Kelsey Road Culvert Replacement

Boxford, MA
June 28, 2016

Prepared for:

Town of Boxford
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HYDRAULIC REPORT

KELSEY ROAD CULVERT REPLACEMENT PROJECT
BOXFORD, MA

Introduction

The Town of Boxford is planning to replace the existing cross culvert on Kelsey Road. The existing culvert collapsed which required an emergency repair to return it to service. Overall, this project will address necessary roadway infrastructure maintenance and improve wildlife connectivity.

This report has been prepared to accompany the NOI in accordance with the requirements of the Massachusetts Wetlands Protection Act, The Boxford Wetland Protection Bylaw and Wetland Protection Regulations. The project will improve roadway safety by providing a new culvert with code-compliant structural capacity and long service life while enhancing wildlife connectivity, reducing stream sediment scour and aggradation, and reducing roadway side slope erosion.

Description of Existing Conditions

This project is being undertaken as a continuing effort by the Boxford Public Works Department to correct roadway deficiencies before they result in more serious roadway and wetland resource damage.

The existing culverts is approximately 50 feet long and consist of a 15-inch diameter corrugated plastic pipe (CPP) inside a deteriorated 18-inch diameter corrugated metal pipe (CMP). The culvert currently has approximately 3 feet of soil cover. The upstream culvert end is protected with a wire mesh "beaver deceiver" structure. The downstream culvert end is perched approximately 6 inches.

Existing culvert data:

Size	15-inch diameter
Type	Corrugated plastic pipe (CPP)
Length	50 feet
Openness	(Area/length) = 4.91 sf/50 ft = 0.10 foot

Proposed Culvert Replacement

The proposed replacement will include removing the existing culvert and installing an embedded reinforced precast concrete box culvert with an open area of 3 feet high x 8 feet wide (2 foot embedment). This alternative has been chosen as the most cost effective rehabilitation method and to provide rapid construction time. The culvert design has been performed in accordance with the MassDOT *Design of Bridges and Culverts for Wildlife Passage*

at Freshwater Streams; December 2010. This document has been developed, in part, from the United States Army Corps. of Engineers (ACOE) Massachusetts Programmatic General Permit crossing standards.

Proposed culvert data:

Size	5 feet x 8 feet with 2 foot embedment (3 feet clear opening)
Type	Precast concrete with wingwalls and headwall
Length	28 feet
Openness	(Area/length) = (3 feet x 8 feet)/28 feet = 0.86 foot

Alternatives Analysis

Several design alternatives were investigated for this project. The evaluation included assessing the performance of each with respect to the following measures:

- Suitability for existing site
- Construction duration and cost
- Maximum culvert "openness" factor
- Relative culvert stream velocity
- Culvert width relative to stream bankfull width
- Resource area impact and wildlife impact
- Expected service life of alternative

Development of Watershed and Stream Model and Evaluation of Alternatives

To perform an analysis of the hydraulic performance rehabilitation methods, a numeric model was developed for the tributary watershed and stream using publicly available data including the GIS, online mapping, historical and synthetic weather events. The model contains a tributary area of approximately 300 acres (235 acres upstream of the Kelsey Road culvert) and includes the land is approximately bounded by Georgetown Road and Ipswich Road to the north/northwest; Killam Hill Road to the northeast; Interstate 95 to the east and the railroad right-of-way south of Kelsey Road.

Numeric data was analyzed using HydroCAD software. Rainfall runoff was generated using the National Resources Conservation Service TR-20 method. Rainfall was routed through stream reaches using the Dynamic Muskingum-Cunge method which allows for watershed-wide dynamic tailwater adjustment. This allows for a more accurate model overall and more closely simulates the storage and discharge characteristics of the various water impoundments along the stream corridor under analysis.

The watershed model was initially developed using digital terrain models available through GIS and the USGS streamstats website. After several additional field investigations and additional

survey points, it was determined that the streamstats watershed delineation was not accurate. This is due to the relatively large flat areas that were not accurately shown in the digital terrain information used by streamstats. During the field investigations, measurements of critical conveyance infrastructure were recorded for incorporation in the models. As a final confirmation, a site visit was performed during a significant rainfall event to visually document runoff flow.

The tributary watershed has deep, well to excessively-drained sandy soils with low runoff potential/high infiltration rates (71% classified as hydrologic soil group A). The watershed also has a tremendous storage capacity with approximately 100 acre-feet (77 acre-feet upstream of Kelsey Road). The surrounding terrain is rolling to moderately steep slopes with low density residential development. Land cover is 57% forested with an average of 7% – 10% total impervious surfaces. These factors contribute to a very resilient, slow runoff response watershed.

An analysis has been performed for the culvert repair options. The alternatives evaluated for replacing the existing culvert include the following:

1.) Do nothing;

2.) Replace culvert with a 30-inch RCP;

3.) Replace the existing culvert with a new open bottom or embedded culvert in the same location as the existing culvert;

The evaluation of the above five alternates has resulted in the follow findings, respectively:

1.) The “Do Nothing” option is not desirable because the existing culvert creates erosive velocities during the 10 year and greater storm recurrence interval and is a barrier to wildlife connectivity.

2.) The “replace existing culvert with a 30-inch RCP” option would only require a small resource area disruption, and would provide a minor increase in wildlife connectivity, but would significantly increase erosive velocities during the 10 year and greater storm recurrence interval. This option would create and acceptable increase the headwater at the downstream railroad ROW crossing.

3.) The “Replace the existing culvert with a new open bottom or embedded culvert in the same location as the existing culvert” will achieve project objective, however, it will require work within wetlands and the waterway and possibly require closure of Kelsey Road during construction. This option would create an acceptable 3 inch increase in the headwater at the downstream railroad ROW crossing during the 100 year recurrence interval storm event. This option would have a higher construction cost, but would provide for considerably better wildlife connectivity compared to the preceding 2 options.

Preferred Alternative

The alternatives analysis for this project based on the above factors has indicated that the "Replace the existing culvert with a new open bottom or embedded culvert in the same location as the existing culvert" (Option 3) will improve the stability and public safety aspects of the structure and the roadway, prevent the potential for further damage to wetland resource areas, and provide greatly for increased wildlife connectivity within the financial constraints of the Town. Overall, this option has a good balance of benefit vs. impact to the resource areas.

Resource Area Impacts

Work on the existing riverbanks, within adjacent BVW, within the limits of the existing waterway land under water (LUW) and banks of the Porter Brook will occur. The work will consist of removing the existing culvert, excavation of the existing streambed, installing a reinforced precast box culvert with integral headwalls and wing walls and repair (as required) of scour or erosion problems that are observed.

Work within the existing waterway and banks below ordinary high water mark (OHWM) will be limited to the areas directly adjacent to and beneath the existing culvert, abutments, substructure, and wing walls. The total maximum temporary impacts from this project are anticipated to be as follows:

LUW added	250 s.f.
BVW converted to LUW	92 s.f.
LUW lost	0 s.f.
Net LUW	+342 s.f.
LUW temp impact	100 s.f.

Total temporary and permanent LUW impacts = 100 s.f.

BVW converted to LUW	92 s.f.
BVW added	145 s.f
BVW temporary impact	570 s.f.
Net BVW impact	+53 s.f. (1.58x replacement)

Total temporary and permanent BVW impacts = 662 s.f.

Riverfront temporary impact	1,800 s.f.
Riverfront permanent impact	1,370 s.f.
River bank added	40 l.f.
River bank temporary alteration	10 l.f.

Total temporary and permanent riverfront impacts = 3,170 s.f.

The temporary impact areas will include areas disturbed for construction access, but have no proposed changes in topography or vegetative cover. All areas will be restored to pre-existing conditions upon completion of the culvert replacement work. As a result of this project, overall adverse permanent impacts are not anticipated.

To accommodate the increase in width, bank will be added approximately 12 feet up and downstream of the culvert. This will include the conversion of existing BVW to LUW which will provide a decrease in sediment scour and aggradation in the vicinity of the culvert as well as provide better wildlife connectivity. As a result of the culvert length reduction, there will be 145 square feet of new BVW. This amount represents a 1.58x wetland replacement for the BVW to LUW conversion. This meets the Town of Boxford wetland regulations requirement of 1.5x area replacement.

Culvert Replacement Standards - 310 CMR 10.54 (8)

1 Crossing Type – Span - Embedded box. This style was selected to achieve the benefits of a 3 sided box with reduced installation time of a 4 sided box (meets standard).

2. Embedment – The proposed culvert is embedded 2 feet (meets standard)

3. Crossing Span – The upstream and downstream channel beyond the influence of hydraulic restrictions measures 5-7 feet depending on the location with an estimated bankfull width of 6 feet. The proposed culvert width spans the channel and is greater than 1.2x bankfull width (meets standard)

4. Openness – The proposed culvert openness is 0.86 feet (meets standard).

5. Substrate – The proposed culvert will accommodate the bankfull stream channel and will include matching substrate (meets standard)

6. Water Depth and Velocity – The velocity and water depth within the culvert will match or be less than the channel velocity. As a result, the channel substrate will be stable under these conditions (meets standard).

Mitigation Measures

Mitigation measures are included with the project to protect the resource areas from damage during and after construction. Sediment and erosion control (BMPs) for this project include the following:

1. Construction will be performed at a low or no flow period.

2. All work performed in the resource area will be done manually. With the exception of hand-held tools, mechanical equipment operation in the resource area is prohibited.

3. The new culvert will be embedded into the streambed to preserve the natural streambed material and comparable velocity to the natural channel upstream and downstream.

4. Equipment refueling will not occur in areas where a spill might reach the resource areas.

5. Areas disturbed during construction will be stabilized to minimize erosion.

6. Any proposed seeding shall be non-hybridized native pure live seed. Any plantings will be native non-hybridized.

7. Plantings and erosion control measures will be checked following each rain event up to one full year following construction, or until vegetation has been established.

8. Sediment and debris collected behind compost filter tubes, straw bales, silt fence or turbidity curtains will be removed before such BMPs are removed.

9. Sedimentation barriers will not become de facto retaining walls during construction.

10. Debris from construction that falls into the resource areas will be removed prior to the completion of the workday.

11. Existing eroded areas will be stabilized.

12. Construction work areas shall be restored to pre-existing conditions upon completion.

Control of Water

The proposed construction will be performed in a perennial stream tributary to Lowe Pond. The proposed rehabilitation will be scheduled to occur at low or no flow. If necessary, there is sufficient storage to temporarily block the stream. The duration of impoundment will not exceed 5 consecutive days. If necessary, a temporary berm will be constructed upstream using sandbags to provide for bypass pumping. Pump discharge will be directed to the downstream side of Kelsey Road after routing through an effluent filtration bag/system. The specifications for the dewatering system are attached to this report for reference.

Stormwater Management Standards

The entire project is defined as a redevelopment according to the Massachusetts Stormwater Standards, and meets to the maximum extent practicable Standards 2, 3 and the pretreatment

and structural stormwater best management practice requirements of Standards 4, 5, and 6 as follows:

Standard #1 - No New Untreated Discharges

This project does not involve new discharges of any kind.

Standard #2 - Peak Rate Attenuation

Existing ground cover will not change as a result of this project. The proposed project will not adversely impact downstream flooding. Hydraulic model calculations have been provided to compare the existing peak discharge with the proposed peak discharge.

Standard #3 – Recharge to Groundwater

Groundwater recharge will not be affected from this project.

Standard #4 – 80% TSS Removal

A long term pollution prevention plan has been attached as part of the Notice of Intent filing. The project will correct excessive roadway side slopes which have caused direct discharge of eroded soil the stream. Post construction, roadway runoff will flow over vegetated areas prior to discharging to Porter Brook.

Standard #5 – Higher Potential Pollutant Loads (HPPL)

This project is not a land use considered a HPPL.

Standard #6 – Critical Area

The project is not located in a critical area.

Standard #7 – Redevelopment Projects

This project is considered a redevelopment with respect to the Stormwater management standards. The project will maintain the same land cover that currently exists at the site, so no increase in runoff will occur. Roadway runoff currently flows overland to wetland areas without collection (and flow concentration/velocity increase) in drainage structures. The headwalls for the proposed culvert will allow for a greatly reduced side slope, which will correct several areas of erosion potential in the vicinity of the culvert. Roadway side slopes will be stabilized and seeded immediately after construction. Combined with the reduction in stream velocity through the culvert, these measures will decrease sediment re-suspension/scour and decrease the direct suspended solid deposition into the stream, which is an improvement over existing conditions. The project meets the standards by improving the existing conditions at the site. Providing additional stormwater treatment would require

additional space which would likely include land acquisition and additional costs, and much more extensive alteration of existing vegetation and terrain for a relatively small benefit.

Standard #8 – Erosion, Sediment Control

The construction period erosion, sedimentation and pollution prevention plan is included with this report.

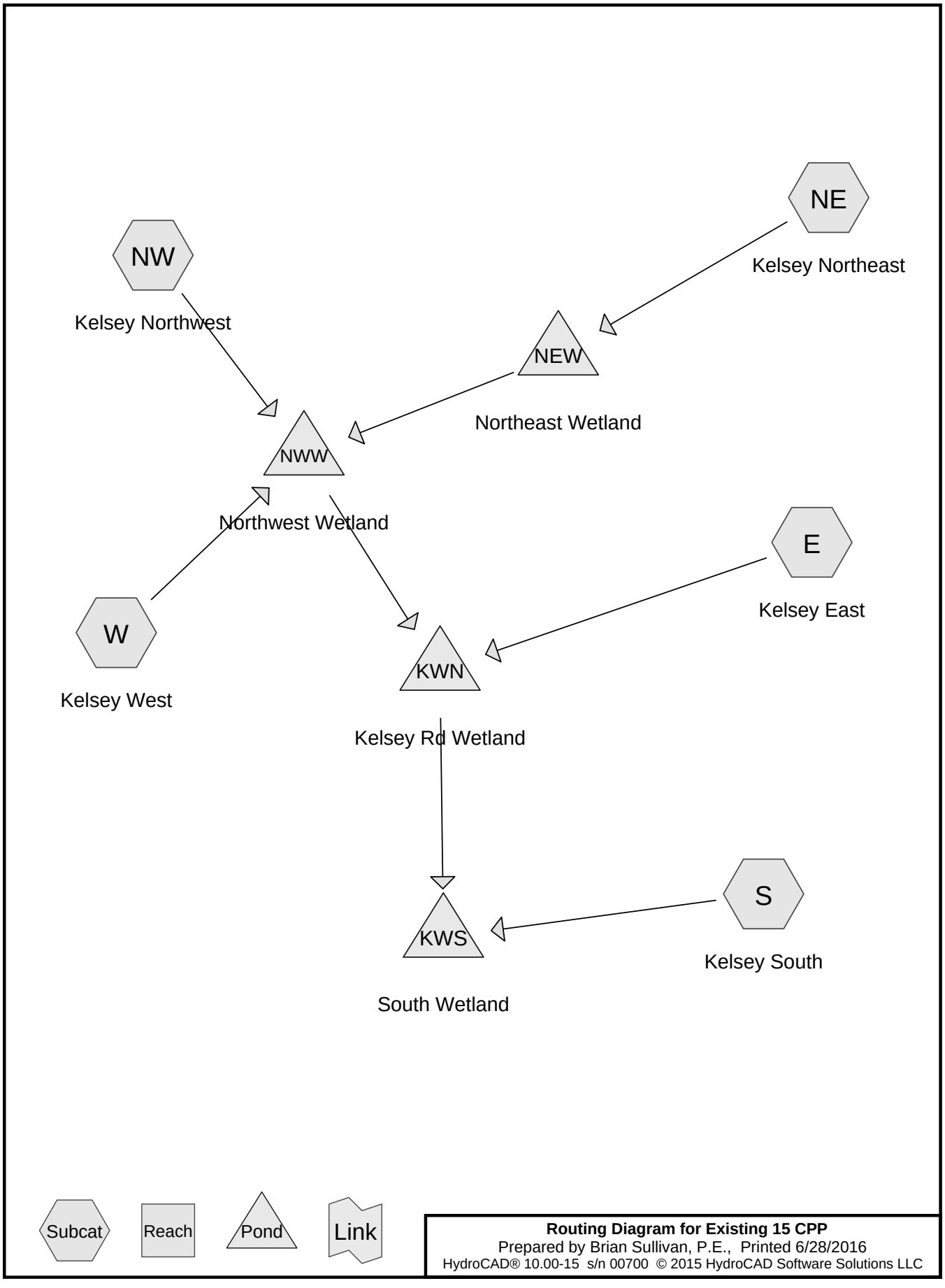
Standard #9 – Operation and Maintenance Plan

The post construction operation and maintenance plan is included with this report

Standard #10 – Prohibition of Illicit Discharges

No known illicit discharges or illicit connections were identified during the development of this design.

Hydraulic Model Output



Routing Diagram for Existing 15 CPP
Prepared by Brian Sullivan, P.E., Printed 6/28/2016
HydroCAD® 10.00-15 s/n 00700 © 2015 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
2,521,952	39	>75% Grass cover, Good, HSG A (E, NE, NW, S, W)
121,615	61	>75% Grass cover, Good, HSG B (S)
79,510	74	>75% Grass cover, Good, HSG C (NE, NW)
93,093	80	>75% Grass cover, Good, HSG D (E, S, W)
209,545	30	Brush, Good, HSG A (NE, NW)
76,420	65	Brush, Good, HSG C (NE, S)
1,269,058	73	Brush, Good, HSG D (NE, NW, S)
271,379	98	Paved parking, HSG A (W)
5,400	98	Paved parking, HSG D (W)
731,957	98	Paved roads w/curbs & sewers, HSG A (E, NE, NW, S)
101,330	98	Paved roads w/curbs & sewers, HSG B (S)
38,036	98	Paved roads w/curbs & sewers, HSG C (NE, NW)
70,015	98	Paved roads w/curbs & sewers, HSG D (NE, NW, S)
43,012	98	Water Surface, 0% imp, HSG D (W)
8,722	98	Water Surface, HSG A (NW)
5,482,545	30	Woods, Good, HSG A (E, NE, NW, S, W)
604,565	70	Woods, Good, HSG C (NE, NW)
830,195	77	Woods, Good, HSG D (E, NE, NW, S, W)
448,300	58	Woods/grass comb., Good, HSG B (S)
13,006,649	**50**	**TOTAL AREA**

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment E: Kelsey East Runoff Area=617,375 sf 11.59% Impervious Runoff Depth>0.03"
Flow Length=1,000' Slope=0.0500 '/' Tc=35.1 min CN=46 Runoff=0.09 cfs 1,727 cf

Subcatchment NE: Kelsey Northeast Runoff Area=2,476,033 sf 7.82% Impervious Runoff Depth>0.09"
Flow Length=1,770' Slope=0.0280 '/' Tc=66.8 min CN=50 Runoff=0.92 cfs 17,715 cf

Subcatchment NW: Kelsey Northwest Runoff Area=3,957,830 sf 9.20% Impervious Runoff Depth>0.13"
Flow Length=3,520' Slope=0.0250 '/' Tc=113.6 min CN=53 Runoff=2.42 cfs 44,279 cf

Subcatchment S: Kelsey South Runoff Area=2,710,195 sf 11.83% Impervious Runoff Depth>0.19"
Flow Length=2,011' Slope=0.0310 '/' Tc=62.0 min CN=55 Runoff=3.07 cfs 42,443 cf

Subcatchment W: Kelsey West Runoff Area=3,245,216 sf 8.53% Impervious Runoff Depth>0.00"
Flow Length=4,860' Slope=0.0170 '/' Tc=243.4 min CN=41 Runoff=0.01 cfs 15 cf

Pond KWN: Kelsey Rd Wetland Peak Elev=104.00' Storage=13,905 cf Inflow=3.42 cfs 63,737 cf
15.0" Round Culvert n=0.013 L=50.0' S=0.0120 '/' Outflow=2.84 cfs 54,612 cf

Pond KWS: South Wetland Peak Elev=99.42' Storage=12,664 cf Inflow=4.41 cfs 97,055 cf
Outflow=4.30 cfs 87,602 cf

Pond NEW: Northeast Wetland Peak Elev=107.00' Storage=0 cf Inflow=0.92 cfs 17,715 cf
Outflow=0.92 cfs 17,715 cf

Pond NWW: Northwest Wetland Peak Elev=106.00' Storage=0 cf Inflow=3.34 cfs 62,009 cf
18.0" Round Culvert w/ 6.0" inside fill n=0.013 L=20.0' S=0.0100 '/' Outflow=3.34 cfs 62,009 cf

Total Runoff Area = 13,006,649 sf Runoff Volume = 106,180 cf Average Runoff Depth = 0.10"
90.57% Pervious = 11,779,810 sf 9.43% Impervious = 1,226,839 sf

Summary for Subcatchment E: Kelsey East

Runoff = 0.09 cfs @ 15.64 hrs, Volume= 1,727 cf, Depth> 0.03"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-yr Rainfall=3.15"

Area (sf)	CN	Description
71,565	98	Paved roads w/curbs & sewers, HSG A
218,025	39	>75% Grass cover, Good, HSG A
12,035	80	>75% Grass cover, Good, HSG D
266,400	30	Woods, Good, HSG A
49,350	77	Woods, Good, HSG D
617,375	46	Weighted Average
545,810		88.41% Pervious Area
71,565		11.59% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
35.1	1,000	0.0500	0.47		**Lag/CN Method,**

Summary for Subcatchment NE: Kelsey Northeast

Runoff = 0.92 cfs @ 14.61 hrs, Volume= 17,715 cf, Depth> 0.09"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-yr Rainfall=3.15"

Area (sf)	CN	Description
164,585	98	Paved roads w/curbs & sewers, HSG A
6,800	98	Paved roads w/curbs & sewers, HSG C
22,310	98	Paved roads w/curbs & sewers, HSG D
332,200	39	>75% Grass cover, Good, HSG A
6,925	74	>75% Grass cover, Good, HSG C
1,000,775	30	Woods, Good, HSG A
302,195	70	Woods, Good, HSG C
229,600	77	Woods, Good, HSG D
168,080	30	Brush, Good, HSG A
17,080	65	Brush, Good, HSG C
225,483	73	Brush, Good, HSG D
2,476,033	50	Weighted Average
2,282,338		92.18% Pervious Area
193,695		7.82% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
66.8	1,770	0.0280	0.44		**Lag/CN Method,**

Summary for Subcatchment NW: Kelsey Northwest

Runoff = 2.42 cfs @ 14.52 hrs, Volume= 44,279 cf, Depth> 0.13"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-yr Rainfall=3.15"

Area (sf)	CN	Description
318,596	98	Paved roads w/curbs & sewers, HSG A
31,236	98	Paved roads w/curbs & sewers, HSG C
5,635	98	Paved roads w/curbs & sewers, HSG D
654,001	39	>75% Grass cover, Good, HSG A
72,585	74	>75% Grass cover, Good, HSG C
1,462,850	30	Woods, Good, HSG A
302,370	70	Woods, Good, HSG C
141,645	77	Woods, Good, HSG D
41,465	30	Brush, Good, HSG A
918,725	73	Brush, Good, HSG D
8,722	98	Water Surface, HSG A
3,957,830	53	Weighted Average
3,593,641		90.80% Pervious Area
364,189		9.20% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
113.6	3,520	0.0250	0.52		**Lag/CN Method,**

Summary for Subcatchment S: Kelsey South

Runoff = 3.07 cfs @ 13.25 hrs, Volume= 42,443 cf, Depth> 0.19"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-yr Rainfall=3.15"

Area (sf)	CN	Description
177,211	98	Paved roads w/curbs & sewers, HSG A
101,330	98	Paved roads w/curbs & sewers, HSG B
42,070	98	Paved roads w/curbs & sewers, HSG D
658,051	39	>75% Grass cover, Good, HSG A
121,615	61	>75% Grass cover, Good, HSG B
72,733	80	>75% Grass cover, Good, HSG D
643,630	30	Woods, Good, HSG A
448,300	58	Woods/grass comb., Good, HSG B
261,065	77	Woods, Good, HSG D
59,340	65	Brush, Good, HSG C
124,850	73	Brush, Good, HSG D
2,710,195	55	Weighted Average
2,389,584		88.17% Pervious Area
320,611		11.83% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
62.0	2,011	0.0310	0.54		**Lag/CN Method,**

Summary for Subcatchment W: Kelsey West

Runoff = 0.01 cfs @ 20.00 hrs, Volume= 15 cf, Depth> 0.00"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-yr Rainfall=3.15"

Area (sf)	CN	Description
43,012	98	Water Surface, 0% imp, HSG D
659,675	39	>75% Grass cover, Good, HSG A
271,379	98	Paved parking, HSG A
2,108,890	30	Woods, Good, HSG A
148,535	77	Woods, Good, HSG D
5,400	98	Paved parking, HSG D
8,325	80	>75% Grass cover, Good, HSG D
3,245,216	41	Weighted Average
2,968,437		91.47% Pervious Area
276,779		8.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
243.4	4,860	0.0170	0.33		**Lag/CN Method,**

Summary for Pond KWN: Kelsey Rd Wetland

Inflow Area = 10,296,454 sf, 8.80% Impervious, Inflow Depth > 0.07" for 2-yr event
Inflow = 3.42 cfs @ 14.57 hrs, Volume= 63,737 cf
Outflow = 2.84 cfs @ 16.47 hrs, Volume= 54,612 cf, Atten= 17%, Lag= 114.5 min
Primary = 2.84 cfs @ 16.47 hrs, Volume= 54,612 cf

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 104.00' @ 16.47 hrs Surf.Area= 23,385 sf Storage= 13,905 cf

Plug-Flow detention time= 73.3 min calculated for 54,430 cf (85% of inflow)
Center-of-Mass det. time= 42.5 min (1,013.2 - 970.6)

Volume	Invert	Avail.Storage	Storage Description
#1	103.00'	379,756 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
103.00	4,312	0	0
104.00	23,348	13,830	13,830
105.00	34,892	29,120	42,950
106.00	77,130	56,011	98,961
107.00	147,835	112,483	211,444
108.00	188,790	168,313	379,756

Device	Routing	Invert	Outlet Devices
#1	Primary	103.00'	**15.0" Round Culvert** L= 50.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 103.00' / 102.40' S= 0.0120 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.23 sf

Primary OutFlow Max=2.84 cfs @ 16.47 hrs HW=104.00' TW=99.41' (Dynamic Tailwater)
↑**1=Culvert** (Inlet Controls 2.84 cfs @ 2.69 fps)

Summary for Pond KWS: South Wetland

Inflow Area = 13,006,649 sf, 9.43% Impervious, Inflow Depth > 0.09" for 2-yr event
Inflow = 4.41 cfs @ 15.63 hrs, Volume= 97,055 cf
Outflow = 4.30 cfs @ 16.30 hrs, Volume= 87,602 cf, Atten= 3%, Lag= 40.2 min
Primary = 4.30 cfs @ 16.30 hrs, Volume= 87,602 cf

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 99.42' @ 16.30 hrs Surf.Area= 35,053 sf Storage= 12,664 cf

Plug-Flow detention time= 48.6 min calculated for 87,311 cf (90% of inflow)
Center-of-Mass det. time= 27.3 min (1,002.2 - 974.9)

Volume	Invert	Avail.Storage	Storage Description
#1	99.00'	1,000,195 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
99.00	25,925	0	0
100.00	47,900	36,913	36,913
101.00	84,045	65,973	102,885
102.00	119,200	101,623	204,508
103.00	235,925	177,563	382,070
104.00	302,175	269,050	651,120
105.00	395,975	349,075	1,000,195

Device	Routing	Invert	Outlet Devices
#1	Primary	99.00'	**60.0" W x 72.0" H Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=4.30 cfs @ 16.30 hrs HW=99.42' (Free Discharge)
↑**1=Orifice/Grate** (Orifice Controls 4.30 cfs @ 2.07 fps)

Summary for Pond NEW: Northeast Wetland

Inflow Area = 2,476,033 sf, 7.82% Impervious, Inflow Depth > 0.09" for 2-yr event
Inflow = 0.92 cfs @ 14.61 hrs, Volume= 17,715 cf
Outflow = 0.92 cfs @ 14.61 hrs, Volume= 17,715 cf, Atten= 0%, Lag= 0.0 min
Primary = 0.92 cfs @ 14.61 hrs, Volume= 17,715 cf

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 107.00' @ 5.00 hrs Surf.Area= 75,200 sf Storage= 0 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 0.0 min (968.2 - 968.2)

Volume	Invert	Avail.Storage	Storage Description
#1	107.00'	739,535 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
107.00	75,200	0	0
108.00	152,000	113,600	113,600
109.00	324,170	238,085	351,685
110.00	451,530	387,850	739,535

Device	Routing	Invert	Outlet Devices
#1	Primary	106.00'	**5.0' long x 10.0' breadth Broad-Crested Rectangular Weir X 2.00** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=0.00 cfs @ 14.61 hrs HW=107.00' TW=106.00' (Dynamic Tailwater)
↑—**1=Broad-Crested Rectangular Weir** (Passes 0.00 cfs of 26.80 cfs potential flow)

Summary for Pond NWW: Northwest Wetland

Inflow Area = 9,679,079 sf, 8.62% Impervious, Inflow Depth > 0.08" for 2-yr event
Inflow = 3.34 cfs @ 14.52 hrs, Volume= 62,009 cf
Outflow = 3.34 cfs @ 14.52 hrs, Volume= 62,009 cf, Atten= 0%, Lag= 0.0 min
Primary = 3.34 cfs @ 14.52 hrs, Volume= 62,009 cf

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 106.00' @ 14.52 hrs Surf.Area= 75,000 sf Storage= 0 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 0.0 min (969.6 - 969.6)

Volume	Invert	Avail.Storage	Storage Description
#1	106.00'	2,216,775 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
106.00	75,000	0	0
107.00	132,500	103,750	103,750
108.00	644,250	388,375	492,125
109.00	889,250	766,750	1,258,875
110.00	1,026,550	957,900	2,216,775

Device	Routing	Invert	Outlet Devices
#1	Primary	104.80'	**18.0" Round Culvert w/ 6.0" inside fill** L= 20.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 104.30' / 104.10' S= 0.0100 '/' Cc= 0.900 n= 0.013 Clay tile, Flow Area= 1.25 sf

Primary OutFlow Max=4.93 cfs @ 14.52 hrs HW=106.00' TW=103.80' (Dynamic Tailwater)
↑—**1=Culvert** (Barrel Controls 4.93 cfs @ 4.10 fps)

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment E: Kelsey East Runoff Area=617,375 sf 11.59% Impervious Runoff Depth>0.36"
Flow Length=1,000' Slope=0.0500 '/' Tc=35.1 min CN=46 Runoff=1.90 cfs 18,335 cf

Subcatchment NE: Kelsey Northeast Runoff Area=2,476,033 sf 7.82% Impervious Runoff Depth>0.52"
Flow Length=1,770' Slope=0.0280 '/' Tc=66.8 min CN=50 Runoff=10.02 cfs 106,542 cf

Subcatchment NW: Kelsey Northwest Runoff Area=3,957,830 sf 9.20% Impervious Runoff Depth>0.64"
Flow Length=3,520' Slope=0.0250 '/' Tc=113.6 min CN=53 Runoff=16.10 cfs 209,905 cf

Subcatchment S: Kelsey South Runoff Area=2,710,195 sf 11.83% Impervious Runoff Depth>0.77"
Flow Length=2,011' Slope=0.0310 '/' Tc=62.0 min CN=55 Runoff=19.71 cfs 172,842 cf

Subcatchment W: Kelsey West Runoff Area=3,245,216 sf 8.53% Impervious Runoff Depth>0.12"
Flow Length=4,860' Slope=0.0170 '/' Tc=243.4 min CN=41 Runoff=1.91 cfs 33,422 cf

Pond KWN: Kelsey Rd Wetland Peak Elev=105.67' Storage=75,856 cf Inflow=8.74 cfs 221,470 cf
15.0" Round Culvert n=0.013 L=50.0' S=0.0120 '/' Outflow=6.67 cfs 145,525 cf

Pond KWS: South Wetland Peak Elev=100.01' Storage=37,395 cf Inflow=22.23 cfs 318,367 cf
Outflow=16.29 cfs 296,157 cf

Pond NEW: Northeast Wetland Peak Elev=107.18' Storage=14,890 cf Inflow=10.02 cfs 106,542 cf
Outflow=10.02 cfs 92,809 cf

Pond NWW: Northwest Wetland Peak Elev=107.18' Storage=136,087 cf Inflow=23.69 cfs 336,136 cf
18.0" Round Culvert w/ 6.0" inside fill n=0.013 L=20.0' S=0.0100 '/' Outflow=8.08 cfs 203,134 cf

Total Runoff Area = 13,006,649 sf Runoff Volume = 541,045 cf Average Runoff Depth = 0.50"
90.57% Pervious = 11,779,810 sf 9.43% Impervious = 1,226,839 sf

Summary for Subcatchment E: Kelsey East

Runoff = 1.90 cfs @ 12.73 hrs, Volume= 18,335 cf, Depth> 0.36"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-yr Rainfall=4.82"

Area (sf)	CN	Description
71,565	98	Paved roads w/curbs & sewers, HSG A
218,025	39	>75% Grass cover, Good, HSG A
12,035	80	>75% Grass cover, Good, HSG D
266,400	30	Woods, Good, HSG A
49,350	77	Woods, Good, HSG D
617,375	46	Weighted Average
545,810		88.41% Pervious Area
71,565		11.59% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
35.1	1,000	0.0500	0.47		**Lag/CN Method,**

Summary for Subcatchment NE: Kelsey Northeast

Runoff = 10.02 cfs @ 13.14 hrs, Volume= 106,542 cf, Depth> 0.52"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-yr Rainfall=4.82"

Area (sf)	CN	Description
164,585	98	Paved roads w/curbs & sewers, HSG A
6,800	98	Paved roads w/curbs & sewers, HSG C
22,310	98	Paved roads w/curbs & sewers, HSG D
332,200	39	>75% Grass cover, Good, HSG A
6,925	74	>75% Grass cover, Good, HSG C
1,000,775	30	Woods, Good, HSG A
302,195	70	Woods, Good, HSG C
229,600	77	Woods, Good, HSG D
168,080	30	Brush, Good, HSG A
17,080	65	Brush, Good, HSG C
225,483	73	Brush, Good, HSG D
2,476,033	50	Weighted Average
2,282,338		92.18% Pervious Area
193,695		7.82% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
66.8	1,770	0.0280	0.44		**Lag/CN Method,**

Summary for Subcatchment NW: Kelsey Northwest

Runoff = 16.10 cfs @ 13.80 hrs, Volume= 209,905 cf, Depth> 0.64"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-yr Rainfall=4.82"

Area (sf)	CN	Description
318,596	98	Paved roads w/curbs & sewers, HSG A
31,236	98	Paved roads w/curbs & sewers, HSG C
5,635	98	Paved roads w/curbs & sewers, HSG D
654,001	39	>75% Grass cover, Good, HSG A
72,585	74	>75% Grass cover, Good, HSG C
1,462,850	30	Woods, Good, HSG A
302,370	70	Woods, Good, HSG C
141,645	77	Woods, Good, HSG D
41,465	30	Brush, Good, HSG A
918,725	73	Brush, Good, HSG D
8,722	98	Water Surface, HSG A
3,957,830	53	Weighted Average
3,593,641		90.80% Pervious Area
364,189		9.20% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
113.6	3,520	0.0250	0.52		**Lag/CN Method,**

Summary for Subcatchment S: Kelsey South

Runoff = 19.71 cfs @ 12.99 hrs, Volume= 172,842 cf, Depth> 0.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-yr Rainfall=4.82"

Area (sf)	CN	Description
177,211	98	Paved roads w/curbs & sewers, HSG A
101,330	98	Paved roads w/curbs & sewers, HSG B
42,070	98	Paved roads w/curbs & sewers, HSG D
658,051	39	>75% Grass cover, Good, HSG A
121,615	61	>75% Grass cover, Good, HSG B
72,733	80	>75% Grass cover, Good, HSG D
643,630	30	Woods, Good, HSG A
448,300	58	Woods/grass comb., Good, HSG B
261,065	77	Woods, Good, HSG D
59,340	65	Brush, Good, HSG C
124,850	73	Brush, Good, HSG D
2,710,195	55	Weighted Average
2,389,584		88.17% Pervious Area
320,611		11.83% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
62.0	2,011	0.0310	0.54		**Lag/CN Method,**

Summary for Subcatchment W: Kelsey West

Runoff = 1.91 cfs @ 17.53 hrs, Volume= 33,422 cf, Depth> 0.12"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-yr Rainfall=4.82"

Area (sf)	CN	Description
43,012	98	Water Surface, 0% imp, HSG D
659,675	39	>75% Grass cover, Good, HSG A
271,379	98	Paved parking, HSG A
2,108,890	30	Woods, Good, HSG A
148,535	77	Woods, Good, HSG D
5,400	98	Paved parking, HSG D
8,325	80	>75% Grass cover, Good, HSG D
3,245,216	41	Weighted Average
2,968,437		91.47% Pervious Area
276,779		8.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
243.4	4,860	0.0170	0.33		**Lag/CN Method,**

Summary for Pond KWN: Kelsey Rd Wetland

Inflow Area = 10,296,454 sf, 8.80% Impervious, Inflow Depth > 0.26" for 10-yr event
Inflow = 8.74 cfs @ 15.16 hrs, Volume= 221,470 cf
Outflow = 6.67 cfs @ 20.00 hrs, Volume= 145,525 cf, Atten= 24%, Lag= 290.2 min
Primary = 6.67 cfs @ 20.00 hrs, Volume= 145,525 cf

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 105.67' @ 20.00 hrs Surf.Area= 63,224 sf Storage= 75,856 cf

Plug-Flow detention time= 108.6 min calculated for 145,525 cf (66% of inflow)
Center-of-Mass det. time= 32.2 min (1,006.5 - 974.3)

Volume	Invert	Avail.Storage	Storage Description
#1	103.00'	379,756 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
103.00	4,312	0	0
104.00	23,348	13,830	13,830
105.00	34,892	29,120	42,950
106.00	77,130	56,011	98,961
107.00	147,835	112,483	211,444
108.00	188,790	168,313	379,756

Device	Routing	Invert	Outlet Devices
#1	Primary	103.00'	**15.0" Round Culvert** L= 50.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 103.00' / 102.40' S= 0.0120 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.23 sf

Primary OutFlow Max=6.67 cfs @ 20.00 hrs HW=105.67' TW=0.00' (Dynamic Tailwater)
↑**1=Culvert** (Inlet Controls 6.67 cfs @ 5.44 fps)

Summary for Pond KWS: South Wetland

Inflow Area = 13,006,649 sf, 9.43% Impervious, Inflow Depth > 0.29" for 10-yr event
Inflow = 22.23 cfs @ 13.02 hrs, Volume= 318,367 cf
Outflow = 16.29 cfs @ 13.61 hrs, Volume= 296,157 cf, Atten= 27%, Lag= 35.5 min
Primary = 16.29 cfs @ 13.61 hrs, Volume= 296,157 cf

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 100.01' @ 13.61 hrs Surf.Area= 48,263 sf Storage= 37,395 cf

Plug-Flow detention time= 39.0 min calculated for 295,173 cf (93% of inflow)
Center-of-Mass det. time= 21.0 min (960.7 - 939.7)

Volume	Invert	Avail.Storage	Storage Description
#1	99.00'	1,000,195 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
99.00	25,925	0	0
100.00	47,900	36,913	36,913
101.00	84,045	65,973	102,885
102.00	119,200	101,623	204,508
103.00	235,925	177,563	382,070
104.00	302,175	269,050	651,120
105.00	395,975	349,075	1,000,195

Device	Routing	Invert	Outlet Devices
#1	Primary	99.00'	**60.0" W x 72.0" H Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=16.29 cfs @ 13.61 hrs HW=100.01' (Free Discharge)
↑**1=Orifice/Grate** (Orifice Controls 16.29 cfs @ 3.23 fps)

Summary for Pond NEW: Northeast Wetland

Inflow Area = 2,476,033 sf, 7.82% Impervious, Inflow Depth > 0.52" for 10-yr event
Inflow = 10.02 cfs @ 13.14 hrs, Volume= 106,542 cf
Outflow = 10.02 cfs @ 13.14 hrs, Volume= 92,809 cf, Atten= 0%, Lag= 0.0 min
Primary = 10.02 cfs @ 13.14 hrs, Volume= 92,809 cf

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 107.18' @ 18.57 hrs Surf.Area= 89,119 sf Storage= 14,890 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= (not calculated: outflow precedes inflow)

Volume	Invert	Avail.Storage	Storage Description
#1	107.00'	739,535 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
107.00	75,200	0	0
108.00	152,000	113,600	113,600
109.00	324,170	238,085	351,685
110.00	451,530	387,850	739,535

Device	Routing	Invert	Outlet Devices
#1	Primary	106.00'	**5.0' long x 10.0' breadth Broad-Crested Rectangular Weir X 2.00** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=0.00 cfs @ 13.14 hrs HW=107.00' TW=106.22' (Dynamic Tailwater)
↑—**1=Broad-Crested Rectangular Weir** (Passes 0.00 cfs of 25.66 cfs potential flow)

Summary for Pond NWW: Northwest Wetland

Inflow Area = 9,679,079 sf, 8.62% Impervious, Inflow Depth > 0.42" for 10-yr event
Inflow = 23.69 cfs @ 13.56 hrs, Volume= 336,136 cf
Outflow = 8.08 cfs @ 15.50 hrs, Volume= 203,134 cf, Atten= 66%, Lag= 116.8 min
Primary = 8.08 cfs @ 15.50 hrs, Volume= 203,134 cf

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 107.18' @ 18.52 hrs Surf.Area= 225,063 sf Storage= 136,087 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 52.7 min (981.1 - 928.4)

Volume	Invert	Avail.Storage	Storage Description
#1	106.00'	2,216,775 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
106.00	75,000	0	0
107.00	132,500	103,750	103,750
108.00	644,250	388,375	492,125
109.00	889,250	766,750	1,258,875
110.00	1,026,550	957,900	2,216,775

Device	Routing	Invert	Outlet Devices
#1	Primary	104.80'	**18.0" Round Culvert w/ 6.0" inside fill** L= 20.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 104.30' / 104.10' S= 0.0100 '/' Cc= 0.900 n= 0.013 Clay tile, Flow Area= 1.25 sf

Primary OutFlow Max=8.07 cfs @ 15.50 hrs HW=107.08' TW=105.07' (Dynamic Tailwater)
↑—**1=Culvert** (Inlet Controls 8.07 cfs @ 6.45 fps)

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment E: Kelsey East Runoff Area=617,375 sf 11.59% Impervious Runoff Depth>0.81"
Flow Length=1,000' Slope=0.0500 '/' Tc=35.1 min CN=46 Runoff=5.86 cfs 41,448 cf

Subcatchment NE: Kelsey Northeast Runoff Area=2,476,033 sf 7.82% Impervious Runoff Depth>1.05"
Flow Length=1,770' Slope=0.0280 '/' Tc=66.8 min CN=50 Runoff=24.15 cfs 216,753 cf

Subcatchment NW: Kelsey Northwest Runoff Area=3,957,830 sf 9.20% Impervious Runoff Depth>1.22"
Flow Length=3,520' Slope=0.0250 '/' Tc=113.6 min CN=53 Runoff=34.23 cfs 403,663 cf

Subcatchment S: Kelsey South Runoff Area=2,710,195 sf 11.83% Impervious Runoff Depth>1.41"
Flow Length=2,011' Slope=0.0310 '/' Tc=62.0 min CN=55 Runoff=40.31 cfs 319,099 cf

Subcatchment W: Kelsey West Runoff Area=3,245,216 sf 8.53% Impervious Runoff Depth>0.39"
Flow Length=4,860' Slope=0.0170 '/' Tc=243.4 min CN=41 Runoff=5.83 cfs 104,683 cf

Pond KWN: Kelsey Rd Wetland Peak Elev=106.04' Storage=101,819 cf Inflow=11.09 cfs 270,788 cf
15.0" Round Culvert n=0.013 L=50.0' S=0.0120 '/' Outflow=7.24 cfs 168,845 cf

Pond KWS: South Wetland Peak Elev=100.57' Storage=69,952 cf Inflow=44.05 cfs 487,944 cf
Outflow=31.51 cfs 462,028 cf

Pond NEW: Northeast Wetland Peak Elev=107.85' Storage=92,118 cf Inflow=24.15 cfs 216,753 cf
Outflow=23.28 cfs 124,581 cf

Pond NWW: Northwest Wetland Peak Elev=107.85' Storage=403,397 cf Inflow=48.00 cfs 632,928 cf
18.0" Round Culvert w/ 6.0" inside fill n=0.013 L=20.0' S=0.0100 '/' Outflow=8.80 cfs 229,340 cf

Total Runoff Area = 13,006,649 sf Runoff Volume = 1,085,647 cf Average Runoff Depth = 1.00"
90.57% Pervious = 11,779,810 sf 9.43% Impervious = 1,226,839 sf

Summary for Subcatchment E: Kelsey East

Runoff = 5.86 cfs @ 12.62 hrs, Volume= 41,448 cf, Depth> 0.81"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-yr Rainfall=6.16"

Area (sf)	CN	Description
71,565	98	Paved roads w/curbs & sewers, HSG A
218,025	39	>75% Grass cover, Good, HSG A
12,035	80	>75% Grass cover, Good, HSG D
266,400	30	Woods, Good, HSG A
49,350	77	Woods, Good, HSG D
617,375	46	Weighted Average
545,810		88.41% Pervious Area
71,565		11.59% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
35.1	1,000	0.0500	0.47		**Lag/CN Method,**

Summary for Subcatchment NE: Kelsey Northeast

Runoff = 24.15 cfs @ 13.04 hrs, Volume= 216,753 cf, Depth> 1.05"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-yr Rainfall=6.16"

Area (sf)	CN	Description
164,585	98	Paved roads w/curbs & sewers, HSG A
6,800	98	Paved roads w/curbs & sewers, HSG C
22,310	98	Paved roads w/curbs & sewers, HSG D
332,200	39	>75% Grass cover, Good, HSG A
6,925	74	>75% Grass cover, Good, HSG C
1,000,775	30	Woods, Good, HSG A
302,195	70	Woods, Good, HSG C
229,600	77	Woods, Good, HSG D
168,080	30	Brush, Good, HSG A
17,080	65	Brush, Good, HSG C
225,483	73	Brush, Good, HSG D
2,476,033	50	Weighted Average
2,282,338		92.18% Pervious Area
193,695		7.82% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
66.8	1,770	0.0280	0.44		**Lag/CN Method,**

Summary for Subcatchment NW: Kelsey Northwest

Runoff = 34.23 cfs @ 13.73 hrs, Volume= 403,663 cf, Depth> 1.22"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-yr Rainfall=6.16"

Area (sf)	CN	Description
318,596	98	Paved roads w/curbs & sewers, HSG A
31,236	98	Paved roads w/curbs & sewers, HSG C
5,635	98	Paved roads w/curbs & sewers, HSG D
654,001	39	>75% Grass cover, Good, HSG A
72,585	74	>75% Grass cover, Good, HSG C
1,462,850	30	Woods, Good, HSG A
302,370	70	Woods, Good, HSG C
141,645	77	Woods, Good, HSG D
41,465	30	Brush, Good, HSG A
918,725	73	Brush, Good, HSG D
8,722	98	Water Surface, HSG A
3,957,830	53	Weighted Average
3,593,641		90.80% Pervious Area
364,189		9.20% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
113.6	3,520	0.0250	0.52		**Lag/CN Method,**

Summary for Subcatchment S: Kelsey South

Runoff = 40.31 cfs @ 12.92 hrs, Volume= 319,099 cf, Depth> 1.41"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-yr Rainfall=6.16"

Area (sf)	CN	Description
177,211	98	Paved roads w/curbs & sewers, HSG A
101,330	98	Paved roads w/curbs & sewers, HSG B
42,070	98	Paved roads w/curbs & sewers, HSG D
658,051	39	>75% Grass cover, Good, HSG A
121,615	61	>75% Grass cover, Good, HSG B
72,733	80	>75% Grass cover, Good, HSG D
643,630	30	Woods, Good, HSG A
448,300	58	Woods/grass comb., Good, HSG B
261,065	77	Woods, Good, HSG D
59,340	65	Brush, Good, HSG C
124,850	73	Brush, Good, HSG D
2,710,195	55	Weighted Average
2,389,584		88.17% Pervious Area
320,611		11.83% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
62.0	2,011	0.0310	0.54		**Lag/CN Method,**

Summary for Subcatchment W: Kelsey West

Runoff = 5.83 cfs @ 16.45 hrs, Volume= 104,683 cf, Depth> 0.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-yr Rainfall=6.16"

Area (sf)	CN	Description
43,012	98	Water Surface, 0% imp, HSG D
659,675	39	>75% Grass cover, Good, HSG A
271,379	98	Paved parking, HSG A
2,108,890	30	Woods, Good, HSG A
148,535	77	Woods, Good, HSG D
5,400	98	Paved parking, HSG D
8,325	80	>75% Grass cover, Good, HSG D
3,245,216	41	Weighted Average
2,968,437		91.47% Pervious Area
276,779		8.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
243.4	4,860	0.0170	0.33		**Lag/CN Method,**

Summary for Pond KWN: Kelsey Rd Wetland

Inflow Area = 10,296,454 sf, 8.80% Impervious, Inflow Depth > 0.32" for 25-yr event
Inflow = 11.09 cfs @ 12.71 hrs, Volume= 270,788 cf
Outflow = 7.24 cfs @ 20.00 hrs, Volume= 168,845 cf, Atten= 35%, Lag= 437.1 min
Primary = 7.24 cfs @ 20.00 hrs, Volume= 168,845 cf

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 106.04' @ 20.00 hrs Surf.Area= 79,707 sf Storage= 101,819 cf

Plug-Flow detention time= 125.4 min calculated for 168,845 cf (62% of inflow)
Center-of-Mass det. time= 36.9 min (995.4 - 958.5)

Volume	Invert	Avail.Storage	Storage Description
#1	103.00'	379,756 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
103.00	4,312	0	0
104.00	23,348	13,830	13,830
105.00	34,892	29,120	42,950
106.00	77,130	56,011	98,961
107.00	147,835	112,483	211,444
108.00	188,790	168,313	379,756

Device	Routing	Invert	Outlet Devices
#1	Primary	103.00'	**15.0" Round Culvert** L= 50.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 103.00' / 102.40' S= 0.0120 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.23 sf

Primary OutFlow Max=7.24 cfs @ 20.00 hrs HW=106.04' TW=0.00' (Dynamic Tailwater)
1=Culvert (Inlet Controls 7.24 cfs @ 5.90 fps)

Summary for Pond KWS: South Wetland

Inflow Area = 13,006,649 sf, 9.43% Impervious, Inflow Depth > 0.45" for 25-yr event
Inflow = 44.05 cfs @ 12.94 hrs, Volume= 487,944 cf
Outflow = 31.51 cfs @ 13.46 hrs, Volume= 462,028 cf, Atten= 28%, Lag= 31.1 min
Primary = 31.51 cfs @ 13.46 hrs, Volume= 462,028 cf

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 100.57' @ 13.46 hrs Surf.Area= 68,431 sf Storage= 69,952 cf

Plug-Flow detention time= 37.3 min calculated for 460,493 cf (94% of inflow)
Center-of-Mass det. time= 22.3 min (935.3 - 913.0)

Volume	Invert	Avail.Storage	Storage Description
#1	99.00'	1,000,195 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
99.00	25,925	0	0
100.00	47,900	36,913	36,913
101.00	84,045	65,973	102,885
102.00	119,200	101,623	204,508
103.00	235,925	177,563	382,070
104.00	302,175	269,050	651,120
105.00	395,975	349,075	1,000,195

Device	Routing	Invert	Outlet Devices
#1	Primary	99.00'	**60.0" W x 72.0" H Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=31.51 cfs @ 13.46 hrs HW=100.57' (Free Discharge)
1=Orifice/Grate (Orifice Controls 31.51 cfs @ 4.02 fps)

Summary for Pond NEW: Northeast Wetland

Inflow Area = 2,476,033 sf, 7.82% Impervious, Inflow Depth > 1.05" for 25-yr event
Inflow = 24.15 cfs @ 13.04 hrs, Volume= 216,753 cf
Outflow = 23.28 cfs @ 12.96 hrs, Volume= 124,581 cf, Atten= 4%, Lag= 0.0 min
Primary = 23.28 cfs @ 12.96 hrs, Volume= 124,581 cf

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 107.85' @ 20.00 hrs Surf.Area= 140,728 sf Storage= 92,118 cf

Plug-Flow detention time= 64.7 min calculated for 124,581 cf (57% of inflow)
Center-of-Mass det. time= (not calculated: outflow precedes inflow)

Volume	Invert	Avail.Storage	Storage Description
#1	107.00'	739,535 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
107.00	75,200	0	0
108.00	152,000	113,600	113,600
109.00	324,170	238,085	351,685
110.00	451,530	387,850	739,535

Device	Routing	Invert	Outlet Devices
#1	Primary	106.00'	**5.0' long x 10.0' breadth Broad-Crested Rectangular Weir X 2.00** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=23.02 cfs @ 12.96 hrs HW=107.00' TW=106.48' (Dynamic Tailwater)
↑—**1=Broad-Crested Rectangular Weir** (Weir Controls 23.02 cfs @ 2.30 fps)

Summary for Pond NWW: Northwest Wetland

Inflow Area = 9,679,079 sf, 8.62% Impervious, Inflow Depth > 0.78" for 25-yr event
Inflow = 48.00 cfs @ 13.27 hrs, Volume= 632,928 cf
Outflow = 8.80 cfs @ 14.77 hrs, Volume= 229,340 cf, Atten= 82%, Lag= 90.2 min
Primary = 8.80 cfs @ 14.77 hrs, Volume= 229,340 cf

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 107.85' @ 20.00 hrs Surf.Area= 569,425 sf Storage= 403,397 cf

Plug-Flow detention time= 176.1 min calculated for 229,340 cf (36% of inflow)
Center-of-Mass det. time= 55.5 min (973.9 - 918.4)

Volume	Invert	Avail.Storage	Storage Description
#1	106.00'	2,216,775 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
106.00	75,000	0	0
107.00	132,500	103,750	103,750
108.00	644,250	388,375	492,125
109.00	889,250	766,750	1,258,875
110.00	1,026,550	957,900	2,216,775

Device	Routing	Invert	Outlet Devices
#1	Primary	104.80'	**18.0" Round Culvert w/ 6.0" inside fill** L= 20.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 104.30' / 104.10' S= 0.0100 '/' Cc= 0.900 n= 0.013 Clay tile, Flow Area= 1.25 sf

Primary OutFlow Max=8.78 cfs @ 14.77 hrs HW=107.51' TW=105.30' (Dynamic Tailwater)
↳**1=Culvert** (Inlet Controls 8.78 cfs @ 7.02 fps)

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment E: Kelsey East Runoff Area=617,375 sf 11.59% Impervious Runoff Depth>2.10"
Flow Length=1,000' Slope=0.0500 '/' Tc=35.1 min CN=46 Runoff=18.52 cfs 108,085 cf

Subcatchment NE: Kelsey Northeast Runoff Area=2,476,033 sf 7.82% Impervious Runoff Depth>2.50"
Flow Length=1,770' Slope=0.0280 '/' Tc=66.8 min CN=50 Runoff=64.69 cfs 516,781 cf

Subcatchment NW: Kelsey Northwest Runoff Area=3,957,830 sf 9.20% Impervious Runoff Depth>2.77"
Flow Length=3,520' Slope=0.0250 '/' Tc=113.6 min CN=53 Runoff=83.39 cfs 913,925 cf

Subcatchment S: Kelsey South Runoff Area=2,710,195 sf 11.83% Impervious Runoff Depth>3.08"
Flow Length=2,011' Slope=0.0310 '/' Tc=62.0 min CN=55 Runoff=93.39 cfs 694,625 cf

Subcatchment W: Kelsey West Runoff Area=3,245,216 sf 8.53% Impervious Runoff Depth>1.27"
Flow Length=4,860' Slope=0.0170 '/' Tc=243.4 min CN=41 Runoff=20.13 cfs 344,203 cf

Pond KWN: Kelsey Rd Wetland Peak Elev=106.62' Storage=160,433 cf Inflow=25.14 cfs 366,979 cf
15.0" Round Culvert n=0.013 L=50.0' S=0.0120 '/' Outflow=8.07 cfs 206,360 cf

Pond KWS: South Wetland Peak Elev=101.62' Storage=162,095 cf Inflow=99.37 cfs 900,985 cf
Outflow=68.19 cfs 867,862 cf

Pond NEW: Northeast Wetland Peak Elev=108.92' Storage=325,845 cf Inflow=64.69 cfs 516,781 cf
Outflow=33.90 cfs 190,512 cf

Pond NWW: Northwest Wetland Peak Elev=108.92' Storage=1,188,972 cf Inflow=117.66 cfs 1,448,640 cf
18.0" Round Culvert w/ 6.0" inside fill n=0.013 L=20.0' S=0.0100 '/' Outflow=9.22 cfs 258,895 cf

Total Runoff Area = 13,006,649 sf Runoff Volume = 2,577,618 cf Average Runoff Depth = 2.38"
90.57% Pervious = 11,779,810 sf 9.43% Impervious = 1,226,839 sf

Summary for Subcatchment E: Kelsey East

Runoff = 18.52 cfs @ 12.55 hrs, Volume= 108,085 cf, Depth> 2.10"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-yr Rainfall=8.92"

Area (sf)	CN	Description
71,565	98	Paved roads w/curbs & sewers, HSG A
218,025	39	>75% Grass cover, Good, HSG A
12,035	80	>75% Grass cover, Good, HSG D
266,400	30	Woods, Good, HSG A
49,350	77	Woods, Good, HSG D
617,375	46	Weighted Average
545,810		88.41% Pervious Area
71,565		11.59% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
35.1	1,000	0.0500	0.47		**Lag/CN Method,**

Summary for Subcatchment NE: Kelsey Northeast

Runoff = 64.69 cfs @ 12.98 hrs, Volume= 516,781 cf, Depth> 2.50"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-yr Rainfall=8.92"

Area (sf)	CN	Description
164,585	98	Paved roads w/curbs & sewers, HSG A
6,800	98	Paved roads w/curbs & sewers, HSG C
22,310	98	Paved roads w/curbs & sewers, HSG D
332,200	39	>75% Grass cover, Good, HSG A
6,925	74	>75% Grass cover, Good, HSG C
1,000,775	30	Woods, Good, HSG A
302,195	70	Woods, Good, HSG C
229,600	77	Woods, Good, HSG D
168,080	30	Brush, Good, HSG A
17,080	65	Brush, Good, HSG C
225,483	73	Brush, Good, HSG D
2,476,033	50	Weighted Average
2,282,338		92.18% Pervious Area
193,695		7.82% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
66.8	1,770	0.0280	0.44		**Lag/CN Method,**

Summary for Subcatchment NW: Kelsey Northwest

Runoff = 83.39 cfs @ 13.57 hrs, Volume= 913,925 cf, Depth> 2.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-yr Rainfall=8.92"

Area (sf)	CN	Description
318,596	98	Paved roads w/curbs & sewers, HSG A
31,236	98	Paved roads w/curbs & sewers, HSG C
5,635	98	Paved roads w/curbs & sewers, HSG D
654,001	39	>75% Grass cover, Good, HSG A
72,585	74	>75% Grass cover, Good, HSG C
1,462,850	30	Woods, Good, HSG A
302,370	70	Woods, Good, HSG C
141,645	77	Woods, Good, HSG D
41,465	30	Brush, Good, HSG A
918,725	73	Brush, Good, HSG D
8,722	98	Water Surface, HSG A
3,957,830	53	Weighted Average
3,593,641		90.80% Pervious Area
364,189		9.20% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
113.6	3,520	0.0250	0.52		**Lag/CN Method,**

Summary for Subcatchment S: Kelsey South

Runoff = 93.39 cfs @ 12.88 hrs, Volume= 694,625 cf, Depth> 3.08"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-yr Rainfall=8.92"

Area (sf)	CN	Description
177,211	98	Paved roads w/curbs & sewers, HSG A
101,330	98	Paved roads w/curbs & sewers, HSG B
42,070	98	Paved roads w/curbs & sewers, HSG D
658,051	39	>75% Grass cover, Good, HSG A
121,615	61	>75% Grass cover, Good, HSG B
72,733	80	>75% Grass cover, Good, HSG D
643,630	30	Woods, Good, HSG A
448,300	58	Woods/grass comb., Good, HSG B
261,065	77	Woods, Good, HSG D
59,340	65	Brush, Good, HSG C
124,850	73	Brush, Good, HSG D
2,710,195	55	Weighted Average
2,389,584		88.17% Pervious Area
320,611		11.83% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
62.0	2,011	0.0310	0.54		**Lag/CN Method,**

Summary for Subcatchment W: Kelsey West

Runoff = 20.13 cfs @ 15.93 hrs, Volume= 344,203 cf, Depth> 1.27"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-yr Rainfall=8.92"

Area (sf)	CN	Description
43,012	98	Water Surface, 0% imp, HSG D
659,675	39	>75% Grass cover, Good, HSG A
271,379	98	Paved parking, HSG A
2,108,890	30	Woods, Good, HSG A
148,535	77	Woods, Good, HSG D
5,400	98	Paved parking, HSG D
8,325	80	>75% Grass cover, Good, HSG D
3,245,216	41	Weighted Average
2,968,437		91.47% Pervious Area
276,779		8.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
243.4	4,860	0.0170	0.33		**Lag/CN Method,**

Summary for Pond KWN: Kelsey Rd Wetland

Inflow Area = 10,296,454 sf, 8.80% Impervious, Inflow Depth > 0.43" for 100-yr event
Inflow = 25.14 cfs @ 12.58 hrs, Volume= 366,979 cf
Outflow = 8.07 cfs @ 20.00 hrs, Volume= 206,360 cf, Atten= 68%, Lag= 445.4 min
Primary = 8.07 cfs @ 20.00 hrs, Volume= 206,360 cf

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 106.62' @ 20.00 hrs Surf.Area= 121,003 sf Storage= 160,433 cf

Plug-Flow detention time= 159.3 min calculated for 206,360 cf (56% of inflow)
Center-of-Mass det. time= 48.4 min (978.9 - 930.5)

Volume	Invert	Avail.Storage	Storage Description
#1	103.00'	379,756 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
103.00	4,312	0	0
104.00	23,348	13,830	13,830
105.00	34,892	29,120	42,950
106.00	77,130	56,011	98,961
107.00	147,835	112,483	211,444
108.00	188,790	168,313	379,756

Device	Routing	Invert	Outlet Devices
#1	Primary	103.00'	**15.0" Round Culvert** L= 50.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 103.00' / 102.40' S= 0.0120 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.23 sf

Primary OutFlow Max=8.07 cfs @ 20.00 hrs HW=106.62' TW=0.00' (Dynamic Tailwater)
↑**1=Culvert** (Inlet Controls 8.07 cfs @ 6.58 fps)

Summary for Pond KWS: South Wetland

Inflow Area = 13,006,649 sf, 9.43% Impervious, Inflow Depth > 0.83" for 100-yr event
Inflow = 99.37 cfs @ 12.89 hrs, Volume= 900,985 cf
Outflow = 68.19 cfs @ 13.39 hrs, Volume= 867,862 cf, Atten= 31%, Lag= 30.0 min
Primary = 68.19 cfs @ 13.39 hrs, Volume= 867,862 cf

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 101.62' @ 13.39 hrs Surf.Area= 105,956 sf Storage= 162,095 cf

Plug-Flow detention time= 37.5 min calculated for 864,979 cf (96% of inflow)
Center-of-Mass det. time= 26.2 min (908.1 - 881.9)

Volume	Invert	Avail.Storage	Storage Description
#1	99.00'	1,000,195 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
99.00	25,925	0	0
100.00	47,900	36,913	36,913
101.00	84,045	65,973	102,885
102.00	119,200	101,623	204,508
103.00	235,925	177,563	382,070
104.00	302,175	269,050	651,120
105.00	395,975	349,075	1,000,195

Device	Routing	Invert	Outlet Devices
#1	Primary	99.00'	**60.0" W x 72.0" H Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=68.17 cfs @ 13.39 hrs HW=101.62' (Free Discharge)
↑**1=Orifice/Grate** (Orifice Controls 68.17 cfs @ 5.20 fps)

Summary for Pond NEW: Northeast Wetland

Inflow Area = 2,476,033 sf, 7.82% Impervious, Inflow Depth > 2.50" for 100-yr event
Inflow = 64.69 cfs @ 12.98 hrs, Volume= 516,781 cf
Outflow = 33.90 cfs @ 13.20 hrs, Volume= 190,512 cf, Atten= 48%, Lag= 13.6 min
Primary = 33.90 cfs @ 13.20 hrs, Volume= 190,512 cf

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 108.92' @ 20.00 hrs Surf.Area= 310,142 sf Storage= 325,845 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= (not calculated: outflow precedes inflow)

Volume	Invert	Avail.Storage	Storage Description
#1	107.00'	739,535 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
107.00	75,200	0	0
108.00	152,000	113,600	113,600
109.00	324,170	238,085	351,685
110.00	451,530	387,850	739,535

Device	Routing	Invert	Outlet Devices
#1	Primary	106.00'	**5.0' long x 10.0' breadth Broad-Crested Rectangular Weir X 2.00** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=31.57 cfs @ 13.20 hrs HW=107.68' TW=107.43' (Dynamic Tailwater)
↑—**1=Broad-Crested Rectangular Weir** (Weir Controls 31.57 cfs @ 1.88 fps)

Summary for Pond NWW: Northwest Wetland

Inflow Area = 9,679,079 sf, 8.62% Impervious, Inflow Depth > 1.80" for 100-yr event
Inflow = 117.66 cfs @ 13.49 hrs, Volume= 1,448,640 cf
Outflow = 9.22 cfs @ 17.47 hrs, Volume= 258,895 cf, Atten= 92%, Lag= 238.8 min
Primary = 9.22 cfs @ 17.47 hrs, Volume= 258,895 cf

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 108.92' @ 20.00 hrs Surf.Area= 869,778 sf Storage= 1,188,972 cf

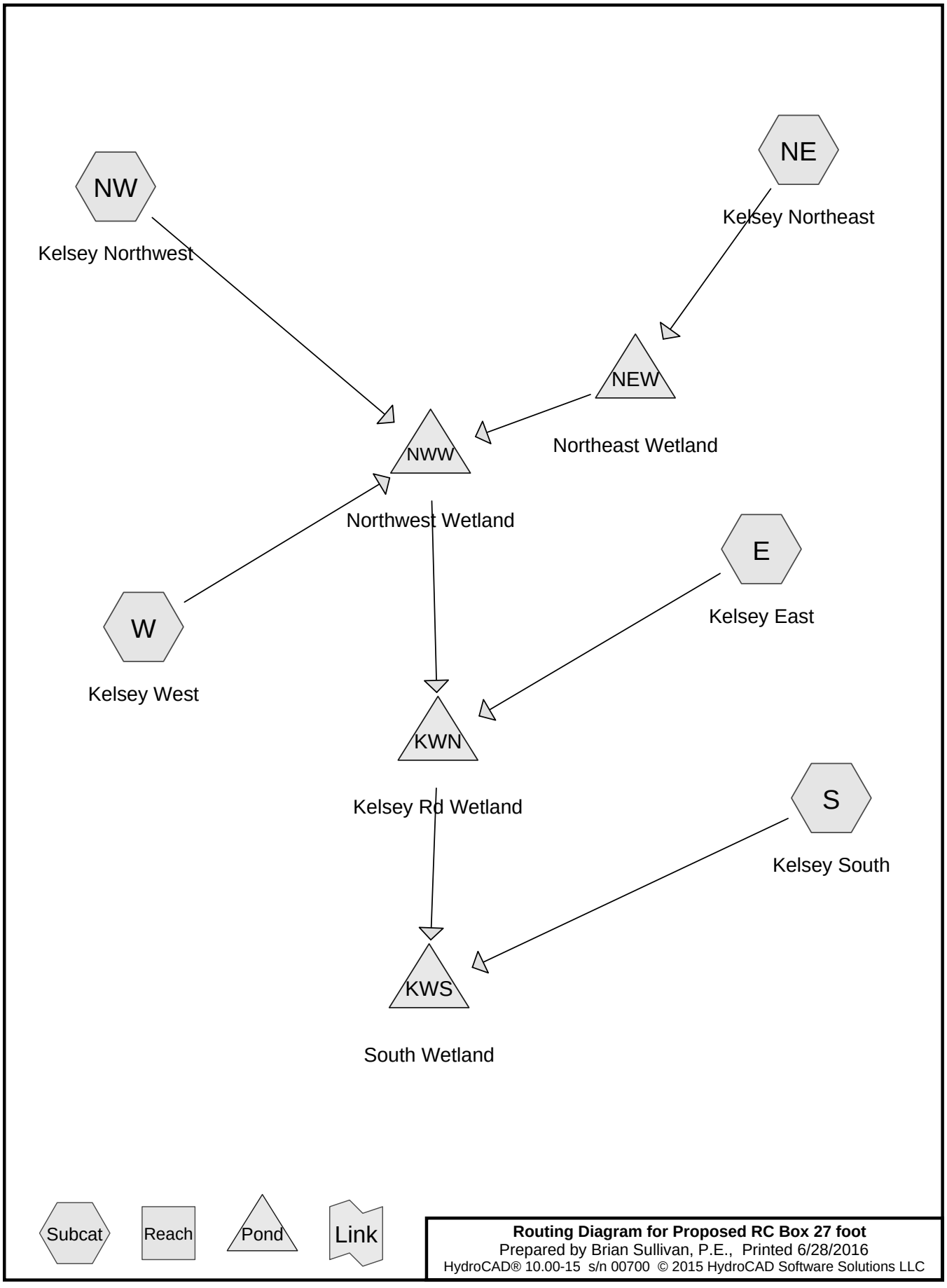
Plug-Flow detention time= 196.7 min calculated for 258,895 cf (18% of inflow)
Center-of-Mass det. time= 60.4 min (964.5 - 904.1)

Volume	Invert	Avail.Storage	Storage Description
#1	106.00'	2,216,775 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
106.00	75,000	0	0
107.00	132,500	103,750	103,750
108.00	644,250	388,375	492,125
109.00	889,250	766,750	1,258,875
110.00	1,026,550	957,900	2,216,775

Device	Routing	Invert	Outlet Devices
#1	Primary	104.80'	**18.0" Round Culvert w/ 6.0" inside fill** L= 20.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 104.30' / 104.10' S= 0.0100 '/' Cc= 0.900 n= 0.013 Clay tile, Flow Area= 1.25 sf

Primary OutFlow Max=9.21 cfs @ 17.47 hrs HW=108.76' TW=106.43' (Dynamic Tailwater)
↳**1=Culvert** (Inlet Controls 9.21 cfs @ 7.36 fps)



Routing Diagram for Proposed RC Box 27 foot
Prepared by Brian Sullivan, P.E., Printed 6/28/2016
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Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
57.896	39	>75% Grass cover, Good, HSG A (E, NE, NW, S, W)
2.792	61	>75% Grass cover, Good, HSG B (S)
1.825	74	>75% Grass cover, Good, HSG C (NE, NW)
2.137	80	>75% Grass cover, Good, HSG D (E, S, W)
4.810	30	Brush, Good, HSG A (NE, NW)
1.754	65	Brush, Good, HSG C (NE, S)
29.134	73	Brush, Good, HSG D (NE, NW, S)
6.230	98	Paved parking, HSG A (W)
0.124	98	Paved parking, HSG D (W)
16.803	98	Paved roads w/curbs & sewers, HSG A (E, NE, NW, S)
2.326	98	Paved roads w/curbs & sewers, HSG B (S)
0.873	98	Paved roads w/curbs & sewers, HSG C (NE, NW)
1.607	98	Paved roads w/curbs & sewers, HSG D (NE, NW, S)
0.987	98	Water Surface, 0% imp, HSG D (W)
0.200	98	Water Surface, HSG A (NW)
125.862	30	Woods, Good, HSG A (E, NE, NW, S, W)
13.879	70	Woods, Good, HSG C (NE, NW)
19.059	77	Woods, Good, HSG D (E, NE, NW, S, W)
10.292	58	Woods/grass comb., Good, HSG B (S)
298.592	**50**	**TOTAL AREA**

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points x 2
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment E: Kelsey East Runoff Area=617,375 sf 11.59% Impervious Runoff Depth>0.03"
Flow Length=1,000' Slope=0.0500 '/' Tc=35.1 min CN=46 Runoff=0.09 cfs 0.040 af

Subcatchment NE: Kelsey Northeast Runoff Area=2,476,033 sf 7.82% Impervious Runoff Depth>0.09"
Flow Length=1,770' Slope=0.0280 '/' Tc=66.8 min CN=50 Runoff=0.92 cfs 0.407 af

Subcatchment NW: Kelsey Northwest Runoff Area=3,957,830 sf 9.20% Impervious Runoff Depth>0.13"
Flow Length=3,520' Slope=0.0250 '/' Tc=113.6 min CN=53 Runoff=2.42 cfs 1.017 af

Subcatchment S: Kelsey South Runoff Area=2,710,195 sf 11.83% Impervious Runoff Depth>0.19"
Flow Length=2,011' Slope=0.0310 '/' Tc=62.0 min CN=55 Runoff=3.07 cfs 0.974 af

Subcatchment W: Kelsey West Runoff Area=3,245,216 sf 8.53% Impervious Runoff Depth>0.00"
Flow Length=4,860' Slope=0.0170 '/' Tc=243.4 min CN=41 Runoff=0.01 cfs 0.000 af

Pond KWN: Kelsey Rd Wetland Peak Elev=103.09' Storage=474 cf Inflow=3.42 cfs 1.463 af
96.0" x 60.0" Box Culvert w/ 24.0" inside fill n=0.022 L=27.0' S=0.0074 '/' Outflow=3.41 cfs 1.463 af

Pond KWS: South Wetland Peak Elev=99.47' Storage=14,632 cf Inflow=5.56 cfs 2.437 af
Outflow=5.18 cfs 2.243 af

Pond NEW: Northeast Wetland Peak Elev=107.00' Storage=0 cf Inflow=0.92 cfs 0.407 af
Outflow=0.92 cfs 0.407 af

Pond NWW: Northwest Wetland Peak Elev=106.00' Storage=0 cf Inflow=3.34 cfs 1.424 af
18.0" Round Culvert w/ 6.0" inside fill n=0.013 L=20.0' S=0.0100 '/' Outflow=3.34 cfs 1.424 af

Total Runoff Area = 298.592 ac Runoff Volume = 2.438 af Average Runoff Depth = 0.10"
90.57% Pervious = 270.427 ac 9.43% Impervious = 28.164 ac

Summary for Subcatchment E: Kelsey East

Runoff = 0.09 cfs @ 15.64 hrs, Volume= 0.040 af, Depth> 0.03"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-yr Rainfall=3.15"

Area (sf)	CN	Description
71,565	98	Paved roads w/curbs & sewers, HSG A
218,025	39	>75% Grass cover, Good, HSG A
12,035	80	>75% Grass cover, Good, HSG D
266,400	30	Woods, Good, HSG A
49,350	77	Woods, Good, HSG D
617,375	46	Weighted Average
545,810		88.41% Pervious Area
71,565		11.59% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
35.1	1,000	0.0500	0.47		**Lag/CN Method,**

Summary for Subcatchment NE: Kelsey Northeast

Runoff = 0.92 cfs @ 14.61 hrs, Volume= 0.407 af, Depth> 0.09"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-yr Rainfall=3.15"

Area (sf)	CN	Description
164,585	98	Paved roads w/curbs & sewers, HSG A
6,800	98	Paved roads w/curbs & sewers, HSG C
22,310	98	Paved roads w/curbs & sewers, HSG D
332,200	39	>75% Grass cover, Good, HSG A
6,925	74	>75% Grass cover, Good, HSG C
1,000,775	30	Woods, Good, HSG A
302,195	70	Woods, Good, HSG C
229,600	77	Woods, Good, HSG D
168,080	30	Brush, Good, HSG A
17,080	65	Brush, Good, HSG C
225,483	73	Brush, Good, HSG D
2,476,033	50	Weighted Average
2,282,338		92.18% Pervious Area
193,695		7.82% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
66.8	1,770	0.0280	0.44		**Lag/CN Method,**

Summary for Subcatchment NW: Kelsey Northwest

Runoff = 2.42 cfs @ 14.52 hrs, Volume= 1.017 af, Depth> 0.13"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-yr Rainfall=3.15"

Area (sf)	CN	Description
318,596	98	Paved roads w/curbs & sewers, HSG A
31,236	98	Paved roads w/curbs & sewers, HSG C
5,635	98	Paved roads w/curbs & sewers, HSG D
654,001	39	>75% Grass cover, Good, HSG A
72,585	74	>75% Grass cover, Good, HSG C
1,462,850	30	Woods, Good, HSG A
302,370	70	Woods, Good, HSG C
141,645	77	Woods, Good, HSG D
41,465	30	Brush, Good, HSG A
918,725	73	Brush, Good, HSG D
8,722	98	Water Surface, HSG A
3,957,830	53	Weighted Average
3,593,641		90.80% Pervious Area
364,189		9.20% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
113.6	3,520	0.0250	0.52		**Lag/CN Method,**

Summary for Subcatchment S: Kelsey South

Runoff = 3.07 cfs @ 13.25 hrs, Volume= 0.974 af, Depth> 0.19"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-yr Rainfall=3.15"

Area (sf)	CN	Description
177,211	98	Paved roads w/curbs & sewers, HSG A
101,330	98	Paved roads w/curbs & sewers, HSG B
42,070	98	Paved roads w/curbs & sewers, HSG D
658,051	39	>75% Grass cover, Good, HSG A
121,615	61	>75% Grass cover, Good, HSG B
72,733	80	>75% Grass cover, Good, HSG D
643,630	30	Woods, Good, HSG A
448,300	58	Woods/grass comb., Good, HSG B
261,065	77	Woods, Good, HSG D
59,340	65	Brush, Good, HSG C
124,850	73	Brush, Good, HSG D
2,710,195	55	Weighted Average
2,389,584		88.17% Pervious Area
320,611		11.83% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
62.0	2,011	0.0310	0.54		**Lag/CN Method,**

Summary for Subcatchment W: Kelsey West

Runoff = 0.01 cfs @ 20.00 hrs, Volume= 0.000 af, Depth> 0.00"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-yr Rainfall=3.15"

Area (sf)	CN	Description
43,012	98	Water Surface, 0% imp, HSG D
659,675	39	>75% Grass cover, Good, HSG A
271,379	98	Paved parking, HSG A
2,108,890	30	Woods, Good, HSG A
148,535	77	Woods, Good, HSG D
5,400	98	Paved parking, HSG D
8,325	80	>75% Grass cover, Good, HSG D
3,245,216	41	Weighted Average
2,968,437		91.47% Pervious Area
276,779		8.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
243.4	4,860	0.0170	0.33		**Lag/CN Method,**

Summary for Pond KWN: Kelsey Rd Wetland

Inflow Area = 236.374 ac, 8.80% Impervious, Inflow Depth > 0.07" for 2-yr event
Inflow = 3.42 cfs @ 14.57 hrs, Volume= 1.463 af
Outflow = 3.41 cfs @ 14.69 hrs, Volume= 1.463 af, Atten= 0%, Lag= 7.5 min
Primary = 3.41 cfs @ 14.69 hrs, Volume= 1.463 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 103.09' @ 14.69 hrs Surf.Area= 6,053 sf Storage= 474 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 1.4 min (972.0 - 970.6)

Volume	Invert	Avail.Storage	Storage Description
#1	103.00'	379,756 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
103.00	4,312	0	0
104.00	23,348	13,830	13,830
105.00	34,892	29,120	42,950
106.00	77,130	56,011	98,961
107.00	147,835	112,483	211,444
108.00	188,790	168,313	379,756

Device	Routing	Invert	Outlet Devices
#1	Primary	102.80'	**96.0" W x 60.0" H Box Culvert w/ 24.0" inside fill** L= 27.0' Box, headwall w/3 square edges, Ke= 0.500 Inlet / Outlet Invert= 100.80' / 100.60' S= 0.0074 '/' Cc= 0.900 n= 0.022 Earth, clean & straight, Flow Area= 24.00 sf

Primary OutFlow Max=3.41 cfs @ 14.69 hrs HW=103.09' TW=99.46' (Dynamic Tailwater)
└**1=Culvert** (Barrel Controls 3.41 cfs @ 1.95 fps)

Summary for Pond KWS: South Wetland

Inflow Area = 298.592 ac, 9.43% Impervious, Inflow Depth > 0.10" for 2-yr event
Inflow = 5.56 cfs @ 14.30 hrs, Volume= 2.437 af
Outflow = 5.18 cfs @ 15.22 hrs, Volume= 2.243 af, Atten= 7%, Lag= 55.5 min
Primary = 5.18 cfs @ 15.22 hrs, Volume= 2.243 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 99.47' @ 15.22 hrs Surf.Area= 36,265 sf Storage= 14,632 cf

Plug-Flow detention time= 47.8 min calculated for 2.243 af (92% of inflow)
Center-of-Mass det. time= 28.9 min (982.4 - 953.5)

Volume	Invert	Avail.Storage	Storage Description
#1	99.00'	1,000,195 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
99.00	25,925	0	0
100.00	47,900	36,913	36,913
101.00	84,045	65,973	102,885
102.00	119,200	101,623	204,508
103.00	235,925	177,563	382,070
104.00	302,175	269,050	651,120
105.00	395,975	349,075	1,000,195

Device	Routing	Invert	Outlet Devices
#1	Primary	99.00'	**60.0" W x 72.0" H Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=5.18 cfs @ 15.22 hrs HW=99.47' (Free Discharge)
└**1=Orifice/Grate** (Orifice Controls 5.18 cfs @ 2.20 fps)

Summary for Pond NEW: Northeast Wetland

Inflow Area = 56.842 ac, 7.82% Impervious, Inflow Depth > 0.09" for 2-yr event
Inflow = 0.92 cfs @ 14.61 hrs, Volume= 0.407 af
Outflow = 0.92 cfs @ 14.61 hrs, Volume= 0.407 af, Atten= 0%, Lag= 0.0 min
Primary = 0.92 cfs @ 14.61 hrs, Volume= 0.407 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 107.00' @ 5.00 hrs Surf.Area= 75,200 sf Storage= 0 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 0.0 min (968.2 - 968.2)

Volume	Invert	Avail.Storage	Storage Description
#1	107.00'	739,535 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
107.00	75,200	0	0
108.00	152,000	113,600	113,600
109.00	324,170	238,085	351,685
110.00	451,530	387,850	739,535

Device	Routing	Invert	Outlet Devices
#1	Primary	106.00'	**5.0' long x 10.0' breadth Broad-Crested Rectangular Weir X 2.00** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=0.00 cfs @ 14.61 hrs HW=107.00' TW=106.00' (Dynamic Tailwater)
↑—**1=Broad-Crested Rectangular Weir** (Passes 0.00 cfs of 26.80 cfs potential flow)

Summary for Pond NWW: Northwest Wetland

Inflow Area = 222.201 ac, 8.62% Impervious, Inflow Depth > 0.08" for 2-yr event
Inflow = 3.34 cfs @ 14.52 hrs, Volume= 1.424 af
Outflow = 3.34 cfs @ 14.52 hrs, Volume= 1.424 af, Atten= 0%, Lag= 0.0 min
Primary = 3.34 cfs @ 14.52 hrs, Volume= 1.424 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 106.00' @ 14.52 hrs Surf.Area= 75,000 sf Storage= 0 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 0.0 min (969.6 - 969.6)

Volume	Invert	Avail.Storage	Storage Description
#1	106.00'	2,216,775 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
106.00	75,000	0	0
107.00	132,500	103,750	103,750
108.00	644,250	388,375	492,125
109.00	889,250	766,750	1,258,875
110.00	1,026,550	957,900	2,216,775

Device	Routing	Invert	Outlet Devices
#1	Primary	104.80'	**18.0" Round Culvert w/ 6.0" inside fill** L= 20.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 104.30' / 104.10' S= 0.0100 '/' Cc= 0.900 n= 0.013 Clay tile, Flow Area= 1.25 sf

Primary OutFlow Max=4.93 cfs @ 14.52 hrs HW=106.00' TW=103.09' (Dynamic Tailwater)
↑—**1=Culvert** (Barrel Controls 4.93 cfs @ 4.10 fps)

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points x 2
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment E: Kelsey East Runoff Area=617,375 sf 11.59% Impervious Runoff Depth>0.36"
Flow Length=1,000' Slope=0.0500 '/' Tc=35.1 min CN=46 Runoff=1.90 cfs 0.421 af

Subcatchment NE: Kelsey Northeast Runoff Area=2,476,033 sf 7.82% Impervious Runoff Depth>0.52"
Flow Length=1,770' Slope=0.0280 '/' Tc=66.8 min CN=50 Runoff=10.02 cfs 2.446 af

Subcatchment NW: Kelsey Northwest Runoff Area=3,957,830 sf 9.20% Impervious Runoff Depth>0.64"
Flow Length=3,520' Slope=0.0250 '/' Tc=113.6 min CN=53 Runoff=16.10 cfs 4.819 af

Subcatchment S: Kelsey South Runoff Area=2,710,195 sf 11.83% Impervious Runoff Depth>0.77"
Flow Length=2,011' Slope=0.0310 '/' Tc=62.0 min CN=55 Runoff=19.71 cfs 3.968 af

Subcatchment W: Kelsey West Runoff Area=3,245,216 sf 8.53% Impervious Runoff Depth>0.12"
Flow Length=4,860' Slope=0.0170 '/' Tc=243.4 min CN=41 Runoff=1.91 cfs 0.767 af

Pond KWN: Kelsey Rd Wetland Peak Elev=103.34' Storage=2,582 cf Inflow=8.80 cfs 5.289 af
96.0" x 60.0" Box Culvert w/ 24.0" inside fill n=0.022 L=27.0' S=0.0074 '/' Outflow=8.80 cfs 5.232 af

Pond KWS: South Wetland Peak Elev=100.15' Storage=44,680 cf Inflow=26.53 cfs 9.200 af
Outflow=19.88 cfs 8.596 af

Pond NEW: Northeast Wetland Peak Elev=107.17' Storage=13,779 cf Inflow=10.02 cfs 2.446 af
Outflow=10.02 cfs 2.192 af

Pond NWW: Northwest Wetland Peak Elev=107.17' Storage=133,273 cf Inflow=23.69 cfs 7.778 af
18.0" Round Culvert w/ 6.0" inside fill n=0.013 L=20.0' S=0.0100 '/' Outflow=8.35 cfs 4.868 af

Total Runoff Area = 298.592 ac Runoff Volume = 12.421 af Average Runoff Depth = 0.50"
90.57% Pervious = 270.427 ac 9.43% Impervious = 28.164 ac

Summary for Subcatchment E: Kelsey East

Runoff = 1.90 cfs @ 12.73 hrs, Volume= 0.421 af, Depth> 0.36"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-yr Rainfall=4.82"

Area (sf)	CN	Description
71,565	98	Paved roads w/curbs & sewers, HSG A
218,025	39	>75% Grass cover, Good, HSG A
12,035	80	>75% Grass cover, Good, HSG D
266,400	30	Woods, Good, HSG A
49,350	77	Woods, Good, HSG D
617,375	46	Weighted Average
545,810		88.41% Pervious Area
71,565		11.59% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
35.1	1,000	0.0500	0.47		**Lag/CN Method,**

Summary for Subcatchment NE: Kelsey Northeast

Runoff = 10.02 cfs @ 13.14 hrs, Volume= 2.446 af, Depth> 0.52"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-yr Rainfall=4.82"

Area (sf)	CN	Description
164,585	98	Paved roads w/curbs & sewers, HSG A
6,800	98	Paved roads w/curbs & sewers, HSG C
22,310	98	Paved roads w/curbs & sewers, HSG D
332,200	39	>75% Grass cover, Good, HSG A
6,925	74	>75% Grass cover, Good, HSG C
1,000,775	30	Woods, Good, HSG A
302,195	70	Woods, Good, HSG C
229,600	77	Woods, Good, HSG D
168,080	30	Brush, Good, HSG A
17,080	65	Brush, Good, HSG C
225,483	73	Brush, Good, HSG D
2,476,033	50	Weighted Average
2,282,338		92.18% Pervious Area
193,695		7.82% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
66.8	1,770	0.0280	0.44		**Lag/CN Method,**

Summary for Subcatchment NW: Kelsey Northwest

Runoff = 16.10 cfs @ 13.80 hrs, Volume= 4.819 af, Depth> 0.64"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-yr Rainfall=4.82"

Area (sf)	CN	Description
318,596	98	Paved roads w/curbs & sewers, HSG A
31,236	98	Paved roads w/curbs & sewers, HSG C
5,635	98	Paved roads w/curbs & sewers, HSG D
654,001	39	>75% Grass cover, Good, HSG A
72,585	74	>75% Grass cover, Good, HSG C
1,462,850	30	Woods, Good, HSG A
302,370	70	Woods, Good, HSG C
141,645	77	Woods, Good, HSG D
41,465	30	Brush, Good, HSG A
918,725	73	Brush, Good, HSG D
8,722	98	Water Surface, HSG A
3,957,830	53	Weighted Average
3,593,641		90.80% Pervious Area
364,189		9.20% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
113.6	3,520	0.0250	0.52		**Lag/CN Method,**

Summary for Subcatchment S: Kelsey South

Runoff = 19.71 cfs @ 12.99 hrs, Volume= 3.968 af, Depth> 0.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-yr Rainfall=4.82"

Area (sf)	CN	Description
177,211	98	Paved roads w/curbs & sewers, HSG A
101,330	98	Paved roads w/curbs & sewers, HSG B
42,070	98	Paved roads w/curbs & sewers, HSG D
658,051	39	>75% Grass cover, Good, HSG A
121,615	61	>75% Grass cover, Good, HSG B
72,733	80	>75% Grass cover, Good, HSG D
643,630	30	Woods, Good, HSG A
448,300	58	Woods/grass comb., Good, HSG B
261,065	77	Woods, Good, HSG D
59,340	65	Brush, Good, HSG C
124,850	73	Brush, Good, HSG D
2,710,195	55	Weighted Average
2,389,584		88.17% Pervious Area
320,611		11.83% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
62.0	2,011	0.0310	0.54		**Lag/CN Method,**

Summary for Subcatchment W: Kelsey West

Runoff = 1.91 cfs @ 17.53 hrs, Volume= 0.767 af, Depth> 0.12"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-yr Rainfall=4.82"

Area (sf)	CN	Description
43,012	98	Water Surface, 0% imp, HSG D
659,675	39	>75% Grass cover, Good, HSG A
271,379	98	Paved parking, HSG A
2,108,890	30	Woods, Good, HSG A
148,535	77	Woods, Good, HSG D
5,400	98	Paved parking, HSG D
8,325	80	>75% Grass cover, Good, HSG D
3,245,216	41	Weighted Average
2,968,437		91.47% Pervious Area
276,779		8.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
243.4	4,860	0.0170	0.33		**Lag/CN Method,**

Summary for Pond KWN: Kelsey Rd Wetland

Inflow Area = 236.374 ac, 8.80% Impervious, Inflow Depth > 0.27" for 10-yr event
Inflow = 8.80 cfs @ 15.81 hrs, Volume= 5.289 af
Outflow = 8.80 cfs @ 15.94 hrs, Volume= 5.232 af, Atten= 0%, Lag= 7.9 min
Primary = 8.80 cfs @ 15.94 hrs, Volume= 5.232 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 103.34' @ 15.94 hrs Surf.Area= 10,812 sf Storage= 2,582 cf

Plug-Flow detention time= 4.7 min calculated for 5.215 af (99% of inflow)
Center-of-Mass det. time= 2.3 min (981.5 - 979.2)

Volume	Invert	Avail.Storage	Storage Description
#1	103.00'	379,756 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
103.00	4,312	0	0
104.00	23,348	13,830	13,830
105.00	34,892	29,120	42,950
106.00	77,130	56,011	98,961
107.00	147,835	112,483	211,444
108.00	188,790	168,313	379,756

Device	Routing	Invert	Outlet Devices
#1	Primary	102.80'	**96.0" W x 60.0" H Box Culvert w/ 24.0" inside fill** L= 27.0' Box, headwall w/3 square edges, Ke= 0.500 Inlet / Outlet Invert= 100.80' / 100.60' S= 0.0074 '/' Cc= 0.900 n= 0.022 Earth, clean & straight, Flow Area= 24.00 sf

Primary OutFlow Max=8.80 cfs @ 15.94 hrs HW=103.34' TW=99.93' (Dynamic Tailwater)
└**1=Culvert** (Barrel Controls 8.80 cfs @ 2.71 fps)

Summary for Pond KWS: South Wetland

Inflow Area = 298.592 ac, 9.43% Impervious, Inflow Depth > 0.37" for 10-yr event
Inflow = 26.53 cfs @ 12.99 hrs, Volume= 9.200 af
Outflow = 19.88 cfs @ 13.63 hrs, Volume= 8.596 af, Atten= 25%, Lag= 38.7 min
Primary = 19.88 cfs @ 13.63 hrs, Volume= 8.596 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 100.15' @ 13.63 hrs Surf.Area= 53,441 sf Storage= 44,680 cf

Plug-Flow detention time= 37.7 min calculated for 8.568 af (93% of inflow)
Center-of-Mass det. time= 20.8 min (960.0 - 939.3)

Volume	Invert	Avail.Storage	Storage Description
#1	99.00'	1,000,195 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
99.00	25,925	0	0
100.00	47,900	36,913	36,913
101.00	84,045	65,973	102,885
102.00	119,200	101,623	204,508
103.00	235,925	177,563	382,070
104.00	302,175	269,050	651,120
105.00	395,975	349,075	1,000,195

Device	Routing	Invert	Outlet Devices
#1	Primary	99.00'	**60.0" W x 72.0" H Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=19.87 cfs @ 13.63 hrs HW=100.15' (Free Discharge)
└**1=Orifice/Grate** (Orifice Controls 19.87 cfs @ 3.45 fps)

Summary for Pond NEW: Northeast Wetland

Inflow Area = 56.842 ac, 7.82% Impervious, Inflow Depth > 0.52" for 10-yr event
Inflow = 10.02 cfs @ 13.14 hrs, Volume= 2.446 af
Outflow = 10.02 cfs @ 13.14 hrs, Volume= 2.192 af, Atten= 0%, Lag= 0.0 min
Primary = 10.02 cfs @ 13.14 hrs, Volume= 2.192 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 107.17' @ 18.08 hrs Surf.Area= 88,156 sf Storage= 13,779 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 1.1 min (903.6 - 902.5)

Volume	Invert	Avail.Storage	Storage Description
#1	107.00'	739,535 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
107.00	75,200	0	0
108.00	152,000	113,600	113,600
109.00	324,170	238,085	351,685
110.00	451,530	387,850	739,535

Device	Routing	Invert	Outlet Devices
#1	Primary	106.00'	**5.0' long x 10.0' breadth Broad-Crested Rectangular Weir X 2.00** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=0.00 cfs @ 13.14 hrs HW=107.00' TW=106.22' (Dynamic Tailwater)
↑—**1=Broad-Crested Rectangular Weir** (Passes 0.00 cfs of 25.66 cfs potential flow)

Summary for Pond NWW: Northwest Wetland

Inflow Area = 222.201 ac, 8.62% Impervious, Inflow Depth > 0.42" for 10-yr event
Inflow = 23.69 cfs @ 13.56 hrs, Volume= 7.778 af
Outflow = 8.35 cfs @ 18.09 hrs, Volume= 4.868 af, Atten= 65%, Lag= 272.1 min
Primary = 8.35 cfs @ 18.09 hrs, Volume= 4.868 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 107.17' @ 18.09 hrs Surf.Area= 218,571 sf Storage= 133,273 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 56.2 min (986.1 - 929.9)

Volume	Invert	Avail.Storage	Storage Description
#1	106.00'	2,216,775 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
106.00	75,000	0	0
107.00	132,500	103,750	103,750
108.00	644,250	388,375	492,125
109.00	889,250	766,750	1,258,875
110.00	1,026,550	957,900	2,216,775

Device	Routing	Invert	Outlet Devices
#1	Primary	104.80'	**18.0" Round Culvert w/ 6.0" inside fill** L= 20.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 104.30' / 104.10' S= 0.0100 '/' Cc= 0.900 n= 0.013 Clay tile, Flow Area= 1.25 sf

Primary OutFlow Max=8.35 cfs @ 18.09 hrs HW=107.17' TW=103.34' (Dynamic Tailwater)
↑—**1=Culvert** (Inlet Controls 8.35 cfs @ 6.67 fps)

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points x 2
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment E: Kelsey East Runoff Area=617,375 sf 11.59% Impervious Runoff Depth>0.81"
Flow Length=1,000' Slope=0.0500 '/' Tc=35.1 min CN=46 Runoff=5.86 cfs 0.952 af

Subcatchment NE: Kelsey Northeast Runoff Area=2,476,033 sf 7.82% Impervious Runoff Depth>1.05"
Flow Length=1,770' Slope=0.0280 '/' Tc=66.8 min CN=50 Runoff=24.15 cfs 4.976 af

Subcatchment NW: Kelsey Northwest Runoff Area=3,957,830 sf 9.20% Impervious Runoff Depth>1.22"
Flow Length=3,520' Slope=0.0250 '/' Tc=113.6 min CN=53 Runoff=34.23 cfs 9.267 af

Subcatchment S: Kelsey South Runoff Area=2,710,195 sf 11.83% Impervious Runoff Depth>1.41"
Flow Length=2,011' Slope=0.0310 '/' Tc=62.0 min CN=55 Runoff=40.31 cfs 7.326 af

Subcatchment W: Kelsey West Runoff Area=3,245,216 sf 8.53% Impervious Runoff Depth>0.39"
Flow Length=4,860' Slope=0.0170 '/' Tc=243.4 min CN=41 Runoff=5.83 cfs 2.403 af

Pond KWN: Kelsey Rd Wetland Peak Elev=103.42' Storage=3,535 cf Inflow=11.09 cfs 6.673 af
96.0" x 60.0" Box Culvert w/ 24.0" inside fill n=0.022 L=27.0' S=0.0074 '/' Outflow=10.86 cfs 6.600 af

Pond KWS: South Wetland Peak Elev=100.74' Storage=82,333 cf Inflow=51.16 cfs 13.925 af
Outflow=36.87 cfs 13.191 af

Pond NEW: Northeast Wetland Peak Elev=107.83' Storage=88,276 cf Inflow=24.15 cfs 4.976 af
Outflow=22.94 cfs 2.949 af

Pond NWW: Northwest Wetland Peak Elev=107.83' Storage=387,476 cf Inflow=47.05 cfs 14.619 af
18.0" Round Culvert w/ 6.0" inside fill n=0.013 L=20.0' S=0.0100 '/' Outflow=9.68 cfs 5.722 af

Total Runoff Area = 298.592 ac Runoff Volume = 24.923 af Average Runoff Depth = 1.00"
90.57% Pervious = 270.427 ac 9.43% Impervious = 28.164 ac

Summary for Subcatchment E: Kelsey East

Runoff = 5.86 cfs @ 12.62 hrs, Volume= 0.952 af, Depth> 0.81"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-yr Rainfall=6.16"

Area (sf)	CN	Description
71,565	98	Paved roads w/curbs & sewers, HSG A
218,025	39	>75% Grass cover, Good, HSG A
12,035	80	>75% Grass cover, Good, HSG D
266,400	30	Woods, Good, HSG A
49,350	77	Woods, Good, HSG D
617,375	46	Weighted Average
545,810		88.41% Pervious Area
71,565		11.59% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
35.1	1,000	0.0500	0.47		**Lag/CN Method,**

Summary for Subcatchment NE: Kelsey Northeast

Runoff = 24.15 cfs @ 13.04 hrs, Volume= 4.976 af, Depth> 1.05"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-yr Rainfall=6.16"

Area (sf)	CN	Description
164,585	98	Paved roads w/curbs & sewers, HSG A
6,800	98	Paved roads w/curbs & sewers, HSG C
22,310	98	Paved roads w/curbs & sewers, HSG D
332,200	39	>75% Grass cover, Good, HSG A
6,925	74	>75% Grass cover, Good, HSG C
1,000,775	30	Woods, Good, HSG A
302,195	70	Woods, Good, HSG C
229,600	77	Woods, Good, HSG D
168,080	30	Brush, Good, HSG A
17,080	65	Brush, Good, HSG C
225,483	73	Brush, Good, HSG D
2,476,033	50	Weighted Average
2,282,338		92.18% Pervious Area
193,695		7.82% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
66.8	1,770	0.0280	0.44		**Lag/CN Method,**

Summary for Subcatchment NW: Kelsey Northwest

Runoff = 34.23 cfs @ 13.73 hrs, Volume= 9.267 af, Depth> 1.22"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-yr Rainfall=6.16"

Area (sf)	CN	Description
318,596	98	Paved roads w/curbs & sewers, HSG A
31,236	98	Paved roads w/curbs & sewers, HSG C
5,635	98	Paved roads w/curbs & sewers, HSG D
654,001	39	>75% Grass cover, Good, HSG A
72,585	74	>75% Grass cover, Good, HSG C
1,462,850	30	Woods, Good, HSG A
302,370	70	Woods, Good, HSG C
141,645	77	Woods, Good, HSG D
41,465	30	Brush, Good, HSG A
918,725	73	Brush, Good, HSG D
8,722	98	Water Surface, HSG A
3,957,830	53	Weighted Average
3,593,641		90.80% Pervious Area
364,189		9.20% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
113.6	3,520	0.0250	0.52		**Lag/CN Method,**

Summary for Subcatchment S: Kelsey South

Runoff = 40.31 cfs @ 12.92 hrs, Volume= 7.326 af, Depth> 1.41"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-yr Rainfall=6.16"

Area (sf)	CN	Description
177,211	98	Paved roads w/curbs & sewers, HSG A
101,330	98	Paved roads w/curbs & sewers, HSG B
42,070	98	Paved roads w/curbs & sewers, HSG D
658,051	39	>75% Grass cover, Good, HSG A
121,615	61	>75% Grass cover, Good, HSG B
72,733	80	>75% Grass cover, Good, HSG D
643,630	30	Woods, Good, HSG A
448,300	58	Woods/grass comb., Good, HSG B
261,065	77	Woods, Good, HSG D
59,340	65	Brush, Good, HSG C
124,850	73	Brush, Good, HSG D
2,710,195	55	Weighted Average
2,389,584		88.17% Pervious Area
320,611		11.83% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
62.0	2,011	0.0310	0.54		**Lag/CN Method,**

Summary for Subcatchment W: Kelsey West

Runoff = 5.83 cfs @ 16.45 hrs, Volume= 2.403 af, Depth> 0.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-yr Rainfall=6.16"

Area (sf)	CN	Description
43,012	98	Water Surface, 0% imp, HSG D
659,675	39	>75% Grass cover, Good, HSG A
271,379	98	Paved parking, HSG A
2,108,890	30	Woods, Good, HSG A
148,535	77	Woods, Good, HSG D
5,400	98	Paved parking, HSG D
8,325	80	>75% Grass cover, Good, HSG D
3,245,216	41	Weighted Average
2,968,437		91.47% Pervious Area
276,779		8.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
243.4	4,860	0.0170	0.33		**Lag/CN Method,**

Summary for Pond KWN: Kelsey Rd Wetland

Inflow Area = 236.374 ac, 8.80% Impervious, Inflow Depth > 0.34" for 25-yr event
Inflow = 11.09 cfs @ 12.71 hrs, Volume= 6.673 af
Outflow = 10.86 cfs @ 12.90 hrs, Volume= 6.600 af, Atten= 2%, Lag= 11.0 min
Primary = 10.86 cfs @ 12.90 hrs, Volume= 6.600 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 103.42' @ 12.90 hrs Surf.Area= 12,376 sf Storage= 3,535 cf

Plug-Flow detention time= 5.2 min calculated for 6.600 af (99% of inflow)
Center-of-Mass det. time= 2.6 min (969.0 - 966.3)

Volume	Invert	Avail.Storage	Storage Description
#1	103.00'	379,756 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
103.00	4,312	0	0
104.00	23,348	13,830	13,830
105.00	34,892	29,120	42,950
106.00	77,130	56,011	98,961
107.00	147,835	112,483	211,444
108.00	188,790	168,313	379,756

Device	Routing	Invert	Outlet Devices
#1	Primary	102.80'	**96.0" W x 60.0" H Box Culvert w/ 24.0" inside fill** L= 27.0' Box, headwall w/3 square edges, Ke= 0.500 Inlet / Outlet Invert= 100.80' / 100.60' S= 0.0074 '/' Cc= 0.900 n= 0.022 Earth, clean & straight, Flow Area= 24.00 sf

Primary OutFlow Max=10.86 cfs @ 12.90 hrs HW=103.42' TW=100.39' (Dynamic Tailwater)
└**1=Culvert** (Barrel Controls 10.86 cfs @ 2.90 fps)

Summary for Pond KWS: South Wetland

Inflow Area = 298.592 ac, 9.43% Impervious, Inflow Depth > 0.56" for 25-yr event
Inflow = 51.16 cfs @ 12.92 hrs, Volume= 13.925 af
Outflow = 36.87 cfs @ 13.47 hrs, Volume= 13.191 af, Atten= 28%, Lag= 32.7 min
Primary = 36.87 cfs @ 13.47 hrs, Volume= 13.191 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 100.74' @ 13.47 hrs Surf.Area= 74,685 sf Storage= 82,333 cf

Plug-Flow detention time= 36.6 min calculated for 13.147 af (94% of inflow)
Center-of-Mass det. time= 21.9 min (938.5 - 916.6)

Volume	Invert	Avail.Storage	Storage Description
#1	99.00'	1,000,195 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
99.00	25,925	0	0
100.00	47,900	36,913	36,913
101.00	84,045	65,973	102,885
102.00	119,200	101,623	204,508
103.00	235,925	177,563	382,070
104.00	302,175	269,050	651,120
105.00	395,975	349,075	1,000,195

Device	Routing	Invert	Outlet Devices
#1	Primary	99.00'	**60.0" W x 72.0" H Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=36.86 cfs @ 13.47 hrs HW=100.74' (Free Discharge)
└**1=Orifice/Grate** (Orifice Controls 36.86 cfs @ 4.24 fps)

Summary for Pond NEW: Northeast Wetland

Inflow Area = 56.842 ac, 7.82% Impervious, Inflow Depth > 1.05" for 25-yr event
Inflow = 24.15 cfs @ 13.04 hrs, Volume= 4.976 af
Outflow = 22.94 cfs @ 12.93 hrs, Volume= 2.949 af, Atten= 5%, Lag= 0.0 min
Primary = 22.94 cfs @ 12.93 hrs, Volume= 2.949 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 107.83' @ 20.00 hrs Surf.Area= 138,616 sf Storage= 88,276 cf

Plug-Flow detention time= 69.8 min calculated for 2.939 af (59% of inflow)
Center-of-Mass det. time= (not calculated: outflow precedes inflow)

Volume	Invert	Avail.Storage	Storage Description
#1	107.00'	739,535 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
107.00	75,200	0	0
108.00	152,000	113,600	113,600
109.00	324,170	238,085	351,685
110.00	451,530	387,850	739,535

Device	Routing	Invert	Outlet Devices
#1	Primary	106.00'	**5.0' long x 10.0' breadth Broad-Crested Rectangular Weir X 2.00** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=23.44 cfs @ 12.93 hrs HW=107.00' TW=106.45' (Dynamic Tailwater)
↑—**1=Broad-Crested Rectangular Weir** (Weir Controls 23.44 cfs @ 2.34 fps)

Summary for Pond NWW: Northwest Wetland

Inflow Area = 222.201 ac, 8.62% Impervious, Inflow Depth > 0.79" for 25-yr event
Inflow = 47.05 cfs @ 13.26 hrs, Volume= 14.619 af
Outflow = 9.68 cfs @ 20.00 hrs, Volume= 5.722 af, Atten= 79%, Lag= 404.4 min
Primary = 9.68 cfs @ 20.00 hrs, Volume= 5.722 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 107.83' @ 20.00 hrs Surf.Area= 554,933 sf Storage= 387,476 cf

Plug-Flow detention time= 179.5 min calculated for 5.722 af (39% of inflow)
Center-of-Mass det. time= 62.2 min (981.8 - 919.7)

Volume	Invert	Avail.Storage	Storage Description
#1	106.00'	2,216,775 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
106.00	75,000	0	0
107.00	132,500	103,750	103,750
108.00	644,250	388,375	492,125
109.00	889,250	766,750	1,258,875
110.00	1,026,550	957,900	2,216,775

Device	Routing	Invert	Outlet Devices
#1	Primary	104.80'	**18.0" Round Culvert w/ 6.0" inside fill** L= 20.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 104.30' / 104.10' S= 0.0100 '/' Cc= 0.900 n= 0.013 Clay tile, Flow Area= 1.25 sf

Primary OutFlow Max=9.68 cfs @ 20.00 hrs HW=107.83' TW=103.40' (Dynamic Tailwater)
↑—**1=Culvert** (Inlet Controls 9.68 cfs @ 7.73 fps)

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points x 2
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment E: Kelsey East Runoff Area=617,375 sf 11.59% Impervious Runoff Depth>2.10"
Flow Length=1,000' Slope=0.0500 '/' Tc=35.1 min CN=46 Runoff=18.52 cfs 2.481 af

Subcatchment NE: Kelsey Northeast Runoff Area=2,476,033 sf 7.82% Impervious Runoff Depth>2.50"
Flow Length=1,770' Slope=0.0280 '/' Tc=66.8 min CN=50 Runoff=64.69 cfs 11.864 af

Subcatchment NW: Kelsey Northwest Runoff Area=3,957,830 sf 9.20% Impervious Runoff Depth>2.77"
Flow Length=3,520' Slope=0.0250 '/' Tc=113.6 min CN=53 Runoff=83.39 cfs 20.981 af

Subcatchment S: Kelsey South Runoff Area=2,710,195 sf 11.83% Impervious Runoff Depth>3.08"
Flow Length=2,011' Slope=0.0310 '/' Tc=62.0 min CN=55 Runoff=93.39 cfs 15.946 af

Subcatchment W: Kelsey West Runoff Area=3,245,216 sf 8.53% Impervious Runoff Depth>1.27"
Flow Length=4,860' Slope=0.0170 '/' Tc=243.4 min CN=41 Runoff=20.13 cfs 7.902 af

Pond KWN: Kelsey Rd Wetland Peak Elev=103.84' Storage=10,423 cf Inflow=25.13 cfs 9.438 af
96.0" x 60.0" Box Culvert w/ 24.0" inside fill n=0.022 L=27.0' S=0.0074 '/' Outflow=23.16 cfs 9.338 af

Pond KWS: South Wetland Peak Elev=101.89' Storage=191,464 cf Inflow=115.74 cfs 25.285 af
Outflow=78.80 cfs 24.315 af

Pond NEW: Northeast Wetland Peak Elev=108.89' Storage=315,905 cf Inflow=64.69 cfs 11.864 af
Outflow=33.33 cfs 4.602 af

Pond NWW: Northwest Wetland Peak Elev=108.89' Storage=1,158,740 cf Inflow=117.32 cfs 33.571 af
18.0" Round Culvert w/ 6.0" inside fill n=0.013 L=20.0' S=0.0100 '/' Outflow=11.50 cfs 6.957 af

Total Runoff Area = 298.592 ac Runoff Volume = 59.174 af Average Runoff Depth = 2.38"
90.57% Pervious = 270.427 ac 9.43% Impervious = 28.164 ac

Summary for Subcatchment E: Kelsey East

Runoff = 18.52 cfs @ 12.55 hrs, Volume= 2.481 af, Depth> 2.10"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-yr Rainfall=8.92"

Area (sf)	CN	Description
71,565	98	Paved roads w/curbs & sewers, HSG A
218,025	39	>75% Grass cover, Good, HSG A
12,035	80	>75% Grass cover, Good, HSG D
266,400	30	Woods, Good, HSG A
49,350	77	Woods, Good, HSG D
617,375	46	Weighted Average
545,810		88.41% Pervious Area
71,565		11.59% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
35.1	1,000	0.0500	0.47		**Lag/CN Method,**

Summary for Subcatchment NE: Kelsey Northeast

Runoff = 64.69 cfs @ 12.98 hrs, Volume= 11.864 af, Depth> 2.50"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-yr Rainfall=8.92"

Area (sf)	CN	Description
164,585	98	Paved roads w/curbs & sewers, HSG A
6,800	98	Paved roads w/curbs & sewers, HSG C
22,310	98	Paved roads w/curbs & sewers, HSG D
332,200	39	>75% Grass cover, Good, HSG A
6,925	74	>75% Grass cover, Good, HSG C
1,000,775	30	Woods, Good, HSG A
302,195	70	Woods, Good, HSG C
229,600	77	Woods, Good, HSG D
168,080	30	Brush, Good, HSG A
17,080	65	Brush, Good, HSG C
225,483	73	Brush, Good, HSG D
2,476,033	50	Weighted Average
2,282,338		92.18% Pervious Area
193,695		7.82% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
66.8	1,770	0.0280	0.44		**Lag/CN Method,**

Summary for Subcatchment NW: Kelsey Northwest

Runoff = 83.39 cfs @ 13.57 hrs, Volume= 20.981 af, Depth> 2.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-yr Rainfall=8.92"

Area (sf)	CN	Description
318,596	98	Paved roads w/curbs & sewers, HSG A
31,236	98	Paved roads w/curbs & sewers, HSG C
5,635	98	Paved roads w/curbs & sewers, HSG D
654,001	39	>75% Grass cover, Good, HSG A
72,585	74	>75% Grass cover, Good, HSG C
1,462,850	30	Woods, Good, HSG A
302,370	70	Woods, Good, HSG C
141,645	77	Woods, Good, HSG D
41,465	30	Brush, Good, HSG A
918,725	73	Brush, Good, HSG D
8,722	98	Water Surface, HSG A
3,957,830	53	Weighted Average
3,593,641		90.80% Pervious Area
364,189		9.20% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
113.6	3,520	0.0250	0.52		**Lag/CN Method,**

Summary for Subcatchment S: Kelsey South

Runoff = 93.39 cfs @ 12.88 hrs, Volume= 15.946 af, Depth> 3.08"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-yr Rainfall=8.92"

Area (sf)	CN	Description
177,211	98	Paved roads w/curbs & sewers, HSG A
101,330	98	Paved roads w/curbs & sewers, HSG B
42,070	98	Paved roads w/curbs & sewers, HSG D
658,051	39	>75% Grass cover, Good, HSG A
121,615	61	>75% Grass cover, Good, HSG B
72,733	80	>75% Grass cover, Good, HSG D
643,630	30	Woods, Good, HSG A
448,300	58	Woods/grass comb., Good, HSG B
261,065	77	Woods, Good, HSG D
59,340	65	Brush, Good, HSG C
124,850	73	Brush, Good, HSG D
2,710,195	55	Weighted Average
2,389,584		88.17% Pervious Area
320,611		11.83% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
62.0	2,011	0.0310	0.54		**Lag/CN Method,**

Summary for Subcatchment W: Kelsey West

Runoff = 20.13 cfs @ 15.93 hrs, Volume= 7.902 af, Depth> 1.27"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-yr Rainfall=8.92"

Area (sf)	CN	Description
43,012	98	Water Surface, 0% imp, HSG D
659,675	39	>75% Grass cover, Good, HSG A
271,379	98	Paved parking, HSG A
2,108,890	30	Woods, Good, HSG A
148,535	77	Woods, Good, HSG D
5,400	98	Paved parking, HSG D
8,325	80	>75% Grass cover, Good, HSG D
3,245,216	41	Weighted Average
2,968,437		91.47% Pervious Area
276,779		8.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
243.4	4,860	0.0170	0.33		**Lag/CN Method,**

Summary for Pond KWN: Kelsey Rd Wetland

Inflow Area = 236.374 ac, 8.80% Impervious, Inflow Depth > 0.48" for 100-yr event
Inflow = 25.13 cfs @ 12.58 hrs, Volume= 9.438 af
Outflow = 23.16 cfs @ 12.74 hrs, Volume= 9.338 af, Atten= 8%, Lag= 9.8 min
Primary = 23.16 cfs @ 12.74 hrs, Volume= 9.338 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 103.84' @ 12.74 hrs Surf.Area= 20,381 sf Storage= 10,423 cf

Plug-Flow detention time= 6.0 min calculated for 9.338 af (99% of inflow)
Center-of-Mass det. time= 3.3 min (943.8 - 940.5)

Volume	Invert	Avail.Storage	Storage Description
#1	103.00'	379,756 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
103.00	4,312	0	0
104.00	23,348	13,830	13,830
105.00	34,892	29,120	42,950
106.00	77,130	56,011	98,961
107.00	147,835	112,483	211,444
108.00	188,790	168,313	379,756

Device	Routing	Invert	Outlet Devices
#1	Primary	102.80'	**96.0" W x 60.0" H Box Culvert w/ 24.0" inside fill** L= 27.0' Box, headwall w/3 square edges, Ke= 0.500 Inlet / Outlet Invert= 100.80' / 100.60' S= 0.0074 '/' Cc= 0.900 n= 0.022 Earth, clean & straight, Flow Area= 24.00 sf

Primary OutFlow Max=23.14 cfs @ 12.74 hrs HW=103.84' TW=101.13' (Dynamic Tailwater)
└**1=Culvert** (Barrel Controls 23.14 cfs @ 3.70 fps)

Summary for Pond KWS: South Wetland

Inflow Area = 298.592 ac, 9.43% Impervious, Inflow Depth > 1.02" for 100-yr event
Inflow = 115.74 cfs @ 12.86 hrs, Volume= 25.285 af
Outflow = 78.80 cfs @ 13.38 hrs, Volume= 24.315 af, Atten= 32%, Lag= 30.7 min
Primary = 78.80 cfs @ 13.38 hrs, Volume= 24.315 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 101.89' @ 13.38 hrs Surf.Area= 115,289 sf Storage= 191,464 cf

Plug-Flow detention time= 37.7 min calculated for 24.235 af (96% of inflow)
Center-of-Mass det. time= 25.9 min (912.6 - 886.6)

Volume	Invert	Avail.Storage	Storage Description
#1	99.00'	1,000,195 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
99.00	25,925	0	0
100.00	47,900	36,913	36,913
101.00	84,045	65,973	102,885
102.00	119,200	101,623	204,508
103.00	235,925	177,563	382,070
104.00	302,175	269,050	651,120
105.00	395,975	349,075	1,000,195

Device	Routing	Invert	Outlet Devices
#1	Primary	99.00'	**60.0" W x 72.0" H Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=78.77 cfs @ 13.38 hrs HW=101.89' (Free Discharge)
└**1=Orifice/Grate** (Orifice Controls 78.77 cfs @ 5.46 fps)

Summary for Pond NEW: Northeast Wetland

Inflow Area = 56.842 ac, 7.82% Impervious, Inflow Depth > 2.50" for 100-yr event
Inflow = 64.69 cfs @ 12.98 hrs, Volume= 11.864 af
Outflow = 33.33 cfs @ 13.21 hrs, Volume= 4.602 af, Atten= 48%, Lag= 14.2 min
Primary = 33.33 cfs @ 13.21 hrs, Volume= 4.688 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 108.89' @ 20.00 hrs Surf.Area= 304,574 sf Storage= 315,905 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= (not calculated: outflow precedes inflow)

Volume	Invert	Avail.Storage	Storage Description
#1	107.00'	739,535 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
107.00	75,200	0	0
108.00	152,000	113,600	113,600
109.00	324,170	238,085	351,685
110.00	451,530	387,850	739,535

Device	Routing	Invert	Outlet Devices
#1	Primary	106.00'	**5.0' long x 10.0' breadth Broad-Crested Rectangular Weir X 2.00** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=33.34 cfs @ 13.21 hrs HW=107.71' TW=107.43' (Dynamic Tailwater)
↑—**1=Broad-Crested Rectangular Weir** (Weir Controls 33.34 cfs @ 1.95 fps)

Summary for Pond NWW: Northwest Wetland

Inflow Area = 222.201 ac, 8.62% Impervious, Inflow Depth > 1.81" for 100-yr event
Inflow = 117.32 cfs @ 13.49 hrs, Volume= 33.571 af
Outflow = 11.50 cfs @ 20.00 hrs, Volume= 6.957 af, Atten= 90%, Lag= 390.6 min
Primary = 11.50 cfs @ 20.00 hrs, Volume= 6.957 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 108.89' @ 20.00 hrs Surf.Area= 861,220 sf Storage= 1,158,740 cf

Plug-Flow detention time= 200.1 min calculated for 6.934 af (21% of inflow)
Center-of-Mass det. time= 67.1 min (973.2 - 906.1)

Volume	Invert	Avail.Storage	Storage Description
#1	106.00'	2,216,775 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
106.00	75,000	0	0
107.00	132,500	103,750	103,750
108.00	644,250	388,375	492,125
109.00	889,250	766,750	1,258,875
110.00	1,026,550	957,900	2,216,775

Device	Routing	Invert	Outlet Devices
#1	Primary	104.80'	**18.0" Round Culvert w/ 6.0" inside fill** L= 20.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 104.30' / 104.10' S= 0.0100 '/' Cc= 0.900 n= 0.013 Clay tile, Flow Area= 1.25 sf

Primary OutFlow Max=11.50 cfs @ 20.00 hrs HW=108.89' TW=103.49' (Dynamic Tailwater)
↑—**1=Culvert** (Inlet Controls 11.50 cfs @ 9.19 fps)

Control of Water Specification

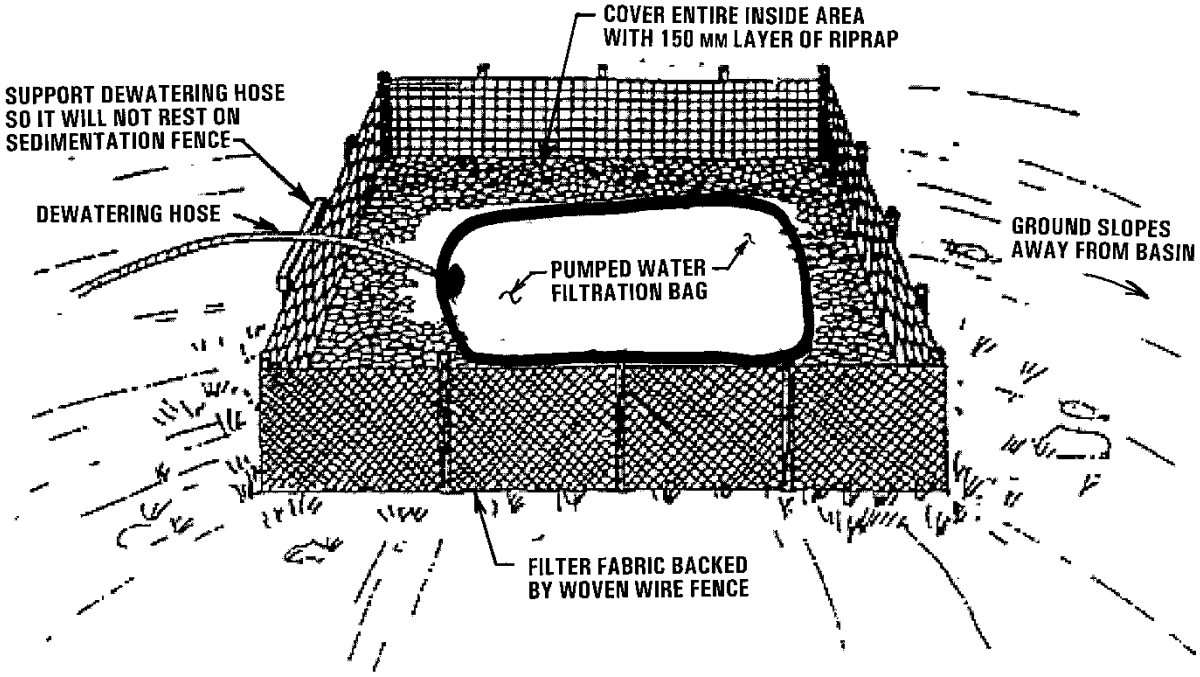
CONTROL OF WATER

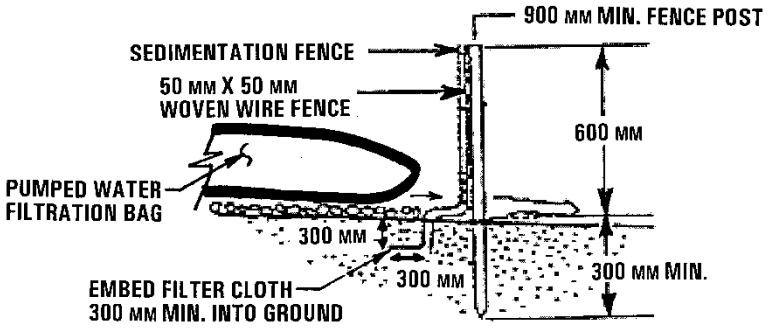
The Contractor shall provide an effective procedure together with all labor, materials and equipment necessary for dewatering any area required to complete construction of the structure in the dry, including installation of riprap, sedimentation fence, woven wire fence and pumped water filtration bag as indicated on the following Dewatering Settling Basin Detail.

Control of water shall include treatment to remove sedimentation and potential water contaminates in a manner which complies with the water quality requirements of the Massachusetts Department of Environmental Protection (MA DEP), the U.S. Army Corps of Engineers (ACOE) and the U.S. Environmental Protection Agency (EPA). All necessary permitting, documents and fees required for all dewatering work shall be the responsibility of the contractor and shall be included in the cost of this item. **Direct discharge from the settling basin into the brook shall not be permitted.**

Pumping effluent shall be discharged into an approved pumped water filtration bag surrounded by hay bales and silt fence as indicated on the following detail. The location for the dewatering settling basin shall be determined in the field based upon site conditions where needed and shall be approximately where shown on plans and shall be approved by the Engineer. The dewatering bag basin shall be placed on stabilized and reasonably level ground to prevent water from spilling over the sides.

Water pumps and hoses used shall be in good working condition and of adequate power and size to handle the dewatering operation(s). Before installing the dewatering settling basin, all other erosion control measures shall be installed. Dewatering settling basin operations shall be maintained in working condition including periodic removal of accumulated sediment within the basin or changing the dewatering bag as necessary. Additional erosion control measures shall be employed as required by the Engineer to prevent erosion and sedimentation of the streambed.





DEWATERING SETTLING BASIN DETAIL

NOT TO SCALE

Stormwater Checklist

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.[1] 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 8[2]
- 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.

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

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

Signature and Date 6/28/10

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)

LID Measures: Stormwater Standards require LID measures to be considered. Document what environmentally sensitive design and LID Techniques were considered during the planning and design of the project:

- ☐ No disturbance to any Wetland Resource Areas
- ☐ Site Design Practices (e.g. clustered development, reduced frontage setbacks)
- ☐ 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
- ☐ Grass Channel
- ☐ Green Roof
- ☐ Other (describe): _____

Standard 1: No New Untreated Discharges

- ☒ 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 Field[1]

☐ Runoff from all impervious areas at the site discharging to the infiltration BMP.

☐ Runoff from all impervious areas at the site is *not* 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 *only* 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

Checklist (continued)

Standard 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.

Standard 4: Water Quality

The 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 for Stormwater Report

Checklist (continued)

Standard 4: Water Quality (continued)

☐ 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.

Standard 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 ***prior to*** the discharge of stormwater to the post-construction stormwater BMPs.

☐ The NPDES Multi-Sector General Permit does ***not*** 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 ***not*** 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.

Standard 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.

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 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 and structural BMP requirements of Standards 4-6 to the maximum extent practicable and (b) improves existing conditions.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control

A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan must include the following information:

- 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;
- 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.

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

☒ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;

☒ An Illicit Discharge Compliance Statement is attached;

☐ NO Illicit Discharge Compliance Statement is attached but will be submitted ***prior to*** the discharge of any stormwater to post-construction BMPs.

Operation and Maintenance

OPERATION AND MAINTENANCE AND
POLLUTION PREVENTION PLAN

Construction Operations

The operation and maintenance plan for construction operations outlines the installation, inspection, cleaning, and upkeep necessary to keep the siltation and erosion control system in good repair and operating efficiently. It is a critical component to the success of the stormwater best management practices designed for construction work on the site. Construction erosion controls minimize the potential for sedimentation in downstream gradient resource areas and abutting properties.

Construction erosion controls cover a wide range of practices, including stabilizing the construction entrance roadway, installing hay bales and silt fences, and controlling erosion at catch basins. The guiding principle for construction erosion control for this development is to minimize the volume of runoff and to minimize contact of stormwater with potential pollutants. Accepted construction management practices can reduce these stormwater pollutant loads and quantities.

The following construction best management practices (BMPs) for sediment and erosion control are included in this operation and maintenance plan.

1. Install compost filter tubes as shown on the plans and as required in the field to prevent sediment from leaving the limits of work.
2. Material stockpiles shall be stabilized with erosion control matting or temporary seeding whenever necessary.
3. Inspect and maintain BMPs at least weekly and after every major rainfall event.
4. Erosion control measures shall be maintained, repaired or replaced as required or at the direction of the Department of Public Works Director.
5. During periodic inspections, if sediment is found to be exiting the site, measures shall be taken to ensure sediment does not reach the resource areas.
6. The contractor shall comply with the General and Erosion Control Notes show on the plans and in the contract documents.
7. Measures shall be taken to control dust during construction.
8. Stabilize unvegetated areas, particularly slopes, which may be prone to erosion by using matting or an erosion control seed mixture.
9. Sediment shall be removed from barriers periodically. Silt fence, hay bales and/or filter tubes shall not be used as *de facto* retaining walls.
10. Remove and properly dispose of hay bales, silt fencing, and accumulated sediment following construction operations.

Developed Facilities

The Town of Boxford will assume responsibility for the maintenance and upkeep of the culvert location in accordance with their planned maintenance and inspection schedule. The operation and maintenance plan outlines the regular inspection and cleaning schedule necessary to keep the area in good repair and operating efficiently, and is a critical component of the success of the stormwater runoff erosion control for the proposed development.

Source controls reduce the types and concentrations of contaminants in stormwater runoff, which, in turn, improve water quality. Source controls cover a wide range of practices, including local bylaws and regulations, fertilizer management in residential areas, reduced road salting in winter, erosion and sediment controls at construction sites, and comprehensive snow management. The guiding principle for pollution prevention and control is to minimize the volume of runoff and to minimize contact of stormwater with potential pollutants.

Source Control

Sweeping

Street sweeping are an effective source control, and are implemented on an annual basis. Sweeping efforts are performed during the period immediately following winter snowmelt, when road sand and other accumulated sediment are washed off.

Snow and Snow Melt Management

Proper management of snow and snow melt, snow removal and storage, use of deicing compounds, and other practices can minimize major runoff and pollutant loading impacts. Use of alternative deicing compounds, such as calcium chloride and calcium magnesium acetate, can be investigated to further reduce the pollutant loading impacts. Groundcover shall be evaluated at least twice per year and reseeded if necessary.

Vegetation Management

Proper management of roadway side slope vegetation is critical to ensuring the longevity of the roadway and to prevent erosion from developing in the vicinity of resource areas. Vegetated areas shall be inspected annually at a minimum. Areas found to be unstable shall be reseeded with a salt tolerant grass mix (for upland areas), or other seed mix appropriate for the soil structure and location.

Photos

Photo No. 1 – Downstream culvert end

Photo No. 2 – Typical downstream channel

Photo No. 3 – Typical downstream channel

Photo No. 4 – Kelsey Road Looking north

Photo No. 5 – Kelsey Road looking south

Photo No. 6 – Downstream railroad crossing – hydraulic outlet of south wetland (1,200 feet south of Kelsey Rd culvert)

Photo No. 6 – Downstream railroad crossing (1,200 feet north of Lowe Pond)

Photo No. 7 – Trap rock weir in railroad roadbed between northeast and northwest wetland (3,500 feet upstream of Kelsey Rd. culvert)

Photo No. 8 – 18" RCP pipe between northwest wetland and Kelsey Road wetland (1,200 feet upstream of Kelsey Rd. culvert under railroad roadbed)