



# PRELIMINARY DRAINAGE REPORT

FOR

POINT ROBERTS

WHATCOM COUNTY, WASHINGTON



**Prepared For:**

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**Date:**

December 2009

**Revised:**

February 2010 (See Table of Contents)

**Core Design No.:**

09048

# **POINT ROBERTS TABLE OF CONTENTS**

- I. Project Overview
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## **SITE PLAN REVISION**

**The current plans reflect a revised site plan different than what these calculations are based on. These calculations are still valid for preliminary design of the proposed stormwater facilities even though the site plan has been revised. The revisions to the site plan are minimal. Road B has been lengthened approximately 30 feet and the clustered homes have been rearranged.**

## **I. PROJECT OVERVIEW**

Point Roberts is located on the southeast shore of Point Roberts, Washington in Whatcom County. The 100.6 acre site is bordered by Paul's Road (County Road #370) to the west, APA Road (County Road #540) to the north, undeveloped property to the east, and the Strait of Georgia to the south. See attached Vicinity Map exhibit on the following pages.

The project is located in the northeast quarter of section 11 and the northwest quarter of section 12, township 40 north, range 3 west, W.M. The tax parcel numbers are: 4053115064270000, 4053120654770000, and 4053120144200000.

The existing topography of the site slopes to the southwest towards the Strait of Georgia with slopes ranging from approximately 5% to 10%. A steep bluff runs from west to east near the southern boundary of the site and ranges between 80' to 100' in height. See attached Existing Conditions exhibit in Section III of this Report. The northern portion of the site is covered with evergreen trees, deciduous trees, and underbrush. The southern portion of the site features some evergreen and deciduous trees along the top of the bluff.

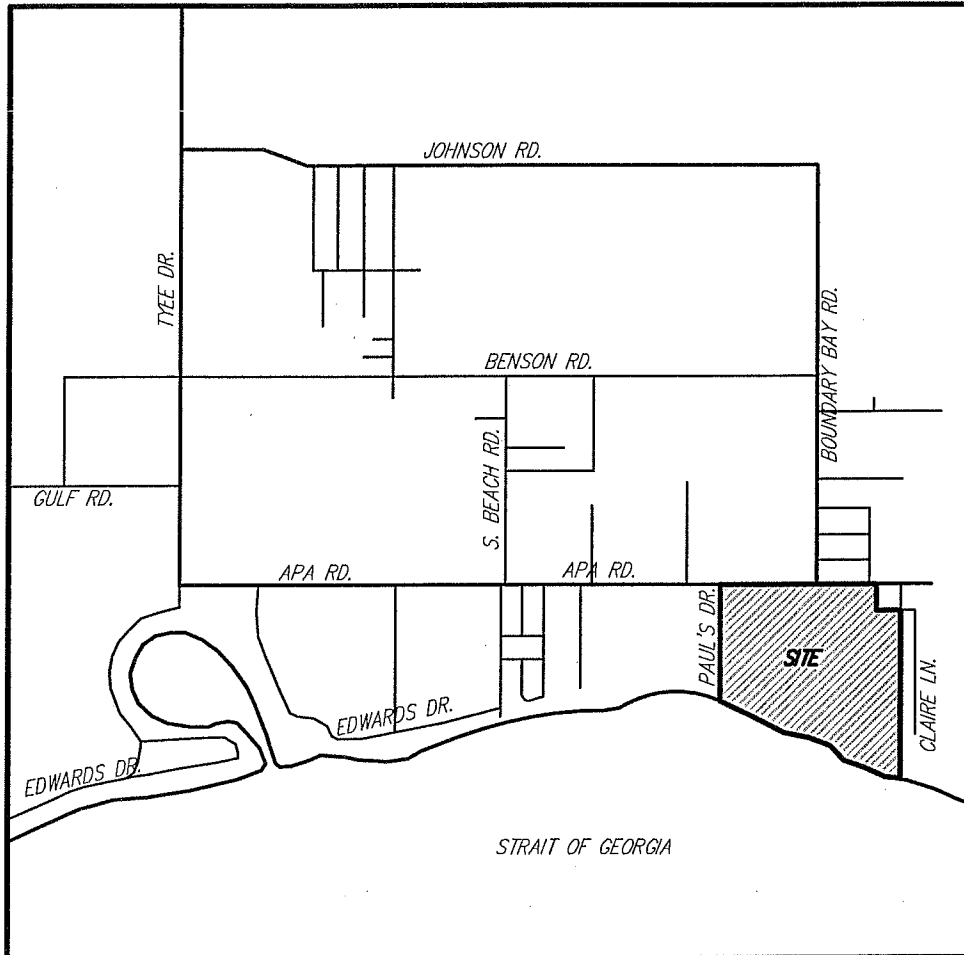
The remainder of the site is cleared of trees and is mainly vegetated with tall grasses. It is used for farming. See attached Hydrologic Soil Group exhibit in Section III of this Report.

The site is currently zoned TZ transitional R5A/RR1. This zone allows for 1 dwelling unit per 5 acres or cluster subdivisions with 50% of the area reserved for open space (per Whatcom County Section 20.37.251). This project is a cluster subdivision that will accommodate 103 single-family homes. See attached Developed Conditions exhibit in Section III of this Report. A narrow road section, 22 feet, will be proposed with an adjacent gravel walkway for access within the project. The road will be sloped 2% in one direction with a grass lined ditch collecting all road drainage. As this property is adjacent to the Strait of Georgia, no detention will be required. However, basic water quality is required. This will be accomplished with water quality ponds distributed throughout the site. These ponds will treat the roads exclusively. Lots will be using Low Impact Development (LID) elements to treat all their pollution-generating impervious surfaces and infiltrate their drainage to the maximum extent possible. Roof drainage will likely be dispersed or placed in cisterns for future water reuse. Development of the site will predominately be limited to the construction of the roads and installation of stormwater facilities and utilities. Limited clearing and grading of the lots will be completed for establishing building pads.

Stormwater runoff collected from the site will be conveyed to a HDPE pipe near the top of the southern bluff on the west side of the property. From here, the HDPE pipe will be installed overland (securely anchored to the ground), to the toe of the bluff. The energy dissipaters for the HDPE pipe is currently in preliminary design and will be coordinated with the Army Corp of Engineers, Whatcom County, and the Department of Fish and Wildlife. A couple of ideas under consideration at this time are as follows:

1. A stilling basin (i.e. buried large diameter manhole) to dissipate energy below ground and allow flows to “bubble up” through the top of structure.
2. A thick rip-rap pad with large boulders and woody debris to naturally integrate into the beachfront.

This report was prepared to conform to the Whatcom County Development Standards (Chapter 2 Stormwater Management) dated September 11, 2002.



## VICINITY MAP

SCALE: 1" = 2000' ±

### VICINITY MAP

#### PRELIMINARY DRAINAGE REPORT



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ENGINEERING · PLANNING · SURVEYING

DATE *MARCH 2009*

SHEET

OF

DESIGNED *TLB*

DRAWN *TLB*

PROJECT NUMBER  
*06093*

## **II. OFFSITE ANALYSIS**

### UPSTREAM

Based on current records and site observations, there is approximately 2.3 acres of offsite area draining onto the project site. The upstream area is from the northeast and contains a small portion (approximately 0.30 acres) of Clare's road and the majority of a graveyard (approximately 2.0 acres). The stormwater from the graveyard is collected in a 12" CMP culvert under Clare's road and then discharged onto the site. See attached Existing Conditions exhibit in Section III of this Report

### DOWNSTREAM

On the west side of the project there is an existing ditch on the east side of Paul's road. The ditch starts out at about 1.5' feet deep at the corner of Paul's road and APA road and gradually gets deeper as it heads in the south direction. There is a Type 1 CB (near the 200' setback) with a 12" CPP going to the beach. The bluff is steep so the pipe is tied to trees with bolted joints. The neighbor has also installed a 6" overflow pipe in the Type 1 CB to direct overflow water into his existing ditch. His ditch flows to the west approximately 600 feet before being tightlined to the beach.

### III. WATER QUALITY FACILITY ANALYSIS AND DESIGN

#### A. HYDRAULIC ANALYSIS

The drainage analysis was modeled using WaterWorks hydrology software utilizing SBUH methodology.

The USDA Natural Resources Conservation Service classifies the majority of the soil onsite as Everett complex with a hydrologic rating of 'A'. A small portion in the southwest corner is classified as Everett gravelly sandy loam, hard substratum, with a hydrologic rating of 'B'. See attached Hydrologic Soil Group exhibit on the following pages.

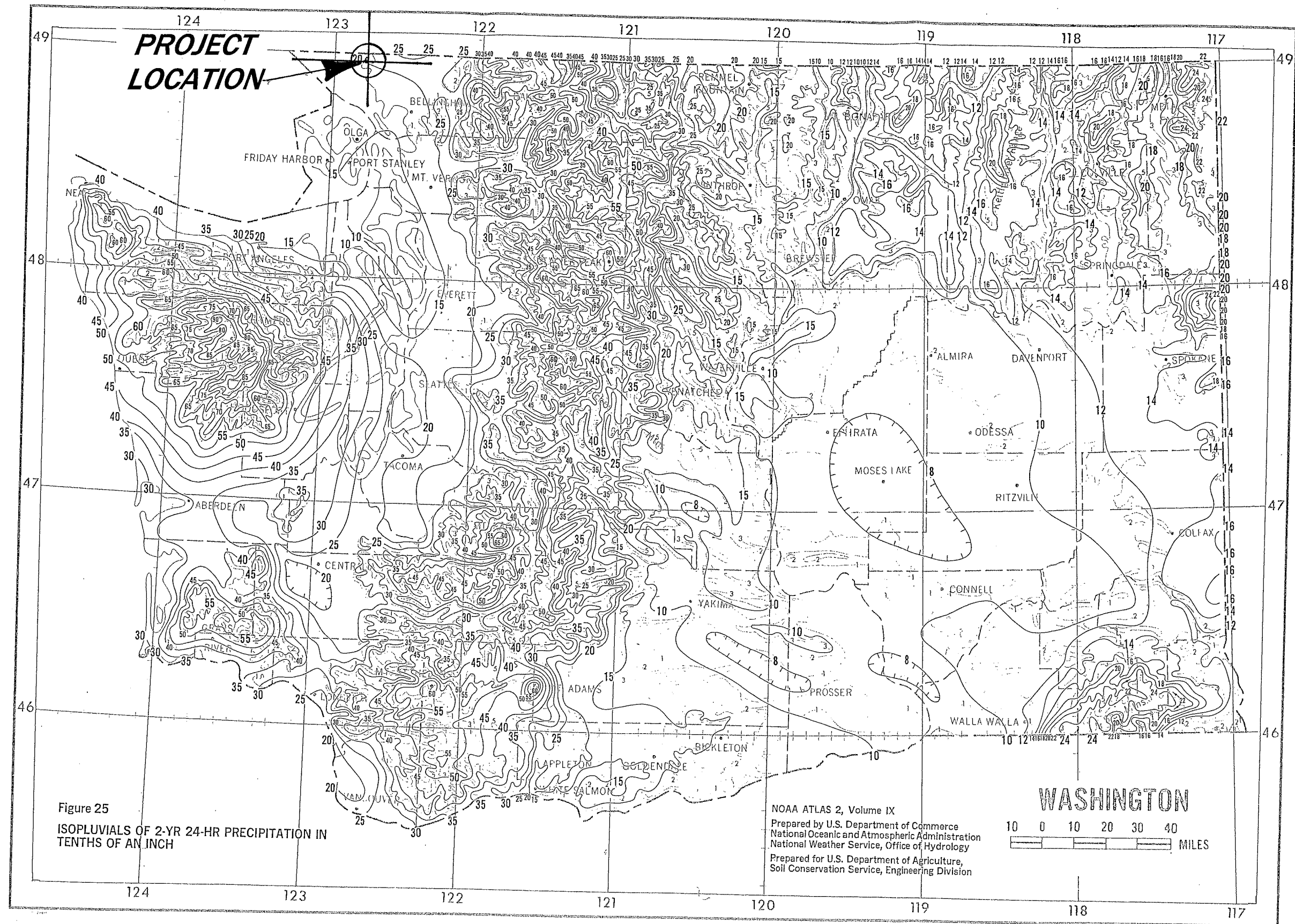
Golder Associates examined the subsurface conditions of the site and developed geotechnical recommendations for the proposed development. The recommendations are summarized in their geotechnical report dated June 28, 2006. The report generalizes on-site soils to consist of up to three feet of topsoil, underlain by 6' of outwash native soils, and further underlain by glaciomarine subtidal deposits and till. For simplicity, B soils will be used for design.

The precipitation rates used for this analysis are as follows (see attached isopluvials):

6-month, 24-hour storm (72% of 2-yr, 24-hr storm)	→ 1.44 in.
2-year, 24-hour storm	→ 2.0 in.
25-year, 24-hour storm	→ 3.5 in.
100-year, 24-hour storm	→ 4.5 in.

Three different facilities will be sized for preliminary design of this project. The first facility will be the HDPE pipe that will discharge all storm drainage over the bluff. The second facility will be the ditch that collects drainage from the internal road. The third facility will be the water quality volume required to treat the entire internal road. Numerous water quality ponds will be distributed throughout the site and sized based on a ratio volume from the total volume calculated for the entire roadway. The ratio will be based on the length of road collected over the total length of road.





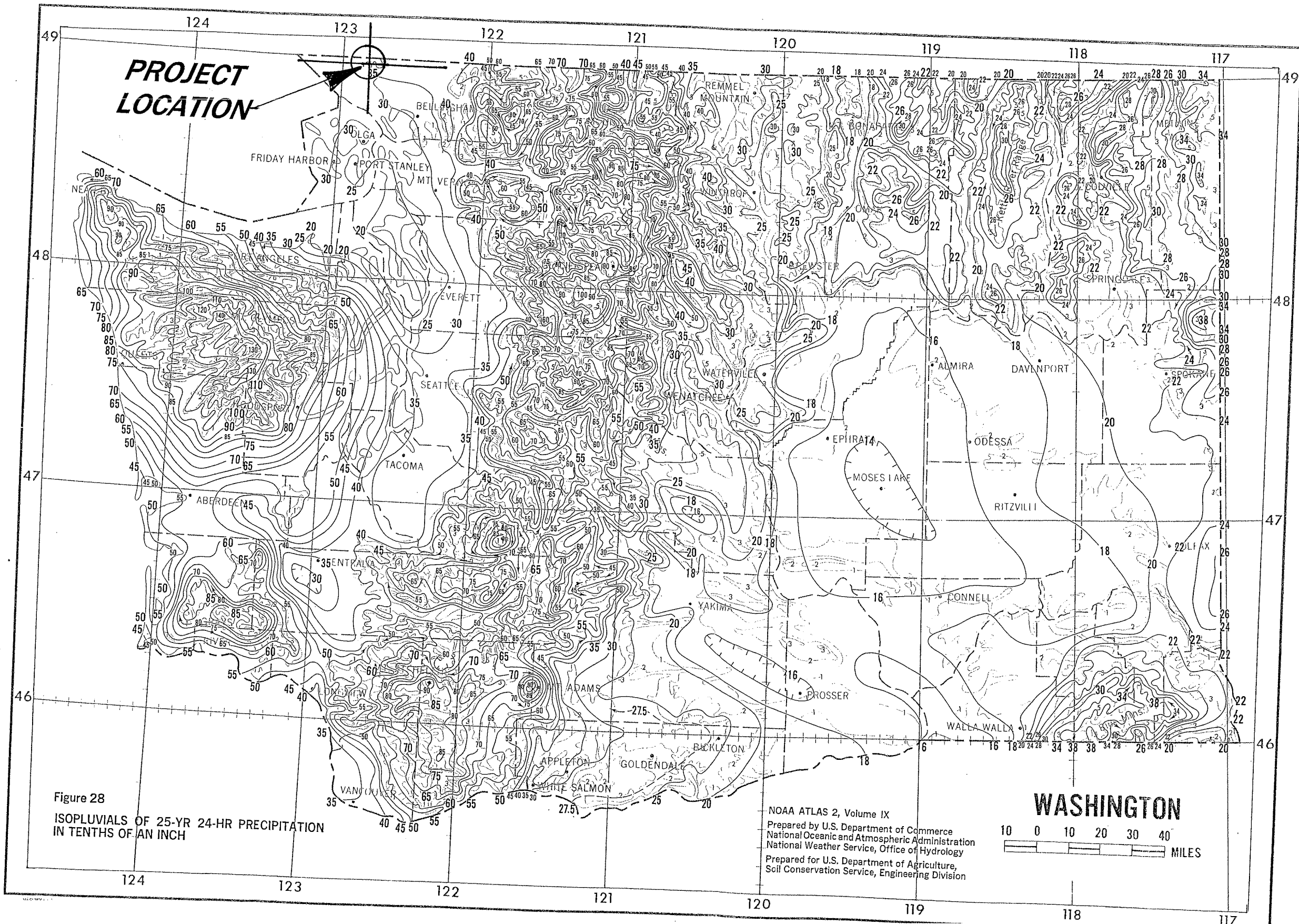


Figure 28  
 ISOPLUVIALS OF 25-YR 24-HR PRECIPITATION  
 IN TENTHS OF AN INCH

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

**WASHINGTON**

10 0 10 20 30 40 MILES

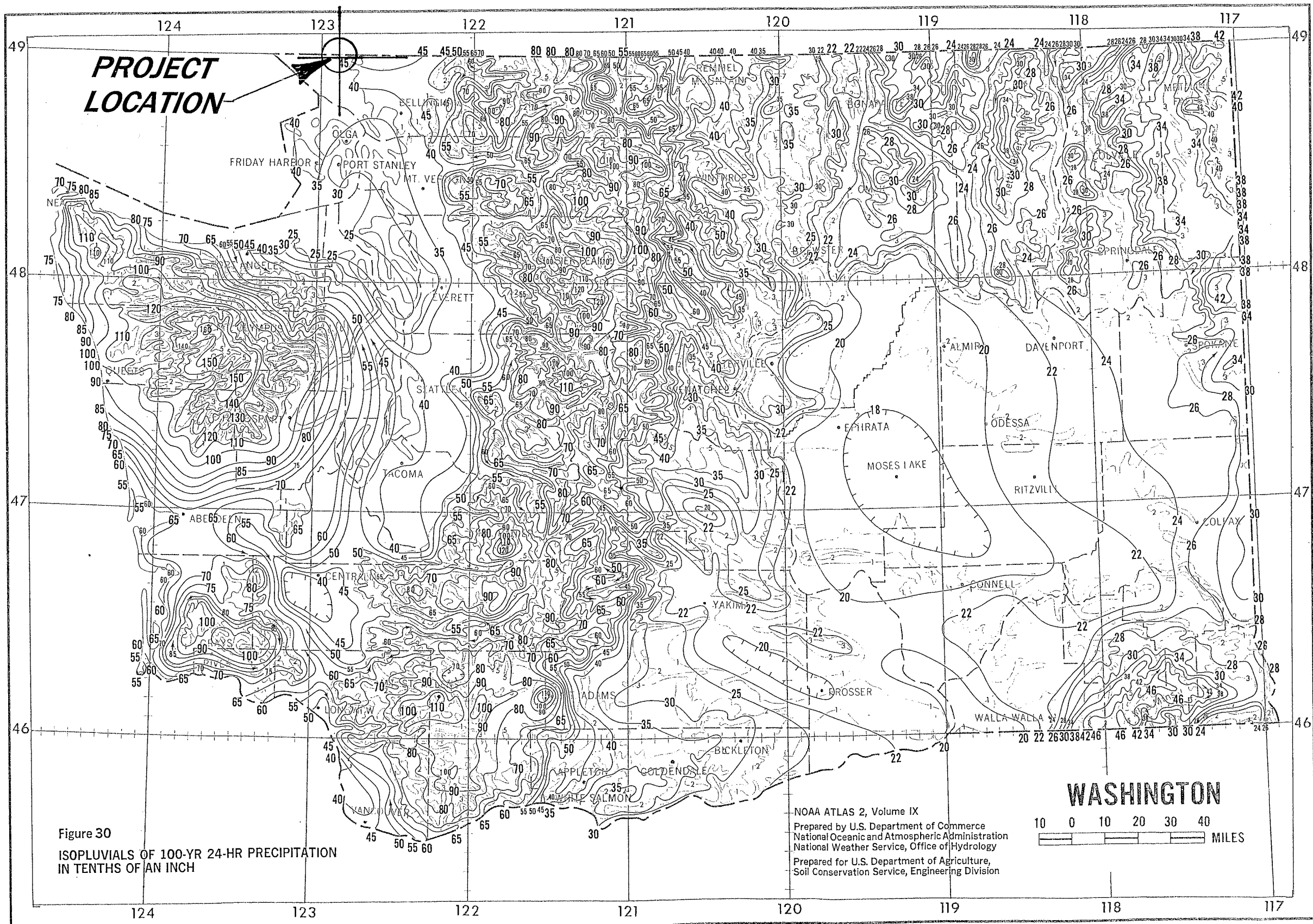
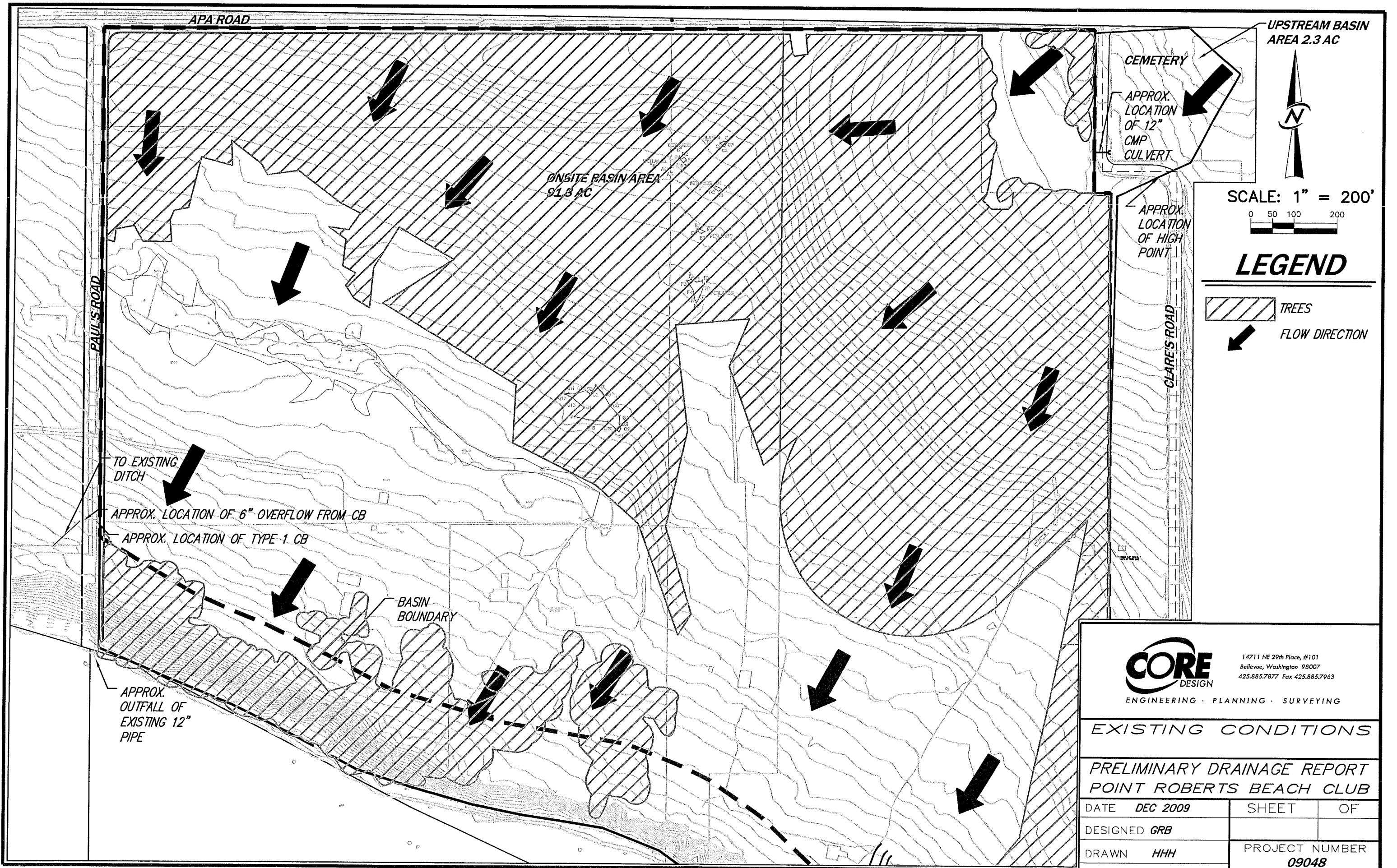


Figure 30  
 ISOPLUVIALS OF 100-YR 24-HR PRECIPITATION  
 IN TENTHS OF AN INCH

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

**WASHINGTON**  
 10 0 10 20 30 40  
 MILES



### DEVELOPED CONDITIONS

The developed site will include a total of 103 lots with associated roadways, utilities, and storm drainage facilities. The lots are considered as pervious landscaping since lots will be using Low Impact Development (LID) elements to treat all their impervious surfaces and infiltrate their drainage to the maximum extent possible. All open spaces are conservatively considered as landscaping even though a large portion of the open space will retain the existing trees. The developed site conditions are delineated below.

<b>DEVELOPED SITE CONDITIONS</b>	Total Area = 91.8 acres	
GROUND COVER	AREA(acre)	CN
Lawn / Landscaping (Lots & Open Space excl. wetlands)	80.41	80
Lawn / Landscaping (ROW)	3.44	80
Wetlands	1.97	100
Gravel (ROW)	1.44	85
Pavement (ROW)	3.98	98
Pavement (Accesses to Clusters)	0.56	98

### UPSTREAM CONDITIONS

The upstream area will be considered in the design of the HDPE pipe that will discharge all storm drainage over the bluff and the ditch that collects drainage from the internal road. The upstream conditions are delineated below.

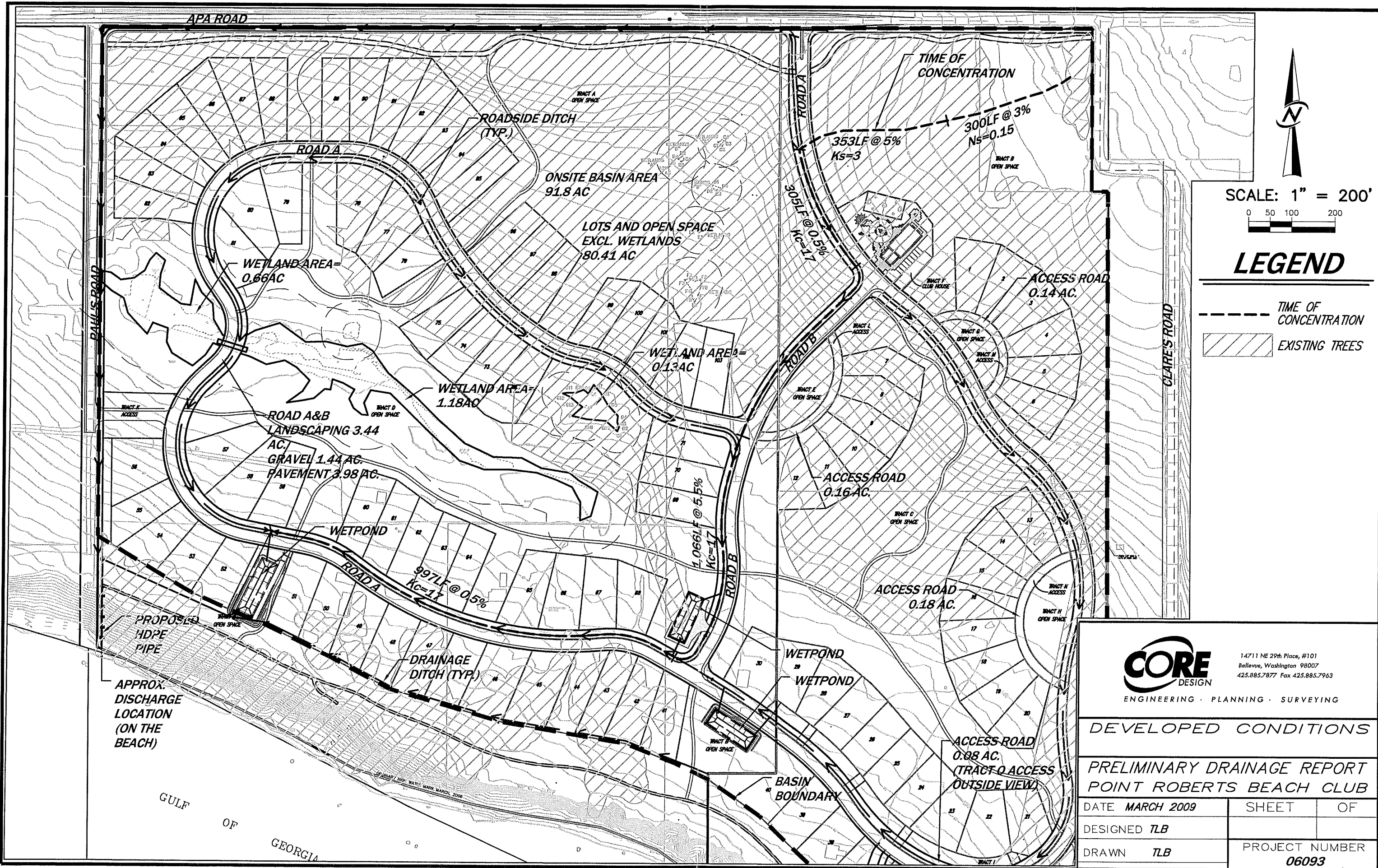
<b>UPSTREAM CONDITIONS</b>	Total Area = 2.3 acres	
GROUND COVER	AREA(acre)	CN
Lawn / Landscaping	2.0	80
Pavement	0.3	98

STORMWATER MANAGEMENT MANUAL FOR THE PUGET SOUND BASIN

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 $\geq 75\%$ 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				
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.



SCALE: 1" = 200'

0 50 100 200

### LEGEND

- TIME OF CONCENTRATION
- ▨ EXISTING TREES

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DEVELOPED CONDITIONS

PRELIMINARY DRAINAGE REPORT  
POINT ROBERTS BEACH CLUB

DATE	MARCH 2009	SHEET	OF
DESIGNED	TLB		
DRAWN	TLB	PROJECT NUMBER 06093	

## B. WATER QUALITY CALCULATIONS

Basic water quality treatment is required for this project. This will be accomplished with water quality ponds distributed throughout the site. These ponds will treat the roads exclusively. Lots will be using Low Impact Development (LID) elements to treat all their pollution-generating impervious surfaces and infiltrate their drainage to the maximum extent possible. Roof drainage will likely be dispersed or placed in cisterns for future water reuse. Since approximately 215 feet of the entry road is sloped towards the APA Road, this road area will not be treated within the water quality ponds. It is assumed that the grass-lined ditch sloped at 0.5% will provide sufficient treatment of the road drainage. Frontage improvements are not included as well, since adjacent ditches for these improvements will provide the required treatment.

The required water quality volume to treat the entire roadway system is calculated using the SCS Curve Number Equations listed on page 2-16 within Volume III of the 2005 DOE Manual. Numerous water quality ponds will be distributed throughout the site and sized based on a ratio volume from the total volume calculated for the entire roadway. The ratio will be based on the length of road collected over the total length of road. The areas considered for calculation of the water quality volume is delineated below.

<b>WATER QUALITY POND TRIBUTARY CONDITIONS</b>	Total Area = 11.72 acres	
GROUND COVER	AREA(acre)	CN
Lawn / Landscaping (Upstream)	2.0	80
Pavement (Upstream)	0.3	98
Lawn / Landscaping (ROW)	3.44	80
Gravel (ROW)	1.44	85
Pavement (ROW)	3.98	98
Pavement (Accesses to Clusters)	0.56	98

$$\text{Total runoff volume (cf)} = 3,630 \text{ (cf/ac-in)} \times Q_d \text{ (in)} \times A \text{ (ac)}$$

Where:

$$Q_d = (P - 0.2S)^2 / (P + 0.8S) \quad \text{for } P \geq 0.2S$$

$$Q_d = 0 \quad \text{for } P < 0.2S$$

$Q_d$  = runoff depth in inches over the area,

P = precipitation depth in inches over the area (6-month, 24-hour storm (72% of 2-yr, 24-hr storm) = 1.44 in), and

S = potential maximum natural detention, in inches over the area, due to infiltration, storage, etc.  $S = (1000/CN) - 10$

$$S = (1000/CN) - 10 = (1000/80) - 10 = 2.50 \text{ (Lawn / Landscaping)}$$

$$S = (1000/CN) - 10 = (1000/85) - 10 = 1.76 \text{ (Gravel)}$$

$$S = (1000/CN) - 10 = (1000/98) - 10 = 0.20 \text{ (Pavement)}$$

$$Q_d = (1.44 - 0.2*2.5)^2 / (1.44 + 0.8*2.5) = 0.26 \text{ (Lawn / Landscaping)}$$

$$Q_d = (1.44 - 0.2*1.76)^2 / (1.44 + 0.8*1.76) = 0.42 \text{ (Gravel)}$$

$$Q_d = (1.44 - 0.2*0.20)^2 / (1.44 + 0.8*0.20) = 1.23 \text{ (Pavement)}$$

$$\text{Total runoff volume (cf)} = 3,630 [(0.26*5.44) + (0.42*1.44) + (1.23*4.84)] = 28,940 \text{ cf}$$

The total length of ROW is 7,867 feet. Therefore, the volume for each water quality pond is  $28,940 \text{ cf} / 7,867 \text{ ft} = 3.68 \text{ cf/lineal foot of road}$ .

#### IV. CONVEYANCE CALCULATIONS

The conveyance system was designed per Whatcom County Development Standards, Chapter 2, Section 219.D. The ditch system that will convey road runoff and the tightlined conveyance system that will convey the site's drainage over the bluff will be sized for the 25-year, 24-hour peak storm using WaterWorks hydrology software utilizing SBUH methodology. The conveyance systems will also, be checked for the 100-year, 24-hour peak storm to ensure that any flooding will have a safe route of travel and will not endanger human life. For preliminary design and for simplicity, the peak flows generated from the entire basin was assumed to be conveyed through all roadside ditches.

The areas considered for calculation of the conveyance systems are delineated below.

<b>CONVEYANCE SYSTEMS TRIBUTARY CONDITIONS</b>	Total Area = 94.1 acres		Imperv./Perv. Areas	
GROUND COVER	AREA(acre)	CN	AREA(acre)	CN <sub>avg</sub>
Lawn / Landscaping (Lots & Open Space excl. wetlands)	80.41	80		
Lawn / Landscaping (ROW)	3.44	80		
Lawn / Landscaping (Upstream)	2.0	80		
Gravel (ROW)	1.44	85	87.29	80.08
Pavement (ROW)	3.98	98		
Pavement (Accesses to Clusters)	0.56	98		
Pavement (Upstream)	0.3	98		
Wetlands	1.97	100	6.81	98.58
Time of concentration	Assumed			15 minutes

The 25-year 24 hour design storm results in 19.14 cfs and the 100-year 24-hour design storm results in 30.30 cfs. See Waterworks Basin Summary on the following page.

PRELIMINARY STORM CALCULATIONS  
CORE NO. 09048

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BASIN SUMMARY

BASIN ID: CONV025 NAME: CONVEYANCE SYSTEM 25YR  
SBUH METHODOLOGY  
TOTAL AREA.....: 94.10 Acres BASEFLOWS: 0.00 cfs  
RAINFALL TYPE.....: TYPE1A PERV IMP  
PRECIPITATION.....: 3.50 inches AREA...: 87.29 Acres 6.81  
Acres  
TIME INTERVAL.....: 10.00 min CN.....: 80.08 98.58  
TC.....: 56.66 min 56.66 min  
ABSTRACTION COEFF: 0.20  
TcReach - Sheet L: 300.00 ns:0.1500 p2yr: 2.00 s:0.0300  
TcReach - Shallow L: 353.00 ks:3.00 s:0.0500  
TcReach - Channel L: 305.00 kc:17.00 s:0.0050  
TcReach - Channel L:1066.00 kc:17.00 s:0.0550  
TcReach - Channel L: 997.00 kc:17.00 s:0.0050  
impTcReach - Sheet L: 300.00 ns:0.1500 p2yr: 2.00 s:0.0300  
impTcReach - Shallow L: 353.00 ks:3.00 s:0.0500  
impTcReach - Channel L: 305.00 kc:17.00 s:0.0050  
impTcReach - Channel L:1066.00 kc:17.00 s:0.0550  
impTcReach - Channel L: 997.00 kc:17.00 s:0.0050  
PEAK RATE: 19.14 cfs VOL: 13.84 Ac-ft TIME: 490 min

BASIN ID: CONV100 NAME: CONVEYANCE SYSTEM 100YR  
SBUH METHODOLOGY  
TOTAL AREA.....: 94.10 Acres BASEFLOWS: 0.00 cfs  
RAINFALL TYPE.....: TYPE1A PERV IMP  
PRECIPITATION.....: 4.50 inches AREA...: 87.29 Acres 6.81  
Acres  
TIME INTERVAL.....: 10.00 min CN.....: 80.08 98.58  
TC.....: 56.66 min 56.66 min  
ABSTRACTION COEFF: 0.20  
TcReach - Sheet L: 300.00 ns:0.1500 p2yr: 2.00 s:0.0300  
TcReach - Shallow L: 353.00 ks:3.00 s:0.0500  
TcReach - Channel L: 305.00 kc:17.00 s:0.0050  
TcReach - Channel L:1066.00 kc:17.00 s:0.0550  
TcReach - Channel L: 997.00 kc:17.00 s:0.0050  
impTcReach - Sheet L: 300.00 ns:0.1500 p2yr: 2.00 s:0.0300  
impTcReach - Shallow L: 353.00 ks:3.00 s:0.0500  
impTcReach - Channel L: 305.00 kc:17.00 s:0.0050  
impTcReach - Channel L:1066.00 kc:17.00 s:0.0550  
impTcReach - Channel L: 997.00 kc:17.00 s:0.0050  
PEAK RATE: 30.30 cfs VOL: 20.41 Ac-ft TIME: 490 min

### ROADSIDE DITCH DESIGN

The roadside ditches will have 2-foot bottom widths, 3-foot depths, 2:1 side slopes, and a worst case 0.5% longitudinal slope. The ditches will be grass-lined with a Manning's n of 0.027. Per the Roadside Ditch Analysis spreadsheet, attached on the following pages, the ditch can accommodate the 25-year 24 hour design storm at a depth of 1.29 feet and the 100-year 24 hour design storm at a depth of 1.60 feet. During the 25-year 24 hour design storm, the ditch will have a freeboard of 1.71 feet which exceeds the minimum 1 foot of freeboard. As well, the 100-year 24 hour design storm is contained within the ditch. The ditches are therefore, adequately sized to accommodate the site's drainage.

STORMWATER MANAGEMENT MANUAL FOR THE PUGET SOUND BASIN

Table III-2.8 - Values of the Roughness Coefficient, "n"

Type of Channel and Description	Manning's "n" (Normal)	Type of Channel and Description	Manning's "n" (Normal)
<b>A. Constructed Channels</b>			
a. Earth, straight and uniform		6. Sluggish reaches, weedy deep pools	0.070
1. Clean, recently completed	0.018	7. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.100
2. Gravel, uniform section, clean	0.025		
3. With short grass, few weeds	0.027	b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages	
b. Earth, winding and sluggish	0.025	1. Bottom: gravel, cobbles, and few boulders	0.040
1. No vegetation	0.025	2. Bottom: cobbles with large boulders	0.050
2. Grass, some weeds	0.030	<b>B-2 Flood plains</b>	
3. Dense weeds or aquatic plants in deep channels	0.035	a. Pasture, no brush	
4. Earth bottom and rubble sides	0.030	1. Short grass	0.030
5. Stony bottom and weedy banks	0.035	2. High grass	0.035
6. Cobble bottom and clean sides	0.040	b. Cultivated areas	
c. Rock lined		1. No crop	0.030
1. Smooth and uniform	0.035	2. Mature row crops	0.035
2. Jagged and irregular	0.040	3. Mature field crops	0.040
d. Channels not maintained, weeds and brush uncut		c. Brush	
1. Dense weeds, high as flow depth	0.080	1. Scattered brush, heavy weeds	0.050
2. Clean bottom, brush on sides	0.050	2. Light brush and trees	0.060
3. Same, highest stage of flow	0.070	3. Medium to dense brush	0.070
4. Dense brush, high stage	0.100	4. Heavy, dense brush	0.100
<b>B. Natural Streams</b>		d. Trees	
<b>B-1 Minor streams (top width at flood stage &lt; 100 ft.)</b>	0.100	1. Dense willows, straight	0.150
a. Streams on plain		2. Cleared land with tree stumps, no sprouts	0.040
1. Clean, straight, full stage no rifts or deep pools	0.030	3. Same as above, but with heavy growth of sprouts	0.060
2. Same as above, but more stones and weeds	0.035	4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.100
3. Clean, winding, some pools and shoals	0.040	5. Same as above, but with flood stage reaching branches	0.120
4. Same as above, but some weeds	0.040		
5. Same as 4, but more stones	0.050		

\*Note. these "n" values are "normal" values for use in analysis of channels. For conservative design for channel capacity the "maximum" values listed in other references should be considered. For channel bank stability the minimum values should be considered.

## ROADSIDE DITCH ANALYSIS

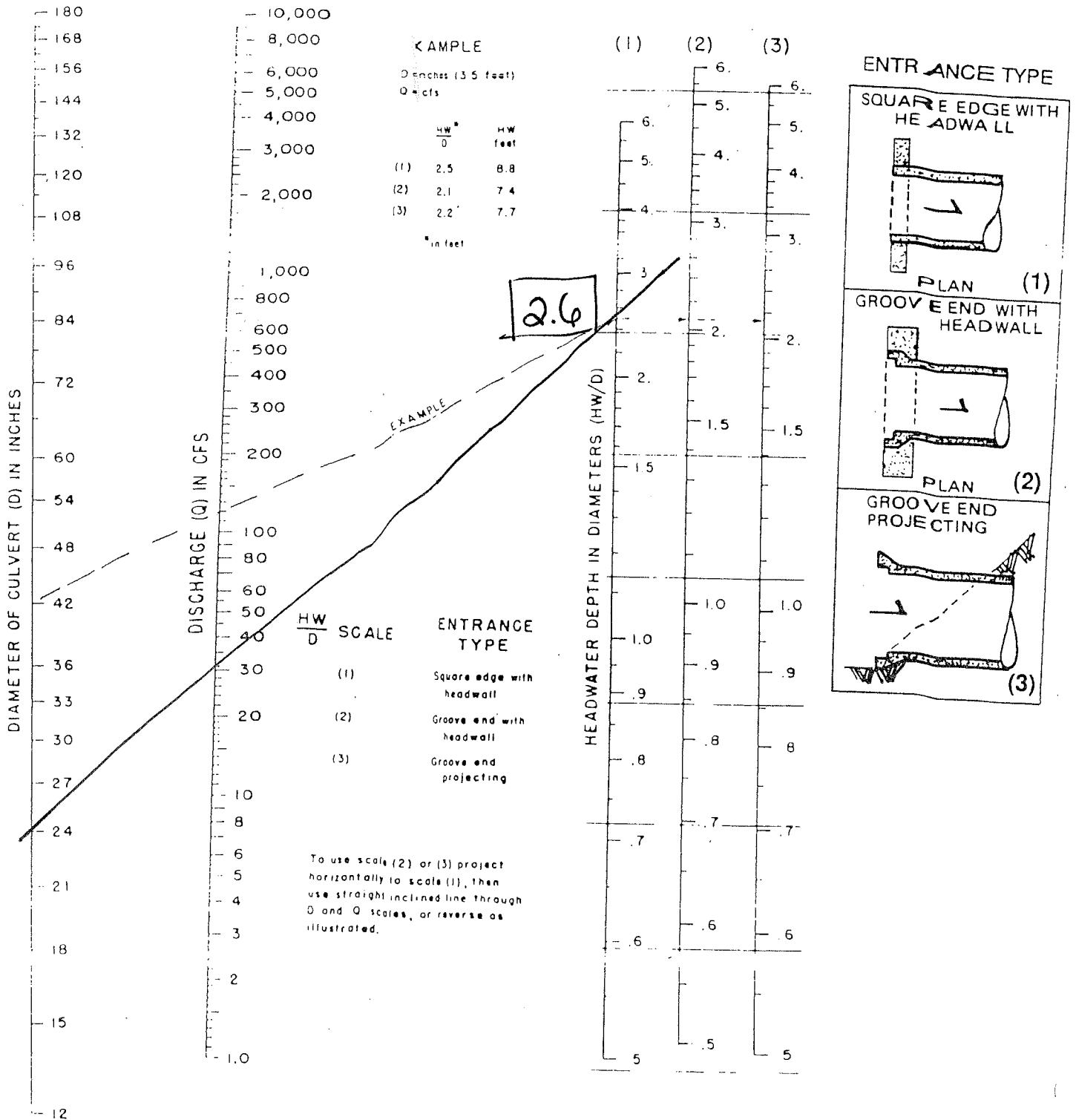
<b>DITCH DATA:</b>		<b>JOB NAME:</b> POINT ROBERTS
<b>BOTTOM WIDTH (FT) =</b>	2.00	<b>JOB #:</b> 09048
<b>LEFT SIDE SLOPE (L:1)</b>	2.00	<b>OPERATOR:</b> G.R. BROOKS
<b>RIGHT SIDE SLOPE (R:1)</b>	2.00	<b>DATE:</b> 12/7/09
<b>BOTTOM SLOPE (FT/FT)</b>	0.0050	
<b>MANNING'S n =</b>	0.027	

FLOW DEPTH (FEET)	FLOW AREA (SQ FT)	WETTED PERIMETER (FEET)	HYDRAULIC RADIUS (FEET)	DITCH CAPACITY (CFS)	FLOW VELOCITY (FPS)
0.00	0.0000	0.0000	0.0000	0.000	0.000
0.05	0.1050	2.2236	0.0472	0.053	0.508
0.10	0.2200	2.4472	0.0899	0.172	0.781
0.15	0.3450	2.6708	0.1292	0.343	0.994
0.20	0.4800	2.8944	0.1658	0.564	1.175
0.25	0.6250	3.1180	0.2004	0.833	1.333
0.30	0.7800	3.3416	0.2334	1.151	1.475
0.35	0.9450	3.5652	0.2651	1.518	1.606
0.40	1.1200	3.7889	0.2956	1.934	1.727
0.45	1.3050	4.0125	0.3252	2.402	1.841
0.50	1.5000	4.2361	0.3541	2.922	1.948
0.55	1.7050	4.4597	0.3823	3.495	2.050
0.60	1.9200	4.6833	0.4100	4.124	2.148
0.65	2.1450	4.9069	0.4371	4.808	2.242
0.70	2.3800	5.1305	0.4639	5.550	2.332
0.75	2.6250	5.3541	0.4903	6.352	2.420
0.80	2.8800	5.5777	0.5163	7.214	2.505
0.85	3.1450	5.8013	0.5421	8.137	2.587
0.90	3.4200	6.0249	0.5676	9.125	2.668
0.95	3.7050	6.2485	0.5929	10.177	2.747
1.00	4.0000	6.4721	0.6180	11.295	2.824
1.10	4.6200	6.9193	0.6677	13.735	2.973
1.20	5.2800	7.3666	0.7168	16.457	3.117
<b>1.29</b>	5.9082	7.7691	0.7605	<b>19.157</b>	3.242
1.30	5.9800	7.8138	0.7653	19.472	3.256
1.40	6.7200	8.2610	0.8135	22.789	3.391
1.50	7.5000	8.7082	0.8613	26.421	3.523
<b>1.60</b>	8.3200	9.1554	0.9088	<b>30.378</b>	3.651
1.70	9.1800	9.6026	0.9560	34.670	3.777
1.80	10.0800	10.0498	1.0030	39.307	3.899
1.90	11.0200	10.4971	1.0498	44.299	4.020
2.00	12.0000	10.9443	1.0965	49.657	4.138
2.10	13.0200	11.3915	1.1430	55.391	4.254
2.20	14.0800	11.8387	1.1893	61.509	4.369
2.30	15.1800	12.2859	1.2356	68.023	4.481
2.40	16.3200	12.7331	1.2817	74.941	4.592
2.50	17.5000	13.1803	1.3277	82.272	4.701
2.60	18.7200	13.6276	1.3737	90.027	4.809
2.70	19.9800	14.0748	1.4196	98.214	4.916
2.80	21.2800	14.5220	1.4654	106.842	5.021
2.90	22.6200	14.9692	1.5111	115.921	5.125
3.00	24.0000	15.4164	1.5568	125.459	5.227

### TIGHTLINED CONVEYANCE SYSTEM OVER THE BLUFF DESIGN

The tightlined conveyance system over the bluff will be designed with HDPE. The HDPE will be anchored into the ground. The sizing of this conveyance system will be governed by inlet control since the pipe will be over a steep slope. Per attached Figure III-2.14 from the 1992 DOE Manual, a 24" pipe can carry the required 100-year, 24-hour peak flow of 30.30 cfs with a headwater elevation equal to  $2.6 \times 24$ " or 5.2 feet. A catch basin at the inlet to the HDPE will be installed such that the invert of the pipe will be at least 5.2 feet below the rim elevation to ensure no overflows.

Figure III-2.14 - Headwater Depth for Smooth Interior Pipe Culverts With Inlet Control



## **V. EROSION/SEDIMENT CONTROL ANALYSIS AND DESIGN**

The purpose of the erosion and sedimentation control plan is to protect existing properties downstream of the site from sediment-laden runoff and erosion during construction. Because of the existing bluff along the southern edge of the development, the potential for erosion is a serious concern. For these reasons, the clearing and grading to develop the site has been phased (ie. installation of roads and utilities prior to 'blanket' lot grading) to reduce the amount of disturbed area. The phasing will allow the Contractor to effectively manage stormwater during construction. The Temporary Erosion and Sediment Control Plan for the project consists of the following:

1. **Perimeter Protection:** Silt fence protection will be used along the clearing limits that will receive sediment-laden runoff.
2. **Traffic Area Stabilization:** A stabilized construction entrance will be installed to prevent sediment from tracking onto the existing roadways when trucks are leaving the site.
3. **Surface Water Control:** The proposed roadway ditches will be used as interceptor swales to collect runoff from the site and convey flows to the proposed water quality ponds for treatment.
4. **Sediment Control:** The permanent water quality ponds will be used as sediment traps for sediment retention prior to discharge from the site. Confirmation of sizing for sediment retention will be completed at final design.
5. **Stabilized Discharge of Stormwater Runoff:** Treated stormwater will be conveyed to the proposed HDPE pipe that will discharge flows into the Strait of Georgia.
6. A construction sequence and erosion/sedimentation control notes will be added to the plans at final design.