DCG civil structural

DRAINAGE MEMORANDUM

TO: City of Lake Forest Park

FROM: Tim Gabelein, P.E.

DATE: August 9th, 2016

RE: 17114 47th Ave NE, Lake Forest Park, WA
On-site Drainage System Design Summary

This memorandum summarizes the drainage system design in accordance with the 2009 King County Surface Water Design Manual with modifications by the Lake Forest Park Municipal Code, Chapter 13.16.

Project Summary
The project site is at 17114 47th Ave NE in Lake Forest Park, and is bordered by single family residences on the east and south, and by Beach Dr NE to the north, and Brentwood Pl NE to the east. The project proposes the demolition of an existing Single Family Residence, attached greenhouse, attached carport, and pool. These improvements currently span across two separate lots. The finished site will contain one single family residence on each of the two lots, a wheel strip driveway, a permeable pavement parking area, and associated stormwater and utility improvements. The site is essentially flat, and the non-impervious ground cover is mostly loose vegetation, with trees scattered around the perimeter. No critical areas are present on the site, however a portion of the site is within stream and wetland buffers from Lyon Creek. As such, a mitigation report prepared by Watershed Company (under separate cover) has been prepared to address the effects of development within this setback and the accompanying mitigation provided. The site area is 9,784 square feet and new plus replaced impervious surfaces total 4,814 square feet. See TABLE 1 for a summary of land cover calculations.

Drainage Requirements
The project is subject to Small Site Drainage Review, since it proposes between 500 and 5,000 SF of new plus replaced impervious surface. The project is not near floodplains or sensitive areas, does propose construction or modification of a 12" (or larger) drainage pipe or ditch or receive runoff from such a pipe or ditch, and is not a high-use site, and therefore triggers does not trigger Targeted Drainage Review (TDR). An annotated Flow Chart to Determine Drainage Review Types, excerpted from Section 1.1 of the 2009 KCSWDM, is included as Attachment A to this memorandum.

Section 1.1.2.1 of the 2009 KCSWDM requires that projects subject to Small Site Drainage Review be designed in accordance with the requirements in Appendix C of the 2009 KCSWDM. As required by Appendix C, Table C.1.1.A was used to determine applicable requirements. An annotated version of Table C.1.1.A is included as Attachment B. As shown in Table C.1.1.A, this project is required to apply flow control BMPs in accordance with Section C.1.3.1 and Section C.1.3.3, apply erosion and sediment control measures in accordance with Section C.1.4, and comply with the small project submittal requirements in Section C.1.5.

As required by Table C.1.1.A, flow control BMPs were assessed in accordance with the Small Lot BMP Requirements in Section C.1.3.1 and Section C.1.3.3.

1) Full Dispersion of runoff is not feasible due to lack of 100-foot vegetated flowpath available onsite, as required by Section C.2.1.1.
2) Full Infiltration of runoff is not feasible due to poorly infiltrating soils onsite with a relatively high hydraulically restrictive layer. A Stormwater Infiltration Letter, prepared by Nelson Geotechnical Associates, and included as Attachment C, recommends against using the high infiltration rate in the north corner of the lot, due to concerns about the highly variable soils across the site.
3) Thus, the project is required to apply one or more BMPs listed in Section C.1.3.1.A.3 for use in mitigating impervious surface equal to 10% of the site area. The total site area, as shown in TABLE 1, is 4,814 SF, so the project is required to mitigate at least 481 SF of impervious area.

TABLE 1 Land Cover Summary

	Project Site Areas			
	Existing		Developed	
	SF	Acres	SF	Acres
Impervious Areas:				
Buildings	3,240	0.07	3,400	0.08
Wheel Strip Driveway	-	-	230	0.01
Paving	478	0.01	1,184	0.03
Pool	629	0.01	-	-
Total Impervious Surface:	4,347	0.1	4,814	0.11
Total New Impervious Surface:	-	-	4,814	0.11
Total Pollution Generating Impervious Surface:	4,347	0.1	1,414	0.03
Total New Pollution Generating Impervious Surface:	-	-	1,414	0.03
Pervious Areas:				
Lawn/Landscaping	5,437	0.12	4,970	0.11
Total Pervious Surface	5,437	0.12	4,970	0.11
Total Areas:	9,784	0.22	9,784	0.22

The areas in TABLE 1 were determined by area measurements in AutoCAD from a topographic survey.

Erosion and sediment control measures are proposed in accordance with the requirements in Section C.1.4. These requirements are addressed below:

A. Mark Clearing Limits
Clearing limits have been marked on the Temporary Erosion and Sediment Control (TESC) plan, submitted under separate cover. The contractor will be responsible for marking clearing limits in the field.

B. Minimize Sediment Tracked Offsite
As shown on the TESC plan, the contractor shall construct a temporary construction entrance in the location of the existing driveway to minimize the tracking of sediment onto public roads. Entrance and exit to the site will be limited to this route. The contractor shall also sweep the street daily or more often if necessary to prevent sediment from entering the City's drainage system.

C. Control Sediment
Silt fence will be installed down-slope of all work areas prior to the beginning of onsite work to control sediment transported by runoff from disturbed areas.

D. Stabilize Exposed Soils
As shown in the TESC plan, the contractor shall mulch exposed and unworked soils as needed to control erosion.

E. Control Runoff

The site is approximately flat. During construction, runoff originating on the site will be intercepted by silt fencing surrounding the disturbed area, and slowly infiltrate into the soil. Erosion due to onsite runoff is not anticipated to be an issue during construction, as the infiltration rates are not so poor as to cause ponding, but not sufficient for a concentrated infiltration facility.

F. *Control Dewatering*
As described in the geotechnical report, included as Attachment C, groundwater was encountered at a depth of 5 feet. If dewatering is necessary, the contractor shall dispose of the dewatering water by transport offsite in a vehicle to a legal discharge location or by discharge to the existing sanitary sewer stub with approval from the local sewer district.

G. *Control Other Pollutants*
The contractor shall be responsible for controlling other pollutants, including but not limited to implementing spill prevention measures.

H. *Final Stabilization*
The project will be stabilized to prevent sediment laden water from leaving the site after project completion. Lawn areas will be restored following construction of the improvements. All temporary erosion and sediment controls shall be removed within 30 days after final site stabilization is achieved.

Drainage System
Access to the site will be via a 57.5 LF Wheel Strip Driveway designed per section C.2.9.3 of the 2009 KCSWDM. The driveway will be sloped either towards the Type 1 Catch Basin (Catch Basin #2) at the front of the site, or towards the area drain in the parking area by the northern SFR in order to provide for an overflow in the case of BMP malfunction.

The wheel strip driveways lead to a parking area in back, comprised of 1,184 SF Permeable Pavement designed per section C.2.6 of the 2009 KCSWDM. The permeable pavement surfacing will be sloped at between 1.00% and 2.00% towards the area drain in the parking area by the garage entrance to the northern SFR to provide for an overflow in the case of BMP malfunction. This area drain is routed to Catch Basin #2 by 6" storm drain pipe.

One rain garden will be installed in front of each of the two new single family residences. These rain gardens have bottom dimensions of 1.5 feet wide by 23 feet long. With a 1 foot storage layer, a 6 inch freeboard, and side slopes of 3:1. In total, this provides a storage volume of 117.4 cubic feet, which is able to mitigate up to 469 square feet of tributary roof area. An expected downspout routing is shown in the drainage plans, under separate cover, as a 4" line feeding the rain garden via gravel pad or splash block. The overflow will be a single area drain located nearest to and piped directly to Catch Basin #2.

Before outflow to the system, the flow will route through 10 lineal feet of perforated pipe connection, as required by Appendix C of the 2009 KCSWDM.

In total, this represents a 50% BMP application rate, in exceedance of the 10% required by Appendix C of the 2009 KCSWDM, as shown by the calculations provided on the drainage plan, submitted under separate cover.

Unmitigated surfaces will be routed through 6" pipe at 1.00% minimum slope and 1.00' minimum cover to Catch Basin #2, a backwatered catch basin downstream of the rain gardens, which will outlet to the existing catch basin in the existing driveway after passing through 10 LF of perforated pipe connection. The outlet elevation of Catch Basin #2 is below the finished floor of the single family residences and also below the overflow of the rain gardens, which allows for flow under normal circumstances.

In the event of a backup within the city system, the outlet to the city system will be equipped with a 6" tideflex inline check valve (or equivalent) in order to prevent overflow of the city system onto the lot. If further backwatering occurs, the rain gardens will eventually overflow towards the right of way, as they are the lowest point of discharge from the site.

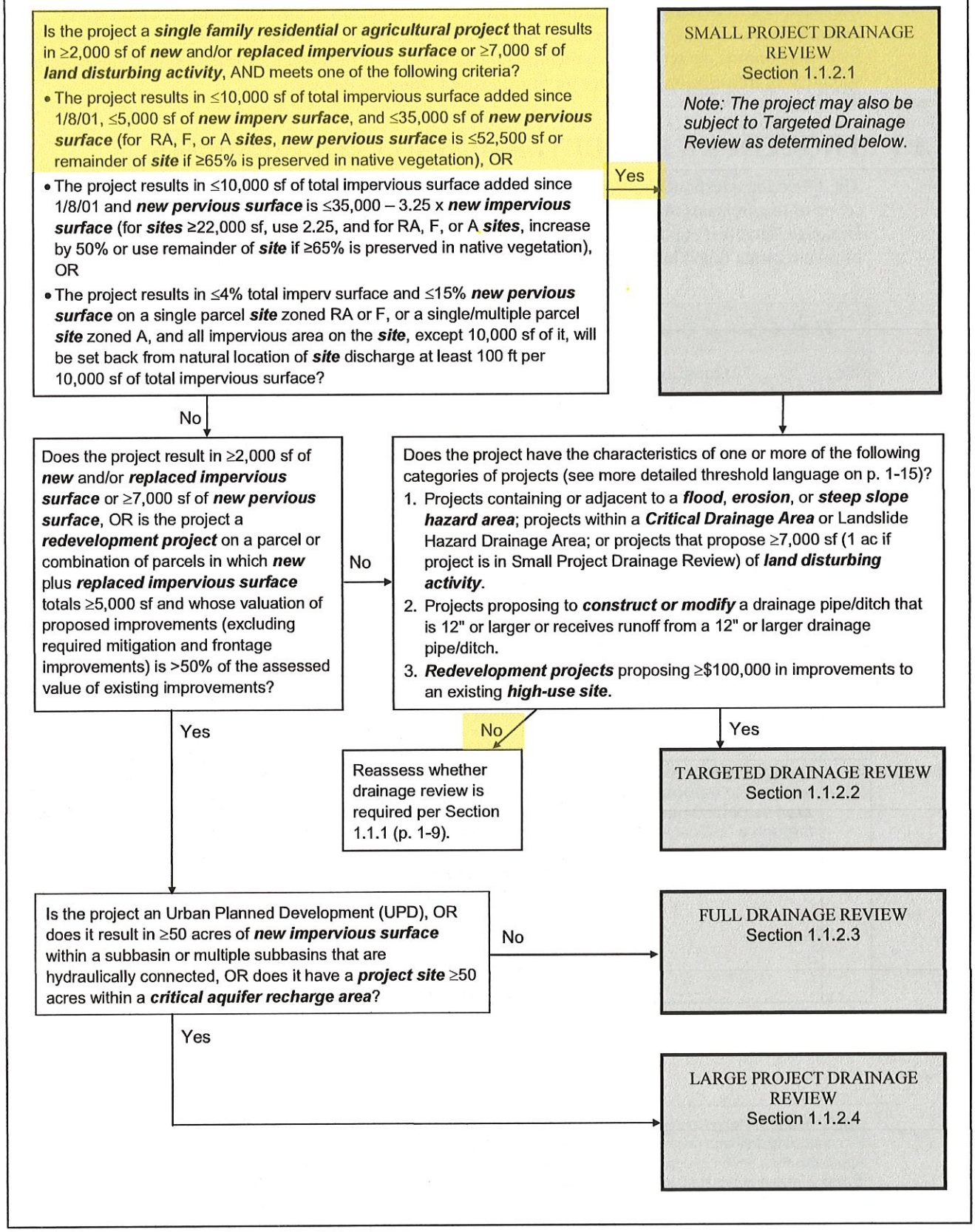
Footing drains will be required for the project, as the observed groundwater level was 5' below existing grade, and the base of the footings will be at approximately 3' below existing grade (4' below finished floor). Due to the depth

of these footing drains, they are routed to an area drain with 2' sump for the settlement of fines, before being routed to a pump station, which is designed using an estimated 30 GPM rate, to be confirmed by geotechnical field measurements. The force main will connect to Catch Basin #2 at above the expected overflow elevation from the point of connection and rain gardens in order to prevent backwatering into the pump station.

Attachments:

A – Flow Chart to Determine Drainage Review Type
B – Small Project Minimum Requirements (2009 KCSWDM Table C.1.1.A)
C – Stormwater Infiltration Letter
D – Operation and Maintenance Details
E – Conveyance Calculations

FIGURE 1.1.2.A FLOW CHART FOR DETERMINING TYPE OF DRAINAGE REVIEW REQUIRED



stamped by a ***civil engineer***. For more information on how Targeted Drainage Review relates to Small Project Drainage Review, see Reference Section C.5.1 (p. C-121).

Use Section C.1.1 (below) to determine the scope of requirements, if any, that must be addressed by a ***civil engineer*** and/or County engineering review staff under Targeted Drainage Review, and learn where to look to determine the scope of requirements for application of flow control BMPs and ESC measures and submittal of information necessary for Small Project Drainage Review.

C.1.1 PROCEDURE FOR DETERMINING REQUIREMENTS

The following questionnaire/flow chart (Table C.1.1.A) is intended to be a guide for determining the scope of requirements that will apply to a project in Small Project Drainage Review, and Targeted Drainage Review if applicable. It will refer or direct you to more specific information on the application of requirements found in subsequent subsections, and in some cases, King County Code.

TABLE C.1.1.A QUESTIONNAIRE/FLOW CHART FOR DETERMINING REQUIREMENTS

No.	Question	If YES	If NO
1.	Is the proposed project subject to drainage review as determined by consulting *DDES*[2] or Section 1.1.1 of the *SWDM*.	Go to the next question.	The project does not need to meet the requirements of the *SWDM* or this appendix.
2.	Is the project subject to Small Project Drainage Review as determined in Section C.1 (p. C-5) and confirmed with DDES?	Step through the following questions to (1) determine the scope of requirements, if any, that must be addressed by a ***civil engineer*** and/or DDES under Targeted Drainage Review, and (2) learn where to look to determine the scope of requirements for application of flow control BMPs and ESC measures and submittal of information necessary for Small Project Drainage Review.	Full Drainage Review, Targeted Drainage Review, or Large Project Drainage Review is required as specified in the *SWDM*, and engineering plans signed and stamped by a ***civil engineer*** must be submitted to DDES. Use the *SWDM* and not this appendix to determine drainage review requirements.
3.	Does the ***site*** contain or is it adjacent to a ***flood hazard area*** as determined by DDES through a "critical area review" per KCC 21A.24.100?	A notice on title will be required as specified in KCC 21A.24.170 and associated public rule, and any proposed structures or substantial improvements within the 100-year floodplain will require a FEMA Elevation Certificate completed by a ***civil engineer*** or ***land surveyor*** per KCC 21A.24.270. See Section C.1.2.1 (p. C-10) for further details. Go to the next question.	Skip to Question 7 (p. C-8).

project is over 500 SF new/replaced impervious

project is single family residence(s) less than 10,000 sf new impervious since 1/8/2001

No, per king county IMAP

[2] *DDES* means the King County Department of Development and Environmental Services, which is the department responsible for conducting drainage review of proposed projects that are subject to a King County development permit or approval. Applicants for a permit or approval should contact DDES permit review staff prior to submittal to determine/confirm that drainage review is required, and if so, what type of drainage review is appropriate. Applicants may also arrange a predesign meeting with DDES permit review staff to confirm the type of drainage review and scope of drainage requirements that apply to the proposed project.

TABLE C.1.1.A QUESTIONNAIRE/FLOW CHART FOR DETERMINING REQUIREMENTS

No.	Question	If YES	If NO
4.	Has the 100-year floodplain boundary and *base flood elevation*[3] been determined for the ***flood hazard area*** based on available flood hazard data and deemed acceptable by DDES in accordance with KCC 21A.24.230?	The floodplain boundary and base flood elevation must be shown on the project's ***site*** plans and on the face of any recorded documents if the project is a subdivision. See Section C.1.2.1 (p. C-10) for further details. Go to the next question.	A floodplain study in accordance with Section 4.4.2 of the *SWDM* must be completed by a ***civil engineer*** (or authorized agency) to determine the appropriate floodplain boundary and base flood elevation that will be used by DDES to evaluate the proposed project's compliance with the ***flood hazard area*** development standards in KCC 21A.24. See Section C.1.2.1 (p. C-10) for further details and requirements. Go to the next question.
5.	Is the ***project site*** portion of the ***site*** located on land that is entirely outside of the 100-year floodplain boundary and above the base flood elevation determined in Question 1?	Go to the next question.	The ***project site*** must be relocated to land that is outside of the 100-year floodplain and above the base flood elevation, or a ***civil engineer*** must evaluate and modify the project as needed to comply with the standards in KCC 21A.24 for development within the floodplain. This may require a major floodplain study in accordance with Section 4.4.2 of the *SWDM* to determine the floodway boundary of the ***flood hazard area***. See Section C.1.2.1 (p. C-10) for further details and requirements. Go to the next question.
6.	Has a *channel migration zone*[4] been mapped by King County for the ***flood hazard area***?	The severe and moderate channel migration hazard area boundaries must be delineated on the project's ***site*** plans and on any recorded documents if the project is a subdivision. DDES will review the proposed project for compliance with the channel migration zone development standards in KCC 21A.24.275. Go to the next question.	Go to the next question.

[3] *Base flood elevation* is the elevation of the 100-year floodplain, at the ***project site***, that has been determined in accordance with the standards in KCC 21A.24.230.

[4] *Channel migration zone* means those areas within the lateral extent of likely stream channel movement that are subject to risk due to stream bank destabilization, rapid stream incision, stream bank erosion and shifts in the location of stream channels, as shown on King County's Channel Migration Zone maps. The channel migration zone includes two additional components, the *severe channel migration hazard area*, which includes the present channel width plus the area at greatest risk of lateral movement, and the *moderate channel migration hazard area*, which is the remaining portion of the channel migration zone.

TABLE C.1.1.A QUESTIONNAIRE/FLOW CHART FOR DETERMINING REQUIREMENTS

No.	Question	If YES	If NO
7.	Does the ***site*** contain or is it adjacent to an ***erosion hazard area*** as determined by DDES through a "critical area review" per KCC 21A.24.100?	DDES may require additional flow control or ESC measures designed by a ***civil engineer*** to avoid impacts to these areas. See Section C.1.2.2 (p. C-11) for further details. Go to the next question.	Go to the next question. No, per King County IMAP
8.	Does the ***site*** contain or is it adjacent to a ***steep slope hazard area*** or ***landslide hazard area*** as determined by DDES through a "critical area review" per KCC 21A.24.100?	DDES will review the project for compliance with the development standards for these hazard areas as specified in KCC 21A.24. The DDES staff geologist must approve all drainage systems for the project and may require a geotechnical analysis. A tightline designed by a ***civil engineer*** may be required to safely convey any concentrated runoff through the hazard area. See Section C.1.2.3 (p. C-11) for further details. Go to the next question.	Go to the next question. No, per King County IMAP
9.	Is the project located in a basin planning area, community planning area, Critical Drainage Area (CDA), or other area with adopted area-specific drainage requirements AND does the project exceed the minimum thresholds for these drainage requirements as determined by DDES (see Section C.1.2.4, p. C-12)?	The project must meet the area-specific drainage requirements, some of which may require drainage systems or measures designed by a ***civil engineer***. DDES will determine which requirements are applicable and if engineering plans signed and stamped by a ***civil engineer*** are required. Go to the next question	Go to the next question. No, per King County IMAP
10.	Is the project proposing 1 acre or more of ***land disturbing activity*** (see Section C.1.2.5, p. C-12)?	ESC plans signed and stamped by a ***civil engineer*** are required to address compliance with the ESC standards for larger projects specified in the *SWDM*. Go to the next question.	Go to the next question. No, project site is proposing less than 10,000 SF land-disturbing activity
11.	Is the project proposing to construct or modify a drainage pipe or ditch that is 12 inches or more in diameter/depth, or does the ***project site*** receive surface or storm water from a drainage pipe or ditch that is 12 inches or more in diameter/depth (see Section C.1.2.6, p. C-12)?	Engineering plans signed and stamped by a ***civil engineer*** are required to address compliance with the Targeted Drainage Review requirements pertaining to constructed or modified conveyance systems in the *SWDM*. Go to the next question.	Go to the next question. No
12.	Are there any other drainage features onsite (swales, ditches, etc.) that may impact the proposed project or downstream properties or be impacted by the project?	Engineering analysis by a ***civil engineer*** may be required. DDES staff will need to assess features. Go to the next question.	Go to the next question. No

TABLE C.1.1.A QUESTIONNAIRE/FLOW CHART FOR DETERMINING REQUIREMENTS

No.	Question	If YES	If NO
13.	Is the proposed project on a ***site/lot*** smaller than 22,000 square feet?	Apply flow control BMPs in accordance with the Small Lot BMP Requirements in Section C.1.3.1 (p. C-13) and the Flow Control BMP Implementation Requirements in Section C.1.3.3 (p. C-18). Apply ESC measures in accordance with Section C.1.4 (p. C-20). Comply with the small project submittal requirements in Section C.1.5 (p. C-23)	Apply flow control BMPs in compliance with the Large Lot BMP Requirements in Section C.1.3.2 (p. C-15) and the Flow Control BMP Implementation Requirements in Section C.1.3.3 (p. C-18). Apply ESC measures in accordance with Section C.1.4 (p. C-20). Comply with the small project submittal requirements in Section C.1.5 (p. C-23)

site is 9,784 SF in total

C.1.2 TARGETED DRAINAGE REVIEW REQUIREMENTS

Targeted Drainage Review is usually required in addition to Small Project Drainage Review for any projects that have one or more of the following characteristics as determined by DDES:

- The project's drainage or improvements may impact or be impacted by the presence of certain critical areas (i.e., streams, lakes, wetlands, ***flood hazard areas***, ***erosion hazard areas***, ***steep slope hazard areas***, and ***landslide hazard areas***).
- The project is subject to additional drainage requirements by virtue of its location in areas where special drainage requirements have been adopted.
- The project proposes 1 acre or more of ***land disturbing activity***.
- The project proposes to construct or modify a drainage pipe/ditch that is 12 inches or more in size or depth or receives runoff from a drainage pipe/ditch that is 12 inches or more in size or depth.
- The project has other concerns that require evaluation, analysis, and/or design by ***civil engineer***.

For some small projects in Targeted Drainage Review, DDES permit review staff may be able to address some of the above concerns/requirements without a ***civil engineer*** through approval of the flow control BMPs/ESC measures in this appendix combined with increased setbacks, geotechnical review, or permit approval conditions. In other cases, a ***civil engineer*** will be required to address specific requirements in the *SWDM* and submit engineering plans.

Note: Targeted Drainage Review is not a substitute for a Critical Area Review. Small project proposals are not exempted from applicable requirements of KCC 21A.24 (critical areas regulations) including critical area reports, notices on title, buffers, building setbacks, and development standards/alterations.

ATTACHMENT C:

NELSON GEOTECHNICAL ASSOCIATES, INC.
GEOTECHNICAL ENGINEERS & GEOLOGISTS

Main Office
17311 – 135th Ave NE, A-500
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June 27, 2016

Ms. Linda Pruitt
The Cottage Company
P.O. Box 15405
Seattle, Washington 98115

Stormwater Infiltration Letter
Brentwood Beach Short Plat Infiltration
17114 – 47th Avenue NE
Lake Forest Park, Washington
NGA Project No. 960016

Dear Ms. Pruitt:

This letter documents our explorations and provides our opinions and recommendations for the feasibility of stormwater infiltration at the proposed residential project located at 17114 - 47th Avenue NE in Lake Forest Park, Washington, as shown on the Vicinity Map in Figure 1.

INTRODUCTION

The site is generally level and is currently occupied by an existing single-family residence, in-ground pool, and detached carport within the central portion of the property. We understand that the proposed development will consist of removing the existing residence, pool and carport structures, subdividing the property to create two separate west and east lots, and constructing a new single-family residence within each lot. We have been retained to evaluate the infiltration capacity of the on-site soils for use in designing the new stormwater infiltration systems within each new lot. The City of Lake Forest Park uses the 2009 King County Surface Water Design Manual to determine the design of infiltration facilities. According to this manual, we understand that long-term design infiltration rates for this site are to be determined by performing on-site infiltration testing consisting of the Falling Head Percolation Test.

Stormwater is proposed to be directed into infiltration systems within the properties. The site conditions and general locations of our explorations are shown on the Schematic Site Plan in Figure 2.

For our use in preparing this letter, we were provided with a site plan titled, "Topographic Survey for The Cottage Company 17114 47th Avenue NE Lake Forest Park, WA" prepared by Signature Surveying and Mapping, PLLC, dated March 16, 2016, showing the existing and proposed site.

SCOPE

The purpose of this study is to explore and characterize the subsurface conditions within the site and to provide opinions and recommendations for stormwater infiltration within each of the new properties. Specifically, our scope of services included the following:

1. Review available soil and geologic maps of the area.
2. Explore the subsurface soil and groundwater conditions within the site with hand excavations.
3. Perform on-site infiltration testing as required.
4. Perform grain-size sieve analysis on soil samples, if necessary.
5. Provide estimates of the infiltration capacity of the soils based on the 2009 King County Surface Water Design Manual.
6. Provide recommendations for infiltration system installation.
7. Document the results of our findings, conclusions, and recommendations in a written geotechnical letter.

SITE CONDITIONS

Surface Conditions

The property consists of a rectangular-shaped parcel covering approximately 0.22 acres. The ground surface within the lot is relatively level. The southern portion of the lot is currently occupied by the paved driveway, grass-covered yard areas, and scattered mature trees. The lot is bounded to the south by 47th Avenue NE, to the north and east by existing single-family residences, and to the west by the Burke-Gilman Trail and Bothell Way NE. We did not observe surface water within the site during our site visit on June 14, 2016.

Subsurface Conditions

Geology: The geologic units for the overall site are shown on Geologic Map of Edmonds East and part of the Edmonds West Quadrangle, Washington, by Minard, J.P., (USGS, 1983). The site is mapped as Older Alluvium (Qoal) with Younger Alluvium deposits (Qyal) mapped in the near vicinity. The Older Alluvium is described as gray to brown stratified sands and gravels with organic-rich silt. The Younger Alluvium deposits are described as poorly drained, fluvial, organic-rich sands and gravels. Our explorations within the site generally encountered loose to medium dense sand with silt and gravel consistent with the description of Alluvium soils at depth.

Explorations: The subsurface conditions within the site were explored on June 14, 2016 by excavating seven explorations with hand tools. Infiltration Pits 1 through 3 were located within the proposed infiltration areas and the supplemental Hand Augers 1 through 4 were located near the infiltration pits and around the existing house. The approximate locations of our explorations are shown on the Schematic Site Plan in Figure 2. Geologists from Nelson Geotechnical Associates, Inc. (NGA) were present during the explorations, collected samples of the soils encountered, and maintained logs of the explorations. The soils were visually classified in general accordance with the Unified Soil Classification System, presented as Figure 3. The log of the explorations are presented as Figures 4 through 6.

At the surface of Infiltration Pits 1 through 3 we encountered approximately 1.0 to 1.5 feet of grass, topsoil and undocumented fill soils. Underlying the topsoil in Infiltration Pits 1 through 3, we encountered medium dense fine to medium sand with gravel, varying amounts of silt and trace roots that we interpreted as native alluvial deposits. Infiltration Pits 1 through 3 were completed at depths of 1.5, 2.0, and 2.0, respectively within the native alluvial deposits.

Within Hand Augers 1 through 4, we generally encountered approximately 2.0 to 3.0 feet of grass, roots, topsoil, and undocumented fill soils. Underlying the surficial fill, we encountered medium dense, gray brown to gray fine to medium sand with varying amounts of silt, gravel and organics to the depths explored. We interpreted these soils to be native alluvial deposits. Hand Augers 1 through 4 were terminated within the native alluvial deposits at depths in the range of 5.0 to 7.0 feet below the existing ground surface.

Hydrogeologic Conditions

In all of our hand-augered explorations we encountered significant groundwater seepage at approximately 5.0 feet below the existing ground surface, which we interpreted as part of the local groundwater table

associated with Lake Washington and the nearby creek. Soils at or below this approximate depth were completely saturated. The groundwater elevation we observed will likely fluctuate somewhat during periods of prolonged rainfall or dry weather.

INFILTRATION TESTING

It is our opinion that the subsurface soils within the site are not suitable for typical stormwater infiltration due to the relatively silty nature of the native soils and shallow groundwater table encountered throughout the site. However, shallow infiltration systems in the form of pervious pavements, bio-swales, or rain gardens may be feasible within the site. We recommend that any infiltration systems within this property be designed utilizing the recommended long-term design infiltration rate provided below. We also recommend that a suitable overflow component be incorporated into the system design that is connected to flow into the existing stormwater system within the southern portion of the property.

We conducted three on-site infiltration tests within the southern and northern portions of the property based on the 2009 King County, Washington, Surface Water Design Manual to determine a long-term design infiltration rate for the above low-impact infiltration systems. The test locations are labeled as Inf-1, Inf-2, and Inf-3 on the Site Plan in Figure 2. The tests were conducted at an approximate depth of 1.5 feet below the existing ground surface.

We installed a six-inch diameter vertical tube into the native soil at the test location. Approximately two inches of pea gravel were placed over the native soil. For each infiltration pit, we performed three falling head tests that included the measurement of the amount of water that infiltrated in a one hour time frame. The results of these infiltration tests are included in Table 1 below. We have not applied a factor of safety to the in-place infiltration test results.

Test Location:	**Trial 1**	**Trial 2**	**Trial 3**
Inf-1	2.8 in/hr	2.1 in/hr	2.0 in/hr
Inf-2	4.0 in/hr	3.1 in/hr	2.9 in/hr
Inf-3	12.4 in/hr	11.3 in/hr	10.6 in/hr

Due to the highly varying nature of the onsite native alluvial soils encountered within the site, we have selected an overall measured field rate of 2.0 in/hr to be utilized in determining the long-term design infiltration rate. We referenced Equation 5-11 within Chapter 5.4.1 of the 2009 King County Surface Water Design Manual that applies correction factors to the field measured infiltration rate to generate a

long-term design infiltration rate. Correction factors of 0.30, 1.0, and 0.80 were utilized in this equation for $F_{testing}$, $F_{geometry}$, $F_{plugging}$, respectively. Using these correction factors, we calculated a long-term design infiltration rate of 0.5 inches per hour to be utilized to design any on-site infiltration systems within the site.

We recommend that the infiltration trenches extend through any organic soil or fill to expose undisturbed native alluvial soils. We should be retained to verify the existence of such material at the time of construction. The storm water management systems should be designed in accordance with the King County Stormwater Design Manual. We recommend that any proposed infiltration systems be located as to not negatively impact any proposed or existing nearby structures and also meet all required setbacks from existing property lines, structures, and sensitive areas in accordance with the City of Lake Forest Park code.

The stormwater manual recommends a three-foot separation between the base of an infiltration system and any underlying bedrock, impermeable horizon, or groundwater. We encountered groundwater that we interpreted as the local groundwater table within this area at depths of approximately 4.0 to 5.0 feet below the existing ground surface. We recommend that any proposed shallow low-impact design infiltration system be as shallow as possible and also incorporate a suitable overflow component that is connected into the existing stomwater system within the southern portion of the property.

Pervious pavement is also feasible for the site. If pervious pavement is utilized, we recommend that the pavement area be over-excavated a minimum of 18-inches to expose the native soils at depth and replaced with a minimum of 18 inches of clean pit run. The subgrade below the pit run layer should be scarified and graded level. The exposed subgrade should not be compacted or contaminated with silt, as these conditions may reduce the infiltration capability of this material. Also, construction and foot traffic on the exposed subgrade should be kept to a minimum. We should be retained to observe subgrade preparation prior to placing the pit run layer. The pervious pavement section should be supported directly on the pit run. The pit run layer should help facilitate infiltration, but will also aid in providing a "storage" space for infiltrating water. This layer should only be lightly compacted. Regular maintenance of the pervious pavement as recommended by the supplier will also be important. This will include pressure washing and regular sweeping to reduce potential closing of pavement voids.

USE OF THIS LETTER

This letter was prepared for Ms. Linda Pruitt and her agents, for their use in planning and budgeting the above-referenced projects only. Our services included an evaluation of the infiltration capability of the site soils at specific locations, and should not be considered as an in-depth geotechnical study of the site or an evaluation of the overall site stability. This letter may be used for bidding and estimating purposes, but our letter, conclusions, and interpretations should not be construed as a warranty of the subsurface conditions. The subsurface conditions between explorations may vary. A contingency for varying conditions should be incorporated into the project plans.

We recommend that NGA be retained to review the design and provide monitoring and consultation services during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether or not earthwork activities comply with contract plans and specifications. We should be contacted a minimum of one week prior to construction activities and could attend pre-construction meetings if requested.

Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted geotechnical engineering practices in effect in this area at the time this letter was prepared. No other warranty, expressed or implied, is made. Our observations, findings, and opinions are a means to identify and reduce the inherent risks to the owner.

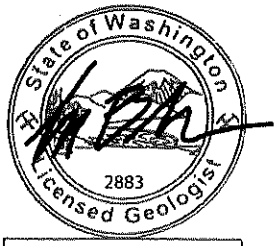
o-o-o

We appreciate the opportunity to provide service to you on this project. If you have any questions or require further information, please call.

Sincerely,

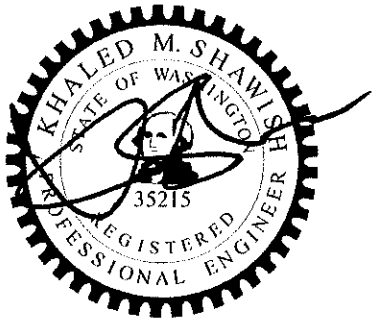
NELSON GEOTECHNICAL ASSOCIATES, INC.

Alex B. Rinaldi, GIT
Staff Geologist



LEE S. BELLAH

Lee S. Bellah, LG
Project Geologist



Exp. July 28, 2017

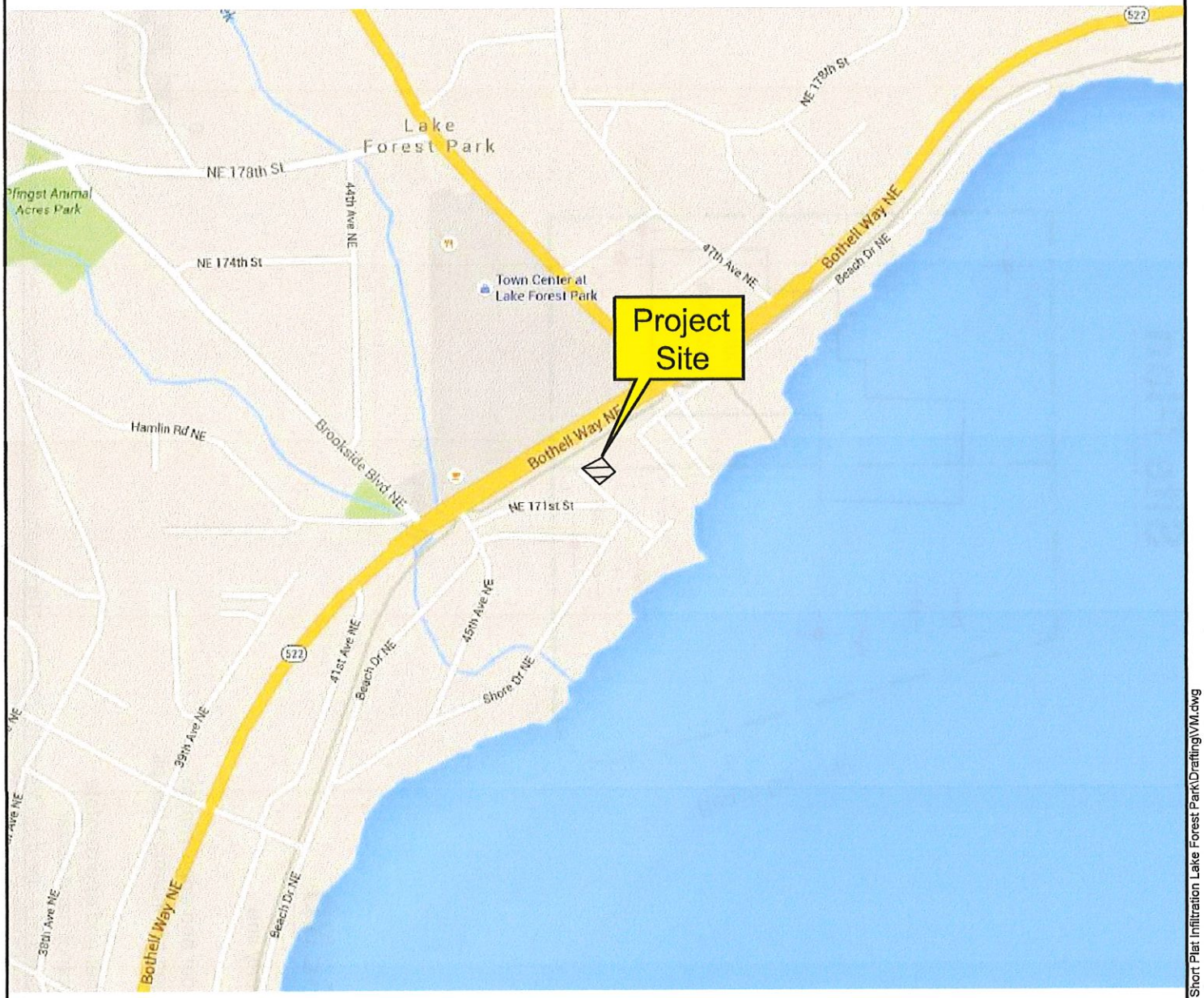
Khaled M. Shawish, PE
Principal

ABR:LSB:KMS:dy

Attachments: Six Figures

VICINITY MAP

Not to Scale



Lake Forest Park, WA

Project Number 960016	Brentwood Beach Short Plat Infiltration Vicinity Map	NELSON GEOTECHNICAL ASSOCIATES, INC. GEOTECHNICAL ENGINEERS & GEOLOGISTS	No.	Date	Revision	By	CK
Figure 1		17311-135th Ave. NE, A-500 Woodinville, WA 98072 (425) 486-1669 / Fax 481-2510 Snohomish County (425) 339-1669 Wenatchee/Chelan (509) 665-7696 www.nelsongeotech.com	1	6/22/16	Original	DPN	ABR

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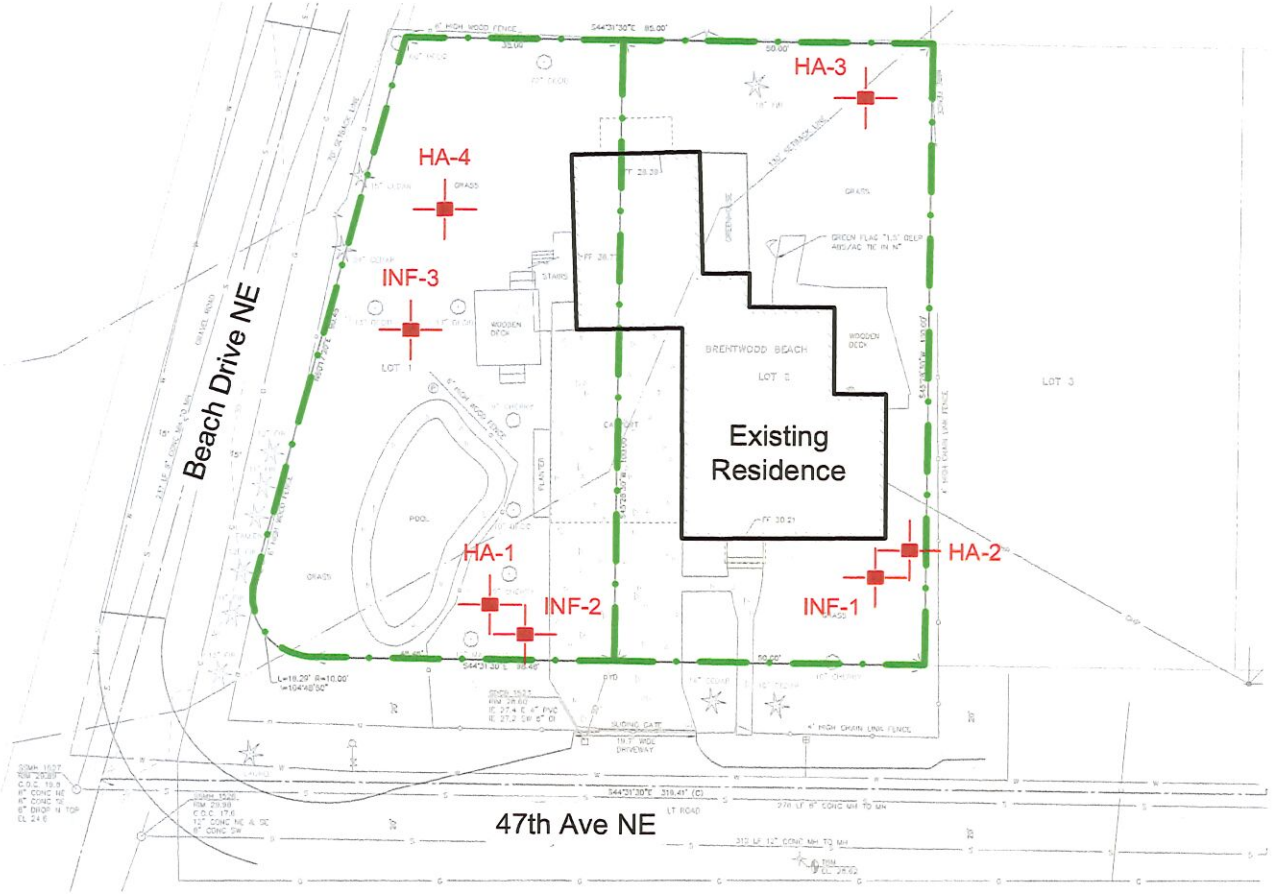
Site Plan



LEGEND

Property line

INF-1 — Number and approximate location of infiltration test pit

HA-1 — Number and approximate location of hand auger

0 30 60

Scale: 1 inch 30 feet

Reference: Site plan based on a plan dated March 16, 2016 titled "Topographic Survey for The Cottage Company," prepared by Signature Surveying & Mapping, PLLC.

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Project Number 960016

Figure 2

Brentwood Beach Short Plat
Infiltration
Site Plan

NELSON GEOTECHNICAL ASSOCIATES, INC.
GEOTECHNICAL ENGINEERS & GEOLOGISTS
17311-135th Ave. NE, A-500
Woodinville, WA 98072
(425) 486-1669 / Fax 486-2510
Snohomish County (425) 337-1669
Wenatchee/Chelan (509) 665-7696
www.nelsongeotech.com

No.	Date	Revision	By	CK
1	6/23/16	Original	DPN	ABR

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE - GRAINED SOILS MORE THAN 50 % RETAINED ON NO. 200 SIEVE	GRAVEL MORE THAN 50 % OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVEL	GW	WELL-GRADED, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND MORE THAN 50 % OF COARSE FRACTION PASSES NO. 4 SIEVE	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE - GRAINED SOILS MORE THAN 50 % PASSES NO. 200 SIEVE	SILT AND CLAY LIQUID LIMIT LESS THAN 50 %	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY LIQUID LIMIT 50 % OR MORE	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FLAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1) Field classification is based on visual examination of soil in general accordance with ASTM D 2488-93.
2) Soil classification using laboratory tests is based on ASTM D 2488-93.
3) Descriptions of soil density or consistency are based on interpretation of blowcount data, visual appearance of soils, and/or test data.

SOIL MOISTURE MODIFIERS:

Dry - Absence of moisture, dusty, dry to the touch

Moist - Damp, but no visible water.

Wet - Visible free water or saturated, usually soil is obtained from below water table

Project Number 960016	Brentwood Beach Short Plat Infiltration Soil Classification Chart	NELSON GEOTECHNICAL ASSOCIATES, INC. NGA GEOTECHNICAL ENGINEERS & GEOLOGISTS	No.	Date	Revision	By	CK
Figure 3		17311-135th Ave. NE, A-500 Woodinville, WA 98072 (425) 486-1669 / Fax 481-2510 Snohomish County (425) 337-1669 Wenatchee/Chelan (509) 665-7696 www.nelsongeotech.com	1	6/23/16	Original	DPN	ABR

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LOG OF EXPLORATION

DEPTH (FEET)	USC	SOIL DESCRIPTION
INFILTRATION PIT ONE		
0.0 – 0.1		GRASS
0.1 – 1.0		BROWN SILTY FINE TO MEDIUM SAND WITH ROOTS, GRAVEL, AND TRACE GRAVEL (LOOSE, MOIST) (**FILL**)
1.0 – 1.5	SP	BROWN FINE TO MEDIUM SAND WITH SILT AND GRAVEL (MEDIUM DENSE, MOIST)
		SAMPLES WERE NOT COLLECTED GROUNDWATER SEEPAGE WAS NOT ENCOUNTERED PIT CAVING WAS NOT ENCOUNTERED PIT COMPLETED AT 1.5 FEET ON 6/14/16
INFILTRATION PIT TWO		
0.0 – 0.2		GRASS
0.2 – 1.5		BROWN SILTY FINE TO MEDIUM SAND WITH SILT, TRACE ROOTS AND GRAVEL (LOOSE TO MEDIUM DENSE MOIST) (**FILL**)
1.5 – 2.0	SP	BROWN FINE TO MEDIUM SAND WITH SILT, TRACE ROOTS AND GRAVEL (MEDIUM DENSE, MOIST)
		SAMPLES WERE NOT COLLECTED GROUNDWATER SEEPAGE WAS NOT ENCOUNTERED PIT CAVING WAS NOT ENCOUNTERED PIT COMPLETED AT 2.0 FEET ON 6/14/16
INFILTRATION PIT THREE		
0.0 – 0.1		GRASS
0.1 – 1.0		BROWN SILTY FINE TO MEDIUM SAND WITH ROOTS, GRAVEL, AND TRACE COBBLES (LOOSE, MOIST) (**FILL**)
1.0 – 2.0	SM	GRAY SILTY FINE TO MEDIUM SAND WITH GRAVEL AND TRACE ROOTS (MEDIUM DENSE, MOIST)
		SAMPLE WAS COLLECTED AT 2.0 FEET GROUNDWATER SEEPAGE WAS NOT ENCOUNTERED PIT CAVING WAS NOT ENCOUNTERED PIT COMPLETED AT 2.0 FEET ON 6/14/16

LOG OF EXPLORATION

DEPTH (FEET)	USC	SOIL DESCRIPTION
HAND AUGER ONE		
0.0 – 0.1		GRASS
0.1 – 2.0		BROWN SILTY FINE TO MEDIUM SAND WITH ROOTS AND TRACE GRAVEL (LOOSE, MOIST) (**FILL**)
2.0 – 2.4		GRAY BROWN FINE TO MEDIUM SAND WITH SILT AND IRON-OXIDE STAINING (MEDIUM DENSE, MOIST)
2.4 – 3.5	SM	BROWN GRAY SILTY FINE TO MEDIUM SAND WITH TRACE IRON-OXIDE STAINING AND GRAVEL (MEDIUM DENSE, MOIST)
3.5 – 5.0	SM	GRAY SILTY FINE SAND WITH TRACE ORGANICS (MEDIUM DENSE, WET)
		SAMPLE WAS COLLECTED AT 5.0 FEET GROUNDWATER WAS ENCOUNTERED AT 4.0 FEET HAND AUGER CAVING WAS NOT ENCOUNTERED HAND AUGER COMPLETED AT 5.0 FEET ON 6/14/16
HAND AUGER TWO		
0.0 – 0.1		GRASS
0.1 – 3.0		BROWN SILTY FINE TO MEDIUM SAND WITH ROOTS, GRAVEL, AND TRACE COBBLES (LOOSE, MOIST) (**FILL**)
3.0 – 5.0	SP-SM	GRAY BROWN FINE TO MEDIUM SAND WITH SILT AND ORGANICS (MEDIUM DENSE, MOIST TO WET)
5.0 – 5.5	SM	GRAY SILTY FINE SAND WITH TRACE ORGANICS (MEDIUM DENSE, WET)
		SAMPLE COLLECTED AT 5.0-5.5 FEET GROUNDWATER WAS ENCOUNTERED AT 5.0 FEET HAND AUGER CAVING WAS NOT ENCOUNTERED HAND AUGER COMPLETED AT 5.5 FEET ON 6/14/16
HAND AUGER THREE		
0.0 – 0.1		GRASS
0.1 – 0.8		TOPSOIL AND ROOTS
0.8 – 2.5		LIGHT BROWN SILTY FINE TO MEDIUM SAND WITH GRAVEL, ROOTS, AND TRACE COBBLES (LOOSE, MOIST) (**FILL**)
2.5 – 3.8	SP-SM	BROWN FINE TO MEDIUM SAND WITH SILT, ROOTS, AND TRACE GRAVEL (LOOSE TO MEDIUM DENSE, MOIST)
3.8 – 6.0	SM	GRAY SILTY FINE SAND WITH TRACE ORGANICS
		SAMPLES WERE COLLECTED AT 2.0, 3.0, 4.5, AND 6.0 FEET GROUNDWATER WAS ENCOUNTERED AT 5.0 FEET HAND AUGER CAVING WAS NOT ENCOUNTERED HAND AUGER COMPLETED AT 6.0 FEET ON 6/14/16

LOG OF EXPLORATION

DEPTH (FEET)	USC	SOIL DESCRIPTION
HAND AUGER FOUR		
0.0 – 0.2		GRASS
0.2 – 1.2		TOPSOIL AND ROOTS
1.2 – 2.5		BROWN SILTY FINE TO MEDIUM SAND WITH ROOTS AND GRAVEL (LOOSE, MOIST) (**FILL**)
2.5 – 4.8	SP-SM	GRAY FINE TO MEDIUM SAND WITH SILT, ORGANICS AND TRACE GRAVEL (LOOSE TO MEDIUM DENSE)
4.8– 7.0	SM	GRAY SILTY FINE SAND WITH TRACE ORGANICS (MEDIUM DENSE, MOIST TO WET)
		SAMPLES WERE COLLECTED AT 2.5, 3.5 AND 6.8-7.0 FEET GROUNDWATER WAS ENCOUNTERED AT 5.0 FEET HAND AUGER CAVING WAS NOT ENCOUNTERED HAND AUGER COMPLETED AT 7.0.0 FEET ON 6/14/16

NO. 2 – INFILTRATION FACILITIES

Maintenance Component	Defect or Problem	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Site	Trash and debris	Any trash and debris which exceed 1 cubic foot per 1,000 square feet (this is about equal to the amount of trash it would take to fill up one standard size office garbage can). In general, there should be no visual evidence of dumping.	Trash and debris cleared from site.
	Noxious weeds	Any noxious or nuisance vegetation which may constitute a hazard to County personnel or the public.	Noxious and nuisance vegetation removed according to applicable regulations. No danger of noxious vegetation where County personnel or the public might normally be.
	Contaminants and pollution	Any evidence of contaminants or pollution such as oil, gasoline, concrete slurries or paint.	Materials removed and disposed of according to applicable regulations. Source control BMPs implemented if appropriate. No contaminants present other than a surface oil film.
	Grass/groundcover	Grass or groundcover exceeds 18 inches in height.	Grass or groundcover mowed to a height no greater than 6 inches.
Infiltration Pond, Top or Side Slopes of Dam, Berm or Embankment	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 removed or destroyed and dam or berm repaired.
	Tree growth	Tree growth threatens integrity of dams, berms or slopes, does not allow maintenance access, or interferes with maintenance activity. If trees are not a threat to dam, berm, or embankment integrity or not interfering with access or maintenance, they do not need to be removed.	Trees do not hinder facility performance or maintenance activities.
	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 slope.	Slopes stabilized using appropriate erosion control measures. If erosion is occurring on compacted slope, a licensed civil engineer should be consulted to resolve source of erosion.
	Settlement	Any part of a dam, berm or embankment that has settled 4 inches lower than the design elevation.	Top or side slope restored to design dimensions. If settlement is significant, a licensed civil engineer should be consulted to determine the cause of the settlement.
Infiltration Pond, Tank, Vault, Trench, or Small Basin Storage Area	Sediment accumulation	If two inches or more sediment is present or a percolation test indicates facility is working at or less than 90% of design.	Facility infiltrates as designed.
	Liner damaged (If Applicable)	Liner is visible or pond does not hold water as designed.	Liner repaired or replaced.
Infiltration Tank Structure	Plugged air vent	Any blockage of the vent.	Tank or vault freely vents.
	Tank bent out of shape	Any part of tank/pipe is bent out of shape more than 10% of its design shape.	Tank repaired or replaced to design.
	Gaps between sections, damaged joints or cracks or tears in wall	A gap wider than ½-inch at the joint of any tank sections or any evidence of soil particles entering the tank at a joint or through a wall.	No water or soil entering tank through joints or walls.
Infiltration Vault Structure	Damage to wall, frame, bottom, and/or top slab	Cracks wider than ½-inch, any evidence of soil entering the structure through cracks or qualified inspection personnel determines that the vault is not structurally sound.	Vault is sealed and structurally sound.

NO. 2 – INFILTRATION FACILITIES

Maintenance Component	Defect or Problem	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Inlet/Outlet Pipes	Sediment accumulation	Sediment filling 20% or more of the pipe.	Inlet/outlet pipes clear of sediment.
	Trash and debris	Trash and debris accumulated in inlet/outlet pipes (includes floatables and non-floatables).	No trash or debris in pipes.
	Damaged	Cracks wider than ½-inch at the joint of the inlet/outlet pipes or any evidence of soil entering at the joints of the inlet/outlet pipes.	No cracks more than ¼-inch wide at the joint of the inlet/outlet pipe.
Access Manhole	Cover/lid not in place	Cover/lid is missing or only partially in place. **Any open manhole requires immediate maintenance.**	Manhole access covered.
	Locking mechanism not working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts cannot be seated. Self-locking cover/lid does not work.	Mechanism opens with proper tools.
	Cover/lid difficult to remove	One maintenance person cannot remove cover/lid after applying 80 lbs of lift.	Cover/lid can be removed and reinstalled by one maintenance person.
	Ladder rungs unsafe	Missing rungs, misalignment, rust, or cracks.	Ladder meets design standards. Allows maintenance person safe access.
Large access doors/plate	Damaged or difficult to open	Large access doors or plates cannot be opened/removed using normal equipment.	Replace or repair access door so it can opened as designed.
	Gaps, doesn't cover completely	Large access doors not flat and/or access opening not completely covered.	Doors close flat and covers access opening completely.
	Lifting Rings missing, rusted	Lifting rings not capable of lifting weight of door or plate.	Lifting rings sufficient to lift or remove door or plate.
Infiltration Pond, Tank, Vault, Trench, or Small Basin Filter Bags	Plugged	Filter bag more than $^1/_2$ full.	Replace filter bag or redesign system.
Infiltration Pond, Tank, Vault, Trench, or Small Basin Pre-settling Ponds and Vaults	Sediment accumulation	6" or more of sediment has accumulated.	Pre-settling occurs as designed
Infiltration Pond, Rock Filter	Plugged	High water level on upstream side of filter remains for extended period of time or little or no water flows through filter during heavy rain storms.	Rock filter replaced evaluate need for filter and remove if not necessary.
Infiltration Pond Emergency Overflow Spillway	Rock missing	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.	Spillway restored to design standards.
	Tree growth	Tree growth impedes flow or threatens stability of spillway.	Trees removed.

NO. 5 – CATCH BASINS AND MANHOLES

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance Is Performed
Structure	Sediment	Sediment exceeds 60% of the depth from the bottom of the catch basin to the invert of the lowest pipe into or out of the catch basin or is within 6 inches of the invert of the lowest pipe into or out of the catch basin.	Sump of catch basin contains no sediment.
	Trash and debris	Trash or debris of more than ½ cubic foot which is located immediately in front of the catch basin opening or is blocking capacity of the catch basin by more than 10%.	No Trash or debris blocking or potentially blocking entrance to catch basin.
		Trash or debris in the catch basin that exceeds $^1/_3$ the depth from the bottom of basin to invert the lowest pipe into or out of the basin.	No trash or debris in the catch basin.
		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 catch basin.
		Deposits of garbage exceeding 1 cubic foot in volume.	No condition present which would attract or support the breeding of insects or rodents.
	Damage to frame and/or top slab	Corner of frame extends more than ¾ inch past curb face into the street (If applicable).	Frame is even with curb.
		Top slab has holes larger than 2 square inches or cracks wider than ¼ inch.	Top slab is free of holes and cracks.
		Frame not sitting flush on top slab, i.e., separation of more than ¾ inch of the frame from the top slab.	Frame is sitting flush on top slab.
	Cracks in walls or bottom	Cracks wider than ½ inch and longer than 3 feet, any evidence of soil particles entering catch basin through cracks, or maintenance person judges that catch basin is unsound.	Catch basin is sealed and structurally sound.
		Cracks wider than ½ 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.	No cracks more than $^1/_4$ inch wide at the joint of inlet/outlet pipe.
	Settlement/ misalignment	Catch basin has settled more than 1 inch or has rotated more than 2 inches out of alignment.	Basin replaced or repaired to design standards.
	Damaged pipe joints	Cracks wider than ½-inch at the joint of the inlet/outlet pipes or any evidence of soil entering the catch basin at the joint of the inlet/outlet pipes.	No cracks more than ¼-inch wide at the joint of inlet/outlet pipes.
	Contaminants and pollution	Any evidence of contaminants or pollution such as oil, gasoline, concrete slurries or paint.	Materials removed and disposed of according to applicable regulations. Source control BMPs implemented if appropriate. No contaminants present other than a surface oil film.
Inlet/Outlet Pipe	Sediment accumulation	Sediment filling 20% or more of the pipe.	Inlet/outlet pipes clear of sediment.
	Trash and debris	Trash and debris accumulated in inlet/outlet pipes (includes floatables and non-floatables).	No trash or debris in pipes.
	Damaged	Cracks wider than ½-inch at the joint of the inlet/outlet pipes or any evidence of soil entering at the joints of the inlet/outlet pipes.	No cracks more than ¼-inch wide at the joint of the inlet/outlet pipe.

NO. 5 – CATCH BASINS AND MANHOLES

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Metal Grates (Catch Basins)	Unsafe grate opening	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.	Grate free of trash and debris. footnote to guidelines for disposal
	Damaged or missing	Grate missing or broken member(s) of the grate. **Any open structure requires urgent maintenance.**	Grate is in place and meets design standards.
Manhole Cover/Lid	Cover/lid not in place	Cover/lid is missing or only partially in place. **Any open structure requires urgent maintenance.**	Cover/lid protects opening to structure.
	Locking mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts cannot be seated. Self-locking cover/lid does not work.	Mechanism opens with proper tools.
	Cover/lid difficult to Remove	One maintenance person cannot remove cover/lid after applying 80 lbs. of lift.	Cover/lid can be removed and reinstalled by one maintenance person.

NO. 6 – CONVEYANCE PIPES AND DITCHES

Maintenance Component	Defect or Problem	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Pipes	Sediment & debris accumulation	Accumulated sediment or debris that exceeds 20% of the diameter of the pipe.	Water flows freely through pipes.
	Vegetation/roots	Vegetation/roots that reduce free movement of water through pipes.	Water flows freely through pipes.
	Contaminants and pollution	Any evidence of contaminants or pollution such as oil, gasoline, concrete slurries or paint.	Materials removed and disposed of according to applicable regulations. Source control BMPs implemented if appropriate. No contaminants present other than a surface oil film.
	Damage to protective coating or corrosion	Protective coating is damaged; rust or corrosion is weakening the structural integrity of any part of pipe.	Pipe repaired or replaced.
	Damaged	Any dent that decreases the cross section area of pipe by more than 20% or is determined to have weakened structural integrity of the pipe.	Pipe repaired or replaced.
Ditches	Trash and debris	Trash and debris exceeds 1 cubic foot per 1,000 square feet of ditch and slopes.	Trash and debris cleared from ditches.
	Sediment accumulation	Accumulated sediment that exceeds 20% of the design depth.	Ditch cleaned/flushed of all sediment and debris so that it matches design.
	Noxious weeds	Any noxious or nuisance vegetation which may constitute a hazard to County personnel or the public.	Noxious and nuisance vegetation removed according to applicable regulations. No danger of noxious vegetation where County personnel or the public might normally be.
	Contaminants and pollution	Any evidence of contaminants or pollution such as oil, gasoline, concrete slurries or paint.	Materials removed and disposed of according to applicable regulations. Source control BMPs implemented if appropriate. No contaminants present other than a surface oil film.
	Vegetation	Vegetation that reduces free movement of water through ditches.	Water flows freely through ditches.
	Erosion damage to slopes	Any erosion observed on a ditch slope.	Slopes are not eroding.
	Rock lining out of place or missing (If Applicable)	One layer or less of rock exists above native soil area 5 square feet or more, any exposed native soil.	Replace rocks to design standards.

NO. 8 – ENERGY DISSIPATERS

Maintenance Component	Defect or Problem	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed.
Site	Trash and debris	Trash and/or debris accumulation.	Dissipater clear of trash and/or debris.
	Contaminants and pollution	Any evidence of contaminants or pollution such as oil, gasoline, concrete slurries or paint.	Materials removed and disposed of according to applicable regulations. Source control BMPs implemented if appropriate. No contaminants present other than a surface oil film.
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 prevents erosion.
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).	Water discharges from feature by sheet flow.
	Perforations plugged.	Over 1/4 of perforations in pipe are plugged with debris or sediment.	Perforations freely discharge flow.
	Water flows out top of "distributor" catch basin.	Water flows out of distributor catch basin during any storm less than the design storm.	No flow discharges from distributor catch basin.
	Receiving area over-saturated	Water in receiving area is causing or has potential of causing landslide problems.	No danger of landslides.
Gabions	Damaged mesh	Mesh of gabion broken, twisted or deformed so structure is weakened or rock may fall out.	Mesh is intact, no rock missing.
	Corrosion	Gabion mesh shows corrosion through more than ¼ of its gage.	All gabion mesh capable of containing rock and retaining designed form.
	Collapsed or deformed baskets	Gabion basket shape deformed due to any cause.	All gabion baskets intact, structure stands as designed.
	Missing rock	Any rock missing that could cause gabion to loose structural integrity.	No rock missing.
Manhole/Chamber	Worn or damaged post, baffles or side of chamber	Structure dissipating flow deteriorates to ½ or original size or any concentrated worn spot exceeding one square foot which would make structure unsound.	Structure is in no danger of failing.
	Damage to wall, frame, bottom, and/or top slab	Cracks wider than ½-inch or any evidence of soil entering the structure through cracks, or maintenance inspection personnel determines that the structure is not structurally sound.	Manhole/chamber is sealed and structurally sound.
	Damaged pipe joints	Cracks wider than ½-inch at the joint of the inlet/outlet pipes or any evidence of soil entering the structure at the joint of the inlet/outlet pipes.	No soil or water enters and no water discharges at the joint of inlet/outlet pipes.

NO. 9 – FENCING

Maintenance Component	Defect or Problem	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Site	Erosion or holes under fence	Erosion or holes more than 4 inches high and 12-18 inches wide permitting access through an opening under a fence.	No access under the fence.
Wood Posts, Boards and Cross Members	Missing or damaged parts	Missing or broken boards, post out of plumb by more than 6 inches or cross members broken	No gaps on fence due to missing or broken boards, post plumb to within 1½ inches, cross members sound.
	Weakened by rotting or insects	Any part showing structural deterioration due to rotting or insect damage	All parts of fence are structurally sound.
	Damaged or failed post foundation	Concrete or metal attachments deteriorated or unable to support posts.	Post foundation capable of supporting posts even in strong wind.
Metal Posts, Rails and Fabric	Damaged parts	Post out of plumb more than 6 inches.	Post plumb to within 1½ inches.
		Top rails bent more than 6 inches.	Top rail free of bends greater than 1 inch.
		Any part of fence (including post, top rails, and fabric) more than 1 foot out of design alignment.	Fence is aligned and meets design standards.
		Missing or loose tension wire.	Tension wire in place and holding fabric.
	Deteriorated paint or protective coating	Part or parts that have a rusting or scaling condition that has affected structural adequacy.	Structurally adequate posts or parts with a uniform protective coating.
	Openings in fabric	Openings in fabric are such that an 8-inch diameter ball could fit through.	Fabric mesh openings within 50% of grid size.

NO. 11 – GROUNDS (LANDSCAPING)

Maintenance Component	Defect or Problem	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Site	Trash or litter	Any trash and debris which exceed 1 cubic foot per 1,000 square feet (this is about equal to the amount of trash it would take to fill up one standard size office garbage can). In general, there should be no visual evidence of dumping.	Trash and debris cleared from site.
	Noxious weeds	Any noxious or nuisance vegetation which may constitute a hazard to County personnel or the public.	Noxious and nuisance vegetation removed according to applicable regulations. No danger of noxious vegetation where County personnel or the public might normally be.
	Contaminants and pollution	Any evidence of contaminants or pollution such as oil, gasoline, concrete slurries or paint.	Materials removed and disposed of according to applicable regulations. Source control BMPs implemented if appropriate. No contaminants present other than a surface oil film.
	Grass/groundcover	Grass or groundcover exceeds 18 inches in height.	Grass or groundcover mowed to a height no greater than 6 inches.
Trees and Shrubs	Hazard	Any tree or limb of a tree identified as having a potential to fall and cause property damage or threaten human life. **A hazard tree identified by a qualified arborist must be removed as soon as possible.**	No hazard trees in facility.
	Damaged	Limbs or parts of trees or shrubs that are split or broken which affect more than 25% of the total foliage of the tree or shrub.	Trees and shrubs with less than 5% of total foliage with split or broken limbs.
		Trees or shrubs that have been blown down or knocked over.	No blown down vegetation or knocked over vegetation. Trees or shrubs free of injury.
		Trees or shrubs which are not adequately supported or are leaning over, causing exposure of the roots.	Tree or shrub in place and adequately supported; dead or diseased trees removed.

NO. 12 – ACCESS ROADS

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Site	Trash and debris	Trash and debris exceeds 1 cubic foot per 1,000 square feet (i.e., trash and debris would fill up one standards size garbage can).	Roadway drivable by maintenance vehicles.
		Debris which could damage vehicle tires or prohibit use of road.	Roadway drivable by maintenance vehicles.
	Contaminants and pollution	Any evidence of contaminants or pollution such as oil, gasoline, concrete slurries or paint.	Materials removed and disposed of according to applicable regulations. Source control BMPs implemented if appropriate. No contaminants present other than a surface oil film.
	Blocked roadway	Any obstruction which reduces clearance above road surface to less than 14 feet.	Roadway overhead clear to 14 feet high.
		Any obstruction restricting the access to a 10- to 12 foot width for a distance of more than 12 feet or any point restricting access to less than a 10 foot width.	At least 12-foot of width on access road.
Road Surface	Erosion, settlement, potholes, soft spots, ruts	Any surface defect which hinders or prevents maintenance access.	Road drivable by maintenance vehicles.
	Vegetation on road surface	Trees or other vegetation prevent access to facility by maintenance vehicles.	Maintenance vehicles can access facility.
Shoulders and Ditches	Erosion	Erosion within 1 foot of the roadway more than 8 inches wide and 6 inches deep.	Shoulder free of erosion and matching the surrounding road.
	Weeds and brush	Weeds and brush exceed 18 inches in height or hinder maintenance access.	Weeds and brush cut to 2 inches in height or cleared in such a way as to allow maintenance access.
Modular Grid Pavement	Contaminants and pollution	Any evidence of contaminants or pollution such as oil, gasoline, concrete slurries or paint.	Materials removed and disposed of according to applicable regulations. Source control BMPs implemented if appropriate. No contaminants present other than a surface oil film.
	Damaged or missing	Access surface compacted because of broken on missing modular block.	Access road surface restored so road infiltrates.

NO. 22 – BAFFLE OIL/WATER SEPARATOR

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Site	Trash and debris	Any trash or debris which impairs the function of the facility.	Trash and debris removed from facility.
	Contaminants and pollution	Floating oil in excess of 1 inch in first chamber, any oil in other chambers or other contaminants of any type in any chamber.	No contaminants present other than a surface oil film.
Vault Treatment Area	Sediment accumulation	Sediment accumulates exceeds 6 inches in the vault.	No sediment in the vault.
	Discharge water not clear	Inspection of discharge water shows obvious signs of poor water quality- effluent discharge from vault shows thick visible sheen.	Effluent discharge is clear.
	Trash or debris accumulation	Any trash and debris accumulation in vault (floatables and non-floatables).	Vault is clear of trash and debris.
	Oil accumulation	Oil accumulations that exceed 1 inch, at the surface of the water in the oil/water separator chamber.	No visible oil depth on water.
Vault Structure	Damage to Wall, Frame, Bottom, and/or Top Slab	Cracks wider than ½-inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determines that the vault is not structurally sound.	Vault replaced or repaired to design specifications.
	Baffles damaged	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance inspection personnel.	Repair or replace baffles to specifications.
Gravity Drain	Inoperable valve	Valve will not open and close.	Valve opens and closes normally.
	Valve won't seal	Valve does not seal completely.	Valve completely seals closed.
Inlet/Outlet Pipe	Sediment accumulation	Sediment filling 20% or more of the pipe.	Inlet/outlet pipes clear of sediment.
	Trash and debris	Trash and debris accumulated in inlet/outlet pipes (includes floatables and non-floatables).	No trash or debris in pipes.
	Damaged	Cracks wider than ½-inch at the joint of the inlet/outlet pipes or any evidence of soil entering at the joints of the inlet/outlet pipes.	No cracks more than ¼-inch wide at the joint of the inlet/outlet pipe.
Access Manhole	Cover/lid not in place	Cover/lid is missing or only partially in place. **Any open manhole requires immediate maintenance.**	Manhole access covered.
	Locking mechanism not working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts cannot be seated. Self-locking cover/lid does not work.	Mechanism opens with proper tools.
	Cover/lid difficult to remove	One maintenance person cannot remove cover/lid after applying 80 lbs of lift.	Cover/lid can be removed and reinstalled by one maintenance person.
	Ladder rungs unsafe	Missing rungs, misalignment, rust, or cracks.	Ladder meets design standards. Allows maintenance person safe access.
Large access doors/plate	Damaged or difficult to open	Large access doors or plates cannot be opened/removed using normal equipment.	Replace or repair access door so it can opened as designed.
	Gaps, doesn't cover completely	Large access doors not flat and/or access opening not completely covered.	Doors close flat and cover access opening completely.
	Lifting Rings missing, rusted	Lifting rings not capable of lifting weight of door or cover/lid.	Lifting rings sufficient to lift or remove cover/lid.

NO. 24 – CATCH BASIN INSERT

Maintenance Component	Defect or Problem	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Media Insert	Visible Oil	Visible oil sheen passing through media	Media inset replaced.
	Insert does not fit catch basin properly	Flow gets into catch basin without going through media.	All flow goes through media.
	Filter media plugged	Filter media plugged.	Flow through filter media is normal.
	Oil absorbent media saturated	Media oil saturated.	Oil absorbent media replaced.
	Water saturated	Catch basin insert is saturated with water, which no longer has the capacity to absorb.	Insert replaced.
	Service life exceeded	Regular interval replacement due to typical average life of media insert product, typically one month.	Media replaced at manufacturer's recommended interval.
	Seasonal maintenance	When storms occur and during the wet season.	Remove, clean and replace or install new insert after major storms, monthly during the wet season or at manufacturer's recommended interval.

ATTACHMENT E:

6/30/2016

RATIONAL METHOD
for Conveyance Facility Sizing

Project: 17114 47th Ave NE
Description: Rational method for conveyance pipe capacity analysis

Design Storm: 100 yr

Q=CIA
Where: Q = peak flow (cfs); I = peak rainfall intensity (inches/hour)
C = estimated composite runoff coefficient; A = drainage subbasin area (acres)

Composite Runoff Coefficient

Cc = (C1*A1+C2*A2...)/At
Where: Cc = composite runoff coefficient; A# = area of land cover (acres)
C# = runoff coefficient for Area #; At = total area (acres)

C #		Description	Area (sf)	Area (acres)	C	A*C
1	Onsite/New	Impervious Surface	4,816	0.11	0.90	0.10
2	Onsite/New	Pervious Surface	0	0.00	0.25	0.00
			Totals:	**0.11**		**0.10**
Cc =	**0.90**	**(total C#*A#)/(total area)**				

Time of Concentration

Seg. #	Description of Flow Path Segment	Length (ft)	kr	Upper Elev	Lower Elev	Slope (ft/ft)	Travel Time (minutes)
1	Paved Area (sheet flow) and shallow gutter flow	80	20	125	60	0.813	0.07
	Totals:	**80**					**0.1**

Unity Peak Intensity Factor
ir = ar*Tc^-br
where: Tc = time of concentration (minutes)
ar and br = coefficients from Table 3.2.1.B

Tc =	6.30	minutes (from table above or 6.3 minimum or 100 max)
ar =	2.61	(from Table 3.2.1.B)
br =	0.63	(from Table 3.2.1.B)
ir =	**0.82**	

Peak Rainfall Intensity

Ir = Pr*ir
where: Ir = peak rainfall intensity (inches/hour)
Pr = total 24-hour precipitation for design return period (inches/24 hours)
ir = unit peak rainfall intensity factor

Pr =	3.4	precipitation (inches)
ir =	0.82	unit peak intensity factor (from above)
Ir =	**2.78**	**inches/hour**

Peak Runoff Rate
Q = C*Ir*A

C =	0.90	Cc (unitless) from above
Ir =	2.78	Ir (inches/hour) from above
A =	0.11	total area (acres) from above

Q = 0.277 cfs

Pipe Capacity Calculations (Manning's Equation)
Full Flow (d/D = 0.90)

Description	ID (inches)	Area (sf)	Wetted Per. (ft)	Hyd. Radius (ft)	Manning's n	Slope (ft/ft)	Velocity (ft/s)	Pipe Capacity (cfs)	Req'd Flow (cfs)	
6" for entire site runoff	6	0.1963495	1.570796327	0.125	0.015	0.01	2.48	0.488	0.277	Capacity OK