Drainage Report for Woodland Ponds

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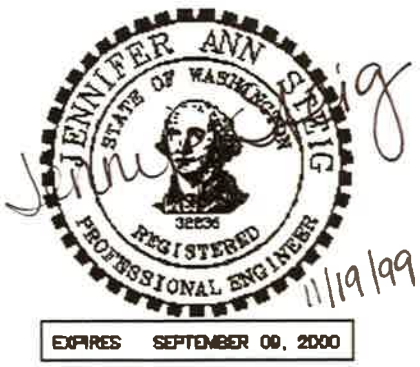


PCE Job No. TREC-0017

TABLE OF CONTENTS

APPENDIX

INTRODUCTION

The proposed plat of Woodland Ponds will consist of 9 multi-family lots. The build out of the lots will include seven duplexes, a 6-plex and an 8-plex. The site is 4.22 acres in size and includes 1.68 acres of Native Growth Protection Easement (NGPE) that will not be developed. The project is located on the south side of 188th Street NE east of 67th Avenue NE (Armar Road) in the City of Arlington.

EXISTING CONDITIONS

The site is flat with a slight slope to the north and is currently overgrown with heavy underbrush. Three Native Growth Protection Areas, Tract 996, 997 and 998, are located within the site. Tract 996 and 998 include existing wetland areas and their buffers, while Tract 997 encompasses existing steep slopes. The soils on the site are listed as Lynnwood Loamy Sand in the Snohomish County SCS study. Terra Associates prepared a geotechnical report for the construction of Pond W2, located directly southwest of this site. The report states that this area is the geologic contact between the Vashon Till (upland, Group C soils) and Marysville Sand (lowland, Group A soils). Since no data is available for the Lynnwood Loamy Sand soil type it has been assumed to be in Hydrologic Group C, given the proximity to the toe of the slopes and the presence of wetlands on the site.

An existing gravel utility access road through the site creates a ridge that divides the site drainage into two main basins; see Existing Conditions Map in the appendix. Basin A is tributary to an existing drainage ditch that discharges into Pond W2 within the Gleneagle Development. The ditch is part of the development's conveyance system routing bypass flows to Pond W2. In addition, an existing storm drainage line parallels the ditch and gravel access road, conveying flows from Heron Court to Pond W2. Currently a "bubble-up" catch basin in the pipe run diverts some of the flows to the existing wetland within Tract 998, to maintain its hydroperiod.

The majority of runoff from Basin B flows northerly toward 188th Street NE where it is conveyed toward 67th Avenue NE. The remainder of Basin B, Tract 996, flows to an existing culvert under 188th Street NE.

DOWNSTREAM ANALYSIS

The site is divided into two basins. Basin A drains southwesterly to Pond W2 within the Gleneagle development, while Basin B flows northerly toward 188th Street NE. Runoff within Basin A is conveyed in an existing drainage ditch westerly through the site then southward to enter Pond W2, located near the entrance of the Gleneagle Development. The ditch is shallow, less than one foot deep with slopes of approximately one to five percent. Flow from the ditch enters Gleneagle Pond W2 and is detained prior to discharge into Gleneagle Pond W1. Outflow from Pond W1 is released to the west side of 67th Avenue NE into an existing ditch paralleling the railroad tracks. Prior to the recent construction of Pond W2 near the entrance of the Gleneagle Development, the downstream system had capacity problems, including localized flooding at the entrance of Gleneagle.

The majority of Basin B currently discharges along 188th Street NE and is conveyed westerly toward the existing drainage system within 67th Avenue NE. A site visit indicated that there was a low point in 188th Street NE between the site and 67th Avenue NE. Recent aerial topography supports the existence of a low point, thus confirming that flows from this site are infiltrated within a low area adjacent to 188th Street NE. Tract 996 and the east half of lots 5, 6, and 7 (the remainder of Basin B) drain to an existing 12-inch CMP culvert that conveys flows under 188th Street NE. Discharge from the culvert is conveyed northerly in a shallow ditch that was constructed with the development of the adjacent Seventh Day Adventist Church. The ditch then turns westerly approximately 500 feet from the culvert outfall and disperses into a large area where the flows are infiltrated into the ground. The soils in this area are highly permeable, Marysville Sands (as noted in the above mentioned geotechnical report) and the majority of drainage facilities installed in this area utilize infiltration systems. The ditch system downstream of the culvert is open, but heavily vegetated along the perimeter. No erosion or capacity problems were observed in this system.

DETENTION CONCEPT

In the developed conditions, drainage will continue to be split in two basins. Basin A will consist of Lots 8 and 9 and Tract 998. The existing ditch that crosses Lot 7, 8, 9 and Tract 998 will be rerouted along the property line between lot 7 and 8 then directed into a closed pipe system at the northwest corner of Lot 7. The portion of the ditch that lies within lots 8 and 9 will be filled, but the ditch will remain open throughout Tract 998. To ensure that the hydroperiod of the wetland within Tract 998 is maintained, roof runoff from Lots 8 and 9 will be directed into the wetland by level spreaders placed at the edge of the wetland buffer. Runoff from the remaining impervious surface and landscape will be directed into the existing ditch within Tract 998. Ditch capacity calculations for the existing and developed conditions have been provided in the Detention Calculations section that follows. Flow in the ditch and conveyance pipe will be conveyed to Pond W2 as in the existing condition. The undetained, developed runoff directed to Pond W2 from Lots 8 and 9 will be similar to the existing flows through the ditch, see detention calculations that follow.

Runoff from Lots 1-7 and the majority of Iris court (Basin B) will be directed into a detention facility located in Tract 999, at the intersection of 188th Street NE and Iris Court. Due to elevation and area limitations, the proposed detention facility will be a combination of a pond located within the Tract and a vault located under Lot 3 and 4. The detention facility will include peak rate runoff control and water quality measures in the pond/vault facility. Runoff from the proposed development will be directed into the pond and then conveyed under the street to the vault by a pipe laid flat.

The detention volumes are based on the SCS Methodology for level pool routing using the City of Arlington detention standards. The required detention volumes are based on detaining the 2-year post-developed flow attenuated to 1/2 of the 2-year pre-developed flow, and matching the 10 and 100-year post-developed flows to the pre-developed. A factor of safety will be applied in accordance to the Department of Ecology Standards. Roof runoff from Lots 5, 6 and 7 will be directed to the wetland located in Tract 996, to ensure the hydroperiod is maintained. Discharge from the detention facility will be directed to the existing culvert that conveys flows under 188th Street NE. Runoff from the frontage improvements and a small portion of Iris Court cannot be

picked up in the conveyance system which tributary to the detention facility. To provide runoff control for this newly created impervious surface an infiltration trench will be installed in the unopened right-of-way directly west of the site. Design of all runoff control facilities follows.

DETENTION CALCULATIONS

The hydrologic analysis for this site was prepared using the Santa Barbara Urban Hydrograph (SBUH) methodology within the Water Works™ software. The Water Works™ output is provided in the appendix.

BASIN A:

Existing Conditions

Total Area = 1.80 Ac

Pervious Area = 0.20 Ac @ CN=89 (gravel road)
= 0.80 Ac @ CN=72 (heavy underbrush)
= 0.80 Ac @ CN=85 (meadow, NGPA)

$CN_W = (89\ (0.20) + 81\ (0.80) + 85\ (0.80)) / 1.80 = 83.67$

Time of Concentration = 54.92 min.
Reach 1: 80' Sheet Flow @ 30.0%; 'n' = 0.80
Reach 2: 100' Sheet Flow @ 3.33%; 'n' = 0.80

Existing Conditions Summary

Storm	Precip. [in]*	Peak Flow [cfs]
2-Year	1.80	0.10
10-Year	2.75	0.26
100-Year	3.75	0.48

*See Appendix for 2, 10 and 100-Year Isopluvials.

Developed Conditions

Total Area = 1.24 Ac

Pervious Area = 0.34 Ac @ CN=86 (landscaping)
= 0.76 Ac @ CN=85 (meadow, NGPA)

CN_W = (86 (0.34) + 85 (0.76)) / 1.10 = 85.31

Time of Concentration = 13.53 min.
Reach 1: 80' Sheet Flow @ 3.00%; 'n' = 0.24

Impervious Area = 0.02 Ac @ CN=98 (Parking Area)
= 0.12 Ac @ CN=98 (Roofs)

Time of Concentration = 6.33 min. (assumed)

Developed Conditions Summary

Storm	Precip. [in]*	Peak Flow [cfs]
2-Year	1.80	0.17
10-Year	2.75	0.37
100-Year	3.75	0.62

*See Appendix for 2, 10 and 100-Year Isopluvials.

The increase in flow due to the proposed improvements is 0.2 cfs. The roof runoff will be directed into the wetland, which will further reduce the peak flow to Pond W2. This should have no impact on the downstream system.

Existing Ditch:

The existing ditch has a v-shape and is approximately 5 feet wide, 1 foot deep with 2:1 side slopes and well vegetated. The existing capacity of the ditch is 3.86 cfs, see Flowmaster printout in Appendix. The proposed ditch to reroute the flow will be trapezoidal with a 1-foot wide bottom, 3:1 side sloped and 2 feet in depth. The capacity of the proposed ditch is 14 cfs, see Flowmaster printout in Appendix. The new ditch will be directed into a 12-inch conveyance pipe at the north end of lot 7. The capacity of the pipe is 3.5 cfs. The new ditch and pipe should provide adequate capacity to convey the existing flow.

BASIN B:

Existing Conditions

Total Area = 1.65 Ac (Does not include Tract 996)

Pervious Area = 1.65 Ac @ CN=85 (meadow with light underbrush)

Time of Concentration = 138.22 min.
Reach 1: 240' Sheet Flow @ 0.90%; 'n' = 0.80

Existing Conditions Summary

Storm	Precip. [in]*	Peak Flow [cfs]
2-Year	1.80	0.07
10-Year	2.75	0.18
100-Year	3.75	0.31

*See Appendix for 2, 10 and 100-Year Isopluvials.

Developed Conditions

Total Area = 2.00 Ac (Includes Lot 7, does not include Tract 996)

Pervious Area = 1.00 Ac @ CN=86 (landscaping)

Time of Concentration = 6.33 min.
Reach 1: 40' Sheet Flow @ 2.00%; 'n' = 0.15

Impervious Area = 0.24 Ac @ CN=98 (Parking Area)
= 0.44 Ac @ CN=98 (Roofs)
= 0.32 Ac @ CN=98 (Roadway)

Time of Concentration = 6.33 min. (assumed)

Developed Conditions Summary

Storm	Precip. [in]*	Peak Flow [cfs]
2-Year	1.80	0.49
10-Year	2.75	0.88
100-Year	3.75	1.30

*See Appendix for 2, 10 and 100-Year Isopluvials.

Level Pool Routing Theoretical

The following level pool table summary represents the results of routing the developed 2-, 10-, and 100-year hydrograph through a theoretical, detention pond. Please note that in all cases the discharge rates are less than or equal to the allowable release rates. A theoretical elevation was used for preliminary sizing. The overflow elevation of the pond will be set at 147.0. Due to the fact that the 100-year storm is being fully detained within the pond and a 30 percent factor of safety has increased the storage volume beyond the standard requirements, additional freeboard has not been provided in this design.

Theoretical

Description	Inflow [CFS]	Storage ID	Discharge ID	P. Stage [FT]	Volume [CF]	Outflow [CFS]
1/2 2YR – 2 YR	0.49	STO1	DIS1	146.05	6256	**0.034**
MATCH 10	0.88	STO1	DIS1	146.21	7340	**0.172**
MATCH 100	1.30	STO1	DIS1	146.43	***8619***	**0.314**

Summary of Release Rates

Description	Developed	Allowable
2-year (cfs)	0.034	0.035
10-year (cfs)	0.172	0.18
100-year (cfs)	0.314	0.31

Factor of Safety

In accordance with the Department of Ecology Standards, a volume correction factor (factor of safety) was applied to the required live storage. The factor of safety required is based on the percentage of the tributary area covered by impervious surfaces. For the site, the impervious cover for the overall site is approximately 50%, which results in a factor of safety of 30% (see the Factor of Safety Table in the Appendix). The factor of safety is to be applied by increasing the surface area of the detention facility while holding the outlet elevation, the size and elevation of any discharge structures and the maximum water surface elevation at a constant.

The theoretical detention volume required is 8,619 cubic-feet. ***The actual required detention volume is thus 11,204 cubic-feet*** (1.30 x 8,619). The volume provided in the proposed pond and vault combination is 13,750 cubic feet.

Culvert Capacity:

The outflow from the pond will combine with upstream runoff and be conveyed under 188th Street NE in a 12-inch CMP culvert. The culvert is sloped at 1.76 percent, providing a capacity of 2.56 cfs, see Flowmaster printout in Appendix. Peak flow from the pond and upstream area in the 100-year storm equals 1.74 cfs. The existing culvert has sufficient capacity to convey the 100-year developed flow.

Water Quality Calculations:

To compute the dead storage the post-developed runoff hydrograph was generated for 64% of the 2-year precipitation, 24-hour storm event per the Department of Ecology Standards.

Volume of Dead Storage Required = (0.10 Ac-ft)x(43,560 cf/Ac) = 4,407 **cubic feet**

Volume of Dead Storage Provided = 5,345 **cubic feet**

Infiltration Trench Design:

The infiltration trench has been designed to detain and infiltrate the 100-year developed storm runoff from the frontage improvements. The runoff rate is 0.14 cfs for the design event and it has been determined that a 15' x 15' x 3' deep trench will provide adequate capacity for storage and sufficient bottom area for infiltration, see calculations in appendix. The infiltration rate was determined by Terra Associates, Inc., a full report is enclosed in the appendix.

APPENDIX

Table III-1.3 SCS Western Washington Runoff Curve Numbers
(Published by SCS in 1982) Runoff curve numbers for selected agricultural, suburban and urban land use for Type 1A rainfall distribution, 24-hour storm duration.

LAND USE DESCRIPTION		CURVE NUMBERS BY HYDROLOGIC SOIL GROUP A	B	C	D
Cultivated land(1):	winter condition	86	91	94	95
Mountain open areas:	low growing brush & grasslands	74	82	89	92
Meadow or pasture:		65	78	85	89
Wood or forest land:	undisturbed	42	64	76	81
Wood or forest land:	young second growth or brush	55	72	81	86
Orchard:	with cover crop	81	88	92	94
Open spaces, lawns, parks, golf courses, cemeteries, landscaping.					
Good condition:	grass cover on ≥75% of the area	68	80	86	90
Fair condition:	grass cover on 50-75% of the area	77	85	90	92
Gravel roads & parking lots:		76	85	89	91
Dirt roads & parking lots:		72	82	87	89
Impervious surfaces, pavement, roofs etc.		98	98	98	98
Open water bodies:	lakes, wetlands, ponds etc.	100	100	100	100
Single family residential(2):					
Dwelling Unit/Gross Acre	%Impervious(3)				
1.0 DU/GA	15				
1.5 DU/GA	20				
2.0 DU/GA	25				
2.5 DU/GA	30				
3.0 DU/GA	34				
3.5 DU/GA	38				
4.0 DU/GA	42				
4.5 DU/GA	46				
5.0 DU/GA	48				
5.5 DU/GA	50				
6.0 DU/GA	52				
6.5 DU/GA	54				
7.0 DU/GA	56				
PUD's, condos, apartments, commercial businesses & industrial areas	%impervious must be computed				
		Separate curve number shall be selected for pervious & impervious portions of the site or basin			

(1) For a more detailed description of agricultural land use curve numbers refer to National Engineering Handbook, Sec. 4, Hydrology, Chapter 9, August 1972.
(2) Assumes roof and driveway runoff is directed into street/storm system.
(3) The remaining pervious areas (lawn) are considered to be in good condition for these curve numbers.

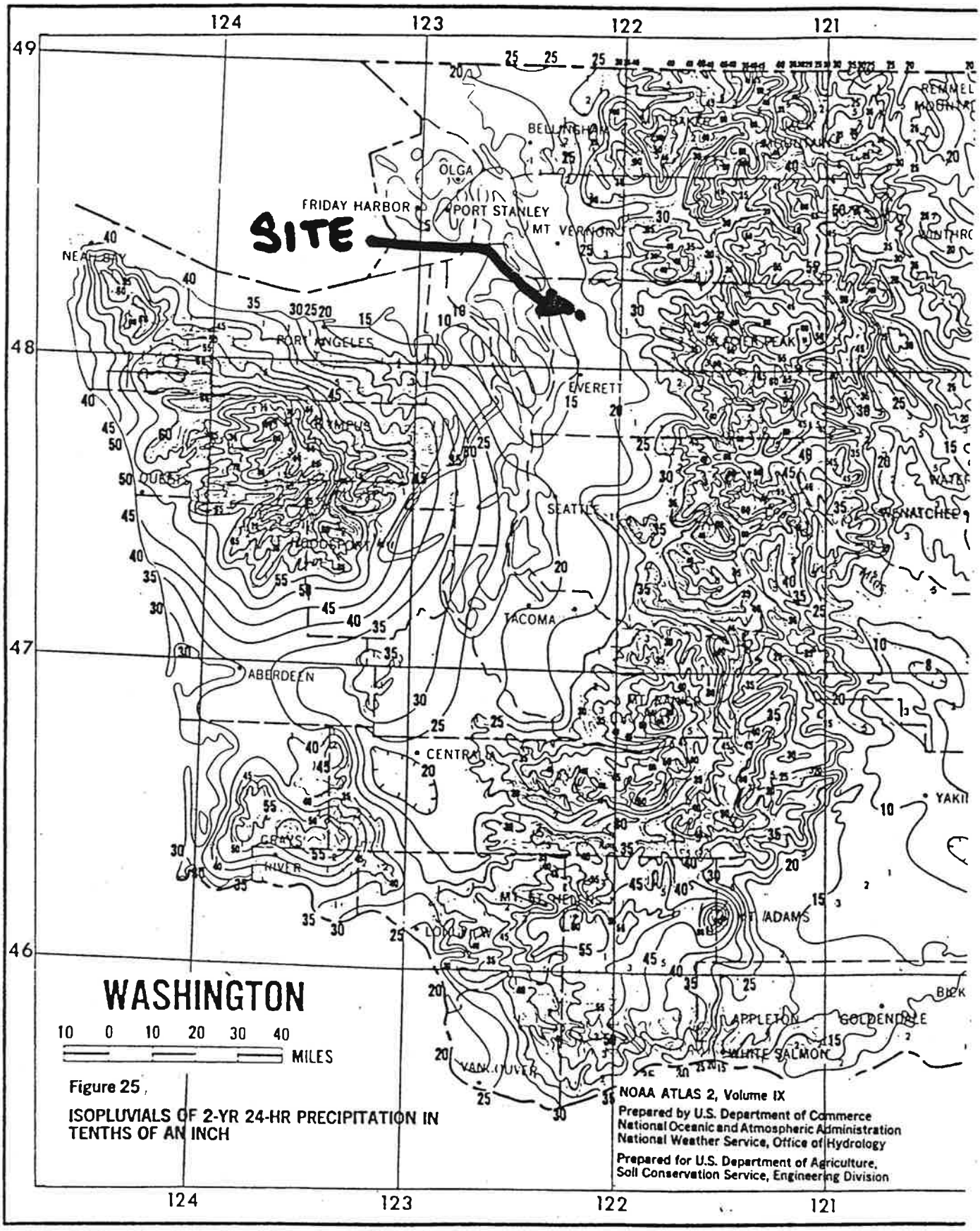


Figure 25,

ISOPLUVIALS OF 2-YR 24-HR PRECIPITATION IN TENTHS OF AN INCH

NOAA ATLAS 2, Volume IX

Prepared by U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Office of Hydrology

Prepared for U.S. Department of Agriculture,
Soil Conservation Service, Engineering Division

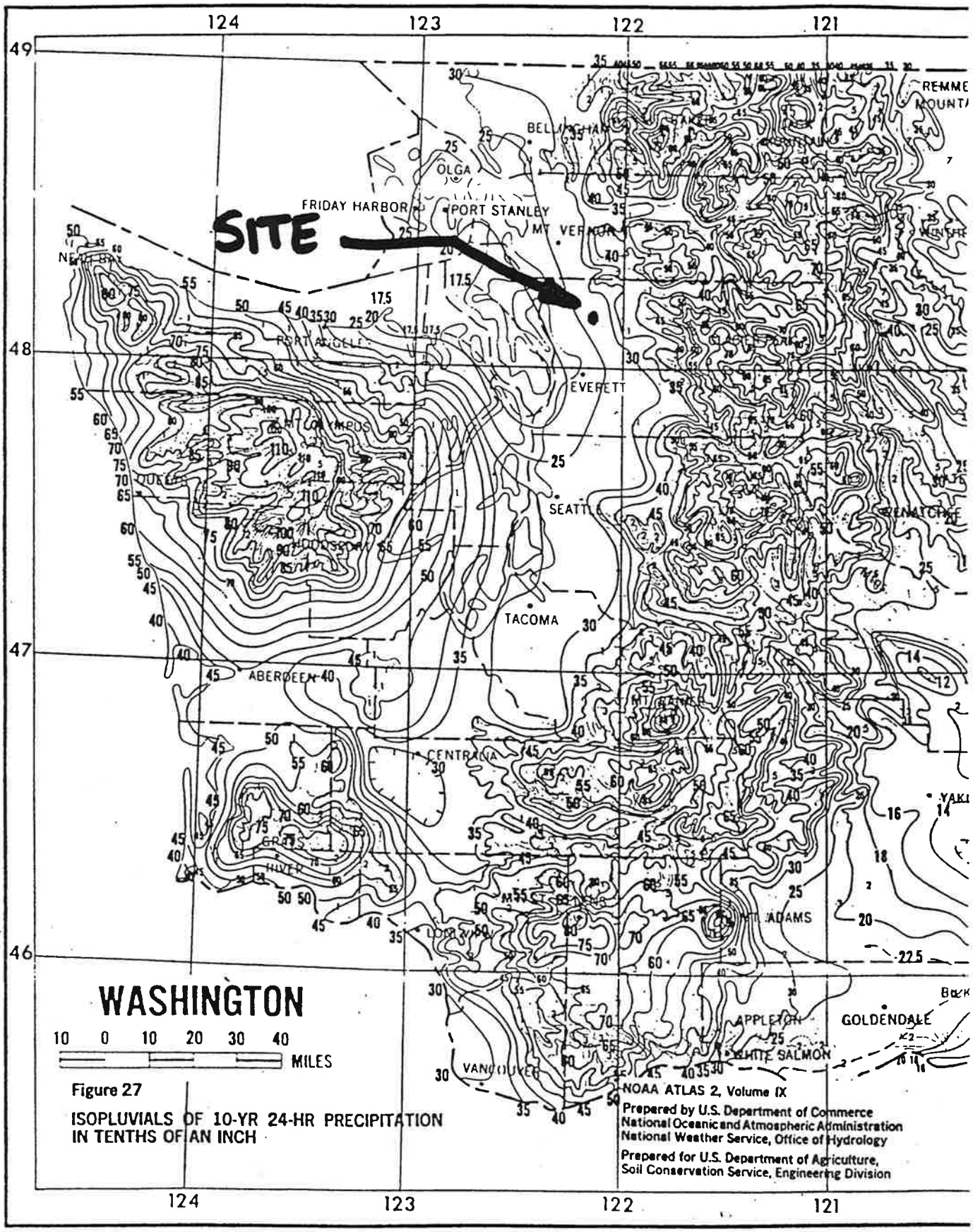


Figure 27

ISOPLUVIALS OF 10-YR 24-HR PRECIPITATION IN TENTHS OF AN INCH

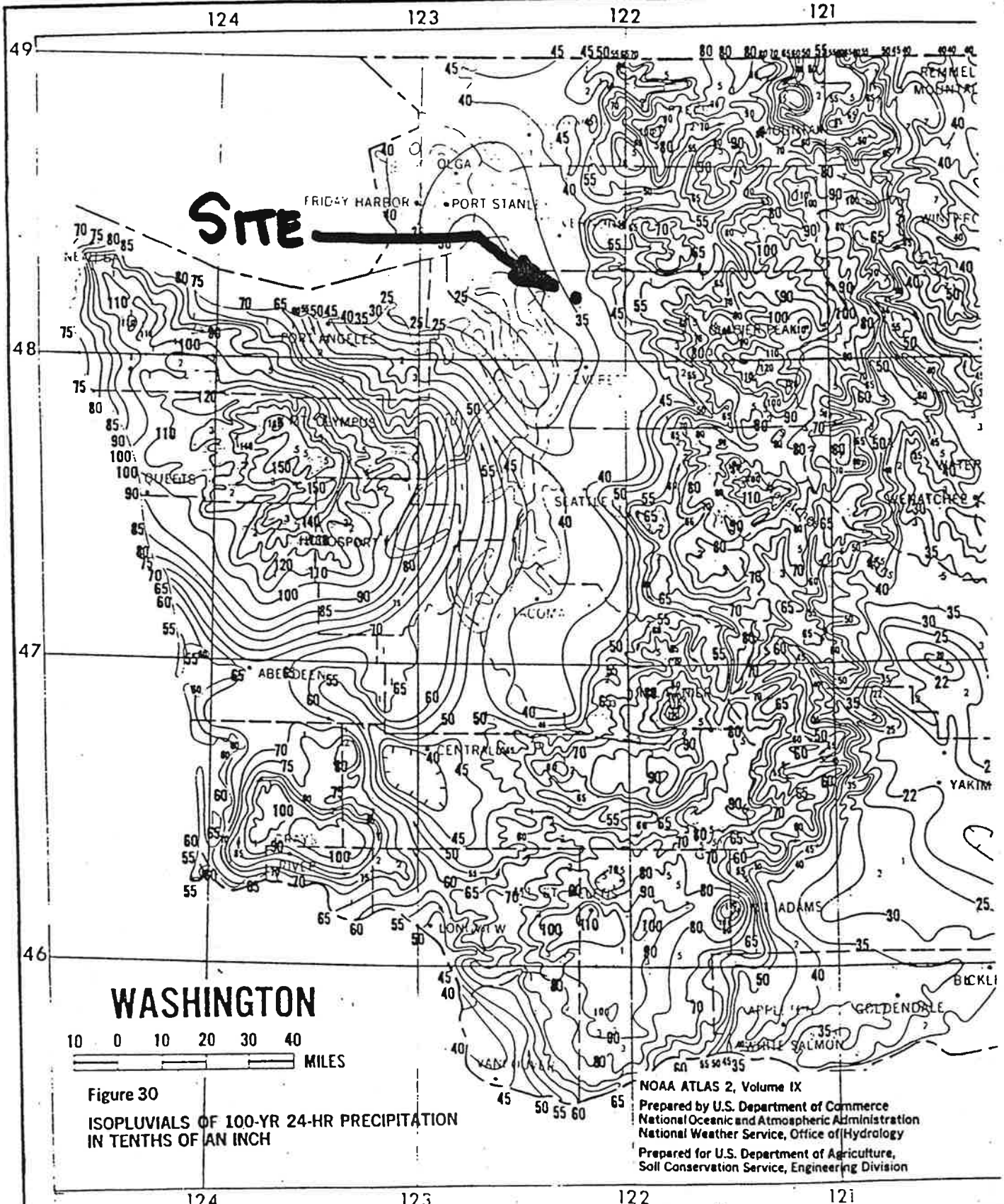


Figure 30

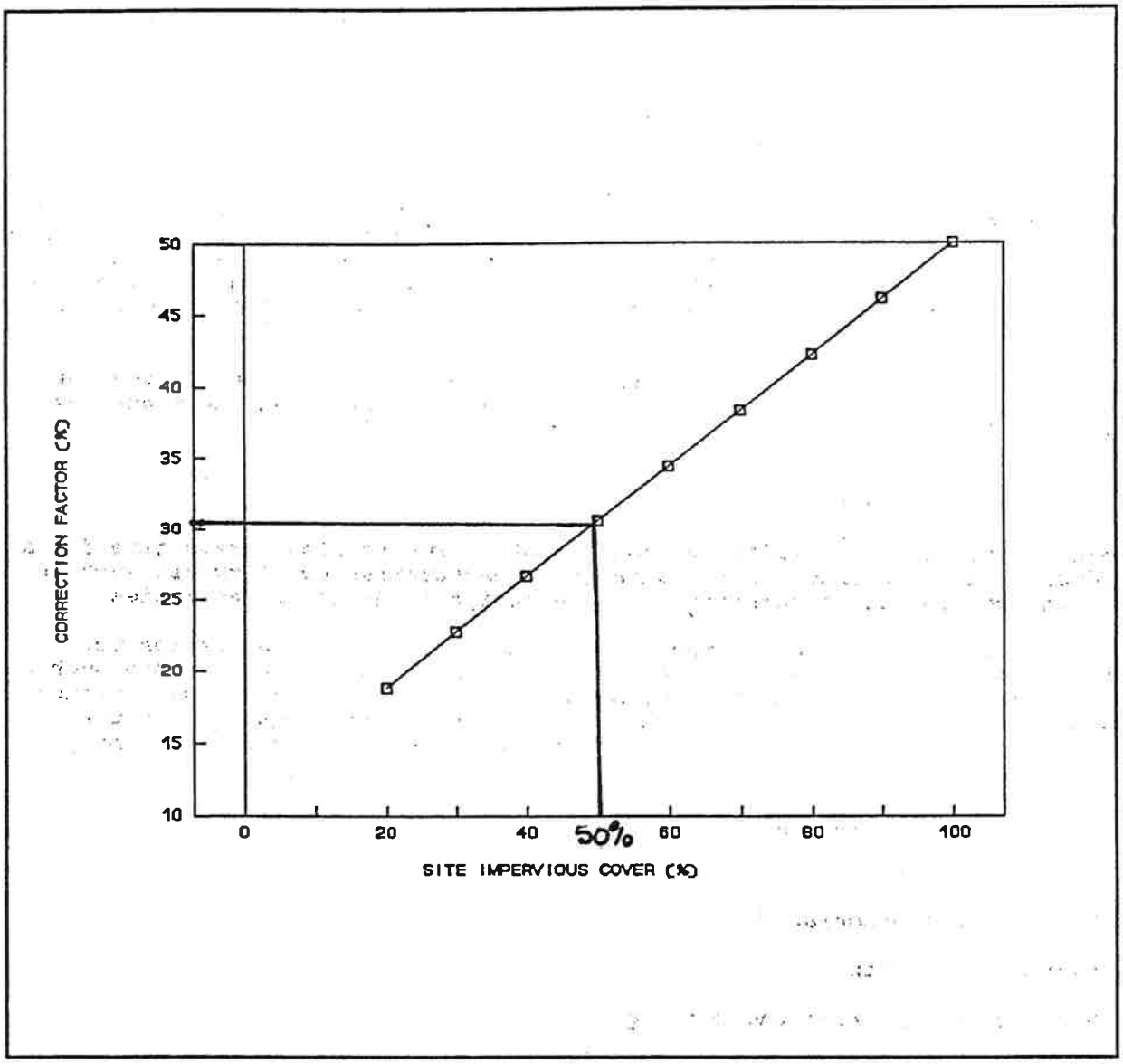
ISOPLUVIALS OF 100-YR 24-HR PRECIPITATION IN TENTHS OF AN INCH

NOAA ATLAS 2, Volume IX

Prepared by U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Office of Hydrology

Prepared for U.S. Department of Agriculture,
Soil Conservation Service, Engineering Division

FIGURE III-1.1
Volume Correction Factor to be Applied to
Streambank Erosion Control BMPs
Based on Site Impervious Cover



BASIN SUMMARY

BASIN ID: EX10-A NAME: EXIST 10 YEAR - LOT 8 AND 9
SBUH METHODOLOGY
TOTAL AREA.....: 1.80 Acres BASEFLOWS: 0.00 cfs
RAINFALL TYPE....: TYPE1A PERV IMP
PRECIPITATION....: 2.75 inches AREA..: 1.80 Acres 0.00 Acres
TIME INTERVAL....: 10.00 min CN....: 83.67 0.00
TC....: 54.92 min 0.00 min
ABSTRACTION COEFF: 0.20
TcReach - Sheet L: 80.00 ns:0.8000 p2yr: 1.80 s:0.3000
TcReach - Sheet L: 100.00 ns:0.8000 p2yr: 1.80 s:0.0330
PEAK RATE: 0.26 cfs VOL: 0.19 Ac-ft TIME: 490 min

BASIN ID: EX100-A NAME: EXIST 100 YEAR - LOT 8 AND 9
SBUH METHODOLOGY
TOTAL AREA.....: 1.81 Acres BASEFLOWS: 0.00 cfs
RAINFALL TYPE....: TYPE1A PERV IMP
PRECIPITATION....: 3.75 inches AREA..: 1.81 Acres 0.00 Acres
TIME INTERVAL....: 10.00 min CN....: 83.67 0.00
TC....: 54.92 min 0.00 min
ABSTRACTION COEFF: 0.20
TcReach - Sheet L: 80.00 ns:0.8000 p2yr: 1.80 s:0.3000
TcReach - Sheet L: 100.00 ns:0.8000 p2yr: 1.80 s:0.0330
PEAK RATE: 0.48 cfs VOL: 0.32 Ac-ft TIME: 490 min

BASIN ID: EX2-A NAME: EXIST 2 YEAR - LOT 8 AND 9
SBUH METHODOLOGY
TOTAL AREA.....: 1.80 Acres BASEFLOWS: 0.00 cfs
RAINFALL TYPE....: TYPE1A PERV IMP
PRECIPITATION....: 1.80 inches AREA..: 1.80 Acres 0.00 Acres
TIME INTERVAL....: 10.00 min CN....: 83.67 0.00
TC....: 54.92 min 0.00 min
ABSTRACTION COEFF: 0.20
TcReach - Sheet L: 80.00 ns:0.8000 p2yr: 1.80 s:0.3000
TcReach - Sheet L: 100.00 ns:0.8000 p2yr: 1.80 s:0.0330
PEAK RATE: 0.10 cfs VOL: 0.09 Ac-ft TIME: 540 min

BASIN SUMMARY

BASIN ID: DEV10-A NAME: DEV 10 YEAR - LOT 8 AND 9
SBUH METHODOLOGY

TOTAL AREA.....:	1.24 Acres	BASEFLOWS:	0.00 cfs	
RAINFALL TYPE....:	TYPE1A		PERV	IMP
PRECIPITATION....:	2.75 inches	AREA..:	1.10 Acres	0.14 Acres
TIME INTERVAL....:	10.00 min	CN....:	85.31	98.00
		TC....:	13.53 min	6.33 min

ABSTRACTION COEFF: 0.20
TcReach - Sheet L: 80.00 ns:0.2400 p2yr: 1.80 s:0.0300
PEAK RATE: 0.37 cfs VOL: 0.16 Ac-ft TIME: 480 min

BASIN ID: DEV100-A NAME: DEV 100 YEAR - LOT 8 AND 9
SBUH METHODOLOGY

TOTAL AREA.....:	1.24 Acres	BASEFLOWS:	0.00 cfs	
RAINFALL TYPE....:	TYPE1A		PERV	IMP
PRECIPITATION....:	3.75 inches	AREA..:	1.10 Acres	0.14 Acres
TIME INTERVAL....:	10.00 min	CN....:	85.31	98.00
		TC....:	13.53 min	6.33 min

ABSTRACTION COEFF: 0.20
TcReach - Sheet L: 80.00 ns:0.2400 p2yr: 1.80 s:0.0300
PEAK RATE: 0.62 cfs VOL: 0.25 Ac-ft TIME: 480 min

BASIN ID: DEV2-A NAME: DEV 2 YEAR - LOT 8 AND 9
SBUH METHODOLOGY

TOTAL AREA.....:	1.24 Acres	BASEFLOWS:	0.00 cfs	
RAINFALL TYPE....:	TYPE1A		PERV	IMP
PRECIPITATION....:	1.80 inches	AREA..:	1.10 Acres	0.14 Acres
TIME INTERVAL....:	10.00 min	CN....:	85.31	98.00
		TC....:	13.53 min	6.33 min

ABSTRACTION COEFF: 0.20
TcReach - Sheet L: 80.00 ns:0.2400 p2yr: 1.80 s:0.0300
PEAK RATE: 0.17 cfs VOL: 0.08 Ac-ft TIME: 480 min

BASIN SUMMARY

BASIN ID: EX10-B NAME: EXIST 10 YEAR - LOT 1-6
SBUH METHODOLOGY

TOTAL AREA.....:	1.65 Acres	BASEFLOWS:	0.00 cfs	
RAINFALL TYPE....:	TYPE1A		PERV	IMP
PRECIPITATION....:	2.75 inches	AREA..:	1.65 Acres	0.00 Acres
TIME INTERVAL....:	10.00 min	CN....:	85.00	0.00
		TC....:	138.22 min	0.00 min

ABSTRACTION COEFF: 0.20
TcReach - Sheet L: 240.00 ns:0.8000 p2yr: 1.80 s:0.0090
PEAK RATE: 0.18 cfs VOL: 0.19 Ac-ft TIME: 550 min

BASIN ID: EX100-B NAME: EXIST 100 YEAR - LOT 1-6
SBUH METHODOLOGY

TOTAL AREA.....:	1.65 Acres	BASEFLOWS:	0.00 cfs	
RAINFALL TYPE....:	TYPE1A		PERV	IMP
PRECIPITATION....:	3.75 inches	AREA..:	1.65 Acres	0.00 Acres
TIME INTERVAL....:	10.00 min	CN....:	85.00	0.00
		TC....:	138.22 min	0.00 min

ABSTRACTION COEFF: 0.20
TcReach - Sheet L: 240.00 ns:0.8000 p2yr: 1.80 s:0.0090
PEAK RATE: 0.31 cfs VOL: 0.31 Ac-ft TIME: 540 min

BASIN ID: EX2-B NAME: EXIST 2 YEAR - LOT 1-6
SBUH METHODOLOGY

TOTAL AREA.....:	1.65 Acres	BASEFLOWS:	0.00 cfs	
RAINFALL TYPE....:	TYPE1A		PERV	IMP
PRECIPITATION....:	1.80 inches	AREA..:	1.65 Acres	0.00 Acres
TIME INTERVAL....:	10.00 min	CN....:	85.00	0.00
		TC....:	138.22 min	0.00 min

ABSTRACTION COEFF: 0.20
TcReach - Sheet L: 240.00 ns:0.8000 p2yr: 1.80 s:0.0090
PEAK RATE: 0.07 cfs VOL: 0.09 Ac-ft TIME: 660 min

BASIN SUMMARY

BASIN ID: DEV10-B NAME: DEV 10 YEAR - LOT 1-6
SBUH METHODOLOGY

TOTAL AREA.....:	2.00 Acres	BASEFLOWS:	0.00 cfs	
RAINFALL TYPE....:	TYPE1A		PERV	IMP
PRECIPITATION....:	2.75 inches	AREA..:	1.00 Acres	1.00 Acres
TIME INTERVAL....:	10.00 min	CN....:	86.00	98.00
		TC....:	6.33 min	6.33 min

ABSTRACTION COEFF: 0.20
TcReach - Sheet L: 40.00 ns:0.1500 p2yr: 1.80 s:0.0200
PEAK RATE: 0.88 cfs VOL: 0.33 Ac-ft TIME: 480 min

BASIN ID: DEV100-B NAME: DEV 100 YEAR - LOT 1-6
SBUH METHODOLOGY

TOTAL AREA.....:	2.00 Acres	BASEFLOWS:	0.00 cfs	
RAINFALL TYPE....:	TYPE1A		PERV	IMP
PRECIPITATION....:	3.75 inches	AREA..:	1.00 Acres	1.00 Acres
TIME INTERVAL....:	10.00 min	CN....:	86.00	98.00
		TC....:	6.33 min	6.33 min

ABSTRACTION COEFF: 0.20
TcReach - Sheet L: 40.00 ns:0.1500 p2yr: 1.80 s:0.0200
PEAK RATE: 1.30 cfs VOL: 0.49 Ac-ft TIME: 480 min

BASIN ID: DEV2-B NAME: DEV 2 YEAR - LOT 1-6
SBUH METHODOLOGY

TOTAL AREA.....:	2.00 Acres	BASEFLOWS:	0.00 cfs	
RAINFALL TYPE....:	TYPE1A		PERV	IMP
PRECIPITATION....:	1.80 inches	AREA..:	1.00 Acres	1.00 Acres
TIME INTERVAL....:	10.00 min	CN....:	86.00	98.00
		TC....:	6.33 min	6.33 min

ABSTRACTION COEFF: 0.20
TcReach - Sheet L: 40.00 ns:0.1500 p2yr: 1.80 s:0.0200
PEAK RATE: 0.49 cfs VOL: 0.19 Ac-ft TIME: 480 min

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BASIN SUMMARY

BASIN ID: WTRQUAL NAME: WATER QUALITY - LOT 1-6
SBUH METHODOLOGY

TOTAL AREA.....:	2.00 Acres	BASEFLOWS:	0.00 cfs	
RAINFALL TYPE....:	TYPE1A		PERV	IMP
PRECIPITATION....:	1.15 inches	AREA..:	1.00 Acres	1.00 Acres
TIME INTERVAL....:	10.00 min	CN....:	86.00	98.00
		TC....:	6.33 min	6.33 min

ABSTRACTION COEFF: 0.20
TcReach - Sheet L: 40.00 ns:0.1500 p2yr: 1.80 s:0.0200
PEAK RATE: 0.25 cfs VOL: 0.10 Ac-ft TIME: 480 min

VOLUME = 4,407 CF

STAGE STORAGE TABLE

CUSTOM STORAGE ID No. STO1
Description: POND AND VAULT

STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-	STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-	STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-	STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-
145.25	0.0000	0.0000	146.00	5948	0.1365	147.00	12118	0.2782	147.00	12118	0.2782
145.50	1983	0.0455	146.50	9033	0.2074						

STAGE STORAGE TABLE

CUSTOM STORAGE ID No. STO1A
Description: POND, VAULT AND WATER QUALITY

STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-	STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-	STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-	STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-
142.00	0.0000	0.0000	143.50	2132	0.0489	145.00	4845	0.1112	146.50	15084	0.3463
142.50	710.75	0.0163	144.00	2843	0.0653	145.50	7255	0.1665	147.00	19094	0.4383
143.00	1422	0.0326	144.50	3844	0.0882	146.00	11074	0.2542			

STAGE DISCHARGE TABLE

MULTIPLE ORIFICE ID No. DIS1
Description: ORIFICE DESIGN
Outlet Elev: 145.25
Elev: 143.25 ft Orifice Diameter: 1.1000 in.
Elev: 146.15 ft Orifice 2 Diameter: 4.4500 in.

STAGE (ft)	<--DISCHARGE---> ---cfs-- -------	STAGE (ft)	<--DISCHARGE---> ---cfs-- -------	STAGE (ft)	<--DISCHARGE---> ---cfs-- -------	STAGE (ft)	<--DISCHARGE---> ---cfs-- -------
145.25	0.0000	146.00	0.0284	147.00	0.5389	147.00	0.5389
145.50	0.0164	146.50	0.3546				

LEVEL POOL TABLE SUMMARY
(w/o F.O.S.)

<--------DESCRIPTION--------->	MATCH (cfs)	INFLOW (cfs)	-STO- --id-	-DIS- --id-	<-PEAK-> <-STAGE>	id	STORAGE VOL (cf)
2 YEAR STORM	0.04	0.49	STO1	DIS1	146.05	1	6256.34 cf
10 YEAR STORM	0.18	0.88	STO1	DIS1	146.21	2	7239.47 cf
100 YEAR STORM	0.31	1.30	STO1	DIS1	146.43	3	8619.50 cf

LEVEL POOL TABLE SUMMARY
(w/ 30% F.O.S.)

<--------DESCRIPTION--------->	MATCH (cfs)	INFLOW (cfs)	-STO- --id-	-DIS- --id-	<-PEAK-> <-STAGE>	id	STORAGE VOL (cf)
2 YEAR STORM	0.04	0.49	STO1A	DIS1	145.57	4	7782.49 cf
10 YEAR STORM	0.18	0.88	STO1A	DIS1	146.11	5	11943.47 cf
100 YEAR STORM	0.31	1.30	STO1A	DIS1	146.27	6	13211.69 cf

Existing Ditch Capacity Check
Worksheet for Triangular Channel

Project Description	
Project File	e:\projects\trec0017\culvert.fm2
Worksheet	existing ditch
Flow Element	Triangular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Mannings Coefficient	0.045	
Channel Slope	1.0000	%
Depth	1.00	ft
Left Side Slope	2.000000	H : V
Right Side Slope	2.000000	H : V

Results		
Discharge	3.86	cfs
Flow Area	2.00	ft²
Wetted Perimeter	4.47	ft
Top Width	4.00	ft
Critical Depth	0.75	ft
Critical Slope	0.047556	ft/ft
Velocity	1.93	ft/s
Velocity Head	0.06	ft
Specific Energy	1.06	ft
Froude Number	0.48	
Flow is subcritical.		

Capacity Check - Pipe @ Lot 8/9
Worksheet for Circular Channel

Project Description	
Project File	e:\projects\trec0017\culvert.fm2
Worksheet	Pipe at Lot 8/9
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Full Flow Capacity

Input Data		
Mannings Coefficient	0.013	
Channel Slope	1.0000	%
Diameter	12.00	in

Results		
Depth	1.00	ft
Discharge	3.56	cfs
Flow Area	0.79	ft^2
Wetted Perimeter	3.14	ft
Top Width	0.00	ft
Critical Depth	0.81	ft
Percent Full	100.00	
Critical Slope	0.010318	ft/ft
Velocity	4.54	ft/s
Velocity Head	0.32	ft
Specific Energy	FULL	ft
Froude Number	FULL	
Maximum Discharge	3.83	cfs
Full Flow Capacity	3.56	cfs
Full Flow Slope	0.010000	ft/ft

Capacity Check - Relocated Ditch Lot 7
Worksheet for Trapezoidal Channel

Project Description	
Project File	e:\projects\trec0017\culvert.fm2
Worksheet	Relocated Ditch - Lot 7
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Mannings Coefficient	0.027	
Channel Slope	1.0000	%
Depth	1.00	ft
Left Side Slope	3.000000	H : V
Right Side Slope	3.000000	H : V
Bottom Width	1.00	ft

Results		
Discharge	14.71	cfs
Flow Area	4.00	ft^2
Wetted Perimeter	7.32	ft
Top Width	7.00	ft
Critical Depth	0.93	ft
Critical Slope	0.013877	ft/ft
Velocity	3.68	ft/s
Velocity Head	0.21	ft
Specific Energy	1.21	ft
Froude Number	0.86	
Flow is subcritical.		

BASIN SUMMARY

BASIN ID: FRONT100 NAME: FRONTAGE IMPROVMENTS - 100 YR
SBUH METHODOLOGY

TOTAL AREA.....:	0.27 Acres	BASEFLOWS:	0.00 cfs	
RAINFALL TYPE....:	TYPE1A		PERV	IMP
PRECIPITATION....:	3.75 inches	AREA..:	0.03 Acres	0.24 Acres
TIME INTERVAL....:	10.00 min	CN....:	81.00	98.00
		TC....:	6.33 min	6.33 min

ABSTRACTION COEFF: 0.20
TcReach - Sheet L: 300.00 ns:0.4000 p2yr: 1.80 s:0.1000
TcReach - Channel L: 300.00 kc:10.00 s:0.1000
PEAK RATE: 0.20 cfs VOL: 0.08 Ac-ft TIME: 480 min

STAGE STORAGE TABLE

RECTANGULAR VAULT ID No. STO-FRNT
Description: FRONTAGE - INFILTRATION TRENCH
Length: 15.00 ft. Width: 15.00 ft. voids: 0.330

STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-	STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-	STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-	STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-
139.00	0.0000	0.0000	140.00	74.250	0.0017	141.00	148.50	0.0034	142.00	222.75	0.0051
139.50	37.125	0.0009	140.50	111.38	0.0026	141.50	185.63	0.0043			

STAGE DISCHARGE TABLE

DISCHARGE LIST ID No. DIS-FRNT
Description: INFILTRATION RATE FOR TRENCH

STAGE (ft)	<--DISCHARGE---> ---cfs-- -------	STAGE (ft)	<--DISCHARGE---> ---cfs-- -------	STAGE (ft)	<--DISCHARGE---> ---cfs-- -------	STAGE (ft)	<--DISCHARGE---> ---cfs-- -------
139.00	0.0520	141.00	0.0520	143.00	0.0520	145.00	0.0520
139.50	0.0520	141.50	0.0520	143.50	0.0520		
140.00	0.0520	142.00	0.0520	144.00	0.0520		
140.50	0.0520	142.50	0.0520	144.50	0.0520		

LEVEL POOL TABLE SUMMARY

<--------DESCRIPTION--------->	MATCH (cfs)	INFLOW (cfs)	-STO- --id-	-DIS- --id-	<-PEAK-> <-STAGE>	id	STORAGE VOL (cf)
100 FRONTAGE	0.00	0.14	STO-FRNT	DIS-FRNT	141.87	10	213.36 cf

Capacity Check - Existing Pipe @ 188th
Worksheet for Circular Channel

Project Description	
Project File	e:\projects\trec0017\culvert.fm2
Worksheet	Culvert
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Full Flow Capacity

Input Data		
Mannings Coefficient	0.024	
Channel Slope	1.7600	%
Diameter	12.00	in

Results		
Depth	1.00	ft
Discharge	2.56	cfs
Flow Area	0.79	ft^2
Wetted Perimeter	3.14	ft
Top Width	0.00	ft
Critical Depth	0.69	ft
Percent Full	100.00	
Critical Slope	0.026522	ft/ft
Velocity	3.26	ft/s
Velocity Head	0.17	ft
Specific Energy	FULL	ft
Froude Number	FULL	
Maximum Discharge	2.75	cfs
Full Flow Capacity	2.56	cfs
Full Flow Slope	0.017600	ft/ft

BASIN SUMMARY

BASIN ID: DEV100-B NAME: DEV 100 YEAR - LOT 1-6
SBUH METHODOLOGY

TOTAL AREA.....:	2.00 Acres	BASEFLOWS:	0.00 cfs	
RAINFALL TYPE....:	TYPE1A		PERV	IMP
PRECIPITATION....:	3.75 inches	AREA..:	1.00 Acres	1.00 Acres
TIME INTERVAL....:	10.00 min	CN....:	86.00	98.00
		TC....:	6.33 min	6.33 min

ABSTRACTION COEFF: 0.20
TcReach - Sheet L: 40.00 ns:0.1500 p2yr: 1.80 s:0.0200
PEAK RATE: 1.30 cfs VOL: 0.49 Ac-ft TIME: 480 min

BASIN ID: OFF100 NAME: OFFSITE BASIN - CULVERT SIZING
SBUH METHODOLOGY

TOTAL AREA.....:	1.17 Acres	BASEFLOWS:	0.00 cfs	
RAINFALL TYPE....:	TYPE1A		PERV	IMP
PRECIPITATION....:	3.75 inches	AREA..:	1.02 Acres	0.15 Acres
TIME INTERVAL....:	10.00 min	CN....:	81.00	98.00
		TC....:	37.80 min	5.00 min

ABSTRACTION COEFF: 0.20
TcReach - Sheet L: 300.00 ns:0.4000 p2yr: 1.80 s:0.1000
TcReach - Channel L: 300.00 kc:10.00 s:0.1000
PEAK RATE: 0.38 cfs VOL: 0.21 Ac-ft TIME: 480 min

TOTAL FLOW = 1.68 cfs
@ CULVERT UNDER 188th

TERRA ASSOCIATES, Inc.

Consultants in Geotechnical Engineering, Geology
and
Environmental Earth Sciences

October 29, 1999
Project No. T-4520

Mr. Randy Woods
c/o Mr. Bart Treece
Treece and Associates
4030 Lake Washington Boulevard NE, Suite 200
Kirkland, Washington 98033

Subject: Infiltration Evaluation
Woodland Ponds
188th Street NE and 71st Drive NE
Arlington, Washington

Dear Mr. Woods:

As requested, we investigated subsurface conditions at the subject site by excavating one backhoe test pit to a depth of approximately 12.5 feet below the ground surface. We performed field testing at a depth of approximately four to six feet to evaluate the infiltration capacity of the site soils. We conducted the test in general conformance with the testing procedures outlined by the Environmental Protection Agency (EPA) On-Site Sewage Disposal and Treatment Systems (1980). We also installed a vertical three-fourths inch diameter slotted PVC pipe in the test pit prior to backfilling in order to provide a means for future monitoring of groundwater levels at that location. The purpose of our work was to observe subsurface conditions at the proposed dry well location. We understand that the dry well will be used to infiltrate stormwater from a relatively small area adjacent the southern edge of 188th Street NE. Based on our conversation with you, we understand that the dry well will consist of an excavation backfilled with drain rock. The exact location or dimensions of the dry well have not been determined.

SUBSURFACE CONDITIONS

Soils

The soils encountered in the test pit consist of 12 inches of sod and topsoil overlying medium dense, dry to moist, fine-grained sand to a depth approximately four feet below the ground surface. The upper sand unit is underlain by medium dense to dense, moist, fine- to coarse-grained sand with varying amounts of gravel. We encountered the sand with gravel unit to the test pit termination depth of 12.5 feet.

12525 Willows Road, Suite 101, Kirkland, Washington 98034
Phone (425) 821-7777 • Fax (425) 821-4334 • terra@terra-associates.com

The *Geologic Map of the Arlington West 7.5 Minute Quadrangle, Snohomish County, Washington,* by James P. Minard (1985), shows the soils in the vicinity of the site belonging to the Marysville Sand Member of the Vashon recessional outwash. These soils are classified as well-drained sand with fine gravel overlying till. The soils we observed in the test pit are generally consistent with the classification of well-drained sand with fine gravel. We did not encounter till in the test pit.

Figure 4 presents detailed descriptions of the subsurface conditions encountered in the test pit. The approximate test pit location is shown on Figure 2.

Groundwater

We did not encounter groundwater seepage or indications of a seasonal water table in the test pit. However, we expect fluctuations in the groundwater levels at the site will occur seasonally and annually, with lowest levels and volumes occurring during late summer to early fall (July through September).

DISCUSSION AND RECOMMENDATIONS

Based on the results of our field testing and analysis, we recommend using a design infiltration rate of ten inches per hour for preliminary design purposes. Because of several unknown parameters, including the barrier depth to flow and the dimensions of the infiltration facility, this rate should be verified by field testing and/or additional analysis.

We trust that the information presented is sufficient for your current needs. If you have any questions or require additional information, please call.

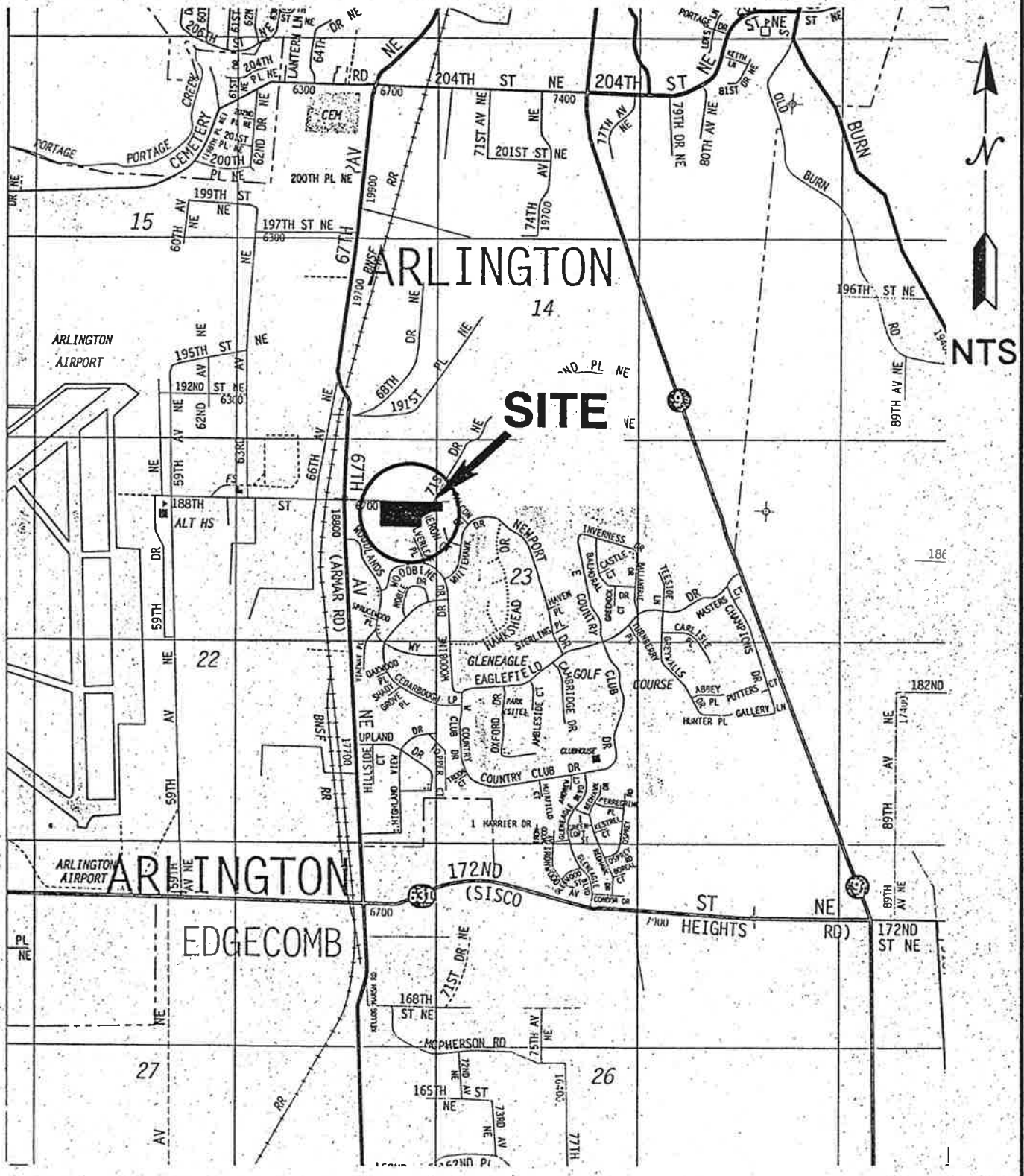
Sincerely yours,
TERRA ASSOCIATES, INC.

John Sadler, R.P.G.
Project Engineering Geologist

Theodore J. Schepper, P.E.
Principal Engineer

THEODORE J. SCHEPPER — STATE OF WASHINGTON — 25742 — REGISTERED PROFESSIONAL ENGINEER — 10-29-99

Encl. Figure 1 – Vicinity Map
Figure 2 – Exploration Location Plan
Figure 3 – Unified Soil Classification System
Figure 4 – Test Pit Log
Figures 5 and 6 – Grain Size Analyses



REFERENCE: THE THOMAS GUIDE, METROPOLITAN PUGET SOUND, PAGES 317 AND 337, 2000 EDITION.

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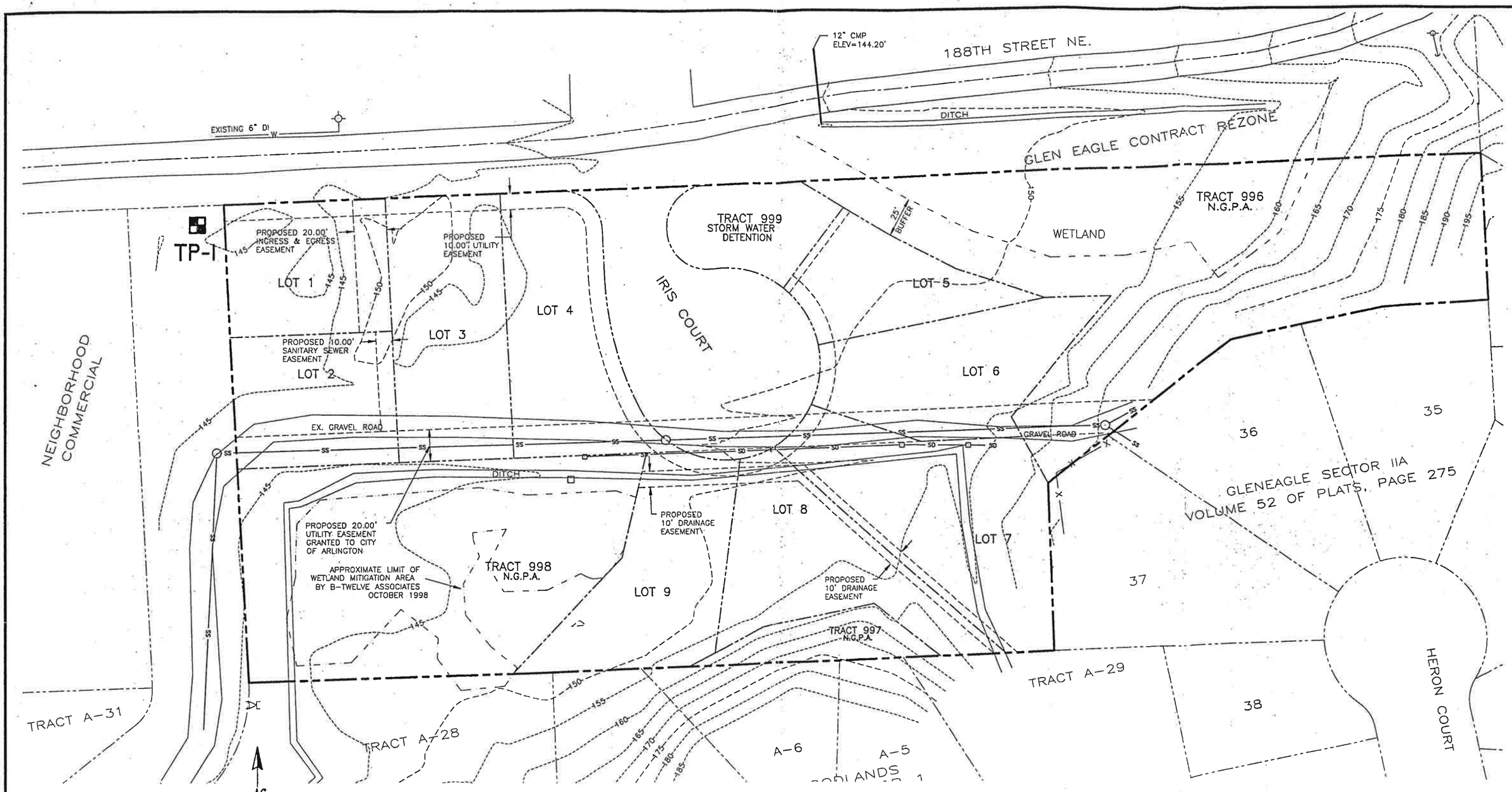
VICINITY MAP
WOODLAND PONDS
ARLINGTON, WASHINGTON

Proj.No. 4520	Date OCT. 1999	Figure 1



LEGEND:

■ APPROXIMATE TEST PIT LOCATION

APPROXIMATE SCALE

60 0 60 120 feet

REFERENCE:

SITE PLAN PREPARED AND PROVIDED BY METRON AND ASSOCIATES, INC., PROJECT No. 99002, SHEET 1 OF 1, DATED 01/99.

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EXPLORATION LOCATION PLAN
WOODLAND PONDS
ARLINGTON, WASHINGTON

Proj.No. 4520	Date OCT. 1999	Figure 2

MAJOR DIVISIONS			LETTER SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS More than 50% material larger than No. 200 sieve size	GRAVELS More than 50% of coarse fraction is larger than No. 4 sieve	Clean Gravels (less than 5% fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures, non-plastic fines.
			GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines.
	SANDS More than 50% of coarse fraction is smaller than No. 4 sieve	Clean Sands (less than 5% fines)	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly-graded sands or gravelly sands, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures, non-plastic fines.
			SC	Clayey sands, sand-clay mixtures, plastic fines.
FINE GRAINED SOILS More than 50% material smaller than No. 200 sieve size	SILTS AND CLAYS Liquid limit is less than 50%		ML	Inorganic silts, rock flour, clayey silts with slight plasticity.
			CL	Inorganic clays of low to medium plasticity, (lean clay).
			OL	Organic silts and organic clays of low plasticity.
	SILTS AND CLAYS Liquid limit is greater than 50%		MH	Inorganic silts, elastic.
			CH	Inorganic clays of high plasticity, fat clays.
			OH	Organic clays of high plasticity.
HIGHLY ORGANIC SOILS			PT	Peat.

DEFINITION OF TERMS AND SYMBOLS

SAND or GRAVEL

Density	Standard Penetration Resistance in Blows/Foot
Very loose	0-4
Loose	4-10
Medium dense	10-30
Dense	30-50
Very dense	>50

SILT or CLAY

Consistency	Standard Penetration Resistance in Blows/Foot
Very soft	0-2
Soft	2-4
Medium stiff	4-8
Stiff	8-16
Very stiff	16-32
Hard	>32

I 2" OUTSIDE DIAMETER SPLIT SPOON SAMPLER

I 2.4" INSIDE DIAMETER RING SAMPLER OR SHELBY TUBE SAMPLER

▼ WATER LEVEL (DATE)

Tr TORVANE READINGS, tsf

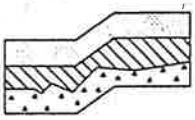
Pp PENETROMETER READING, tsf

DD DRY DENSITY, pounds per cubic foot

LL LIQUID LIMIT, percent

PI PLASTIC INDEX

N STANDARD PENETRATION, blows per foot



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UNIFIED SOIL CLASSIFICATION SYSTEM
WOODLAND PONDS
ARLINGTON, WASHINGTON

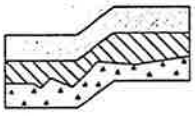
Proj. No. T-4520	Date OCT 1999	Figure 3

Test Pit No. TP-1

Logged by: JCS
Date: 10/12/99

Approximate Elev. 145

Depth (ft.)	Soil Description	Moisture Content (%)	
0	12 inches sod and topsoil. Tan SAND, fine grained, medium dense, dry to moist. (SP)	5	*62 in/hr.
5	Gray-brown SAND to SAND with gravel, fine to coarse sand, fine to coarse gravel, medium dense to dense, moist. (SP)	6	
10		6	
15	Test pit terminated at 12.5 feet. No groundwater seepage. Installed slotted 3/4-inch diameter PVC pipe. *Infiltration rate determined by field testing.		



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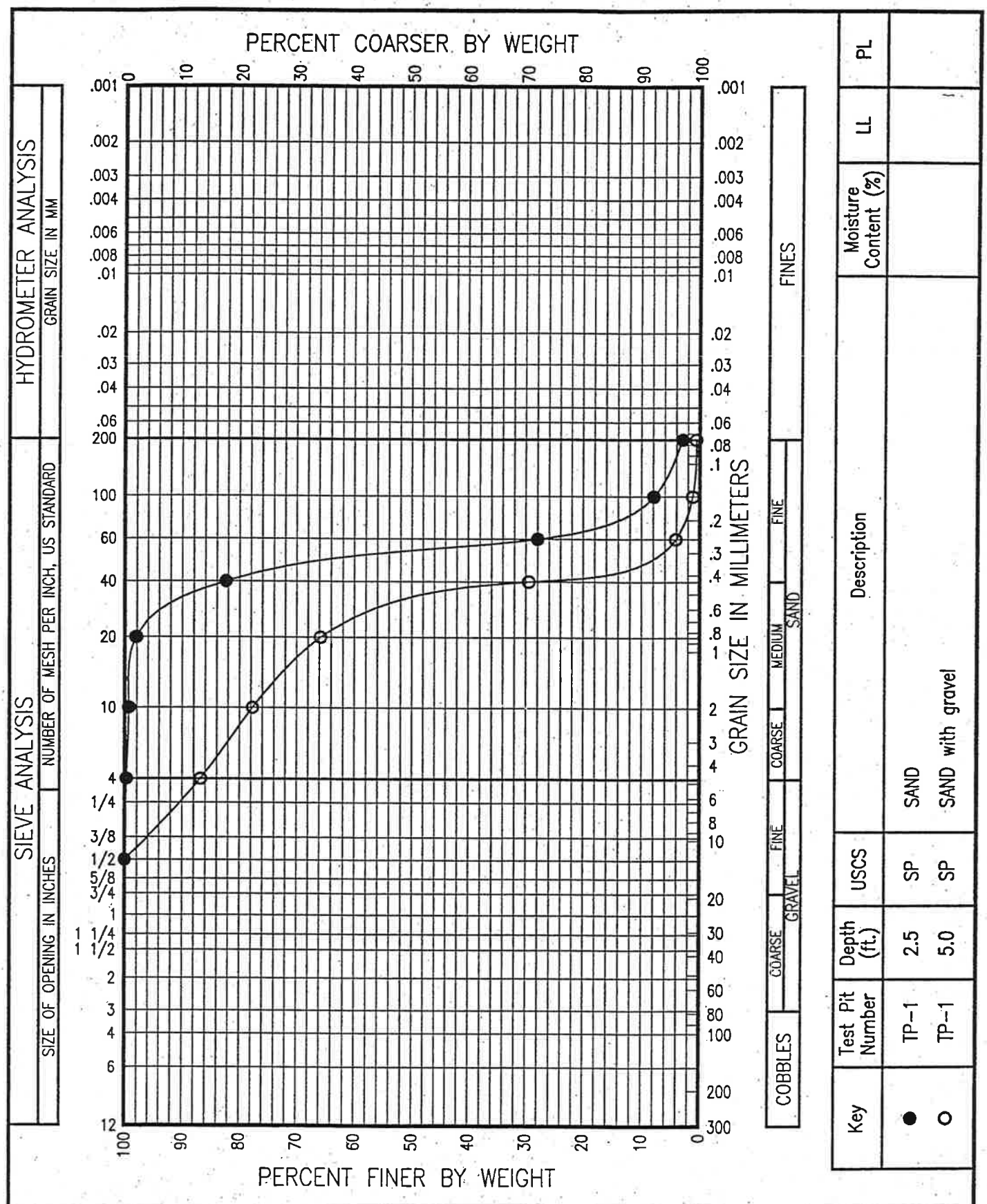
TEST PIT LOG
WOODLAND PONDS
ARLINGTON, WASHINGTON

Proj. No. T-4520	Date OCT 1999	Figure 4



Key	Test Pit Number	Depth (ft.)	USCS	Description	Moisture Content (%)	LL	PL
●	TP-1	2.5	SP	SAND			
○	TP-1	5.0	SP	SAND with gravel			

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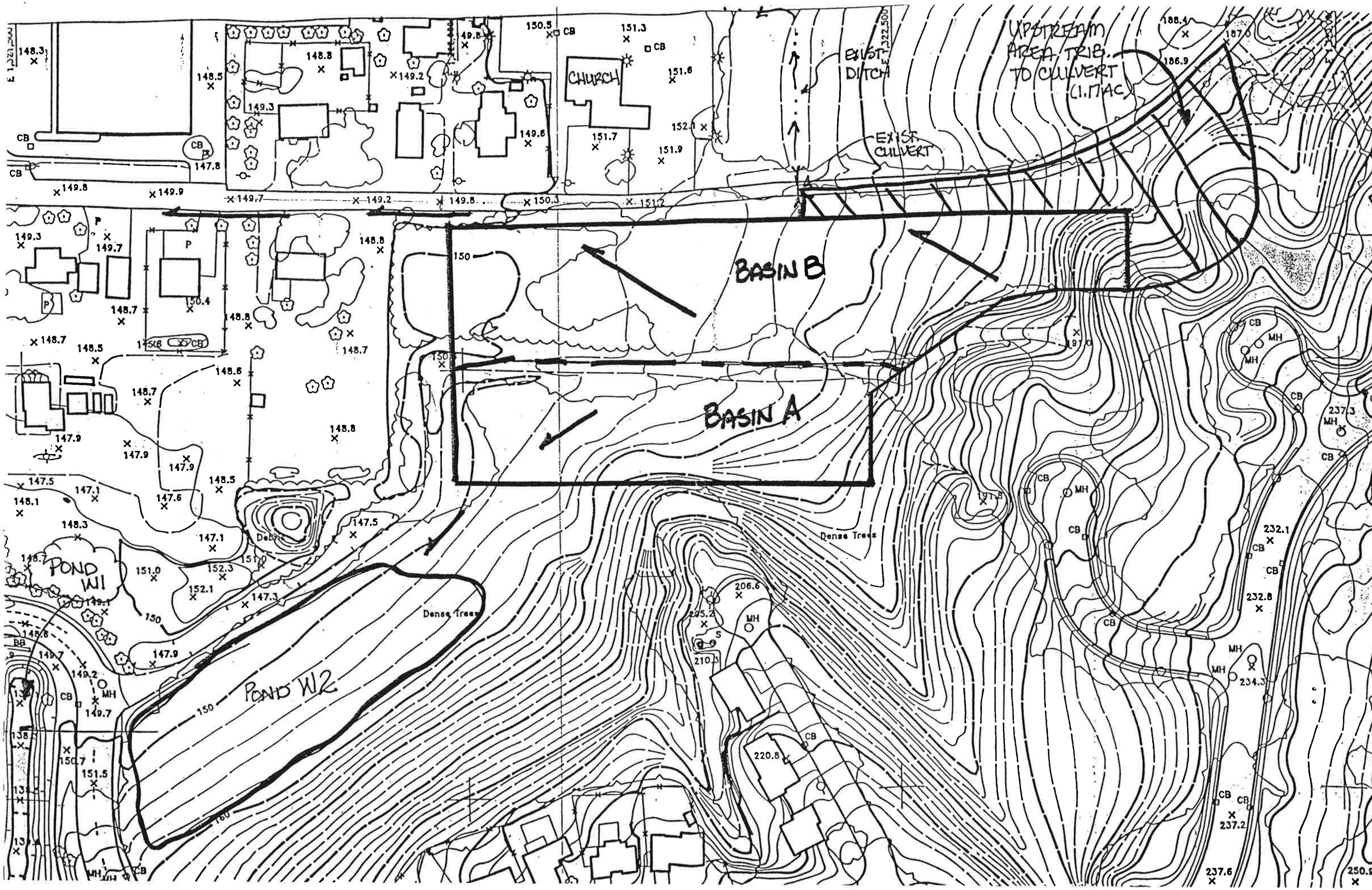
GRAIN SIZE ANALYSIS
WOODLAND PONDS
ARLINGTON, WASHINGTON

Proj.No. 4520 | Date OCT. 1999 | Figure 5

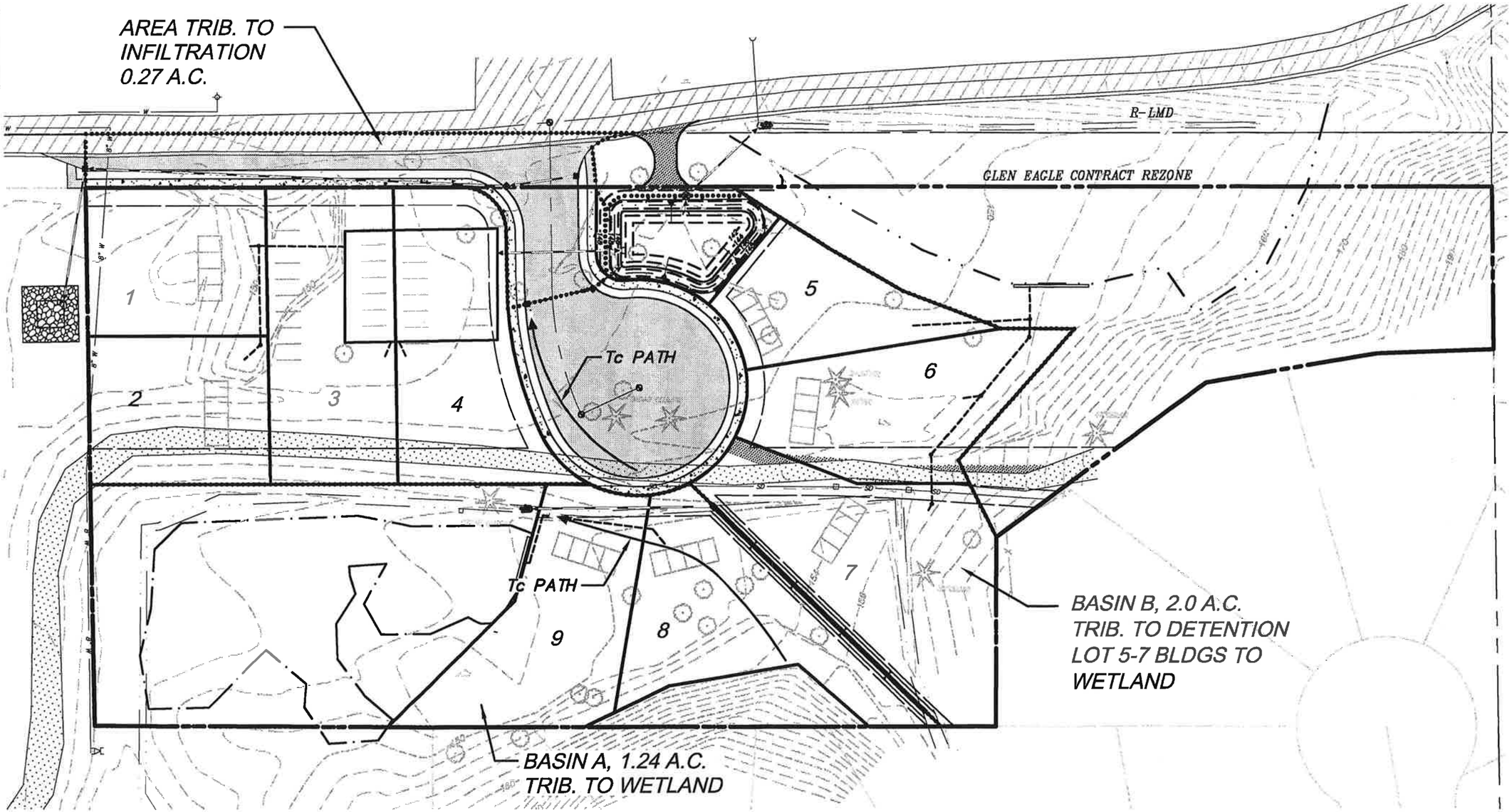


UPSTREAM/DOWNSTREAM BASIN MAP

SEC. 23, TWP. 31 N., RGE. 5 E., W.M.

60' 0 60'

SCALE: 1" = 60'



PETERSON CONSULTING ENGINEERS
4030 Lake Washington Blvd. N.E., Suite 200
Kirkland, WA 98033
Tel (425) 827-5874
Fax (425) 822-7216

DEVELOPED CONDITIONS

WOODLAND PONDS

CITY OF ARLINGTON, WASHINGTON

NO.	DATE	REVISION	BY	CK

BART THERGE, P.E.
PROJECT MANAGER:
DESIGNED: J. STERO
CADD: R. GREEN
CHECKED:
DATE:
FILE NAME: DC1TRE17

STAMP NOT VALID UNLESS SIGNED AND DATED

JOB NUMBER **TREC-0017**

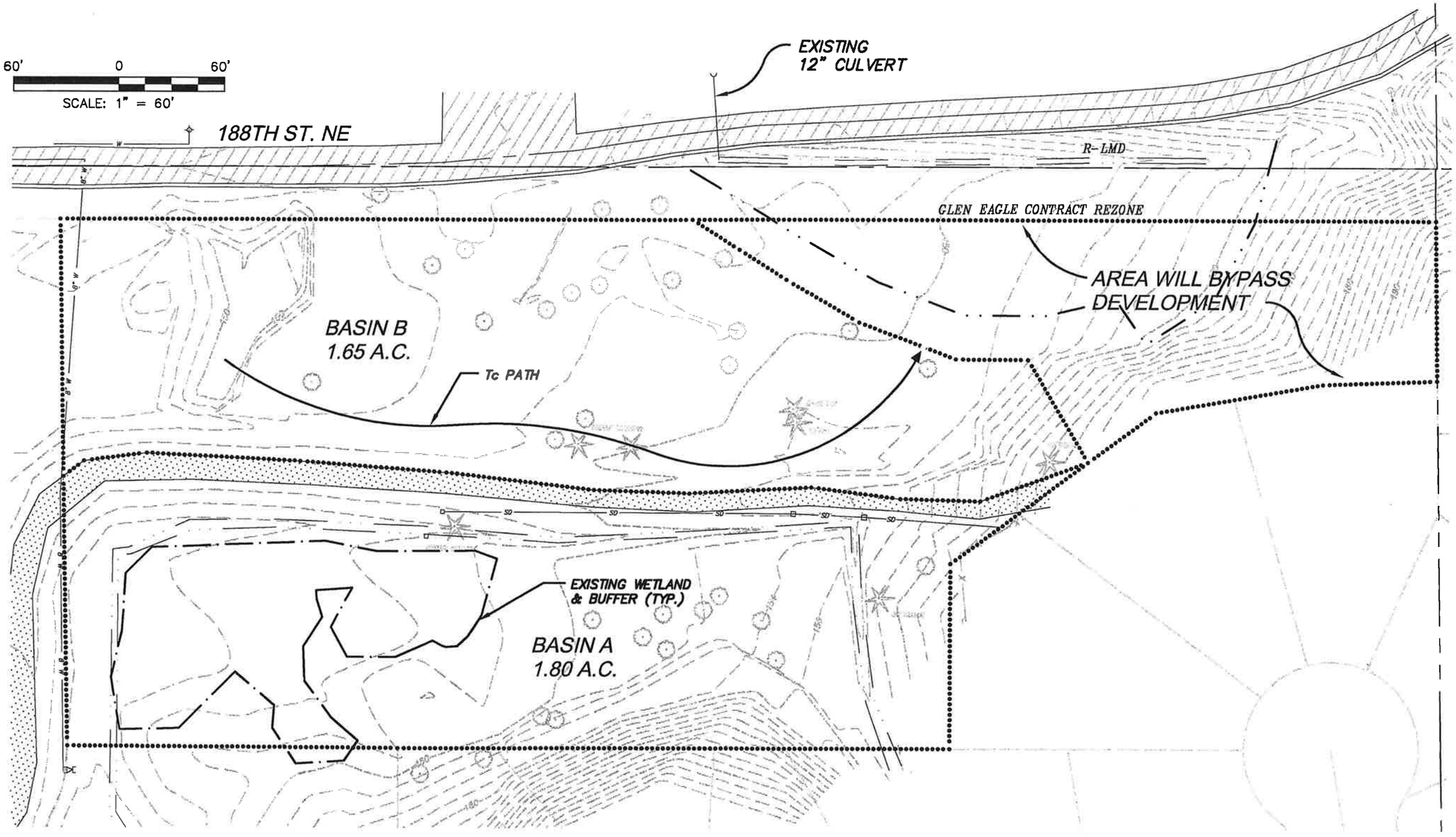
SHEET NUMBER OF

11/19/99
E:\PROJECTS\TREC0017

SEC. 23, TWP. 31 N., RGE. 5 E., W.M.

60' 0 60'

SCALE: 1" = 60'



PETERSON CONSULTING ENGINEERS
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Kirkland, WA 98033
Tel (425) 827-5874
Fax (425) 822-7216

EXISTING CONDITIONS

WOODLAND PONDS

CITY OF ARLINGTON, WASHINGTON

BY | CK

NO. | DATE | REVISION

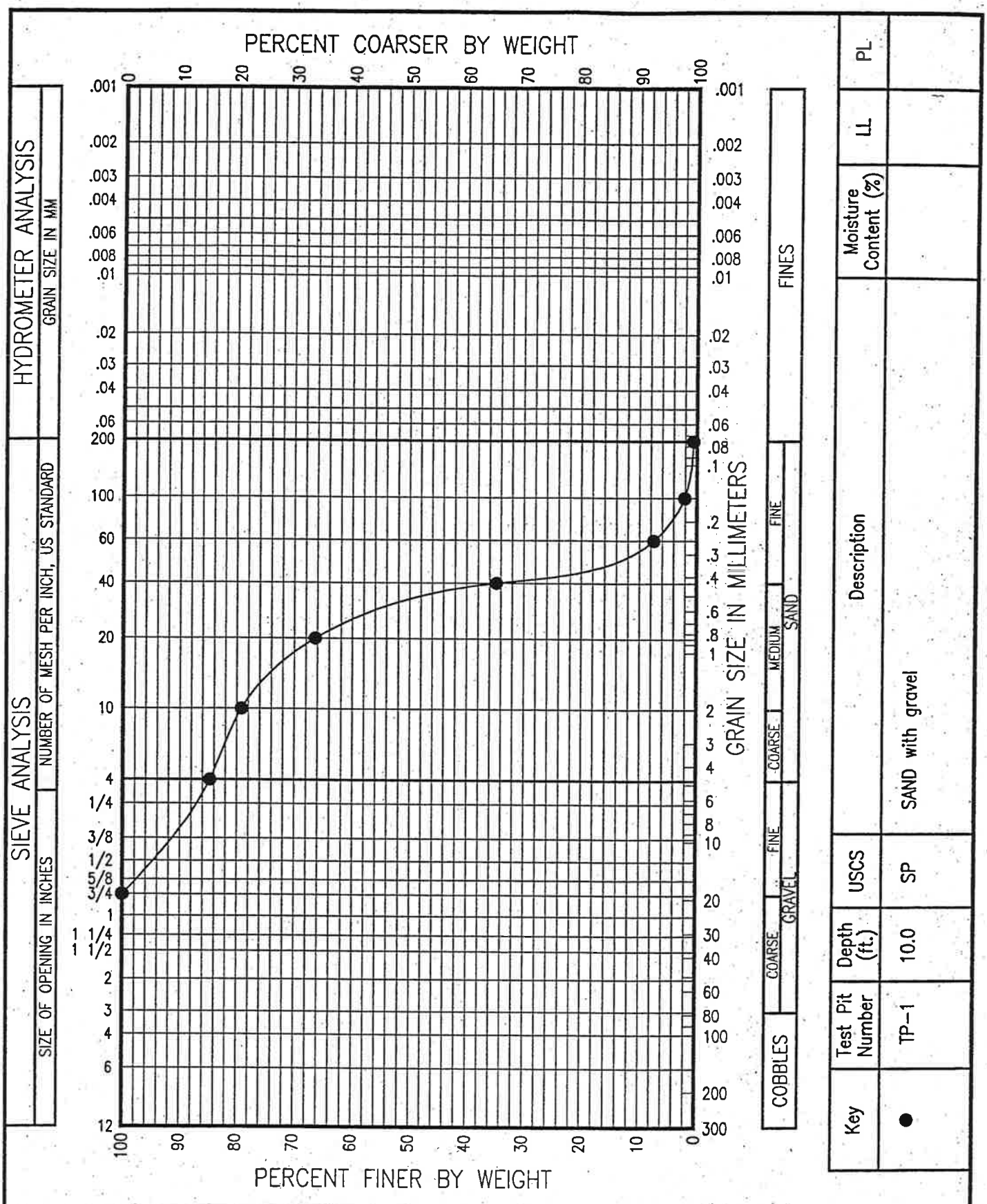
BART TREECE, P.E.
PROJECT MANAGER:
DESIGNED: J. STEIG
CADD: R. GREEN
CHECKED:
DATE:
FILE NAME: EC1TREE17

STAMP NOT VALID
UNLESS SIGNED AND DATED

JOB NUMBER TREC-0017

SHEET NUMBER
OF

11/19/99
E:\PROJECTS\TREC0017



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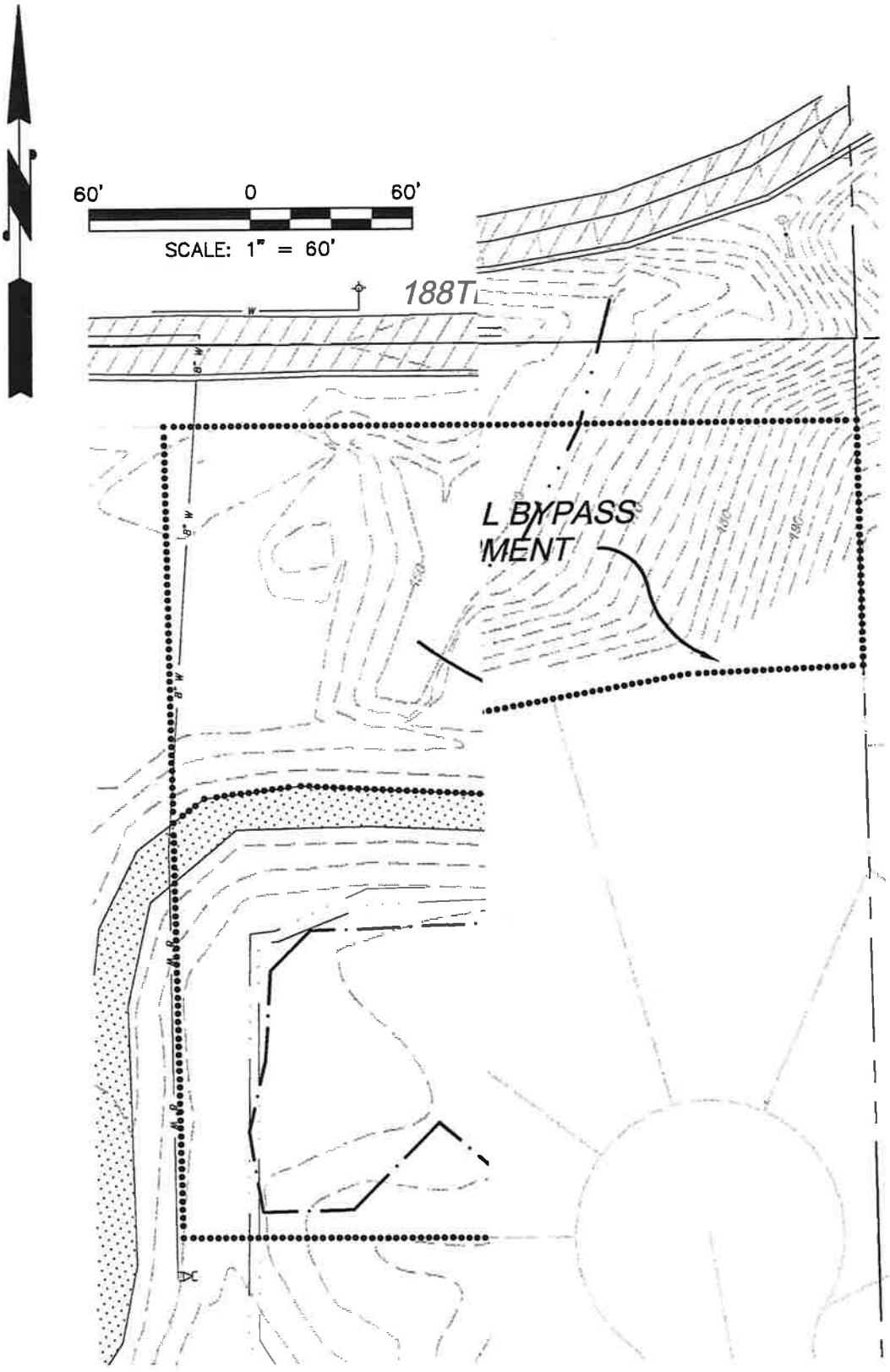
GRAIN SIZE ANALYSIS
WOODLAND PONDS
ARLINGTON, WASHINGTON

Proj.No. 4520 | Date OCT. 1999 | Figure 6



PETERSON CONSULTING ENGINEERS
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Kirkland, WA 98033
Tel (425) 827-5874
Fax (425) 822-7216

EXISTING CONDITIONS

WOODLAND PONDS

CITY OF ARLINGTON, WASHINGTON

NO.	DATE	REVISION	BY	CK

BART TREECE, P.E.
PROJECT MANAGER:
DESIGNED: J. STEIG
CADD: R. GREEN
CHECKED:
DATE:
FILE NAME: EC1TREE7

STAMP NOT VALID
UNLESS SIGNED AND DATED

JOB NUMBER TREC-0017

SHEET NUMBER
OF

11/19/99
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