40.0% Voids
Device	Routing	Invert Out	let Devices

#1	Discarded	68.75'	2.410 in/hr Exfiltration over Surface area
			Conductivity to Groundwater Elevation = 0.00'
#2	Primary	71.00'	1,530.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s)

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 40

2.2' Crest Height

Discarded OutFlow Max=0.35 cfs @ 12.48 hrs HW=71.01' (Free Discharge) 1=Exfiltration (Controls 0.35 cfs)

Primary OutFlow Max=6.51 cfs @ 12.48 hrs HW=71.01' (Free Discharge) 2=Sharp-Crested Rectangular Weir (Weir Controls 6.51 cfs @ 0.36 fps)

Summary for Pond 12P: Infiltration Trench "A-A"

[88] Warning: Qout>Qin may require smaller dt or Finer Routing

[85] Warning: Oscillations may require smaller dt or Finer Routing (severity=70)

Inflow Area = 3.464 ac, 23.70% Impervious, Inflow Depth = 0.77" for 10-Year event
Inflow = 1.87 cfs @ 12.19 hrs, Volume= 0.222 af
Outflow = 2.48 cfs @ 12.20 hrs, Volume= 0.222 af, Atten= 0%, Lag= 0.8 min
Discarded = 0.02 cfs @ 12.20 hrs, Volume= 0.028 af
Primary = 2.45 cfs @ 12.20 hrs, Volume= 0.194 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 67.28' @ 12.20 hrs Surf.Area= 440 sf Storage= 141 cf

Plug-Flow detention time= 11.1 min calculated for 0.222 af (100% of inflow) Center-of-Mass det. time= 11.2 min (920.2 - 909.0)

Volume	Invert	Avail.Storage	Storage Description
#1	66.01'	176 cf	24.0" W x 12.0" H Box Pipe Storage L= 220.0' S= 0.0039 '/' 440 cf Overall x 40.0% Voids
Device	Routing	Invert Out	let Devices
#1	Discarded	66.01' 2.4 1	10 in/hr Exfiltration over Surface area
		Cor	inductivity to Groundwater Elevation = 0.00' Phase-In= 0.01'
#2	Primary	67.26' 220	.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s)

Discarded OutFlow Max=0.02 cfs @ 12.20 hrs HW=67.28' (Free Discharge) 1=Exfiltration (Controls 0.02 cfs)

1.2' Crest Height

Primary OutFlow Max=2.27 cfs @ 12.20 hrs HW=67.28' (Free Discharge) 2=Sharp-Crested Rectangular Weir (Weir Controls 2.27 cfs @ 0.48 fps)

Summary for Pond 13P: Infield Storage Area

Inflow Area = 21.912 ac, 22.13% Impervious, Inflow Depth = 0.72" for 10-Year event Inflow = 6.06 cfs @ 12.77 hrs, Volume= 1.308 af Outflow = 5.44 cfs @ 12.96 hrs, Volume= 1.308 af, Atten= 10%, Lag= 11.2 min 1.308 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Invert

Volume

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 41

Peak Elev= 59.74' @ 12.96 hrs Surf.Area= 8,898 sf Storage= 1,875 cf

Plug-Flow detention time= 3.4 min calculated for 1.306 af (100% of inflow)

Avail Storage Storage Description

Center-of-Mass det. time= 3.4 min (949.7 - 946.2)

VOIGITIC	11110	rt /tvaii.Oto	rage Clorage	Description	
#1	59.3	3' 56,39	92 cf Custom	Stage Data (Pi	rismatic)Listed below (Recalc)
Elevatio		Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	
59.3	33	290	0	0	
60.0	00	14,422	4,929	4,929	
60.8	30	114,236	51,463	56,392	
Device	Routing	Invert	Outlet Devices	S	
#1	Device 2	56.83'	18.0" Round	18" Round Cu	Ivert
			L= 1.0' RCP	, square edge he	eadwall, Ke= 0.500
			Inlet / Outlet In	nvert= 56.83' / 5	66.82' S= 0.0100 '/' Cc= 0.900
			n= 0.012, Flo	w Area= 1.77 sf	f
#2	Primary	59.33'	8.0' long Sha 0.5' Crest Hei		ctangular Weir 2 End Contraction(s)

Primary OutFlow Max=5.43 cfs @ 12.96 hrs HW=59.74' (Free Discharge)

2=Sharp-Crested Rectangular Weir (Passes 5.43 cfs of 7.41 cfs potential flow)

1=18" Round Culvert (Inlet Controls 5.43 cfs @ 3.07 fps)

Summary for Pond 15P: Infiltration Trench "A-B"

[88] Warning: Qout>Qin may require smaller dt or Finer Routing

[85] Warning: Oscillations may require smaller dt or Finer Routing (severity=77)

Inflow Area = 4.726 ac, 14.47% Impervious, Inflow Depth = 0.51" for 10-Year event
Inflow = 1.10 cfs @ 12.44 hrs, Volume= 0.203 af
Outflow = 1.49 cfs @ 12.45 hrs, Volume= 0.203 af, Atten= 0%, Lag= 0.7 min
Discarded = 0.03 cfs @ 12.45 hrs, Volume= 0.031 af
Primary = 1.46 cfs @ 12.45 hrs, Volume= 0.171 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 68.24' @ 12.45 hrs Surf.Area= 505 sf Storage= 122 cf

Plug-Flow detention time= 10.5 min calculated for 0.203 af (100% of inflow) Center-of-Mass det. time= 10.6 min (953.8 - 943.1)

Volume	Invert	Avail.Storage	Storage Description
#1	66.98'	230 cf	24.0" W x 12.0" H Box Pipe Storage
			L= 287.0' S= 0.0050 '/'
			574 cf Overall x 40.0% Voids
Device	Routing	Invert Out	tlet Devices
#1	Discarded	66.98' 2.4	10 in/hr Exfiltration over Surface area

Conductivity to Groundwater Elevation = 0.00'

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 42

#2 Primary 68.23' **287.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s) 1.2' Crest Height

Discarded OutFlow Max=0.03 cfs @ 12.45 hrs HW=68.24' (Free Discharge) 1=Exfiltration (Controls 0.03 cfs)

Primary OutFlow Max=1.27 cfs @ 12.45 hrs HW=68.24' (Free Discharge) 2=Sharp-Crested Rectangular Weir (Weir Controls 1.27 cfs @ 0.36 fps)

Summary for Pond 16P: Infiltration Trench "A-C"

[88] Warning: Qout>Qin may require smaller dt or Finer Routing

[85] Warning: Oscillations may require smaller dt or Finer Routing (severity=34)

Inflow Area = 9.450 ac, 11.30% Impervious, Inflow Depth = 0.42" for 10-Year event

Inflow = 0.89 cfs @ 13.31 hrs, Volume= 0.334 af

Outflow = 0.95 cfs @ 13.30 hrs, Volume= 0.334 af, Atten= 0%, Lag= 0.0 min

Discarded = 0.90 cfs @ 13.30 hrs, Volume= 0.062 af

Primary = 0.90 cfs @ 13.30 hrs, Volume= 0.272 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 73.99' @ 13.30 hrs Surf.Area= 704 sf Storage= 242 cf

Plug-Flow detention time= 13.8 min calculated for 0.334 af (100% of inflow) Center-of-Mass det. time= 13.8 min (1,019.6 - 1,005.8)

Volume	Invert	Avail.Storage	Storage Description
#1	72.23'	620 cf	24.0" W x 18.0" H Box Pipe Storage
			L= 517.0' S= 0.0050 '/'
			1,551 cf Overall x 40.0% Voids

Device	Routing	Invert	Outlet Devices
#1	Discarded	72.23'	2.410 in/hr Exfiltration over Surface area
			Conductivity to Groundwater Elevation = 70.23'
#2	Primary	73.98'	220.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s)
	-		1.7' Crest Height

Discarded OutFlow Max=0.05 cfs @ 13.30 hrs HW=73.99' (Free Discharge) 1=Exfiltration (Controls 0.05 cfs)

Primary OutFlow Max=0.67 cfs @ 13.30 hrs HW=73.99' (Free Discharge)
2=Sharp-Crested Rectangular Weir (Weir Controls 0.67 cfs @ 0.32 fps)

Summary for Pond 19P: Infiltration Trench "5 D"

[93] Warning: Storage range exceeded by 0.17'

[88] Warning: Qout>Qin may require smaller dt or Finer Routing

[85] Warning: Oscillations may require smaller dt or Finer Routing (severity=118)

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 43

Inflow Area =	3.285 ac, 34.03% Impervious,	Inflow Depth = 1.12"	for 10-Year event
Inflow =	1.79 cfs @ 12.67 hrs, Volume:	= 0.307 af	

Outflow = 2.62 cfs @ 12.65 hrs, Volume= 0.307 af, Atten= 0%, Lag= 0.0 min

Discarded = 0.05 cfs @ 12.65 hrs, Volume= 0.065 af Primary = 2.57 cfs @ 12.65 hrs, Volume= 0.242 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 71.02' @ 12.65 hrs Surf.Area= 816 sf Storage= 653 cf

Plug-Flow detention time= 42.2 min calculated for 0.307 af (100% of inflow) Center-of-Mass det. time= 42.4 min (958.1 - 915.7)

Volume	Invert	Avail.Storage	Storage Description
#1	68.75'	653 cf	48.0" W x 24.0" H Box Pipe Storage
			L= 204.0' S= 0.0005 '/'
			1,632 cf Overall x 40.0% Voids

Device	Routing	Invert	Outlet Devices
#1	Discarded	68.75'	2.410 in/hr Exfiltration over Surface area
			Conductivity to Groundwater Elevation = 0.00'
#2	Primary	71.00'	204.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s)
	•		2.2' Crest Height

Discarded OutFlow Max=0.05 cfs @ 12.65 hrs HW=71.02' (Free Discharge) 1=Exfiltration (Controls 0.05 cfs)

Primary OutFlow Max=2.51 cfs @ 12.65 hrs HW=71.02' (Free Discharge) 2=Sharp-Crested Rectangular Weir (Weir Controls 2.51 cfs @ 0.51 fps)

Summary for Pond 21P: Infiltration Trench "5 E"

[93] Warning: Storage range exceeded by 0.20'

[88] Warning: Qout>Qin may require smaller dt or Finer Routing

[85] Warning: Oscillations may require smaller dt or Finer Routing (severity=118)

Inflow Area =	=	3.245 ac, 4	11.11% Imperv	vious, Inflow [Depth =	1.38"	for	10-Year event
Inflow =	•	3.19 cfs @	12.32 hrs, V	olume=	0.374	af		

Outflow = 4.37 cfs @ 12.35 hrs, Volume= 0.374 af, Atten= 0%, Lag= 1.7 min

Discarded = 0.05 cfs @ 12.35 hrs, Volume= 0.070 af Primary = 4.32 cfs @ 12.35 hrs, Volume= 0.304 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 71.04' @ 12.35 hrs Surf.Area= 875 sf Storage= 700 cf

Plug-Flow detention time= 36.9 min calculated for 0.374 af (100% of inflow)

Center-of-Mass det. time= 37.1 min (920.1 - 882.9)

Volume	Invert	Avail.Storage	Storage Description
#1	68.75'	700 cf	60.0" W x 24.0" H Box Pipe Storage
			L= 175.0' S= 0.0005 '/'
			1.750 cf Overall x 40.0% Voids

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016 Page 44

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Device	Routing	Invert	Outlet Devices
#1	Discarded	68.75'	2.410 in/hr Exfiltration over Surface area
			Conductivity to Groundwater Elevation = 0.00'
#2	Primary	71.00'	175.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s)
	-		2.2' Crest Height

Discarded OutFlow Max=0.05 cfs @ 12.35 hrs HW=71.04' (Free Discharge) 1=Exfiltration (Controls 0.05 cfs)

Primary OutFlow Max=4.14 cfs @ 12.35 hrs HW=71.04' (Free Discharge) 2=Sharp-Crested Rectangular Weir (Weir Controls 4.14 cfs @ 0.63 fps)

Summary for Pond 25P: Prop Drainage System "A"

[57] Hint: Peaked at 60.81' (Flood elevation advised)

Inflow Area =	3.617 ac, 31.68% Impervious, Inflow	Depth = 1.13" for 10-Year event
Inflow =	2.77 cfs @ 12.33 hrs, Volume=	0.341 af
Outflow =	2.77 cfs @ 12.33 hrs, Volume=	0.341 af, Atten= 0%, Lag= 0.0 min
Primary =	2.77 cfs @ 12.33 hrs, Volume=	0.341 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 60.81' @ 12.33 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	59.15'	12.0" Round Culvert
			L= 170.0' RCP, groove end projecting, Ke= 0.200
			Inlet / Outlet Invert= 59.15' / 58.70' S= 0.0026 '/' Cc= 0.900
			n= 0.012 Concrete pipe, finished, Flow Area= 0.79 sf

Primary OutFlow Max=2.76 cfs @ 12.33 hrs HW=60.80' (Free Discharge) 1=Culvert (Barrel Controls 2.76 cfs @ 3.51 fps)

Summary for Pond 26P: Infiltration Trench - "5 A"

Inflow Area =	10.668 ac, 3	37.32% Impervious, Inflo	w Depth = 1.32"	for 10-Year event
Inflow =	9.77 cfs @	12.33 hrs, Volume=	1.170 af	
Outflow =	8.86 cfs @	12.35 hrs, Volume=	1.131 af, Atte	en= 9%, Lag= 1.1 min
Discarded =	0.23 cfs @	12.35 hrs, Volume=	0.312 af	_
Primary =	8.63 cfs @	12.35 hrs, Volume=	0.819 af	

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs / 2 Peak Elev= 59.27' @ 12.35 hrs Surf.Area= 4,055 sf Storage= 2,949 cf

Plug-Flow detention time= 73.7 min calculated for 1.131 af (97% of inflow) Center-of-Mass det. time= 55.3 min (941.5 - 886.2)

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 45

Volume	Invert	Avail.Storage	Storage Description
#1	57.25'	3,244 cf	60.0" W x 24.0" H Box Pipe Storage L= 811.0' S= 0.0005 '/' 8,110 cf Overall x 40.0% Voids
Device	Routing	Invert Out	let Devices
#1	Discarded		10 in/hr Exfiltration over Surface area nductivity to Groundwater Elevation = 0.00'
#2	Primary		.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s) Crest Height

Discarded OutFlow Max=0.23 cfs @ 12.35 hrs HW=59.27' (Free Discharge) 1=Exfiltration (Controls 0.23 cfs)

Primary OutFlow Max=8.47 cfs @ 12.35 hrs HW=59.27' (Free Discharge) 2=Sharp-Crested Rectangular Weir (Weir Controls 8.47 cfs @ 0.48 fps)

Summary for Pond 27P: Ex-Outfall 1

[57] Hint: Peaked at 65.60' (Flood elevation advised)

Inflow Area =	8.190 ac, 18.38% Impervious, Inflow	Depth = 0.54 "	for 10-Year event
Inflow =	2.40 cfs @ 12.45 hrs, Volume=	0.365 af	
O (f)	0.40 - (- @ 40.45)/-	0.005 -1. 411	

Outflow = 2.40 cfs @ 12.45 hrs, Volume= 0.365 af, Atten= 0%, Lag= 0.0 min Primary = 2.40 cfs @ 12.45 hrs, Volume= 0.365 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 65.60' @ 12.45 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	64.21'	12.0" Round Culvert
			L= 124.0' RCP, groove end projecting, Ke= 0.200
			Inlet / Outlet Invert= 64.21' / 63.94' S= 0.0022 '/' Cc= 0.900
			n= 0.012 Concrete pipe, finished, Flow Area= 0.79 sf

Primary OutFlow Max=2.40 cfs @ 12.45 hrs HW=65.60' (Free Discharge) 1=Culvert (Barrel Controls 2.40 cfs @ 3.06 fps)

Summary for Pond 34P: Wetland "H"

[81] Warning: Exceeded Pond 27P by 2.23' @ 18.25 hrs

Inflow Area =	88.999 ac,	9.25% Impervious,	Inflow Depth = 0.93" for 10-Year event
Inflow =	25.78 cfs @	12.35 hrs, Volume	= 6.932 af
Outflow =	5.88 cfs @	16.22 hrs, Volume:	= 6.932 af, Atten= 77%, Lag= 232.6 min
Primary =	5.88 cfs @	16.22 hrs, Volume:	= 6.932 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016 Page 46

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Plug-Flow detention time= 250.4 min calculated for 6.924 af (100% of inflow)

Peak Elev= 66.77' @ 16.22 hrs Surf.Area= 222,337 sf Storage= 128,144 cf

Center-of-Mass det. time= 250.5 min (1,176.3 - 925.8)

Volume	Inv	ert Avail.Sto	rage Storage	Description	
#1	63.2	23' 338,18	B1 cf Custon	n Stage Data (Pi	rismatic)Listed below (Recalc)
Elevatio		Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	
63.2	23	1,000	0	0	
64.0	00	8,186	3,537	3,537	
65.0	00	14,900	11,543	15,080	
66.0	00	23,207	19,054	34,133	
67.0	00	283,259	153,233	187,366	
67.5	50	320,000	150,815	338,181	
Device	Routing	Invert	Outlet Device	es	
#1	Primary	63.23'	12.0" Round	d Culvert	
			Inlet / Outlet		/headwall, Ke= 0.200 33.09' S= 0.0020 '/' Cc= 0.900

Primary OutFlow Max=5.88 cfs @ 16.22 hrs HW=66.77' (Free Discharge) 1=Culvert (Barrel Controls 5.88 cfs @ 7.49 fps)

Summary for Pond 42R: EX-CB-3

[57] Hint: Peaked at 61.52' (Flood elevation advised)

[79] Warning: Submerged Pond 3P Primary device # 1 INLET by 1.60'

Inflow Area = 76.806 ac, 18.23% Impervious, Inflow Depth = 0.47" for 10-Year event

Inflow = 11.67 cfs @ 12.55 hrs, Volume= 2.990 af

Outflow = 11.67 cfs @ 12.55 hrs, Volume= 2.990 af, Atten= 0%, Lag= 0.0 min

Primary = 11.67 cfs @ 12.55 hrs, Volume= 2.990 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Peak Elev= 61.52' @ 12.55 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	59.30'	24.0" Round Culvert
			L= 354.0' RCP, groove end projecting, Ke= 0.200
			Inlet / Outlet Invert= 59.30' / 58.75' S= 0.0016 '/' Cc= 0.900
			n= 0.012 Concrete pipe, finished, Flow Area= 3.14 sf

Primary OutFlow Max=11.67 cfs @ 12.55 hrs HW=61.52' (Free Discharge) 1=Culvert (Barrel Controls 11.67 cfs @ 4.17 fps)

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

Page 47

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Summary for Pond 43R: EX-CB-2

[57] Hint: Peaked at 63.26' (Flood elevation advised)

[81] Warning: Exceeded Pond 42R by 1.74' @ 12.55 hrs

[81] Warning: Exceeded Pond 49R by 2.08' @ 12.60 hrs

Inflow Area = 85.468 ac, 20.00% Impervious, Inflow Depth = 0.52" for 10-Year event

Inflow = 17.44 cfs @ 12.55 hrs, Volume= 3.714 af

Outflow = 17.44 cfs @ 12.55 hrs, Volume= 3.714 af, Atten= 0%, Lag= 0.0 min

Primary = 17.44 cfs @ 12.55 hrs, Volume= 3.714 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Peak Elev= 63.26' @ 12.55 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	58.65'	24.0" Round Culvert
	-		L= 409.0' RCP, groove end projecting, Ke= 0.200
			Inlet / Outlet Invert= 58.65' / 58.61' S= 0.0001 '/' Cc= 0.900
			n= 0.012 Concrete pipe, finished, Flow Area= 3.14 sf

Primary OutFlow Max=17.42 cfs @ 12.55 hrs HW=63.26' (Free Discharge)

1=Culvert (Barrel Controls 17.42 cfs @ 5.54 fps)

Summary for Pond 46R: EX-CB-1

[57] Hint: Peaked at 61.36' (Flood elevation advised)

[79] Warning: Submerged Pond 43R Primary device # 1 INLET by 2.71'

Inflow Area = 85.468 ac, 20.00% Impervious, Inflow Depth = 0.52" for 10-Year event

Inflow = 17.44 cfs @ 12.55 hrs, Volume= 3.714 af

Outflow = 17.44 cfs @ 12.55 hrs, Volume= 3.714 af, Atten= 0%, Lag= 0.0 min

Primary = 17.44 cfs @ 12.55 hrs, Volume= 3.714 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Peak Elev= 61.36' @ 12.55 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	58.61'	24.0" Round Culvert
			L= 36.0' RCP, groove end projecting, Ke= 0.200
			Inlet / Outlet Invert= 58.61' / 58.60' S= 0.0003 '/' Cc= 0.900
			n= 0.012 Concrete pipe, finished, Flow Area= 3.14 sf

Primary OutFlow Max=17.40 cfs @ 12.55 hrs HW=61.35' (Free Discharge)

T-1=Culvert (Barrel Controls 17.40 cfs @ 5.54 fps)

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Printed 9/30/2016 Page 48

Summary for Pond 48R: EX-CB-8

[57] Hint: Peaked at 61.03' (Flood elevation advised)

Inflow Area = 5.377 ac, 36.64% Impervious, Inflow Depth = 1.08" for 10-Year event

Inflow = 3.60 cfs @ 12.41 hrs, Volume= 0.482 af

Outflow = 3.60 cfs @ 12.41 hrs, Volume= 0.482 af, Atten= 0%, Lag= 0.0 min

Primary = 3.60 cfs @ 12.41 hrs, Volume= 0.482 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Peak Elev= 61.03' @ 12.41 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	59.86'	18.0" Round Culvert
			L= 364.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 59.86' / 59.06' S= 0.0022 '/' Cc= 0.900
			n= 0.012 Concrete pipe, finished, Flow Area= 1.77 sf

Primary OutFlow Max=3.59 cfs @ 12.41 hrs HW=61.03' (Free Discharge) 1=Culvert (Barrel Controls 3.59 cfs @ 3.36 fps)

Summary for Pond 49R: EX-CB-7

[57] Hint: Peaked at 61.54' (Flood elevation advised)

[81] Warning: Exceeded Pond 48R by 0.57' @ 12.55 hrs

Inflow Area = 8.662 ac, 35.65% Impervious, Inflow Depth = 1.00" for 10-Year event

Inflow = 5.77 cfs @ 12.55 hrs, Volume= 0.724 af

Outflow = 5.77 cfs @ 12.55 hrs, Volume= 0.724 af, Atten= 0%, Lag= 0.0 min

Primary = 5.77 cfs @ 12.55 hrs, Volume= 0.724 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Peak Elev= 61.54' @ 12.55 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	58.96'	18.0" Round Culvert
			L= 425.0' RCP, groove end projecting, Ke= 0.200
			Inlet / Outlet Invert= 58.96' / 58.75' S= 0.0005 '/' Cc= 0.900
			n= 0.012 Concrete pipe, finished, Flow Area= 1.77 sf

Primary OutFlow Max=5.73 cfs @ 12.55 hrs HW=61.53' (Free Discharge) 1=Culvert (Barrel Controls 5.73 cfs @ 3.24 fps)

Summary for Pond 51R: EX-CB-11

[57] Hint: Peaked at 58.91' (Flood elevation advised)

Type III 24-hr 10-Year Rainfall=4.80"

Prepared by Hewlett-Packard Company

Printed 9/30/2016

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 49

Inflow Area = 21.912 ac, 22.13% Impervious, Inflow Depth = 0.72" for 10-Year event

Inflow = 5.44 cfs @ 12.96 hrs, Volume= 1.308 af

Outflow = 5.44 cfs @ 12.96 hrs, Volume= 1.308 af, Atten= 0%, Lag= 0.0 min

Primary = 5.44 cfs @ 12.96 hrs, Volume= 1.308 af

Routing by Stor-Ind method, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs Peak Elev= 58.91' @ 12.96 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	56.83'	18.0" Round Culvert
	-		L= 307.0' RCP, groove end projecting, Ke= 0.200
			Inlet / Outlet Invert= 56.83' / 56.53' S= 0.0010 '/' Cc= 0.900
			n= 0.012 Concrete pipe, finished, Flow Area= 1.77 sf

Primary OutFlow Max=5.43 cfs @ 12.96 hrs HW=58.91' (Free Discharge) 1=Culvert (Barrel Controls 5.43 cfs @ 3.07 fps)

Summary for Link AP-1: Analysis Point #1

Inflow Area = 1,675.825 ac, 10.09% Impervious, Inflow Depth > 1.87" for 10-Year event

Inflow = 398.01 cfs @ 17.58 hrs, Volume= 260.904 af

Primary = 398.01 cfs @ 17.58 hrs, Volume= 260.904 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Summary for Link AP-2: Analysis Point #2

Inflow Area = 114.531 ac, 6.38% Impervious, Inflow Depth = 2.30" for 10-Year event

Inflow = 103.63 cfs @ 12.54 hrs, Volume= 21.942 af

Primary = 103.63 cfs @ 12.54 hrs, Volume= 21.942 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-48.00 hrs, dt= 0.05 hrs

Type III 24-hr 100-Year Rainfall=7.00" Printed 9/30/2016

Runoff Area=3.464 ac 23.70% Impervious Runoff Depth=1.94"

Flow Length=353' Tc=10.0 min CN=53 Runoff=6.19 cfs 0.559 af

103-040-Proposed Drainage

Subcatchment 16S: PROP-RW23-E6

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 1

Post-development

Time span=5.00-48.00 hrs, dt=0.05 hrs, 861 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Reach routing by Stor-In	d+Trans method - Pond routing by Stor-Ind method
Subcatchment1S: PROP-WEST1	Runoff Area=286.694 ac 2.76% Impervious Runoff Depth=3.20" Flow Length=6,115' Tc=90.6 min CN=66 Runoff=321.26 cfs 76.558 af
Subcatchment 2S: PROP-NW2	Runoff Area=29.472 ac 10.76% Impervious Runoff Depth=1.15" Flow Length=2,730' Tc=56.3 min CN=44 Runoff=12.17 cfs 2.836 af
Subcatchment 3S: PROP-SOUTH Flow	Runoff Area=662.283 ac 5.89% Impervious Runoff Depth=4.04" Length=10,096' Tc=125.9 min CN=74 Runoff=754.33 cfs 223.083 af
Subcatchment 4S: PROP-EAST	Runoff Area=243.444 ac 19.98% Impervious Runoff Depth=4.37" Flow Length=5,766' Tc=94.7 min CN=77 Runoff=365.65 cfs 88.569 af
Subcatchment 5S: PROP-NEAST	Runoff Area=121.656 ac 17.92% Impervious Runoff Depth=4.15" Flow Length=4,620' Tc=50.7 min CN=75 Runoff=256.71 cfs 42.067 af
Subcatchment 6S: PROP-NW1	Runoff Area=23.135 ac 5.60% Impervious Runoff Depth=3.51" Flow Length=1,415' Tc=26.5 min CN=69 Runoff=56.70 cfs 6.775 af
Subcatchment7S: PROP-NW3	Runoff Area=23.363 ac 2.88% Impervious Runoff Depth=4.04" Flow Length=1,310' Tc=24.4 min CN=74 Runoff=68.49 cfs 7.870 af
Subcatchment 8S: PROP-NORTH	Runoff Area=64.926 ac 7.58% Impervious Runoff Depth=4.47" Flow Length=2,892' Tc=69.3 min CN=78 Runoff=122.24 cfs 24.211 af
Subcatchment 9S: PROP-WEST2	Runoff Area=141.341 ac 10.61% Impervious Runoff Depth=2.70" Flow Length=4,198' Tc=55.7 min CN=61 Runoff=178.23 cfs 31.825 af
Subcatchment 10S: PROP-RW23-W1	Runoff Area=11.251 ac 37.77% Impervious Runoff Depth=2.70" Flow Length=336' Tc=31.7 min CN=61 Runoff=19.10 cfs 2.533 af
Subcatchment11S: PROP-RW5-E1	Runoff Area=21.912 ac 22.13% Impervious Runoff Depth=1.85" Flow Length=1,467' Tc=45.1 min CN=52 Runoff=19.68 cfs 3.372 af
Subcatchment 12S: PROP-RW23-E4	Runoff Area=10.361 ac 36.22% Impervious Runoff Depth=2.60" Flow Length=336' Tc=28.6 min CN=60 Runoff=17.63 cfs 2.248 af
Subcatchment 13S: PROP-RW23-W2	Runoff Area=3.107 ac 13.45% Impervious Runoff Depth=3.10" Flow Length=431' Tc=26.1 min CN=65 Runoff=6.70 cfs 0.803 af
Subcatchment14S: PROP-RW23-E2	Runoff Area=22.469 ac 9.29% Impervious Runoff Depth=2.80" Flow Length=1,209' Tc=18.8 min CN=62 Runoff=49.66 cfs 5.245 af
Subcatchment 15S: PROP-RW23-E3	Runoff Area=9.450 ac 11.30% Impervious Runoff Depth=1.32" Flow Length=1,277' Tc=70.0 min CN=46 Runoff=4.14 cfs 1.040 af

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

ware Solutions LLC Page 2

Subcatchment 17S: PROP-RW23-E5

Runoff Area=4.091 ac 30.73% Impervious Runoff Depth=2.31"

Flow Length=2,359' Tc=34.9 min CN=57 Runoff=5.53 cfs 0.789 af

Subcatchment 18S: PROP-RW5-E2

Runoff Area=3.285 ac 34.03% Impervious Runoff Depth=2.51"

Flow Length=387' Tc=42.5 min CN=59 Runoff=4.43 cfs 0.686 af

Subcatchment 19S: PROP-TWA-E1

Runoff Area=2.423 ac 46.35% Impervious Runoff Depth=3.20"

Flow Length=322' Tc=21.8 min CN=66 Runoff=5.85 cfs 0.647 af

Subcatchment 20S: PROP-RW5-E3 Runoff Area=3.245 ac 41.11% Impervious Runoff Depth=2.90" Flow Length=203' Slope=0.0133 '/' Tc=20.8 min CN=63 Runoff=7.15 cfs 0.784 af

Subcatchment 21S: PROP-RW5-E5

Runoff Area=2.132 ac 29.83% Impervious Runoff Depth=2.31"

Flow Length=1,056' Tc=46.6 min CN=57 Runoff=2.49 cfs 0.411 af

Subcatchment 22S: PROP-TWA-E2

Runoff Area=1.194 ac 1.93% Impervious Runoff Depth=0.84"

Flow Length=338' Tc=21.4 min CN=40 Runoff=0.47 cfs 0.084 af

Subcatchment 24S: PROP-RW23-W3

Runoff Area=20.185 ac 4.44% Impervious Runoff Depth=0.92"
Flow Length=2,853' Tc=57.2 min CN=41 Runoff=5.82 cfs 1.544 af

Subcatchment 25S: PROP-RW5-W1

Runoff Area=10.668 ac 37.32% Impervious Runoff Depth=2.80"
Flow Length=210' Tc=21.1 min CN=62 Runoff=22.48 cfs 2.490 af

Subcatchment 26S: PROP-TWA-W1

Runoff Area=4.726 ac 14.47% Impervious Runoff Depth=1.49"
Flow Length=595' Tc=17.6 min CN=48 Runoff=4.81 cfs 0.587 af

Subcatchment 32S: PROP-RW23-E1 Runoff Area=48.890 ac 7.30% Impervious Runoff Depth=2.22" Flow Length=2,965' Tc=67.6 min CN=56 Runoff=43.30 cfs 9.037 af

Subcatchment 33S: PROP-RW5-W2

Runoff Area=1.446 ac 46.96% Impervious Runoff Depth=3.31"
Flow Length=1,182' Tc=35.4 min CN=67 Runoff=2.91 cfs 0.398 af

Subcatchment 36S: PROP-32N-1Runoff Area=9.743 ac 14.47% Impervious Runoff Depth=1.49"
Flow Length=1,616' Slope=0.0100 '/' Tc=19.2 min CN=48 Runoff=9.63 cfs 1.211 af

Reach 10R: EAST DITCH - NORTH Avg. Flow Depth=3.03' Max Vel=2.99 fps Inflow=196.23 cfs 42.067 af n=0.025 L=3,667.0' S=0.0009 '/' Capacity=291.82 cfs Outflow=172.71 cfs 42.064 af

Reach 15R: WetlandsAvg. Flow Depth=1.06' Max Vel=2.20 fps Inflow=9.18 cfs 3.372 af n=0.050 L=413.0' S=0.0097'/' Capacity=82.03 cfs Outflow=9.18 cfs 3.372 af

Reach 17R: Drainage ChannelAvg. Flow Depth=0.57' Max Vel=1.96 fps Inflow=5.09 cfs 0.555 af n=0.030 L=281.0' S=0.0061 '/' Capacity=81.66 cfs Outflow=4.72 cfs 0.555 af

Reach 18R: Drainage ChannelAvg. Flow Depth=0.63' Max Vel=2.09 fps Inflow=6.16 cfs 0.530 af n=0.030 L=281.0' S=0.0061 '/' Capacity=81.66 cfs Outflow=5.83 cfs 0.530 af

Reach 24R: Drainage ChannelAvg. Flow Depth=0.48' Max Vel=1.71 fps Inflow=5.82 cfs 1.544 af n=0.025 L=2,354.0' S=0.0032 '/' Capacity=20.34 cfs Outflow=4.89 cfs 1.544 af

Printed 9/30/2016

103-040-Proposed Drainage

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 3

Reach 27R: West DitchAvg. Flow Depth=10.20' Max Vel=1.17 fps Inflow=236.21 cfs 45.068 af n=0.050 L=531.0' S=0.0003 '/' Capacity=53.46 cfs Outflow=227.67 cfs 45.068 af

Reach 28R: EAST DITCH TOAvg. Flow Depth=8.29' Max Vel=4.10 fps Inflow=678.67 cfs 420.209 af n=0.050 L=1,705.0' S=0.0030 '/' Capacity=284.51 cfs Outflow=677.51 cfs 420.162 af

Reach 29R: Paskamansett River Avg. Flow Depth=22.67' Max Vel=0.98 fps Inflow=737.68 cfs 496.720 af n=0.035 L=1,905.0' S=0.0001 '/' Capacity=103.50 cfs Outflow=710.66 cfs 496.421 af

Reach 30R: Culvert 1 Avg. Flow Depth=2.93' Max Vel=8.68 fps Inflow=190.66 cfs 148.914 af 90.0" x 45.0" Box Pipe n=0.015 L=48.0' S=0.0040 '/' Capacity=203.41 cfs Outflow=190.66 cfs 148.914 af

Reach 31R: EAST DITCH - NORTH Avg. Flow Depth=68.46' Max Vel=0.48 fps Inflow=921.66 cfs 375.368 af n=0.050 L=2,413.0' S=0.0000 '/' Capacity=18.43 cfs Outflow=642.16 cfs 375.141 af

Reach 34R: Drainage ChannelAvg. Flow Depth=0.30' Max Vel=3.51 fps Inflow=5.53 cfs 0.789 af n=0.025 L=331.0' S=0.0230'/ Capacity=240.18 cfs Outflow=5.51 cfs 0.789 af

Reach 37R: Drainage ChannelAvg. Flow Depth=1.26' Max Vel=0.91 fps Inflow=17.22 cfs 1.710 af n=0.080 L=1,795.0' S=0.0035 '/' Capacity=6.58 cfs Outflow=10.10 cfs 1.709 af

Reach 38R: Drainage System "C"Avg. Flow Depth=1.00' Max Vel=2.43 fps Inflow=9.63 cfs 1.211 af 12.0" Round Pipe n=0.012 L=796.0' S=0.0019 '/' Capacity=1.68 cfs Outflow=1.68 cfs 1.211 af

Reach 39R: EAST DITCH - N2Avg. Flow Depth=0.69' Max Vel=0.58 fps Inflow=1.68 cfs 1.211 af n=0.050 L=2,017.0' S=0.0011 '/' Capacity=68.77 cfs Outflow=1.68 cfs 1.210 af

Reach 41R: Drainage System "B"Avg. Flow Depth=1.64' Max Vel=6.69 fps Inflow=37.37 cfs 17.070 af 36.0" Round Pipe n=0.012 L=1,593.0' S=0.0040 '/' Capacity=45.62 cfs Outflow=26.35 cfs 17.070 af

Reach 45R: Drainage ChannelAvg. Flow Depth=0.92' Max Vel=2.34 fps Inflow=22.35 cfs 2.183 af n=0.025 L=2,480.0' S=0.0030 '/' Capacity=86.58 cfs Outflow=16.55 cfs 2.183 af

Reach 47R: Drainage ChannelAvg. Flow Depth=0.53' Max Vel=2.17 fps Inflow=7.24 cfs 0.709 af n=0.025 L=170.0' S=0.0047 '/' Capacity=108.73 cfs Outflow=7.02 cfs 0.709 af

Pond 1P: Wetland "P" Peak Elev=60.28' Storage=2,040,346 cf Inflow=521.79 cfs 148.914 af 90.0" x 45.0" Box Culvert n=0.015 L=1.0' S=0.0000 '/' Outflow=190.66 cfs 148.914 af

Pond 1R: EX-CB-9 Peak Elev=63.39' Inflow=5.51 cfs 0.789 af 18.0" Round Culvert n=0.012 L=425.0' S=0.0022 '/' Outflow=5.51 cfs 0.789 af

Pond 2P: Wetland "K"Peak Elev=62.18' Storage=391,393 cf Inflow=256.71 cfs 42.067 af

Outflow=196.23 cfs 42.067 af

Pond 3P: EX-DMH-1 Peak Elev=67.88' Inflow=30.90 cfs 8.926 af

24.0" Round Culvert n=0.012 L=293.0' S=0.0018 '/' Outflow=30.90 cfs 8.926 af

Pond 4P: Infiltration Trench "23 C" Peak Elev=78.31' Storage=14 cf Inflow=49.66 cfs 5.245 af Discarded=0.01 cfs 0.002 af Primary=49.65 cfs 5.242 af Outflow=49.66 cfs 5.245 af

Prepared by Hewlett-Packard Company

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solutions LLC

Page 4

Peak Elev=68.63' Inflow=30.90 cfs 8.926 af Pond 5P: EX-CB-4

24.0" Round Culvert n=0.012 L=308.0' S=0.0018 '/' Outflow=30.90 cfs 8.926 af

Pond 6P: Infiltration Trench "23 C" Peak Elev=70.77' Storage=4,492 cf Inflow=17.63 cfs 2.248 af

Discarded=0.41 cfs 0.549 af Primary=17.22 cfs 1.710 af Outflow=17.63 cfs 2.259 af

Peak Elev=71.31' Inflow=18.77 cfs 5.301 af Pond 7P: EX-CB-5

18.0" Round Culvert n=0.012 L=250.0' S=0.0022 '/' Outflow=18.77 cfs 5.301 af

Peak Elev=65.61' Inflow=10.10 cfs 1.709 af Pond 8P: EX-CB-6

18.0" Round Culvert n=0.012 L=250.0' S=0.0022 '/' Outflow=10.10 cfs 1.709 af

Peak Elev=71.79' Inflow=4.44 cfs 0.975 af Pond 9P: Ex-Outfall 2

12.0" Round Culvert n=0.012 L=107.0' S=0.0140 '/' Outflow=4.44 cfs 0.975 af

Peak Elev=67.65' Inflow=10.10 cfs 1.709 af Pond 10P: EX-CB-10

18.0" Round Culvert n=0.012 L=425.0' S=0.0022 '/' Outflow=10.10 cfs 1.709 af

Pond 11P: Infiltration Trench - "23 A" Peak Elev=71.02' Storage=4,509 cf Inflow=19.10 cfs 2.533 af

Discarded=0.35 cfs 0.496 af Primary=18.77 cfs 2.048 af Outflow=19.12 cfs 2.544 af

Pond 12P: Infiltration Trench "A-A" Peak Elev=67.30' Storage=143 cf Inflow=6.19 cfs 0.559 af

Discarded=0.02 cfs 0.030 af Primary=6.16 cfs 0.530 af Outflow=6.18 cfs 0.559 af

Pond 13P: Infield Storage Area Peak Elev=60.49' Storage=27,236 cf Inflow=19.68 cfs 3.372 af

Outflow=9.18 cfs 3.372 af

Pond 15P: Infiltration Trench "A-B" Peak Elev=68.26' Storage=125 cf Inflow=4.81 cfs 0.587 af

Discarded=0.03 cfs 0.032 af Primary=5.09 cfs 0.555 af Outflow=5.12 cfs 0.587 af

Pond 16P: Infiltration Trench "A-C" Peak Elev=74.01' Storage=247 cf Inflow=4.14 cfs 1.040 af

Discarded=0.05 cfs 0.065 af Primary=4.44 cfs 0.975 af Outflow=4.49 cfs 1.040 af

Pond 19P: Infiltration Trench "5 D" Peak Elev=71.04' Storage=653 cf Inflow=4.43 cfs 0.686 af

Discarded=0.05 cfs 0.069 af Primary=5.00 cfs 0.617 af Outflow=5.05 cfs 0.686 af

Pond 21P: Infiltration Trench "5 E" Peak Elev=71.05' Storage=700 cf Inflow=7.15 cfs 0.784 af

Discarded=0.05 cfs 0.076 af Primary=7.24 cfs 0.709 af Outflow=7.29 cfs 0.784 af

Peak Elev=65.32' Inflow=6.23 cfs 0.731 af Pond 25P: Prop Drainage System "A"

12.0" Round Culvert n=0.012 L=170.0' S=0.0026 '/' Outflow=6.23 cfs 0.731 af

Pond 26P: Infiltration Trench - "5 A" Peak Elev=59.29' Storage=2,978 cf Inflow=22.48 cfs 2.490 af

Discarded=0.23 cfs 0.336 af Primary=22.35 cfs 2.183 af Outflow=22.58 cfs 2.519 af

Peak Elev=75.45' Inflow=9.61 cfs 1.085 af Pond 27P: Ex-Outfall 1

12.0" Round Culvert n=0.012 L=124.0' S=0.0022 '/' Outflow=9.61 cfs 1.085 af

Pond 34P: Wetland "H" Peak Elev=167.42' Storage=338,181 cf Inflow=69.63 cfs 16.339 af

12.0" Round Culvert n=0.012 L=70.0' S=0.0020 '/' Outflow=36.56 cfs 16.339 af

HydroCAD® 10.00-14 s/n 06680 © 2015 HydroCAD Software Solo Pond 42R: EX-CB-3	utions LLC Page 5 Peak Elev=69.64' Inflow=33.76 cfs 9.324 af	
Prepared by Hewlett-Packard Company	Printed 9/30/2016	
103-040-Proposed Drainage	Post-development "7.00 III 24-hr 100-Year Rainfall	

Inflow=193.82 cfs 39.659 af Primary=193.82 cfs 39.659 af

Pond 42R: EX-CB-3	Peak Elev=69.64' Inflow=33.76 cfs 9.324 af
	24.0" Round Culvert n=0.012 L=354.0' S=0.0016 '/' Outflow=33.76 cfs 9.324 af
Pond 43R: EX-CB-2	Peak Elev=78.91' Inflow=45.81 cfs 11.061 af
	24.0" Round Culvert n=0.012 L=409.0' S=0.0001 '/' Outflow=45.81 cfs 11.061 af
Pond 46R: EX-CB-1	Peak Elev=65.82' Inflow=45.81 cfs 11.061 af
	24.0" Round Culvert n=0.012 L=36.0' S=0.0003 '/' Outflow=45.81 cfs 11.061 af
Pond 48R: EX-CB-8	Peak Elev=63.03' Inflow=8.50 cfs 1.120 af
	18.0" Round Culvert n=0.012 L=364.0' S=0.0022 '/' Outflow=8.50 cfs 1.120 af
Pond 49R: EX-CB-7	Peak Elev=66.44' Inflow=12.62 cfs 1.736 af
	18.0" Round Culvert n=0.012 L=425.0' S=0.0005 '/' Outflow=12.62 cfs 1.736 af
Pond 51R: EX-CB-11	Peak Elev=60.54' Inflow=9.18 cfs 3.372 af
	18.0" Round Culvert n=0.012 L=307.0' S=0.0010 '/' Outflow=9.18 cfs 3.372 af
Link AP-1: Analysis Point #	Inflow=710.66 cfs 496.421 af
,	Primary=710.66 cfs 496.421 af

Link AP-2: Analysis Point #2

Total Runoff Area = 1,790.356 ac Runoff Volume = 538.261 af Average Runoff Depth = 3.61" 90.15% Pervious = 1,613.970 ac 9.85% Impervious = 176.386 ac

APPENDIX C

TSS REMOVAL CALCULATIONS

1. In BMP Column, click on Blue Cell to Activate Drop Down Menu

2. Select BMP from Drop Down Menu

3. After BMP is selected, TSS Removal and other Columns are automatically completed.

Separate Form Needs to be Completed for Each Remaining **Outlet or BMP Train** Load (D-E) Equals remaining load from previous BMP (E) 0.28 0.28 0.28 0.28 0.55 Removed (C*D) which enters the BMP Amount 0.45 0.28 0.00 0.00 0.00 73% Ш Total TSS Removal = Starting TSS Load* 1.00 0.55 0.28 0.28 0.28 TSS Removal Project: New Bedford Regional Airport Prepared By: Mark K. Ottariano Rate 0.45 0.50 0.00 0.00 0.00 Location: PROP-WEST2 Date: 31-0ct-16 Vegetated Filter Strip >50 **Grass Channel** BMP¹ feet മ Calculation Worksheet **ISS Removal**

1. From MassDEP Stormwater Handbook Vol. 1 must be used if Proprietary BMP Proposed Non-automated TSS Calculation Sheet

- In BMP Column, click on Blue Cell to Activate Drop Down Menu
 Select BMP from Drop Down Menu
 After BMP is selected, TSS Removal and other Columns are automatically completed.

		gi (∷						eds to Each in			
	ш	Remaining Load (D-E)	0.55	0.28	0.28	0.28	0.28	Separate Form Needs to be Completed for Each Outlet or BMP Train		revious BMP (E)	
	ш	Amount Removed (C*D)	0.45	0.28	0.00	0.00	0.00	73%		*Equals remaining load from previous BMP (E)	which enters the BMP
	۵	Starting TSS Load*	1.00	0.55	0.28	0.28	0.28	Total TSS Removal =	_		
PROP-NW2	O	TSS Removal Rate ¹	0.45	0.50	0.00	0.00	0.00	Total T	Project: New Bedford Regional Airport	Mark K. Ottariano	Date: 31-0ct-16
Location: PROP-NW2	Ф	BMP ¹	Vegetated Filter Strip >50 feet	Grass Channel					Project:	Prepared By: Mark K. Ottariano	Date:
			1991		məЯ W no	SST itsluc	Calo				

INSTRUCTIONS:

- In BMP Column, click on Blue Cell to Activate Drop Down Menu
 Select BMP from Drop Down Menu
 After BMP is selected, TSS Removal and other Columns are automatically completed.

		IL.	Remaining	0.55	0.28	0.28	0.28	0.28	Separate Form Needs to be Completed for Each Outlet or BMP Train		MP (E)	
			Ren						Separate Form Need be Completed for Ea	1	m previous Bľ	
		Ш	Amount Removed (C*D)	0.45	0.28	0.00	0.00	0.00	73%		*Equals remaining load from previous BMP (E)	which enters the BMP
		۵	Starting TSS	1.00	0.55	0.28	0.28	0.28	Total TSS Removal =			
	Location: PROR-RW23-W1	O	TSS Removal Rate ¹	0.45	0.50	0.00	0.00	0.00	Total T	Project: New Bedford Regional Airport	Prepared By: Mark K. Ottariano	Date: 31-0ct-16
•	Location:	Δ	BMP ¹	Vegetated Filter Strip >50 feet	Grass Channel					Project:	Prepared By:	Date:
				1991	oval orksh	Mem W no		Calo				

Non-automated TSS Calculation Sheet must be used if Proprietary BMP Proposed 1. From MassDEP Stormwater Handbook Vol. 1

Mass. Dept. of Environmental Protection

- In BMP Column, click on Blue Cell to Activate Drop Down Menu
 Select BMP from Drop Down Menu
 After BMP is selected, TSS Removal and other Columns are automatically completed.

	L	_	:"U) Load (U-E)	0.55	0.28	0.28	0.28	0.28	Separate Form Needs to be Completed for Each Outlet or BMP Train		*Equals remaining load from previous BMP (E)	<u>a</u>
	Ш	Amount	Kemoved (C゚D)	0.45	0.28	0.00	0.00	0.00	73%		*Equals remaining lo	which enters the BMP
	۵	Starting TSS	Load	1.00	0.55	0.28	0.28	0.28	Total TSS Removal =			
PROP-RW23-E5	O	TSS Removal	Kate	0.45	0.50	0.00	0.00	0.00	Total T	Project: New Bedford Regional Airport	Mark K. Ottariano	31-Oct-16
Location: PROP-RW2	Ф	0	BIMIR	Vegetated Filter Strip >50 feet	Grass Channel					Project:	Prepared By: Mark K. Otta	Date:
				jəəl		Mem W no	SST itsluc	Olso				

- In BMP Column, click on Blue Cell to Activate Drop Down Menu
 Select BMP from Drop Down Menu
 After BMP is selected, TSS Removal and other Columns are automatically completed.

	Ш	Amount Remaining Removed (C*D) Load (D-E)		0.28	0.00	0.00	0.00	Separate Form Needs to be Completed for Each 73% Outlet or BMP Train		*Equals remaining load from previous BMP (E)	which enters the BMP
	۵	TSS 1*		0.55	0.28	0.28	0.28	Total TSS Removal =		*Equ	which
PROP-RW23-E6	O	TSS Removal Rate ¹	0.45	0.50	0.00	0.00	0.00	Total TS	Project: New Bedford Regional Airport	Mark K. Ottariano	31-Oct-16
Location: PROP-RW2	Δ	BMP ¹	Vegetated Filter Strip >50 feet	Grass Channel					Project:	Prepared By:	
			199 (MeM W no	SST itsluc	Calo	ı			

- In BMP Column, click on Blue Cell to Activate Drop Down Menu
 Select BMP from Drop Down Menu
 After BMP is selected, TSS Removal and other Columns are automatically completed.

	Ш		Removed (C*D) Load (D-E)	0.45	0.28	0.00	0.00	0.00	Separate Form Needs to be Completed for Each 73% Outlet or BMP Train		*Equals remaining load from previous BMP (E)	which enters the BMP
	۵	SS	Load* R	1.00	0.55	0.28	0.28	0.28	Total TSS Removal =		*Equ	whic
Location: PROP-RW23-E1	O	TSS Removal	Rate	0.45	0.50	0.00	0.00	0.00	Total TS	Project: New Bedford Regional Airport	Mark K. Ottariano	Date: 31-0ct-16
Location:	Δ	7	BMP	Vegetated Filter Strip >50 feet	Grass Channel					Project:	Prepared By:	Date:
			Ľ	ຸງອອເ		Mem W no	SST italuc	Calo	I			

- In BMP Column, click on Blue Cell to Activate Drop Down Menu
 Select BMP from Drop Down Menu
 After BMP is selected, TSS Removal and other Columns are automatically completed.

					eds to Each in			
0.55	0.28	0.28	0.28	0.28	Separate Form Ned be Completed for I Outlet or BMP Trai	ī.	n previous BMP (E)	
0.45	0.28	0:00	0.00	0.00	73%		*Equals remaining load fron	which enters the BMP
1.00	0.55	0.28	0.28	0.28	-SS Removal =			
0.45	0.50	0.00	0.00	0.00	Total 1	New Bedford Regional Airport	Mark K. Ottariano	Date: 31-0ct-16
Vegetated Filter Strip >50 feet	Grass Channel					Project:	Prepared By:	Date:
ງອອເ				Calo				
	Vegetated Filter Strip >500.451.000.45	Cegetated Filter Strip >50 0.45 1.00 0.45 Channel 0.50 0.55 0.28	Control Control <t< th=""><th>Vegetated Filter Strip >50 0.45 1.00 0.45 Grass Channel 0.50 0.28 0.00 Grass Channel 0.00 0.28 0.00 0.00 0.28 0.00 0.00</th><th>Vegetated Filter Strip > 50 0.45 1.00 0.45 Carss Channel 0.50 0.55 0.28 0.00 Calculation 0.00 0.28 0.00 0.00 Calculation 0.00 0.28 0.00 0.00</th><th>Crass Channel 0.00 0.28 0.00 0.00 0.00 0.00 Separate Pec Compte Compt</th><th> Vegetated Filter Strip > 50 0.45 1.00 0.45 1.00 0.45 1.00 0.45 1.00 0.45 1.00 0.28 0.00 0.28 0.00 0.28 0.00 0.00</th><th> Vegetated Filter Strip >50 0.45 1.00 0.45 Solution Crass Channel 0.50 0.28 0.00 Solution Company C</th></t<>	Vegetated Filter Strip >50 0.45 1.00 0.45 Grass Channel 0.50 0.28 0.00 Grass Channel 0.00 0.28 0.00 0.00 0.28 0.00 0.00	Vegetated Filter Strip > 50 0.45 1.00 0.45 Carss Channel 0.50 0.55 0.28 0.00 Calculation 0.00 0.28 0.00 0.00 Calculation 0.00 0.28 0.00 0.00	Crass Channel 0.00 0.28 0.00 0.00 0.00 0.00 Separate Pec Compte Compt	Vegetated Filter Strip > 50 0.45 1.00 0.45 1.00 0.45 1.00 0.45 1.00 0.45 1.00 0.28 0.00 0.28 0.00 0.28 0.00 0.00	Vegetated Filter Strip >50 0.45 1.00 0.45 Solution Crass Channel 0.50 0.28 0.00 Solution Company C

- In BMP Column, click on Blue Cell to Activate Drop Down Menu
 Select BMP from Drop Down Menu
 After BMP is selected, TSS Removal and other Columns are automatically completed.

	ட	Remaining	Load (D-E)	0.55	0.28	0.28	0.28	0.28	Separate Form Needs to be Completed for Each Outlet or BMP Train	=	previous BMP (E)	
	ш	Amount	Removed (C*D)	0.45	0.28	0.00	0.00	0.00	73%		*Equals remaining load from previous BMP (E)	which enters the BMP
	Ω	Starting TSS	Load*	1.00	0.55	0.28	0.28	0.28	Total TSS Removal =	<u>-</u>		
Location: PROP-NEAST	O	TSS Removal	Rate ¹	0.45	0.50	0.00	0.00	0.00	Total T	Project: New Bedford Regional Airport	Mark K. Ottariano	31-Oct-16
Location: I	Ф		BMP ¹	Vegetated Filter Strip >50 feet	Grass Channel					Project:	Prepared By:	Date:
			l			M no	TSS italuc	OlsO	I			

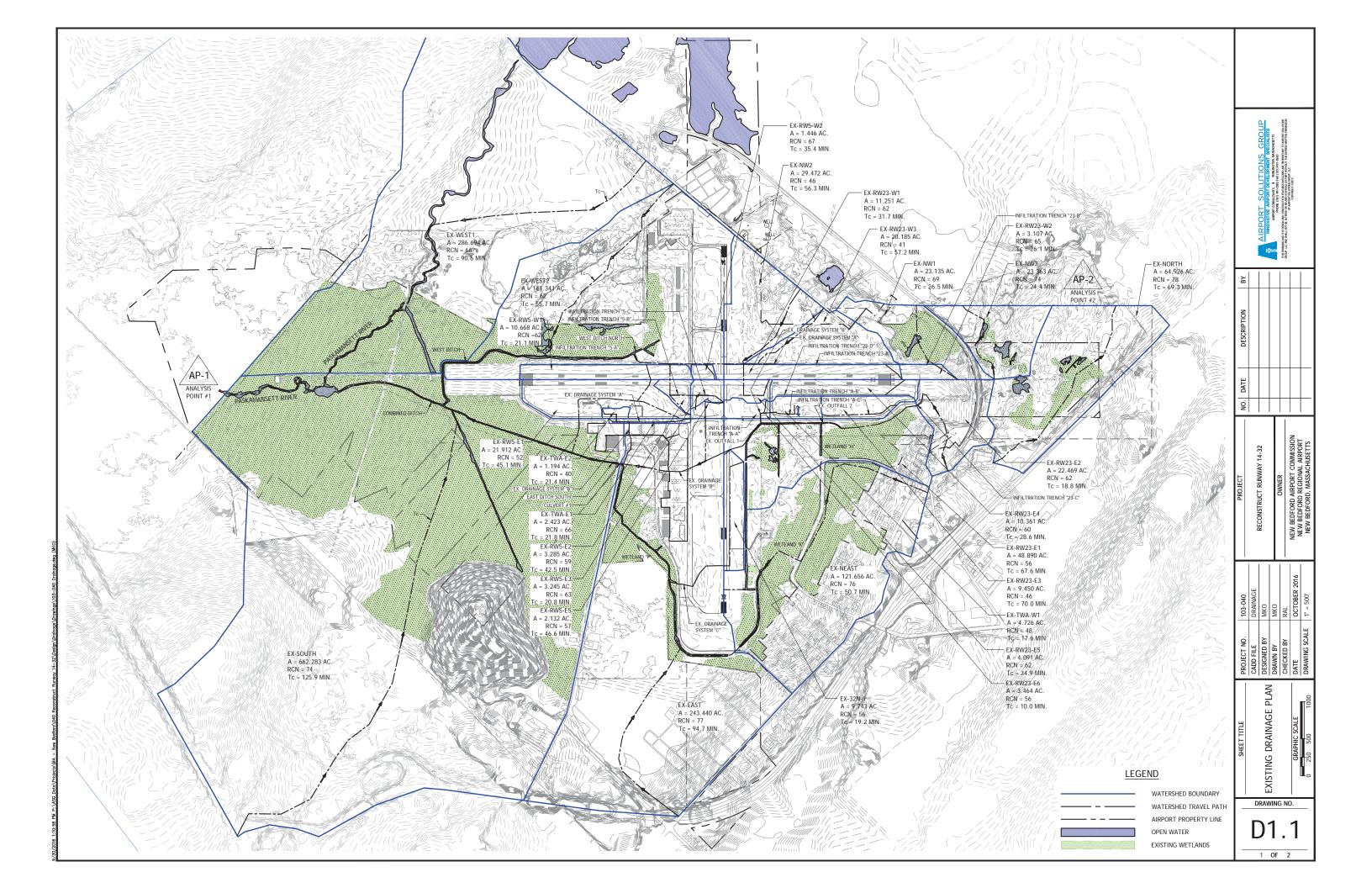
- In BMP Column, click on Blue Cell to Activate Drop Down Menu
 Select BMP from Drop Down Menu
 After BMP is selected, TSS Removal and other Columns are automatically completed.

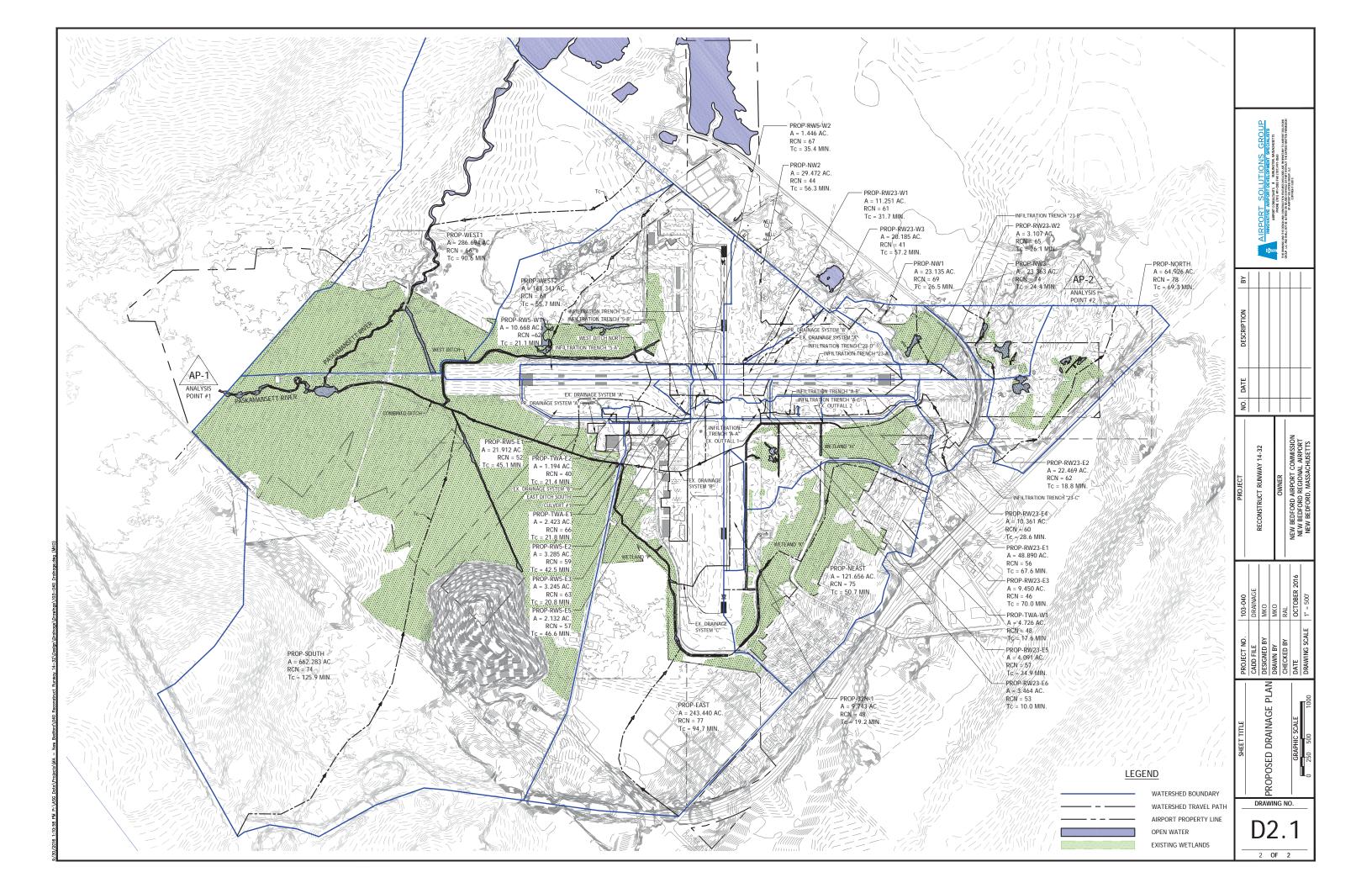
		ning J-E)						Needs to or Each Frain		E)	
	L	Remaining Load (D-E)	0.55	0.28	0.28	0.28	0.28	Separate Form Needs to be Completed for Each Outlet or BMP Train		previous BMP (
	ш	Amount Removed (C*D)	0.45	0.28	0.00	0.00	0.00	%£Z		*Equals remaining load from previous BMP (E)	which enters the BMP
	۵	Starting TSS Load*	1.00	0.55	0.28	0.28	0.28	Total TSS Removal =			
PROP-EAST	O	TSS Removal Rate ¹	0.45	0.50	0.00	0.00	0.00	Total T	Project: New Bedford Regional Airport	Mark K. Ottariano	Date: 31-0ct-16
Location: PROP-EAST	Ф	BMP¹	Vegetated Filter Strip >50 feet	Grass Channel					Project:	Prepared By:	Date:
		•	1991		Mem W no	SST italuc	OlsO				

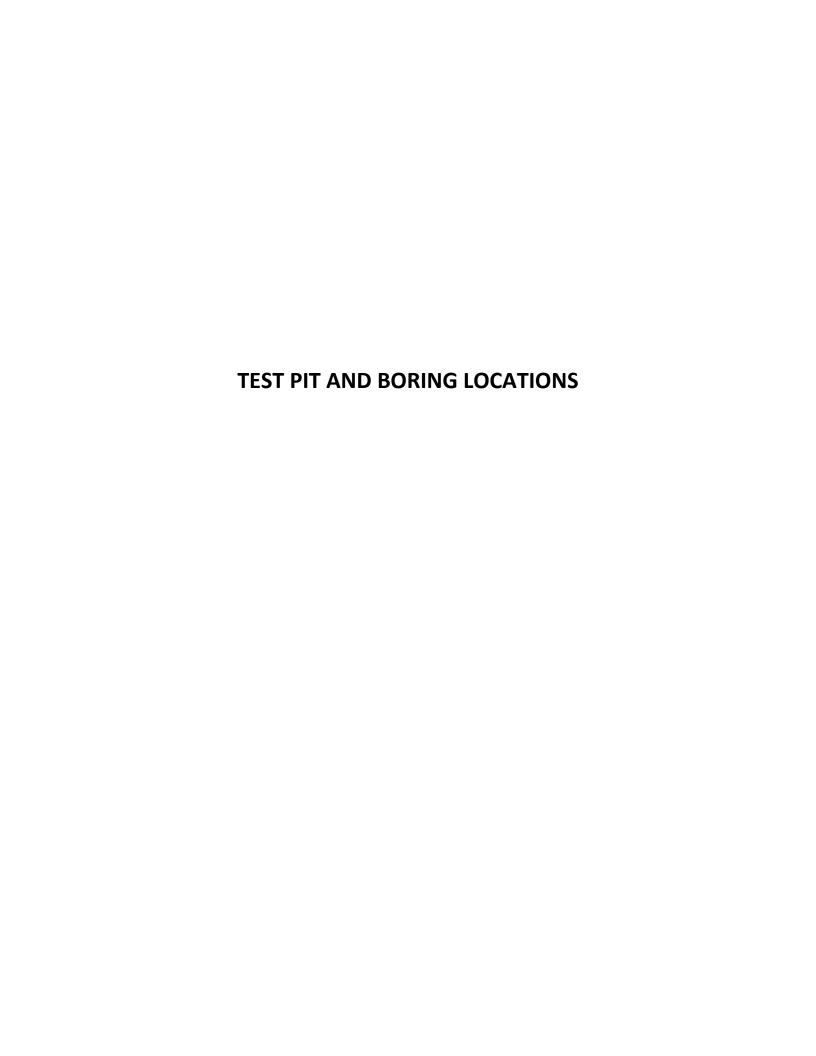
APPENDIX D

EXHIBITS









STORMWATER OPERATIONS AND MAINTENANCE PLAN



NEW BEDFORD REGIONAL AIRPORT NEW BEDFORD, MASSACHUSETTS

STORMWATER MANAGEMENT SYSTEM OPERATION AND MAINTENANCE PLAN

City of New Bedford

OCTOBER 2016





Prepared For:

City of New Bedford Airport Commission 1569 Airport Road New Bedford, Massachusetts

Prepared By:

Airport Solutions Group 39 Winn Street Burlington, Massachusetts (P) 780.491.0083





Table of Contents

1.	Introduction	1
2.	Purpose and Need	1
3.	Stormwater Management System Owner	2
4.	Parties Responsible for Operation and Maintenance	2
5.	Routine and Non-Routine Maintenance Tasks	2
6.	Plan of Stormwater BMP's	7
7.	Public Safety Features	7
8.	Estimated Operations and Maintenance Budget	8
9.	O & M Compliance Statement	8
10.	Maintenance Log Book	8
11.	Snow Removal	9
12.	Pollution Prevention	9
Stor	rmwater Management System Plans	Appendix A
ВМІ	P Specifications Massachusetts Stormwater Management Policy	Appendix B
Stor	rmwater Management Review Reports	Appendix C

1. Introduction

The New Bedford Regional Airport, owned and operated by the City of New Bedford through the New Bedford Airport Commission, is located in southeastern Massachusetts approximately fifty-five miles south of Boston. The airport just completed a multiphase project to improve the safety of Runway 5-23, its main runway. Included in that project was the rebuilding of the existing stormwater management system associated with Runway 5-23. The Airport recently reconstructed Taxiway A (the Airport's main parallel taxiway) which included a closed drainage system to capture and treat stormwater runoff before it is discharged into the existing drainage system and also reused existing outfalls to drain the taxiway. The Operation and Maintenance Plan was updated during the design process for Taxiway A. The Plan is being updated again as a result of another Airport project. The Airport wishes to reconstruct it's crosswind runway, Runway 14-32, and as part of this project new stormwater BMPs will be constructed.

Pursuant to New Bedford Regional Airport Massachusetts Department of Environmental Protection (MassDEP) Wetland Variance Decision / Order of Conditions (DEP file no: SE-049-0635) and Stormwater Standard No. 9 of the MassDEP's Stormwater Management Policy, with any new development or redevelopment, "a Long-Term Operation and Maintenance (O&M) Plan shall be developed and implemented to ensure that stormwater management systems function by design." Moreover, Special Condition 58 of the Variance requires the following:

Post Construction Stormwater Operation and Maintenance Plan: A written operation and maintenance plan (O/M Plan) shall be submitted by Applicant to MassDEP for its review and written approval for all post construction man-made stormwater structures including, but not limited to, extended detention basins, water quality swales, deep sump catch basins, pipes, and outlets. Said O/M Plan shall include a schedule for implementation and shall be provided to the Commission for review and to MassDEP for review and written approval at least ninety (90) days prior to disturbance of any Resource Area or BZ

The airport, and any future responsible parties, shall be accountable for implementing this plan following the completion of the project's construction and the termination of the contractor's interim Storm Water Pollution Prevention Plan (SWPPP) per the National Pollutant Discharge Elimination System (NPDES) General Permit.

2. Purpose and Need

This document prescribes the methods required for the New Bedford Regional Airport to properly maintain the airport-wide stormwater management system. A program of regular stormwater drainage system field reviews and assessments, scheduled maintenance and repairs, as-needed, will be necessary. The program will be conducted by trained airport staff and/or licensed contractors, as required, familiar with the airport facility.

Included in this document is a list of Best Management Practices (BMP's) incorporated into the design of the stormwater management system, a summary of requirements and procedures for reviewing the BMP's, and a drainage system review checklist. It is understood that documentation of routine and non-routine maintenance of the system is not only required by the Massachusetts Stormwater Regulations, but is an important tool for the airport to access future maintenance requirements and improvements.

3. Stormwater Management System Owner

The New Bedford Regional Airport is publicly owned by the City of New Bedford, Massachusetts under the care, custody, and control of the New Bedford Airport Commission. The Airport Commission currently appoints a full time Airport Manager who is responsible for the management and operation of the airport.

New Bedford Regional Airport Commission 1569 Airport Road New Bedford, MA 02746 Phone: 508.991.6161

Airport Manager New Bedford Regional Airport 1569 Airport Road New Bedford, MA 02746

4. Parties Responsible for Operation and Maintenance

The New Bedford Regional Airport is under the direct authority of the airport manager and the policies of the New Bedford Regional Airport Commission, for the maintenance of the airport and the airport's stormwater management systems. Therefore, the responsible party of this O & M Plan will be referred to collectively as the Airport.

The Airport keeps on file record plans of the Airport's stormwater management system, O & M plans developed during previous improvement projects, routine drainage system, review and maintenance reports, and the facilities Stormwater Pollution Prevention Plan per the EPA NPDES Multi-Sector General Permit.

In the event that the New Bedford Regional Airport was to change ownership, the above mentioned stormwater management system documentation and EPA NPDES Multi-Sector SWPPP would remain on file at the Airport.

This O & M plan shall be located in the Airport Manager's office. The O&M Plan located in the Airport Manager's office shall be the O&M plan of record and shall be maintained up-to-date at all times. Any changes to the stormwater system, runways, taxiways, or any stormwater BMP's shall be recorded in this O&M plan and all drawings or exhibits shall be updated to reflect said changes.

5. Routine and Non-Routine Maintenance Tasks

The New Bedford Regional Airport's stormwater management system has been designed to comply with the Massachusetts Stormwater Management Standards that were incorporated into the Wetlands Protection Act Regulations on January 2, 2008 (see 310 CMR 10.05(6)(k)). To ensure the proposed stormwater management systems are functioning adequately, routine and non-routine maintenance, system reviews, and preventative measures are necessary. The system utilizes Best Management Practices (BMP) source controls including the following:

Vegetative Filter Strips

Description: Grassed Area

Location: Adjacent to Runway or Taxiway edge of pavement.

Purpose: Pre-treat stormwater run-off from asphalt surfaces prior to discharging to catch basins

or infiltration trenches.

Review: At least once a year (every six months during first year) the edge of pavement and toe-of-slope shall be checked for sediment build up and vegetation reviewed for signs of erosion and bare spots.

Maintenance: Mowing to occur on routine basis. Sediment, debris and trash removal from edge of pavement and reseeded as necessary to fill in bare spots.

2. Drainage Channels

Description: Grass Channels

Location: Various locations throughout the airport property.

Purpose: To provide for non-erosive conveyance of stormwater to inlets, infiltration trenches and other bodies of water.

Review: At least twice per year review channels for adequate vegetation growth, rilling or gullying.

Maintenance: Mowing to occur on routine basis. Sediment, debris and trash removal shall occur at least once per year or as necessary. Repair of any erosion and reseeding shall occur as necessary.

3. Grassed Channels

Description: Grass Channels

Location: Along construction access road.

Purpose: To provide for pre-treatment for and conveyance of stormwater to inlets, infiltration trenches, sediment forebays, and other bodies of water

Review: At least once per year review channels for adequate vegetation growth, rilling or gullying.

Maintenance: Mowing to occur once a month during growing season. Sediment, debris and trash removal shall occur at least once per year or as necessary. Repair of any erosion and reseeding shall occur as necessary, but no less than once a year.

4. Catch Basin (Deep Sump Hooded)

Description: Underground Retention Basins.

Location: Various locations throughout the airport property.

Purpose: Designed to remove trash debris and coarse sediment from stormwater runoff. Also serve as temporary spill containment devices for oils and grease.

Review: At least four times per year, and at the end of foliage and snow-removal seasons, review structures for sedimentation, debris build-up, floatables and structural damage. Maintenance: Remove sediment debris at least four times per year or whenever depth of deposits is greater than or equal to one half the depth from the bottom of the sump to the invert of the lowest pipe in the basin. Remove trash and floatables as required. Replace structure as necessary.

5. Infiltration Trenches

Description: Shallow Excavations Filled with Stone.

Location: At the toe of slope of vegetative filter strips, typically at the edge of Runway and Taxiway Safety Area.

Purpose: The stone provides underground storage for stormwater runoff which gradually exfiltrates through the bottom and/or sides of the trench into the subsoil and eventually into the water table.

Review: At least two times per year review for sedimentation, debris, trash and grass clippings within trench. Check pre-treatment BMP's as required, to maximize infiltration trench useable lifetime.

Maintenance: At least two times per year remove sedimentation, debris, trash and grass clipping from trench and pretreatment BMP's. Rehabilitate the trench when required.

6. Proprietary Separator

Description: Underground Storage Tanks with Three Chambers.

Location: Adjacent to Aircraft Aprons or Hangars.

Purpose: Removes heavy particulates, floating debris and hydrocarbons from stormwater.

Review: At least once a month (and after every major storm) review for sediments and debris.

Maintenance: At least twice per year, by qualified personnel, the unit shall be cleaned of oil, grease and sediments using a specialized vacuum truck.

7. Infiltration Basin

Description: Stormwater runoff impoundment constructed over permeable soils.

Location: Adjacent to Northwest Ramp and along construction access road.

Purpose: Stormwater runoff is stored until it exfiltrates through the soil of the basin floor, typically within 72 hours.

Review: At least twice per year review for sediments and debris. Review pre-treatment BMP's, as specified, to reduce maintenance for basin.

Maintenance: At least twice per year mow buffer area, side slopes and basin bottom (if grass) or rake (if stone bottom). Remove grass clippings, accumulated organic matter, trash and debris and eradicate any invasive plant species. Note: Remove sediment from basin as necessary, but wait until basin floor is dry. Use light equipment to remove the top layer so as not to compact the underlying soil.

8. Leaching Catch Basin

Description: Pre-cast concrete structure with an open bottom.

Location: Main Ramp Apron Area

Purpose: To permit runoff to infiltrate into the ground.

Review: At once per year, and at the end of foliage and snow-removal seasons, review structures for sedimentation, debris build-up, floatables, grass clippings and structural damage. *Maintenance*: Remove sediment debris at once per year, 50% full or whenever deposits impact exfiltration. Replace structure as necessary.

9. Outlet Erosion Control Protection

Description: Devices that controls the flow of stormwater from an outlet device (i.e. Rip-Rap) *Location:* Downstream of headwalls or any outlet.

Purpose: To dissipate energy from stormwater runoff to control erosion as it enters streams and wetland areas.

Review: At least two times per year review for erosion sedimentation, vegetation debris, trash and grass clippings. Review pre-treatment BMP's to reduce maintenance.

Maintenance: At least two times per year remove sedimentation, debris, trash and grass clipping from outlet erosion control device and pretreatment BMP's.

10. Check Dams

Description: A small earthen or stone dam constructed across a drainage ditch, swale or channel.

Location: Various locations throughout the airport property.

Purpose: To lower the velocity of flow to reduce erosion and gullying in a channel and allow sediments to settle out.

Review: After every significant rainfall event review the check dams.

Maintenance: Repair damage and remove sediment as necessary.

11. Catch Basin Inlet Controls (Temporary during construction)

Description: Filter media insert that fits into a catch basin opening.

Location: Currently none at the airport.

Purpose: To remove a range of pollutants including debris, trash, fine sediments, oil/grease and metals depending on type of filter media.

Review: Per manufacturer's schedule, review inserts for effectiveness and structural integrity. Must be OSHA certified to enter the structure.

Maintenance: Per manufacturer's requirements, replace inserts as necessary or when ineffective.

12. Drain Manholes

Description: Underground chambers with access from surface.

Location: Various locations throughout the airport property.

Purpose: Used for pipe connections, flow diversions and review access.

Review: At least four times per year, and at the end of foliage and snow-removal seasons, review structures for sedimentation, debris build-up, floatables and structural damage. Must be OSHA certified to enter the structure.

Maintenance: Remove sediment debris at least four times per year or whenever depth of deposits is greater than or equal to one half the depth from the bottom of the sump to the invert of the lowest pipe in the basin. Remove trash and floatables as required. Replace structure as necessary.

13. Drainage Pipe

Description: Hollow cylindrical conduit of varying material such as steel, concrete, plastic and clay.

Location: Throughout stormwater system, typically between catch basins, manholes and outfalls.

Purpose: To convey stormwater throughout the system.

Review: At least four times per year, and at the end of foliage and snow-removal seasons, review pipes for sedimentation, debris build-up, floatables and structural damage. *Maintenance:* Remove sediment debris at least four times per year or whenever depth of deposits is impeding stormwater conveyance. Remove trash and floatables as required. Replace pipe as necessary if structural failure is apparent.

14. Culverts

Description: A covered channel that crosses under a roadway or other paved airport surface.

Location: West Ditch under RW 5 End Localizer access road; Along Taxiway "A" (3)

Purpose: To convey stormwater under a roadway crossing.

Review: At least four times per year review structures for sedimentation, debris build-up, floatables and structural damage.

Maintenance: Remove sediment debris at least four times per year or as required. Replace structure as necessary.

Table 1 includes a summary all BMP's associated with the Airport's stormwater management system and routine and non-routine maintenance required:

Table 1 – Operation and Maintenance Requirements

BMP Approx. Quantity		Maintenance Required	Frequency	
Vegetative Filter Strips	TBD LF	Review edge of pavement and toe-of- slope for sediment build up. Review vegetation for signs of erosion, bare spots and overall health. Mowing	1 Time/Year; Every six months during first year. As Needed	
		Remove sediment from the tow of slope or edge of pavement. Reseed bare spots.	As Needed	
Drainage Channels	TBD LF	Review Channels to ensure adequate vegetation growth and no rilling or gullying. Repair rills, gullies and dead vegetation.	2 Times/Year ; and first few months after construction.	
		Mowing	As Necessary; Grass height shall not exceed 6 inches.	
		Manually remove sediment and debris	1 Time/Year (Minimum)	
		Reseed	As necessary; Deicing will necessitate yearly reseeding in the spring.	
Grassed Channels	TBD LF	Review Channels to ensure adequate vegetation growth and no rilling or gullying. Repair rills, gullies and dead vegetation.	1 Time/Year (Minimum)	
		Mowing	Once a month during growing season	
		Manually remove sediment and debris	1 Time/Year (Minimum)	
		Reseed	As necessary; Deicing will necessitate yearly reseeding in the spring.	
Catch Basins (deep sump hooded)	TBD EA	Review Units	4 Times/Year; And at the end of foliage and snow-removal seasons.	
		Clean Units	4 Times/Year; Or whenever depth of deposits is greater than or equal to one half the depth from the bottom of the sump to the invert of the lowest pipe in the basin.	
Infiltration Trench	TBD LF	Review units and remove debris.	2 Times/Year; and after every major storm	
		Remove sediment from pretreatment BMP's	2 Times/Year; and after every major storm	

ВМР	Approx. Quantity	Maintenance Required	Frequency	
Proprietary Separator	TBD EA	Review Units	1 Time/Month ; and after every major storm	
		Clean Units	2 Times/Year	
Infiltration Basins	1 EA	Preventative Maintenance	2 Times/Year	
		Review to ensure proper functioning	2 Times/Year ; After every major storm for first 3 months of operation; after discharges through high outlet orifice.	
		Mow the buffer area, side slopes, and basin bottom if grass; Rake if stone bottom	2 Times/Year	
Infiltration Basin (Cont'd)	1 EA	Remove trash, debris, grass clippings and accumulated organic matter from unit	2 Times/Year	
		Review and clean pretreatment devices	2 Times/Year (Minimum) ; Every Two Months (Recommended); After Every Major Storm.	
Leaching Catch Basin	2 EA	Review Units	1 Time/Year ; And at the end of foliage and snow-removal seasons.	
		Clean Units	1 Times/Year; 50% Full; As required	
Outlet Erosion Control	N/A	Review and clean sedimentation, debris, trash and grass clippings . Review pre-treatment BMP's.	2 Times/Year	
Check Dams	N/A	Review and repair or remove sediment.	Following significant rainfall Per Manufacturer	
Catch Basin Inlet Controls	All CB's	Review and Replace per manufacturer's requirements		
Drain Manhole	TBD EA	Review Units	2 Times/Year	
		Clean Units	As Required	
Drainage Pipe	TBD LF	Review Pipes	2 Times/Year	
		Clean/Repair Pipes	As Required	
Open Box Culvert	4 EA	Review Structure	2 Times/Year	
		Clean/Repair	As Required	
Invasive Species Removal		Review for the presence of invasive species.	1 Time/Year	
		Mechanical removal preferred (i.e., hand tools); apply herbicides as necessary.	As Required	

For reference, MassDEP Specifications from the Stormwater Management Standards have been included in **Appendix B** for all BMP's associated with the Airport's stormwater system.

6. Plan of Stormwater BMP's

Maps of the New Bedford Regional Airport's existing stormwater management system can be found in this Plan. Existing and Proposed Drainage Plans for the current project can be found in the Stormwater Management Report for "Reconstruct Runway 14-32."

7. Public Safety Features

The proposed stormwater management system will be constructed entirely within the Airport's restricted and fenced-in areas. These areas are controlled by the Airport and are closed to public access.

The proposed systems have been, and will be designed to manage any changes in the existing rate of runoff due to airport improvements. System designs to control increases in runoff include infiltration trenches and basins that will be designed to infiltrate stormwater runoff quickly to prevent water retention and eliminate the migration of wildlife such as water fowl and the infestation of insects.

8. Estimated Operations and Maintenance Budget

The City of New Bedford owns and operates the Airport through the New Bedford Airport Commission. The Airport has a maintenance staff of municipal employees who are responsible for the maintenance of the Airport's facilities. The additional cost associated with reviewing and maintaining proposed Gravel Access Road drainage improvements would not add any significant burden onto the current maintenance budget for the entire Airport facility.

9. O & M Compliance Statement

The Airport shall report compliance with the following statements during all drainage system reviews and maintenance activities:

The site has been reviewed for erosion and appropriate steps have been taken to permanently stabilize any eroded areas;

- 1. All aspects of the stormwater BMP's have been reviewed for damage, wear and malfunction, and appropriate steps have been taken to repair or replace the system or portions of the system so that the stormwater at the site may be managed in accordance with the Stormwater Management Standards;
- 2. Future responsible parties must be notified of their continuing legal responsibility to operate and maintain the structure; and
- 3. The Operation and Maintenance Plan for the stormwater BMP's is being implemented.

10. Maintenance Log Book

All stormwater BMP's shall be operated and maintained in accordance with the design plans and this O&M Plan. The Airport will report on all drainage system reviews, repairs, replacement, and disposal (for disposal, the log shall indicate the type of material and the disposal location) activities. These reports will be kept on file for a minimum of three (3) years and will be made available to the MassDEP and the City of New Bedford Conservation Commission upon request. In addition, the Airport will escort members of the MassDEP and the City of New Bedford Conservation Commission onto the Airport premises to review, evaluate, and ensure compliance with this O&M Plan during regular business hours.

A 24-hour advanced notice is requested to ensure proper escort is available and to prevent interference with airport operations.

An example copy of the drainage system review worksheet for use by Airport Maintenance Staff is included in **Appendix C**.

11. Snow Removal

Snow shall not be plowed, deposited, or dumped into any Wetland Resource Area or buffer zone. Snow shall not be plowed, deposited, or dumped into stormwater management structures including infiltration trenches. Snow removal shall be directed away from these areas to the extent practicable.

Excess snow shall be stored in prescribed areas. Prescribed snow storage areas include:

- a.) infield areas between taxiways and runways a minimum of 50' from infiltration trenches,
- b.) east of Taxiway "B" south of Runway 32,
- c.) west of the Bridgewater State apron, and
- d.) west of the T-hangar adjacent to the west end of Taxiway "B".

Winter conditions and rates of accumulations of precipitation vary widely. Wind speed and direction, available equipment, and conditions may require special equipment and techniques collectively for snow storage. Snow shall be positioned off the movement area surfaces so all airplane propellers, engine pods, rotors, and wing tips will clear any snowdrift and snow bank as the airplane's landing gear traverses any portion of the movement area.

Snow storage sites shall not compromise airplane operations, airport NAVAIDS, airport traffic, and ATCT operations such as ATCT line-of-sight requirements.

Depending on the amount of snow cleared and the size of the ramp, ramp signage directing pilots toward the runway could become obscured (covered with snow), and the resulting height of snow stockpiles could cause clearance issues between taxiing airplanes and the snow stockpile. Snow banks piled adjacent to paved Aircraft Operating Areas shall be in accordance with the FAA AC 150/5200-30B Airport Winter Safety and Operations.

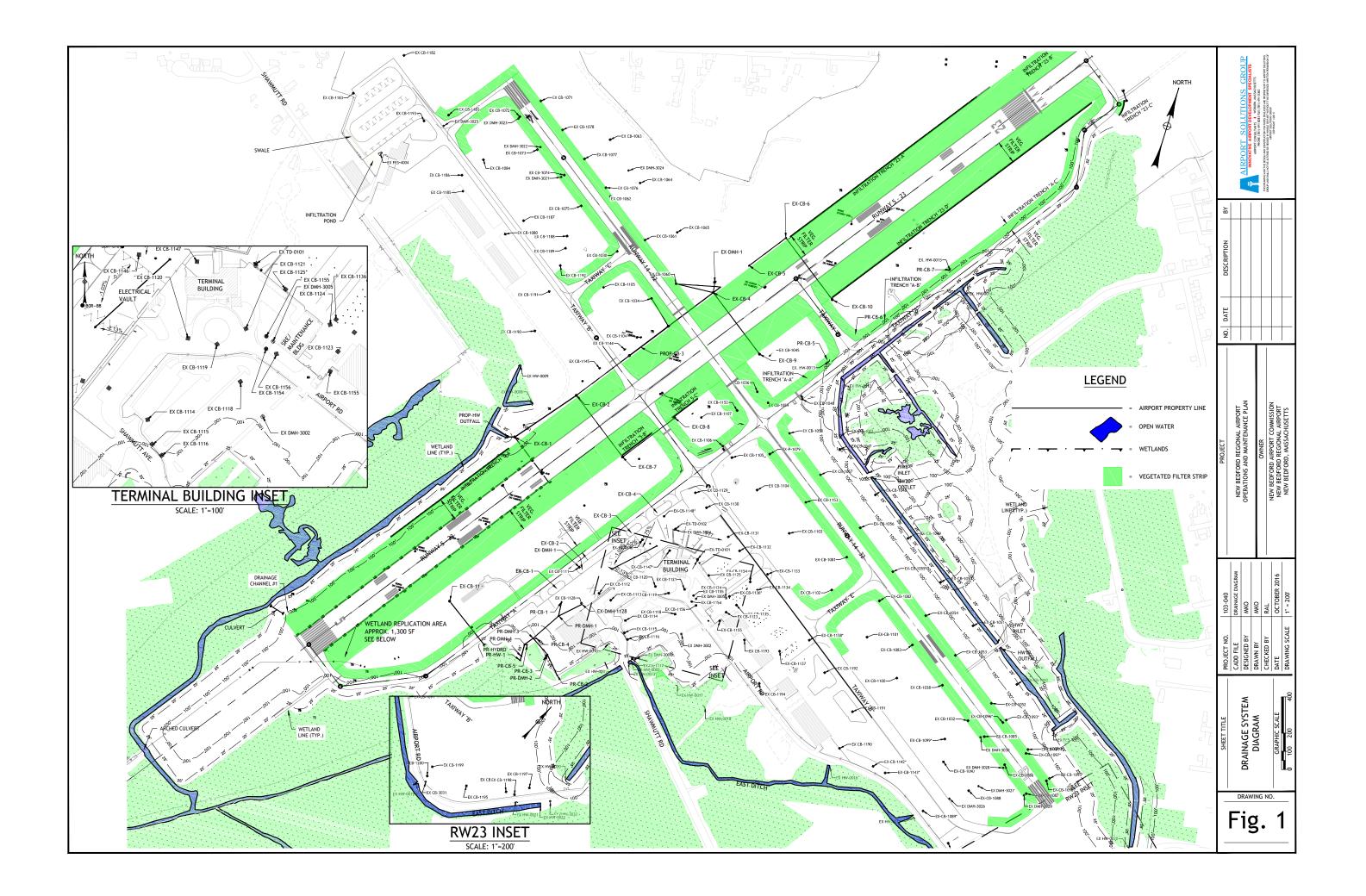
12. Pollution Prevention

A stormwater pollution prevention plan (SWPPP) was previously developed for the New Bedford Regional Airport. This SWPPP contains helpful information regarding pollution prevention, spill containment, and maintenance procedures to be enacted to limit the pollution potential from the Airport.

Operators and Maintenance Staff shall thoroughly read, understand, and enact all procedures as indicated in the SWPPP. Operators and Staff shall pay special attention to Section 3 – Stormwater Control Measures. The SWPPP shall be kept and maintained in the Airport Manager's office. Any questions regarding the SWPPP shall be directed to the Airport Manager, or his/her designate.

Appendix A

Stormwater Management System Plans



Appendix B

BMP Specifications

Massachusetts Stormwater Management Policy

Vegetated Filter Strips



Description: Vegetated filter strips, also known as filter strips, grass buffer strips and grass filters, are uniformly graded vegetated surfaces (i.e., grass or close-growing native vegetation) that receive runoff from adjacent impervious areas. Vegetated filter strips typically treat sheet flow or small concentrated flows that can be distributed along the width of the strip using a level spreader. Vegetated filter strips are designed to slow runoff velocities, trap sediment, and promote infiltration, thereby reducing runoff volumes.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	Provides some peak flow attenuation but usually not enough to achieve compliance with Standard 2
3 - Recharge	No recharge credit
4 - TSS Removal	If greater than or equal to 25' and less than 50' wide, 10% TSS removal. If greater than or equal to 50' wide, 45% TSS removal.
5 - Higher Pollutant Loading	May be used as part of a pretreatment train if lined
6 - Discharges near or to Critical Areas	May be used as part of a pretreatment train if lined. May be used near cold-water fisheries.
7 - Redevelopment	Suitable for pretreatment or as a stand-alone practice if sufficient land is available.

Advantages/Benefits:

- Reduces runoff volumes and peak flows.
- Slows runoff velocities and removes sediment.
- Low maintenance requirements.
- Serves as an effective pretreatment for bioretention cells
- Can mimic natural hydrology
- Small filter strips may be used in certain urban settings.
- Ideal for residential settings and to treat runoff from small parking lots and roads.
- Can be used as part of runoff conveyance system in combination with other BMPs
- Little or no entrapment hazard for amphibians or other small creatures

Disadvantages/Limitations:

- · Variability in removal efficiencies, depending on design
- Little or no treatment is provided if the filter strip is short-circuited by concentrated flows.
- Often a poor retrofit option due to large land requirements.
- Effective only on drainage areas with gentle slopes (less than 6 percent).
- · Improper grading can greatly diminish pollutant removal.

Pollutant Removal Efficiencies

- TSS (if filter strip is 25 feet wide)
- TSS (if filter strip is 50 feet wide)
- Nutrients (Nitrogen, phosphorus)
- Metals (copper, lead, zinc, cadmium)
- Pathogens (coliform, e coli)

10% assumed (Regulatory)

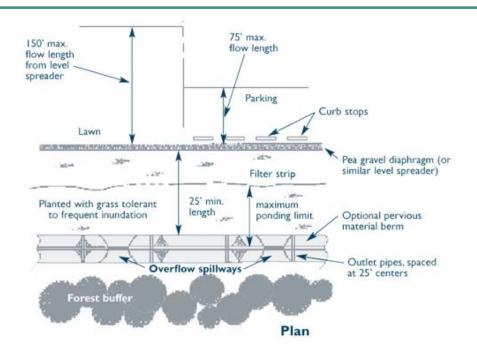
45% assumed (Regulatory)

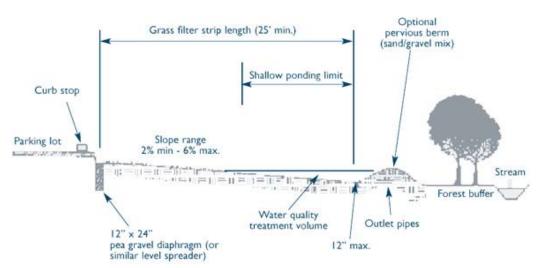
Insufficient data

Insufficient data

Insufficient data

Structural BMPs - Volume 2 | Chapter 2 page 17





adapted from the "Design of Stormwater Systems" 1996

Maintenance

Activity	Frequency
Inspect the level spreader for sediment buildup and the vegetation for signs of erosion, bare spots, and overall health.	Every six months during the first year. Annually thereafter.
Regularly mow the grass.	As needed
Remove sediment from the toe of slope or level spreader and reseed bare spots.	As needed

Special Features

Include an impermeable liner and underdrain for discharges from Land Use with Higher Potential Pollutant Loads and for discharges within Zone IIs and Interim Wellhead Protection Areas; for discharges near or to other critical areas or in soils with rapid infiltration rates greater than 2.4 inches per hour.

Vegetated Filter Strips

Applicability

Vegetated filter strips are used to pretreat sheet flow from roads, highways, and small parking lots. In residential settings, they are useful in pretreating sheet flow from driveways. They provide effective pretreatment, especially when combined with bioretention areas and stream buffers. Urban areas can sometimes accommodate small filter strips depending on available land area, making them potential retrofit options in certain urban settings. Vegetated filter strips can also be used as side slopes of grass channels or water quality swales to enhance infiltration and remove sediment.

Effectiveness

Variable TSS removal efficiencies have been reported for filter strips, depending on the size of the contributing drainage area, the width of the filter strip, the underlying parent soil, the land slope, the type of vegetation, how well the vegetation is established, and maintenance practices. Vegetated filter strips may remove nutrients and metals depending on the length and slope of the filter, soil permeability, size and characteristics of the drainage area, type of vegetative cover, and runoff velocity.

Planning Considerations

Vegetated filter strips may be used as a stand-alone practice for redevelopments, only where other practices are not feasible. Vegetated filter strips can be designed to fit within the open space and rights of way that are available along roads and highways. Do not design vegetated filter strips to accept runoff from land uses with higher potential pollutant loads (LUHHPL) without a liner. Vegetated filter strips function best for drainage areas of one acre or less with gentle slopes.

Design

Do not locate vegetated filter strips in soils with high clay content that have limited infiltration or in soils that cannot sustain grass cover.

The filter strip cannot extend more than 50 feet into a Buffer Zone to a wetland resource area.

The contributing drainage area to a vegetated filter strip is limited to one acre of less.

Design vegetated filter strips with slopes between 2 and 6 percent. Steeper slopes tend to create

concentrated flows. Flatter slopes can cause ponding and create mosquito-breeding habitat.

Design the top and toe of the slope to be as flat as possible. Use a level spreader at the top of the slope to evenly distribute overland flows or concentrated runoff across the entire length of the filter strip. Many variations of level spreader designs may be used including level trenches, curbing and concrete weirs. The key to any level spreader design is creating a continuous overflow elevation along the entire width of the filter strip.

Velocity dissipation (e.g. by using riprap) may be required for concentrated flows.

Design the filter strip to drain within 24 hours after a storm. The design flow depth must not exceed 0.5 inches.

To recieve TSS removal credit, make the filter strip at least 25 feet long and generally as wide as the area draining to the strip. To prevent high-velocity concentrated flows, the length of the flow path must be limited to 75 feet if the filter strip handles runoff from impervious surfaces, and 150 feet if the filter strip handles runoff from pervious surfaces. The minimum width of the filter strip must be 20% of the length of the flow path or 8 feet, whichever is greater.

To prevent groundwater contamination, the filter strip must be constructed at least 2 feet above seasonal high groundwater and 2 to 4 feet above bedrock.

The filter strip must be planted with grasses that are relatively salt-tolerant. Select grasses to withstand high flow velocities under wet weather conditions.

A vegetated filter strip may be used as a qualifying pervious area for purposes of the LID Site Design Credits for disconnecting rooftop and nonroof top runoff.

Construction

Proper grading is essential to establish sheet flow from the level spreader and throughout the filter strip.

Implement soil stabilization measures until permanent vegetation is established.

Protect the area to be used for the filter strip by using upstream sediment traps.

Use as much of the existing topsoil on the site as possible to enhance plant growth.

Maintenance

Regular maintenance is critical for filter strips to be effective and to ensure that flow does not short-circuit the system. Conduct semi-annual inspections during the first year (and annually thereafter). Inspect the level spreader for sediment buildup and the vegetation for signs of erosion, bare spots, and overall health. Regular, frequent mowing of the grass is required. Remove sediment from the toe of slope or level spreader, and reseed bare spots as necessary. Periodically, remove sediment that accumulates near the top of the strip to maintain the appropriate slope and prevent formation of a "berm" that could impede the distribution of runoff as sheet flow.

When the filter strip is located in the buffer zone to a wetland resource area, the operation and maintenance plan must include strict measures to ensure that maintenance operations do not alter the wetland resource areas. Please note, filter strips are restricted to the outer 50 feet of the buffer zone.

Cold Climate Considerations

In cold climates such as Massachusetts, the depth of soil media that serves as the planting bed must extend below the frost line to minimize the effects of freezing. Avoid using peat and compost media, which retain water and freeze during the winter, and become impermeable and ineffective.

References:

Center for Watershed Protection, Stormwater Management Fact Sheet: Grassed Filter Strip, http:// www.stormwatercenter.net/Assorted%20Fact%20 Sheets/Tool6_Stormwater_Practices/Filtering%20 Practice/Grassed%20Filter%20Strip.htm

Claytor, R.A. and T.R. Schueler. 1996. Design of Stormwater Filtering Systems. Center for Watershed Protection. Silver Spring, Maryland.

Connecticut Department of Environmental Protection. 2004. Connecticut Stormwater Quality Manual.

International Stormwater BMP Database, Biofilter – Grass Strip, http://www.bmpdatabase.org

Knox County, Stormwater Management Manual, Volume 2, Section 4.3.9, Filter Strip, Pp. 4-155 to 4-164, http://knoxcounty.org/stormwater/pdfs/vol2/4-3-9%20 Filter%20Strip.pdf

Knoxville, City of, 2003, Knoxville BMP Manual Stormwater Treatment, Filter Strips and Swales, Practice No. ST – 05, http://www.ci.knoxville.tn.us/engineering/bmp_manual/ST-05.pdf

Maine Department of Environmental Protection. 2006, Maine Stormwater Best Management Practices Manual, Chapter 5, Pp. 5-1 to 5-18, http://www.maine.gov/dep/blwq//docstand/stormwater/stormwaterbmps/vol3/chapter5.pdf

Maryland Department of the Environment, 2000, Maryland Stormwater Design Manual, Volume I, Chapter 2, Unified Sizing Criteria, P. 2.39, http://www. mde.state.md.us/assets/document/chapter2.pdf

Massachusetts Highway Department. 2004. Storm Water Handbook for Highways and Bridges.

Metropolitan Council. 2001. Minnesota Urban Small Sites BMP Manual: Stormwater Best Management Practices for Cold Climates. Prepared by Barr Engineering Company. St. Paul, Minnesota.

New Jersey Department of Environmental Protection, 2004, Best Management Practice Manual, Chapter 9.10, Standard for Vegetated Filter Strip, Pp. 9.10-1 to 9.11-10, http://www.njstormwater.org/tier_A/pdf/NJ_SWBMP_9.10.pdf

New York State Department of Environmental Conservation (NYDEC). 2001. New York State Stormwater Management Design Manual. Prepared by Center for Watershed Protection. Albany, New York.

United States Environmental Protection Agency (EPA). 1999. Preliminary Data Summary of Urban Storm Water Best Management Practices. EPA 821-R99-012.

United States Environmental Protection Agency (EPA). 2002. National Menu of Best Management Practices for Stormwater Phase II. URL: http://www.epa.gov/npdes/menuofbmps/menu.htm, Last Modified January 24, 2002.

Virginia Department of Conservation and Recreation, Chapter 3, Minimum Standard 3.14, Vegetated Filter Strip, Pp. 3.14-1 to 3.14.-14, http://dcr.state.va.us/ soil_&_water/documents/Chapter_3-14.pdf

Yu, S.L., S.L. Barnes, and V.W. Gerde, 993. Testing of Best Management Practices for Controlling Highway Runoff. Virginia Transportation Research Council, Charlottesville, VA.

Drainage Channels



Description: Drainage channels are traditional vegetated open channels that are designed to provide for non-erosive conveyance. They receive no infiltration or TSS removal credit (Standards 3 and 4).

Ability to meet specific standards

Standard	Description
2 - Peak Flow	Provides no peak flow attenuation
3 - Recharge	Provides negligible groundwater recharge.
4 - TSS Removal	0% TSS removal credit.
5 - Higher Pollutant Loading	Use as conveyance.
6 - Discharges near or to Critical Areas	May be used to achieve temperature reduction for runoff discharging to cold-water fisheries.
7 - Redevelopment	Limited applicability

Advantages/Benefits:

- Conveys stormwater
- Generally less expensive than curb and gutter systems.
- Accents natural landscape.
- Compatible with LID design practices
- Roadside channels reduce driving hazards by keeping stormwater flows away from street surfaces during storms

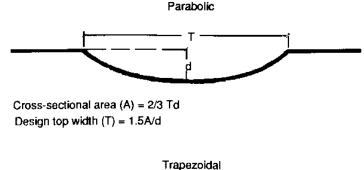
Disadvantages/Limitations:

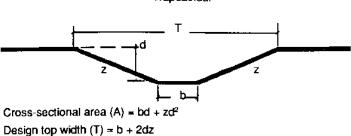
- Higher degree of maintenance required than for curb and gutter systems.
- Roadside channels are subject to damage from off-street parking and snow removal.
- Provides limited pollutant removal compared to water quality swales
- May be impractical in areas with flat grades, steep topography or poorly drained soils
- Large area requirements for highly impervious sites.

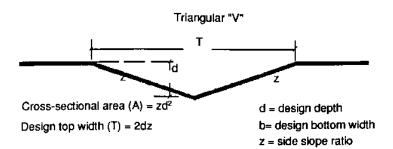
Pollutant Removal Efficiencies

- Total Suspended Solids (TSS) 0%
- Nutrients (Nitrogen, phosphorus) Insufficient data
- Metals (copper, lead, zinc, cadmium) Insufficient data
- Pathogens (coliform, e coli) Insufficient data

Figure DC 1







adapted from the University of New Hampshire

Maintenance

Activity	Frequency
Inspect channels to make sure vegetation is adequate and for signs of rilling and gullying. Repair any rills or gullies. Replace dead vegetation.	The first few months after construction and twice a year thereafter.
Mow	As necessary. Grass height shall not exceed 6 inches.
Remove sediment and debris manually	At least once a year
Reseed	As necessary. Use of road salt or other deicers during the winter will necessitate yearly reseeding in the spring.

Special Features

Drainage channels cannot be used to meet the Stormwater Management Standards. They are a component of a larger stormwater management system and serve to convey runoff from impervious surfaces to or from stormwater treatment BMPs.

Drainage Channels

Drainage Channels versus Water Quality Swales

The distinction between drainage channels and water quality swales lies in the design and planned use of the open channel conveyance. Drainage channels are designed to have sufficient capacity to convey runoff safely during large storm events without causing erosion. Drainage channels typically have a cross-section with sufficient hydraulic capacity to handle the peak discharge for the 10-year storm. The dimensions (slope and bottom width) of a drainage channel must not exceed a critical erosive velocity during the peak discharge. They must be vegetated with grasses to maintain bank and slope integrity. Other than basic channel size and geometry, there are no other design modifications to enhance pollutant removal capabilities. Therefore, pollutant removal efficiency is typically low for drainage channels.

Water quality swales and grass channels, on the other hand, are designed for the required water quality volume and incorporate specific features to enhance their stormwater pollutant removal effectiveness. Pollutant removal rates are significantly higher for water quality swales and grass channels. A water quality swale or grass channel must be used in place of the drainage channel when a water quality treatment credit is sought.

Applicability

Drainage channels are suitable for residential and institutional areas of low to moderate density. The percentage of impervious cover in the contributing areas must be relatively small. Drainage channels can also be used in parking lots to break up areas of impervious cover.

Along the edge of roadways, drainage channels can be used in place of curb and gutter systems. However, the effectiveness of drainage channels may decrease as the number of driveway culverts increases. They are also generally not compatible with extensive sidewalk systems. When using drainage channels in combination with roadways and sidewalks, it is most appropriate to place the channel between the two impervious covers (e.g., between the sidewalk and roadway).

The topography of the site should allow for the design of a drainage channel with sufficient slope and cross-sectional area to maintain non-erosive flow velocities. The longitudinal slope of the swale should be as close to zero as possible and not greater than 5%.

Planning Considerations

The two primary considerations when designing a drainage channel are maximizing channel capacity and minimizing erosion. Use the maximum expected retardance when checking drainage channel capacity. Usually the greatest flow retardance occurs when vegetation is at its maximum growth for the year. This usually occurs during the early growing season and dormant periods.

Other factors to be considered when planning for the drainage channel are land availability, maintenance requirements and soil characteristics. The topography of the site should allow for the design of a drainage channel with sufficient slope and cross-sectional area to maintain a non-erosive flow velocity, generally less than five feet per second.

The shape of the cross-sectional channel is also an important planning consideration. Figure DC 1 shows three different design shapes. The V-shaped or triangular cross-section can result in higher velocities than other shapes, especially when combined with steeper side slopes, so use this design only if the quantity of flow is relatively small. The parabolic cross-section results in a wide shallow channel that is suited to handling larger flows and blends in well with natural settings. Use trapezoidal channels when deeper channels are needed to carry larger flows and conditions require relatively high velocities. Select a grass type for the channel lining that is appropriate for site conditions, including one that is able to resist shear from the design flow, is shade tolerant, is drainage tolerant, and has low maintenance requirements. Use vegetation that is water tolerant and has a dense root system. Alternatively, the drainage channel may be lined with stone.

Design

See the following for complete design references: Site Planning for Urban Stream Protection. 1995. Schueler. Center for Watershed Protection.

The length of the drainage channel depends on the slope, contributing impervious surface area, and runoff volume. Because drainage channels with low velocities can act as sediment traps, add extra capacity to address sediment accumulation without reducing design capacity. Add an extra 0.3 to 0.5

feet of freeboard depth, if sediment accumulation is expected. Use side slopes of 3:1 or flatter to prevent side slope erosion. Make the longitudinal slope of the channel as flat as possible and not greater than 5%.

Install check dams in drainage channels when necessary to achieve velocities of 5 feet per second or less. Do not use earthen check dams because they tend to erode on the downstream side, and it is difficult to establish and maintain grass on the dams. The maximum ponding time behind the check dam should not exceed 24 hours. Use outlet protection at discharge points from a drainage channel to prevent scour at the outlet.

The design for the drainage channel must include access for maintenance. When located along a highway, provide a breakdown lane with a width of 15 feet. When located along a street, off-street parking can be doubled up as the access, provided signs are posted indicating no parking is allowed during maintenance periods. When locating drainage channels adjacent to pervious surfaces, include a 15-foot wide grass strip to provide access for maintenance trucks.

Construction

Use temporary erosion and sediment controls during construction. Soil amendments, such as aged compost that contains no biosolids, may be needed to encourage vegetation growth. Select a vegetation mix that suits the characteristics of the site. Seeding will require mulching with appropriate materials, such as mulch matting, straw, wood chips, other natural blankets, or synthetic blankets. Anchor blanket immediately after seeding. Provide new seedlings with adequate water until they are well established. Refer to the "Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas: A Guide for Planners, Designers, and Municipal Officials" for information regarding seeding, mulching, and use of blankets.

Maintenance

The maintenance and inspection schedule should take into consideration the effectiveness of the drainage channel. Inspect drainage channels the first few months after construction to make sure that there is no rilling or gullying, and that vegetation in the channels is adequate. Thereafter, inspect the

channel twice a year for slope integrity, soil moisture, vegetative health, soil stability, soil compaction, soil erosion, ponding, and sediment accumulation.

Regular maintenance tasks include mowing, fertilizing, liming, watering, pruning, weeding, and pest control. Mow channels at least once per year. Do not cut the grass shorter than three to four inches. Keep grass height under 6 inches to maintain the design depth necessary to serve as a conveyance. Do not mow excessively, because it may increase the design flow velocity.

Remove sediment and debris manually at least once per year. Re-seed periodically to maintain the dense growth of grass vegetation. Take care to protect drainage channels from snow removal procedures and off-street parking. When drainage channels are located on private residential property, the operation and maintenance plan must clearly specify the private property owner who is responsible for carrying out the required maintenance. If the operation and maintenance plan calls for maintenance of drainage channels on private properties to be performed by a public entity or an association (e.g. homeowners association), maintenance easements must be obtained.

Grassed Channel (Biofilter Swale)



Description: Grassed Channels (formerly known as Biofilter swales) are treatment systems with a longer hydraulic residence time than drainage channels. The removal mechanisms are sedimentation and gravity separation, rather than filtration. To receive TSS credit, a sediment forebay or equivalent must be provided for pretreatment. Note that the sediment forebay does not receive a separate TSS removal credit.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	N/A
3 - Recharge	No infiltration credit
4 - TSS Removal	50% TSS with adequate pretreatment
5 - Higher Pollutant Loading	N/A
6 - Discharges near or to Critical Areas	Not suitable for vernal pools or bathing beaches. At other critical areas, may be used as a pretreatment device.
7 - Redevelopment	Typically not suited for retrofits.

Advantages/Benefits:

- Provides pretreatment if used as the first part of a treatment train.
- Open drainage system aids maintenance
- · Accepts sheet or pipe flow
- Compatible with LID design measures.
- Little or no entrapment hazard for amphibians or other small animals

Disadvantages/Limitations:

- Short retention time does not allow for full gravity separation.
- Limited biofiltration provided by grass lining.
 Cannot alone achieve 80% TSS removal
- Must be designed carefully to achieve low flow rates for Water Quality Volume purposes (<1.0 fps)
- Mosquito control considerations

Pollutant Removal Efficiencies

- Total Suspended Solids (TSS)
- Total phosphorus (TP)
- Total Nitrogen
- Metals (copper, lead, zinc, cadmium)
- Pathogens (coliform, e. coli)

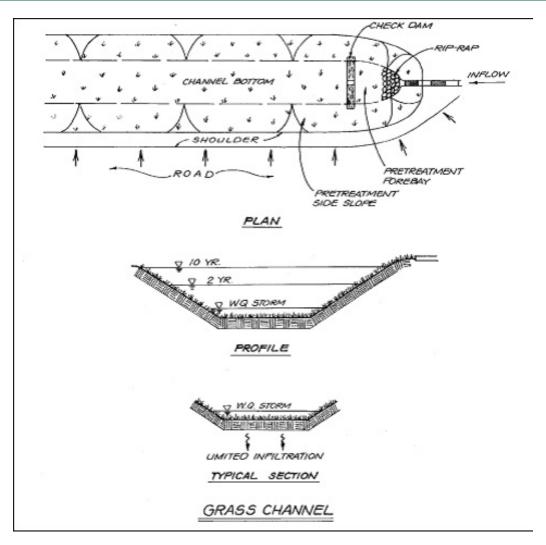
50%¹ for Regulatory Purposes (47%)² -121%²

Insufficient Data Insufficient Data

Insufficient Data Insufficient Data

¹ Atlanta Regional Commission et al, 2001, Georgia Stormwater Manual, Volume 2, Section 3-3-2, http://georgiastormwater.com/vol2/3-3-2.pdf

² International Stormwater Database, based on MassDEP analysis of raw influent & effluent values reported in 2005.



adapted from the Vermont Stormwater Manual

Maintenance

Activity	Frequency
Remove sediment from forebay	Annually
Remove sediment from grass channel	Annually
Mow	Once a month during growing season
Repair areas of erosion and revegetate	As needed, but no less than once a year

Special FeaturesReduces volume and rate of runoff.

Grass Channels

Grass channels convey and treat stormwater. Grass channels were referred to as biofilter swales in the 1996 MassDEP/CZM Stormwater Handbook, based on the nomenclature coined by the Center for Watershed Protection (CWP). The CWP is now referring to biofilter swales as grass channels – so MassDEP is adopting the same name as the CWP to minimize confusion.

Properly designed grass channels are ideal when used adjacent to roadways or parking lots, where runoff from the impervious surfaces can be directed to the channel via sheet flow. Runoff can also be piped to the channel. If piped, locate the sediment forebay at the pipe outlet and include a check dam separating the forebay from the channel. For sheet flow, use a vegetated filter strip on a gentle slope or a pea gravel diaphragm. Make the longitudinal slope as flat as possible. This increases the Hydraulic Residence Time (HRT) and allows gravity separation of solids and maximizes sediment removal. Install check dams to further increase the HRT.

Review of the International Stormwater Database, updated in 2005, indicates lower TSS removal when compared to similar treatment practices (dry water quality swales, wet water quality swales, and bioretention areas). The information in the International Stormwater Database indicates grass channels are likely to export phosphorus (hence the negative removal efficiency cited above). Grass channels are not a practice suitable for treating stormwater that discharges to waters impaired by phosphorus or for waters where phosphorus TMDLs have been established.

Differences from dry water quality swales, wet water quality swales, bioretention cells, and drainage channels: Dry water quality swales contain a specific soil media mix and underdrain, providing greater treatment than grass channels. Wet water quality swales are designed with a permanent wet channel, whereas grass channels must be designed to completely drain between storms. Bioretention areas, including rain gardens, are designed solely as a treatment practice, and not for conveyance. Lastly, drainage channels act solely as a conveyance, in contrast to properly designed grass channels where runoff flow is deliberately lagged to provide treatment.

Design Considerations Sizing:

may increase the HRT.

Water Quality Volume: Design grass channels to maximize contact with vegetation and soil surface to promote greater gravity separation of solids during the storm associated with the water quality event (either ½ inch or 1-inch runoff). Design the channel such that the velocity does not exceed 1 foot per second during the 24-hour storm associated with the water quality event. Do not allow the water depth during the storm associated with the water quality event to exceed 4 inches (for design purposes). Make sure the selected design storm provides at least 9 minutes of HRT within the channel. Increasing the HRT beyond 9 minutes increases the likelihood of achieving the 50% TSS removal efficiency. Adding

<u>2-year and 10-year conveyance capacity:</u> Design grass channels to convey both the 2-year and 10-year 24-hour storms. Provide a minimum of 1-foot freeboard above the 10-year storm. Make sure that the runoff velocities during the 2-year 24-hour storm do not cause erosion problems. <u>Channel Length:</u> Length depends on design factors to achieve the minimum 9-minute residence time for the storm associated with the water quality event.

meanders to the swale increases its length and

<u>Channel Crossings:</u> In residential settings, driveways will cross over the channel, typically via culverts (pre-cast concrete, PVC, or corrugated metal pipe).

Soils: Grass channels may be constructed from most parent soils, unless the soils are highly impermeable. Soils must be able to support a dense grass growth. MassDEP recommends sandy loams, with an organic content of 10 to 20%, and no more than 20% clay. Highly impermeable soils, such as clays, are not suitable for grass channels, because they do not support dense grass stands. Similarly, gravelly and coarse soils may not be suitable due to their lower moisture retention capability, leading to potential die-back of the grass lining during the summer when the inter-event period between storms is longer than during other times of the year. **Grasses:** The grasses serve to stabilize the channel, and promote conditions suitable for sedimentation, such as offering resistance to flow, which reduces water velocities and turbulence. Select a grass height of 6 inches or less. Grasses over that height tend to flatten when water flows

over them, inhibiting sedimentation. Select grasses that produce a fine, uniform and dense cover that can withstand varying moisture conditions. Regularly mow the channel to ensure that the grass height does not exceed 6 inches. Select grasses that are salt tolerant to withstand winter deicing of roadways. In the spring, replant any areas where grasses died off due to deicing. (Franklin 2002 and Knoxville 2003 provide recommendations for the best grass species.) Pea Gravel Diaphragm: Use clean bank-run gravel, conforming to ASTM D 448, varying in size from 1/8 inch to 3/8 inch (No. 6 stone). Outlet Protection: Must be used at discharge points to prevent scour downstream of the outlet. Construction Considerations: Stabilize the channel after it is shaped before permanent turf is established, using natural or synthetic blankets. Never allow grass channels to receive construction period runoff.

Site Constraints

A proponent may not be able to install a grass channel swale because of:

- High groundwater;
- Presence of utilities; or
- Other site conditions that limit depth of excavation because of stability.

Maintenance

Access: Maintenance access must be designed as part of the grass channel. If located adjacent to a roadway, make the maintenance access at least 15 feet wide, which can also be combined with a breakdown lane along a highway or onstreet parking along a residential street. When combined with on-street parking, post signs prohibiting parking when the swale is to be inspected and cleaned. Do not use travel lanes along highways and streets as the required maintenance access.

Mowing: Set the mower blades no lower than 3 to 4 inches above the ground. Do not mow beneath the depth of the design flow during the storm associated with the water quality event (e.g., if the design flow is no more than 4 inches, do not cut the grass shorter than 4 inches). Mow on an as-needed basis during the growing season so that the grass height does not exceed 6 inches. Inspection: Inspect semi-annually the first year, and at least once a year thereafter. Inspect the grass for growth and the side slopes for signs of erosion and formation of rills and gullies. Plant an alternative grass species if the original grass

cover is not successfully established. If grass growth is impaired by winter road salt or other deicer use, re-establish the grass in the spring. *Trash/Debris Removal:* Remove accumulated trash and debris prior to mowing. *Sediment Removal:* Check on a yearly basis and clean as needed. Use hand methods (i.e., a person with a shovel) when cleaning to minimize disturbance to vegetation and underlying soils. Sediment build-up in the grass channel reduces its capacity to treat and convey the water quality event, 2-year and 10-year 24-hour storm.

References:

Atlanta Regional Commission et al, 2001, Georgia Stormwater Management Manual, Volume 2, Section 3-3-2, Grass Channel, http://georgiastormwater.com/vol2/3-3-2.pdf

Center for Watershed Protection, undated, Stormwater Management Fact Sheet: Grass Channel, http://www.stormwatercenter.net/Assorted%20 Fact%20Sheets/Tool6_Stormwater_Practices/ Open%20Channel%20Practice/Grassed%20Channel. htm (accessed October 23, 2007)

Shanti R. Colwell, Richard R. Horner, Derek B. Booth, 2000, Characterization of Performance Predictors and Evaluation of Mowing Practices in Biofiltration Swales, http://depts.washington.edu/cwws/Research/Reports/swale%20mowing.pdf

Franklin, City of, 2002, PTP-05, Biofilters: Swales and Strips, http://www.franklin-gov.com/engineering/STORMWATER/bmp/ptp/ptp-05.pdf

Idaho Department of Environmental Quality, 2005, Storm Water Best Management Practices Catalog, BMP 1, Biofiltration Swale (Vegetated Swale).

International Stormwater BMP Data Base, 2005

Knoxville, City of, 2003, ST-05, Filter Strips and Swales, http://www.ci.knoxville.tn.us/engineering/bmp_manual/ST-05.pdf

Minton, G., 2002, Stormwater Treatment, Resource Planning Associates, Seattle, WA, p. 174

Deep Sump Catch Basin



Description: Deep sump catch basins, also known as oil and grease or hooded catch basins, are underground retention systems designed to remove trash, debris, and coarse sediment from stormwater runoff, and serve as temporary spill containment devices for floatables such as oils and greases.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	Provides no peak flow attenuation
3 - Recharge	Provides no groundwater recharge
4 - TSS Removal	25% TSS removal credit when used for pretreatment. Because of their limited effectiveness and storage capacity, deep sump catch basins receive credit for removing TSS only if they are used for pretreatment and designed as off-line systems.
5 - Higher Pollutant Loading	Recommended as pretreatment BMP. Although provides some spill control capability, a deep sump catch basin may not be used in place of an oil grit separator or sand filter for land uses that have the potential to generate runoff with high concentrations of oil and grease such as: high-intensity-use parking lots, gas stations, fleet storage areas, vehicle and/or equipment maintenance and service areas.
6 - Discharges near or to Critical Areas	May be used as pretreatment BMP. not an adequate spill control device for discharges near or to critical areas.
7 - Redevelopment	Highly suitable.

Advantages/Benefits:

- Located underground, so limited lot size is not a deterrent.
- Compatible with subsurface storm drain systems.
- Can be used for retrofitting small urban lots where larger BMPs are not feasible.
- Provide pretreatment of runoff before it is delivered to other BMPs.
- Easily accessed for maintenance.
- Longevity is high with proper maintenance.

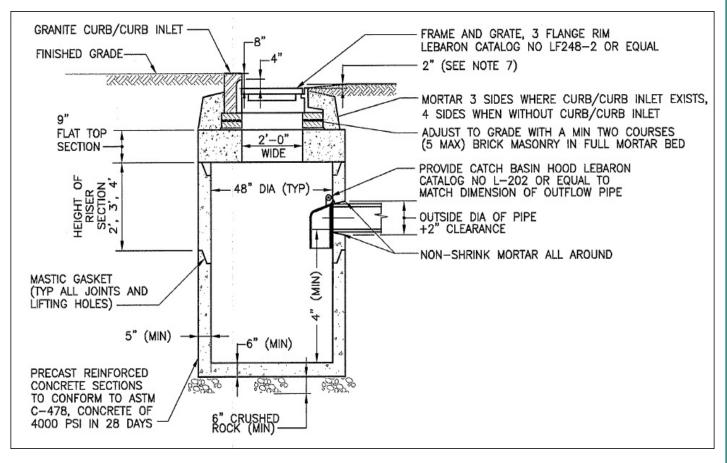
Disadvantages/Limitations:

- Limited pollutant removal.
- Expensive to install and maintain, resulting in high cost per unit area treated.
- No ability to control volume of stormwater
- Frequent maintenance is essential
- Requires proper disposal of trapped sediment and oil and grease
- Entrapment hazard for amphibians and other small animals

Pollutant Removal Efficiencies

- Total Suspended Solids (TSS) 25% (for regulatory purposes)
- Nutrients (Nitrogen, phosphorus) -Insufficient data
- Metals (copper, lead, zinc, cadmium) -Insufficient data
- Pathogens (coliform, e coli) Insufficient data

Structural BMPs - Volume 2 | Chapter 2 page 2



adapted from the University of New Hampshire

Maintenance

Activity	Frequency
Inspect units	Four times per year
Clean units	Four times per year or whenever the depth of deposits is greater than or equal to one half the depth from the bottom of the invert of the lowest pipe in the basin.

Special Features

All deep sump catch basins must include hoods. For MassHighway projects, consult the Stormwater Handbook for Highways and Bridges for hood requirements.

LID Alternative

Reduce Impervious Surface Disconnect rooftop and non-rooftop runoff Vegetated Filter Strip

Deep Sump Catch Basin

Suitable Applications

- Pretreatment
- Residential subdivisions
- Office
- Retail

Design Considerations

- The contributing drainage area to any deep sump catch basin should not exceed ¼ acre of impervious cover.
- Design and construct deep sump catch basins as off-line systems.
- Size the drainage area so that the flow rate does not exceed the capacity of the inlet grate.
- Divert excess flows to another BMP intended to meet the water quantity requirements (peak rate attenuation) or to a storm drain system.
 An off-line design enhances pollutant removal efficiency, because it prevents the resuspension of sediments in large storms.

Make the sump depth (distance from the bottom of the outlet pipe to the bottom of the basin) at least four feet times the diameter of the outlet pipe and more if the contributing drainage area has a high sediment load. The minimum sump depth is 4 feet. Double catch basins, those with 2 inlet grates, may require deeper sumps. Install the invert of the outlet pipe at least 4 feet from the bottom of the catch basin grate.

The inlet grate serves to prevent larger debris from entering the sump. To be effective, the grate must have a separation between the grates of one square inch or less. The inlet openings must not allow flows greater than 3 cfs to enter the deep sump catch basin. If the inlet grate is designed with a curb cut, the grate must reach the back of the curb cut to prevent bypassing. The inlet grate must be constructed of a durable material and fit tightly into the frame so it won't be dislodged by automobile traffic. The inlet grate must not be welded to the frame so that sediments may be easily removed. To facilitate maintenance, the inlet grate must be placed along the road shoulder or curb line rather than a traffic lane.

Note that within parking garages, the State Plumbing Code regulates inlet grates and other stormwater management controls. Inlet grates inside parking garages are currently required to have much smaller openings than those described herein.

To receive the 25% removal credit, hoods must be used in deep sump catch basins. Hoods also help contain oil spills. MassHighway may install catch basins without hoods provided they are designed, constructed, operated, and maintained in accordance with the Mass Highway Stormwater Handbook.

Install the weep hole above the outlet pipe. Never install the weep hole in the bottom of the catch basin barrel.

Site Constraints

A proponent may not be able to install a deep sump catch basin because of:

- Depth to bedrock;
- · High groundwater;
- Presence of utilities; or
- Other site conditions that limit depth of excavation because of stability.

Maintenance

Regular maintenance is essential. Deep sump catch basins remain effective at removing pollutants only if they are cleaned out frequently. One study found that once 50% of the sump volume is filled, the catch basin is not able to retain additional sediments.

Inspect or clean deep sump basins at least four times per year and at the end of the foliage and snow-removal seasons. Sediments must also be removed four times per year or whenever the depth of deposits is greater than or equal to one half the depth from the bottom of the invert of the lowest pipe in the basin. If handling runoff from land uses with higher potential pollutant loads or discharging runoff near or to a critical area, more frequent cleaning may be necessary.

Clamshell buckets are typically used to remove sediment in Massachusetts. However, vacuum trucks are preferable, because they remove more trapped sediment and supernatant than clamshells. Vacuuming is also a speedier process and is less likely to snap the cast iron hood within the deep sump catch basin.

Always consider the safety of the staff cleaning deep sump catch basins. Cleaning a deep sump catch basin within a road with active traffic or even within a parking lot is dangerous, and a police detail may be necessary to safeguard workers.

Although catch basin debris often contains concentrations of oil and hazardous materials such as petroleum hydrocarbons and metals, MassDEP classifies them as solid waste. Unless there is evidence that they have been contaminated by a spill or other means, MassDEP does not routinely require catch basin cleanings to be tested before disposal. Contaminated catch basin cleanings must be evaluated in accordance with the Hazardous Waste Regulations, 310 CMR 30.000, and handled as hazardous waste.

In the absence of evidence of contamination, catch basin cleanings may be taken to a landfill or other facility permitted by MassDEP to accept solid waste, without any prior approval by MassDEP. However, some landfills require catch basin cleanings to be tested before they are accepted.

With prior MassDEP approval, catch basin cleanings may be used as grading and shaping materials at landfills undergoing closure (see Revised Guidelines for Determining Closure Activities at Inactive Unlined Landfill Sites) or as daily cover at active landfills. MassDEP also encourages the beneficial reuse of catch basin cleanings whenever possible. A Beneficial Reuse Determination is required for such use.

MassDEP regulations prohibit landfills from accepting materials that contain free-draining liquids. One way to remove liquids is to use a hydraulic lift truck during cleaning operations so that the material can be decanted at the site. After loading material from several catch basins into a truck, elevate the truck so that any free-draining liquid can flow back into the structure. If there is no free water in the truck, the material may be deemed to be sufficiently dry. Otherwise the catch basin cleanings must undergo a Paint Filter Liquids Test. Go to www. Mass.gov/dep/recycle/laws/cafacts.doc for information on all of the MassDEP requirements pertaining to the disposal of catch basin cleanings.

Proprietary Separators



Ability to meet specific standards

Standard	Description
2 - Peak Flow	Provides no peak flow attenuation
3 - Recharge	Provides no groundwater recharge
4 - TSS Removal	Varies by unit. Must be used for pretreatment and be placed first in the treatment train to receive TSS removal credit. Follow procedures described in Chapter 4 to determine TSS credit.
5 - Higher Pollutant Loading	Suitable as pretreatment device.
6 - Discharges near or to Critical Areas	Suitable as pretreatment device or potentially a spill control device
7 - Redevelopment	Suitable as pretreatment device or treatment device if it is not possible to provide other BMPs.

Description: A proprietary separator is a flow-through structure with a settling or separation unit to remove sediments and other pollutants. They typically use the power of swirling or flowing water to separate floatables and coarser sediments, are typically designed and manufactured by private businesses, and come in different sizes to accommodate different design storms and flow conditions. Some rely solely on gravity separation and contain no swirl chamber. Since proprietary separators can be placed in almost any location on a site, they are particularly useful when either site constraints prevent the use of other stormwater techniques or as part of a larger treatment train. The effectiveness of proprietary separators varies greatly by size and design, so make sure that the units are sized correctly for the site's soil conditions and flow profiles, otherwise the unit will not work as designed.

Advantages/Benefits:

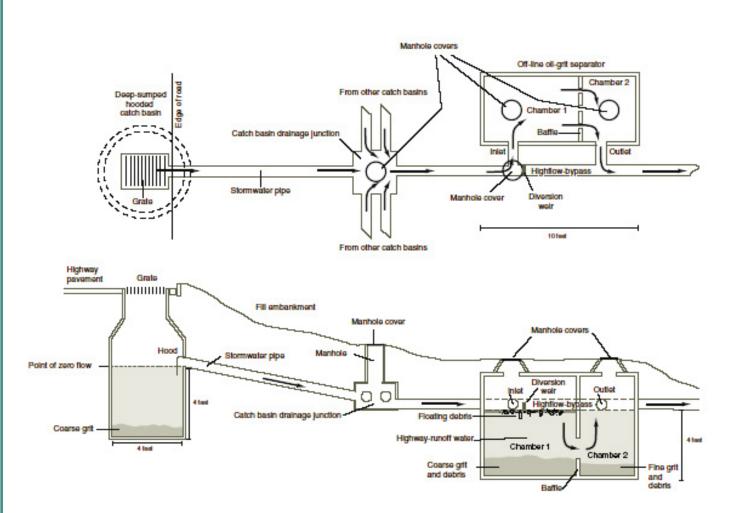
- Removes coarser sediment.
- Useful on constrained sites.
- Can be custom-designed to fit specific needs of a specific site.

Disadvantages/Limitations:

- Removes only coarse sediment fractions
- · Provides no recharge to groundwater
- No control of the volume of runoff
- Frequent maintenance is essential

Pollutant Removal Efficiencies

- Total Suspended Solids (TSS) Varies.
- Nutrients (Nitrogen, phosphorus) Insufficient data
- Metals (copper, lead, zinc, cadmium) Insufficient data
- Pathogens (coliform, e coli) Insufficient data



Schematic section of a deep-sump hooded catch basin and a 1,500-gallon off-line water quality inlet.

adapted from the MassHighway Storm Water Handbook for Highways

Maintenance

Activity	Frequency
Inspect in accordance with manufacturer requirements, but no less than twice a year following installation, and no less than once a year thereafter.	See activity
Remove sediment and other trapped pollutants at frequency or level specified by manufacturer.	See manufacturer information

Special Features

Can be custom-designed to fit specific needs at a specific site.

LID Alternative

Reduce impervious surfaces

Disconnect runoff from non-metal roofs, roadways, and driveways

Proprietary Separators

Applicability

Because they have limited pollutant removal and storage capacity, proprietary separators must be used for pretreatment only. Because they are placed underground, proprietary separators may be the only structural pretreatment BMPs feasible on certain constrained redevelopment sites where space or storage is not available for more effective BMPs. They may be especially useful in ultra-urban settings such as Boston or Worcester. Some proprietary separators may be used for spill control.

Effectiveness

Proprietary separators have a wide range of TSS efficiencies. To assess the ability of proprietary separators to remove TSS and other pollutants, a proponent should follow the procedures set forth in Chapter 4. The specific units proposed for a particular project cannot be effective unless they are sized correctly. Proprietary separators are usually sized based on flow rate. A proprietary separator must be sized to treat the required water quality volume. To be effective at removing TSS and other pollutants the system must be designed, constructed, and maintained in accordance with the manufacturer's specifications and the specifications in this Handbook.

Planning Considerations

To receive TSS removal credit, proprietary separators must be used for pretreatment and placed at the beginning of a stormwater treatment train. They can be configured either in-line or if subject to higher flows, off-line to reduce scouring. They must be sized in accordance with the manufacturer's specifications and the specifications in this Handbook. Proprietary separators used as spill control devices may have to be sized differently than those used for TSS removal.

Design

The design of proprietary separators varies by manufacturer. Units are typically precast concrete, but larger systems may be cast in place. Units may have baffles or other devices to direct incoming water into and through a series of chambers, slowing the water down to allow sediment to drop out into internal storage areas, then directing this pre-treated water to exit to other treatment or infiltration devices. In some cases, flow will be introduced tangentially, to induce swirl or vortex. Units may include skirts or weirs, to keep trapped sediments from becoming re-

entrained. Some units combine a catch basin with the treatment function, providing off-line rather than in-line treatment.

Generally they are placed below ground on a gravel or stone base. Make sure all units contain inspection and access ports so that they may be inspected and cleaned. During design, take care to place the inspection and access ports where they will be accessible. Do not place the ports in locations such as travel lanes of roadways/highways and parking stalls.

Construction

Install construction barriers around the excavation area to prevent access by pedestrians. Use diversions and other soil erosion practices up-slope of the proprietary separator to prevent runoff from entering the site before construction of the units is complete. Implement practices to prevent construction period runoff from being discharged to the units until construction is complete and the soil is stabilized. Stabilize all surrounding area and any established outlets. Remove temporary structures after vegetation is established.

Maintenance

Inspect and clean these units in strict accordance with manufacturers' recommendations and requirements. Clean the units using the method specified by the manufacturer. Vactor trucks are typically used to clean these units. Clamshell buckets typically used for cleaning catch basins are almost never allowed by manufacturers. Sometimes it will be necessary to remove sediment manually.

Adapted from:

MassHighway. Storm Water Handbook for Highways and Bridges. May 2004.

Infiltration Trenches



Ability to meet specific standards

Standard	Description
2 - Peak Flow	Full exfiltration trench systems may be designed for peak rate attenuation
3 - Recharge	Provides groundwater recharge.
4 - TSS Removal	80% TSS removal credit when combined with one or more pretreatment BMPs.
5 - Higher Pollutant Loading	May be used if 44% of TSS is removed with a pretreatment BMP prior to infiltration. For some land uses with higher potential pollutant load an oil grit separator or equivalent must be used prior to discharge to the infiltration structure. Infiltration must be done in compliance with 314 CMR 5.00.
6 - Discharges near or to Critical Areas	Highly recommended with pretreatment to remove at least 44% TSS removal prior to discharge.
7 - Redevelopment	Suitable with pretreatment.

Description: Infiltration trenches are shallow excavations filled with stone. They can be designed to capture sheet flow or piped inflow. The stone provides underground storage for stormwater runoff. The stored runoff gradually exfiltrates through the bottom and/or sides of the trench into the subsoil and eventually into the water table.

Advantages/Benefits:

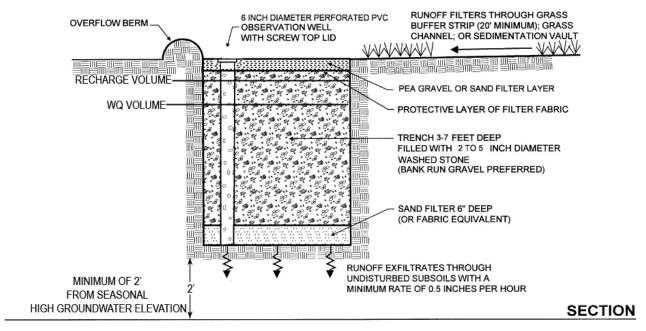
- Provides groundwater recharge.
- Reduces downstream flooding and protects stream bank integrity for small storms.
- Preserves the natural water balance of the site
- Provides a high degree of runoff pollution control when properly designed and maintained.
- Reduces the size and cost of downstream stormwater control facilities and/or storm drain systems by infiltrating stormwater in upland areas.
- Suitable where space is limited.

Disadvantages/Limitations:

- High failure rates due to improper siting, inadequate pollution prevention and pretreatment, poor design, construction and maintenance.
- Use restricted to small drainage areas.
- Depending on runoff quality, potential risk of groundwater contamination.
- Requires frequent maintenance.
- Susceptible to clogging with sediment.

Pollutant Removal Efficiencies

Total Suspended Solids (TSS)
Total Nitrogen
Total Phosphorus
Metals (copper, lead, zinc, cadmium)
Pathogens (coliform, e coli)
80% with pretreatment
40% to 70%
85% to 90%
Up to 90%



Example of Infiltration Trench

adapted from the University of New Hampshire

Maintenance

Activity	Frequency
Inspect units and remove debris	Every 6 months and after every major storm
Remove sediment from pretreatment BMPs	Every 6 months and after every major storm

Special Features:

High failure rate without adequate pretreatment and regular maintenance

LID Alternative:

Reduce impervious areas Bioretention areas

Infiltration Trenches

Infiltration trenches can be designed for complete exfiltration or partial exfiltration, where a portion of the runoff volume is directed to the trench and the remainder is conveyed to other BMPs.

Full Exfiltration Trench Systems

Infiltration trenches must be sized to provide storage and exfiltration of the required water quality volume. Full exfiltration systems also provide control of peak discharges and water quality treatment for all storm events equal to or less than the design storm selected. In selecting the design storm, the minimum peak rate attenuation storm event must include the 2- and 10-year 24-hour storm events and may include the 100-year 24-hour storm event, if the runoff from that storm will increase flooding up- or downstream of the site. An emergency overflow channel is required to discharge runoff volumes in excess of the design storm. Economic and physical constraints can restrict the use of full exfiltration systems. Generally, it is not practical to provide storage for large infrequent storms, such as the 100-year storm.

Partial or Water Quality Exfiltration Trench Systems

These systems exfiltrate a portion of the runoff, while the remainder is conveyed to other BMPs. At a minimum, they must be sized to exfiltrate the recharge volume required by Stormwater Management Standard 3. There are two methods of partial infiltration. The first relies on off-line treatment where a portion of the runoff, or the "first-flush," is routed from the main channel to the trench by means of a weir or other diversion structure. The second method is on-line, and uses a perforated pipe at the top of the trench. This underdrain must be placed near the top of the trench. Refer to the design section below. After the trench fills to capacity, excess runoff is discharged through the perforated pipe and directed to other BMPs.

Applicability

Infiltration trenches always require a pretreatment BMP. For sheet flow, pretreatment BMP structures that may be used include vegetated filter strips and pea stone gravel diaphragms. For piped flow, a sediment forebay should be used.

Infiltration trenches are feasible at sites with gentle slopes, permeable soils, and where seasonal high groundwater levels are at least two feet below the bottom of the trench. MassDEP recommends providing greater depths from the bottom of the trench to seasonal high groundwater elevation to reduce the potential for failure. Depth to bedrock will need to be evaluated to determine if use of an infiltration trench is feasible.

Contributing drainage areas must be relatively small and not exceed 5 acres. Infiltration trenches are suitable for parking lots, rooftop areas, local roads, highways, and small residential developments.

Infiltration trenches are adaptable to many sites because of their thin profile. Table IT.1 lists the recommended site criteria. Infiltration trenches can be used in upland areas of larger sites to reduce the overall amount of runoff and improve water quality while reducing the size and costs of downgradient BMPs.

Infiltration trenches are effective at mimicking the natural, pre-development hydrological regime at a site. Full exfiltration systems that have been carefully designed may be capable of controlling peak discharges from the 2-year and 10-year 24-hour storm.

Planning Considerations

MassDEP highly recommends using infiltration trenches near Critical Areas. They may be used to treat stormwater discharges from areas of higher potential pollutant loads, provided 44% of TSS is removed prior to infiltration. For some land uses with higher potential pollutant load, an oil grit separator or equivalent device may be required prior to discharge to the infiltration trench. When an oil/grit separator is used, pipe the runoff to the infiltration trench. Discharges from land uses with higher potential pollutant loads require compliance with 314 CMR 5.00.

Before planning infiltration trenches, carefully evaluate the subsurface of the site including soils, depth to bedrock, and depth to the water table. Make sure soils have a minimum percolation rate of 0.17 inches per hour.

Make the slopes of the contributing drainage area less than 5%. Infiltration trenches have extremely high failure rates, usually due to clogging, so pretreatment is essential. Infiltration trenches are not intended to remove coarse particulate pollutants, and generally are difficult to rehabilitate once clogged. Typical pretreatment BMPs for infiltration trenches

Structural BMPs - Volume 2 | Chapter 2 page 96

Table IT.1 - Site Criteria for Infiltration Trenches

- 1. The contributing drainage area to any individual infiltration trench should be restricted to 5 acres or less.
- 2. The minimum depth to the seasonal high water table, bedrock, and/or impermeable layer should be 2 ft. from the bottom of the trench.
- 3. The minimum acceptable soil infiltration rate is 0.17 inches per hour. Infiltration trenches must be sized in accordance with the procedures set forth in Volume 3.
- 4. A minimum of 2 soil borings should be taken for each infiltration trench. Infiltration trenches over 100 ft. in length should include at least one additional boring location for each 50 ft. increment. Borings should be taken at the actual location of the proposed infiltration trench so that any localized soil conditions are detected.
- 5. Infiltration trenches should not be used at sites where soils have 30% or greater clay content, or 40% or greater silt clay content. Infiltration trenches will not function adequately in areas with hydrologic soils in group D and infiltration will be limited for hydrologic soils in group C.
- 6. Infiltration trenches should not be placed over fill materials.
- 7. The following setback requirements apply to infiltration trench installations:
 - Distance from any slope greater than 5% to any surface exposed trench: minimum of 100 ft.
 - Distance from any slope greater than 20% to any underground trench: minimum of 100 ft.
 - Distance from septic system soil absorption system: minimum of 50 ft.
 - Distance from any private well: minimum of 100 feet, additional setback distance may be required depending on hydrogeological conditions.
 - Distance from any public groundwater drinking water supplies: Zone I radius, additional setback distance may be required depending on hydrogeological conditions.
 - Distance from any surface water supply and its tributaries: Zone A
- 8. Distance from any surface water of the Commonwealth (other than surface drinking water supplies and their tributaries): minimum of 150 ft downslope and 100 ft upslope.
- 9. Distance from any building foundations including slab foundations without basements: minimum of 20 ft.

include oil grit separators, deep sump catch basins, vegetated filter strips, pea stone gravel diaphragms, or sediment forebays.

Clogging can be an issue even when infiltrating uncontaminated rooftop runoff as well, so it is important to implement some form of pretreatment to remove sediments, leaf litter, and debris to ensure the proper functioning of the trench and allow for longer periods between maintenance.

Consider the impacts of infiltrating stormwater on nearby resources. Infiltration trenches need to be set back outside Zone Is and Zone As for public drinking water supplies. Finally, avoid creating groundwater mounds near Chapter 21e sites that could alter subsurface flow patterns and spread groundwater pollution.

Design

See the following for complete design references: Maryland Stormwater Design Manual, Volumes I and II. October 2000. Maryland Department of Environment. Baltimore, MD.

The volume and surface area of an infiltration trench relate to the quantity of runoff entering the trench from the contributing area, the void space, and the infiltration rate. Because the infiltration

trench is filled with stone, only the space between the stone is available for runoff storage. Effective designs call for infiltration trenches to be filled with 1.5-inch to 3.0-inch diameter clean washed stone. Conduct a geotechnical study to determine the final soil infiltration rate below the trench. For sizing purposes, assume a void ratio of 0.4.

Take a minimum of two borings or observation pits for each infiltration trench. For trenches over 100 feet long, include at least one additional boring or pit for each 50-foot increment. Take borings or dig observation pits at the actual location of the proposed infiltration trench to determine localized soil conditions.

Base the design of the infiltration trench on the soil evaluation set forth in Volume 3. The minimum acceptable rate is 0.17 inches per hour. Never use the results of a Title 5 percolation test to estimate an infiltration rate, as these tend to greatly overestimate the rate that water will infiltrate into the subsurface.

Place the maximum depth of the trench at least two feet above the seasonal high water table or bedrock, and below the frost line. Include vegetated buffers (20-foot minimum) around surface trenches. Place permeable filter fabric 6 to 12 inches below the surface of the trench, along the sides, and at the bottom of the trench. Use filter fabric, especially at the surface to prevent clogging; if failure does occur, it can be alleviated without reconstructing the infiltration trench. Another option is to place twelve inches of sand at the bottom of the trench.

Install an observation well at the center of the trench to monitor how quickly runoff is clearing the system. Use a well-anchored, vertical perforated PVC pipe with a lockable above-ground cap.

The visible surface of the trench may either be stone or grassed. Stone is easier to rake out when clogged. If it is vegetated with grasses, use fabric above the stone to keep the soil that serves as the planting medium from clogging the stone. When trenches are designed to accept sheet flow, take into account the grass surface when determining how much of the runoff will exfiltrate into the trench.

A perforated pipe underdrain is sometimes used as part of the design. The purpose of the underdrain is to facilitate exfiltration into the parent soil. Except for underdrains placed between different trench cells, MassDEP does not allow underdrains placed near the bottom of the trench. Placement of an underdrain near the bottom of the trench reduces the amount of treatment and exfiltration, because more water is conveyed through the underdrain to the outlet point when it rains than exfiltrates into the surrounding soils.

Construction

Table IT.2 presents the minimum construction criteria for infiltration trenches. Take precautions before and during construction to minimize the risk of premature failure of the infiltration trench. First, prevent heavy equipment from operating at the locations where infiltration trenches are planned. Heavy equipment will compact soil and adversely affect the performance of the trench. Isolate the areas where the trenches will be located by roping them off and flagging them.

Construct infiltration trenches only after the site has been stabilized. Never use trenches as temporary sediment traps during construction. Use diversion berms or staked and lined hay bales around the perimeter of the trenches during their construction. Excavate and build the trench manually or with light earth-moving equipment. Deposit all excavated material downgradient of the trench to prevent redeposition during runoff events.

Line the sides and bottom of the trench with permeable geotextile fabric. Twelve inches of sand (clean, fine aggregate) may be substituted or used in addition on the bottom. Place one to three inches of clean, washed stone in the lined trench and lightly compact the stone with plate compactors, to within approximately one foot of the surface. Place fabric filter over the top, with at least a 12-inch overlap on both sides. An underground trench may be filled with topsoil and planted. A surface trench may be filled with additional aggregate stone.

Divert drainage away from the infiltration trench until the contributing drainage area is fully stabilized, including full establishment of any vegetation.

Table IT.2 - Construction Criteria for Infiltration Trenches

- 1. Infiltration trenches should never serve as temporary sediment traps for construction.
- 2. Before the development site is graded, the area of the infiltration trench should be roped off and flagged to prevent heavy equipment from compacting the underlying soils.
- 3. Infiltration trenches should not be constructed until the entire contributing drainage area has been stabilized. Diversion berms should be placed around the perimeter or the infiltration trench during all phases of construction. Sediment and erosion controls should be used to keep runoff and sediment away from the trench area.
- 4. During and after excavation, all excavated materials should be placed downstream, away from the infiltration trench, to prevent redeposition of these materials during runoff events. These materials should be properly handled and disposed of during and after construction.

Light earth-moving equipment should be used to excavate the infiltration trench. Use of heavy equipment causes compaction of the soils in the trench floor, resulting in reduced infiltration capacity.

Maintenance

Because infiltration trenches are prone to failure due to clogging, it is imperative that they be aggressively maintained on a regular schedule. Using pretreatment BMPs will significantly reduce the maintenance requirements for the trench itself. Removing accumulated sediment from a deep sump catch basin or a vegetated filter strip is considerably less difficult and less costly than rehabilitating a trench. Eventually, the infiltration trench will have to be rehabilitated, but regular maintenance will prolong its operational life and delay the day when rehabilitation is needed. With appropriate design and aggressive maintenance, rehabilitation can be delayed for a decade or more. Perform preventive maintenance at least twice a year.

Inspect and clean pretreatment BMPs every six months and after every major storm event (2 year return frequency). Check inlet and outlet pipes to determine if they are clogged. Remove accumulated sediment, trash, debris, leaves and grass clippings from mowing. Remove tree seedlings, before they become firmly established.

Inspect the infiltration trench after the first several rainfall events, after all major storms, and on regularly scheduled dates every six months. If the top of the trench is grassed, it must be mowed on a seasonal basis. Grass height must be maintained to be no more than four inches. Routinely remove grass clippings leaves and accumulated sediment from the surface of the trench.

Inspect the trench 24 hours or several days after a rain event, to look for ponded water. If there is ponded water at the surface of the trench, it is likely that the trench surface is clogged. To address surface clogging, remove and replace the topsoil or first layer of stone aggregate and the filter fabric. If water is ponded inside the trench, it may indicate that the bottom of the trench has failed. To rehabilitate a failed trench, all accumulated sediment must be stripped from the bottom, the bottom of the trench must be scarified and tilled to induce infiltration, and all of the stone aggregate and filter fabric or media must be removed and replaced.

REFERENCES:

California Stormwater Quality Association, 2003, California Stormwater BMP Handbook 1 of 7, New Development and Redevelopment, Infiltration Trench, Practice TC-10, http://www.cabmphandbooks.com/Documents/Development/TC-10.pdf

Center for Watershed Protection, Stormwater Management Fact Sheet, Infiltration Trench, http://www. stormwatercenter.net/Assorted%20Fact%20Sheets/ Tool6_Stormwater_Practices/Infiltration%20Practice/ Infiltration%20Trench.htm

Center for Watershed Protection, Stormwater Design Example, Infiltration Trench, http://www. stormwatercenter.net/Manual_Builder/infiltration_design_ example.htm

Duchene, M., McBean, E.A., Thomson, N.R., 1994, Modeling of Infiltration from Trenches for Storm-Water Control, Journal of Water Resources Planning and Management, Vol. 120, No. 3, pp. 276-293

Dewberry Companies, 2002, Land Development Handbook, McGraw Hill, New York, pp. 521, 523.

Georgia Stormwater Management Manual, Section 3.2.5, Infiltration Trench, Pp. 3.2-75 to 3.2-88, http://www.georgiastormwater.com/vol2/3-2-5.pdf

Guo, James C.Y., 2001, Design of Infiltration Basins for Stormwater, in Mays, Larry W. (ed.), 2001, Stormwater Collection Systems Design Handbook, McGraw-Hill, New York, pp. 9.1 to 9.35

Livingston, E.H. 2000. Lessons Learned about Successfully Using Infiltration Practices. Pp 81-96 in National Conference on Tools for Urban Water Resource Management and Protection Proceedings of Conference held February 7-10, 2000 in Chicago, IL. EPA/625/R-00/001 Metropolitan Council, 2001, Minnesota Urban Small Sites BMP Manual, Infiltration Trenches, Pp. 3-169 to 3-180 http://www.metrocouncil.org/Environment/Watershed/BMP/CH3_STInfilTrenches.pdf

U.S. EPA, 1999, Stormwater Technology Fact Sheet, Infiltration Trench, EPA 832-F-99-019, http://www.epa.gov/owm/mtb/infltrenc.pdf

Infiltration Basins



Description: Infiltration basins are stormwater runoff impoundments that are constructed over permeable soils. Pretreatment is critical for effective performance of infiltration basins. Runoff from the design storm is stored until it exfiltrates through the soil of the basin floor.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	Can be designed to provide peak flow attenuation.
3 - Recharge	Provides groundwater recharge.
4 - TSS Removal	80% TSS removal, with adequate pretreatment
5 - Higher Pollutant Loading	May be used if 44% of TSS is removed with a pretreatment BMP prior to infiltration. For some land uses with higher potential pollutant loads, use an oil grit separator, sand filter or equivalent for pretreatment prior to discharge to the infiltration basin. Infiltration must be done in compliance with 314 CMR 5.00
6 - Discharges near or to Critical Areas	Highly recommended, especially for discharges near cold-water fisheries. Requires 44% removal of TSS prior to discharge to infiltration basin
7 - Redevelopment	Typically not an option due to land area constraints

Advantages/Benefits:

- Provides groundwater recharge.
- Reduces local flooding.
- Preserves the natural water balance of the site.
- Can be used for larger sites than infiltration trenches or structures.

Disadvantages/Limitations:

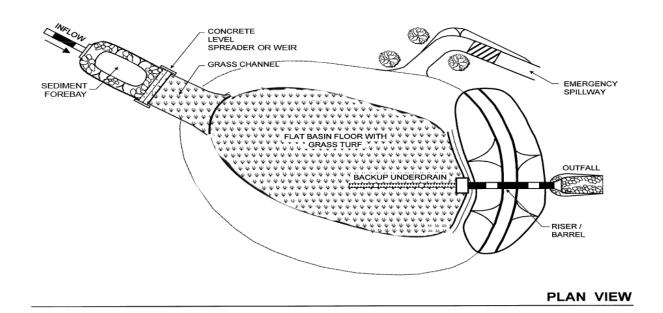
- High failure rates due to improper siting, inadequate pretreatment, poor design and lack of maintenance.
- Restricted to fairly small drainage areas.
- Not appropriate for treating significant loads of sediment and other pollutants.
- Requires frequent maintenance.
- Can serve as a "regional" stormwater treatment facility

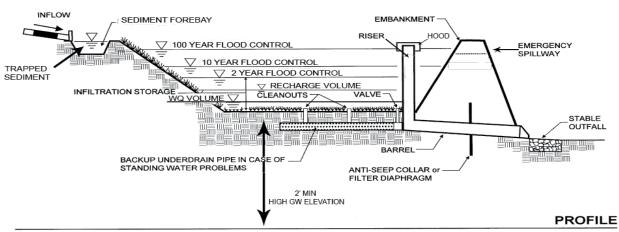
Pollutant Removal Efficiencies

• Total Suspended Solids (TSS) 80% with pretreatment

Total Nitrogen
Total Phosphorus
Metals (copper, lead, zinc, cadmium)
50% to 60%
60% to 70%
85% to 90%

• Pathogens (coliform, e coli) 90%





adapted from the Vermont Stormwater Manual

Maintenance

Activity	Frequency
Preventative maintenance	Twice a year
Inspect to ensure proper functioning	After every major storm during first 3 months of operation and twice a year thereafter and when there are discharges through the high outlet orifice.
Mow the buffer area, side slopes, and basin bottom if grassed floor; rake if stone bottom; remove trash and debris; remove grass clippings and accumulated organic matter	Twice a year
Inspect and clean pretreatment devices	Every other month recommended and at least twice a year and after every major storm event.

Special Features: High failure rate without adequate pretreatment and regular maintenance.

LID Alternative: Reduce impervious surfaces. Bioretention areas

Infiltration Basins

The following are variations of the infiltration basin design.

Full Exfiltration Basin Systems

These basin systems are sized to provide storage and exfiltration of the required recharge volume and treatment of the required water quality volume. They also attenuate peak discharges. Designs typically include an emergency overflow channel to discharge runoff volumes in excess of the design storm.

Partial or Off-line Exfiltration Basin Systems

Partial basin systems exfiltrate a portion of the runoff (usually the first flush or the first half inch), with the remaining runoff being directed to other BMPs. Flow splitters or weirs divert flows containing the first flush into the infiltration basin. This design is useful at sites where exfiltration cannot be achieved by downstream detention BMPs because of site condition limitations.

Applicability

The suitability of infiltration basins at a given site is restricted by several factors, including soils, slope, depth to water table, depth to bedrock, the presence of an impermeable layer, contributing watershed area, proximity to wells, surface waters, and foundations. Generally, infiltration basins are suitable at sites with gentle slopes, permeable soils, relatively deep bedrock and groundwater levels, and a contributing watershed area of approximately 2 to 15 acres. Table IB.1 presents the recommended site criteria for infiltration basins.

Pollution prevention and pretreatment are particularly important at sites where infiltration basins are located. A pollution prevention program that separates contaminated and uncontaminated runoff is essential. Uncontaminated runoff can be infiltrated directly, while contaminated runoff must be collected and pretreated using an appropriate combination of BMPs and then rerouted to the infiltration basin. This approach allows uncontaminated stormwater to be infiltrated during and immediately after the storm and permits the infiltration of contaminated stormwater after an appropriate detention time. The Pollution Prevention and Source Control Plan required by Stormwater Standard 4 must take these factors into account. For land uses with higher potential pollutant loads, provide a bypass to divert contaminated stormwater from the infiltration basin in storms larger than the design storm.

Table IB.1 - Site Criteria for Infiltration Basins

- 1. The contributing drainage area to any individual infiltration basin should be restricted to 15 acres or less.
- 2. The minimum depth to the seasonal high water table, bedrock, and/or impermeable layer should be 2 ft. from the bottom of the basin.
- 3. The minimum infiltration rate is 0.17 inches per hour. Infiltration basins must be sized in accordance with the procedures set forth in Volume 3.
- 4. One soil sample for every 5000 ft. of basin area is recommended, with a minimum of three samples for each infiltration basin. Samples should be taken at the actual location of the proposed infiltration basin so that any localized soil conditions are detected.
- 5. Infiltration basins should not be used at sites where soil have 30% or greater clay content, or 40% or greater silt clay content.
- 6. Infiltration basins should not be placed over fill materials.
- 7. The following setback requirements should apply to infiltration basin installations:
 - Distance from any slope greater than 15% Minimum of 50 ft.
 - Distance from any soil absorption system- Minimum of 50 ft.
 - Distance from any private well Minimum of 100 ft., additional setback distance may be required depending on hydrogeological conditions.
 - Distance from any public groundwater drinking supply wells Zone I radius, additional setback distance may be required depending on hydrogeological conditions.
 - Distance from any surface drinking water supply Zone A
 - Distance from any surface water of the commonwealth (other than surface water supplies and their tributaries) Minimum of 50 ft.
 - Distance from any building foundations including slab foundations without basements Minimum of 10 ft. downslope and 100 ft. upslope.

Prior to pretreatment, implement the pollution prevention and source control program specified in the Pollution Prevention and Source Control Plan to reduce the concentration of pollutants in the discharge. Program components include careful management of snow and deicing chemicals, fertilizers, herbicides, and pest control. The Plan must prohibit snow disposal in the basin and include measures to prevent runoff of stockpiled snow from entering the basin. Stockpiled snow contains concentrations of sand and deicing chemicals. At industrial sites, keep raw materials and wastes from being exposed to precipitation. Select pretreatment BMPs that remove coarse sediments, oil and grease, and floatable organic and inorganic materials, and soluble pollutants.

Effectiveness

Infiltration basins are highly effective treatment systems that remove many contaminants, including TSS. However, infiltration basins are not intended to remove coarse particulate pollutants. Use a pretreatment device to remove them before they enter the basin. The pollutant removal efficiency of the basin depends on how much runoff is exfiltrated by the basin.

Infiltration basins can be made to control peak discharges by incorporating additional stages in the design. To do this, design the riser outlet structure or weir with multiple orifices, with the lowest orifice set to achieve storage of the full recharge volume required by Standard 3. Design the upper orifices using the same procedures as extended detention basins. The basins can also be designed to achieve exfiltration of storms greater than the required recharge volume. However, in such cases, make sure the soils are permeable enough to allow the basin to exfiltrate the entire volume in a 72-hour period. This may necessitate increasing the size of the floor area of the basin. Generally, it is not economically feasible to provide storage for large infrequent storms, such as the 100-year 24-hour storm.

Planning Considerations

Carefully evaluate sites before planning infiltration basins, including investigating soils, depth to bedrock, and depth to water table. Suitable parent soils should have a minimum infiltration rate of 0.17 inches per hour. Infiltration basis must be sized in accordance with the procedures set forth in Volume 3. The slopes of the contributing drainage area for the infiltration basin must be less than 5%.

Design

Infiltration basins are highly effective treatment and disposal systems when designed properly. The first step before design is providing source control and implementing pollution prevention measures to minimize sediment and other contaminants in runoff discharged to the infiltration basin. Next, consider the appropriate pretreatment BMPs.

Design pretreatment BMPs to pretreat runoff before stormwater reaches the infiltration basin. For Critical Areas, land uses with potentially higher pollutant loads, and soils with rapid infiltration rates (greater than 2.4 inches/hour), pretreatment must remove at least 44% of the TSS. Proponents may comply with this requirement by proposing two pretreatment BMPs capable of removing 25% TSS. However, the issuing authorities (i.e., Conservation Commissions or MassDEP) may require additional pretreatment for other constituents beyond TSS for land uses with higher potential pollutant loads. If the land use has the potential to generate stormwater runoff with high concentrations of oil and grease, treatment by an oil grit separator or equivalent is required before discharge to the infiltration basin.

For discharges from areas other than Critical Areas, land uses with potentially higher pollutant loads, and soils with rapid infiltration rates, MassDEP also requires some TSS pretreatment. Common pretreatment for infiltration basins includes aggressive street sweeping, deep sump catch basins, oil/grit separators, vegetated filter strips, water quality swales, or sediment forebays. Fully stabilize all land surfaces contributing drainage to the infiltration practice after construction is complete to reduce the amount of sediment in runoff that flows to the pretreatment devices.

Always investigate site conditions. Infiltration basins must have a minimum separation from seasonal high groundwater of at least 2 feet. Greater separation is necessary for bedrock. If there is bedrock on the site, conduct an analysis to determine the appropriate vertical separation. The greater the distance from the bottom of the basin media to the seasonal high groundwater elevation, the less likely the basin will fail to drain in the 72-hour period following precipitation.

Determine soil infiltration rates using samples collected at the proposed location of the basin. Take one soil boring or dig one test pit for every 5,000 feet

of basin area, with a minimum of three borings for each infiltration basin. Conduct the borings or test pits in the layer where infiltration is proposed. For example, if the A and B horizons are to be removed and the infiltration will be through the C horizon, conduct the borings or test pits through the C horizon. MassDEP requires that borings be at least 20 feet deep or extend to the depth of the limiting layer.

For each bore hole or test pit, evaluate the saturated hydraulic conductivity of the soil, depth to seasonal high groundwater, NRCS soil textural class, NRCS Hydrologic Soil Group, and the presence of fill materials in accordance with Volume 3. Never locate infiltration basins above fill. Never locate infiltration basins in Hydrologic Soil Group "D" soils. The minimum acceptable final soil infiltration rate is 0.17 inches per hour. Design the infiltration basin based on the soil evaluation set forth in Volume 3.

If the proposed basin is determined to be in Hydrologic Soil Group "C" soils, incorporate measures in the design to reduce the potential for clogging, such as providing more pretreatment or greater media depth to provide additional storage. Never use the results of a Title 5 percolation test to estimate a saturated hydraulic conductivity rate, because it tends to greatly overestimate the rate that water will infiltrate into the subsurface.

Estimate seasonal high groundwater based on soil mottles or through direct observation when borings are conducted in April or May, when groundwater levels are likely to be highest. If it is difficult to determine the seasonal high groundwater elevation from the borings or test pits, then use the Frimpter method developed by the USGS (Massachusetts/Rhode Island District Office) to estimate seasonal high groundwater. After estimating the seasonal high groundwater using the Frimpter method, re-examine the bore holes or test pits to determine if there are any field indicators that corroborate the Frimpter method estimate.

Stabilize inlet channels to prevent incoming flow velocities from reaching erosive levels, which can scour the basin floor. Riprap is an excellent inlet stabilizer. Design the riprap so it terminates in a broad apron, thereby distributing runoff more evenly over the basin surface to promote better infiltration.

At a minimum, size the basin to hold the required recharge volume. Determine the required recharge

volume using either the static or dynamic methods set forth in Volume 3. Remember that the required storage volume of an infiltration basin is the sum of the quantity of runoff entering the basin from the contributing area and the precipitation directly entering the basin. Include one foot of freeboard above the total of the required recharge volume and the direct precipitation volume to account for design uncertainty. When applying the dynamic method to size the basin, use only the bottom of the basin (i.e., do not include side wall exfiltration) for the effective infiltration area.

Design the infiltration basin to exfiltrate in no less than 72 hours. Consider only the basin floor as the effective infiltration area when determining whether the basin meets this requirement.

Design the basin floor to be as flat as possible to provide uniform ponding and exfiltration of the runoff. Design the basin floor to have as close to a 0% slope as possible. In no case shall the longitudinal slope exceed 1%. Enhanced deposition of sediment in low areas may clog the surface soils, resulting in reduced infiltration and wet areas. Design the side slopes of the basin to be no steeper than 3:1 (horizontal: vertical) to allow for proper vegetative stabilization, easier mowing, easier access, and better public safety.

For basins with a 1% longitudinal slope, it will be necessary to incorporate cells into the design, making sure that the depth of ponded water does not exceed 2 feet, because sloped basin floors cause water to move downhill, thereby decreasing the likelihood of infiltration. Make lateral slopes flat (i.e., 0% slope).

After the basin floor is shaped, place soil additives on the basin floor to amend the soil. The soil additives shall include compost, properly aged to kill any seed stock contained within the compost. Do not put biosolids in the compost. Mix native soils that were excavated from the A or B horizons to create the basin with the compost, and then scarify the native materials and compost into the parent material using a chisel plow or rotary device to a depth of 12 inches. Immediately after constructing the basin, stabilize its bottom and side slopes with a dense turf of water-tolerant grass. Use low-maintenance, rapidly germinating grasses, such as fescues. The selected grasses must be capable of surviving in both wet and dry conditions. Do not use sod, which can prevent roots from directly contacting the underlying soil. During the first two months, inspect the newly established vegetation several times to determine if any remedial actions (e.g., reseeding, irrigating) are necessary.

Never plant trees or shrubs within the basin or on the impounding embankments as they increase the chance of basin failure due to root decay or subsurface disturbance. The root penetration and thatch formation of the turf helps to maintain and may even enhance the original infiltration capacity. Soluble nutrients are taken up by the turf for growth, improving the pollutant removal capacity. Dense turf will impede soil erosion and scouring of the basin floor.

In place of turf, use a basin liner of 6 to 12 inches of fill material, such as coarse sand. Clean and replace this material as needed. Do not use loose stone, riprap, and other irregular materials requiring hand removal of debris and weeds.

Design embankments and spillways to conform to the regulatory guidelines of the state's Office of Dam Safety (302 CMR 10.00). Design infiltration basins to be below surrounding grade to avoid issues related to potential embankment failure. All infiltration basins must have an emergency spillway capable of bypassing runoff from large storms without damage to the impounding structure. Design the emergency spillway to divert the storm associated with brimful conditions without impinging upon the structural integrity of the basin. The brimful condition could be the required recharge volume or a design storm (such as the 2-year, 10-year, or 100-year storm if the basin is designed to provide peak rate attenuation in addition to exfiltration). The storm associated with the brimful conditions should not include the one foot of freeboard required to account for design uncertainty. Design the emergency spillway to shunt water toward a location where the water will not damage wetlands or buildings. A common error is to direct the spillway runoff toward an adjoining property not owned by an applicant. If the emergency spillway is designed to drain the emergency overflow toward an adjoining property, obtain a drainage easement and submit it to the Conservation Commission as part of the Wetlands NOI submission. Place vegetative buffers around the perimeter of the basin for erosion control and additional sediment and nutrient removal.

Monitoring wells: Install one monitoring well in the basin floor per every 5,000 square feet of basin floor. Make sure the monitoring well(s) extend 20 feet beneath the basin floor or to the limiting layer, whichever is higher.

Access: Include access in the basin design. The area at the top of the basin must provide unimpeded vehicular access around the entire basin perimeter. The access area shall be no less than 15 feet.

Inlet Structures: Place inlet structures at one longitudinal end of the basin, to maximize the flow path from the inlet to the overflow outlet. A common error is to design multiple inlet points around the entire basin perimeter.

Outlet structures: Infiltration basins must include an overflow outlet in addition to an emergency spillway. Whether using a single orifice or multiple orifices in the design, at a minimum, set the lowest orifice at or above the required recharge volume.

Drawdown device: Include a device to draw the basin down for maintenance purposes. If the basin includes multiple cells, include a drawdown device for each cell.

Fences: Do not place fences around basins located in Riverfront Areas, as required by 310 CMR 10.58(4) (d)1.d. to avoid impeding wildlife movement. In such cases, consider including a safety bench as part of the design.

Construction

Prior to construction, rope or fence off the area selected for the infiltration basin. Never allow construction equipment to drive across the area intended to serve as the infiltration basin.

Never use infiltration basins as temporary sediment traps for construction activities.

To limit smearing or compacting soils, never construct the basin in winter or when it is raining. Use light earth-moving equipment to excavate the infiltration basin because heavy equipment compacts the soils beneath the basin floor and side slopes and reduces infiltration capacity. Because some compaction of soils is inevitable during construction, add the required soil amendments and deeply till the basin floor with a rotary tiller or a disc harrow to a depth of 12 inches to restore infiltration rates after final grading.

Use proper erosion/sediment control during construction. Immediately following basin construction, stabilize the floor and side slopes of the basin with a dense turf of water-tolerant grass. Use low maintenance, rapidly germinating grasses, such as fescues. Do not sod the basin floor or side slopes. After the basin is completed, keep the basin roped or fenced off while construction proceeds on other parts of the site. Never direct construction period drainage to the infiltration basin. After construction is completed, do not direct runoff into the basin until the bottom and side slopes are fully stabilized.

Maintenance

Infiltration basins are prone to clogging and failure, so it is imperative to develop and implement aggressive maintenance plans and schedules. Installing the required pretreatment BMPs will significantly reduce maintenance requirements for the basin.

The Operation and Maintenance Plan required by Standard 9 must include inspections and preventive maintenance at least twice a year, and after every time drainage discharges through the high outlet orifice. The Plan must require inspecting the pretreatment BMPs in accordance with the minimal requirements specified for those practices and after every major storm event. A major storm event is defined as a storm that is equal to or greater than the 2-year, 24-hour storm (generally 2.9 to 3.6 inches in a 24-hour period, depending in geographic location in Massachusetts).

Once the basin is in use, inspect it after every major storm for the first few months to ensure it is stabilized and functioning properly and if necessary take corrective action. Note how long water remains standing in the basin after a storm; standing water within the basin 48 to 72 hours after a storm indicates that the infiltration capacity may

have been overestimated. If the ponding is due to clogging, immediately address the reasons for the clogging (such as upland sediment erosion, excessive compaction of soils, or low spots).

Thereafter, inspect the infiltration basin at least twice per year. Important items to check during the inspection include:

- Signs of differential settlement,
- · Cracking,
- Erosion,
- Leakage in the embankments
- Tree growth on the embankments
- Condition of riprap,
- · Sediment accumulation and
- The health of the turf.

At least twice a year, mow the buffer area, side slopes, and basin bottom. Remove grass clippings and accumulated organic matter to prevent an impervious organic mat from forming. Remove trash and debris at the same time. Use deep tilling to break up clogged surfaces, and revegetate immediately.

Remove sediment from the basin as necessary, but wait until the floor of the basin is thoroughly dry. Use light equipment to remove the top layer so as to not compact the underlying soil. Deeply till the remaining soil, and revegetate as soon as possible. Inspect and clean pretreatment devices associated with basins at least twice a year, and ideally every other month.

References:

Center for Watershed Protection, http://www.stormwatercenter.net/Manual_Builder/Construction%20 Specifications/Infiltration%20Trench%20Specifications.htm

Center for Watershed Protection, http://www. stormwatercenter.net/Manual_Builder/Performance%20 Criteria/Infiltration.htm

Center for Watershed Protection, Stormwater Management Fact Sheet, Infiltration Basin, http://www.stormwatercenter.net/Assorted%20Fact%20 Sheets/Tool6_Stormwater_Practices/Infiltration%20 Practice/Infiltration%20Basin.htm

Ferguson, B.K., 1994. Stormwater Infiltration. CRC Press, Ann Arbor, MI.

Galli, J. 1992. Analysis of Urban BMP Performance and Longevity in Prince George's County, Maryland. Metropolitan Washington Council of Governments, Washington, DC.

Maryland Department of the Environment, 2000, Maryland Stormwater Design Manual, Appendix B-2, Construction Specifications for Infiltration Practices, http://www.mde.state.md.us/assets/document/appendixb2.pdf

Pitt, R., et al. 1994, Potential Groundwater Contamination from Intentional and Nonintentional Stormwater Infiltration, EPA/600/R-94/051, Risk Reduction Engineering Laboratory, U.S. EPA, Cincinnati, OH

Schroeder, R.A., 1995, Potential For Chemical Transport Beneath a Storm-Runoff Recharge (Retention) Basin for an Industrial Catchment in Fresno, CA, USGS Water-Resource Investigations Report 93-4140.

Wisconsin Department of Natural Resources, 2004, Conservation Practice Standard 1003, Infiltration Basin, http://www.dnr.state.wi.us/org/water/wm/nps/stormwater/ technote.htm

Winiarski, T. Bedell, J.P., Delolme, C., and Perrodin, Y., 2006, The impact of stormwater on a soil profile in an infiltration basin, Hydrogeology Journal (2006) 14: 1244–1251

Leaching Catch Basins



Ability to meet specific standards

Standard	Description
2 - Peak Flow	May provide some peak rate attenuation if sufficient number of leaching catch basins are provided to control 10-year storm
3 - Recharge	Provides groundwater recharge
4 - TSS Removal	80% TSS removal providing a deep sump catch basin is used for pretreatment and provided it is designed to be off-line
5 - Higher Pollutant Loading	May be used if 44% of TSS is removed with a pretreatment BMP prior to infiltration. For land uses that have the potential to generate runoff with high concentrations of oil and grease, an oil grit separator or equivalent may be required for pretreatment prior to discharge to the leaching catch basin. Infiltration must be done in compliance with 314 CMR 5.00.
6 - Discharges	Not suitable except as terminal
near or to	treatment for discharges to or
Critical Areas	near cold-water fisheries.
7 - Redevelopment	May be a good retrofit for sites with existing catch basins

Description: A leaching catch basin is pre-cast concrete barrel and riser with an open bottom that permits runoff to infiltrate into the ground. There are two configurations:

- 1. Stand-alone barrel/riser and
- 2. Barrel/riser combined with a deep sump catch basins that provides pretreatment.

80% TSS removal is awarded to the deep sump catch basin/leaching catch basin pretreatment combination provided the system is off-line.

Advantages/Benefits:

- Provide groundwater recharge.
- Remove coarse sediment

Disadvantages/Limitations:

- Need frequent maintenance. Can become a source of pollutants via resuspension if not properly maintained.
- Cannot effectively remove soluble pollutants or fine particles.
- Do not provide adequate treatment of runoff unless combined with deep sump catch basin
- Entrapment hazard for amphians and other small animals.

Pollutant Removal Efficiencies

• Total Suspended Solids (TSS)

• Nutrients (Nitrogen, phosphorus)

• Metals (copper, lead, zinc, cadmium)

• Pathogens (coliform, e coli)

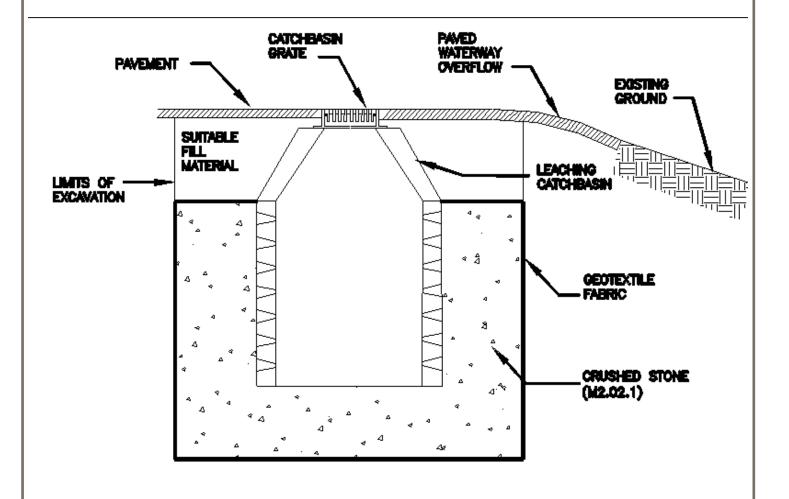
80% if combined with deep sump catch basin and if

designed to be off-line

Insufficient data

Insufficient data

Insufficient data



adapted from the MassHighway Department

Maintenance

Activity	Frequency
Inspect units and remove debris	Inspect annually or more frequently as
	indicated by structure performance
Remove sediment	When the basin is 50% filled
Rehabilitate the basin if it fails due to clogging	As needed

Special Features:

Use as off-line device

LID Alternative:

Reduce pervious areas Bioretention areas and rain gardens

Leaching Catch Basins

Planning Considerations

Use leaching catch basins as off-line devices in areas with highly permeable soils. Provide for the safe overflow from these devices in severe storm events, or in the event of clogging of the soils surrounding the device. Because leaching catch basins discharge runoff to groundwater, do not use them in areas of higher potential pollutant loadings (such as gas stations) without adequate pretreatment such as an oil grit separator.

Design

Leaching catch basins are typically set in an excavation lined with a geotextile liner to prevent fine soil particles from migrating into the void spaces of the stone. The basin is placed on a pad of free-draining crushed stone, with the excavation around the basin back-filled with similar material. The base and barrel of the basin are perforated so that water entering the basin can enter the surrounding stone fill and infiltrate into the ground.

Use stone material with a void ratio of 0.39 or less. Make the depth to groundwater at least 2 feet below the bottom of the leaching catch basin. When designing structural components, design for dead and live loads as appropriate. Include provisions for overflows such as redundant devices and paved chutes.

The basin inlet cover is an important component. The openings must be no larger than 1 inch square to prevent coarse debris larger than 1 inch from entering the basin. The inlet grate must fit tightly into the underlying steel frame to prevent it from being dislodged by traffic. Do not weld the inlet grate to the underlying frame.

The riser section shall be mortared, grouted, gasketed, or otherwise sealed, to prevent exfiltration through the joint. Leaching catch basins shall contain no weep holes. Do not perforate the barrel section.

Make sure leaching catch basins contain no outlet pipes. The only pipe that is allowed in a leaching catch basin is an inlet pipe from an off-line deep sump catch basin paired with that leaching catch basin. Seal all pipe joints.

Construction

Install construction barriers around the excavation area to prevent access by pedestrians. Use diversions and other erosion control practices up-slope of the leaching catch basin to prevent runoff from entering the site before catch basins are complete. Stabilize the surrounding area and any established outlet. Put controls in place to prevent any drainage from being discharged to the leaching catch basin until the contributing drainage area is fully stabilized. Remove all temporary structures after the contributing drainage area and vegetation is stabilized.

Maintenance

- Inspect annually or more frequently as indicated by structure performance
- Remove sediment when the basin is 50% filled.
- · Rehabilitate the basin if it fails due to clogging

Adapted from:

MassHighway. Storm Water Handbook for Highways and Bridges. May 2004.

BMP Accessories: Level Spreaders, Check Dams, Outlet Structures, Catch Basin Inserts

BMP accessories are not BMPs themselves but are required to facilitate the operation and function of BMPs. This section presents four of the most common and important BMP accessories: level spreaders, check dams, outlet structures, and catch basin inserts.

Level Spreaders

Description

A level spreader receives concentrated flow from channels, outlet structures, or other conveyance structures, and converts it to sheet flow where it can disperse uniformly across a stable slope. A level spreader is not a pollutant reduction device. It improves the efficiency of other BMPs, such as vegetated swales, filter strips, or infiltration systems that depend on sheet flow to operate properly.



Applicability and Planning Considerations

Level spreaders are used in wide, level areas where concentrated runoff occurs. They should be placed on undisturbed soil that has been stabilized with vegetation. Disturbed soils are more erodible. If the spreader is not absolutely level, flow will concentrate at the low point and may worsen erosion problems. Flows to the level spreader should be relatively free of sediment, or the level spreader could be quickly overwhelmed by sediment and lose its effectiveness.

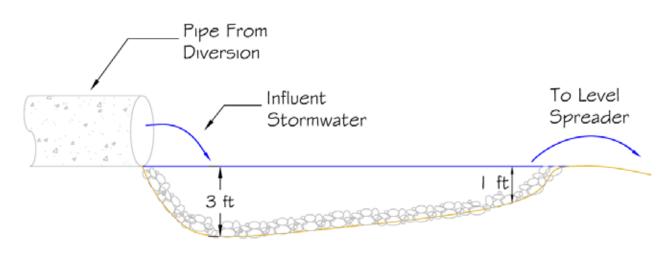
Design and Construction

Level spreaders are usually made of rocks, lumber, or concrete. Typical depths of flow behind each spreader range from 6 to 12 inches.

Construct level spreaders to be absolutely level. Small variations in height of even 0.25 inches can cause water to quickly concentrate and create erosion problems. A 4-inch variation in ground elevation across the entire length of the level spreader can make level construction difficult.

The height of the spreader is based on design flow, allowing for sediment and debris deposition. Design the length of the spreader based on the 10-year design flow for the site or the sheet flow path width, whichever is greater. When designing for the 10-year design flow, use the following table:

Level Spreader



adapted from the North Carolina State University

Drainage Area	Minimum spreader
length	
1 acre	10 feet
2 acres	10 feet
3 acres	15 feet
4 acres	18 feet
5 acres	20 feet

The slope leading to the level spreader should be less than 1% for at least 20 feet immediately upstream, to keep runoff velocities less than 2 feet per second during the 10-year storm event. The slope at the outlet of the spreader should be 6% or less.

Maintenance

Inspect level spreaders regularly, especially after large rainfall events. Note and repair any erosion or low spots in the spreader.

Adapted from:

Idaho Department of Environmental Quality. Catalog of Stormwater BMPs for Cities and Counties, 209-210. MassDEP, Massachusetts Nonpoint Source Pollution Management Manual, 2006.

http://www.mass.gov/dep/water/laws/policies.htm#storm Additional Resources:

Hunt, W.F. et al. Designing Level Spreaders to Treat Stormwater Runoff. North Carolina State University, as presented at North Carolina Department of Transportation Level Spreader Workshop, February 19, 2001, Raleigh, NC.



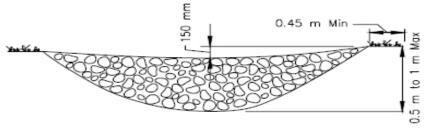
Applicability

Use check dams where temporary channels or permanent channels are not yet vegetated, channel lining is infeasible, where velocity checks are needed, or to induce stormwater exfiltration into the ground within a BMP such as a dry water quality swale. Check dams may also be used as a temporary or emergency measure to limit erosion by reducing flow in small open channels. Other uses for

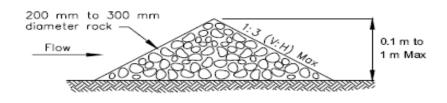
Check Dams

Description

A check dam is a small dam constructed across a drainage ditch, swale, or channel to lower the velocity of flow. Reduced runoff velocity reduces erosion and gullying in the channel and allows sediments to settle out. A check dam may be built from stone, sandbags (filled with pea gravel), logs, or concrete. Check dams are relatively easy and inexpensive to construct. Permanent check dams should be constructed from stone or concrete. Sandbag dams filled with pea gravel or logs are suitable only as temporary practices. Never use a filter fence or a hay bale as a check dam, either on a temporary or permanent basis.



ELEVATION



TYPICAL ROCK CHECK DAM SECTION

CHECK DAM NOT TO SCALE

adapted from Caltrans Stormwater Handbooks

Structural BMPs - Volume 2 | Chapter 2 page 129

check dams include:

- To reduce flow in small temporary channels that are presently undergoing degradation,
- Where permanent stabilization is impractical due to the temporary nature of the problem,
- To reduce flow in small eroding channels where construction delays or weather conditions prevent timely installation of non-erosive liners.

Check dams can be installed in small open channels that drain 10 acres or less, or channels where stormwater velocities exceed 5 feet per second. Note that some BMPs such as grass channels require flows to not exceed 1 foot per second for the water quality volume. Check dams cause water to pond. Under low-flow situations, water ponds behind the structure and then slowly seeps through the check dam and/or exfiltrates into the underlying soil, depending on the soil permeability. Under high-flow situations, water flows over and/or through the structure.

Advantages

- Inexpensive and easy to install.
- Reduces velocity and may provide aeration of the water.
- Prevents gully erosion from occurring before vegetation is established, and also causes a high proportion of the sediment load in runoff to settle out.
- In some cases, if carefully located and designed, check dams can remain as permanent installations with very minor regrading, etc.
- They may be left as either spillways, in which case accumulated sediment would be graded and seeded, or as check dams to capture sediment coming off that site.
- They must be constructed in dry water quality swales to reduce velocity and induce exfiltration.

Disadvantages

- May kill grass linings in channels if the water level remains high after rainstorms or if there is significant sedimentation.
- Clogging by leaves in the fall may be a problem.
- Should not be used in live streams
- Promotes sediment trapping but resuspension can occur during subsequent storms
- Require extensive maintenance following high velocity flows
- Should not be made from straw bales or silt fences

Design

Install check dams at a distance and a height to allow small pools to form behind them. Install the first check dam about 15 feet from the outfall device and at regular intervals after that, depending on slope and soil type. In multiple check dam installations, design the system so that backwater from the downstream check dam reaches the toe of the next upstream dam. High flows (typically a 2-year or larger storm) should flow over the check dam without increasing upstream flooding or damaging the dam. Form check dams by hand or mechanically. Never dump rock directly into the channel or swale. Rock check dams should consist of well-graded stone consisting of a mixture of rock sizes.

When used in dry water quality swales, the height of the check dam shall be no less than the elevation associated with the Water Quality Volume (1/2 inch or 1-inch times contributing impervious surface).

Exercise care in designing the ends of a check dam to ensure that it is long enough and adequately anchored to prevent ponded water from scouring the soil at the ends, and flowing around the dam.

Some check dam designs may require weirs. For example, if the same check dam is used for water quality treatment (for the water quality volume), and to lag the peak rate of runoff (for the velocity associated with runoff from the 2-year storm), a weir must be included as part of the check dam design. In instances where a permanent check dam is to be used for both water quality treatment and lag peak flows with a weir, use a durable material such as concrete. If the check dam is constructed from stone such as pea gravel, the weir would most likely lose its shape when higher velocities occur.

Maintenance

Inspect check dams after every significant rainfall event. Repair damage as needed. Remove sediment as needed.

Adapted from:

Caltrans, Storm Water Quality Handbooks. Section 4. SC-4 P.

MassDEP, Massachusetts Nonpoint Source Pollution Management Manual, 2006.

http://www.mass.gov/dep/water/laws/policies. htm#storm

OUTLET STRUCTURES

Description

Outlets of BMPs are devices that control the flow of stormwater out of the BMP to the conveyance system.

Outlet Protection Design in Relation to Receiving Wetlands

This section describes the various types of common outlets such as flared end structures, risers, single-stage outlets, and multi-stage outlets. Considerations include setting back the outlet from a brook, providing appropriate energy dissipation, and orientating the outlet to reduce scour effects on the opposite bank.

Alignment of Outlets into Regulatory Streams

The Wetlands and 401 regulations require that stormwater treatment be provided prior to discharge into wetland resource areas such as vegetated wetlands (BVW, IVW, salt marshes), land under water (streams, lakes, rivers, ponds, ocean), and other resource areas, except for Riverfront Areas ILSF, BLSF, and land subject to coastal zone flowage, where such practices may be sited, provided the structures meet the performance standards specified in the Wetland regulations applicable to all projects.

The impact of new pipe outfalls on wetlands can be significantly reduced by locating the outfall point back from the receiving stream, using a flared-end structure, installing riprap or bio-engineered splash pad, and either digging a channel from the outfall to the stream or designing the splash pad to act as a level spreader to sheet the discharged stormwater to the stream.

In addition to not placing the outfall and energy dissipation in a wetland resource area such as a BVW or LUW, care must be exercised in the outlet design to ensure its orientation is such to reduce scour at the entry point and opposite bank. The preferred approach is to end the outlet pipe at a headwall or flared-end structure with a riprap or bio-engineered splash pad, discharging to a manmade drainage swale that is aligned at no more than a 45 degree

angle to a stream channel. Design the outlet point and riprap or bio-engineered splash pad to reduce the energy sufficiently to eliminate a need to



install riprap on the bank opposite the outfall point to protect it from scour.

References for BMP Accessories:

Note that sections of the Massachusetts Stormwater Update were adapted from a variety of manuals, checklists and other references in the public domain previously developed by other states and federal agencies, including:

Caltrans, Storm Water Quality Handbooks. 2003. (http://www.dot.ca.gov/hq/construc/stormwater/manuals.htm)

Connecticut Department of Environmental Protection. Connecticut Stormwater Quality Manual. 2004. (http://dep.state.ct.us/wtr/stormwater/strmwtrman.htm)

Idaho Department of Environmental Quality. Catalog of Stormwater BMPs for Cities and Counties. March 2003. (http://www.google.com/u/ DEQ?q=stormwater&domains=www.deq.idaho. gov&sitesearch=www.deq.idaho.gov)

Maine Department of Environmental Protection. Maine Stormwater Best Management Practices Manual. January 2006. (http://www.maine.gov/dep/blwq/docstand/stormwater/stormwaterbmps/index.htm)

Maryland Department of the Environment. Maryland Stormwater Design Manual, Volumes I and II, October 2000. (http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp)

New Jersey Department of Environmental Protection. New Jersey Stormwater Best Management Practices Manual. April 2004. http://www.state.nj.us/dep/ stormwater/bmp_manual2.htm

U.S. Department of Transportation. Federal Highway Administration. Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring. (Undated).

U.S.Environmental Protection Agency. Office of Research and Development. The Use of Best Management Practices (BMPs) in Urban Watersheds. EPA/600/R-04/184. September 2004.

Vermont Agency of Natural Resources. The Vermont Stormwater Management Manual. April 2002. (http://www.vtwaterquality.org/stormwater.htm)

Catch Basin Inserts

Description

Catch Basin Inserts are a BMP accessory recently developed to add filtering efficiency to traditional catch basins. These proprietary BMPs are capable of removing a range of pollutants, from trash and debris to fine sediments and oil/grease and metals depending upon the filtering medium used. They typically have three components:

- an insert that fits in into the catch basin
- absorbent material (can be a single unit or a series of filters)
- · a housing to hold the absorbent material



applications. Additionally, larger sized sediment can clog and significantly reduce the effectiveness of some Catch Basin Insert filtering media. Therefore it is important to ensure that flow rates, sediment removal, and the frequency of inspection and maintenance are evaluated.

Design and Construction

Since Catch Basin Inserts are usually proprietary devices, the manufacturer should be asked to ensure that the device will work in the type of catch basin in which it is installed. Flow characteristics and sediment loading should be evaluated and any resulting modifications to the catch basin made before installation of the insert.

Maintenance

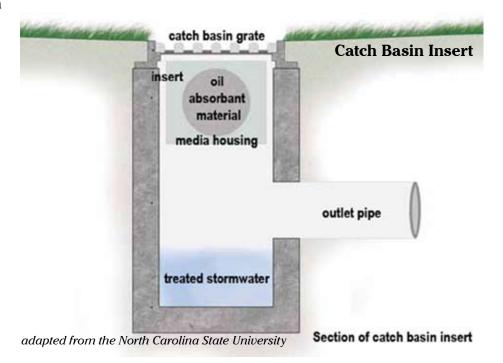
Inspect Catch Basin Inserts per the manufacturer's schedule, and especially after large rainfall events. Whoever is responsible for maintenance should explicitly agree to conduct the maintenance per the manufacturer's recommendation and to lawfully dispose of the cleanings or used filtration media.

Applicability and Planning Considerations

Catch Basin Inserts can be useful for specialized applications, such as targeting specific pollutants

other than TSS, at Land Uses with Higher Potential Pollution Loads, for oil control at small sites, for retrofits of existing catch basins with no or undersized sumps, to add TSS capability to areas with higher sediment loading, or to improve existing conditions at size-constrained sites (e.g., catch basins near bathing beaches).

If using a proprietary Catch Basin Insert, the manufacturer's specifications must be followed, which may include modifications to the catch basin. Such modifications may include a high flow bypass or other feature to handle clogging or larger storm events.

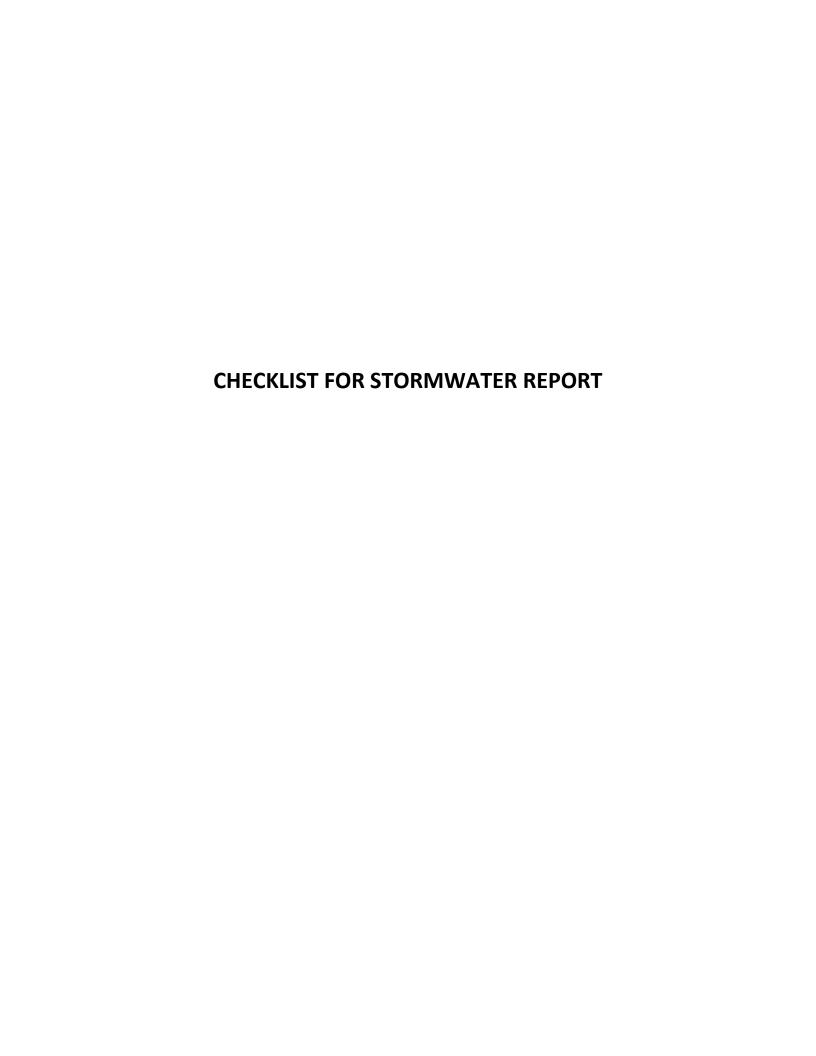


Catch Basin Inserts are typically designed for and used for smaller volume

Appendix C

Stormwater Management Review Reports

Name:		Date:
2 12 12	(-	
General Notes/Comments: (Describe weather and general drainage system co	onditions)
Structure	Current Condition	Maintenance Performed
Vegetative Filter Strip:	Current Condition	Waintenance renormed
Review (Grass height,		
sediment, and debris)		
,		
Drainage Channels:		
Review (Vegetated		
condition, sediment,		
and debris)		
Grassed Channels:		
Review (Vegetated		
condition, sediment,		
and debris)		
Catch Basin/Manhole:		
Review (Overall		
structure conditions,		
hood, sediment		
depth, and debris)		
		'
Leaching Basin:		
Review (Overall		
structure condition,		
sediment depth, and		
debris)		
1 City 12 1		T
Infiltration Trench:		
Review (Signs of effective operation,		
sediment, and debris)		
scament, and acons,		
Infiltration Basins:		
Review (Grass height,		
sediment, debris,		
signs of effective		
operation)		
Proprietary Separator:		
Review (Oil depth and		
debris)		
Outlets/Headwalls:		
Review (Structure		
integrity and debris)		
Dines/Ones Devices		
Pipes/Open Box Culvert:		
Review (structural integrity, silting, and		
clogging)		



This Page Intentionally Left Blank



Massachusetts Department of Environmental Protection

Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

A. Introduction

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.





A Stormwater Report must be submitted with the Notice of Intent permit application to document compliance with the Stormwater Management Standards. The following checklist is NOT a substitute for the Stormwater Report (which should provide more substantive and detailed information) but is offered here as a tool to help the applicant organize their Stormwater Management documentation for their Report and for the reviewer to assess this information in a consistent format. As noted in the Checklist, the Stormwater Report must contain the engineering computations and supporting information set forth in Volume 3 of the Massachusetts Stormwater Handbook. The Stormwater Report must be prepared and certified by a Registered Professional Engineer (RPE) licensed in the Commonwealth.

The Stormwater Report must include:

- The Stormwater Checklist completed and stamped by a Registered Professional Engineer (see page 2) that certifies that the Stormwater Report contains all required submittals. This Checklist is to be used as the cover for the completed Stormwater Report.
- Applicant/Project Name
- Project Address
- Name of Firm and Registered Professional Engineer that prepared the Report
- Long-Term Pollution Prevention Plan required by Standards 4-6
- Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan required by Standard 8²
- Operation and Maintenance Plan required by Standard 9

In addition to all plans and supporting information, the Stormwater Report must include a brief narrative describing stormwater management practices, including environmentally sensitive site design and LID techniques, along with a diagram depicting runoff through the proposed BMP treatment train. Plans are required to show existing and proposed conditions, identify all wetland resource areas, NRCS soil types, critical areas, Land Uses with Higher Potential Pollutant Loads (LUHPPL), and any areas on the site where infiltration rate is greater than 2.4 inches per hour. The Plans shall identify the drainage areas for both existing and proposed conditions at a scale that enables verification of supporting calculations.

As noted in the Checklist, the Stormwater Management Report shall document compliance with each of the Stormwater Management Standards as provided in the Massachusetts Stormwater Handbook. The soils evaluation and calculations shall be done using the methodologies set forth in Volume 3 of the Massachusetts Stormwater Handbook.

To ensure that the Stormwater Report is complete, applicants are required to fill in the Stormwater Report Checklist by checking the box to indicate that the specified information has been included in the Stormwater Report. If any of the information specified in the checklist has not been submitted, the applicant must provide an explanation. The completed Stormwater Report Checklist and Certification must be submitted with the Stormwater Report.

¹ The Stormwater Report may also include the Illicit Discharge Compliance Statement required by Standard 10. If not included in the Stormwater Report, the Illicit Discharge Compliance Statement must be submitted prior to the discharge of stormwater runoff to the post-construction best management practices.

² For some complex projects, it may not be possible to include the Construction Period Erosion and Sedimentation Control Plan in the Stormwater Report. In that event, the issuing authority has the discretion to issue an Order of Conditions that approves the project and includes a condition requiring the proponent to submit the Construction Period Erosion and Sedimentation Control Plan before commencing any land disturbance activity on the site.



Checklist for Stormwater Report

B. Stormwater Checklist and Certification

The following checklist is intended to serve as a guide for applicants as to the elements that ordinarily need to be addressed in a complete Stormwater Report. The checklist is also intended to provide conservation commissions and other reviewing authorities with a summary of the components necessary for a comprehensive Stormwater Report that addresses the ten Stormwater Standards.

Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the item is not applicable (N.A.) and provide the reasons for that determination.

A complete checklist must include the Certification set forth below signed by the Registered Professional Engineer who prepared the Stormwater Report.

Registered Professional Engineer's Certification

I have reviewed the Stormwater Report, including the soil evaluation, computations, Long-term Pollution Prevention Plan, the Construction Period Erosion and Sedimentation Control Plan (if included), the Long-term Post-Construction Operation and Maintenance Plan, the Illicit Discharge Compliance Statement (if included) and the plans showing the stormwater management system, and have determined that they have been prepared in accordance with the requirements of the Stormwater Management Standards as further elaborated by the Massachusetts Stormwater Handbook. I have also determined that the information presented in the Stormwater Checklist is accurate and that the information presented in the Stormwater Report accurately reflects conditions at the site as of the date of this permit application.

Registered Professional Engineer Block and Signature



1		
MIN	10/31116	
Signature and Date		

Checklist

Project Type: Is the application for new development, redevelopment, or a mix of new and redevelopment?	
New development	
□ Redevelopment	
Mix of New Development and Redevelopment	



Checklist for Stormwater Report

Checklist (continued)

env	vironmentally sensitive design and LID Techniques were considered during the planning and design of project:
	No disturbance to any Wetland Resource Areas
	Site Design Practices (e.g. clustered development, reduced frontage setbacks)
\boxtimes	Reduced Impervious Area (Redevelopment Only)
	Minimizing disturbance to existing trees and shrubs
	LID Site Design Credit Requested:
	☐ Credit 1
	☐ Credit 2
	☐ Credit 3
	Use of "country drainage" versus curb and gutter conveyance and pipe
	Bioretention Cells (includes Rain Gardens)
	Constructed Stormwater Wetlands (includes Gravel Wetlands designs)
	Treebox Filter
	Water Quality Swale
\boxtimes	Grass Channel
	Green Roof
	Other (describe):
Sta	andard 1: No New Untreated Discharges
\boxtimes	No new untreated discharges
	Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth
	Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.



Checklist for Stormwater Report

Checklist (continued)
Standard 2: Peak Rate Attenuation
 Standard 2 waiver requested because the project is located in land subject to coastal storm flowage and stormwater discharge is to a wetland subject to coastal flooding. Evaluation provided to determine whether off-site flooding increases during the 100-year 24-hour storm.
□ Calculations provided to show that post-development peak discharge rates do not exceed pre- development rates for the 2-year and 10-year 24-hour storms. If evaluation shows that off-site flooding increases during the 100-year 24-hour storm, calculations are also provided to show that post-development peak discharge rates do not exceed pre-development rates for the 100-year 24- hour storm.
Standard 3: Recharge
☐ Soil Analysis provided.
Required Recharge Volume calculation provided.
Required Recharge volume reduced through use of the LID site Design Credits.
☐ Sizing the infiltration, BMPs is based on the following method: Check the method used.
☐ Static ☐ Simple Dynamic ☐ Dynamic Field¹
Runoff from all impervious areas at the site discharging to the infiltration BMP.
Runoff from all impervious areas at the site is <i>not</i> discharging to the infiltration BMP and calculations are provided showing that the drainage area contributing runoff to the infiltration BMPs is sufficient to generate the required recharge volume.
Recharge BMPs have been sized to infiltrate the Required Recharge Volume.
Recharge BMPs have been sized to infiltrate the Required Recharge Volume <i>only</i> to the maximum extent practicable for the following reason:
☐ Site is comprised solely of C and D soils and/or bedrock at the land surface
M.G.L. c. 21E sites pursuant to 310 CMR 40.0000
Solid Waste Landfill pursuant to 310 CMR 19.000
Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.
☐ Calculations showing that the infiltration BMPs will drain in 72 hours are provided.
Property includes a M.G.L. c. 21E site or a solid waste landfill and a mounding analysis is included.

¹ 80% TSS removal is required prior to discharge to infiltration BMP if Dynamic Field method is used.



Checklist for Stormwater Report

Cł	necklist (continued)
Sta	andard 3: Recharge (continued)
	The infiltration BMP is used to attenuate peak flows during storms greater than or equal to the 10-year 24-hour storm and separation to seasonal high groundwater is less than 4 feet and a mounding analysis is provided.
	Documentation is provided showing that infiltration BMPs do not adversely impact nearby wetland resource areas.
Sta	indard 4: Water Quality
The	e Long-Term Pollution Prevention Plan typically includes the following: Good housekeeping practices; Provisions for storing materials and waste products inside or under cover; Vehicle washing controls; Requirements for routine inspections and maintenance of stormwater BMPs; Spill prevention and response plans; Provisions for maintenance of lawns, gardens, and other landscaped areas; Requirements for storage and use of fertilizers, herbicides, and pesticides; Pet waste management provisions; Provisions for operation and management of septic systems; Provisions for solid waste management; Snow disposal and plowing plans relative to Wetland Resource Areas; Winter Road Salt and/or Sand Use and Storage restrictions; Street sweeping schedules; Provisions for prevention of illicit discharges to the stormwater management system; Documentation that Stormwater BMPs are designed to provide for shutdown and containment in the event of a spill or discharges to or near critical areas or from LUHPPL; Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan; List of Emergency contacts for implementing Long-Term Pollution Prevention Plan.
	A Long-Term Pollution Prevention Plan is attached to Stormwater Report and is included as an attachment to the Wetlands Notice of Intent. Treatment BMPs subject to the 44% TSS removal pretreatment requirement and the one inch rule for calculating the water quality volume are included, and discharge: is within the Zone II or Interim Wellhead Protection Area
	is near or to other critical areas
	is within soils with a rapid infiltration rate (greater than 2.4 inches per hour)
	involves runoff from land uses with higher potential pollutant loads.
	The Required Water Quality Volume is reduced through use of the LID site Design Credits.

☐ Calculations documenting that the treatment train meets the 80% TSS removal requirement and, if

applicable, the 44% TSS removal pretreatment requirement, are provided.



Checklist (continued)

Checklist for Stormwater Report

Standard 4: Water Quality (continued)				
\boxtimes	The BMP is sized (and calculations provided) based on:			
	☐ The ½" or 1" Water Quality Volume or			
	☐ The equivalent flow rate associated with the Water Quality Volume and documentation is provided showing that the BMP treats the required water quality volume.			
	The applicant proposes to use proprietary BMPs, and documentation supporting use of proprietary BMP and proposed TSS removal rate is provided. This documentation may be in the form of the propriety BMP checklist found in Volume 2, Chapter 4 of the Massachusetts Stormwater Handbook and submitting copies of the TARP Report, STEP Report, and/or other third party studies verifying performance of the proprietary BMPs.			
	A TMDL exists that indicates a need to reduce pollutants other than TSS and documentation showing that the BMPs selected are consistent with the TMDL is provided.			
Sta	ndard 5: Land Uses With Higher Potential Pollutant Loads (LUHPPLs)			
	The NPDES Multi-Sector General Permit covers the land use and the Stormwater Pollution Prevention Plan (SWPPP) has been included with the Stormwater Report. The NPDES Multi-Sector General Permit covers the land use and the SWPPP will be submitted <i>prior to</i> the discharge of stormwater to the post-construction stormwater BMPs.			
	The NPDES Multi-Sector General Permit does <i>not</i> cover the land use.			
	LUHPPLs are located at the site and industry specific source control and pollution prevention measures have been proposed to reduce or eliminate the exposure of LUHPPLs to rain, snow, snow melt and runoff, and been included in the long term Pollution Prevention Plan.			
	All exposure has been eliminated.			
	All exposure has <i>not</i> been eliminated and all BMPs selected are on MassDEP LUHPPL list.			
	The LUHPPL has the potential to generate runoff with moderate to higher concentrations of oil and grease (e.g. all parking lots with >1000 vehicle trips per day) and the treatment train includes an oil grit separator, a filtering bioretention area, a sand filter or equivalent.			
Sta	ndard 6: Critical Areas			
	The discharge is near or to a critical area and the treatment train includes only BMPs that MassDEP has approved for stormwater discharges to or near that particular class of critical area.			
	Critical areas and BMPs are identified in the Stormwater Report.			



Massachusetts Department of Environmental Protection

Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

Checklist (continued)

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the maximum extent practicable The project is subject to the Stormwater Management Standards only to the maximum Extent Practicable as a: Limited Project Small Residential Projects: 5-9 single family houses or 5-9 units in a multi-family development provided there is no discharge that may potentially affect a critical area. Small Residential Projects: 2-4 single family houses or 2-4 units in a multi-family development with a discharge to a critical area Marina and/or boatyard provided the hull painting, service and maintenance areas are protected from exposure to rain, snow, snow melt and runoff ☐ Bike Path and/or Foot Path Redevelopment Project Redevelopment portion of mix of new and redevelopment. Certain standards are not fully met (Standard No. 1, 8, 9, and 10 must always be fully met) and an explanation of why these standards are not met is contained in the Stormwater Report. The project involves redevelopment and a description of all measures that have been taken to

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control

and structural BMP requirements of Standards 4-6 to the maximum extent practicable and (b)

A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan must include the following information:

improve existing conditions is provided in the Stormwater Report. The redevelopment checklist found in Volume 2 Chapter 3 of the Massachusetts Stormwater Handbook may be used to document that the proposed stormwater management system (a) complies with Standards 2. 3 and the pretreatment

- Narrative;
- Construction Period Operation and Maintenance Plan;
- Names of Persons or Entity Responsible for Plan Compliance;
- Construction Period Pollution Prevention Measures:
- Erosion and Sedimentation Control Plan Drawings;
- Detail drawings and specifications for erosion control BMPs, including sizing calculations;
- Vegetation Planning;
- Site Development Plan;

improves existing conditions.

- Construction Sequencing Plan;
- Sequencing of Erosion and Sedimentation Controls;
- Operation and Maintenance of Erosion and Sedimentation Controls;
- Inspection Schedule;
- Maintenance Schedule:
- Inspection and Maintenance Log Form.

 A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan containing
the information set forth above has been included in the Stormwater Report.



Massachusetts Department of Environmental Protection

Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

Checklist (continued) Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control (continued) The project is highly complex and information is included in the Stormwater Report that explains why it is not possible to submit the Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan with the application. A Construction Period Pollution Prevention and Erosion and Sedimentation Control has not been included in the Stormwater Report but will be submitted **before** land disturbance begins. ☐ The project is **not** covered by a NPDES Construction General Permit. The project is covered by a NPDES Construction General Permit and a copy of the SWPPP is in the Stormwater Report. The project is covered by a NPDES Construction General Permit but no SWPPP been submitted. The SWPPP will be submitted BEFORE land disturbance begins. Standard 9: Operation and Maintenance Plan The Post Construction Operation and Maintenance Plan is included in the Stormwater Report and includes the following information: Name of the stormwater management system owners; Party responsible for operation and maintenance; Schedule for implementation of routine and non-routine maintenance tasks: Plan showing the location of all stormwater BMPs maintenance access areas; Description and delineation of public safety features; Estimated operation and maintenance budget; and Operation and Maintenance Log Form. The responsible party is **not** the owner of the parcel where the BMP is located and the Stormwater Report includes the following submissions: A copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the project site stormwater BMPs; A plan and easement deed that allows site access for the legal entity to operate and maintain BMP functions. Standard 10: Prohibition of Illicit Discharges

NO Illicit Discharge Compliance Statement is attached but wany stormwater to post-construction BMPs.	will be submitted <i>prior to</i> the discharge of

The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;