787-14

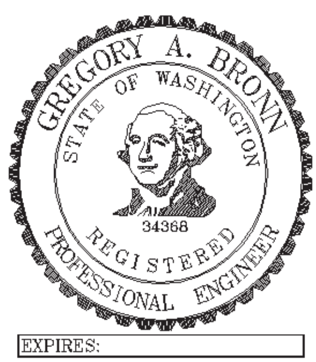
Rosario Hilltop Housing / Maintenance
TPN 173043001

Stormwater Site Plan (SSP)

3231 Olga Road
Orcas Island, WA

October 2015

Rosario Signal LLC
c/o Nels Strandberg
PO Box 319
Anacortes, WA 98221



HART PACIFIC ENGINEERING
PO Box 3287, Friday Harbor, WA 98250 Ph. 360-378-7048
PO Box 124, Eastsound, WA 98245 Ph. 360-376-3996

HART PACIFIC ENGINEERING
P.O. Box 3287, Friday Harbor, WA 98250 Ph. 360-378-7048
P.O. Box 124, Eastsound, WA 98245 Ph. 360-376-3996

Stormwater Site Plan
Rosario Hilltop Housing / Maintenance

The Stormwater Site Plan presented in this report conforms to the requirements of the Washington State Dept. of Ecology's *Stormwater Management Manual for the Puget Sound Basin*, (SWMM February 2005). The plan includes a description of existing and proposed land use conditions, an analysis of downstream impacts due to development, and a drainage plan for the subject property. The structure of this report is based on the required elements for Stormwater Site Plans that are outlined in SWMM Volume I, Chapter 3, page 3-1.

The Unified Development Code for San Juan County (UDC), which outlines the storm drainage standards for the County, incorporates the *Stormwater Management Manual for the Puget Sound Basin*, (Washington State Dept. of Ecology, Feb, 1992) by reference in Section 6.7. The successor manuals to this manual were published in August 2001 and February 2005 (SWMM) and are now authorized for use in the county. The SWMM was used to determine standards for the design and implementation of best management practices (BMPs) for stormwater control and treatment at this site.

According to San Juan County Community Development and Planning Department policy 09-002 issued 11/18/2009 the thresholds for determining which minimum requirements apply to the project will be based on the additions of impervious surfaces and the area of land disturbed *in the previous 2 years together with the proposed development*. Existing impervious surfaces and land disturbed at an earlier date will not be added to the proposed to determine which requirements apply.

The plans presented herein have been based on proposed development plans provided by the property owner and are shown on the accompanying drawings. This plan is being submitted for approval. If final development of the property differs in any significant way from the scheme presented here, the drainage plan should be reevaluated by a qualified professional and revised accordingly.

1. Project Overview

The general vicinity of the property is shown on Figure 1. The property consists of approximately 39.9 acre of property located on the east side of Orcas Island about 5 miles east of the Eastsound Village. Access is off of Olga County Road and Vusario Private Road. An aerial photograph from the Assessor's website showing the existing condition and the topography of the site is shown on Figure 2. Under the proposed plan a laundry building, maintenance building, two dorm buildings, a dining building and five cottages with water tank will be constructed in the locations shown on the Development Plan, Figure 3.5 and 3.6. Parking areas will be provided for the buildings as well as a lower parking area to serve the Rosario Resort property with a shuttle. A tabulation of impervious surfaces and converted areas created under this project is provided in the table below. The areas listed for each unit include roofs, decks, walkways and all impervious surfaces associated with the planned unit development.

The site includes three drainage basins which flow into directly into Cascade Lake. The project will include an estimated 2' cut to create each building site, and imported gravel will be need for structural fills, utility work and road building. We have done a preliminary estimate of the earthwork for this project and expect a total of 3400 cy of stripping and haul away, 5100 cy of onsite cuts and fills and 7000 cy of imported gravels. The local gravel pit will be the source for haul-away and imported gravels. The project is currently planned for construction in 2016 through 2018. Existing contours have been provided for the building sites, and preliminary finish grades established for buildings and roads, but a formal grading plan with proposed contours has not be prepared at this time. The clearing limits provide maximum limits of grading work.

A summary of impervious surfaces and converted areas created under this project is provided in the table below.

Table 1 – New and Converted Surfaces After Development

Converted Surface	All Basins
Gravel road and parking areas (PGIS)	88996 sf
Roof Areas†	26270 sf
Decks, patios, and sidewalks	14070 sf
Total Impervious Surface	129336 sf
Total clearing and grading area – max. limits	4.91 AC
Forest converted to lawn & landscaping (PGPS)	20000 sf

† Horizontal projection

Rosario Hilltop Housing / Maintenance SSP
10/19/15, Page 3

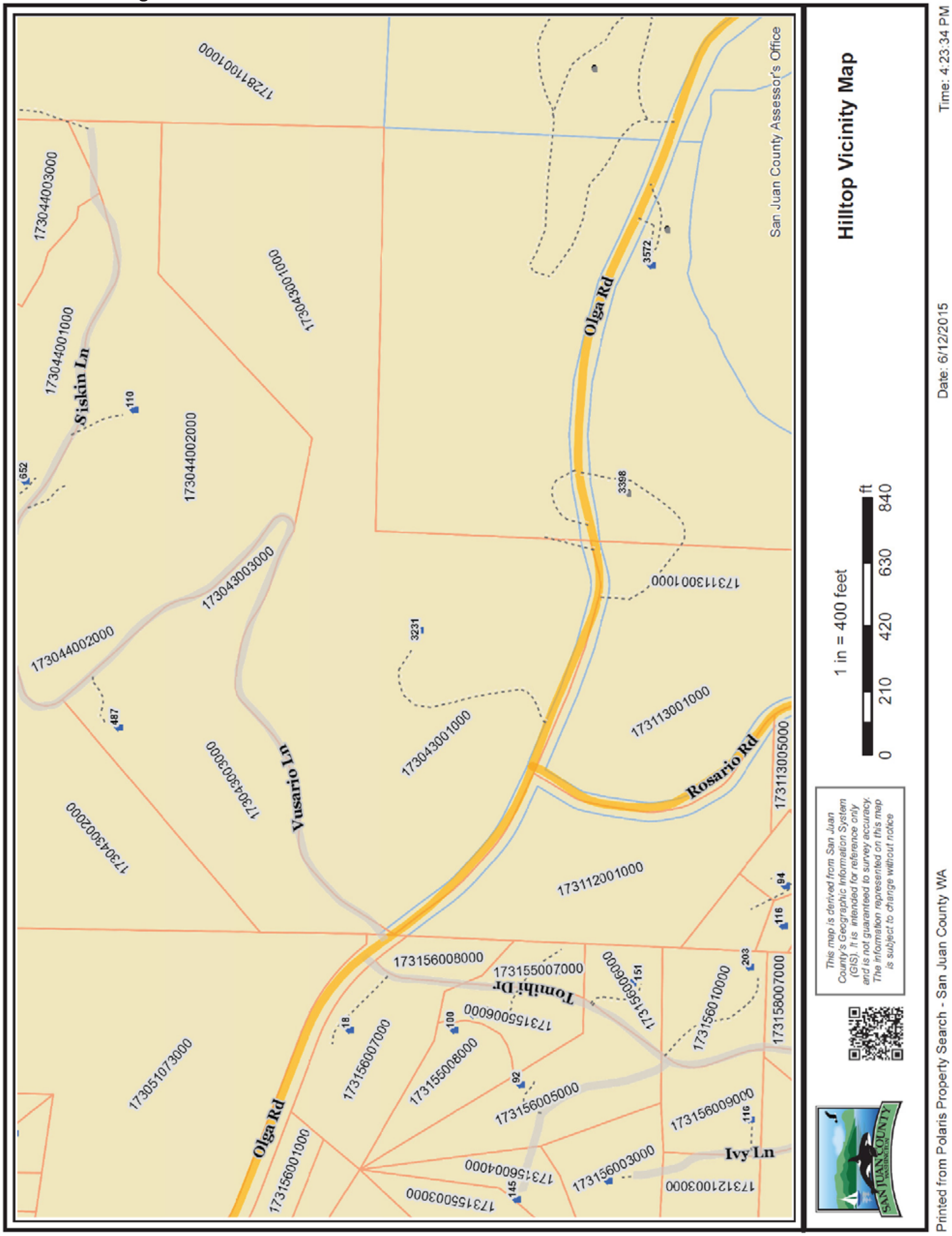
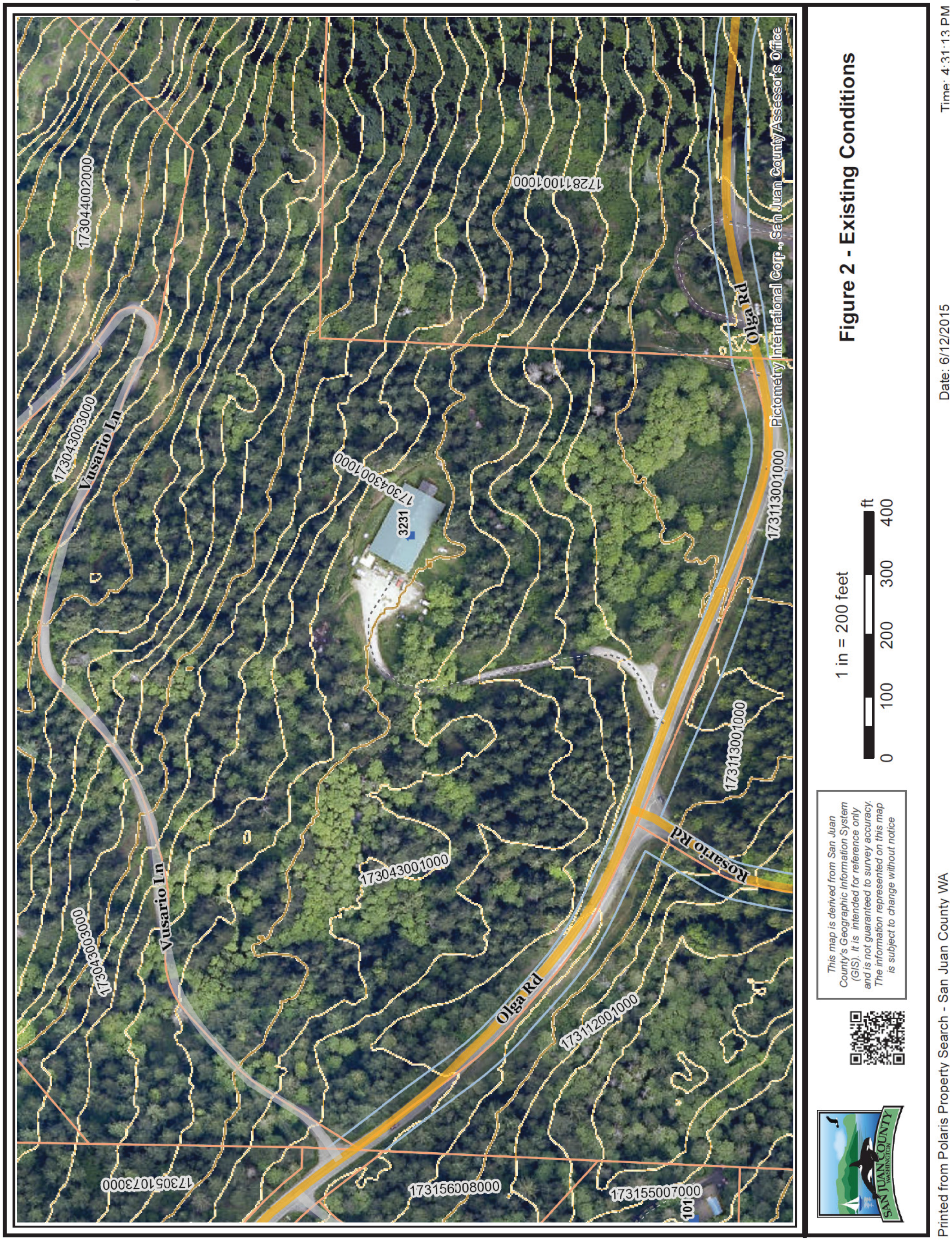


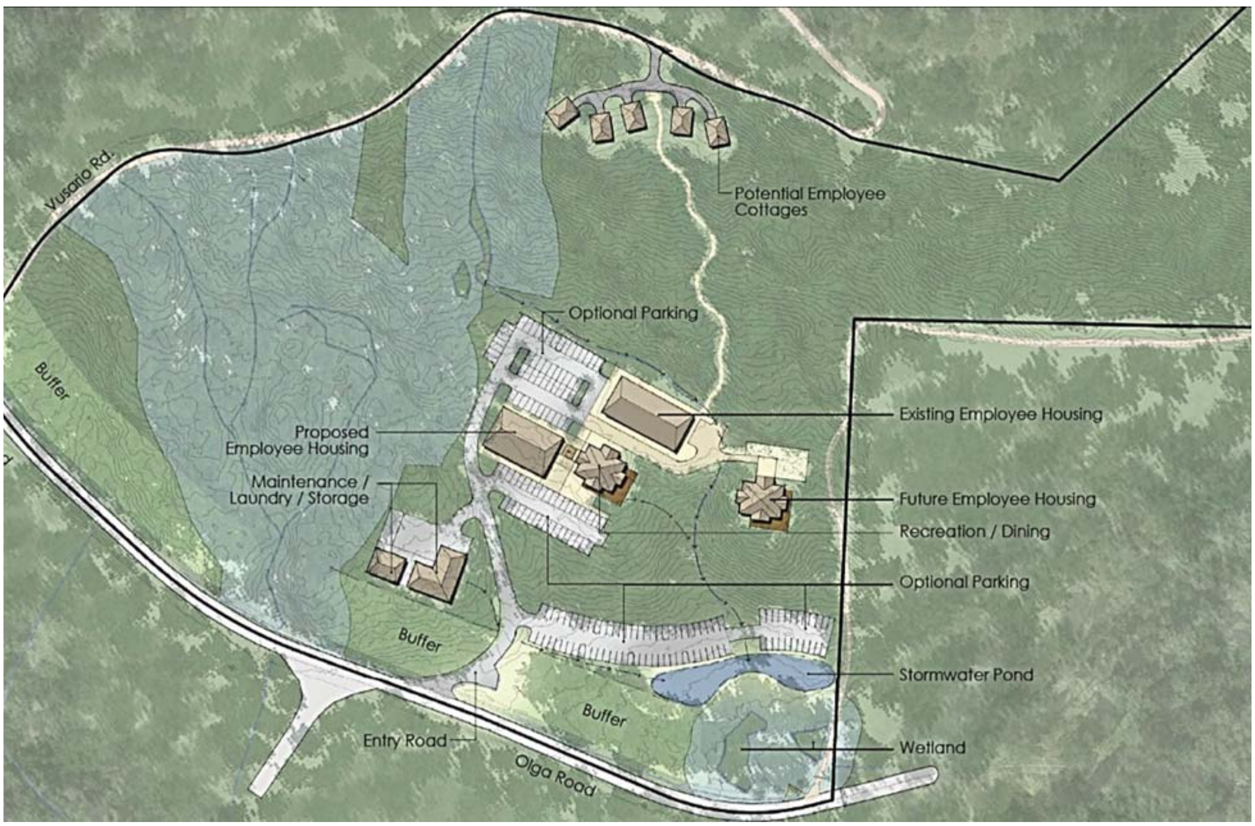
Figure 1 – Vicinity Map, 3231 Olga Rd.

Rosario Hilltop Housing / Maintenance SSP
10/19/15, Page 4



Rosario Hilltop Housing / Maintenance SSP
10/19/15, Page 5
2. Existing Conditions Summary

The existing condition of the property is shown on Figure 2 above. The site includes three major drainage basins which flow indirectly into Cascade Lake. The site has been developed with a 20 room employee dorm housing building to serve Rosario Resort over the last 50 years. The site is mostly all wooded but has been previously disturbed and cleared to provide a road and parking area for the housing dorm. The site is generally rocky with shallow soils, but some deeper soils are expected in the wetland and pasture area, near the low point of the property. The site is fairly steep with most slopes in the 10% – 50% range. There are delineated streams and wetlands with protective buffers on the property as shown in the Development Plan below.



GCH – Development Plan (insert 11x17)

Rosario Hilltop Housing / Maintenance SSP

10/19/15, Page 6

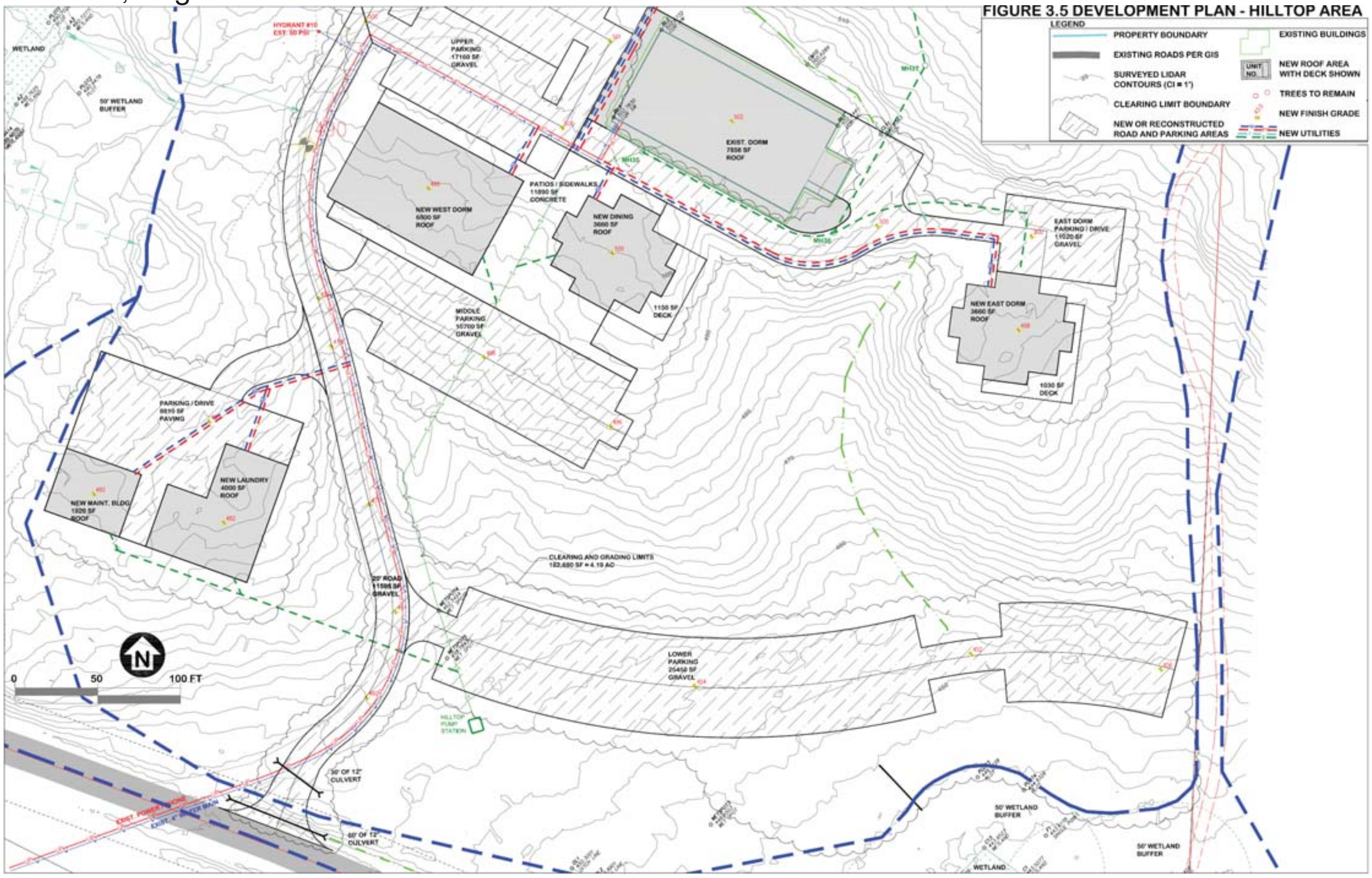


Figure 3.5 – Development Plan (insert 11x17)

Rosario Hilltop Housing / Maintenance SSP

10/19/15, Page 7

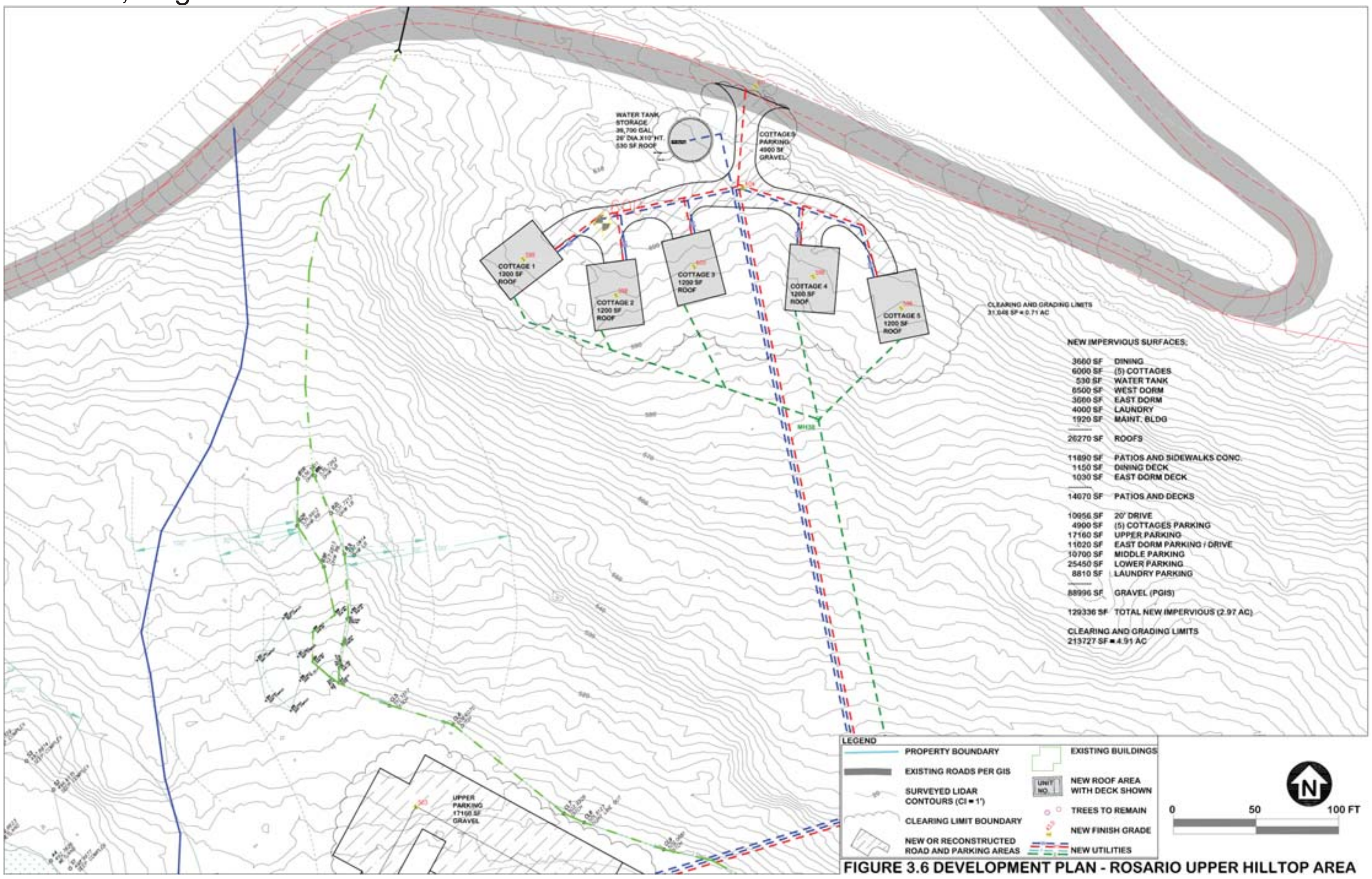


Figure 3.6 – Development Plan (insert 11x17)

Rosario Hilltop Housing / Maintenance SSP
10/19/15, Page 8

Site Soil Characteristics

Figure 4 presents a map of the soil types in the vicinity of the project site. The soils covering the property are classified by the SCS Soils Survey of San Juan County as Rock Land and Pickett Rock Outcrop soils. The types mapped by the SCS for the property include PrD (Pickett Rock Outcrop, 0 to 30% slopes) and PrE (Pickett Rock Outcrop, 30 to 70% slopes). According to the SCS the Pickett series soils belong to hydrologic group C. This soil is generally not well suited for infiltration and does exhibit a high rate of runoff and potential for erosion due to thin soil layers over rock.

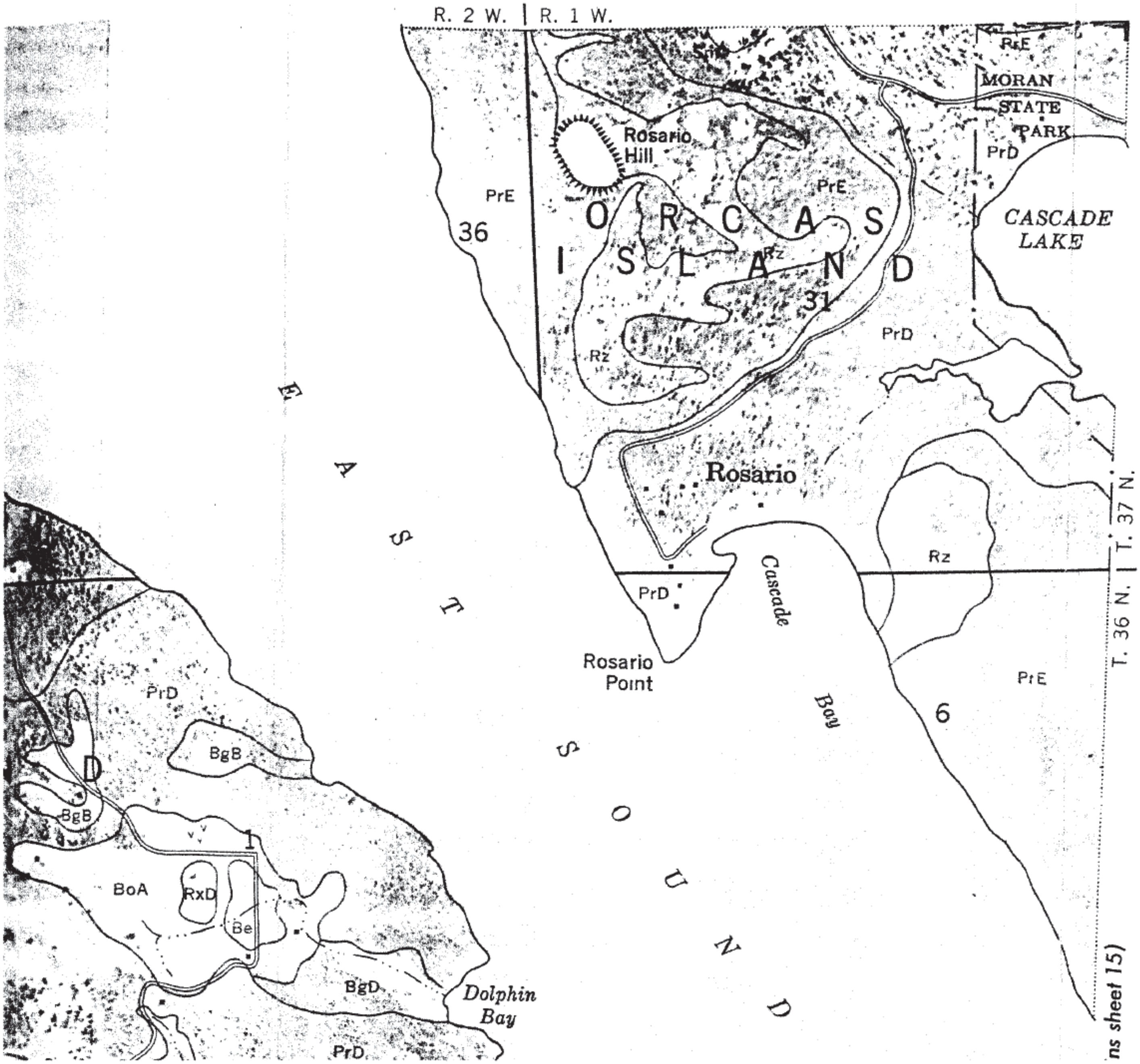


Figure 4 – Soils Map

3. Offsite Analysis Report

Figure 5 provides a drainage basin map for the project area. The map which is based on the USGS 7.5 minute series shows the general stormwater drainage routes in the vicinity of the site, contour interval is 5'. As shown in the Proposed Development Figures 3.5 and 3.6 surface runoff from the property includes multiple discharge points located in several basins. Each of these basins can be considered to represent a separate threshold discharge area since each provides a different flowpath from the development site which does not join within ¼ mile of the site with any other prior to discharge into the receiving waters of the state (per the SWMM definition for separate threshold discharge areas). The upstream and downstream flowpaths are characterized below;

Basin H1:

Refer to Figure 5 for the boundary of Basin H1 which is estimated at 71 acres. Flow from the upper portion of the basin originates at the Vusario Road ridge and most of the flow bypasses the developed area of the site due to a ditch in the Vusario Road switchback that diverts it to the east. The lower 16.6 acres of the basin is designated as H1A (Pond Basin) and flows into an existing wetland at the lowest corner of the site. The Pond Basin crosses the Hilltop property via a 12" culvert crossing Vusario Road. This flow enters the site in a stream course that travels south and then east around the existing Hilltop housing building and then continues south into an existing wetland area at the southeast corner of the site. Flow from this Pond Basin will be routed through the new combined stormwater treatment and detention pond, which is proposed adjacent to the existing wetland. Rozewood Environmental has evaluated and delineated the streams and wetland areas in the basin in a separate report, and those surveyed locations and buffers are shown in this stormwater site plan. The combined 71 acres flow from Basin H1 crosses under a Park Loop Road with a 12" culvert and then also under Olga Road with a 12" culvert. Both culverts appeared to be in good condition in my April 2015 site visit, with no signs of erosion or flooding. The flow continues south and east through wooded areas of Moran State Park before entering Cascade Lake in a small intermittent stream. Downstream flow is 0.12 miles down to Cascade Lake. The outflow of Cascade Lake is down Bowman's Creek about 0.25 mile to Cascade Bay.

Rosario Hilltop Housing / Maintenance SSP
10/19/15, Page 10

Ditch at Moran State Park entrance, at lowest part of the site.

12” culvert at Park Loop Road

12” culvert at Olga Road.

Basin H2:

Refer to Figure 5 for the boundary of Basin H2 which is estimated at 22.6 acres. Flow from this basin originates north, above the site and is concentrated by the Vusario Road ditch and crosses onto the site with two 12” culverts. There are two stream courses through the site that were located by Rosewood Environmental, and the appropriate buffers and setback established. There are no proposed development improvements in this basin. The flow crosses under Olga road with a 12” culvert and then combines with the outflow stream from Otter’s Pond, and the stream from Basin H3, flowing east. There is a 24” culvert at Rosario Road and continues east about .25 mile to Cascade Lake and then out to Cascade Bay via. Bowman’s Creek.

12” culvert at Olga Road for Basin H2

Basin H3:

Refer to Figure 5 for the boundary of Basin H3 which is estimated at 7.2 acres. Flow from this basin on the site is limited to the area near the entrance to Vusario Road. There are no now improvements planned in this basin. The flow crosses under Olga road with a 12” culvert and then combines with the outflow stream from Otter’s Pond, and the stream from Basin H2, flowing east. There is a 24” culvert at Rosario Road and continues east about .25 mile to Cascade Lake and then out to Cascade Bay via. Bowman’s Creek.

Rosario Hilltop Housing / Maintenance SSP
10/19/15, Page 13

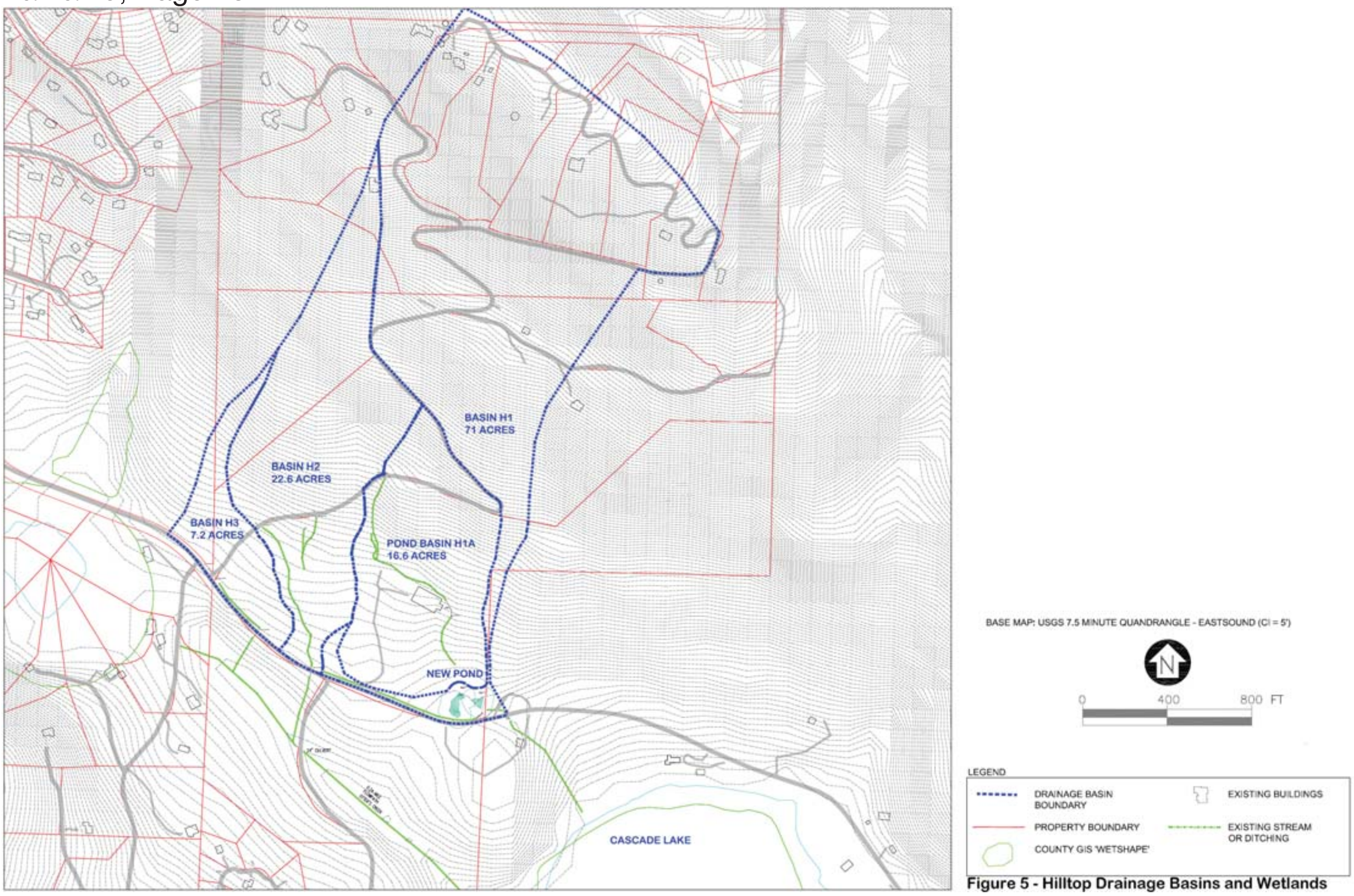


Figure 5 – Basins and Wetlands (insert 11x17)

4. Applicable Minimum Requirements

The SWMM sets out the minimum requirements for all new development and redevelopment projects depending on the size of the project. The thresholds are as follows:

1. Projects proposing less than 2000 square feet of new plus replaced impervious surface must meet SWMM requirement #2.
2. Projects proposing more than 2000 sf but less than 5000 sf or have land disturbing activity of 7000 sf or greater are required to meet SWMM requirements #1 through #5.
3. Projects proposing 5000 sf or more of new impervious surface, converts ¾ acres, or more, of native vegetation to lawn or landscaped areas, or converts 2.5 acres, or more, of native vegetation to pasture are required to meet SWMM requirements #1 through #10.

The development planned for this property is shown in Figure 3. The total area converted to landscaping and impervious surfaces for this project are tallied in Table 1. The plan for this property includes 129,336 sf of new or replaced impervious surface. The level of development planned for this site falls into the threshold limits specified under category 3 above. Therefore, the development must comply with SWMM requirements #1 through #10. The SWMM requirements for this site are evaluated and summarized below.

Minimum Requirement #1: Preparation of Stormwater Site Plans

This drainage plan shall satisfy the requirement for a stormwater site plan. This report is intended to satisfy that requirement and has been prepared in accordance with Chapter 3 of the SWMM.

Minimum Requirement #2: Construction Stormwater Pollution Prevention Plan (SWPPP)

This is a requirement for implementing erosion and sediment control measures during construction. Hart Pacific Engineering has yet to prepare a SWPPP for this project, since this is expected to be constructed in phases. We expect a SWPPP will be prepared and submitted for approval for each building phase.

Minimum Requirement #3: Source Control of Pollution

This is a requirement to provide controls to prevent stormwater from coming into contact with pollutants. The site development includes the construction of a laundry building and maintenance building for storing about five trucks, two small boats or docks, and a backhoe which will improve the separation of potential pollutants from the runoff. The BMPs for Parking and Storage of Vehicles and Equipment high-use sites are defined on page 2-48 Volume IV shown below. These BMPs do not apply in this case since our site is not high-use. Vehicles and equipment are not proposed to be washed, maintained or repaired at this site. All storage of chemicals, fertilizers, oils, paints etc. shall be contained inside of the buildings and prevented from coming into contact with surface flows. The dorm buildings are residential and normally do not require source control measures. Occupants are not allowed to maintain or repair vehicles on the property.

BMPs for Parking and Storage of Vehicles and Equipment

Description of Pollutant Sources: Public and commercial parking lots such as retail store, fleet vehicle (including rent-a-car lots and car dealerships), equipment sale and rental parking lots, and parking lot driveways, can be sources of toxic hydrocarbons and other organic compounds, oils and greases, metals, and suspended solids caused by the parked vehicles.

Pollutant Control Approach: If the parking lot is a **high-use site** as defined below, provide appropriate oil removal equipment for the contaminated stormwater runoff.

Applicable Operational BMPs:

- If washing of a parking lot is conducted, discharge the washwater to a sanitary sewer, if allowed by the local sewer authority, or other approved wastewater treatment system, or collect it for off-site disposal.
- Do not hose down the area to a storm drain or to a receiving water. Sweep parking lots, storage areas, and driveways, regularly to collect dirt, waste, and debris.

Applicable Treatment BMPs: An oil removal system such as an API or CP oil and water separator, catch basin filter, or equivalent BMP, approved by the local jurisdiction, is applicable for parking lots meeting the threshold vehicle traffic intensity level of a *high-use site.*

Vehicle High-Use Sites

Establishments subject to a vehicle high-use intensity have been determined to be significant sources of oil contamination of stormwater. Examples of potential high use areas include customer parking lots at fast food stores, grocery stores, taverns, restaurants, large shopping malls, discount warehouse stores, quick-lube shops, and banks. If the PGIS for a high-use site exceeds 5,000 square feet in a threshold discharge area, and oil control BMP from the Oil Control Menu is necessary. A high-use site at a commercial or industrial establishment has one of the following characteristics: (Gaus/King County, 1994)

- Is subject to an expected average daily vehicle traffic (ADT) count equal to or greater than 100 vehicles per 1,000 square feet of gross building area: or
- Is subject to storage of a fleet of 25 or more diesel vehicles that are over 10 tons gross weight (trucks, buses, trains, heavy equipment, etc.).

OPALCO SHOP

or "phosphorus" treatment requirements apply to the project. Those decisions are made in the steps below.

Step 2: Determine if an Oil Control Facility/Device is Required

The use of oil control devices and facilities is dependent upon the specific land use proposed for development.

The Oil Control Menu (Volume V, Section 3.2) applies to projects that have "high-use sites." High-use sites are those that typically generate high concentrations of oil due to high traffic turnover or the frequent transfer of oil. High-use sites include:

- NO An area of a commercial or industrial site subject to an expected average daily traffic (ADT) count equal to or greater than 100 vehicles per 1,000 square feet of gross building area;
- NO An area of a commercial or industrial site subject to petroleum storage and transfer in excess of 1,500 gallons per year, not including routinely delivered heating oil;
- NO An area of a commercial or industrial site subject to parking, storage or maintenance of 25 or more vehicles that are over 10 tons gross weight (trucks, buses, trains, heavy equipment, etc.);
- NO A road intersection with a measured ADT count of 25,000 vehicles or more on the main roadway and 15,000 vehicles or more on any intersecting roadway, excluding projects proposing primarily pedestrian or bicycle use improvements.

Note: The traffic count can be estimated using information from "Trip Generation," published by the Institute of Transportation Engineers, or from a traffic study prepared by a professional engineer or transportation specialist with experience in traffic estimation.

Please refer to the Oil Control Menu for a listing of oil control facility options. Then see Chapter 11 of Volume V for guidance on the proper selection of options and design details.

Note that some land use types require the use of a spill control (SC-type) oil/water separator. Those situations are described in Volume IV and are separate from this treatment requirement. While a number of activities may be required to use spill control (SC-type) separators, only a few will necessitate American Petroleum Institute (API) or coalescing plate (CP)-type separators for treatment. The following urban land uses are likely to have areas that fall within the definition of "high-use sites" or have sufficient quantities of free oil present that can be treated by an API or CP-type oil/water separator.

Rosario Hilltop Housing / Maintenance SSP
10/19/15, Page 18

OPALCO SHOP

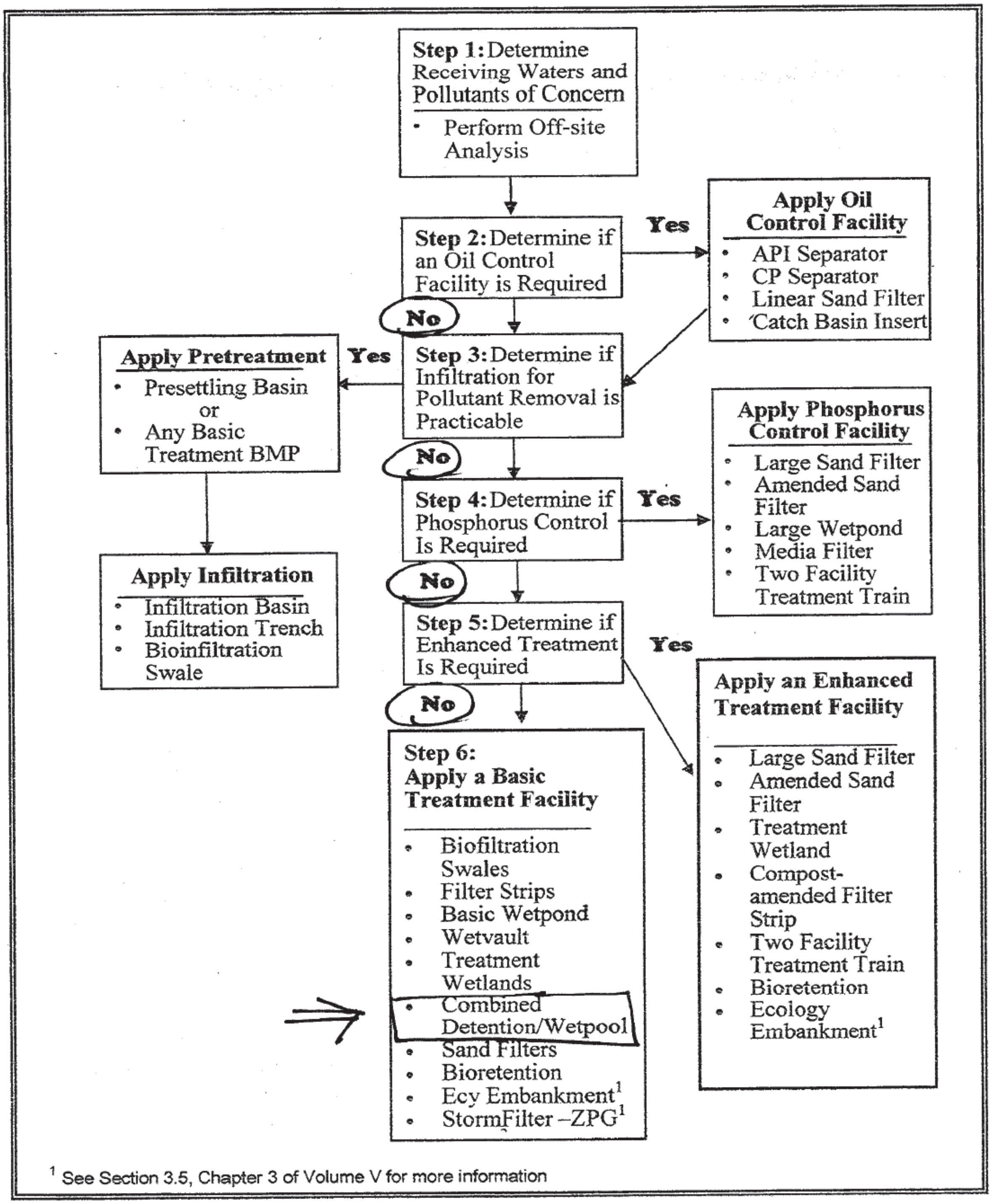


Figure 4.1 Treatment Facility Selection Flow Chart

Minimum Requirement #4: Preservation of Natural Drainage Systems and Outfalls

This is a requirement to maintain historical natural drainage patterns for the site, if possible. Stormwater runoff from this site has historically drained to the southeast toward Cascade Lake through a small wetland in the lowest corner of the property. No new channels to divert stormwater runoff are proposed for this site, other than to allow treatment and flow detention. Flow from wetpond will be dispersed into wetland areas with a dispersion trench outlet to mimic predevelopment conditions. Following development, stormwater will continue to flow from this site through wetland and continue to east. The roof dispersion BMPs proposed for this development will help to minimize impacts to the wetland and downstream properties.

Minimum Requirement # 5: On-site Stormwater Management

This is a requirement to employ appropriate permanent on-site stormwater management BMPs to infiltrate, disperse, and retain stormwater runoff onsite to the maximum extent feasible. Appropriate BMPs will be used for this project. See Figures 6.5 and 6.6 and Item 5 below for a description of the elements of the Permanent Stormwater Control Plan for this project.

Rosario Hilltop Housing / Maintenance SSP

10/19/15, Page 20

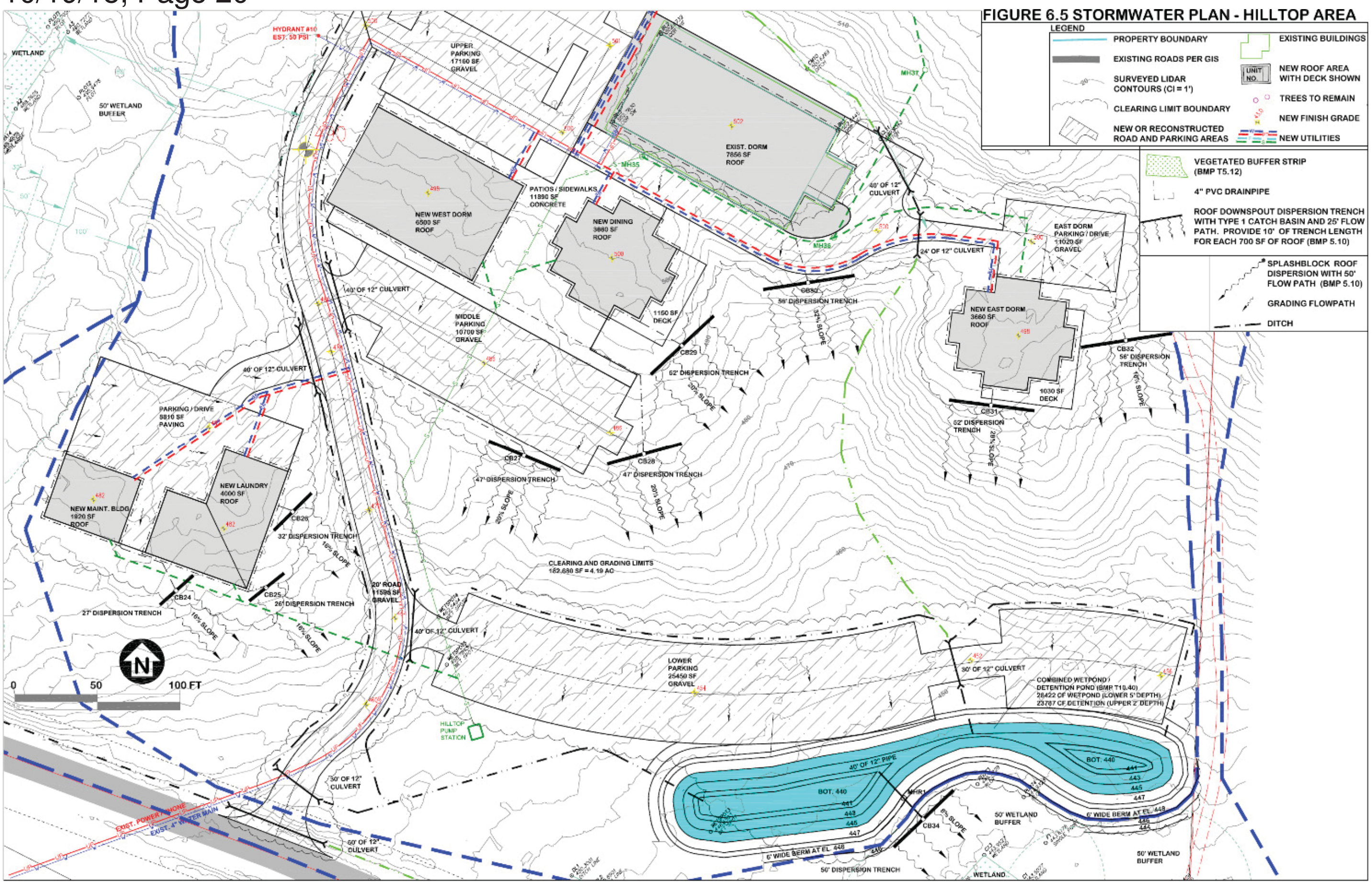


Figure 6.5 – Stormwater Plan (insert 11x17)

Rosario Hilltop Housing / Maintenance SSP
10/19/15, Page 21

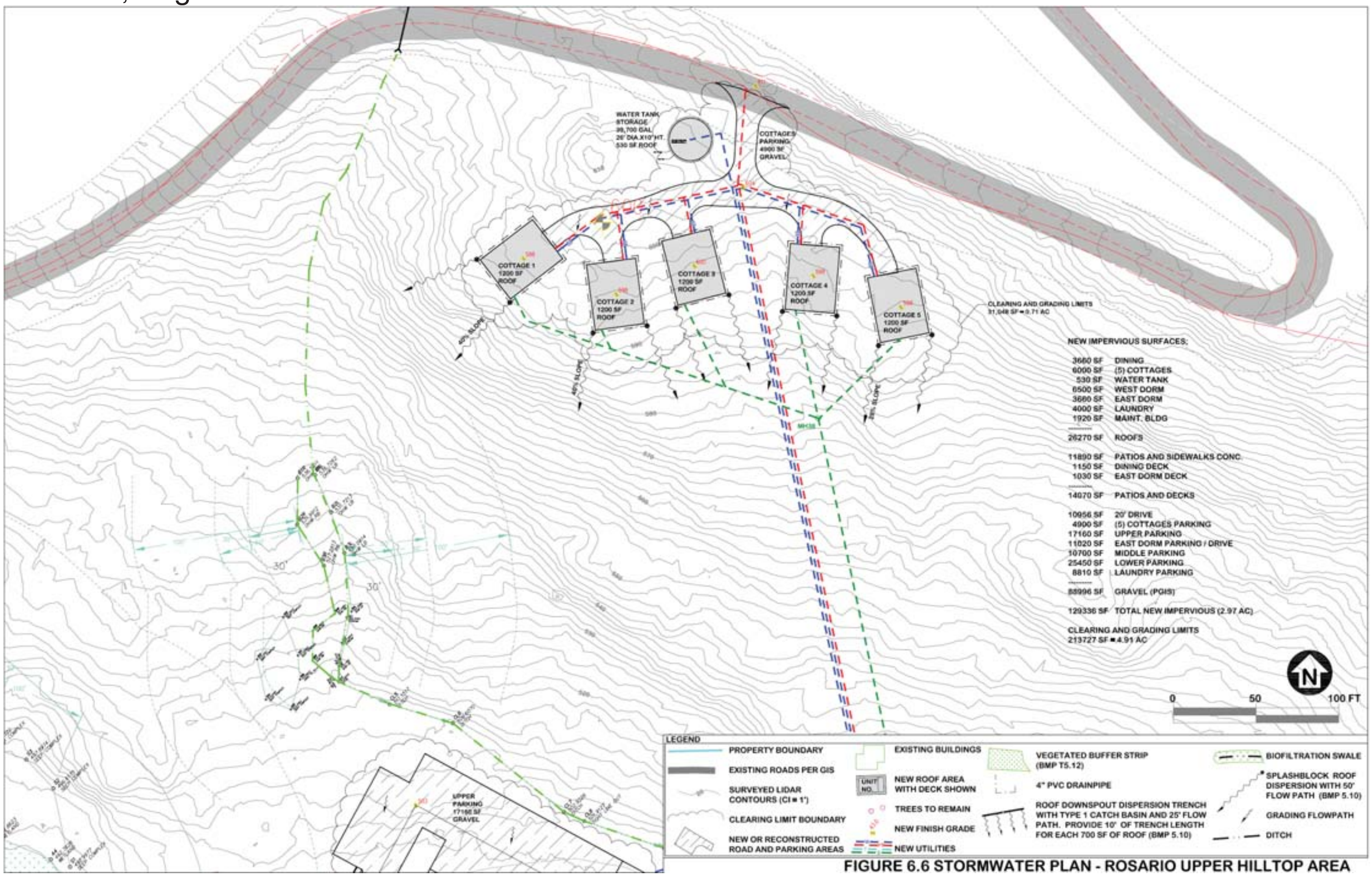


FIGURE 6.6 STORMWATER PLAN - ROSARIO UPPER HILLTOP AREA

Figure 6.6 – Stormwater Plan (insert 11x17)

Minimum Requirement # 6: Runoff Treatment

This requirement applies to:

- Projects in which the total of effective, pollution-generating impervious surface (PGIS) is 5,000 square feet or more in a threshold discharge area of the project, or
- Projects in which the total of pollution-generating pervious surfaces (PGPS) is three-quarters (3/4) of an acre (32,670 sf) or more in a threshold discharge area, and from which there is a surface discharge in a natural or man-made conveyance system from the site.

The thresholds limits for requiring treatment and detention facilities are based on the pollution-generating impervious surfaces in each basin. A tabulation of converted surfaces created within each of the basins is provided in Table 2 below.

Table 2 - New or Replaced PGPS and PGIS by Basin

Converted Surface	Basin H1	Basin H2	Basin H3
Gravel roads and parking areas (PGIS)	88,996 sf	0 sf	0 sf
Forest converted to lawn & landscaping (PGPS)	20,000 sf	0 sf	0 sf

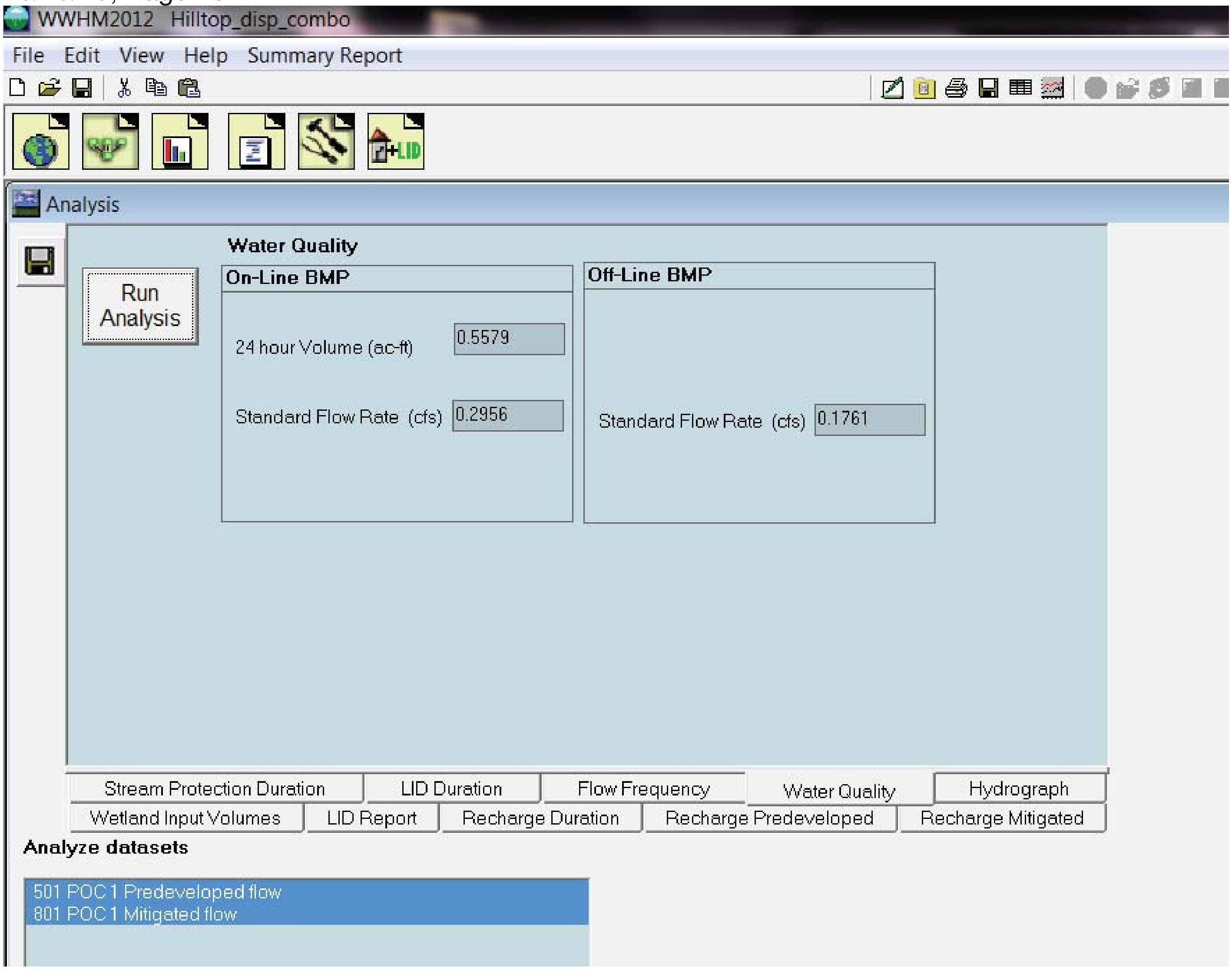
† Horizontal projection

Runoff treatment will be required for only Basin H1 since the PGIS resulting from the planned development is above the 5,000 sf threshold limit in this basin and there are no improvements planned in the other two basins.

Basin H1: 88,996 sf new PGIS is proposed so stormwater treatment is required. A combined wetpond / detention pond with a volume of 52,209 cf = 1.20 ac-ft is proposed to treat the runoff. The minimum size required by the WWHM model is 45,995 cf = 1.06 ac-ft. The wetpond is required to be a minimum of 24,302 cf = 0.5579 ac-ft, per the attached calculations, and is 28,422 cf as drawn, from elevation 440 to 445. The preliminary pond sizing includes a 5' wetpond depth and 2' detention depth with 3:1 side slopes. See attached standard BMP T10.10 and T10.40 wetpond details and limitations. The pond calculations account for run-off credit for roof downspout dispersion trenches with min. 50' vegetated flowpaths, by modeling the roof areas as lawn, per the WWHM12 allowances. Construction drawings of the combined detention and wetpond will be provided to the County once this report is approved.

Runoff treatment due to pollution generating pervious surfaces (PGPS) should also not be necessary in any basin since the PGPS created by the entire proposed development is less than the ¾ acres allowed by the PGPS threshold limit. The PGPS proposed is 20,000 sf which is 0.46 acres.

Rosario Hilltop Housing / Maintenance SSP



Wetpond sizing results using inflow 0.5579 acre-ft = 24,302 cf required.
The wetpond volume proposed is estimated 28,422 cf as drawn.

Minimum Requirement #7: Flow Control

This is a requirement to reduce the impacts of increased storm water runoff from new impervious surfaces and land cover conversions to a fresh water. This requirement applies to:

- Projects in which the total of effective impervious surfaces is 10,000 square feet or more in a threshold discharge area, or
- Projects that convert ¾ acres (32,670 sf) or more of native vegetation to lawn or landscape, or convert 2.5 acres or more of native vegetation to pasture in a

threshold discharge area, and from which there is a surface discharge in a natural or man-made conveyance system from the site, or

- Projects that through a combination of effective impervious surfaces and converted pervious surfaces, cause a 0.1 cubic feet per second (cfs) increase in the 100-year flow frequency from a threshold discharge area as estimated using the Western-Washington Hydrology Model or other approved model. (Ecology has approved a simple proportional method for determining if 0.1 cfs increase is caused).

Refer to the Development Assumptions sheet is attached to this report for calculations of the amount of new impervious surfaces for each drainage basin. The currently existing impervious surfaces were all constructed more than 2 years ago, as reported by the Owner, and therefore are not included in the impervious surface calculation for each basin.

Basin H1:

129,339 sf of new or replaced imperious surfaces are proposed and fresh water resources are located downstream, so stormwater flow control is required. A combined wetpond / detention pond is proposed to be located in the south east corner of the site, see Figure 6.5 and 6.6, Stormwater Site Plan. The designed detention volume is 23,787 cf to mitigate the impacts of increased runoff. The minimum size required by the WWHM12 model is 21,693 cf. The preliminary pond sizing includes a 2' detention depth in the upper portion of the pond and 3:1 side slopes. The detention pond portion has a lower area of 9734 sf at elevation 445 and upper area of 14053 sf at elevation 447. The BMP T10.10, T10.40 and Section 3.2.1 details and requirements are attached for reference. Construction drawings of the combined detention and wetpond will be provided to the County once this report is approved and prior to the first building permit submittal. See detention pond calculations using WWHM12 from the DOE Stormwater Manual below.

Rosario Hilltop Housing / Maintenance SSP
10/19/15, Page 25

General Model Information

Project Name:	Hilltop_disp
Site Name:	Hilltop
Site Address:	Olga Road
City:	san juan
Report Date:	8/28/2015
Gage:	Blaine
Data Start:	1948/10/01
Data End:	2009/09/30
Timestep:	15 Minute
Precip Scale:	0.80
Version:	2013/04/17

POC Thresholds

Low Flow Threshold for POC1:	50 Percent of the 2 Year
High Flow Threshold for POC1:	50 Year

Rosario Hilltop Housing / Maintenance SSP
10/19/15, Page 26

Landuse Basin Data
Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	Acres
C, Forest, Steep	14.908
C, Pasture, Mod	0.7436
Pervious Total	15.6516
Impervious Land Use	Acres
ROADS MOD	0.768
ROOF TOPS FLAT	0.18
Impervious Total	0.948
Basin Total	16.5996

Element Flows To:

Surface	Interflow	Groundwater

Rosario Hilltop Housing / Maintenance SSP
10/19/15, Page 27

Mitigated Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	Acres
C, Forest, Steep	10.946
C, Pasture, Mod	0.7436
C, Pasture, Steep	1.548
C IMP DISP MOD	0.649
Pervious Total	13.8866
Impervious Land Use	Acres
ROADS MOD	2.39
SIDEWALKS FLAT	0.323
Impervious Total	2.713
Basin Total	16.5996

Element Flows To:

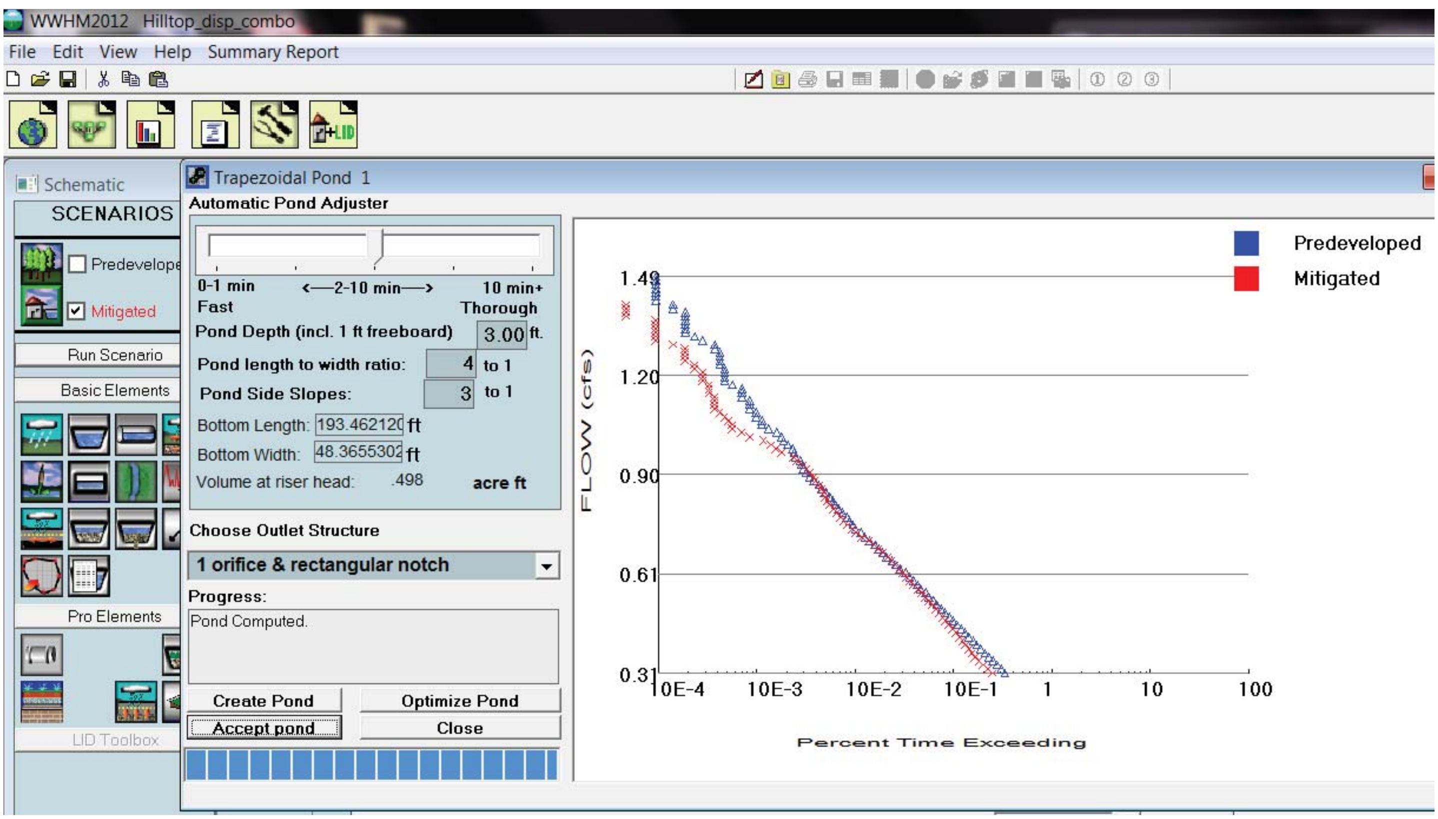
Surface	Interflow	Groundwater
Surface retention 1	Surface retention 1	

Rosario Hilltop Housing / Maintenance SSP
10/19/15, Page 28

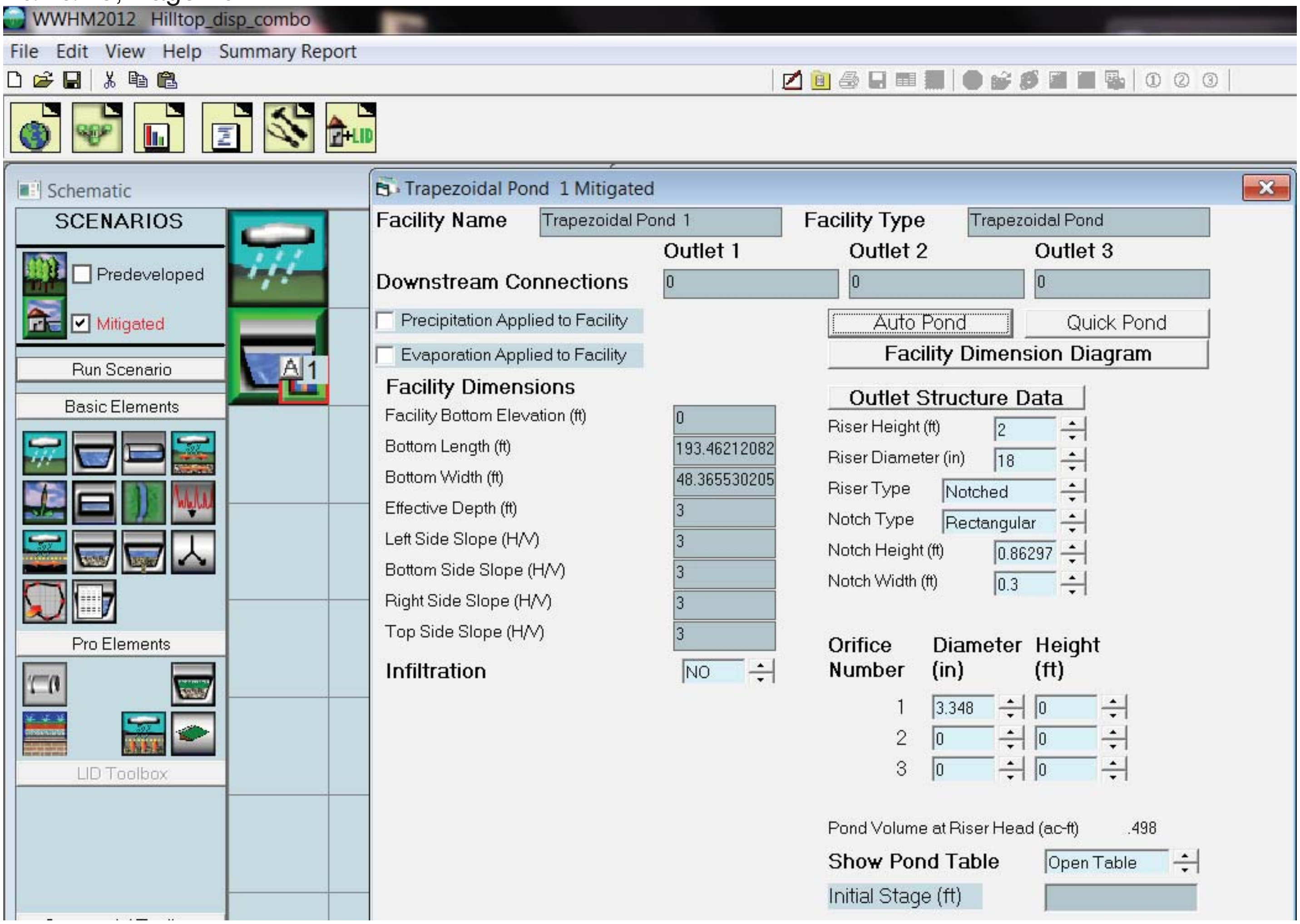
Mitigated Routing

Trapezoidal Pond 1

Bottom Length:	193.46 ft.
Bottom Width:	48.37 ft.
Depth:	3 ft.
Volume at riser head:	0.4984 acre-ft.
Side slope 1:	3 To 1
Side slope 2:	3 To 1
Side slope 3:	3 To 1
Side slope 4:	3 To 1
Discharge Structure	
Riser Height:	2 ft.
Riser Diameter:	18 in.
Notch Type:	Rectangular
Notch Width:	0.300 ft.
Notch Height:	0.863 ft.
Orifice 1 Diameter:	3.348 in. Elevation:0 ft.
Element Flows To:	
Outlet 1	Outlet 2

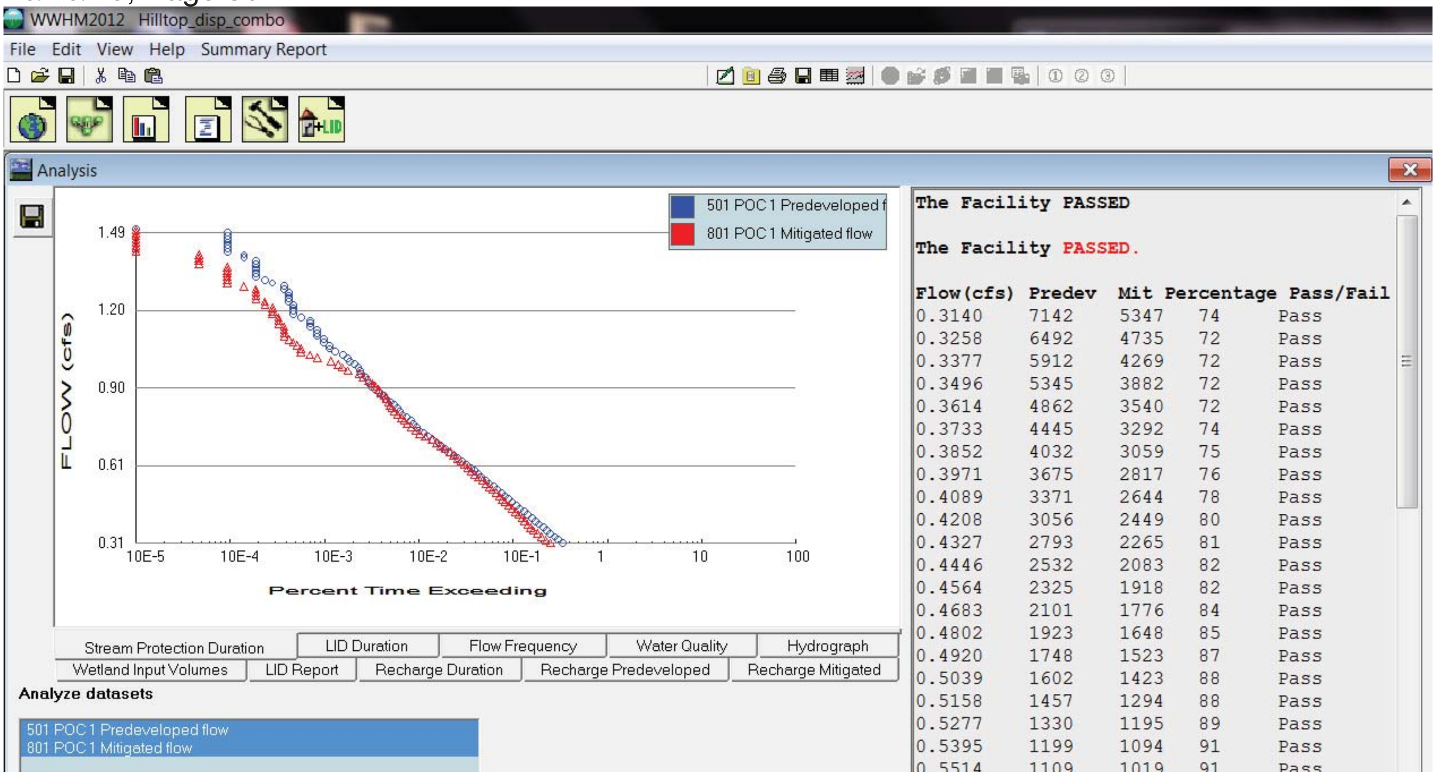


Rosario Hilltop Housing / Maintenance SSP
10/19/15, Page 29



WWHM12 results for Autopond detention sizing, 0.498 ac-ft = 21,693 cf required.

Rosario Hilltop Housing / Maintenance SSP
10/19/15, Page 30



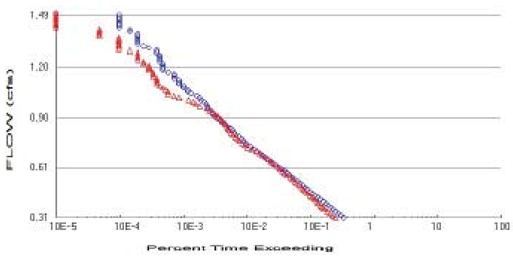
Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.3140	7142	5347	74	Pass
0.3258	6492	4735	72	Pass
0.3377	5912	4269	72	Pass
0.3496	5345	3882	72	Pass
0.3614	4862	3540	72	Pass
0.3733	4445	3292	74	Pass
0.3852	4032	3059	75	Pass
0.3971	3675	2817	76	Pass
0.4089	3371	2644	78	Pass
0.4208	3056	2449	80	Pass
0.4327	2793	2265	81	Pass
0.4446	2532	2083	82	Pass
0.4564	2325	1918	82	Pass
0.4683	2101	1776	84	Pass
0.4802	1923	1648	85	Pass
0.4920	1748	1523	87	Pass
0.5039	1602	1423	88	Pass
0.5158	1457	1294	88	Pass
0.5277	1330	1195	89	Pass
0.5395	1199	1094	91	Pass
0.5514	1109	1019	91	Pass

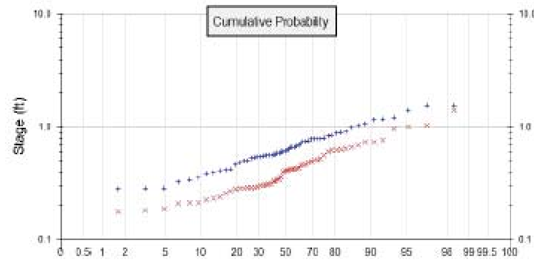
Stream protection report from the calculations.

Rosario Hilltop Housing / Maintenance SSP
10/19/15, Page 31

Analysis Results

POC 1





+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 15.6516
Total Impervious Area: 0.948

Mitigated Landuse Totals for POC #1
Total Pervious Area: 13.8866
Total Impervious Area: 2.713

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.627901
5 year	0.894558
10 year	1.076365
25 year	1.311129
50 year	1.489353
100 year	1.67027

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.387245
5 year	0.587094
10 year	0.73986
25 year	0.956915
50 year	1.136608
100 year	1.332212

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	Predeveloped	Mitigated
1949	0.693	0.420
1950	0.591	0.489
1951	0.708	0.734
1952	0.281	0.210
1953	0.326	0.232
1954	0.677	0.312
1955	0.611	0.302
1956	0.634	0.604
1957	1.072	0.461
1958	0.411	0.255

WWHM12 analysis results for pre-developed vs. mitigated condition

Minimum Requirement #8: Wetlands Protection

This requirement is for the protection of wetlands where stormwater is discharged to them either directly or indirectly. The county GIS data base shows a wetland (“ wet shapes”) in the vicinity of the streams leading east to Cascade Lake. A wetlands review was done by Scott Rozenbaum of Rozewood Environmental and determined that there are wetlands on the site and applied appropriate buffer widths, and is available from the Owner. I have reviewed the proposed plans for the site with Scott Rozenbaum onsite including specific location of the combined wetpond/ detention pond and dispersion trench outlet in relation to the wetland buffers. The BMPs recommended in this permanent stormwater control plan will be used to mitigate potential impacts to the wetland areas.

Minimum Requirement #9: Basin/Watershed Planning

This is a requirement for the implementation of more stringent pollution controls in basins, which have adopted Basin/Watershed Plans. However, at this time there are no known special requirements for development or for stormwater treatment or control within this watershed. Minimum Requirement #9 should not apply to this project.

Minimum Requirement #10: Operation and Maintenance

Minimum requirement #10 applies to Basin H1 where permanent stormwater treatment and flow control drainage facilities are proposed to be constructed. Refer to the attached Maintenance Standards for Drainage Facilities for detention ponds, wetponds and control structures/flow restrictors. The Owners shall ensure that development restrictions and covenants include requirements for drainage maintenance per the attached Standards. We have not prepared a formal Operations and Maintenance manual at this time but could do so if the County feels it is needed for this project.

The ongoing maintenance of the drainage facilities, ie ditches culverts, detention pond, pond outlet structure, and biofiltration swale shall be the responsibility of the Owners.

5. Permanent Stormwater Control Plan

A drainage plan has been developed which includes a combined detention/wetpond where required and dispersion best management practices to the greatest extent feasible.

A drainage plan has been developed for this site to address the above-referenced requirements. This plan employs on-site stormwater management BMPs for mitigation of runoff impacts. A description of the proposed drainage plan is provided below and the location of the BMPs is shown on Figures 6.5 and 6.6.

DESCRIPTION OF PROPOSED NEW DRAINAGE FACILITIES

Combined Detention / Wetpond (BMP T10.40): A combined wetpond / detention pond is proposed to treat and detain the runoff. The preliminary pond sizing includes a 5' wetpond depth and 2' detention depth with 3:1 side slopes. See attached standard BMP T10.10 and T10.40 wetpond details and limitations. The pond calculations account for run-off credit for roof downspout dispersion trenches with min. 50' vegetated flowpaths, by modeling the roof areas as lawn, per the WWHM12 allowances. The calculations require the pond to have a minimum of 21,693 cf of detention and 24,302 cf of wetpond volume for a total of 45,995 cf. The proposed pond shown would provide 23,787 cf of detention and 28,422 cf of wetpond volume for a total of 52,209 cf, exceeding the requirements. The parking area surface will be graded to provide a minimum cross slope of 2 percent toward ditching which will direct the increased flow to the detention / wetpond. Upon approval of this stormwater site plan, and prior to construction, final design and engineered construction drawings for the combined wetpond / detention pond will be prepared and submitted to San Juan County for review and approval.

Roof Downspout Dispersion (BMP T5.10): Dispersion trenches have been sized for all of the new and existing roofs (10' per 700 sf roof). The location of these BMPs are shown on Figures 6.5 and 6.6. A photo of the flowpath area for each dispersion trench is also shown below. The downspouts will need to be piped to the dispersion location shown on the plan. Care should be taken to ensure that the catch basin rims are set at least 6" below the bottom of footings or crawlspace to avoid possible back flooding of these areas from downspout flows. Splash blocks are planned at the discharge outlets of all downspouts for the five upper cottage buildings and will be limited to no more than 700 sf of roof area per splashblock. BMP T5.10 requires this geotechnical review for flowpath slopes steeper than 20%. The site has been walked and reviewed with Dan Sorenson of Geotest Inc. and each dispersion trench steeper than 20% was discussed and documented. See attached geotechnical letter.

Parking Area Flow Dispersion (BMP T5.12): Runoff control for the parking areas in front of the houses will be accomplished by sheet flow dispersion (BMP T5.12). The parking area surfaces will be graded to provide a cross slope of 2 to 5 percent toward a vegetated buffer. Due to the topography of the site, natural vegetated buffers lie on the down slope side of all parking areas. Ditches will be constructed to convey flows to the pond as needed.

Constructed slopes: All cut and fill slopes shall be designed and constructed in a manner that will minimize erosion. The maximum side slope shall be 2H:1V for this project and all side slopes shall be stabilized as specified in the attached SWPPP – see Elements 3, 4, and 5.

Source control BMPS: Pressure washing, maintenance and repair of equipment will not be done onsite. Storage of possible contaminates will be inside, under cover.

Vegetated flowpath area for Maintenance Building dispersion trench, at CB 24.

Rosario Hilltop Housing / Maintenance SSP
10/19/15, Page 35

Vegetated flowpath area for Laundry Building dispersion trench, at CB 25.

Vegetated flowpath area for Laundry Building dispersion trench, at CB 26.

Rosario Hilltop Housing / Maintenance SSP
10/19/15, Page 36

Vegetated flowpath area for West Dorm Building dispersion trench, at CB 27.

Vegetated flowpath area for West Dorm Building dispersion trench, at CB 28.

Rosario Hilltop Housing / Maintenance SSP
10/19/15, Page 37

Vegetated flowpath area for Dining Building dispersion trench, at CB 29.

Vegetated flowpath area for Existing Dorm Building dispersion trench, at CB 30.

Rosario Hilltop Housing / Maintenance SSP
10/19/15, Page 38


Vegetated flowpath area for East Dorm Building dispersion trench, CB 31.


Vegetated flowpath area for Existing Dorm Building dispersion trench, at CB 32.

Rosario Hilltop Housing / Maintenance SSP
10/19/15, Page 39

Vegetated flowpath area for Wetpond/Detention Pond dispersion trench, at CB 34.

Vegetated flowpath area for Cottage 4-5 downspout dispersion area.

Vegetated flowpath area for Cottage 1-3 downspout dispersion area.

6. Construction Stormwater Pollution Prevention Plan (SWPPP)

The SWPPP and not been prepared yet, but will be prepared and submitted for review and approval by San Juan County along with the permit submittal package for each building phase.

7. Other Permits

A NPDES permit will be required for this project if 1 acre or more is disturbed during the preparation of the roads, driveways and building areas. This project is planned to be done in phases. The total planned clearing and grading limit is 4.91 acres. If and when warranted it will be submitted separately.

8. Operations and Maintenance Manual

An O & M Manual is attached for the appropriate stormwater facilities included in this plan.

9. Bond Quantities Worksheet

There are no bonds for this project. At this time San Juan County does not require a bond for construction.

Prepared by:
Gregg Bronn, PE

Attachments:

- 2005 SWMM BMPs
  - 3.2.1 Detention Pond, Volume 3, pp 3-19 to 3-40, 3-52
  - T10.10 Wetponds – Basic and Large, Volume 5, pp 10-1 to 10-14
  - T10.40 Combined Detention and Wetpool Facilities, Volume 5, pp 10-34 to 10-40
  - 4.5.3 Outfall Systems, Figure 4.8 Flow Dispersion Trench
  - T5.10 Downspout Dispersion, pp 5-3 to 5-8.
  - T5.12 Sheet Flow Dispersion, pp 5-11 to 5-12
- O & M Manual – drainage maintenance standards, Vol. V, pp 4-30 – pp 4-42
- Geotechnical Review Letter - August 2015

2005 SWMM 3.2.1 Detention Pond
Volume 3, pp 3-19 to 3-40, 3-52

3.2 Detention Facilities

This section presents the methods, criteria, and details for design and analysis of detention facilities. These facilities provide for the temporary storage of increased surface water runoff resulting from development pursuant to the performance standards set forth in Minimum Requirement #7 for flow control (Volume I).

There are three primary types of detention facilities described in this section: detention ponds, tanks, and vaults.

3.2.1 Detention Ponds

The design criteria in this section are for detention ponds. However, many of the criteria also apply to infiltration ponds (Section 3.3 and Volume V), and water quality wetponds and combined detention/wetponds (Volume V).

Dam Safety for Detention BMPs

Stormwater detention facilities that can impound 10 acre-feet (435,600 cubic feet; 3.26 million gallons) or more with the water level at the embankment crest are subject to the state's dam safety requirements, even if water storage is intermittent and infrequent (WAC 173-175-020(1)). The principal safety concern is for the downstream population at risk if the dam should breach and allow an uncontrolled release of the pond contents. Peak flows from dam failures are typically much larger than the 100-year flows which these ponds are typically designed to accommodate.

The Dam Safety Office of the Department of Ecology uses consequence dependent design levels for critical project elements. There are eight design levels with storm recurrence intervals ranging from 1 in 500 for design step, 1 to 1 in 1,000,000 for design step 8. The specific design step for a particular project depends on the downstream population and other resources that would be at risk from a failure of the dam. Precipitation events more extreme than the 100-year event may be rare at any one location, but have historically occurred somewhere within Washington State every few years on average.

With regard to the engineering design of stormwater detention facilities, the primary effect of the state's dam safety requirements is in sizing the emergency spillway to accommodate the runoff from the dam safety design storm without overtopping the dam. The hydrologic computation procedures are the same as for the original pond design, except that the computations must use more extreme precipitation values and the appropriate dam safety design storm hyetographs. This information is described in detail within guidance documents developed by and available from the Dam Safety Office. In addition to the other design requirements for stormwater detention BMPs described elsewhere in this manual, dam safety requirements should be an integral part of planning and design for stormwater detention ponds. It is most cost-effective to consider these requirements right from the beginning of the project.

In addition to the hydrologic and hydraulic issues related to precipitation and runoff, other dam safety requirements include geotechnical issues, construction inspection and documentation, dam breach analysis, inundation mapping, emergency action planning, and periodic inspections by project owners and by Dam Safety engineers. All of these requirements, plus procedural requirements for plan review and approval and payment of construction permit fees are described in detail in guidance documents developed by and available from the Dam Safety Office.

In addition to the written guidance documents, Dam Safety engineers are available to provide technical assistance to project owners and design engineers in understanding and addressing the dam safety requirements for their specific project. In the interest of providing a smooth integration of dam safety requirements into the stormwater detention project and streamlining Dam Safety's engineering review and issuance of the construction permit, it is recommended and requested that Dam Safety be contacted early in the facilities planning process. The Dam Safety Office is located in the Ecology headquarters building in Lacey. Electronic versions of the guidance documents in PDF format are available on the Department of Ecology Web site at http://www.ecy.wa.gov/programs/wr/dams/dss.html.

Design Criteria

Standard details for detention ponds are shown in Figure 3.9 through Figure 3.11. Control structure details are provided in Section 3.2.4.

General

1. Ponds must be designed as flow-through systems (however, parking lot storage may be utilized through a back-up system; see Section 3.2.5). Developed flows must enter through a conveyance system separate from the control structure and outflow conveyance system. Maximizing distance between the inlet and outlet is encouraged to promote sedimentation.
2. Pond bottoms should be level and be located a minimum of 0.5 foot (preferably 1 foot) below the inlet and outlet to provide sediment storage.
3. Design guidelines for outflow control structures are specified in Section 3.2.4.
4. A geotechnical analysis and report must be prepared for steep slopes (i.e., slopes over 15%), or if located within 200 feet of the top of a steep slope or landslide hazard area. The scope of the geotechnical report

should include the assessment of impoundment seepage on the stability of the natural slope where the facility will be located within the setback limits set forth in this section.

Side Slopes

1. Interior side slopes up to the emergency overflow water surface should not be steeper than 3H:1V unless a fence is provided (see "Fencing").
2. Exterior side slopes must not be steeper than 2H:1V unless analyzed for stability by a geotechnical engineer.
3. Pond walls may be vertical retaining walls, provided: (a) they are constructed of reinforced concrete per Section 3.2.3, Material; (b) a fence is provided along the top of the wall; (c) the entire pond perimeter may be retaining walls, however, it is recommended that at least 25 percent of the pond perimeter be a vegetated soil slope not steeper than 3H:1V; and (d) the design is stamped by a licensed civil engineer with structural expertise. Other retaining walls such as rockeries, concrete, masonry unit walls, and keystone type wall may be used if designed by a geotechnical engineer or a civil engineer with structural expertise. If the entire pond perimeter is to be retaining walls, ladders should be provided on the walls for safety reasons.

Embankments

1. Pond berm embankments higher than 6 feet must be designed by a professional engineer with geotechnical expertise.
2. For berm embankments 6 feet or less, the minimum top width should be 6 feet or as recommended by a geotechnical engineer.
3. Pond berm embankments must be constructed on native consolidated soil (or adequately compacted and stable fill soils analyzed by a geotechnical engineer) free of loose surface soil materials, roots, and other organic debris.
4. Pond berm embankments greater than 4 feet in height must be constructed by excavating a key equal to 50 percent of the berm embankment cross-sectional height and width unless specified otherwise by a geotechnical engineer.
5. Embankment compaction should be accomplished in such a manner as to produce a dense, low permeability engineered fill that can tolerate post-construction settlements with a minimum of cracking. The embankment fill should be placed on a stable subgrade and compacted to a minimum of 95% of the Standard Proctor Maximum Density, ASTM Procedure D698. Placement moisture content should lie within 1% dry to 3% wet of the optimum moisture content. The referenced compaction standard may have to be increased to comply with local regulations.

The berm embankment should be constructed of soils with the following characteristics per the United States Department of Agriculture's Textural Triangle: a minimum of 20% silt and clay, a maximum of 60% sand, a maximum of 60% silt, with nominal gravel and cobble content. Soils outside this specified range can be used, provided the design satisfactorily addresses the engineering concerns posed by these soils. The paramount concerns with these soils are their susceptibility to internal erosion or piping and to surface erosion from wave action and runoff on the upstream and downstream slopes, respectively. *Note: In general, excavated glacial till is well suited for berm embankment material*.

6. Anti-seepage filter-drain diaphragms must be placed on outflow pipes in berm embankments impounding water with depths greater than 8 feet at the design water surface. See Dam Safety Guidelines, Part IV, Section 3.3.B on pages 3-27 to 3-30. An electronic version of the Dam Safety Guidelines is available in PDF format at www.ecy.wa.gov/programs/wr/dams/dss.html.

Overflow

1. In all ponds, tanks, and vaults, a primary overflow (usually a riser pipe within the control structure; see Section 3.2.4) must be provided to bypass the 100-year developed peak flow over or around the restrictor system. This assumes the facility will be full due to plugged orifices or high inflows; the primary overflow is intended to protect against breaching of a pond embankment (or overflows of the upstream conveyance system in the case of a detention tank or vault). The design must provide controlled discharge directly into the downstream conveyance system or another acceptable discharge point.
2. A secondary inlet to the control structure must be provided in ponds as additional protection against overtopping should the inlet pipe to the control structure become plugged. A grated opening ("jailhouse window") in the control structure manhole functions as a weir (see Figure 3.10) when used as a secondary inlet.
   Note: The maximum circumferential length of this opening must not exceed one-half the control structure circumference. The "birdcage" overflow structure as shown in Figure 3.11 may also be used as a secondary inlet.

Emergency Overflow Spillway

1. In addition to the above overflow provisions, ponds must have an emergency overflow spillway. For impoundments of 10 acre-feet or greater, the emergency overflow spillway must meet the state's dam safety requirements (see above). For impoundments under 10 acre-feet, ponds must have an emergency overflow spillway that is sized to pass the 100-year developed peak flow in the event of total control structure

failure (e.g., blockage of the control structure outlet pipe) or extreme inflows. Emergency overflow spillways are intended to control the location of pond overtopping and direct overflows back into the downstream conveyance system or other acceptable discharge point.

2. Emergency overflow spillways must be provided for ponds with constructed berms over 2 feet in height, or for ponds located on grades in excess of 5 percent. As an option for ponds with berms less than 2 feet in height and located at grades less than 5 percent, emergency overflow may be provided by an emergency overflow structure, such as a Type II manhole fitted with a birdcage as shown in Figure 3.11. The emergency overflow structure must be designed to pass the 100-year developed peak flow, with a minimum 6 inches of freeboard, directly to the downstream conveyance system or another acceptable discharge point. Where an emergency overflow spillway would discharge to a steep slope, consideration should be given to providing an emergency overflow structure *in addition to* the spillway.

3. The emergency overflow spillway must be armored with riprap in conformance with the "Outlet Protection" BMP in Volume II. The spillway must be armored full width, beginning at a point midway across the berm embankment and extending downstream to where emergency overflows re-enter the conveyance system (see Figure 3.10).

4. Emergency overflow spillway designs must be analyzed as broad-crested trapezoidal weirs as described in Methods of Analysis at the end of this section (Section 3.2.1). Either one of the weir sections shown in Figure 3.10 may be used.

Access

The following guidelines for access may be used.

1. Maintenance access road(s) should be provided to the control structure and other drainage structures associated with the pond (e.g., inlet or bypass structures). It is recommended that manhole and catch basin lids be in or at the edge of the access road and at least three feet from a property line.

2. An access ramp is needed for removal of sediment with a trackhoe and truck. The ramp must extend to the pond bottom if the pond bottom is greater than 1,500 square feet (measured without the ramp) and it may end at an elevation 4 feet above the pond bottom, if the pond bottom is less than 1,500 square feet (measured without the ramp).

   On large, deep ponds, truck access to the pond bottom via an access ramp is necessary so loading can be done in the pond bottom. On small deep ponds, the truck can remain on the ramp for loading. On small shallow ponds, a ramp to the bottom may not be required if the trackhoe can load a truck parked at the pond edge or on the internal berm of a wetpond or combined pond (trackhoes can negotiate interior pond side slopes).

3. The internal berm of a wetpond or combined detention and wetpond may be used for access if it is no more than 4 feet above the first wetpool cell, if the first wetpool cell is less than 1,500 square feet (measured without the ramp), and if it is designed to support a loaded truck, considering the berm is normally submerged and saturated.
4. Access ramps must meet the requirements for design and construction of access roads specified below.
5. If a fence is required, access should be limited by a double-posted gate or by bollards – that is, two fixed bollards on each side of the access road and two removable bollards equally located between the fixed bollards.

Design of Access Roads

The design guidelines for access road are given below.

1. Maximum grade should be 15 percent.
2. Outside turning radius should be a minimum of 40 feet.
3. Fence gates should be located only on straight sections of road.
4. Access roads should be 15 feet in width on curves and 12 feet on straight sections.
5. A paved apron must be provided where access roads connect to paved public roadways.

Construction of Access Roads

Access roads may be constructed with an asphalt or gravel surface, or modular grid pavement. All surfaces must conform to the jurisdictional standards and manufacturer's specifications.

Fencing

1. A fence is needed at the emergency overflow water surface elevation, or higher, where a pond interior side slope is steeper than 3H:1V, or where the impoundment is a wall greater than 24 inches in height. The fence need only be constructed for those slopes steeper than 3H:1V. Note, however, that other regulations such as the Uniform Building Code may require fencing of vertical walls. If more than 10 percent of slopes are steeper 3H:1V, it is recommended that the entire pond be fenced.

Also note that detention ponds on school sites will need to comply with safety standards developed by the Department of Health (DOH) and the Superintendent for Public Instruction (SPI). These standards include what is called a 'non-climbable fence.' One example of a non-climbable fence is a chain-link fence with a tighter mesh, so children cannot get a foot-hold for climbing. For school sites, and possibly for parks and playgrounds, the designer should consult the DOH's Office of Environmental Programs.

A fence is needed to discourage access to portions of a pond where steep side slopes (steeper than 3:1) increase the potential for slipping into the pond. Fences also serve to guide those who have fallen into a pond to side slopes that are flat enough (flatter than 3:1 and unfenced) to allow for easy escape.

2. It is recommended that fences be 6 feet in height. For example designs, see WSDOT Standard Plan L-2, Type 1 or Type 3 chain link fence. The fence may be a minimum of 4 feet in height if the depth of the impoundment (measured from the lowest elevation in the bottom of the impoundment, directly adjacent to the bottom of the fenced slope, up to the emergency overflow water surface) is 5 feet or less. For example designs, see WSDOT Standard Plan L-2, Type 4 or Type 6 chain link fence.
3. Access road gates may be 16 feet in width consisting of two swinging sections 8 feet in width. Additional vehicular access gates may be needed to facilitate maintenance access.
4. Pedestrian access gates (if needed) should be 4 feet in width.
5. Vertical metal balusters or 9 gauge galvanized steel fabric with bonded vinyl coating can be used as fence material. For steel fabric fences, the following aesthetic features may be considered:
   a) Vinyl coating that is compatible with the surrounding environment (e.g., green in open, grassy areas and black or brown in wooded areas). All posts, cross bars, and gates may be painted or coated the same color as the vinyl clad fence fabric.
   b) Fence posts and rails that conform to WSDOT Standard Plan L-2 for Types 1, 3, or 4 chain link fence.
6. For metal baluster fences, Uniform Building Code standards apply.
7. Wood fences may be used in subdivisions where the fence will be maintained by homeowners associations or adjacent lot owners.
8. Wood fences should have pressure treated posts (ground contact rated) either set in 24-inch deep concrete footings or attached to footings by galvanized brackets. Rails and fence boards may be cedar, pressure-treated fir, or hemlock.

9. Where only short stretches of the pond perimeter (< 10 percent) have side slopes steeper than 3:1, split rail fences (3-foot minimum height) or densely planted thorned hedges (e.g., barberry, holly, etc.) may be used in place of a standard fence.

Signage

Detention ponds, infiltration ponds, wetponds, and combined ponds should have a sign placed for maximum visibility from adjacent streets, sidewalks, and paths. An example of sign specifications for a permanent surface water control pond is illustrated in Figure 3.12.

Right-of-Way

Right-of-way may be needed for detention pond maintenance. It is recommended that any tract not abutting public right-of-way have 15-20 foot wide extension of the tract to an acceptable access location.

Setbacks

It is recommended that facilities be a minimum of 20 feet from any structure, property line, and any vegetative buffer required by the local government. The detention pond water surface at the pond outlet invert elevation must be set back 100 feet from proposed or existing septic system drainfields. However, the setback requirements are generally specified by the local government, uniform building code, or other statewide regulation and may be different from those mentioned above.

All facilities must be a minimum of 50 feet from the top of any steep (greater than 15 percent) slope. A geotechnical analysis and report must be prepared addressing the potential impact of the facility on a steep slope.

Seeps and Springs

Intermittent seeps along cut slopes are typically fed by a shallow groundwater source (interflow) flowing along a relatively impermeable soil stratum. These flows are storm driven and should discontinue after a few weeks of dry weather. However, more continuous seeps and springs, which extend through longer dry periods, are likely from a deeper groundwater source. When continuous flows are intercepted and directed through flow control facilities, adjustments to the facility design may have to be made to account for the additional base flow (unless already considered in design).

Planting Requirements

Exposed earth on the pond bottom and interior side slopes should be sodded or seeded with an appropriate seed mixture. All remaining areas of the tract should be planted with grass or be landscaped and mulched with a 4-inch cover of hog fuel or shredded wood mulch. Shredded wood mulch is made from shredded tree trimmings, usually from trees cleared on site. The mulch should be free of garbage and weeds and should not contain excessive resin, tannin, or other material detrimental to plant growth.

Landscaping

Landscaping is encouraged for most stormwater tract areas (see below for areas not to be landscaped). However, if provided, landscaping should adhere to the criteria that follow so as not to hinder maintenance operations. Landscaped stormwater tracts may, in some instances, provide a recreational space. In other instances, "naturalistic" stormwater facilities may be placed in open space tracts.

The following guidelines should be followed if landscaping is proposed for facilities.

1. No trees or shrubs may be planted within 10 feet of inlet or outlet pipes or manmade drainage structures such as spillways or flow spreaders. Species with roots that seek water, such as willow or poplar, should be avoided within 50 feet of pipes or manmade structures.
2. Planting should be restricted on berms that impound water either permanently or temporarily during storms. This restriction does not apply to cut slopes that form pond banks, only to berms.
   a) Trees or shrubs may not be planted on portions of water-impounding berms taller than four feet high. Only grasses may be planted on berms taller than four feet.

      Grasses allow unobstructed visibility of berm slopes for detecting potential dam safety problems such as animal burrows, slumping, or fractures in the berm.

   b) Trees planted on portions of water-impounding berms less than 4 feet high must be small, not higher than 20 feet mature height, and have a fibrous root system. Table 3.1 gives some examples of trees with these characteristics developed for the central Puget Sound.

      These trees reduce the likelihood of blow-down trees, or the possibility of channeling or piping of water through the root system, which may contribute to dam failure on berms that retain water.

Note: The internal berm in a wetpond is not subject to this planting restriction since the failure of an internal berm would be unlikely to create a safety problem.

3. All landscape material, including grass, should be planted in good topsoil. Native underlying soils may be made suitable for planting if amended with 4 inches of well-aged compost tilled into the subgrade. Compost used should meet specifications for Grade A compost quality as described in Ecology publication 94-38.

4. Soil in which trees or shrubs are planted may need additional enrichment or additional compost top-dressing. Consult a nurseryman, landscape professional, or arborist for site-specific recommendations.
5. For a naturalistic effect as well as ease of maintenance, trees or shrubs should be planted in clumps to form *"landscape islands"* rather than evenly spaced.
6. The landscaped islands should be a minimum of six feet apart, and if set back from fences or other barriers, the setback distance should also be a minimum of 6 feet. Where tree foliage extends low to the ground, the six feet setback should be counted from the outer drip line of the trees (estimated at maturity).

   This setback allows a 6-foot wide mower to pass around and between clumps.
7. Evergreen trees and trees which produce relatively little leaf-fall (such as Oregon ash, mimosa, or locust) are preferred in areas draining to the pond.
8. Trees should be set back so that branches do not extend over the pond (to prevent leaf-drop into the water).
9. Drought tolerant species are recommended.

Table 3.1 – Small Trees and Shrubs with Fibrous Roots

Small Trees / High Shrubs	Low Shrubs
*Red twig dogwood *(Cornus stolonifera)*	*Snowberry *(Symporicarpus albus)*
*Serviceberry *(Amelanchier alnifolia)*	*Salmonberry *(Rubus spectabilis)*
*Filbert (*Corylus cornuta*, others)	Rosa rugosa (avoid spreading varieties)
Highbush cranberry *(Vaccinium opulus)*	Rock rose *(Cistus spp.)*
Blueberry *(Vaccinium spp.)*	Ceanothus spp. choose hardier varieties)
Fruit trees on dwarf rootstock	New Zealand flax *(Phormium penax)*
Rhododendron (native and ornamental varieties)	Ornamental grasses (e.g., *Miscanthis, Pennisetum*)
*Native species	

Guidelines for Naturalistic Planting. Stormwater facilities may sometimes be located within open space tracts if "natural appearing." Two generic kinds of naturalistic planting are outlined below, but other options are also possible. Native vegetation is preferred in naturalistic plantings.

Open Woodland. In addition to the general landscaping guidelines above, the following are recommended.

1. Landscaped islands (when mature) should cover a minimum of 30 percent or more of the tract, exclusive of the pond area.
2. Tree clumps should be underplanted with shade-tolerant shrubs and groundcover plants. The goal is to provide a dense understory that need not be weeded or mowed.
3. Landscaped islands should be placed at several elevations rather than "ring" the pond, and the size of clumps should vary from small to large to create variety.
4. Not all islands need to have trees. Shrub or groundcover clumps are acceptable, but lack of shade should be considered in selecting vegetation.

Note: Landscaped islands are best combined with the use of wood-based mulch (hog fuel) or chipped onsite vegetation for erosion control (only for slopes above the flow control water surface). *It is often difficult to sustain a low-maintenance understory if the site was previously hydroseeded. Compost or composted mulch (typically used for constructed wetland soil) can be used below the flow control water surface (materials that are resistant to and preclude flotation). The method of construction of soil landscape systems can also cause natural selection of specific plant species. Consult a soil restoration or wetland soil scientist for site-specific recommendations.*

Northwest Savannah or Meadow. In addition to the general landscape guidelines above, the following are recommended.

1. Landscape islands (when mature) should cover 10 percent or more of the site, exclusive of the pond area.
2. Planting groundcovers and understory shrubs is encouraged to eliminate the need for mowing under the trees when they are young.
3. Landscape islands should be placed at several elevations rather than "ring" the pond.

The remaining site area should be planted with an appropriate grass seed mix, which may include meadow or wildflower species. Native or dwarf grass mixes are preferred. Table 3.2 below gives an example of dwarf grass mix developed for central Puget Sound. Grass seed should be applied at 2.5 to 3 pounds per 1,000 square feet.

Note: Amended soil or good topsoil is required for all plantings.

Creation of areas of emergent vegetation in shallow areas of the pond is recommended. Native wetland plants, such as sedges (Carex sp.), bulrush (*Scirpus sp.*), water plantain (*Alisma sp.*), and burreed (*Sparganium sp.*) are recommended. If the pond does not hold standing water, a clump of wet-tolerant, non-invasive shrubs, such as salmonberry or snowberry, is recommended below the detention design water surface.

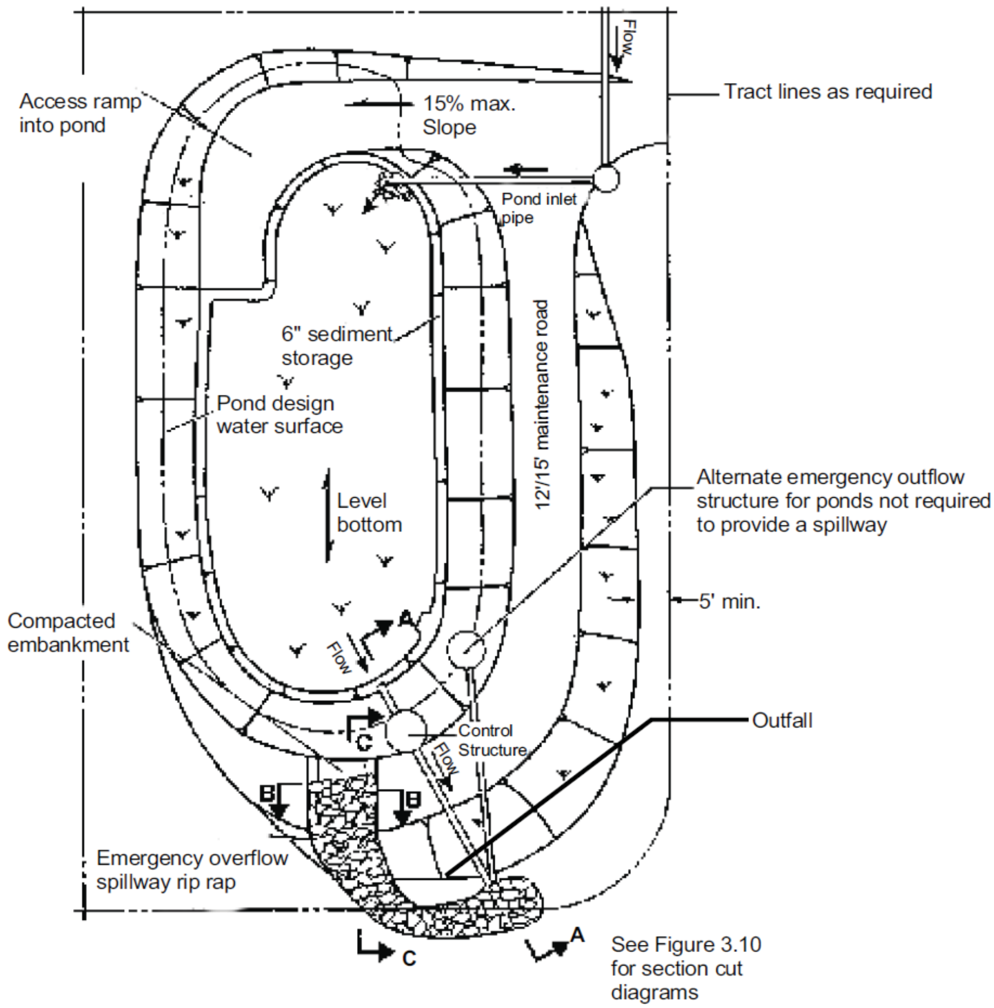
Note: This landscape style is best combined with the use of grass or sod for site stabilization and erosion control.

Seed Mixes. The seed mixes listed below were developed for central Puget Sound.

Table 3.2 – Stormwater Tract "Low Grow" Seed Mix

Seed Name	Percentage of Mix
Dwarf tall fescue	40%
Dwarf perennial rye "Barclay"*	30%
Red fescue	25%
Colonial bentgrass	5%

* If wildflowers are used and sowing is done before Labor Day, the amount of dwarf perennial rye can be reduced proportionately to the amount of wildflower seed used.



Note:
This detail is a schematic representation only. Actual configuration will vary depending on specific site constraints and applicable design criteria.

Figure 3.9 Typical Detention Pond

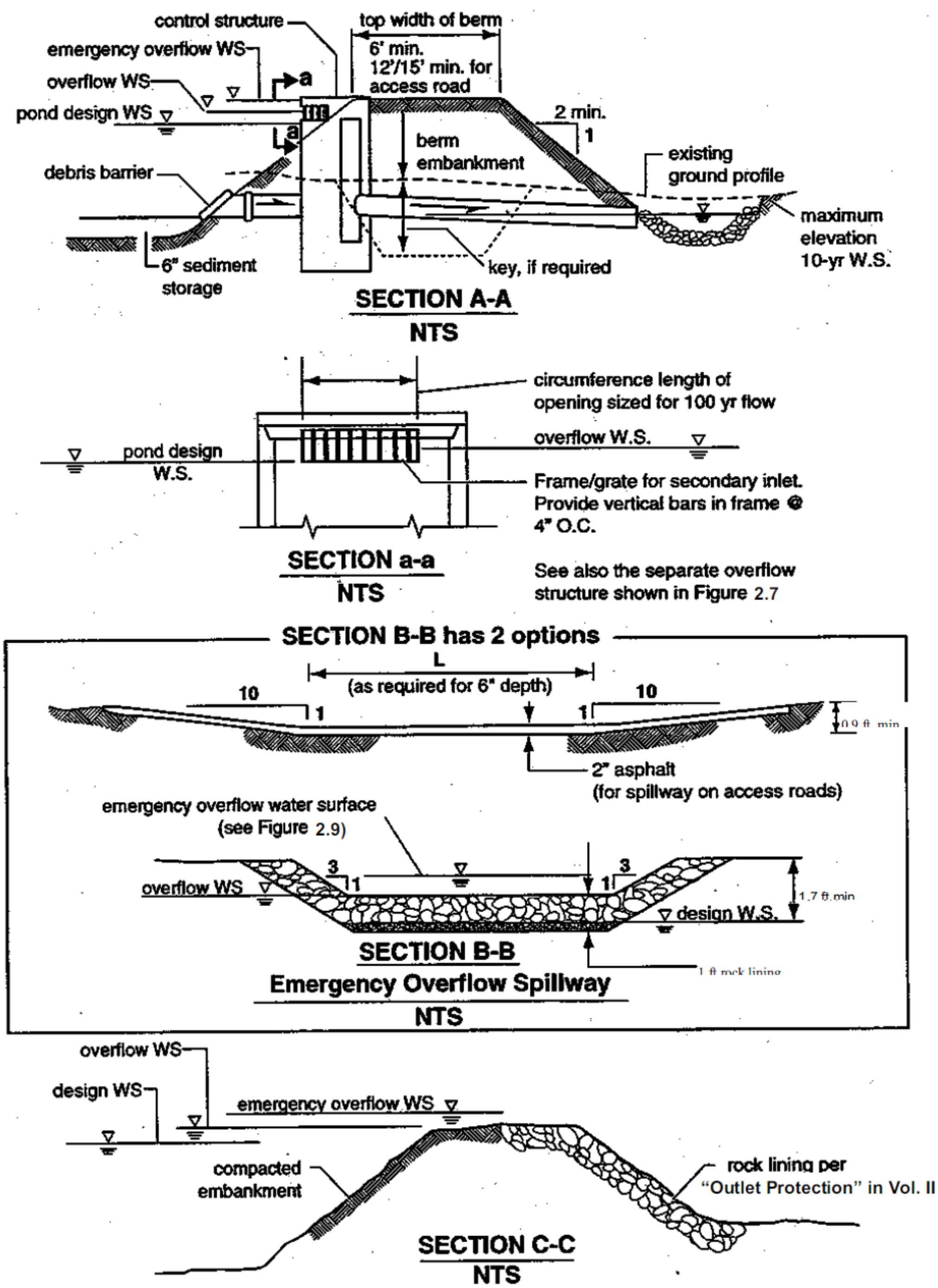
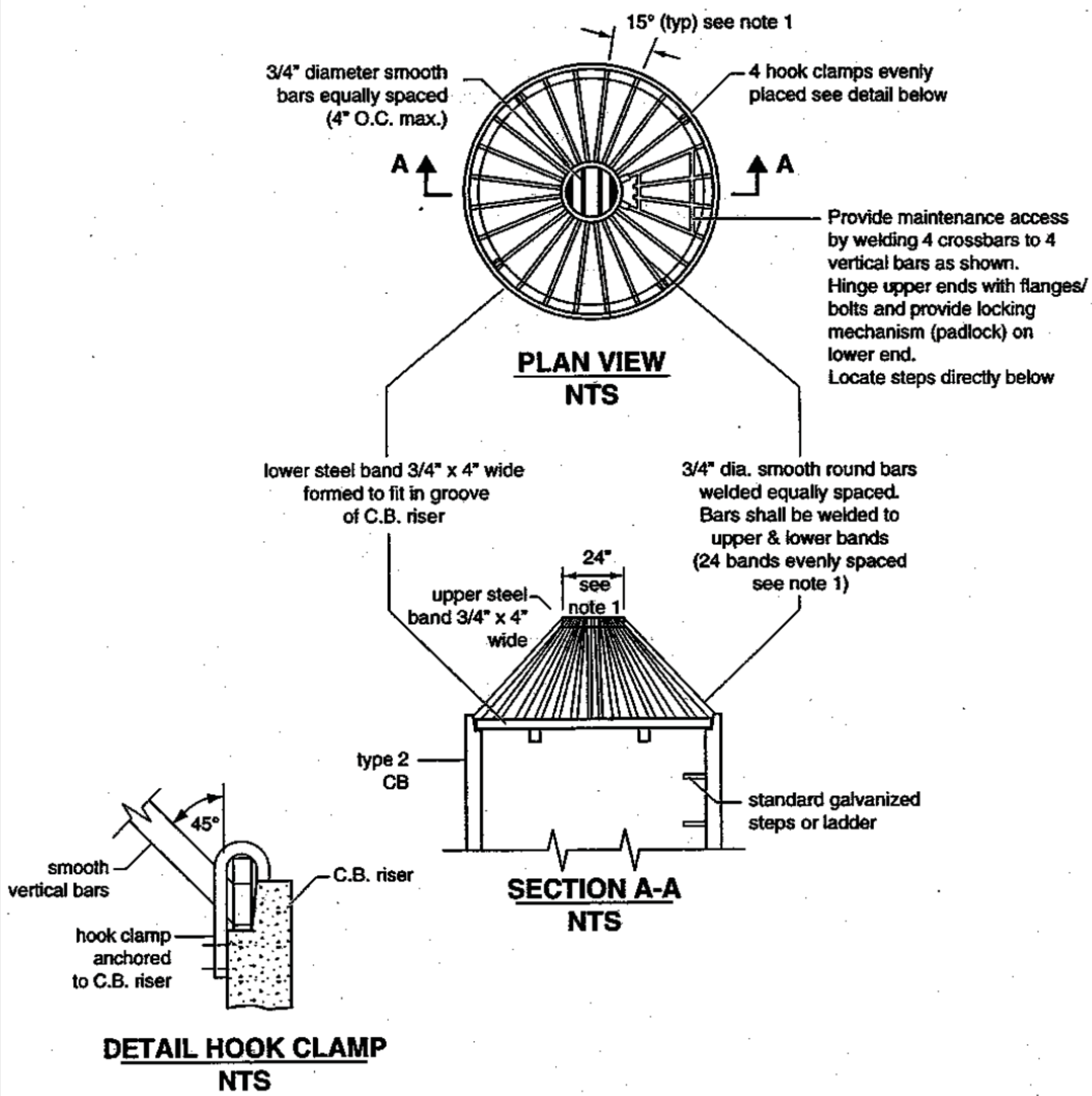


Figure 3.10 Typical Detention Pond Sections



NOTES:

1. Dimensions are for illustration on 54" diameter CB For different diameter CB's adjust to maintain 45° angle on "vertical" bars and 7" o.c. maximum spacing of bars around lower steel band.
2. Metal parts must be corrosion resistant; steel bars must be galvanized.
3. This debris barrier is also recommended for use on the inlet to roadway cross-culverts with high potential for debris collection (except on type 2 streams)

Figure 3.11 Overflow Structure

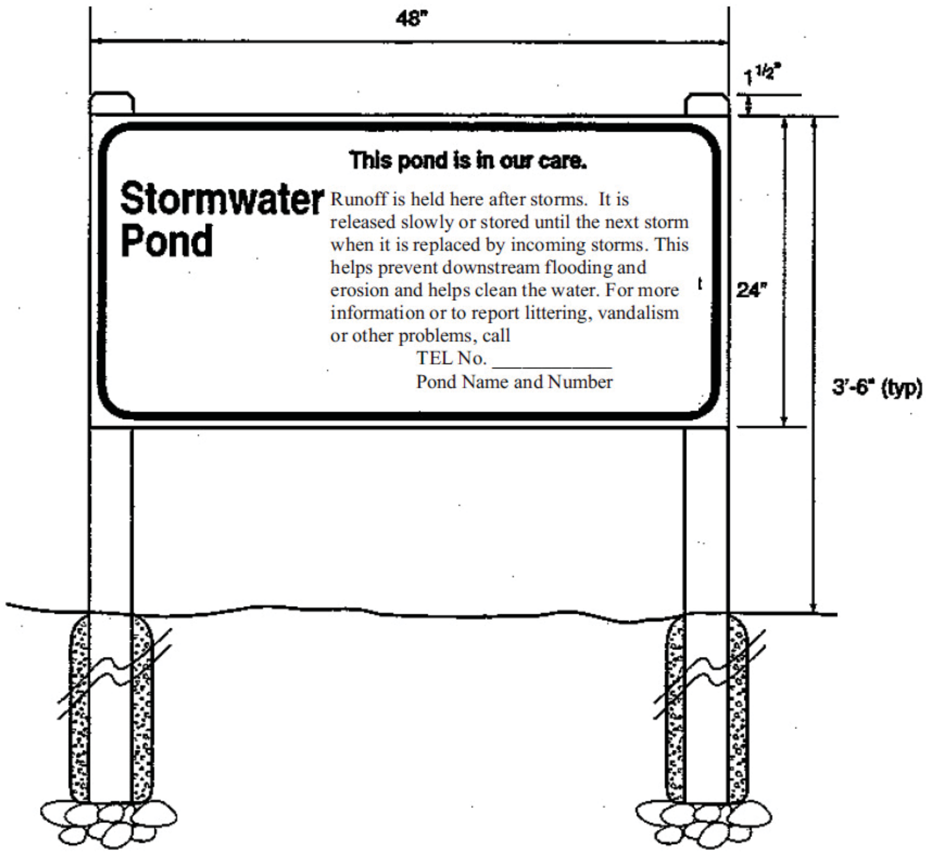


Figure 3.12 Example of Permanent Surface Water Control Pond Sign

Sample Specifications:

Size:	48 inches by 24 inches
Material:	0.125-gauge aluminum
Face:	Non-reflective vinyl or 3 coats outdoor enamel (sprayed).
Lettering:	Silk screen enamel where possible, or vinyl letters.
Colors:	Beige background, teal letters.
Type face:	Helvetica condensed. Title: 3 inch; Sub-Title: 1½ inch; Text: 1 inch; Outer
border:	1/8 inch border distance from edge: 1/4 inch; all text 1¾ inch from border.
Posts:	Pressure treated, beveled tops, 1½ inch higher than sign.
Installation:	Secure to chain link fence if available. Otherwise install on two 4"x4" posts, pressure treated, mounted atop gravel bed, installed in 30-inch concrete filled post holes (8-inch minimum diameter). Top of sign no higher than 42 inches from ground surface.
Placement:	Face sign in direction of primary visual or physical access. Do not block any access road. Do not place within 6 feet of structural facilities (e.g. manholes, spillways, pipe inlets).
Special Notes:	This facility is lined to protect groundwater (if a liner that restricts infiltration of stormwater exists).

Maintenance

General. Maintenance is of primary importance if detention ponds are to continue to function as originally designed. A local government, a designated group such as a homeowners' association, or some individual must accept the responsibility for maintaining the structures and the impoundment area. A specific maintenance plan must be formulated outlining the schedule and scope of maintenance operations. Debris removal in detention basins can be achieved through the use of trash racks or other screening devices.

Design with maintenance in mind. Good maintenance will be crucial to successful use of the impoundment. Hence, provisions to facilitate maintenance operations must be built into the project when it is installed. Maintenance must be a basic consideration in design and in determination of first cost. See Table 3.3 for specific maintenance requirements.

Any standing water removed during the maintenance operation must be disposed of to a sanitary sewer at an approved discharge location *Pretreatment may be necessary.* Residuals must be disposed in accordance with state and local solid waste regulations (See Minimum Functional Standards For Solid Waste Handling, Chapter 173-304 WAC).

Vegetation. If a shallow marsh is established, then periodic removal of dead vegetation may be necessary. Since decomposing vegetation can release pollutants captured in the wet pond, especially nutrients, it may be necessary to harvest dead vegetation annually prior to the winter wet season. Otherwise the decaying vegetation can export pollutants out of the pond and also can cause nuisance conditions to occur. If harvesting is to be done in the wetland, a written harvesting procedure should be prepared by a wetland scientist and submitted with the drainage design to the local government.

Sediment. Maintenance of sediment forebays and attention to sediment accumulation within the pond is extremely important. Sediment deposition should be continually monitored in the basin. Owners, operators, and maintenance authorities should be aware that significant concentrations of metals (e.g., lead, zinc, and cadmium) as well as some organics such as pesticides, may be expected to accumulate at the bottom of these treatment facilities. Testing of sediment, especially near points of inflow, should be conducted regularly to determine the leaching potential and level of accumulation of potentially hazardous material before disposal.

Table 3.3
Specific Maintenance Requirements for Detention Ponds

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Emergency Overflow/Spillway	Emergency Overflow/ Spillway	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil at the top of out flow path of spillway. (Rip-rap on inside slopes need not be replaced.)	Rocks and pad depth are restored to design standards.
	Erosion	See "Side slopes of Pond"	

Methods of Analysis

Detention Volume and Outflow. The volume and outflow design for detention ponds must be in accordance with Minimum Requirements #7 in Volume I and the hydrologic analysis and design methods in Chapter 1 of this Volume. Design guidelines for restrictor orifice structures are given in Section 3.2.4.

Note: The design water surface elevation is the highest elevation which occurs in order to meet the required outflow performance for the pond.

Detention Ponds in Infiltrative Soils. Detention ponds may occasionally be sited on till soils that are sufficiently permeable for a properly functioning infiltration system (see Section 3.3). These detention ponds have a surface discharge and may also utilize infiltration as a second pond outflow. Detention ponds sized with infiltration as a second outflow must meet all the requirements of Section 3.3 for infiltration ponds, including a soils report, testing, groundwater protection, pre-settling, and construction techniques.

Emergency Overflow Spillway Capacity. For impoundments under 10-acre-feet, the emergency overflow spillway weir section must be designed to pass the 100-year runoff event for developed conditions assuming a broad-crested weir. The **broad-crested weir equation** for the spillway section in Figure 3.13, for example, would be:

$$Q_{100} = C\,(2g)^{1/2}\left[\frac{2}{3}LH^{3/2} + \frac{8}{15}(\operatorname{Tan}\theta)\,H^{5/2}\right] \qquad \text{(equation 1)}$$

Where Q_{100} = peak flow for the 100-year runoff event (cfs)
C = discharge coefficient (0.6)
g = gravity (32.2 ft/sec^2)
L = length of weir (ft)

H = height of water over weir (ft)
θ = angle of side slopes

Q_{100} is either the peak 10-minute flow computed from the 100-year, 24-hour storm and a Type 1A distribution, or the 100-year, 1-hour flow, indicated by an approved continuous runoff model, multiplied by a factor of 1.6.

Assuming C = 0.6 and Tan θ = 3 (for 3:1 slopes), the equation becomes:

$$Q_{100} = 3.21[LH^{3/2} + 2.4\ H^{5/2}] \quad \text{(equation 2)}$$

To find width *L* for the weir section, the equation is rearranged to use the computed Q_{100} and trial values of H (0.2 feet minimum):

$$L = [Q_{100}/(3.21H^{3/2})] - 2.4\ H \quad \text{or} \quad 6 \text{ feet minimum} \quad \text{(equation 3)}$$

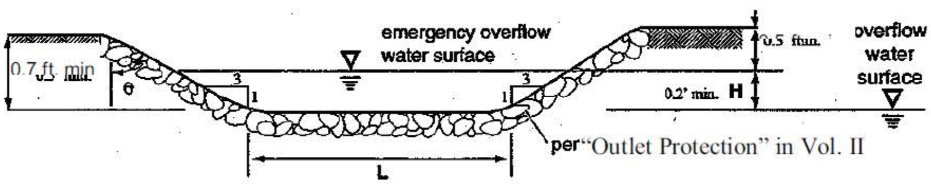


Figure 3.13 Weir Section for Emergency Overflow Spillway

3.2.2 Detention Tanks

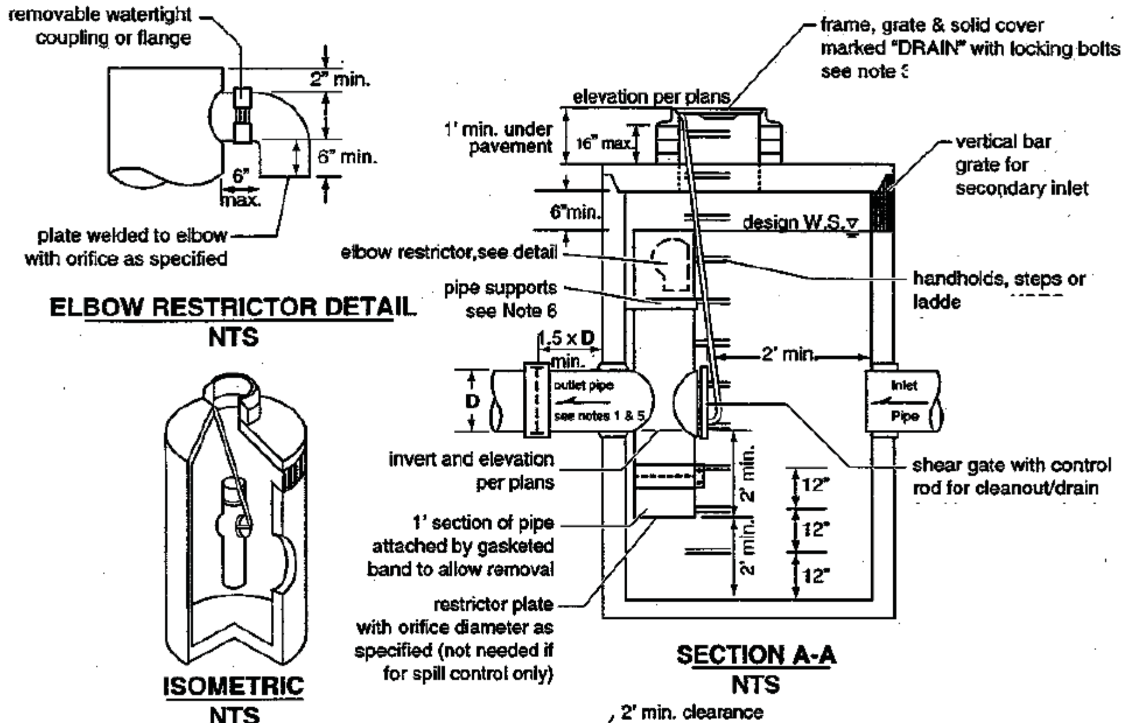
Detention tanks are underground storage facilities typically constructed with large diameter corrugated metal pipe. Standard detention tank details are shown in Figure 3.14 and Figure 3.15. Control structure details are shown in Section 3.2.4.

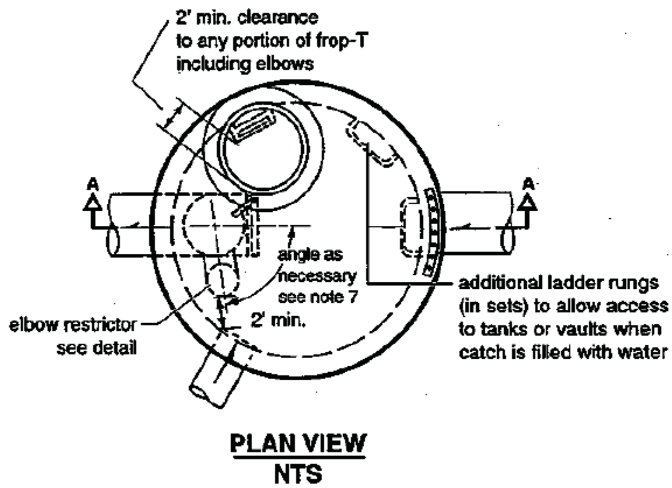
Design Criteria

General. Typical design guidelines are as follows:

1. Tanks may be designed as flow-through systems with manholes in line (see Figure 3.14) to promote sediment removal and facilitate maintenance. Tanks may be designed as back-up systems if preceded by water quality facilities, since little sediment should reach the inlet/control structure and low head losses can be expected because of the proximity of the inlet/control structure to the tank

2. The detention tank bottom should be located 0.5 feet below the inlet and outlet to provide dead storage for sediment.





NOTES:

1. Use a minimum of a 54" diameter type 2 catch basin.
2. Outlet Capacity: 100-Year developed peak flow.
3. Metal Parts: Corrosion resistant. Non-Galvanized parts perferred. Galvanized pipe parts to have asphalt treatment 1.
4. Frame and ladder or steps offset so:
   - A. Cleanout gate is visible from top.
   - B. Climb-down space is clear of riser and cleanout gate.
   - C. Frame is clear of curb.
5. If metal outlet pipe connects to cement concrete pipe: outlet pipe to have smooth O.D. equal to concrete pipe I.D. less 1/4".
6. Provide at least one 3" X .090 inches support bracket anchored to concrete wall. (maximum 3'-0" vertical spacing)
7. Locate elbow restrictor(s) as necessary to provide minimum clearance as shown.
8. Locate additional ladder rungs in structures used as access to tanks or vaults to allow access when catch basin is filled with water.

Figure 3.17 Flow Restrictor (TEE)

2005 SWMM BMP T10.10 Wetpond
Chapter 10, vol 5, pp 10-1 to 10-14

Chapter 10 - Wetpool Facilities

Note: Figures in Chapter 10 are from the King County Surface Water Design Manual

10.1 Purpose

This Chapter presents the methods, criteria, and details for analysis and design of wetponds, wetvaults, and stormwater wetlands. These facilities have as a common element a permanent pool of water - the wetpool. Each of the wetpool facilities can be combined with a detention or flow control pond in a combined facility. Included are the following specific facility designs:

BMP T10.10 - Wetponds - Basic and Large
BMP T10.20 - Wetvaults
BMP T10.30 - Stormwater Wetlands
BMP T10.40 - Combined Detention and Wetpool Facilities

10.2 Application

The wetpool facility designs described for the four BMPs in this Chapter will achieve the performance objectives cited in Chapter 3 for specific treatment menus.

10.3 Best Management Practices (BMPs) for Wetpool Facilities

The four BMPs discussed below are currently recognized as effective treatment techniques using wetpool facilities. The specific BMPs that are selected should be coordinated with the Treatment Facility Menus discussed in Chapter 3.

BMP T10.10 Wetponds - Basic and Large

Purpose and Definition

A wetpond is a constructed stormwater pond that retains a permanent pool of water ("wetpool") at least during the wet season. The volume of the wetpool is related to the effectiveness of the pond in settling particulate pollutants. As an option, a shallow marsh area can be created within the permanent pool volume to provide additional treatment for nutrient removal. Peak flow control can be provided in the "live storage" area above the permanent pool. Figures 10-1a and 1b illustrates a typical wet pond BMP.

The following design, construction, and operation and maintenance criteria cover two wetpond applications - the basic wetpond and the large wetpond. Large wetponds are designed for higher levels of pollutant removal.

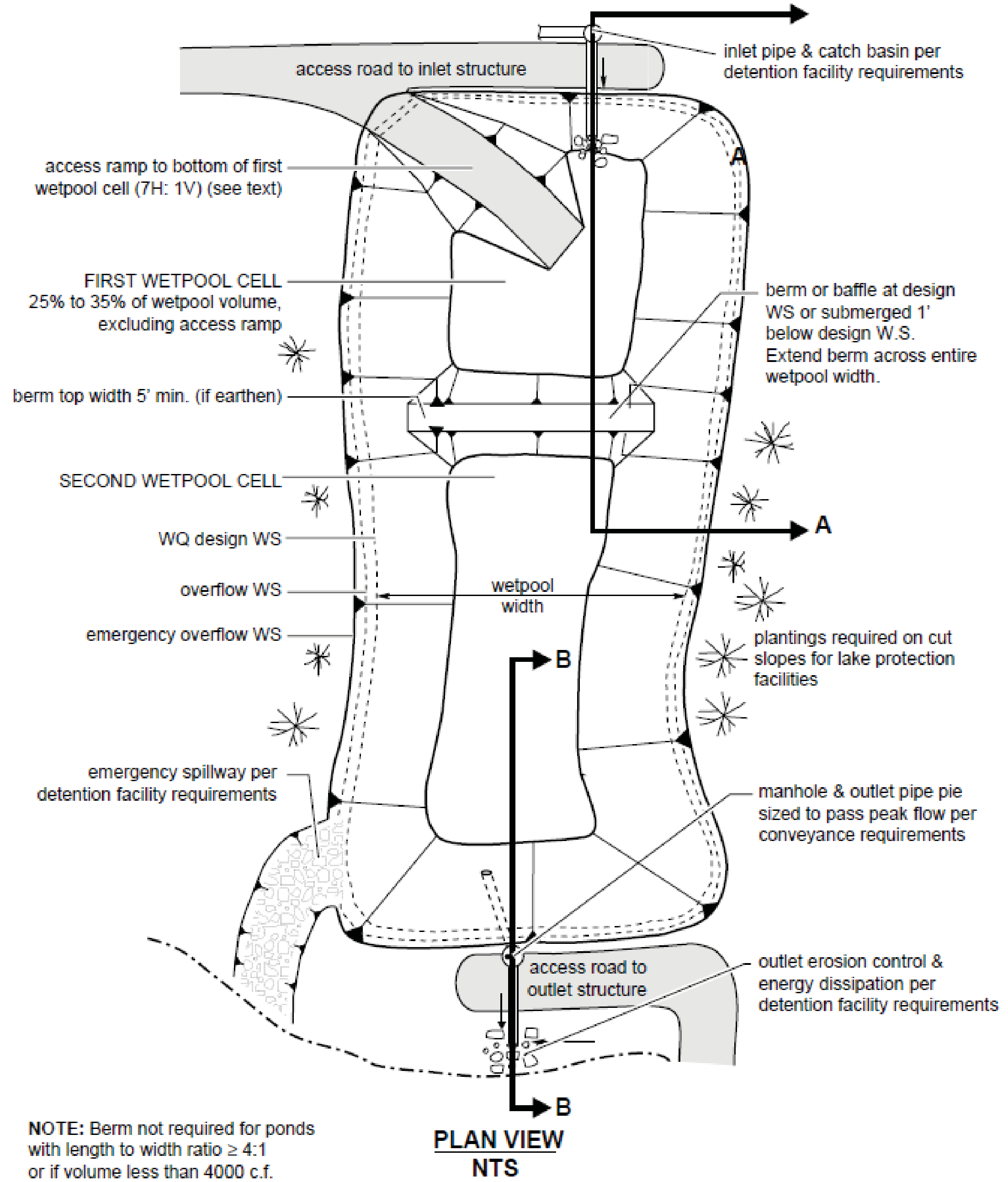
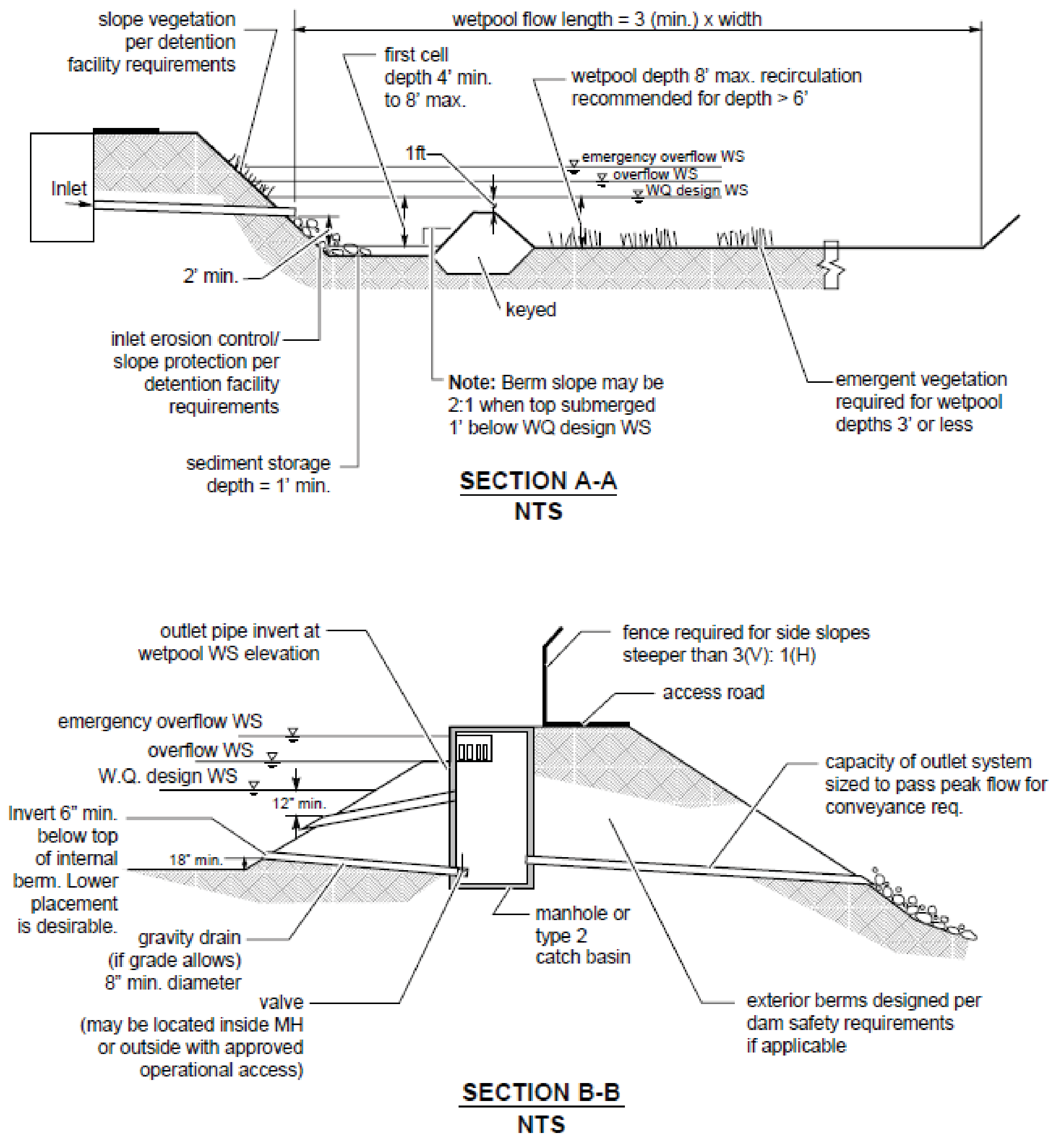


Figure 10.1a – Wetpond



NOTE: See detention facility requirements for location and setback requirements.

Figure 10.1b – Wetpond

Applications and Limitations

A wetpond requires a larger area than a biofiltration swale or a sand filter, but it can be integrated to the contours of a site fairly easily. In till soils, the wetpond holds a permanent pool of water that provides an attractive aesthetic feature. In more porous soils, wetponds may still be used, but water seepage from unlined cells could result in a dry pond, particularly in the summer months. Lining the first cell with a low permeability liner is one way to deal with this situation. As long as the first cell retains a permanent pool of water, this situation will not reduce the pond's effectiveness but may be an aesthetic drawback.

Wetponds work best when the water already in the pond is moved out en masse by incoming flows, a phenomenon called "plug flow." Because treatment works on this displacement principle, the wetpool storage of wetponds may be provided below the groundwater level without interfering unduly with treatment effectiveness. However, if combined with a detention function, the live storage must be above the seasonal high groundwater level.

Wetponds may be single-purpose facilities, providing only runoff treatment, or they may be combined with a detention pond to also provide flow control. If combined, the wetpond can often be stacked under the detention pond with little further loss of development area. See BMP T10.40 for a description of combined detention and wetpool facilities.

Design Criteria

The primary design factor that determines a wetpond's treatment efficiency is the volume of the wetpool. The larger the wetpool volume, the greater the potential for pollutant removal. For a basic wetpond, the wetpool volume provided shall be equal to or greater than the total volume of runoff from the water quality design storm - the 6-month, 24-hour storm event. **Alternatively, the 91st percentile, 24-hour runoff volume indicated by an approved continuous runoff model.**
A large wetpond requires a wetpool volume at least 1.5 times larger than the total volume of runoff from the 6-month, 24-hour storm event. Also important are the avoidance of short-circuiting and the promotion of plug flow. ***Plug flow*** describes the hypothetical condition of stormwater moving through the pond as a unit, displacing the "old" water in the pond with incoming flows. To prevent short-circuiting, water is forced to flow, to the extent practical, to all potentially available flow routes, avoiding "dead zones" and maximizing the time water stays in the pond during the active part of a storm.

Design features that encourage plug flow and avoid dead zones are:

- Dissipating energy at the inlet.
- Providing a large length-to-width ratio.
- Providing a broad surface for water exchange using a berm designed as a broad-crested weir to divide the wetpond into two cells rather than a constricted area such as a pipe.
- Maximizing the flowpath between inlet and outlet, including the vertical path, also enhances treatment by increasing residence time.

Sizing Procedure

Procedures for determining a wetpond's dimensions and volume are outlined below.

Step 1: Identify required wetpool volume using the SCS (now known as NRCS) curve number equations presented in Volume III, Chapter 2, Section 2.3.2. A basic wetpond requires a volume equal to or greater than the total volume of runoff from the 6-month, 24-hour storm event. Alternatively, use the 91st percentile, 24-hour runoff volume indicated by an approved continuous runoff model. A large wetpond requires a volume at least 1.5 times the total volume of runoff from the 6-month, 24-hour storm event, or 1.5 times the 91st percentile, 24-hour runoff volume indicated by an approved continuous runoff model.

Step 2: Determine wetpool dimensions. Determine the wetpool dimensions satisfying the design criteria outlined below and illustrated in Figures 10.1a and 10.1b. A simple way to check the volume of each wetpool cell is to use the following equation:

$$V = \frac{h(A_1 + A_2)}{2}$$

where V = wetpool volume (cf)
h = wetpool average depth (ft)
A_1 = water quality design surface area of wetpool (sf)
A_2 = bottom area of wetpool (sf)

Step 3: Design pond outlet pipe and determine primary overflow water surface. The pond outlet pipe shall be placed on a reverse grade from the pond's wetpool to the outlet structure. Use the following procedure to design the pond outlet pipe and determine the primary overflow water surface elevation:

a) Use the nomographs in Figures 10.2 and 10.3 to select a trial size for the pond outlet pipe sufficient to pass the on-line WQ design flow, Q_{wq} indicated by WWHM or other approved continuous runoff model.

b) Use Figure 10.4 to determine the critical depth d_c at the outflow end of the pipe for Q_{wq}.

c) Use Figure 10.5 to determine the flow area A_c at critical depth.

d) Calculate the flow velocity at critical depth using continuity equation ($V_c = Q_{wq} / A_c$).

e) Calculate the velocity head V_H ($V_H = V_c^2 / 2g$, where g is the gravitational constant, 32.2 feet per second).

f) Determine the primary overflow water surface elevation by adding the velocity head and critical depth to the invert elevation at the outflow end of the pond outlet pipe (i.e., overflow water surface elevation = outflow invert + d_c + V_H).

g) Adjust outlet pipe diameter as needed and repeat Steps (a) through (e).

Step 4: Determine wetpond dimensions. General wetpond design criteria and concepts are shown in Figure 10.1a and 10.1b.

Wetpool Geometry

- The wetpool shall be divided into two cells separated by a baffle or berm. The first cell shall contain between 25 to 35 percent of the total wetpool volume. The baffle or berm volume shall not count as part of the total wetpool volume. The term baffle means a vertical divider placed across the entire width of the pond, stopping short of the bottom. A berm is a vertical divider typically built up from the bottom, or if in a vault, connects all the way to the bottom.

Intent: The full-length berm or baffle promotes plug flow and enhances quiescence and laminar flow through as much of the entire water volume as possible. Alternative methods to the full-length berm or baffle that provide equivalent flow characteristics may be approved on a case-by-case basis by the Local Plan Approval Authority.

- Sediment storage shall be provided in the first cell. The sediment storage shall have a minimum depth of 1-foot. A fixed sediment depth monitor should be installed in the first cell to gauge sediment accumulation unless an alternative gauging method is proposed.
- The minimum depth of the first cell shall be 4 feet, exclusive of sediment storage requirements. The depth of the first cell may be greater than the depth of the second cell.
- The maximum depth of each cell shall not exceed 8 feet (exclusive of sediment storage in the first cell). Pool depths of 3 feet or shallower (second cell) shall be planted with emergent wetland vegetation (see Planting requirements).
- Inlets and outlets shall be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet shall be at least 3:1. The ***flowpath length*** is defined as the distance from the inlet to the outlet, as measured at mid-depth. The ***width*** at mid-depth can be found as follows: width = (average top width + average bottom width)/2.
- Wetponds with wetpool volumes less than or equal to 4,000 cubic feet may be single celled (i.e., no baffle or berm is required). However, it is especially important in this case that the flow path length be maximized. The ratio of flow path length to width shall be at least 4:1 in single celled wetponds, but should preferably be 5:1.
- All inlets shall enter the first cell. If there are multiple inlets, the length-to-width ratio shall be based on the average flowpath length for all inlets.

- The first cell may be lined in accordance with the liner requirements contained in Section 4.4.

Berms, Baffles, and Slopes

- A berm or baffle shall extend across the full width of the wetpool, and tie into the wetpond side slopes. If the berm embankments are greater than 4 feet in height, the berm must be constructed by excavating a key equal to 50 percent of the embankment cross-sectional height and width. This requirement may be waived if recommended by a geotechnical engineer for specific site conditions. The geotechnical analysis shall address situations in which one of the two cells is empty while the other remains full of water.
- The top of the berm may extend to the WQ design water surface or be 1-foot below the WQ design water surface. If at the WQ design water surface, berm side slopes should be 3H:1V. Berm side slopes may be steeper (up to 2:1) if the berm is submerged 1-foot.

  Intent: Submerging the berm is intended to enhance safety by discouraging pedestrian access when side slopes are steeper than 3H:1V. An alternative to the submerged berm design is the use of barrier planting to prevent easy access to the divider berm in an unfenced wetpond.
- If good vegetation cover is not established on the berm, erosion control measures should be used to prevent erosion of the berm back-slope when the pond is initially filled.
- The interior berm or baffle may be a retaining wall provided that the design is prepared and stamped by a licensed civil engineer. If a baffle or retaining wall is used, it should be submerged one foot below the design water surface to discourage access by pedestrians.
- Criteria for wetpond side slopes are included in Section 4.3.

Embankments

Embankments that impound water must comply with the Washington State Dam Safety Regulations (Chapter 173-175 WAC). If the impoundment has a storage capacity (including both water and sediment storage volumes) greater than 10 acre-feet (435,600 cubic feet or 3.26 million gallons) above natural ground level, then dam safety design and review are required by the Department of Ecology. See Section 3.2.1 of Volume III.

Inlet and Outlet

See Figure 10.1a and 10.1b for details on the following requirements:

- The inlet to the wetpond shall be submerged with the inlet pipe invert a minimum of two feet from the pond bottom (not including sediment storage). The top of the inlet pipe should be submerged at least 1-foot, if possible.

Intent: The inlet is submerged to dissipate energy of the incoming flow. The distance from the bottom is set to minimize resuspension of settled sediments. Alternative inlet designs that accomplish these objectives are acceptable.

- An outlet structure shall be provided. Either a Type 2 catch basin with a grated opening (jail house window) or a manhole with a cone grate (birdcage) may be used (see Volume III, Figure 3.11 for an illustration). No sump is required in the outlet structure for wetponds not providing detention storage. The outlet structure receives flow from the pond outlet pipe. The grate or birdcage openings provide an overflow route should the pond outlet pipe become clogged. The overflow criteria provided below specifies the sizing and position of the grate opening.

- The pond outlet pipe (as opposed to the manhole or type 2 catch basin outlet pipe) shall be back-sloped or have a turn-down elbow, and extend 1 foot below the WQ design water surface. Note: A floating outlet, set to draw water from 1-foot below the water surface, is also acceptable if vandalism concerns are adequately addressed.

  Intent: The inverted outlet pipe provides for trapping of oils and floatables in the wetpond.

- The pond outlet pipe shall be sized, at a minimum, to pass the on-line WQ design flow. Note: The highest invert of the outlet pipe sets the WQ design water surface elevation.

- The overflow criteria for single-purpose (treatment only, not combined with flow control) wetponds are as follows:

  a) The requirement for primary overflow is satisfied by either the grated inlet to the outlet structure or by a birdcage above the pond outlet structure.

  b) The bottom of the grate opening in the outlet structure shall be set at or above the height needed to pass the WQ design flow through the pond outlet pipe. *Note: The grate invert elevation sets the overflow water surface elevation.*

  c) The grated opening should be sized to pass the 100-year design flow. The capacity of the outlet system should be sized to pass the peak flow for the conveyance requirements.

- An emergency spillway shall be provided and designed according to the requirements for detention ponds (see Section 3.2.1 of Volume III).

- The Local Plan Approval Authority may require a bypass/ shutoff valve to enable the pond to be taken offline for maintenance purposes.

- A gravity drain for maintenance is recommended if grade allows.

Intent: It is anticipated that sediment removal will only be needed for the first cell in the majority of cases. The gravity drain is intended to allow water from the first cell to be drained to the second cell when the first cell is pumped dry for cleaning.

- The drain invert shall be at least 6 inches below the top elevation of the dividing berm or baffle. Deeper drains are encouraged where feasible, but must be no deeper than 18 inches above the pond bottom.

  Intent: To prevent highly sediment-laden water from escaping the pond when drained for maintenance.

- The drain shall be at least 8 inches (minimum) diameter and shall be controlled by a valve. Use of a shear gate is allowed only at the inlet end of a pipe located within an approved structure.

  Intent: Shear gates often leak if water pressure pushes on the side of the gate opposite the seal. The gate should be situated so that water pressure pushes toward the seal.

- Operational access to the valve shall be provided to the finished ground surface.
- The valve location shall be accessible and well-marked with 1-foot of paving placed around the box. It must also be protected from damage and unauthorized operation.
- A valve box is allowed to a maximum depth of 5 feet without an access manhole. If over 5 feet deep, an access manhole or vault is required.
- All metal parts shall be corrosion-resistant. Galvanized materials should not be used unless unavoidable.

  Intent: Galvanized metal contributes zinc to stormwater, sometimes in very high concentrations.

Access and Setbacks

- All facilities shall be a minimum of 20 feet from any structure, property line, and any vegetative buffer required by the local government, and 100 feet from any septic tank/drainfield.
- All facilities shall be a minimum of 50 feet from any steep (greater than 15 percent) slope. A geotechnical report must address the potential impact of a wet pond on a steep slope.
- Access and maintenance roads shall be provided and designed according to the requirements for detention ponds. Access and maintenance roads shall extend to both the wetpond inlet and outlet structures. An access ramp (7H minimum:1V) shall be provided to the bottom of the first cell unless all portions of the cell can be reached and sediment loaded from the top of the pond.

- If the dividing berm is also used for access, it should be built to sustain loads of up to 80,000 pounds.

Planting Requirements

Planting requirements for detention ponds also apply to wetponds.

- Large wetponds intended for phosphorus control should not be planted within the cells, as the plants will release phosphorus in the winter when they die off.
- If the second cell of a basic wetpond is 3 feet or shallower, the bottom area shall be planted with emergent wetland vegetation. See Table 10.1 for recommended emergent wetland plant species for wetponds. Intent: Planting of shallow pond areas helps to stabilize settled sediment and prevent resuspension.

Note: The recommendations in Table 10.1 are for western Washington only. Local knowledge should be used to adapt this information if used in other areas.

- Cattails (Typha latifolia) are not recommended because they tend to crowd out other species and will typically establish themselves anyway.
- If the wetpond discharges to a phosphorus-sensitive lake or wetland, shrubs that form a dense cover should be planted on slopes above the WQ design water surface on at least three sides. For banks that are berms, no planting is allowed if the berm is regulated by dam safety requirements. The purpose of planting is to discourage waterfowl use of the pond and to provide shading. Some suitable trees and shrubs include vine maple (Acer circinatum), wild cherry (Prunus emarginata), red osier dogwood (Cornus stolonifera), California myrtle (Myrica californica), Indian plum (Oemleria cerasiformis), and Pacific yew (Taxus brevifolia) as well as numerous ornamental species.

Recommended Design Features

The following design features should be incorporated into the wetpond design where site conditions allow:

- The method of construction of soil/landscape systems can cause natural selection of specific plant species. Consult a soil restoration or wetland soil scientist for site-specific recommendations. The soil formulation will impact the plant species that will flourish or suffer on the site, and the formulation should be such that it encourages desired species and discourages undesired species.
- For wetpool depths in excess of 6 feet, it is recommended that some form of recirculation be provided in the summer, such as a fountain or aerator, to prevent stagnation and low dissolved oxygen conditions.

- A flow length-to-width ratio greater than the 3:1 minimum is desirable. If the ratio is 4:1 or greater, then the dividing berm is not required, and the pond may consist of one cell rather than two. A one-cell pond must provide at least 6-inches of sediment storage depth.
- A tear-drop shape, with the inlet at the narrow end, rather than a rectangular pond is preferred since it minimizes dead zones caused by corners.
- A small amount of base flow is desirable to maintain circulation and reduce the potential for low oxygen conditions during late summer.
- Evergreen or columnar deciduous trees along the west and south sides of ponds are recommended to reduce thermal heating, except that no trees or shrubs may be planted on berms meeting the criteria of dams regulated for safety. In addition to shade, trees and shrubs also discourage waterfowl use and the attendant phosphorus enrichment problems they cause. Trees should be set back so that the branches will not extend over the pond.

  Intent: Evergreen trees or shrubs are preferred to avoid problems associated with leaf drop. Columnar deciduous trees (e.g., hornbeam, Lombardy poplar, etc.) typically have fewer leaves than other deciduous trees.
- The number of inlets to the facility should be limited; ideally there should be only one inlet. The flowpath length should be maximized from inlet to outlet for all inlets to the facility.
- The access and maintenance road could be extended along the full length of the wetpond and could double as playcourts or picnic areas. Placing finely ground bark or other natural material over the road surface would render it more pedestrian friendly.
- The following design features should be incorporated to enhance aesthetics where possible:
  - Provide pedestrian access to shallow pool areas enhanced with emergent wetland vegetation. This allows the pond to be more accessible without incurring safety risks.
  - Provide side slopes that are sufficiently gentle to avoid the need for fencing (3:1 or flatter).
  - Create flat areas overlooking or adjoining the pond for picnic tables or seating that can be used by residents. Walking or jogging trails around the pond are easily integrated into site design.
  - Include fountains or integrated waterfall features for privately maintained facilities.
  - Provide visual enhancement with clusters of trees and shrubs. On most pond sites, it is important to amend the soil before planting since ponds are typically placed well below the native soil horizon

in very poor soils. Make sure dam safety restrictions against planting do not apply.

  - Orient the pond length along the direction of prevailing summer winds (typically west or southwest) to enhance wind mixing.

Construction Criteria

- Sediment that has accumulated in the pond must be removed after construction in the drainage area of the pond is complete (unless used for a liner - see below).

- Sediment that has accumulated in the pond at the end of construction may be used in excessively drained soils to meet the liner requirements if the sediment meets the criteria for low permeability or treatment liners in keeping with guidance in Chapter 4. Sediment used for a soil liner must be graded to provide uniform coverage and must meet the thickness specifications in Chapter 4. The sediment must not reduce the design volume of the pond. The pond must be over-excavated initially to provide sufficient room for the sediments to serve as a liner.

Operation and Maintenance

- Maintenance is of primary importance if wetponds are to continue to function as originally designed. A local government, a designated group such as a homeowners' association, or a property owner shall accept the responsibility for maintaining the structures and the impoundment area. A specific maintenance plan shall be formulated outlining the schedule and scope of maintenance operations.

- The pond should be inspected by the local government annually. The maintenance standards contained in Section 4.6 are measures for determining if maintenance actions are required as identified through the annual inspection.

- Site vegetation should be trimmed as necessary to keep the pond free of leaves and to maintain the aesthetic appearance of the site. Slope areas that have become bare should be revegetated and eroded areas should be regraded prior to being revegetated.

- Sediment should be removed when the 1-foot sediment zone is full plus 6 inches. Sediments should be tested for toxicants in compliance with current disposal requirements. Sediments must be disposed in accordance with current local health department requirements and the Minimum Functional Standards for Solid Waste Handling. See Volume IV, Appendix IV-G Recommendations for Management of Street Waste for additional guidance.

- Any standing water removed during the maintenance operation must be properly disposed of. The preferred disposal option is discharge to a sanitary sewer at an approved location. Other disposal options include discharge back into the wetpool facility or the storm sewer system if certain conditions are met. See Volume IV, Appendix IV-G for additional guidance.

Table 10.1 – Emergent Wetland Plant Species Recommended for Wetponds			
Species	**Common Name**	**Notes**	**Maximum Depth**
INUNDATION TO 1-FOOT			
Agrostis exarata[(1)]	Spike bent grass	Prairie to coast	to 2 feet
Carex stipata	Sawbeak sedge	Wet ground	
Eleocharis palustris	Spike rush	Margins of ponds, wet meadows	to 2 feet
6.1.1.1.1.1.1.1 Glyceria occidentalis	Western mannagrass	Marshes, pond margins	to 2 feet
Juncus tenuis	Slender rush	Wet soils, wetland margins	
Oenanthe sarmentosa	Water parsley	Shallow water along stream and pond margins; needs saturated soils all summer	
Scirpus atrocinctus (formerly S. cyperinus)	Woolgrass	Tolerates shallow water; tall clumps	
Scirpus microcarpus	Small-fruited bulrush	Wet ground to 18 inches depth	18 inches
Sagittaria latifolia	Arrowhead		
INUNDATION 1 TO 2 FEET			
Agrostis exarata[(1)]	Spike bent grass	Prairie to coast	
Alisma plantago-aquatica	Water plantain		
Eleocharis palustris	Spike rush	Margins of ponds, wet meadows	
Glyceria occidentalis	Western mannagrass	Marshes, pond margins	
Juncus effusus	Soft rush	Wet meadows, pastures, wetland margins	
Scirpus microcarpus	Small-fruited bulrush	Wet ground to 18 inches depth	18 inches
Sparganium emmersum	Bur reed	Shallow standing water, saturated soils	
INUNDATION 1 TO 3 FEET			
Carex obnupta	Slough sedge	Wet ground or standing water	1.5 to 3 feet
Beckmania syzigachne[(1)]	Western sloughgrass	Wet prairie to pond margins	
Scirpus acutus[(2)]	Hardstem bulrush	Single tall stems, not clumping	to 3 feet
Scirpus validus[(2)]	Softstem bulrush		
INUNDATION GREATER THAN 3 FEET			
Nuphar polysepalum	Spatterdock	Deep water	3 to 7.5 feet
Nymphaea odorata[(1)]	White waterlily	Shallow to deep ponds	to 6 feet

Notes:

(1) Non-native species. *Beckmania syzigachne* is native to Oregon. Native species are preferred.

(2) *Scirpus* tubers must be planted shallower for establishment, and protected from foraging waterfowl until established. Emerging aerial stems should project above water surface to allow oxygen transport to the roots.

Primary sources: Municipality of Metropolitan Seattle, *Water Pollution Control Aspects of Aquatic Plants*, 1990. Hortus Northwest, *Wetland Plants for Western Oregon*, Issue 2, 1991. Hitchcock and Cronquist, *Flora of the Pacific Northwest*, 1973.

2005 SWMM BMP T10.40 Combined Detention Wetpond
pp 10-34 to 10-40, Volume 5

BMP T10.40 Combined Detention and Wetpool Facilities

Purpose and Definition

Combined detention and WQ wetpool facilities have the appearance of a detention facility but contain a permanent pool of water as well. The following design procedures, requirements, and recommendations cover differences in the design of the stand-alone WQ facility when combined with detention storage. The following combined facilities are addressed:

- Detention/wetpond (basic and large)
- Detention/wetvault
- Detention/stormwater wetland.

There are two sizes of the combined wetpond, a basic and a large, but only a basic size for the combined wetvault and combined stormwater wetland. The facility sizes (basic and large) are related to the pollutant removal goals. See Chapter 3 for more information about treatment performance goals.

Applications and Limitations

Combined detention and water quality facilities are very efficient for sites that also have detention requirements. The water quality facility may often be placed beneath the detention facility without increasing the facility surface area. However, the fluctuating water surface of the live storage will create unique challenges for plant growth and for aesthetics alike.

The basis for pollutant removal in combined facilities is the same as in the stand-alone WQ facilities. However, in the combined facility, the detention function creates fluctuating water levels and added turbulence. For simplicity, the positive effect of the extra live storage volume and the negative effect of increased turbulence are assumed to balance, and are thus ignored when sizing the wetpool volume. For the combined detention/stormwater wetland, criteria that limit the extent of water level fluctuation are specified to better ensure survival of the wetland plants.

Unlike the wetpool volume, the live storage component of the facility should be provided above the seasonal high water table.

Combined Detention and Wetpond (Basic and Large)

Typical design details and concepts for a combined detention and wetpond are shown in Figures 10.9 and 10.10. The detention portion of the facility shall meet the design criteria and sizing procedures set forth in Volume 3.

Sizing Procedure

The sizing procedure for combined detention and wetponds are identical to those outlined for wetponds and for detention facilities. The wetpool volume for a combined facility shall be equal to or greater than the total volume of runoff from the 6-month, 24-hour storm event. Alternatively, the 91st percentile, 24-hour runoff volume estimated by an approved continuous runoff model may be used to size the wetpool. Follow the standard procedure specified in Volume III to size the detention portion of the pond.

Detention and Wetpool Geometry

- The wetpool and sediment storage volumes shall not be included in the required detention volume.
- The "Wetpool Geometry" criteria for wetponds (see BMP T10.10) shall apply with the following modifications/clarifications:

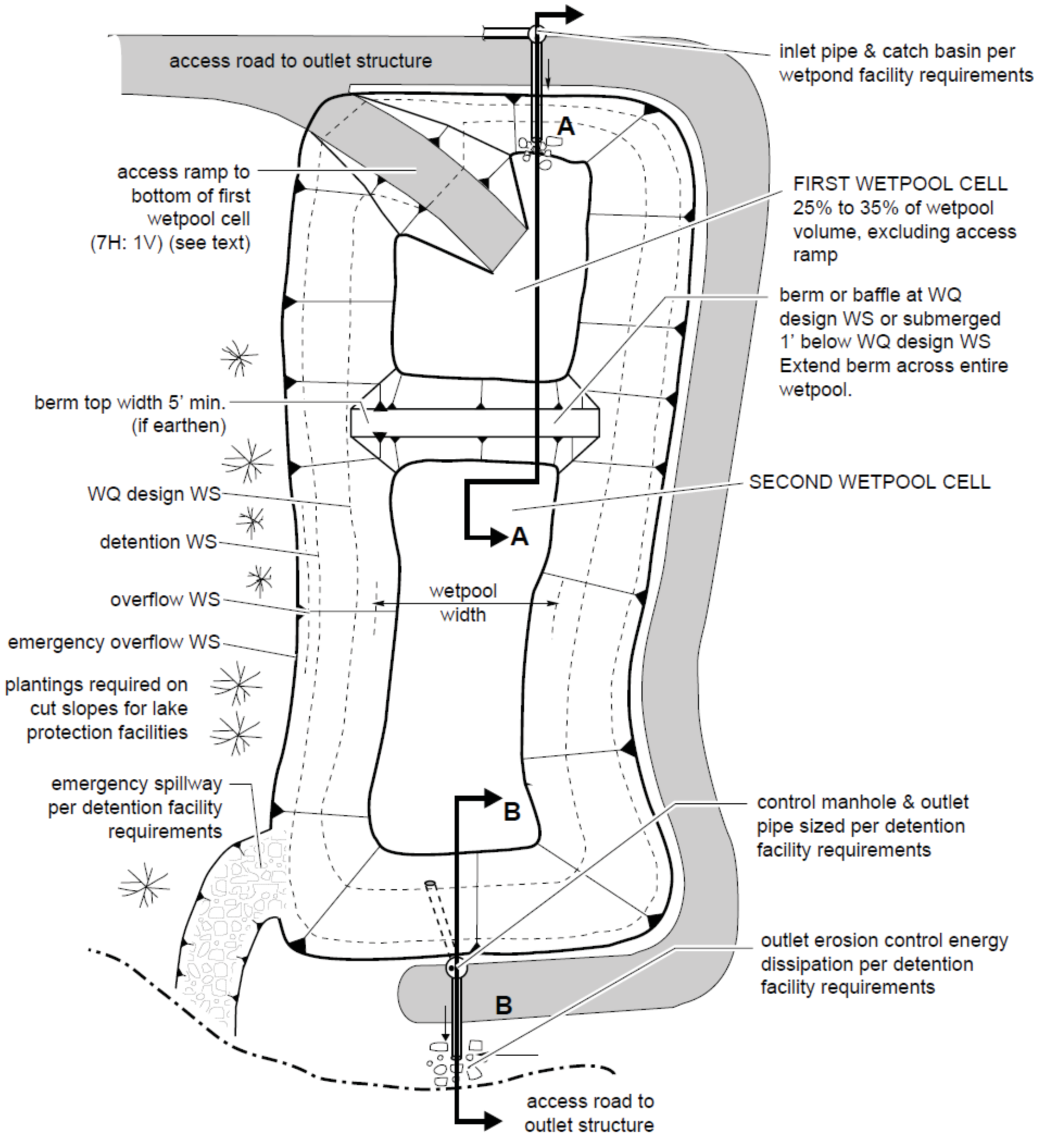
Criterion 1: The permanent pool may be made shallower to take up most of the pond bottom, or deeper and positioned to take up only a limited portion of the bottom. Note, however, that having the first wetpool cell at the inlet allows for more efficient sediment management than if the cell is moved away from the inlet. Wetpond criteria governing water depth must, however, still be met. See Figure 10.11 for two possibilities for wetpool cell placement.

Intent: This flexibility in positioning cells is provided to allow for multiple use options, such as volleyball courts in live storage areas in the drier months.

Criterion 2: The minimum sediment storage depth in the first cell is 1-foot. The 6 inches of sediment storage required for detention ponds does not need to be added to this, but 6 inches of sediment storage must be added to the second cell to comply with the detention sediment storage requirement.

Berms, Baffles, and Slopes

Same as for wetponds (see BMP T10.10).



PLAN VIEW
NTS

Figure 10.9 – Combined Detention and Wetpond

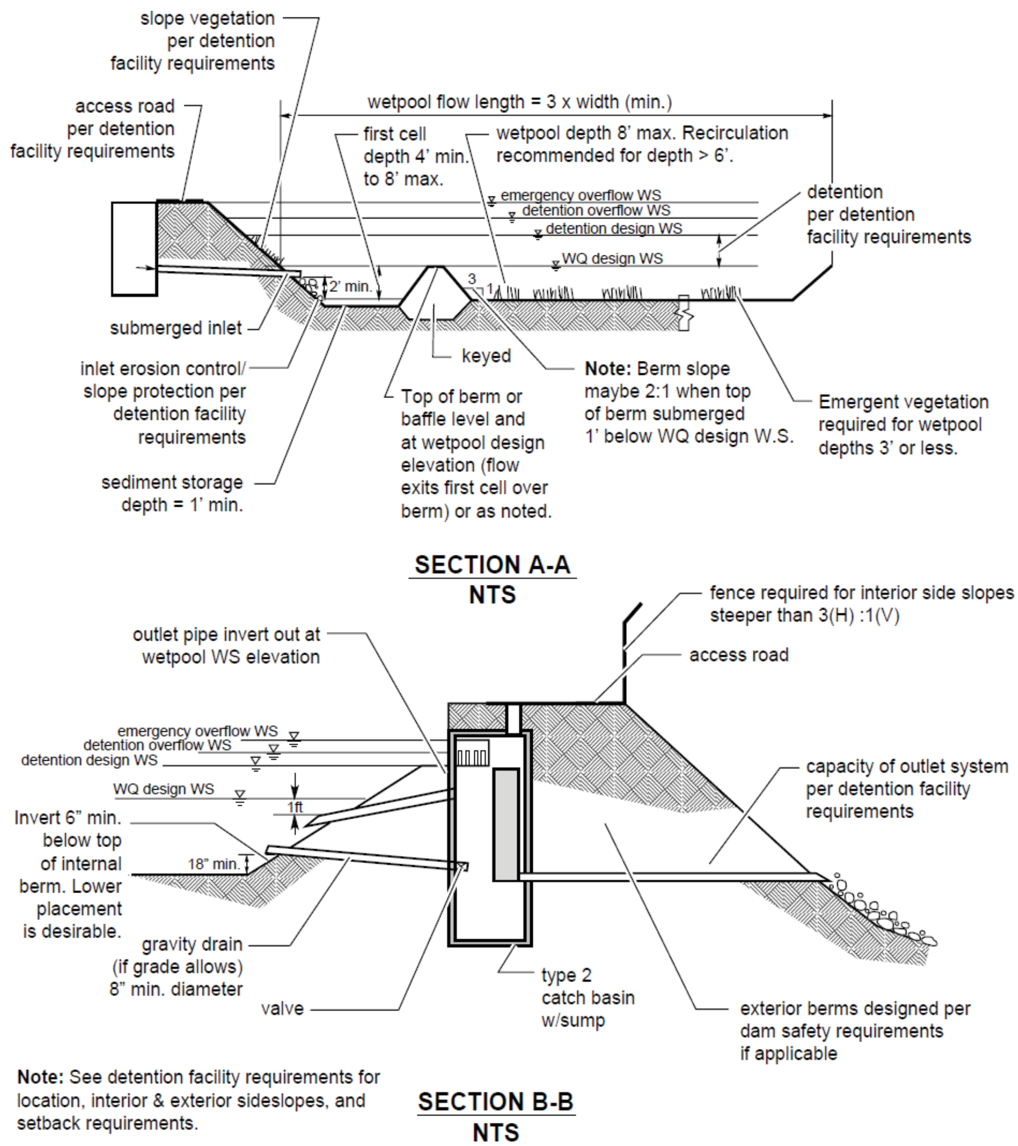
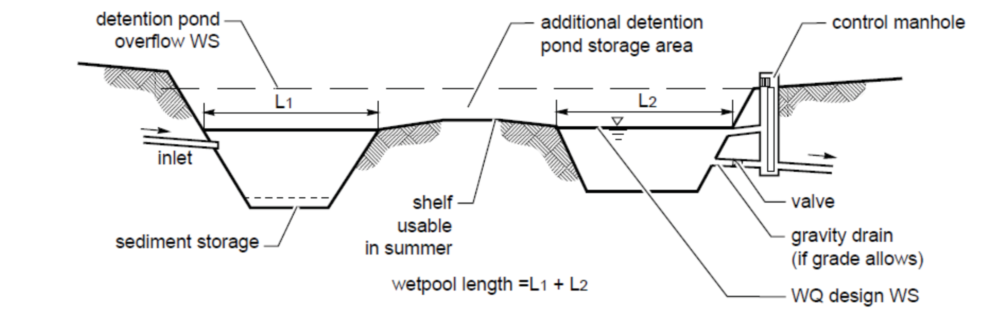
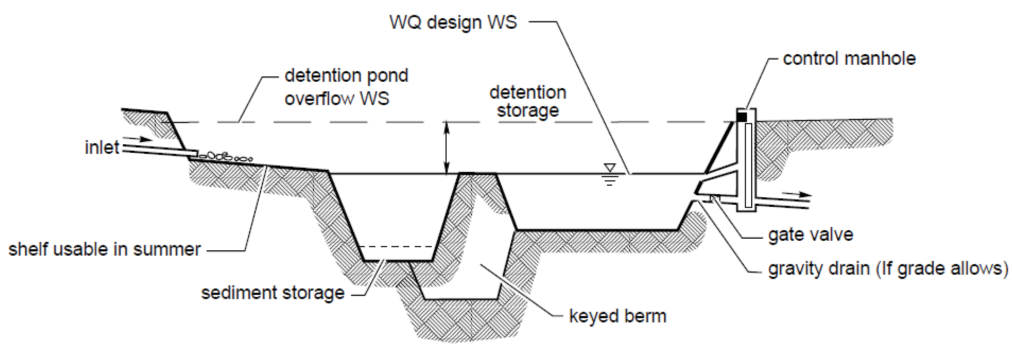


Figure 10.10 – Combined Detention and Wetpond (Continued)



SECTION VIEW
NTS



SECTION VIEW
NTS

Note: These examples show how the combined detention/wetpool can be configured to allow for "shelves" for joint use opportunities in dry weather. Other options may also be acceptable.

Figure 10.11 – Alternative Configurations of Detention and Wetpool Areas

Inlet and Outlet

The "Inlet and Outlet" criteria for wetponds shall apply with the following modifications:

- A sump must be provided in the outlet structure of combined ponds.
- The detention flow restrictor and its outlet pipe shall be designed according to the requirements for detention ponds (see Volume III).

Access and Setbacks

Same as for wetponds.

Planting Requirements

Same as for wetponds.

Combined Detention and Wetvault

The sizing procedure for combined detention and wetvaults is identical to those outlined for wetvaults and for detention facilities. The wetvault volume for a combined facility shall be equal to or greater than the total volume of runoff from the 6-month, 24-hour storm event. Alternatively, the 91st percentile, 24-hour runoff volume estimated by an approved continuous runoff model may be used to size the wetpool portion of vault. Follow the standard procedure specified in Volume 3 to size the detention portion of the vault.

The design criteria for detention vaults and wetvaults must both be met, except for the following modifications or clarifications:

- The minimum sediment storage depth in the first cell shall average 1-foot. The 6 inches of sediment storage required for detention vaults does not need to be added to this, but 6 inches of sediment storage must be added to the second cell to comply with detention vault sediment storage requirements.
- The oil retaining baffle shall extend a minimum of 2 feet below the WQ design water surface.

<u>Intent:</u> The greater depth of the baffle in relation to the WQ design water surface compensates for the greater water level fluctuations experienced in the combined vault. The greater depth is deemed prudent to better ensure that separated oils remain within the vault, even during storm events.

Note: If a vault is used for detention as well as water quality control, the facility may not be modified to function as a baffle oil/water separator as allowed for wetvaults in BMP T10.20. This is because the added pool fluctuation in the combined vault does not allow for the quiescent conditions needed for oil separation.

Combined Detention and Stormwater Wetland

The sizing procedure for combined detention and stormwater wetlands is identical to those outlined for stormwater wetlands and for detention facilities. Follow the procedure specified in BMP T10.30 to determine the stormwater wetland size. Follow the standard procedure specified in Volume III to size the detention portion of the wetland.

The design criteria for detention ponds and stormwater wetlands must both be met, except for the following modifications or clarifications:

- The "Wetland Geometry" criteria for stormwater wetlands (see BMP T10.30) are modified as follows:
- The minimum sediment storage depth in the first cell is 1-foot. The 6 inches of sediment storage required for detention ponds does not need to be added to this, nor does the 6 inches of sediment storage in the second cell of detention ponds need to be added.

Intent: Since emergent plants are limited to shallower water depths, the deeper water created before sediments accumulate is considered detrimental to robust emergent growth. Therefore, sediment storage is confined to the first cell which functions as a presettling cell.

The "Inlet and Outlet" criteria for wetponds shall apply with the following modifications:

- A sump must be provided in the outlet structure of combined facilities.
- The detention flow restrictor and its outlet pipe shall be designed according to the requirements for detention ponds (see Volume III).

  The "Planting Requirements" for stormwater wetlands are modified to use the following plants which are better adapted to water level fluctuations:

Scirpus acutus (hardstem bulrush)	2 - 6' depth
Scirpus microcarpus (small-fruited bulrush)	1 - 2.5' depth
Sparganium emersum (burreed)	1 - 2' depth
Sparganium eurycarpum (burreed)	1 - 2' depth
Veronica sp. (marsh speedwell)	0 - 1' depth

  In addition, the shrub Spirea douglasii (Douglas spirea) may be used in combined facilities.

  Water Level Fluctuation Restrictions: The difference between the WQ design water surface and the maximum water surface associated with the 2-year runoff shall not be greater than 3 feet. If this restriction cannot be met, the size of the stormwater wetland must be increased. The additional area may be placed in the first cell, second cell, or both. If placed in the second cell, the additional area need not be planted with wetland vegetation or counted in calculating the average depth.

Intent: This criterion is designed to dampen the most extreme water level fluctuations expected in combined facilities to better ensure that fluctuation-tolerant wetland plants will be able to survive in the facility. It is not intended to protect native wetland plant communities and is not to be applied to natural wetlands.

2005 SWMM BMP T5.10 Downspout Dispersion
pp 5-3 to 5-8, Figure 5.1, 5.2, and 5.3

5.3.1 Dispersion and Soil Quality BMPs (Required for Manual Equivalency)

The following BMPs pertain to dispersion and soil quality applications.

BMP T5.10 Downspout Dispersion

Purpose and Definition

Downspout dispersion BMPs are splashblocks or gravel-filled trenches that serve to spread roof runoff over vegetated pervious areas. Dispersion attenuates peak flows by slowing entry of the runoff into the conveyance system, allows for some infiltration, and provides some water quality benefits.

Applications and Limitations

- Downspout dispersion is required on all subdivision single family lots which meet one of the following criteria:
  1. Lots greater than or equal to 22,000 square feet where downspout infiltration is not being provided according to the requirements in Volume III, Chapter 3.
  2. Lots smaller than 22,000 square feet where soils are not suitable for downspout infiltration as determined in Volume III, Chapter 3 and where the design criteria below can be met.
- All other projects required to apply Roof Downspout BMPs must provide downspout dispersion if downspout infiltration is not feasible or applicable as determined in Volume III, Chapter 3, and if the design criteria below can be met.

Flow Credit for Roof Downspout Dispersion

If roof runoff is dispersed according to the requirements of this section on single-family lots greater than 22,000 square feet, and the *vegetative flow*path• is 50 feet or larger through undisturbed native landscape or lawn/landscape area that meets BMP T5.13, the designer may click on the "Credits" button in the WWHM and enter the percent of roof area that is being dispersed.

General Design Guidelines

- Dispersion trenches designed as shown in the Figures 5.1 and 5.2 shall be used for all downspout dispersion applications except where

---

Vegetative flow path is measured from the downspout or dispersion system discharge point to the downstream property line, stream, wetland, or other impervious surface.

splashblocks are allowed below. See Figure 5.3 for a typical splashblock.

- Splashblocks may be used for downspouts discharging to a vegetated flowpath at least 50 feet in length as measured from the downspout to the downstream property line, structure, sensitive steep slope, stream, wetland, or other impervious surface. Sensitive area buffers may count toward flowpath lengths. The vegetated flowpath must be covered with well-established lawn or pasture, landscaping with well-established groundcover, or native vegetation with natural groundcover. The groundcover shall be dense enough to help disperse and infiltrate flows and to prevent erosion.
- If the vegetated flowpath (measured as defined above) is less than 25 feet on a subdivision single-family lot, a perforated stub-out connection may be used in lieu of downspout dispersion (See Volume III, Chapter 3). A perforated stub-out may also be used where implementation of downspout dispersion might cause erosion or flooding problems, either on site or on adjacent lots. This provision might be appropriate, for example, for lots constructed on steep hills where downspout discharge could be cumulative and might pose a potential hazard for lower lying lots, or where dispersed flows could create problems for adjacent offsite lots. This provision does not apply to situations where lots are flat and onsite downspout dispersal would result in saturated yards.

  Note: For all other types of projects, the use of a perforated stub-out in lieu of downspout dispersion shall be as determined by the Local Plan Approval Authority.

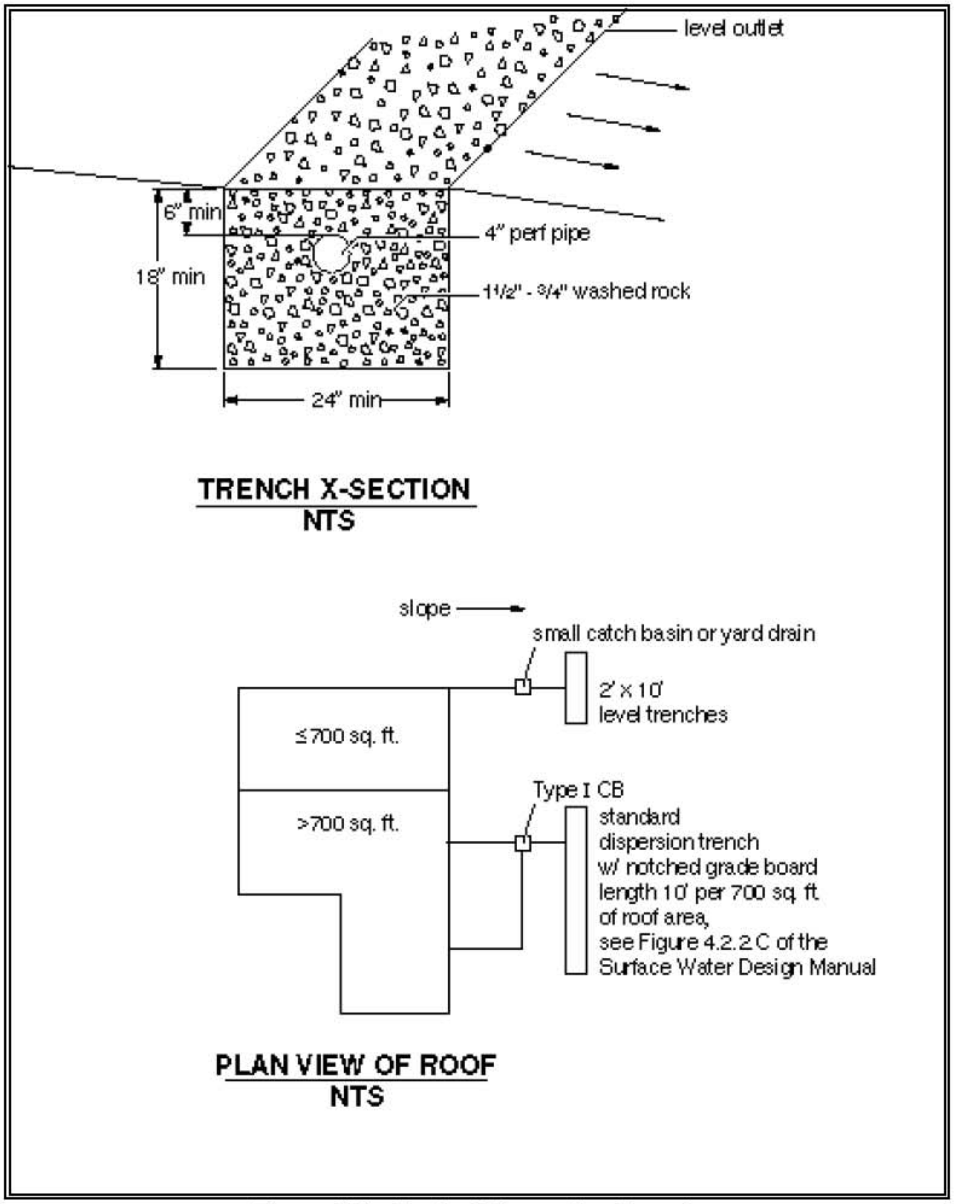


Figure 5.1 – Typical Dispersion Trench

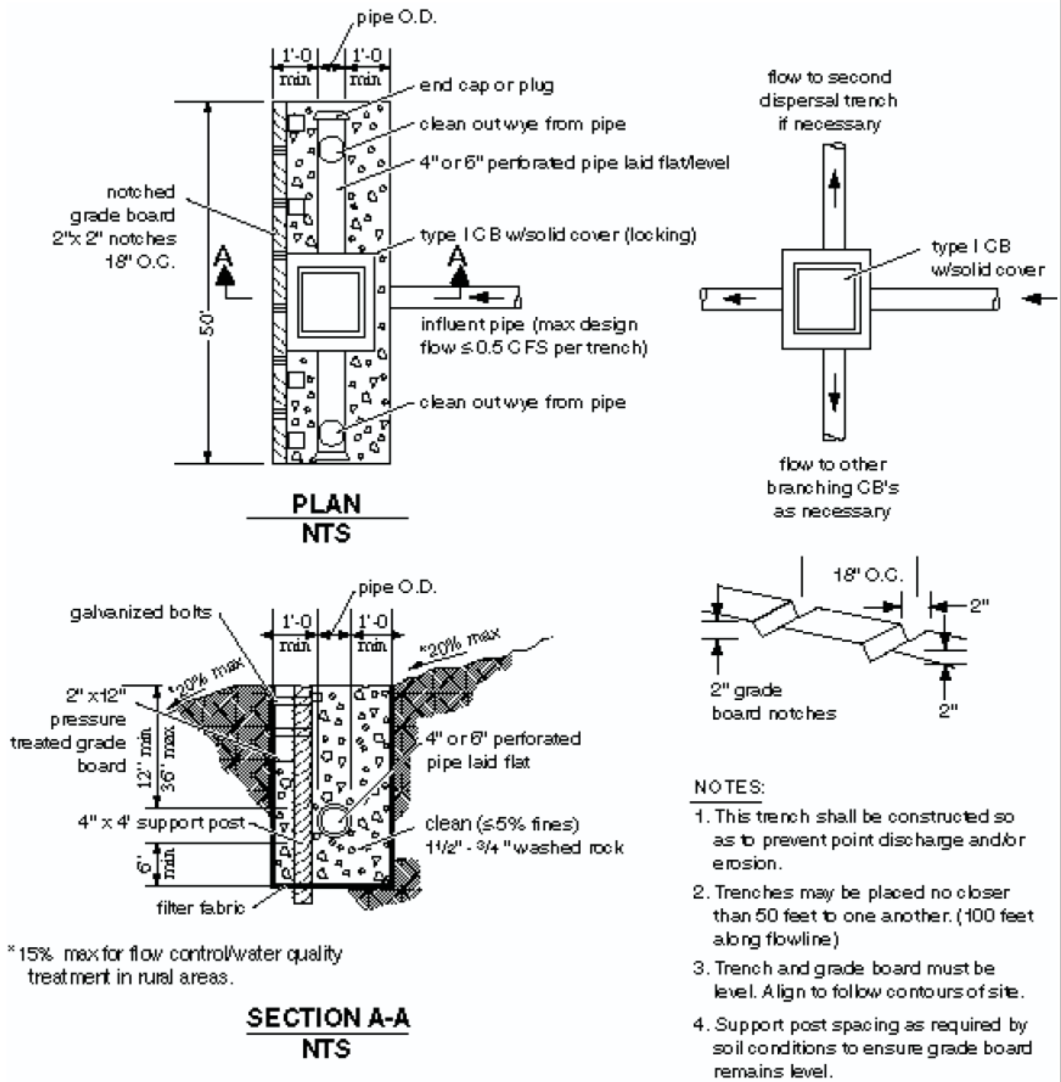


Figure 5.2 – Standard Dispersion Trench with Notched Grade Board

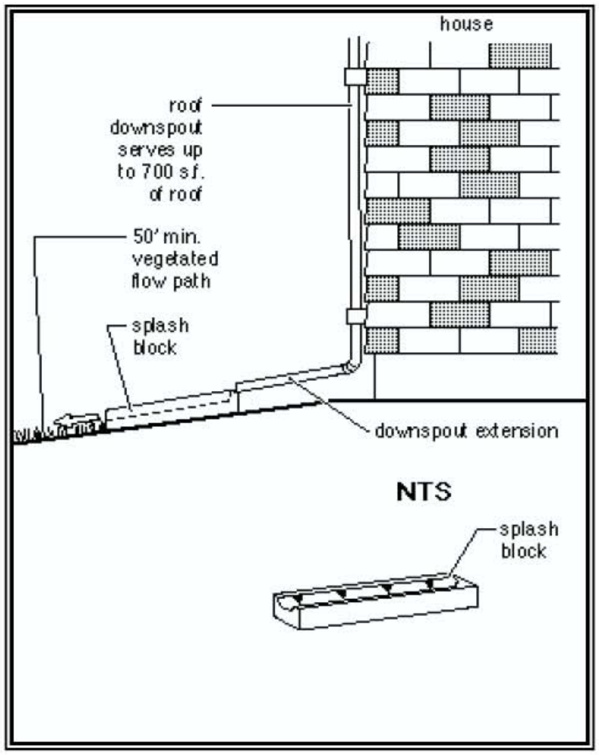


Figure 5.3 – Typical Downspout Splashblock Dispersion

Additional Design Criteria for Dispersion Trenches

- A vegetated flowpath of at least 25 feet in length must be maintained between the outlet of the trench and any property line, structure, stream, wetland, or impervious surface. A vegetated flowpath of at least 50 feet in length must be maintained between the outlet of the trench and any steep slope. Sensitive area buffers may count towards flowpath lengths.
- Trenches serving up to 700 square feet of roof area may be simple 10-foot-long by 2-foot wide gravel filled trenches as shown on Figure 5-1. For roof areas larger than 700 square feet, a dispersion trench with notched grade board as shown in Figure 5-2 may be used as approved by the Local Plan Approval Authority. The total length of this design must provide at least 10 feet of trench per 700 square feet of roof area and not exceed 50 feet.
- A setback of at least 5 feet must be maintained between any edge of the trench and any structure or property line.
- No erosion or flooding of downstream properties may result.

- Runoff discharged towards landslide hazard areas must be evaluated by a geotechnical engineer or qualified geologist. The discharge point may not be placed on or above slopes greater than 20% or above erosion hazard areas without evaluation by a geotechnical engineer or qualified geologist and jurisdiction approval.
- For sites with septic systems, the discharge point must be downgradient of the drainfield primary and reserve areas. This requirement can be waived by the jurisdiction's permit review staff if site topography will clearly prohibit flows from intersecting the drainfield.

Additional Design Criteria for Splashblocks

In general, if the ground is sloped away from the foundation, and there is adequate vegetation and area for effective dispersion, splashblocks will adequately disperse storm runoff. If the ground is fairly level, if the structure includes a basement, or if foundation drains are proposed, splashblocks with downspout extensions may be a better choice because the discharge point is moved away from the foundation. Downspout extensions can include piping to a splashblock/discharge point a considerable distance from the downspout, as long as the runoff can travel through a well-vegetated area as described below.

The following conditions must be met to use splashblocks:

- A vegetated flowpath of at least 50 feet must be maintained between the discharge point and any property line, structure, steep slope, stream, wetland, lake, or other impervious surface. Sensitive area buffers may count toward flowpath lengths.
- A maximum of 700 square feet of roof area may drain to each splashblock.
- A splashblock or a pad of crushed rock (2 feet wide by 3 feet long by 6 inches deep) shall be placed at each downspout discharge point.
- No erosion or flooding of downstream properties may result.
- Runoff discharged towards landslide hazard areas must be evaluated by a geotechnical engineer or qualified geologist. Splashblocks may not be placed on or above slopes greater than 20% or above erosion hazard areas without evaluation by a geotechnical engineer or qualified geologist and approval by the Local Plan Approval Authority.
- For sites with septic systems, the discharge point must be downslope of the primary and reserve drainfield areas. This requirement can be waived by the Local Plan Approval Authority if site topography clearly prohibits flows from intersecting the drainfield.

2005 SWMM BMP T5.12 Sheet Flow Dispersion
pp 5-11 to 5-12, Figure 5.5

BMP T5.12 Sheet Flow Dispersion

Purpose and Definition

Sheet flow dispersion is the simplest method of runoff control. This BMP can be used for any impervious or pervious surface that is graded so as to avoid concentrating flows. Because flows are already dispersed as they leave the surface, they need only traverse a narrow band of adjacent vegetation for effective attenuation and treatment.

Applications and Limitations

Flat or moderately sloping (<15% slope) impervious surfaces such as driveways, sport courts, patios, and roofs without gutters; sloping cleared areas that are comprised of bare soil, non-native landscaping, lawn, and/or pasture; or any situation where concentration of flows can be avoided.

Design Guidelines

- See Figure 5.5 for details for driveways.
- A 2-foot-wide transition zone to discourage channeling should be provided between the edge of the driveway pavement and the downslope vegetation, or under building eaves. This may be an extension of subgrade material (crushed rock), modular pavement, drain rock, or other material acceptable to the Local Plan Approval Authority.
- A vegetated buffer width of 10 feet of vegetation must be provided for up to 20 feet of width of paved or impervious surface. An additional 5 feet of width must be added for each addition 20 feet of width or fraction thereof.
- A vegetated buffer width of 25 feet of vegetation must be provided for up to 150 feet of contributing cleared area (i.e., bare soil, non-native landscaping, lawn, and/or pasture). Slopes within the 25-foot minimum flowpath through vegetation should be no steeper than 8 percent. If this criterion cannot be met due to site constraints, the 25-foot flowpath length must be increased 1.5 feet for each percent increase in slope above 8%.
- No erosion or flooding of downstream properties may result.
- Runoff discharge toward landslide hazard areas must be evaluated by a geotechnical engineer or a qualified geologist. The discharge point may not be placed on or above slopes greater than 20% or above erosion hazard areas without evaluation by a geotechnical engineer or qualified geologist and approval by the Local Plan Approval Authority.
- For sites with septic systems, the discharge point must be downgradient of the drainfield primary and reserve areas. This requirement may be waived by the Local Plan Approval Authority if site topography clearly prohibits flows from intersecting the drainfield.

Flow Credits

- Where BMPT5.12 is used to disperse runoff into an undisturbed native landscape area or an area that meets BMP T5.13, the impervious area may be modeled as landscaped area. This is done in the WWHM by entering the impervious area into the" landscaped area" field.

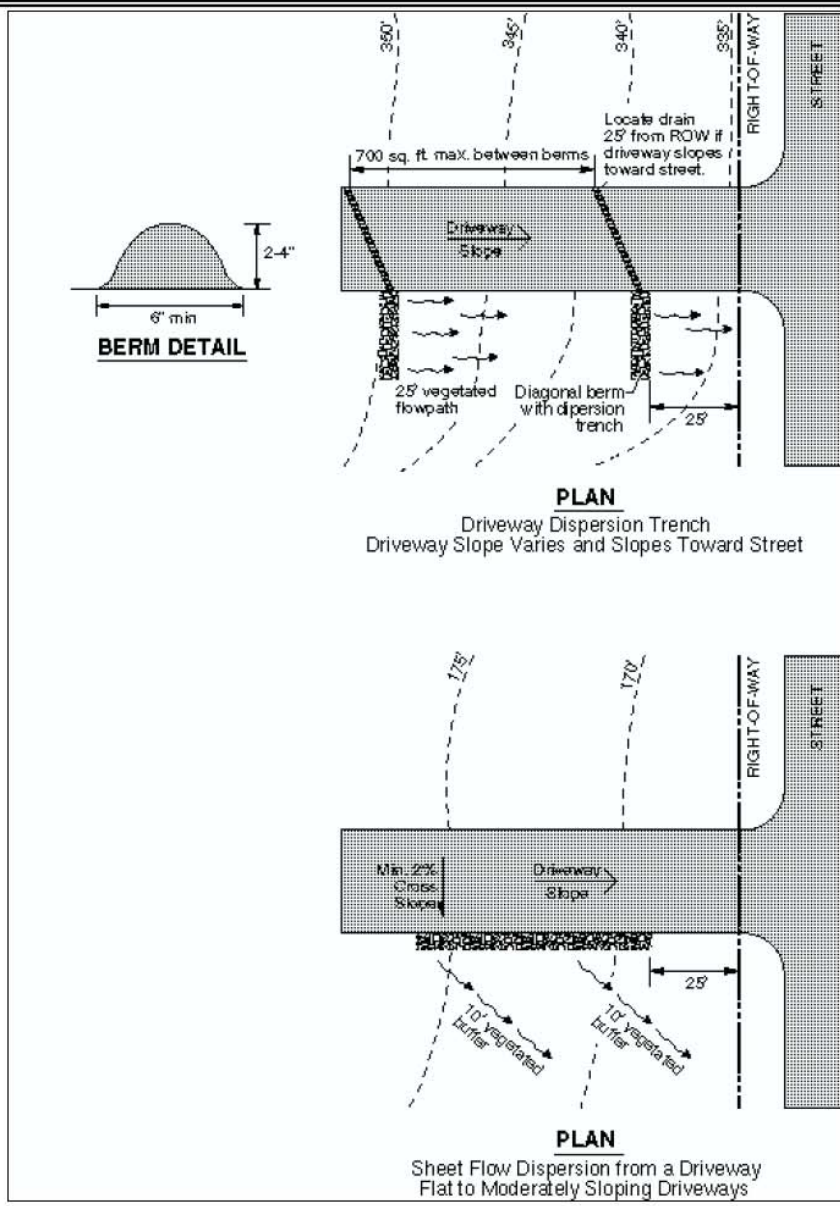


Figure 5.5 – Sheet Flow Dispersion for Driveways

2005 SWMM BMP Maintenance Standards
pp 4-30 to 4-42 Volume 5

4.6 Maintenance Standards for Drainage Facilities

The facility-specific maintenance standards contained in this section are intended to be conditions for determining if maintenance actions are required as identified through inspection. They are not intended to be measures of the facility's required condition at all times between inspections. In other words, exceedence of these conditions at any time between inspections and/or maintenance does not automatically constitute a violation of these standards. However, based upon inspection observations, the inspection and maintenance schedules shall be adjusted to minimize the length of time that a facility is in a condition that requires a maintenance action.

Table 4.5 – Maintenance Standards

No. 1 – Detention Ponds

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash & Debris	Any trash and debris which exceed 5 cubic feet per 1,000 square feet (this is about equal to the amount of trash it would take to fill up one standard size garbage can). In general, there should be no visual evidence of dumping. If less than threshold all trash and debris will be removed as part of next scheduled maintenance.	Trash and debris cleared from site.
	Poisonous Vegetation and noxious weeds	Any poisonous or nuisance vegetation which may constitute a hazard to maintenance personnel or the public. Any evidence of noxious weeds as defined by State or local regulations. (Apply requirements of adopted IPM policies for the use of herbicides).	No danger of poisonous vegetation where maintenance personnel or the public might normally be. (Coordinate with local health department) Complete eradication of noxious weeds may not be possible. Compliance with State or local eradication policies required
	Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants (Coordinate removal/cleanup with local water quality response agency).	~~No contaminants or pollutants present.~~
	Rodent Holes	Any evidence of rodent holes if facility is acting as a dam or berm, or any evidence of water piping through dam or berm via rodent holes.	Rodents destroyed and dam or berm repaired. (Coordinate with local health department; coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.)

No. 1 – Detention Ponds

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
	Beaver Dams	Dam results in change or function of the facility.	Facility is returned to design function. (Coordinate trapping of beavers and removal of dams with appropriate permitting agencies)
	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted IPM policies
	Tree Growth and Hazard Trees	Tree growth does not allow maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). If trees are not interfering with access or maintenance, do not remove If dead, diseased, or dying trees are identified (Use a certified Arborist to determine health of tree or removal requirements)	Trees do not hinder maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses (e.g., alders for firewood). Remove hazard Trees
Side Slopes of Pond	Erosion	Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion. Any erosion observed on a compacted berm embankment.	Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction. If erosion is occurring on compacted berms a licensed civil engineer should be consulted to resolve source of erosion.
Storage Area	Sediment	Accumulated sediment that exceeds 10% of the designed pond depth unless otherwise specified or affects inletting or outletting condition of the facility.	Sediment cleaned out to designed pond shape and depth; pond reseeded if necessary to control erosion.
	Liner (If Applicable)	Liner is visible and has more than three 1/4-inch holes in it.	Liner repaired or replaced. Liner is fully covered.

No. 1 – Detention Ponds

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Pond Berms (Dikes)	Settlements	Any part of berm which has settled 4 inches lower than the design elevation. If settlement is apparent, measure berm to determine amount of settlement. Settling can be an indication of more severe problems with the berm or outlet works. A licensed civil engineer should be consulted to determine the source of the settlement.	Dike is built back to the design elevation.
	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Recommend a Goethechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.	Piping eliminated. Erosion potential resolved.
Emergency Overflow/ Spillway and Berms over 4 feet in height.	Tree Growth	Tree growth on emergency spillways creates blockage problems and may cause failure of the berm due to uncontrolled overtopping. Tree growth on berms over 4 feet in height may lead to piping through the berm which could lead to failure of the berm.	Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. A licensed civil engineer should be consulted for proper berm/spillway restoration.
	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Recommend a Goethechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.	Piping eliminated. Erosion potential resolved.
Emergency Overflow/ Spillway	Emergency Overflow/ Spillway	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil at the top of out flow path of spillway. (Rip-rap on inside slopes need not be replaced.)	Rocks and pad depth are restored to design standards.
	Erosion	See "Side Slopes of Pond"	

No. 4 – Control Structure/Flow Restrictor

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris (Includes Sediment)	Material exceeds 25% of sump depth or 1 foot below orifice plate.	Control structure orifice is not blocked. All trash and debris removed.
	Structural Damage	Structure is not securely attached to manhole wall.	Structure securely attached to wall and outlet pipe.
		Structure is not in upright position (allow up to 10% from plumb).	Structure in correct position.
		Connections to outlet pipe are not watertight and show signs of rust.	Connections to outlet pipe are water tight; structure repaired or replaced and works as designed.
		Any holes--other than designed holes--in the structure.	Structure has no holes other than designed holes.
Cleanout Gate	Damaged or Missing	Cleanout gate is not watertight or is missing.	Gate is watertight and works as designed.
		Gate cannot be moved up and down by one maintenance person.	Gate moves up and down easily and is watertight.
		Chain/rod leading to gate is missing or damaged.	Chain is in place and works as designed.
		Gate is rusted over 50% of its surface area.	Gate is repaired or replaced to meet design standards.
Orifice Plate	Damaged or Missing	Control device is not working properly due to missing, out of place, or bent orifice plate.	Plate is in place and works as designed.
	Obstructions	Any trash, debris, sediment, or vegetation blocking the plate.	Plate is free of all obstructions and works as designed.
Overflow Pipe	Obstructions	Any trash or debris blocking (or having the potential of blocking) the overflow pipe.	Pipe is free of all obstructions and works as designed.
Manhole	See "Closed Detention Systems" (No. 3).	See "Closed Detention Systems" (No. 3).	See "Closed Detention Systems" (No. 3).
Catch Basin	See "Catch Basins" (No. 5).	See "Catch Basins" (No. 5).	See "Catch Basins" (No. 5).

No. 5 – Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
General	Trash & Debris	Trash or debris which is located immediately in front of the catch basin opening or is blocking inletting capacity of the basin by more than 10%.	No Trash or debris located immediately in front of catch basin or on grate opening.
		Trash or debris (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of six inches clearance from the debris surface to the invert of the lowest pipe.	No trash or debris in the catch basin.
		Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height.	Inlet and outlet pipes free of trash or debris.
		Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No dead animals or vegetation present within the catch basin.
	Sediment	Sediment (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of 6 inches clearance from the sediment surface to the invert of the lowest pipe.	No sediment in the catch basin
	Structure Damage to Frame and/or Top Slab	Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch (Intent is to make sure no material is running into basin).	Top slab is free of holes and cracks.
		Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab. Frame not securely attached	Frame is sitting flush on the riser rings or top slab and firmly attached.
	Fractures or Cracks in Basin Walls/ Bottom	Maintenance person judges that structure is unsound.	Basin replaced or repaired to design standards.
		Grout fillet has separated or cracked wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	Pipe is regrouted and secure at basin wall.
	Settlement/ Misalignment	If failure of basin has created a safety, function, or design problem.	Basin replaced or repaired to design standards.
	Vegetation	Vegetation growing across and blocking more than 10% of the basin opening.	No vegetation blocking opening to basin.
		Vegetation growing in inlet/outlet pipe joints that is more than six inches tall and less than six inches apart.	No vegetation or root growth present.

No. 5 – Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
	Contamination and Pollution	See "Detention Ponds" (No. 1).	No pollution present.
Catch Basin Cover	Cover Not in Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Catch basin cover is closed
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread.	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. (Intent is keep cover from sealing off access to maintenance.)	Cover can be removed by one maintenance person.
Ladder	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, not securely attached to basin wall, misalignment, rust, cracks, or sharp edges.	Ladder meets design standards and allows maintenance person safe access.
Metal Grates (If Applicable)	Grate opening Unsafe	Grate with opening wider than 7/8 inch.	Grate opening meets design standards.
	Trash and Debris	Trash and debris that is blocking more than 20% of grate surface inletting capacity.	Grate free of trash and debris.
	Damaged or Missing.	Grate missing or broken member(s) of the grate.	Grate is in place and meets design standards.

No. 6 – Debris Barriers (e.g., Trash Racks)

Maintenance Components	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris	Trash or debris that is plugging more than 20% of the openings in the barrier.	Barrier cleared to design flow capacity.
Metal	Damaged/ Missing Bars.	Bars are bent out of shape more than 3 inches.	Bars in place with no bends more than 3/4 inch.
		Bars are missing or entire barrier missing.	Bars in place according to design.
		Bars are loose and rust is causing 50% deterioration to any part of barrier.	Barrier replaced or repaired to design standards.
	Inlet/Outlet Pipe	Debris barrier missing or not attached to pipe	Barrier firmly attached to pipe

No. 7 – Energy Dissipaters

Maintenance Components	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
External:			
Rock Pad	Missing or Moved Rock	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil.	Rock pad replaced to design standards.
	Erosion	Soil erosion in or adjacent to rock pad.	Rock pad replaced to design standards.
Dispersion Trench	Pipe Plugged with Sediment	Accumulated sediment that exceeds 20% of the design depth.	Pipe cleaned/flushed so that it matches design.
	Not Discharging Water Properly	Visual evidence of water discharging at concentrated points along trench (normal condition is a "sheet flow" of water along trench). Intent is to prevent erosion damage.	Trench redesigned or rebuilt to standards.
	Perforations Plugged.	Over 1/2 of perforations in pipe are plugged with debris and sediment.	Perforated pipe cleaned or replaced.
	Water Flows Out Top of "Distributor" Catch Basin.	Maintenance person observes or receives credible report of water flowing out during any storm less than the design storm or its causing or appears likely to cause damage.	Facility rebuilt or redesigned to standards.
	Receiving Area Over-Saturated	Water in receiving area is causing or has potential of causing landslide problems.	No danger of landslides.
Internal:			
Manhole/Chamber	Worn or Damaged Post, Baffles, Side of Chamber	Structure dissipating flow deteriorates to 1/2 of original size or any concentrated worn spot exceeding one square foot which would make structure unsound.	Structure replaced to design standards.
	Other Defects	See "Catch Basins" (No. 5).	See "Catch Basins" (No. 5).

No. 11 – Wetponds

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Water level	First cell is empty, doesn't hold water.	Line the first cell to maintain at least 4 feet of water. Although the second cell may drain, the first cell must remain full to control turbulence of the incoming flow and reduce sediment resuspension.
	Trash and Debris	Accumulation that exceeds 1 CF per 1000-SF of pond area.	Trash and debris removed from pond.
	Inlet/Outlet Pipe	Inlet/Outlet pipe clogged with sediment and/or debris material.	No clogging or blockage in the inlet and outlet piping.
	Sediment Accumulation in Pond Bottom	Sediment accumulations in pond bottom that exceeds the depth of sediment zone plus 6-inches, usually in the first cell.	Sediment removed from pond bottom.
	Oil Sheen on Water	Prevalent and visible oil sheen.	Oil removed from water using oil-absorbent pads or vactor truck. Source of oil located and corrected. If chronic low levels of oil persist, plant wetland plants such as Juncus effusus (soft rush) which can uptake small concentrations of oil.
	Erosion	Erosion of the pond's side slopes and/or scouring of the pond bottom, that exceeds 6-inches, or where continued erosion is prevalent.	Slopes stabilized using proper erosion control measures and repair methods.
	Settlement of Pond Dike/Berm	Any part of these components that has settled 4-inches or lower than the design elevation, or inspector determines dike/berm is unsound.	Dike/berm is repaired to specifications.
	Internal Berm	Berm dividing cells should be level.	Berm surface is leveled so that water flows evenly over entire length of berm.
	Overflow Spillway	Rock is missing and soil is exposed at top of spillway or outside slope.	Rocks replaced to specifications.

Geotechnical Review Letter – June 2015