DRAINAGE REPORT

ZHANG SHORT PLAT

7908 53rd Ave W

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Engineer:

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SECTION I

PROJECT OVERVIEW

PROJECT OVERVIEW

This project consists of the development of a 170,261 square feet (3.91 acres) site that is currently occupied by a single family residence. The house area is landscaped, but the back yard to the east is forested with mature trees and groundcover. Beyond this area, both the east and west portions of the site are encumbered with heavily vegetated steep slopes, which will be outside of the development area. Thus the area subject to development is 66,872 sq. ft., or 1.54 acres. Since the ultimate development will consist of a three lot short plat, this report will address the drainage impacts of the full development of the 1.54 acres. The current work will only result in the construction of one single family residence. However, all of the access, storm drainage and utilities completed for the single house will also provide for the construction of two more single family residences in the future, in accordance with the conditions that will be issued for the short plat. This report and the construction drawings call out the parcels as "A, B, and C"; however, the short plat shows them as parcels 1, 2, & 3, respectively.

The easement access road on the east side of the development area will be graded and resurfaced as shown in the construction drawings. Improvements will include a hammerhead turn-around, which also is the driveway entrance to Parcel A. The total site of 3.91 acres is broken down as follows:

Existing Impervious:

Roof Conc porches:	3,872 sq. ft.
Walks & stairs:	96 sq. ft.
Driveway:	7,203 sq. ft.
Total Impervious:	11,171 sq. ft. (0.26 acres)

Existing Pervious:

Landscaped:	11,228 sq. ft.
Forest:	147,862 sq. ft.
Total Pervious:	159,090 sq. ft.(3.65 acres)

Post-developed Impervious:

Roof (includes Terrace on Parcel A):	20,527 sq. ft. (0.47 acres)
Driveway/Parking:	12,252 sq. ft. (0.28 acres)
Total Hard Surface:	32,779 sq. ft. (**0.75 acres**)

Post-developed Pervious:

Landscaped:	34,093 sq. ft. (0.78 acres)
Forest (all steep slope area):	103,389 sq. ft. (2.38 acres)
Total:	137,482 sq. ft. (3.16 acres)

Because the new impervious area is over 5000 square feet, all minimum requirements from the 2014 DOE Surface Water Manual apply, and since the predeveloped impervious is less than 35% of the lot area, the project is classified as "New Development".
The site consists of two threshold discharge areas; one flowing to the east and one to the west (see "Basin Map"). The west basin drains to Puget Sound and the east basin to Olympic View Creek, a Type 4 stream. These areas are broken down as follows:

THRESHOLD DISCHARGE AREAS:

Predeveloped areas:

West:

Development Area:	30,709 sq. ft. (0.70 acres)
Forested Steep Slope Area:	76,486 sq. ft. (1.76 acres)
Total West Area:	107,195 sq. ft.(2.46 acres)

Existing Impervious Area:

Roof Conc porches:	3,872 sq. ft. (0.09 acres)
Walks & stairs:	96 sq. ft. (0 acres)
Driveway:	1,667 sq. ft. (0.04 acres)
Total Impervious:	5,635 sq. ft. (0.13 acres)

Existing Pervious Area:

Landscaped:	25,074 sq. ft. (0.58 acres)
Forested:	76,486 sq. ft. (1.76 acres)
Total:	101,560 sq. ft. (2.33 acres)

East:

Development Area:	36,163 sq. ft. (0.83 acres)
Forested steep slope area:	26,903 sq. ft. (0.62 acres)
Total East Area:	63,066 sq. ft. (1.45 acres)

Existing Impervious Area (all rdwy & dwy): 5,536 sq. ft. (0.13 acres)

Pervious Area (all forest): 57,530 sq. ft.(1.32 acres)

As shown in the above areas, of the Development area of 66,872 square feet, 30,709 square feet (0.71 acres) is in the west basin and 36,163 square feet (0.83 acres) is in the east basin.

Postdeveloped areas:

West:

Impervious Area:

Roof:	10,523 sq. ft. (0.24 acres)
Terrace:	1,443 sq. ft. (0.03 acres)
Driveway/Parking:	2,230 sq. ft. (0.05 acres)
Total Impervious Surface:	14,196 sq. ft. (**0.32 acres**)

Pervious Area:

Landscaped:	2,667 sq. ft. (0.06 acres)
Forest:	89,637 sq. ft. (2.06 acres)
Total Pervious:	92,304 sq. ft. (2.12 acres)

East:

Impervious area:

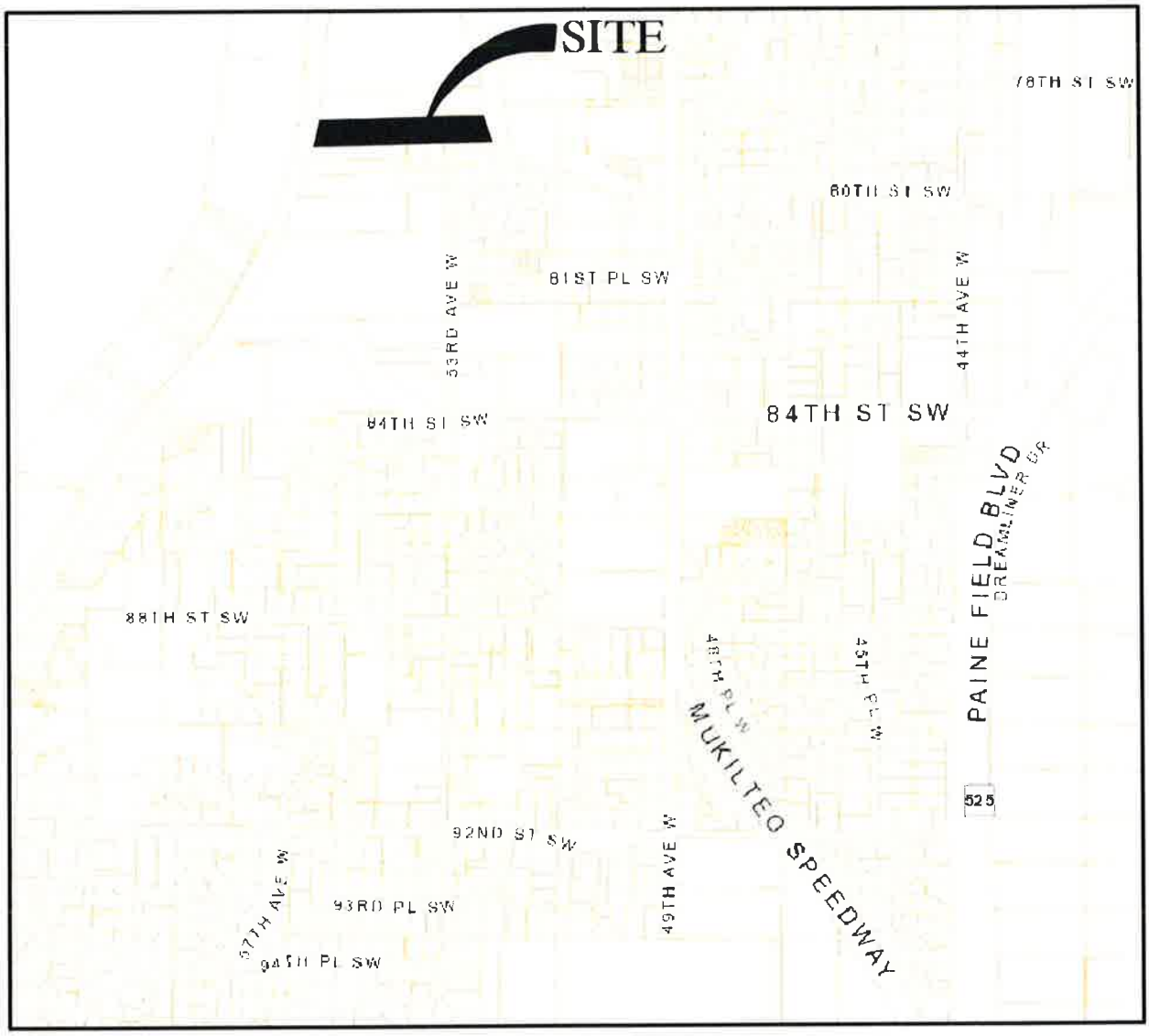
Roof:	8,561 sq. ft. (0.20 acres)
(561 sq. ft. from Parcel A and 8000* sq. ft. from Parcels B & C)	
Roads & Dwy:	10,022 sq. ft. (0.23 acres)
Total Impervious Surface:	18,583 sq. ft. (**0.43 acres**)

Pervious Area:

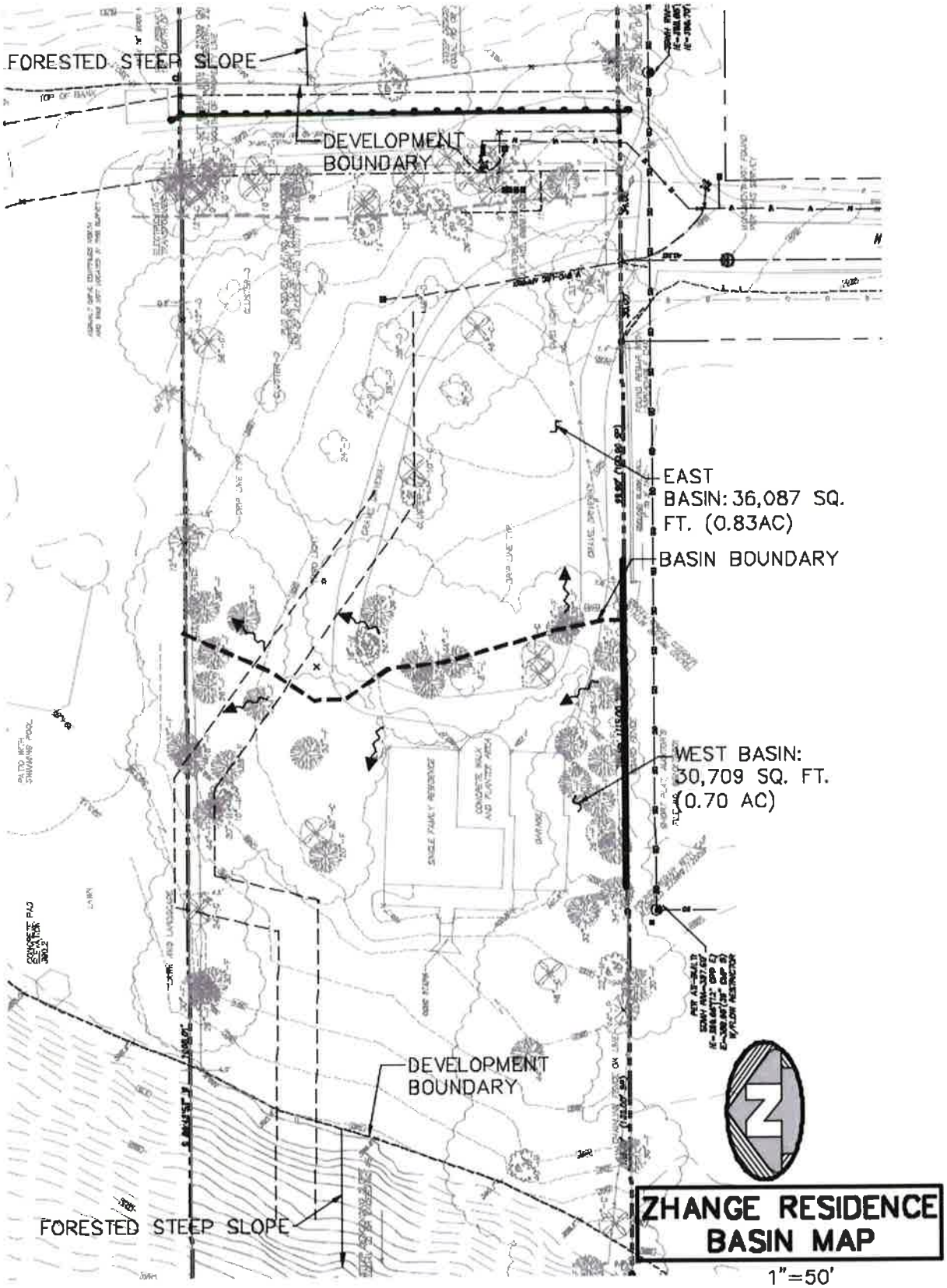
Landscaped:	17,424 sq. ft. (0.40 acres)
Forest:	27,754 sq. ft. (0.64 acres)
Total Pervious:	45,178 sq. ft. (1.04 acres)

*Some of this area is driveway, but for these calculations it will all be labeled roof.

Although both paths drain to Puget Sound, they do not converge within 1/4 of a mile. After considerable study and research, it has been decided to direct all site runoff to the west to the BNSF ROW, except that a "base flow" will be directed to the east basin. This is in compliance with recommendations in MR#4, "Preservation of Natural Drainage Systems and Outfalls", but requires applying a Direct Discharge Exemption from MR#7, "Flow Control". As a condition of applying the Direct Discharge Exemption, the Manual states that no flow can be diverted from a Type 1, 2, 3, or 4 stream. Therefore, since a Type 4 stream is in the downstream flow path to the east the above described runoff in that direction will be maintained. The discussion of these issues is provided in Section II under the respective MR. Of the 0.83 East Development Area, all of the proposed impervious area on Parcel C will be conveyed to the east basin to meet this requirement. The assumed impervious area for this report is 4000 square feet, or 0.09 acres.



VICINITY MAP


FORESTED STEEP SLOPE
DEVELOPMENT BOUNDARY
EAST BASIN: 36,087 SQ. FT. (0.83AC)
BASIN BOUNDARY
WEST BASIN: 30,709 SQ. FT. (0.70 AC)
DEVELOPMENT BOUNDARY
FORESTED STEEP SLOPE
N
ZHANGE RESIDENCE
BASIN MAP
1"=50'

SECTION II

MINIMUM REQUIREMENTS

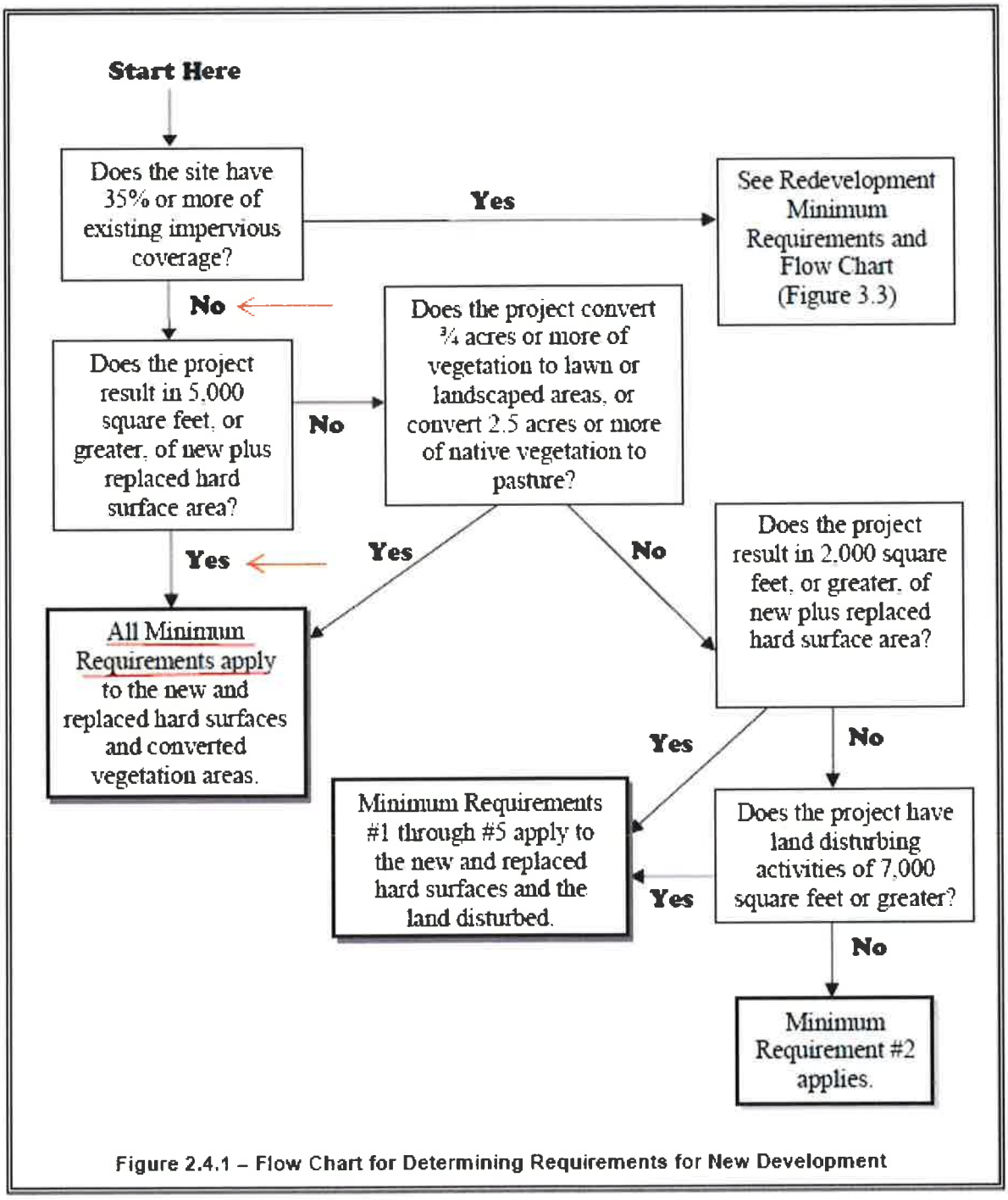


Figure 2.4.1 – Flow Chart for Determining Requirements for New Development

MINIMUM REQUIREMENTS

MR#1: Preparation of Stormwater Site Plans

The above discussion demonstrates that a Stormwater Site Plan is required, so it is included in the construction documents. The downstream analysis, required as a part of the Stormwater Site Plan, is included in this report.

MR#2: SWPP

See Section IV. This is labeled as a TESC Plan, which shows that the site will be treated with sheet flow through a silt fence. Although about 53,000 square feet of area will be cleared, only about 41,800 square feet will be graded. The area limited to clearing will consist of the future lots, so the grading there will be done as a part of the respective building permits. Work on Parcels B and C consists of tree and stump removal, plantings as specified in the Landscape Plans, and placement of amended soils.

Because the site drains in two directions, capturing the runoff and directing it to a sedimentation pond is difficult. In addition it would result in one or more concentrated flows going down the steep slopes. Thus the best way to capture silt and prevent concentrated runoff is to do it with water sheet flowing through silt fences rather than as concentrated flow, which results when sediment ponds are used. Due to short, multiple flow paths using silt fences as the primary method of sediment control is reasonable. Good ground cover practices will further ensure the control of silt runoff.

MR#3: Source Control of Pollution:

No significant sources of pollution will be created with this project, as it consists of access and utility construction for residential improvements on a small scale.

MR#4: Preservation of Natural Drainage Systems and Outfalls:

The existing site sheet flows to the east and west. The developed site is proposed to drain only to the west, with the exception that the impervious area on Parcel C is detained and released at a rate slow enough to not create an erosive condition. The outfall from the detention system will connect to the City's storm drain located at the end of 53rd Ave. This pipe drains down to the north into Olympic View Creek. Thus, no work is proposed in the ravine to the east. The reasons for draining most of the flow to the west are as follows:

1. The construction of only one drainage system down a steep hill is preferable to constructing two systems. The existing storm drain conveying the runoff from Eagle Lane to the south of this project does not extend to the bottom of the ravine to the east. Thus it would likely have to be modified or upgraded if used as a discharge point for all of the east threshold discharege area runoff.

2. No flow control exemptions are possible for runoff directed to the east. Thus detention would be required. Preliminary design of such systems revealed that due to existing site

grades, either two detention systems are required or one very large, deep vault. Not only is this very costly and impactive, it is not possible to provide the required release rate for the lower storm events using a standard orifice riser. Doing this with a pump is not a desirable solution if there are alternatives, which there are in this case.

3. Discussions with the BNRR have revealed a general agreement with the concept of draining the site to their ROW without detention. The size of the drainage basin this site presents is very small and will not result in any capacity or erosion issues on the downstream condition.

4. The application of this MR in the DOE Manual states that runoff will be directed to the natural drainage patterns "to the maximum extent possible", and then sites reasons for this. Thus the Manual writers recognize that this is a case by case requirement subject to site evaluation. The reasons for this requirement as specified in the Manual are the exact reasons that the flow should be directed as proposed.

5. Concerns with flows being diverted from Olympic View Creek are addressed by releasing the 0.09 acres at a rate that will still provide flow to the Creek without causing or aggravating erosive conditions.

As required in this MR, runoff will be conveyed by a pipe/ditch system to the Puget Sound. An energy dispersal tee will be constructed using BNSF standards so the flow will be safely released at the bottom of the hill and into the railroad ditch. Depending on the exact final location of the dissipater, the runoff will travel in the ditch a short distance to a crossing culvert under the tracks and into the receiving water.

MR#5: On-site Stormwater Management:

List#2 in Volume I, Section 2.5.5 for cases requiring adherence to MR#1-9 states that dispersion or infiltration are the first priorities. As stated in the geotechnical report, infiltration cannot be used on the site except for the use of permeable pavement or rain gardens. This is due to shallow soil depths and the steep slopes to which the water will migrate. In addition, since much of the driveway is in a cut section, permeable surfacing is not feasible. This is also true for any rain garden placed east of the house, therefore, they are infeasible.

Because dispersion will also result in the water flowing on the surface or via interflow to the steep slopes, it is not feasible. Bioretention (or rain gardens) are not feasible for the roof area, as the lawn area between the house and the steep slope is too close to the top of the slope, and the limited area to the east of the house will be graded down so that adequate separation to the hardpan layer is not possible. Thus, no BMPs are feasible for the roof area.

Finally, with regard to the private road, no BMP is recommended due to the fact that it is next to the top of the steep slope.

MR#6: Runoff Treatment

Runoff treatment is required, as the new PGIS is greater than 5000 square feet. The method chosen was a StormFilter, which was sized using the WWHM model to determine the runoff from the basin area draining to the device. This basin is less than the total 1.54 acres, as the roof on Parcel A will not drain to it. However, to be conservative, that area was included. Thus the basin includes all of the roof area, the paved areas, and the landscaped areas. The driveways were modeled as impervious. The WWHM report can be found in Appendix A, and the water quality flow rate is at the end of the report. That is what Contech used to size the StormFilter.

MR#7. Flow Control

An Adjustment is being requested modify the amount of runoff directed to the stream in the east basin so that a direct discharge to the west into Puget Sound can be done, and so no flow control is required. The runoff directed to the east will be reduced through the use of detention with the goal of removing erosive flows. The Adjustment is provided in a separate document but a background for the request is provided here. Doing a direct discharge to the west eliminates the difficulty of applying detention to the site. The elevation change across the site would result in a very deep vault or the use of two detention systems. In either case, achieving the required release rate for the low flow events is not possible without a pump (see the discussion under MR#4). Other reasons are that the BNSF Railway has expressed concern with the inherent risk of placing detention facilities above the steep

Conditions present in the downstream path to the west meet the requirements of the Manual in that the entire downstream path consists of man-made systems. Conveyance down the hillside will be done with a surface mounted pipe ending in a energy dissipater, which would be required even if the adjustment was not being requested.

All runoff directed down the west slope enters the railroad ditch, and then drains through an 18 inch culvert that discharges into the Sound. All of the installation will be designed to properly manage "erodible elements". Finally the capacity of the system will be adequate to convey all future build-out conditions. A downstream basin map was prepared showing the area draining to the culvert under the BNSF tracks. To the south of the basin the drainage is directed to the east in an existing storm drain. The area to the north is limited to a portion of the adjacent lot. All areas to the north and south of the indicated basin that drain to the west will be collected by adjacent culverts. The existing basin size is 5.66 acres. It will be increased by the size of the east basin, which is less than 0.83 acres. As a conservative measure, the 0.83 acres includes the impervious area of Parcel C even though it will be detained and directed to the east. The WWHM input and results are:

Basin size: 5.66 acres + 0.83 acres = 6.49 acres
Impervious 0.75 acres + 0.17 acres = 0.92 acres
(this includes the full development of the site plus 0.17 acres from the site to the north)
Landscaped: 1.29 acres
Forest: 4.28 acres

Results from the WWHM model input and results are:

Basin data input:

Name : Basin 1
Bypass: No
GroundWater: No

Pervious Land Use	Acres
C, Lawn, Mod	1.29
C, Forest, Steep	4.28
Pervious Total	5.57

Impervious Land Use	Acres
ROOF TOPS FLAT	0.92
Impervious Total	0.92
Basin Total	6.49

Flow Results:

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.369424
5 year	0.540692
10 year	0.673744
25 year	0.865894
50 year	1.027587
100 year	1.206133

The output yields a 100 year flow of 1.21cfs. By observation, this flow is much smaller than the capacity of an 18 inch culvert. Using the Manning formula for a trapezoidal ditch with a slope of 0.04%, a roughness factor of 0.025, and a depth of 1.5 feet, the capacity of the ditch is 8.07 cfs. Therefore the ditch capacity is adequate and the final condition for the direct discharge is fulfilled.

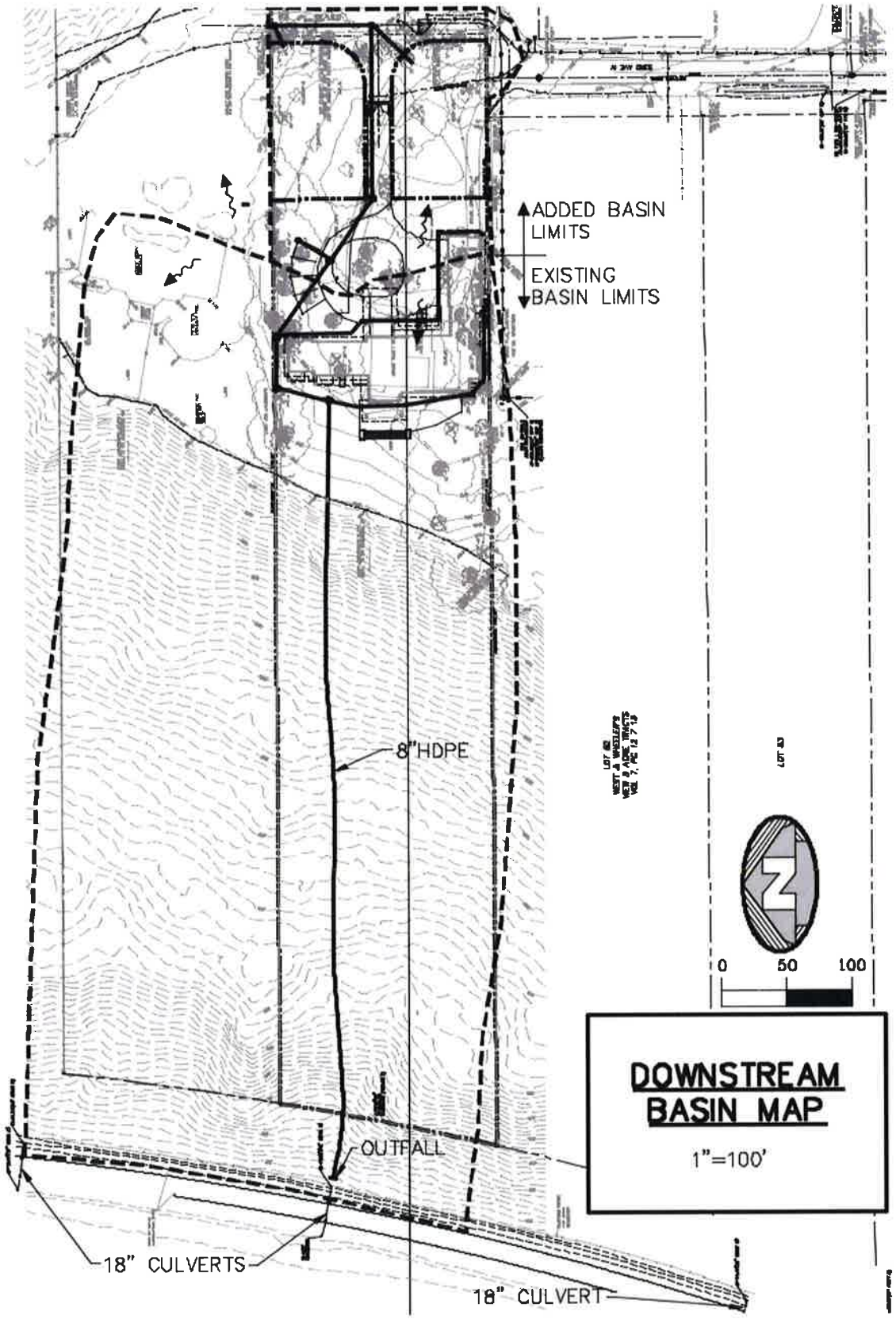
See Appendix B for the WWHM report.

MR#8. Wetlands Protection:

This requirement does not apply here, as there are no wetlands or their buffers on or adjacent to the site.

MR#9. Inspection, Operation and Maintenance Requirements

Maintenance and operations instructions are presented in Section VI.


ADDED BASIN LIMITS
EXISTING BASIN LIMITS
8"HDPE
OUTFALL
18" CULVERTS
18" CULVERT
N
0
50
100
DOWNSTREAM BASIN MAP
1"=100'

SECTION III

DOWNSTREAM ANALYSIS

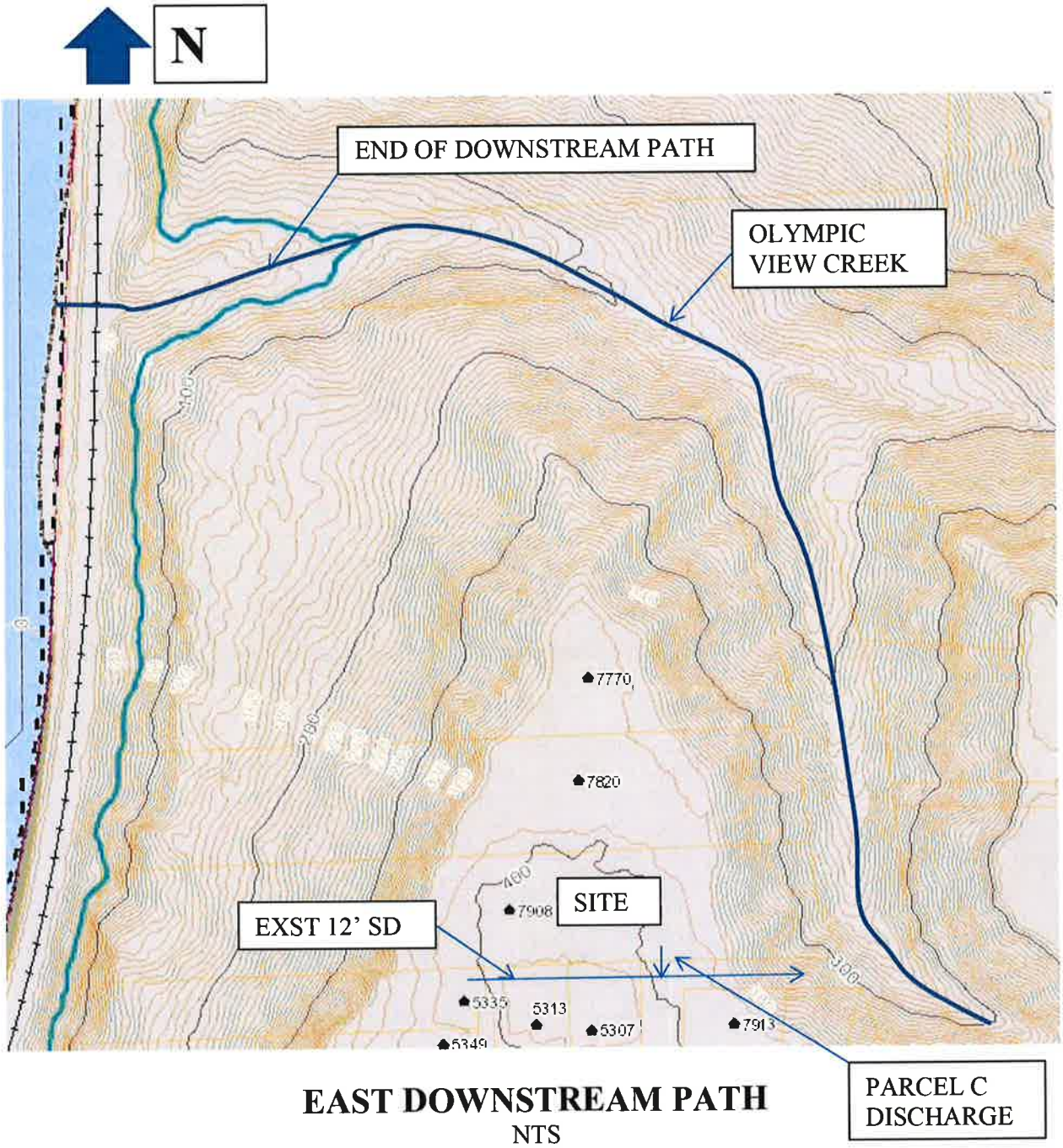
DOWNSTREAM ANALYSIS

Because all but a very small portion of the site will drain to the BNSF ROW, the downstream analysis concentrates on the drainage path down to the railroad tracks and into Puget Sound. The Zhang site has a natural north-south ridge so that the drainage sheet flows to the east and west. As described in the Project Overview, both the east and west portions of the site consist of steep forested hillsides. Because the current improvements consist of only one vacated house and a narrow gravel driveway, there are no drainage systems and the downspouts either discharge onto the ground or into buried pipes. No outfalls were found for those pipes, so they either enter buried gravel trenches or discharge to a covered point on the west hillside. The easement road on the east side of the site sheet flows over the hillside to the east.

No significant off site areas drain onto the site. As described above the ground slopes away steeply to the east and west. In addition, the site slopes away gently to the north, therefore, runoff flows away from the development area on all three of those areas. Although the property to the south is higher that the subject site, it is fully developed and its runoff conveyed to the east in a pipe drainage system.

All but 0.09 acres of the developed site will drain down to the west in an HDPE pipe to be laid on the surface. It will discharge into the BNSF ROW through an energy dissipater. This is the same path that any existing sheet flow coming down the hillside follows. A man-made ditch adjacent to the railroad tracks collects the hillside runoff and conveys it to an 18 inch culvert that passes under the tracks and outfall to the Sound. As shown in the Downstream Plath Map" above, there are culverts located about every 200 to 300 feet along the tracks, with one of those culverts located very close to the proposed HDPE pipe. Although the ditch and culverts collect sediment from the hillside, the BNSF maintains them so that they appear to be functioning adequately. No signs of capacity problems were observed. Photos of the BNSF drainage system follow.

The flow that goes to the east will be discharged to an existing 12 inch storm drain that runs east in a vacated right-of-way. That pipe outfalls on the hillside and then flows down to Olympic View Creek, which runs over ¼ mile where it outfalls to Puget Sound. A Stream Qualitative Assessment Report was prepared in November of 2017 that determined the stream to be non-fish bearing, Type 4. Running in a forested area, the stream is in a natural, undisturbed condition; however, it is experiencing erosion to due high flows from development that has occurred in the basin. There is no evidence of capacity limitations within the ¼ mile reach evaluated with this report.



EAST DOWNSTREAM PATH
NTS

18" CULVERT ENTRANCE FRONTING ZHANGE SITE ON THE WEST

TYPICAL DITCH SECTION

SECTION IV

EAST BASIN FLOW CONTROL

EAST BASIN FLOW CONTROL

This section sizes a detention system for runoff directed to the east basin. This was done in order to generate a base flow to the east basin to satisfy the requirement that flow is not diverted from a Type 4 stream when the Direct Discharge Flow Control Exemption is used. This was accomplished most effectively by directing all of the runoff from the impervious area on Parcel C to a detention system that releases a suitable flow to the east. Using a minimum orifice size of 0.5 inches with a detention tank size of 36 inches, the tank length was set such that the 100 year release rate is 0.003cfs greater than the predeveloped 5 year storm (see Flow Frequency Table, below). The overflow depth was set at 2.5 feet. Because the restrictor tee is set 6 inches above the bottom of the detention tank, this results in the top of the riser being equal to the crown of the 36 inch detention tank. Based on the stage-discharge table in Appendix C, the release rate is 0.01cfs at a stage of 2.5 feet. However, the 2 year release shown on the Flow Frequency Table shows a value of 0.0207. This is because as soon as the flow overtops the riser it increases rapidly. In any case the WWHM Model stating that for a 100 year flow, the release rate is 0.076cfs, which is approximately equal to the 5 year predeveloped flow, as stated above. Due to the rapid increase in flow when the water level reaches the top of the riser and due to the sensitive condition of Olympic View Creek, an additional foot was added to the riser height. This will not result in any overflow or flooding condition. The lowest point that an inlet can be placed on the site is elevation 396, and the top of the riser will be 394.0. The stage discharge table shows that any possible flows will be able to discharge through the top of the riser before reaching an elevation of 396.

See Appendix C for the WWHM report.

Flow Frequency Table from the WWHM Report:

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.054146
5 year	0.072634
10 year	0.086066
25 year	0.104441
50 year	0.119183
100 year	0.134857

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.020693
5 year	0.0328
10 year	0.041943
25 year	0.054731
50 year	0.065137
100 year	0.076288

SECTION V

SWPP(TESC)

SWPP (TESC)

The following is a summary of the SWPP Elements, how each is addressed, the type and location of BMP used to satisfy the required element, and justification if an element is found to not be applicable. In addition to the elements below, a separate SWPPP has been prepared.

Mark Clearing Limits: This was addressed on the TESC Plan with callouts along the project perimeter defining the limit, as required to perform the necessary construction. The future lots will be cleared, and landscaped, but not graded.

Establish Construction Access: A Construction entrance is proposed coming off of the end of 53rd Ave where the current site driveway is located.

Control Flow Rates: Flow rates during construction are not controlled due to the relatively small disturbed area and short duration of the construction. Thus, there is a low probability of large storms occurring while the site is vulnerable. In addition, controlling flow rates requires collecting runoff and concentrating it. This creates a problem of discharging a concentrated flow. Rather than do this, the TESC Plan calls for runoff to sheet flow through a silt fence. See the next element.

Install Sediment Controls: Due to short travel distances and the fact that water sheet flows off of the site in three directions, a system of silt fences is proposed as the primary method of silt trapping. After clearing, the majority of the site will no longer be worked, so ground cover can be applied. Thus very little disturbed area will not be covered. With diligent maintenance of the silt fence and providing a consistent cover silt runoff will be avoided. Special Notes on the TESC Plan address the operation and maintenance of the silt fences.

Stabilize Soils: Specific details governing the covering of soils are provided in the TESC Plan and the general notes. It provides for straw mulch over ground that will not be disturbed again for a specified time period.

Protect Slopes: No steep slopes will be disturbed with this project. Special notes address the construction of the HDPE pipe on the steep slope to the west.

Protect Drain Inlets: All downstream inlets are to be protected with catch basin filters.

Stabilize Channels and Outlets: No channels or outlets are proposed during construction, except the HDPE pipe outfall. The provisions for stabilization of that outfall are provided on the construction drawings.

Control Pollutants: Because of the nature of this work, no significant pollutants will be generated. Maintenance of equipment to prevent leaks is the best way to control pollutants.

Control Dewatering: This will not be necessary on this project, as the geotechnical investigations found no groundwater.

Maintain BMP's: This is provided for in the Construction Sequence on the SWPPP. The level of maintenance required depends on the amount of precipitation and the extent of ground disturbance.

Manage the Project: This requires good communication on the part of the inspector and the contractor. The contractor shall have a contact person in the event that emergency maintenance is required.

SECTION VI

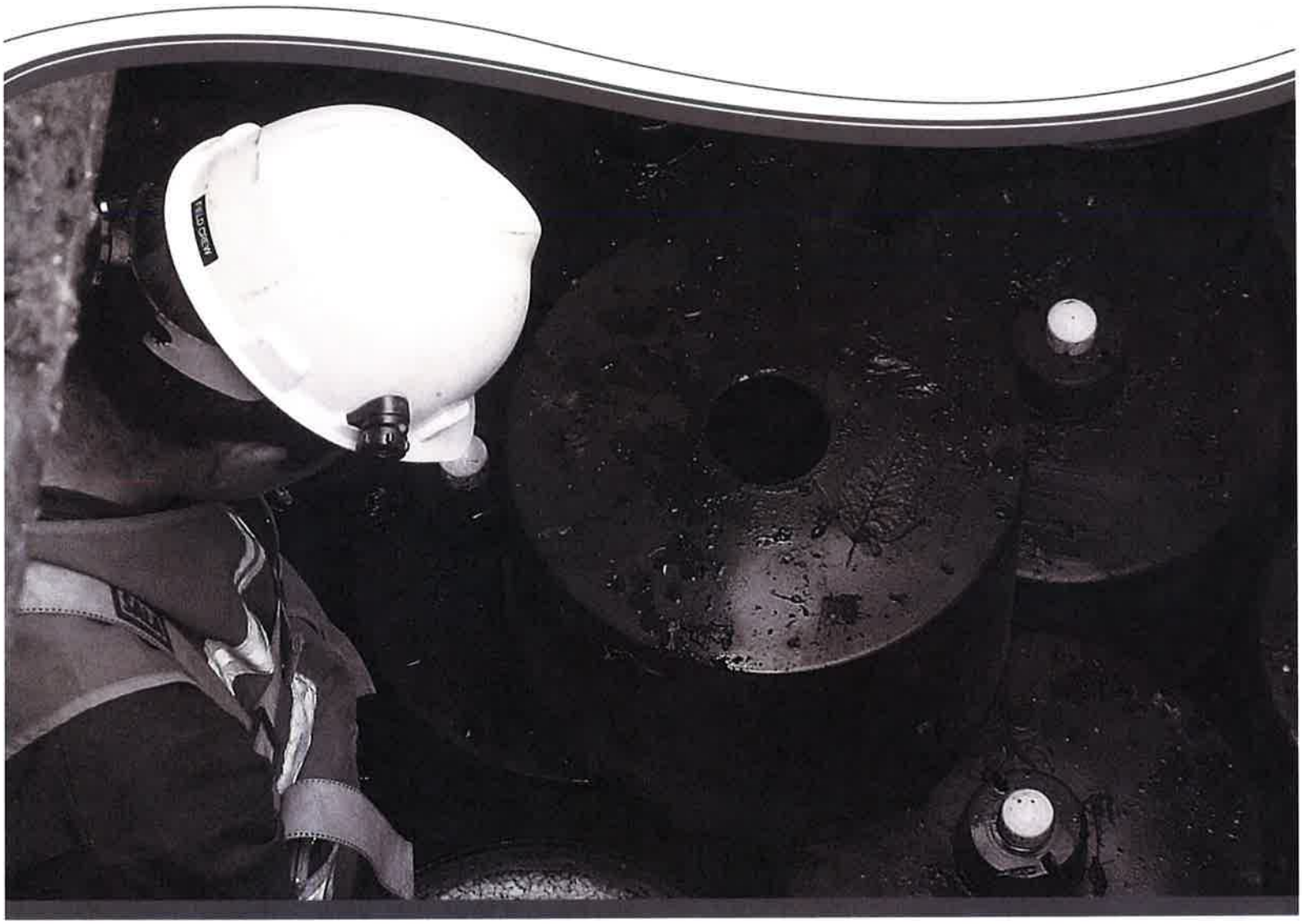
OPERATION & MAINTENANCE GUIDELINES

OPERATION & MAINTENANCE

The following matrices provide guidance for maintenance of storm water conveyance systems. More or less intense maintenance may be required as time dictates. Maintenance requirements for the StormFilter are also included.

CONTECH
CONSTRUCTION PRODUCTS INC.

StormFilter Inspection and Maintenance Procedures



The Stormwater Management
StormFilter

Maintenance Guidelines

The primary purpose of the Stormwater Management StormFilter® is to filter out and prevent pollutants from entering our waterways. Like any effective filtration system, periodically these pollutants must be removed to restore the StormFilter to its full efficiency and effectiveness.

Maintenance requirements and frequency are dependent on the pollutant load characteristics of each site. Maintenance activities may be required in the event of a chemical spill or due to excessive sediment loading from site erosion or extreme storms. It is a good practice to inspect the system after major storm events.

Maintenance Procedures

Although there are likely many effective maintenance options, we believe the following procedure is efficient and can be implemented using common equipment and existing maintenance protocols. A two step procedure is recommended as follows:

1. Inspection

Inspection of the vault interior to determine the need for maintenance.

2. Maintenance

Cartridge replacement

Sediment removal

Inspection and Maintenance Timing

At least one scheduled inspection should take place per year with maintenance following as warranted.

First, an inspection should be done before the winter season. During the inspection the need for maintenance should be determined and, if disposal during maintenance will be required, samples of the accumulated sediments and media should be obtained.

Second, if warranted, a maintenance (replacement of the filter cartridges and removal of accumulated sediments) should be performed during periods of dry weather.

In addition to these two activities, it is important to check the condition of the StormFilter unit after major storms for potential damage caused by high flows and for high sediment accumulation that may be caused by localized erosion in the drainage area. It may be necessary to adjust the inspection/ maintenance schedule depending on the actual operating conditions encountered by the system. In general, inspection activities can be conducted at any time, and maintenance should occur, if warranted, in late summer to early fall when flows into the system are not likely to be present.

Maintenance Frequency

The primary factor controlling timing of maintenance of the StormFilter is sediment loading.

A properly functioning system will remove solids from water by trapping particulates in the porous structure of the filter media inside the cartridges. The flow through the system will naturally decrease as more and more particulates are trapped. Eventually the flow through the cartridges will be low enough to require replacement. It may be possible to extend the usable span of the cartridges by removing sediment from upstream trapping devices on a routine as-needed basis in order to prevent material from being re-suspended and discharged to the StormFilter treatment system.

Site conditions greatly influence maintenance requirements. StormFilter units located in areas with erosion or active construction may need to be inspected and maintained more often than those with fully stabilized surface conditions.

The maintenance frequency may be adjusted as additional monitoring information becomes available during the inspection program. Areas that develop known problems should be inspected more frequently than areas that demonstrate no problems, particularly after major storms. Ultimately, inspection and maintenance activities should be scheduled based on the historic records and characteristics of an individual StormFilter system or site. It is recommended that the site owner develop a database to properly manage StormFilter inspection and maintenance programs.

Prior to the development of the maintenance database, the following maintenance frequencies should be followed:

Inspection

One time per year

After major storms

Maintenance

As needed, based on results of inspection (The average maintenance lifecycle is approximately 1-3 years)

Per Regulatory requirement

In the event of a chemical spill

Frequencies should be updated as required. The recommended initial frequency for inspection is one time per year. StormFilter units should be inspected after major storms.

Sediment removal and cartridge replacement on an as needed basis is recommended unless site conditions warrant.

Once an understanding of site characteristics has been established, maintenance may not be needed for one to three years, but inspection is warranted and recommended annually.

Inspection Procedures

The primary goal of an inspection is to assess the condition of the cartridges relative to the level of visual sediment loading as it relates to decreased treatment capacity. It may be desirable to conduct this inspection during a storm to observe the relative flow through the filter cartridges. If the submerged cartridges are severely plugged, then typically large amounts of sediments will be present and very little flow will be discharged from the drainage pipes. If this is the case, then maintenance is warranted and the cartridges need to be replaced.

Warning: In the case of a spill, the worker should abort inspection activities until the proper guidance is obtained. Notify the local hazard control agency and CONTECH Construction Products immediately.

To conduct an inspection:

Important: Inspection should be performed by a person who is familiar with the operation and configuration of the StormFilter treatment unit.

1. If applicable, set up safety equipment to protect and notify surrounding vehicle and pedestrian traffic.
2. Visually inspect the external condition of the unit and take notes concerning defects/problems.

3. Open the access portals to the vault and allow the system vent.
4. Without entering the vault, visually inspect the inside of the unit, and note accumulations of liquids and solids.
5. Be sure to record the level of sediment build-up on the floor of the vault, in the forebay, and on top of the cartridges. If flow is occurring, note the flow of water per drainage pipe. Record all observations. Digital pictures are valuable for historical documentation.
6. Close and fasten the access portals.
7. Remove safety equipment.
8. If appropriate, make notes about the local drainage area relative to ongoing construction, erosion problems, or high loading of other materials to the system.
9. Discuss conditions that suggest maintenance and make decision as to weather or not maintenance is needed.

Maintenance Decision Tree

The need for maintenance is typically based on results of the inspection. The following Maintenance Decision Tree should be used as a general guide. (Other factors, such as Regulatory Requirements, may need to be considered)

1. Sediment loading on the vault floor.
   a. If >4" of accumulated sediment, maintenance is required.
2. Sediment loading on top of the cartridge.
   a. If >1/4" of accumulation, maintenance is required.
3. Submerged cartridges.
   a. If >4" of static water in the cartridge bay for more that 24 hours after end of rain event, maintenance is required.
4. Plugged media.
   a. If pore space between media granules is absent, maintenance is required.
5. Bypass condition.
   a. If inspection is conducted during an average rain fall event and StormFilter remains in bypass condition (water over the internal outlet baffle wall or submerged cartridges), maintenance is required.
6. Hazardous material release.
   a. If hazardous material release (automotive fluids or other) is reported, maintenance is required.
7. Pronounced scum line.
   a. If pronounced scum line (say ≥ 1/4" thick) is present above top cap, maintenance is required.
8. Calendar Lifecycle.
   a. If system has not been maintained for 3 years maintenance is required.

Assumptions

- No rainfall for 24 hours or more
- No upstream detention (at least not draining into StormFilter)
- Structure is online
- Outlet pipe is clear of obstruction
- Construction bypass is plugged

Maintenance

Depending on the configuration of the particular system, maintenance personnel will be required to enter the vault to perform the maintenance.

Important: If vault entry is required, OSHA rules for confined space entry must be followed.

Filter cartridge replacement should occur during dry weather. It may be necessary to plug the filter inlet pipe if base flows is occurring.

Replacement cartridges can be delivered to the site or customers facility. Information concerning how to obtain the replacement cartridges is available from CONTECH Construction Products.

Warning: In the case of a spill, the maintenance personnel should abort maintenance activities until the proper guidance is obtained. Notify the local hazard control agency and CONTECH Construction Products immediately.

To conduct cartridge replacement and sediment removal maintenance:

1. If applicable, set up safety equipment to protect maintenance personnel and pedestrians from site hazards.
2. Visually inspect the external condition of the unit and take notes concerning defects/problems.
3. Open the doors (access portals) to the vault and allow the system to vent.
4. Without entering the vault, give the inside of the unit, including components, a general condition inspection.
5. Make notes about the external and internal condition of the vault. Give particular attention to recording the level of sediment build-up on the floor of the vault, in the forebay, and on top of the internal components.
6. Using appropriate equipment offload the replacement cartridges (up to 150 lbs. each) and set aside.
7. Remove used cartridges from the vault using one of the following methods:

Method 1:

A. This activity will require that maintenance personnel enter the vault to remove the cartridges from the under drain manifold and place them under the vault opening for lifting (removal). Unscrew (counterclockwise rotations) each filter cartridge from the underdrain connector. Roll the loose cartridge, on edge, to a convenient spot beneath the vault access.

Using appropriate hoisting equipment, attach a cable from the boom, crane, or tripod to the loose cartridge. Contact CONTECH Construction Products for suggested attachment devices.

Important: Note that cartridges containing leaf media (CSF) do not require unscrewing from their connectors. Take care not to damage the manifold connectors. This connector should remain installed in the manifold and could be capped during the maintenance activity to prevent sediments from entering the underdrain manifold.

B. Remove the used cartridges (up to 250 lbs. each) from the vault.

Important: Care must be used to avoid damaging the cartridges during removal and installation. The cost of repairing components damaged during maintenance will be the responsibility of the owner unless CONTECH Construction Products performs the maintenance activities and damage is not related to discharges to the system.

C. Set the used cartridge aside or load onto the hauling truck.

D. Continue steps a through c until all cartridges have been removed.

Method 2:

A. Enter the vault using appropriate confined space protocols.

B. Unscrew the cartridge cap.

C. Remove the cartridge hood screws (3) hood and float.

D. At location under structure access, tip the cartridge on its side.

Important: Note that cartridges containing media other than the leaf media require unscrewing from their threaded connectors. Take care not to damage the manifold connectors. This connector should remain installed in the manifold and capped if necessary.

D. Empty the cartridge onto the vault floor. Reassemble the empty cartridge.

E. Set the empty, used cartridge aside or load onto the hauling truck.

F. Continue steps a through e until all cartridges have been removed.

8. Remove accumulated sediment from the floor of the vault and from the forebay. This can most effectively be accomplished by use of a vacuum truck.
9. Once the sediments are removed, assess the condition of the vault and the condition of the connectors. The connectors are short sections of 2-inch schedule 40 PVC, or threaded schedule 80 PVC that should protrude about 1" above the floor of the vault. Lightly wash down the vault interior.
   a. Replace any damaged connectors.
10. Using the vacuum truck boom, crane, or tripod, lower and install the new cartridges. Once again, take care not to damage connections.
11. Close and fasten the door.
12. Remove safety equipment.
13. Finally, dispose of the accumulated materials in accordance with applicable regulations. Make arrangements to return the used empty cartridges to CONTECH Construction Products.

Related Maintenance Activities -

Performed on an as-needed basis

StormFilter units are often just one of many structures in a more comprehensive stormwater drainage and treatment system.

In order for maintenance of the StormFilter to be successful, it is imperative that all other components be properly maintained. The maintenance/repair of upstream facilities should be carried out prior to StormFilter maintenance activities.

In addition to considering upstream facilities, it is also important to correct any problems identified in the drainage area. Drainage area concerns may include: erosion problems, heavy oil loading, and discharges of inappropriate materials.

Material Disposal

The accumulated sediment found in stormwater treatment and conveyance systems must be handled and disposed of in accordance with regulatory protocols. It is possible for sediments to contain measurable concentrations of heavy metals and organic chemicals (such as pesticides and petroleum products). Areas with the greatest potential for high pollutant loading include industrial areas and heavily traveled roads.

Sediments and water must be disposed of in accordance with all applicable waste disposal regulations. When scheduling maintenance, consideration must be made for the disposal of solid and liquid wastes. This typically requires coordination with a local landfill for solid waste disposal. For liquid waste disposal a number of options are available including a municipal vacuum truck decant facility, local waste water treatment plant or on-site treatment and discharge.

RECYCLED PAPER

CONTECH CONSTRUCTION PRODUCTS INC.
800.338.1122
www.contech-cpi.com

Support

- Drawings and specifications are available at contechstormwater.com.
- Site-specific design support is available from our engineers.

CONTECH Construction Products Inc. provides site solutions for the civil engineering industry. CONTECH's portfolio includes bridges, drainage, sanitary sewer, stormwater and earth stabilization products. For information on other CONTECH division offerings, visit contech-cpi.com or call 800.338.1122

Nothing in this catalog should be construed as an expressed warranty or an implied warranty of merchantability or fitness for any particular purpose. See the CONTECH standard quotation or acknowledgement for applicable warranties and other terms and conditions of sale.

Inspection Report

Date: _____ Personnel: _____

Location: _____ System Size: _____

System Type: Vault ☐ Cast-In-Place ☐ Linear Catch Basin ☐ Manhole ☐ Other ☐

Sediment Thickness in Forebay: _____ Date: _____

Sediment Depth on Vault Floor: _____

Structural Damage: _____

Estimated Flow from Drainage Pipes (if available): _____

Cartridges Submerged: Yes ☐ No ☐ Depth of Standing Water: _____

StormFilter Maintenance Activities (check off if done and give description)

☐ Trash and Debris Removal: _____

☐ Minor Structural Repairs: _____

☐ Drainage Area Report _____

Excessive Oil Loading: Yes ☐ No ☐ Source: _____

Sediment Accumulation on Pavement: Yes ☐ No ☐ Source: _____

Erosion of Landscaped Areas: Yes ☐ No ☐ Source: _____

Items Needing Further Work: _____

Owners should contact the local public works department and inquire about how the department disposes of their street waste residuals.

Other Comments:

_____

_____

_____

_____

_____

_____

_____

_____

Review the condition reports from the previous inspection visits.

StormFilter Maintenance Report

Date: _____ Personnel: _____

Location: _____ System Size: _____

System Type: Vault ☐ Cast-In-Place ☐ Linear Catch Basin ☐ Manhole ☐ Other ☐

List Safety Procedures and Equipment Used: _____

_____

_____

System Observations

Months in Service:

Oil in Forebay: Yes ☐ No ☐

Sediment Depth in Forebay: _____

Sediment Depth on Vault Floor: _____

Structural Damage: _____

Drainage Area Report

Excessive Oil Loading: Yes ☐ No ☐ Source: _____

Sediment Accumulation on Pavement: Yes ☐ No ☐ Source: _____

Erosion of Landscaped Areas: Yes ☐ No ☐ Source: _____

StormFilter Cartridge Replacement Maintenance Activities

Remove Trash and Debris: Yes ☐ No ☐ Details: _____

Replace Cartridges: Yes ☐ No ☐ Details: _____

Sediment Removed: Yes ☐ No ☐ Details: _____

Quantity of Sediment Removed (estimate?):

Minor Structural Repairs: Yes ☐ No ☐ Details: _____

Residuals (debris, sediment) Disposal Methods: _____

Notes:

_____

_____

_____

_____

_____

_____

_____

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.
	Contamination and Pollution	See "Detention Ponds" (No. 1).	No pollution present.

No. 5 – Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
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.

APPENDIX A

WWHM REPORT for STORMFILTER DESIGN

The following WWHM output is for the developed site basin of 1.22 acres served by the StormFilter. Although the StormFilter will not be receiving the roof area from the house on Parcel A, to be conservative, that area is included. It will not increase the filter requirements significantly.

WWHM2012
PROJECT REPORT

Project Name: ZHANG STORMFILTER 11-17-17
Site Name: Zhang
Site Address: 7908 53rd Ave W
City : Mukilteo
Report Date: 11/17/2017
Gage : Everett
Data Start : 1948/10/01
Data End : 2009/09/30
Precip Scale: 0.80
Version : 2015/03/18

MITIGATED LAND USE

Name : Stormfilter Basin
Bypass: No

GroundWater: No

Pervious Land Use	Acres
C, Lawn, Mod	.47
Pervious Total	0.47

Impervious Land Use	Acres
ROOF TOPS FLAT	0.47
DRIVEWAYS MOD	0.28
Impervious Total	0.75
Basin Total	1.22

Element Flows To:

Surface	Interflow	Groundwater

ANALYSIS RESULTS

Stream Protection Duration

Predeveloped Landuse Totals for POC #1
Total Pervious Area:1.22
Total Impervious Area:0

Mitigated Landuse Totals for POC #1
Total Pervious Area:0.47
Total Impervious Area:0.75

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.015022
5 year	0.023494
10 year	0.028768
25 year	0.034914
50 year	0.039104
100 year	0.042976

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.271494
5 year	0.377375
10 year	0.458069
25 year	0.57286
50 year	0.668222
100 year	0.77249

Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume:	0.0683 acre-feet
On-line facility target flow:	0.0935 cfs.
Adjusted for 15 min:	0.0935 cfs.
Off-line facility target flow:	0.0528 cfs.
Adjusted for 15 min:	0.0528 cfs.

Determining Number of Cartridges for Flow Based Systems

CONTECH Stormwater Solutions Inc. Engineer:	JWM
Date	11/20/2017

Site Information

Project Name	Zhang Short Plat
Project State	Washington
Project Location	Mukilteo
Drainage Area, Ad	1.22 ac
Impervious Area, Ai	0.75 ac
Pervious Area, Ap	0.47
% Impervious	61%
Runoff Coefficient, Rc	0.60
Water quality flow	0.09 cfs
Peak storm flow	0.77 cfs

Filter System

Filtration brand	StormFilter
Cartridge height	18 in
Specific Flow Rate	1.00 gpm/ft²
Flow rate per cartridge	7.5 gpm

SUMMARY

Number of Cartridges	6

APPENDIX B

ANALYSIS OF HDPE OUTFALL PIPE SYSTEM

This section examines the stresses on the HDPE pipe that extends down the west slope to the BNRR tracks. The proposed pipe is 8 inch Driscoplex HDPE with an SDR of 13.5. The dimensions are provided on the next page.

As shown is Section I, the developed site basin and flow data is:

Post-developed Impervious:

Development Area (excludes lawn area west of proposed house on parcel A): 52,950 sq. ft. (1.22 acres)

Roof (includes Terrace on Parcel A):	20,527 sq. ft. (0.47 acres)
Driveway/Parking:	12,252 sq. ft. (0.28 acres)
Total Hard Surface:	32,779 sq. ft. (**0.75 acres**)

Post-developed Pervious:

Pervious: **0.47 acres**

The 100 year flow based on 15 year time steps using WWHM is 0.77cfs, as shown in Appendix A. The capacity of an 8 inch smooth wall pipe at 0.5% (the flattest grade proposed) is 0.95cfs, so the pipe capacity is adequate.

Forces in Pipe:

Pipe length will be approximately 640LF after accounting for horizontal and vertical serpentine nature of layout. The vertical distance as defined in the drawings is 364.67'. Using the sine function:

Slope angle = $\sin^{-1}$ (364.67/640) = 34.75°

Calculate the pressure at the low end of the pipe:

1psi = 2.31' of water. Therefore, 364.67' of water height is: 364.67'/2.31' = 158psi

Calculate the weight of the water:

Pipe inside area: $A_p = (7.27^2)(3.142)/4 = 41.51$ sq. in. Water weighs 62.4lbs/cf. The volume of water is V = 640LF(41.51/144) = 184.5cf

Therefore the weight of the water is W = (184.5cf)(62.4lbs/cf) = 11,512lbs

The component of force along the pipe is:

F_p = [sin(34.75°)][11,512lbs] = 6,562lbs

Checking the 158psi pressure calculated above: p = 6562lbs/41.51sq. in. = 158psi. This is the same pressure as calculated above, therefore the analysis is OK.

The thrust based on the 100 year flow of 0.77cfs shown in Appendix A is less than 100lbs, which adds 100/41.51 = 2.4psi to the pressure. This is not significant.

Results:

Maximum pipe pressure: 158psi
Longitudinal pipe force: 6,562lbs
Vertical loading on soil: 11,512lbs

Pressure Rating:

The following table shows that the HDPE pipe pressure capacities exceed the 158psi calculated above.

Table 3 DriscoPlex® 4000/4100 Surge and Fatigue Resistance

Surge Capability Comparison of HDPE and PVC Pipe									
Working Pressure	Material	DR	PC	Total Pressure During Occasional Surge	Allowable Total Pressure Occasional Surge	Total Pressure During Recurring Surge	Allowable Total Pressure Recurring Surge	Cycles to Failure (N) f(WP,PRS)	Fatigue SF
125 psi	PE4710	17	125	215 psi	250 psi	170 psi	188 psi	1.9×10^7	9.5
	PVC	18	235	264 psi	376 psi	195 psi	235 psi	1.9×10^6	[illegible]
160 psi	PE4710	13.5	160	262 psi	320 psi	211 psi	240 psi	2.6×10^7	13.0
	PVC	14	305	319 psi	488 psi	239 psi	305 psi	3.2×10^6	[illegible]
200 psi	PE4710	11	200	315 psi	400 psi	258 psi	300 psi	3.3×10^7	16.4
	PVC	14	305	359 psi	488 psi	279 psi	305 psi	2.8×10^6	[illegible]

1. Ratings shown are for 73°F service temperature
2. Values for PVC pipe are evaluated per guidance in AWWA C900-07 including N values in Appendix B.
3. Occasional and recurring surge pressures calculated based on 8ft/s and 4ft/s flow velocity change respectively.
4. Fatigue Safety Factor (SF) is based on 100-year service at 55 surge cycles per day (~2 million cycles).

Table 6 DriscoPlex® 4100 IPS Pipe Sizing System

Common Dimension Ratio's for DriscoPlex® 4100 IPS Pipe (Custom DR's available. Contact Performance Pipe)														
IPS AWWA C906 PC		DR 21 PC = 100 psi			DR 17 PC = 125 psi			DR 13.5 PC = 160 psi			DR 11 PC = 200 psi			DR 9 PC = 250 psi		
Pipe Size, in	OD, in	Min Wall, in	Avg ID, in	Wgt lbs/ft	Min Wall, in	Avg ID, in	Wgt lbs/ft	Min Wall, in	Avg ID, in	Wgt lbs/ft	Min Wall, in	Avg ID, in	Wgt lbs/ft	Min Wall, in	Avg ID, in	Wgt Lbs/ft
2	2.375				0.140	2.078	0.43	0.176	2.002	0.53	0.216	1.917	0.64	0.264	1.815	0.77
3	3.500				0.206	3.063	0.94	0.259	2.951	1.16	0.318	2.826	1.39	0.389	2.675	1.66
4	4.500	0.214	4.046	1.27	0.265	3.938	1.55	0.333	3.794	1.92	0.409	3.633	2.31	0.500	3.440	2.75
6	6.625	0.315	5.957	2.75	0.390	5.798	3.36	0.491	5.584	4.15	0.602	5.349	5.00	0.736	5.065	5.96
8	8.625	0.411	7.754	4.68	0.507	7.550	5.69	0.639	7.270	7.04	0.784	6.963	8.47	0.958	6.594	10.11
10	10.750	0.512	9.665	7.24	0.632	9.410	8.83	0.796	9.062	10.93	0.977	8.679	13.16	1.194	8.219	15.70
12	12.750	0.607	11.463	10.19	0.750	11.160	12.43	0.944	10.749	15.38	1.159	10.293	18.51	1.417	9.746	22.08
14	14.000	0.667	12.586	12.28	0.824	12.253	14.98	1.037	11.802	18.54	1.273	11.301	22.32	1.556	10.701	26.63
16	16.000	0.762	14.385	16.04	0.941	14.005	19.57	1.185	13.488	24.22	1.455	12.915	29.15	1.778	12.231	34.78
18	18.000	0.857	16.183	20.30	1.059	15.755	24.77	1.333	15.174	30.65	1.636	14.532	36.89	2.000	13.760	44.02
20	20.000	0.952	17.982	25.07	1.176	17.507	30.58	1.481	16.860	37.84	1.818	16.146	45.54	2.222	15.289	54.34
22	22.000	1.048	19.778	30.33	1.294	19.257	37.00	1.630	18.544	45.79	2.000	17.760	55.10	2.444	16.819	65.75
24	24.000	1.143	21.577	36.10	1.412	21.007	44.03	1.778	20.231	54.49	2.182	19.374	65.58	2.667	18.346	78.25
26	26.000	1.238	23.375	42.36	1.529	22.759	51.67	1.926	21.917	63.95	2.364	20.988	76.96	2.889	19.875	91.84
28	28.000	1.333	25.174	49.13	1.647	24.508	59.93	2.074	23.603	74.17	2.545	22.605	89.26	3.111	21.405	106.51
30	30.000	1.429	26.971	56.40	1.765	26.258	68.80	2.222	25.289	85.14	2.727	24.219	102.47	3.333	22.934	122.27
32	32.000	1.524	28.769	64.17	1.882	28.010	78.28	2.370	26.976	96.87	2.909	25.833	116.58	3.333	22.934	122.27
34	34.000	1.619	30.568	72.44	2.000	29.760	88.37	2.519	28.660	109.36	3.091	27.447	131.61			
36	36.000	1.714	32.366	81.21	2.118	31.510	99.07	2.667	30.346	122.60	3.273	29.061	147.55			
42	42.000	2.000	37.760	110.54	2.471	36.761	134.84	3.111	35.405	166.88						
48	48.000	2.286	43.154	144.38	2.824	42.013	176.12									
54	54.000	2.571	48.549	182.73	3.176	47.266	222.90									

For pipe smaller than 2" see PP415, DriscoPlex® 5100 Water Service Tubing.
Average inside diameter is calculated using Nominal OD and Minimum Wall plus 6% for use in estimating fluid flow. Actual ID will vary. When designing components to fit the pipe ID, refer to pipe dimensions and tolerances in the applicable pipe manufacturing specification.

Calculate Pipe Elongation:

Using the calculation method as provided by the Plastic Pipe Institute for an assumed temperature variation from 35° to 90° and a 640 foot length, the unrestrained expansion was about 38 inches.

Polyethylene Piping - Calculator http://www.hdpipecalc.com

Reference: PPI Polyethylene Design Handbook

PLASTICS·PIPE·INSTITUTE

Above-Ground
Unrestrained Length Change

ref equation 3, Chapter 8, p 311

$$\Delta L = 12\alpha\,(T_2 - T_1)\,L$$

Information

Date	11-18-2017
Project	Zhang Short Plat
Engineer Name	David Dougherty
Comments	

Variables

T_1	35	Initial Temperature, °F
T_2	90	Final Temperature, °F
α	0.00009	Coefficient of Linear Expansion
L	640	Length of Pipe @ Initial Temperature, ft

Result

ΔL	38.016	Theoretical Change in Length, in ΔL > 0 is expanseion ΔL < 0 is contraction

Due to resistance generated by ground contact and the curvilinear alignment of the pipe, the elongation will not be that great, since the above calculation assumed the pipe is unrestrained. Because the pipe anchors will allow the pipe to move and the end of the pipe is unrestrained, this movement can occur without issue.

APPENDIX C

WWHM REPORT FOR EAST BASIN FLOW

WWHM2012
PROJECT REPORT

Project Name: ZHANG EAST
Site Name: Zhang
Site Address: 7908 53rd Ave W
City : Mukilteo
Report Date: 4/16/2018
Gage : Everett
Data Start : 1948/10/01
Data End : 2009/09/30
Precip Scale: 0.80
Version : 2015/03/18

Low Flow Threshold for POC 1 : 50 Percent of the 2 Year

High Flow Threshold for POC 1: 50 year

PREDEVELOPED LAND USE

Name : EAST BASIN
Bypass: No

GroundWater: No

Pervious Land Use	Acres
C, Forest, Mod	.7
Pervious Total	0.7

Impervious Land Use	Acres
DRIVEWAYS MOD	0.13
Impervious Total	0.13
Basin Total	0.83

Element Flows To:

Surface	Interflow	Groundwater

MITIGATED LAND USE

Name : EAST BASIN
Bypass: No

GroundWater: No

Pervious Land Use	Acres
Pervious Total	0

Impervious Land Use	Acres
ROOF TOPS FLAT	0.09
Impervious Total	0.09
Basin Total	0.09

Element Flows To:

Surface	Interflow	Groundwater
Tank 1	Tank 1	

Name : Tank 1
Tank Name: Tank 1

Dimensions
Depth: 3 ft.
Tank Type : Circular
Diameter : 3 ft.
Length : 8 ft.
Discharge Structure
Riser Height: 2.5 ft.
Riser Diameter: 4 in.
Orifice 1 Diameter: 0.5 in. **Elevation:** 0 ft.

Element Flows To:

Outlet 1	Outlet 2

Tank Hydraulic Table

Stage(ft)	Area(ac)	Volume(ac-ft)	Discharge(cfs)	Infilt(cfs)
0.0000	0.000	0.000	0.000	0.000
0.0333	0.000	0.000	0.001	0.000
0.0667	0.000	0.000	0.001	0.000
0.1000	0.000	0.000	0.002	0.000
0.1333	0.000	0.000	0.002	0.000
0.1667	0.000	0.000	0.002	0.000
0.2000	0.000	0.000	0.002	0.000
0.2333	0.000	0.000	0.003	0.000
0.2667	0.000	0.000	0.003	0.000
0.3000	0.000	0.000	0.003	0.000
0.3333	0.000	0.000	0.003	0.000
0.3667	0.000	0.000	0.004	0.000
0.4000	0.000	0.000	0.004	0.000
0.4333	0.000	0.000	0.004	0.000
0.4667	0.000	0.000	0.004	0.000

0.5000	0.000	0.000	0.004	0.000
0.5333	0.000	0.000	0.004	0.000
0.5667	0.000	0.000	0.004	0.000
0.6000	0.000	0.000	0.005	0.000
0.6333	0.000	0.000	0.005	0.000
0.6667	0.000	0.000	0.005	0.000
0.7000	0.000	0.000	0.005	0.000
0.7333	0.000	0.000	0.005	0.000
0.7667	0.000	0.000	0.005	0.000
0.8000	0.000	0.000	0.005	0.000
0.8333	0.000	0.000	0.006	0.000
0.8667	0.000	0.000	0.006	0.000
0.9000	0.000	0.000	0.006	0.000
0.9333	0.000	0.000	0.006	0.000
0.9667	0.000	0.000	0.006	0.000
1.0000	0.000	0.000	0.006	0.000
1.0333	0.000	0.000	0.006	0.000
1.0667	0.000	0.000	0.006	0.000
1.1000	0.000	0.000	0.006	0.000
1.1333	0.000	0.000	0.007	0.000
1.1667	0.000	0.000	0.007	0.000
1.2000	0.000	0.000	0.007	0.000
1.2333	0.000	0.000	0.007	0.000
1.2667	0.000	0.000	0.007	0.000
1.3000	0.000	0.000	0.007	0.000
1.3333	0.000	0.000	0.007	0.000
1.3667	0.000	0.000	0.007	0.000
1.4000	0.000	0.000	0.007	0.000
1.4333	0.000	0.000	0.007	0.000
1.4667	0.000	0.000	0.008	0.000
1.5000	0.000	0.000	0.008	0.000
1.5333	0.000	0.000	0.008	0.000
1.5667	0.000	0.000	0.008	0.000
1.6000	0.000	0.000	0.008	0.000
1.6333	0.000	0.000	0.008	0.000
1.6667	0.000	0.000	0.008	0.000
1.7000	0.000	0.000	0.008	0.000
1.7333	0.000	0.000	0.008	0.000
1.7667	0.000	0.000	0.008	0.000
1.8000	0.000	0.000	0.008	0.000
1.8333	0.000	0.000	0.008	0.000
1.8667	0.000	0.000	0.009	0.000
1.9000	0.000	0.000	0.009	0.000
1.9333	0.000	0.000	0.009	0.000
1.9667	0.000	0.000	0.009	0.000
2.0000	0.000	0.000	0.009	0.000
2.0333	0.000	0.000	0.009	0.000
2.0667	0.000	0.001	0.009	0.000
2.1000	0.000	0.001	0.009	0.000
2.1333	0.000	0.001	0.009	0.000
2.1667	0.000	0.001	0.009	0.000
2.2000	0.000	0.001	0.009	0.000
2.2333	0.000	0.001	0.009	0.000
2.2667	0.000	0.001	0.009	0.000
2.3000	0.000	0.001	0.010	0.000
2.3333	0.000	0.001	0.010	0.000
2.3667	0.000	0.001	0.010	0.000

2.4000	0.000	0.001	0.010	0.000
2.4333	0.000	0.001	0.010	0.000
2.4667	0.000	0.001	0.010	0.000
2.5000	0.000	0.001	0.010	0.000
2.5333	0.000	0.001	0.030	0.000
2.5667	0.000	0.001	0.066	0.000
2.6000	0.000	0.001	0.113	0.000
2.6333	0.000	0.001	0.168	0.000
2.6667	0.000	0.001	0.231	0.000
2.7000	0.000	0.001	0.301	0.000
2.7333	0.000	0.001	0.376	0.000
2.7667	0.000	0.001	0.458	0.000
2.8000	0.000	0.001	0.544	0.000
2.8333	0.000	0.001	0.635	0.000
2.8667	0.000	0.001	0.731	0.000
2.9000	0.000	0.001	0.832	0.000
2.9333	0.000	0.001	0.937	0.000
2.9667	0.000	0.001	1.046	0.000
3.0000	0.000	0.001	1.159	0.000
3.0333	0.000	0.000	1.275	0.000

ANALYSIS RESULTS

Stream Protection Duration

Predeveloped Landuse Totals for POC #1
Total Pervious Area:0.7
Total Impervious Area:0.13

Mitigated Landuse Totals for POC #1
Total Pervious Area:0
Total Impervious Area:0.09

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.054146
5 year	0.072634
10 year	0.086066
25 year	0.104441
50 year	0.119183
100 year	0.134857

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.020693
5 year	0.0328
10 year	0.041943
25 year	0.054731
50 year	0.065137
100 year	0.076288