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GEOTECHNICAL LABORATORY REPORTS AND BORING LOGS

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GeoTesting
EXPRESS

125 Nagog Park
Acton, MA 01720
978 635 0424 Tel
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Transmittal

TO:
Tim Adair
Ecology & Environment, Inc.
720 Third Avenue, Suite 1700
Seattle, WA 98104

DATE: 9/21/2011	GTX NO: 11124
RE: 10-08-0011	

COPIES	DATE	DESCRIPTION
	9/21/2011	**September 2011 Laboratory Test Report**

REMARKS:

SIGNED:
Joe Tomei, Laboratory Manager

CC:

APPROVED BY:
Nancy Hubbard, Project Manager

GeoTesting
EXPRESS

Boston
Atlanta
New York

www.geotesting.com

September 21, 2011

Tim Adair
Ecology & Environment, Inc.
720 Third Avenue, Suite 1700
Seattle, WA 98104

RE: 10-08-0011, (GTX-11124)

Dear Tim:

Enclosed are the test results you requested for the above referenced project. GeoTesting Express, Inc. (GTX) received 18 samples from you between 9/2/2011 and 9/6/2011. These samples were labeled as follows:

Boring Number	Depth
SB-01	20.5
SB-01	25
SB-01	50-52
SB-02	22
SB-02	30.5
SB-02	50.5
SB-02	55
SB-03	20.5
SB-03	21
SB-03	25
SB-03	50
SB-03	57.5
SB-04	10
SB-04	10.5
SB-04	11
SB-05	20
SB-05	25.5
SB-05	55

GTX performed the following tests on these samples:

9 ASTM D 422 - Grain Size Analyses (sieve only)
9 ASTM D 3080 - Direct Shear Test Points

A copy of your test request is attached.

The results presented in this report apply only to the items tested. This report shall not be reproduced except in full, without written approval from GeoTesting Express. The remainder of these samples will be retained for a period of sixty (60) days and will then be discarded unless otherwise notified by you. Please call me if you have any questions or require additional information. Thank you for allowing GeoTesting Express the opportunity of providing you with testing services. We look forward to working with you again in the future.

Respectfully yours,

Joe Tomei
Laboratory Manager

GeoTesting
EXPRESS

125 Nagog Park
Acton, MA 01720
978 635 0424 Tel
978 635 0266 Fax

Geotechnical Test Report

9/21/2011

GTX-11124
10-08-0011

Client Project No.: TDD No. 10-08-0011

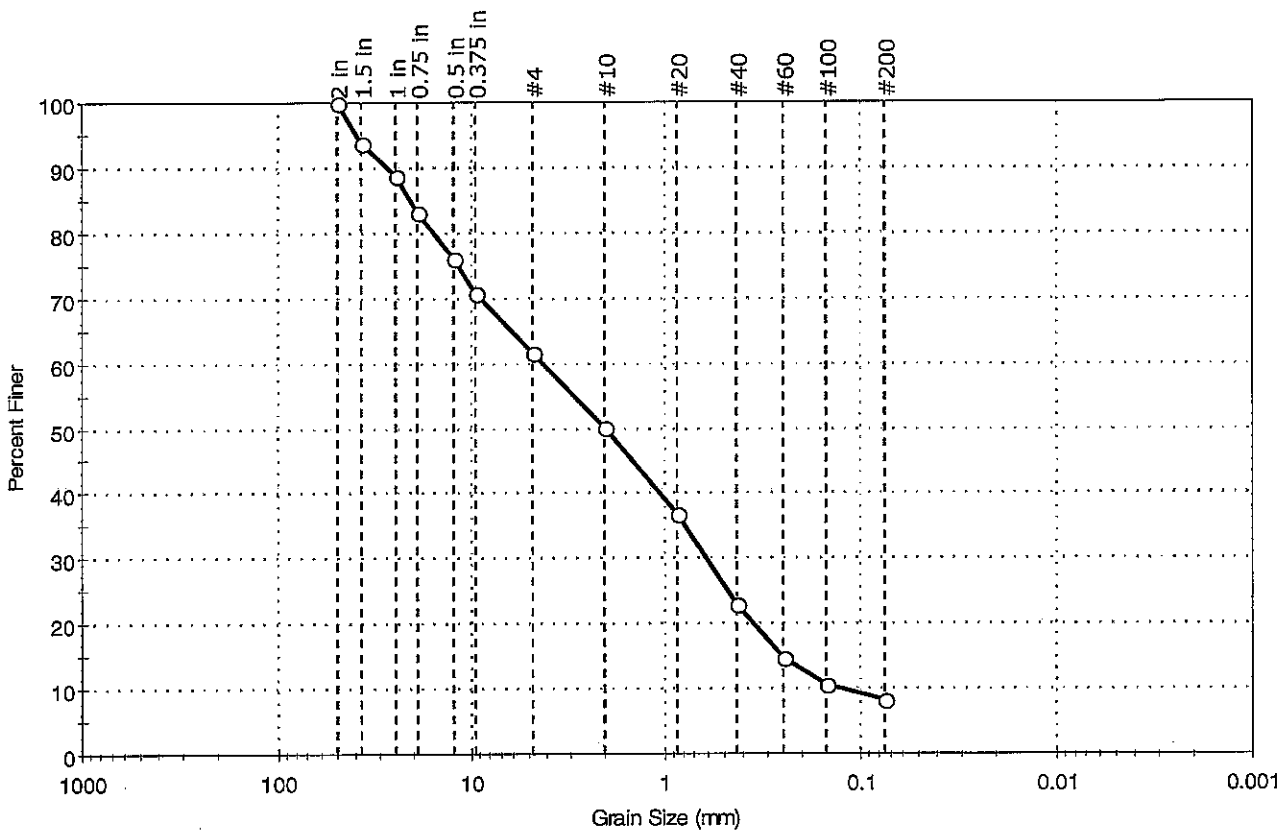
Prepared for:

Ecology & Environment, Inc.

GeoTesting EXPRESS

Client: Ecology & Environment, Inc.			
Project: 10-08-0011			
Location: ---		Project No:	GTX-11124
Boring ID: SB-01	Sample Type: bag	Tested By:	jbr
Sample ID:---	Test Date: 09/12/11	Checked By:	jdt
Depth : 25	Test Id: 217167		
Test Comment: ---			
Sample Description: Moist, brown sand with silt and gravel			
Sample Comment: ---			

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	38.3	53.4	8.3

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
2 in	50.00	100		
1.5 in	37.50	94		
1 in	25.00	89		
0.75 in	19.00	83		
0.5 in	12.50	76		
0.375 in	9.50	71		
#4	4.75	62		
#10	2.00	50		
#20	0.85	37		
#40	0.42	23		
#60	0.25	15		
#100	0.15	11		
#200	0.075	8		

Coefficients

D_{85} =20.7886 mm D_{30} =0.6037 mm
D_{60} =4.1858 mm D_{15} =0.2554 mm
D_{50} =1.9716 mm D_{10} =0.1224 mm
C_u =34.198 C_c =0.711

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

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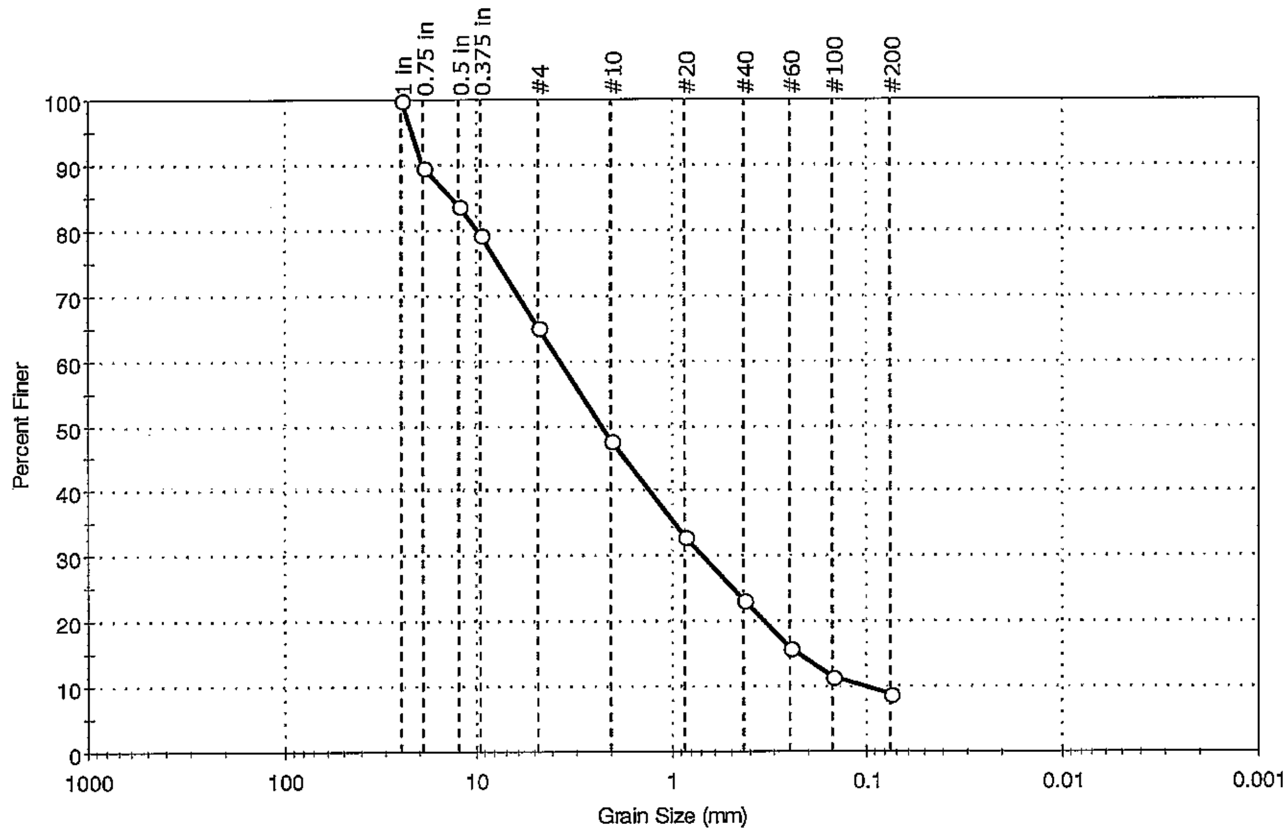
GeoTesting EXPRESS

Client: Ecology & Environment, Inc.			
Project: 10-08-0011			
Location: ---		Project No:	GTX-11124
Boring ID: SB-01	Sample Type: bag	Tested By:	jbr
Sample ID:---	Test Date: 09/14/11	Checked By:	jdt
Depth : 50-52	Test Id: 217168		
Test Comment: ---			
Sample Description: Moist, brown sand with silt and gravel			
Sample Comment: ---			

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	34.9	56.3	8.8

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 in	25.00	100		
0.75 in	19.00	90		
0.5 in	12.50	84		
0.375 in	9.50	79		
#4	4.75	65		
#10	2.00	48		
#20	0.85	33		
#40	0.42	23		
#60	0.25	16		
#100	0.15	11		
#200	0.075	9		

Coefficients

D_{85} = 13.6407 mm	D_{30} = 0.6882 mm
D_{60} = 3.6895 mm	D_{15} = 0.2238 mm
D_{50} = 2.2436 mm	D_{10} = 0.1031 mm
C_u = 35.786	C_c = 1.245

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-a (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

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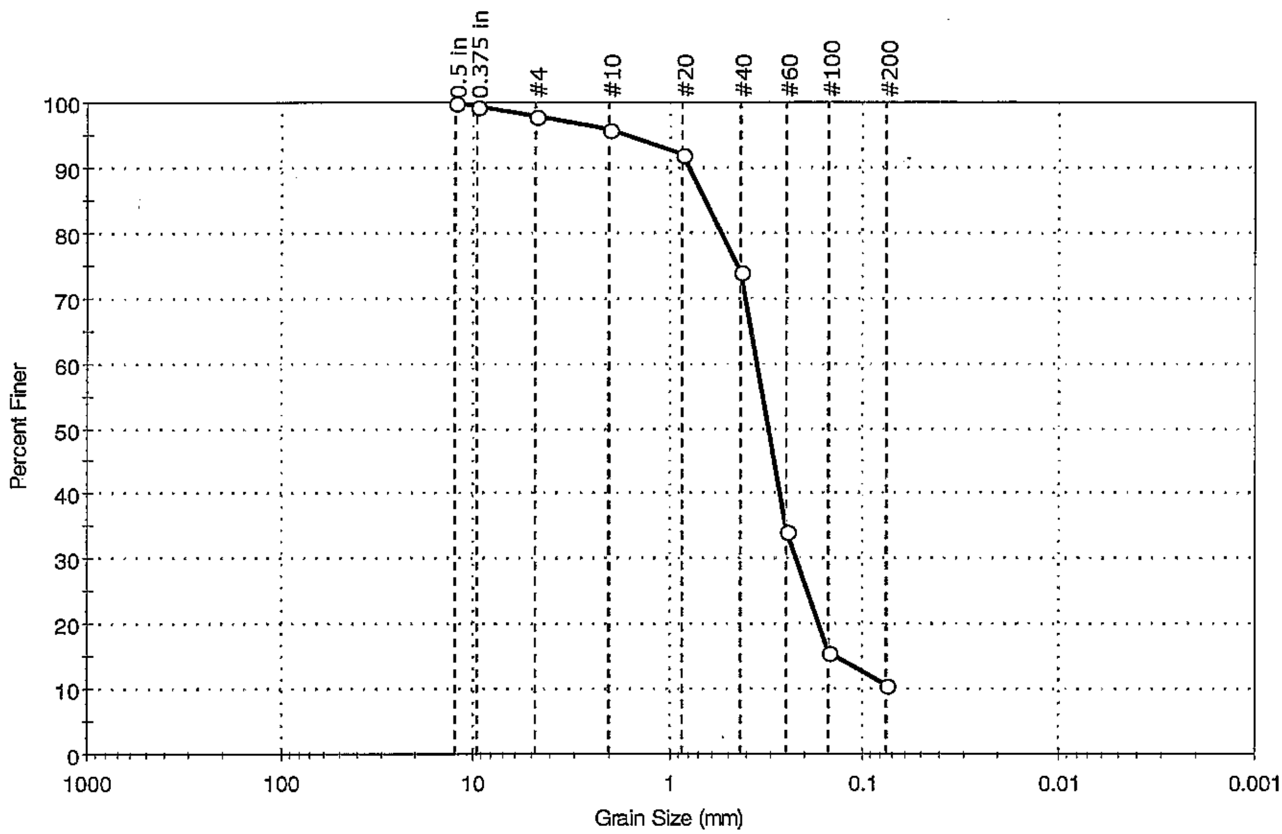
GeoTesting EXPRESS

Client: Ecology & Environment, Inc.			
Project: 10-08-0011			
Location: ---		Project No:	GTX-11124
Boring ID: SB-02	Sample Type: bag	Tested By:	jbr
Sample ID:---	Test Date: 09/13/11	Checked By:	jdt
Depth : 22	Test Id: 217169		
Test Comment: ---			
Sample Description: Moist, brown sand with silt			
Sample Comment: ---			

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	2.0	87.3	10.7

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.5 in	12.50	100		
0.375 in	9.50	99		
#4	4.75	98		
#10	2.00	96		
#20	0.85	92		
#40	0.42	74		
#60	0.25	34		
#100	0.15	16		
#200	0.075	11		

Coefficients

D_{85} =0.6476 mm D_{30} =0.2234 mm

D_{60} =0.3528 mm D_{15} =0.1387 mm

D_{50} =0.3089 mm D_{10} =0.0680 mm

C_u =5.188 C_c =2.080

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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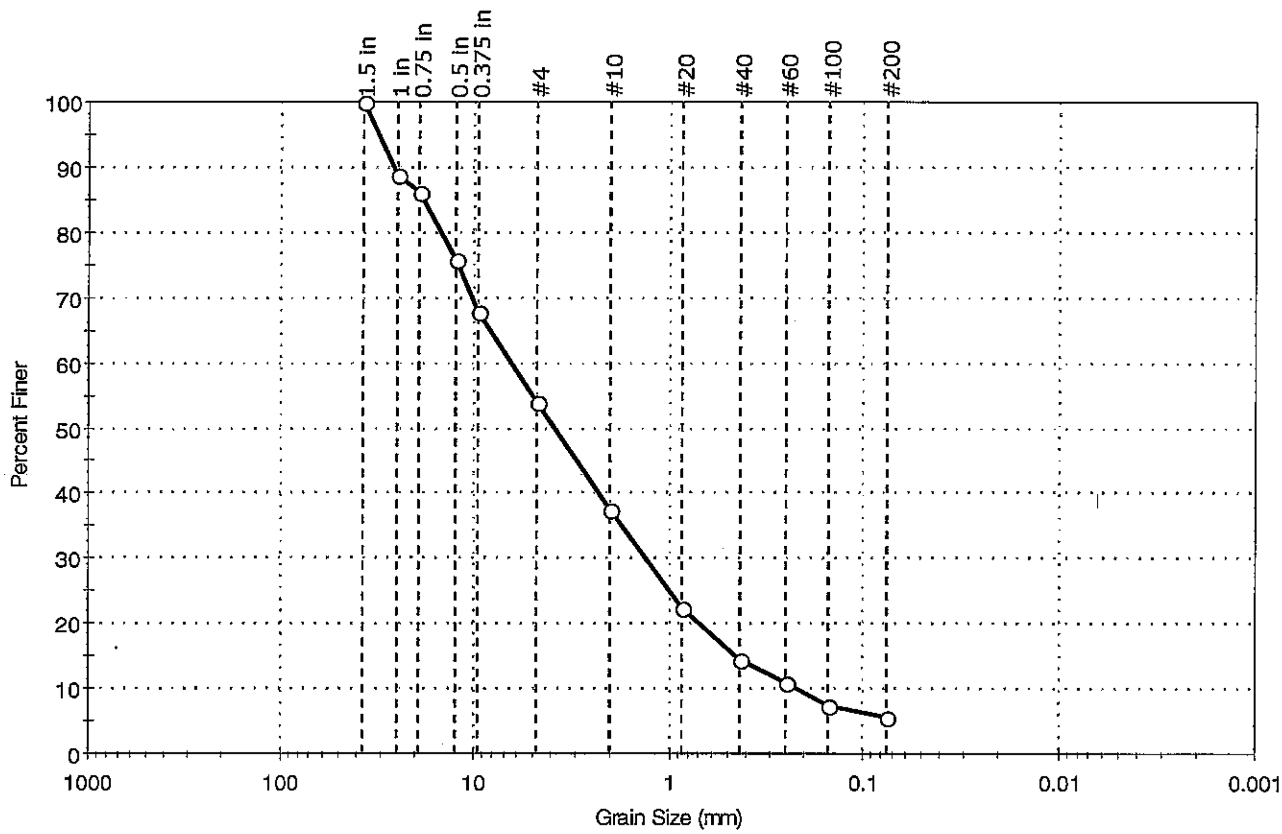
GeoTesting EXPRESS

Client: Ecology & Environment, Inc.			
Project: 10-08-0011			
Location: ---		Project No:	GTX-11124
Boring ID: SB-02	Sample Type: bag	Tested By:	jbr
Sample ID:---	Test Date: 09/13/11	Checked By:	jdt
Depth : 55	Test Id: 217170		
Test Comment: ---			
Sample Description: Moist, brown sand with silt and gravel			
Sample Comment: ---			

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	46.1	48.4	5.5

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1.5 in	37.50	100		
1 in	25.00	89		
0.75 in	19.00	86		
0.5 in	12.50	76		
0.375 in	9.50	68		
#4	4.75	54		
#10	2.00	38		
#20	0.85	22		
#40	0.42	15		
#60	0.25	11		
#100	0.15	7		
#200	0.075	6		

Coefficients

D_{85} =18.1146 mm	D_{30} =1.3047 mm

D_{60} =6.4238 mm	D_{15} =0.4417 mm

D_{50} =3.8666 mm	D_{10} =0.2203 mm

C_u =29.159	C_c =1.203

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-a (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

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GeoTesting EXPRESS

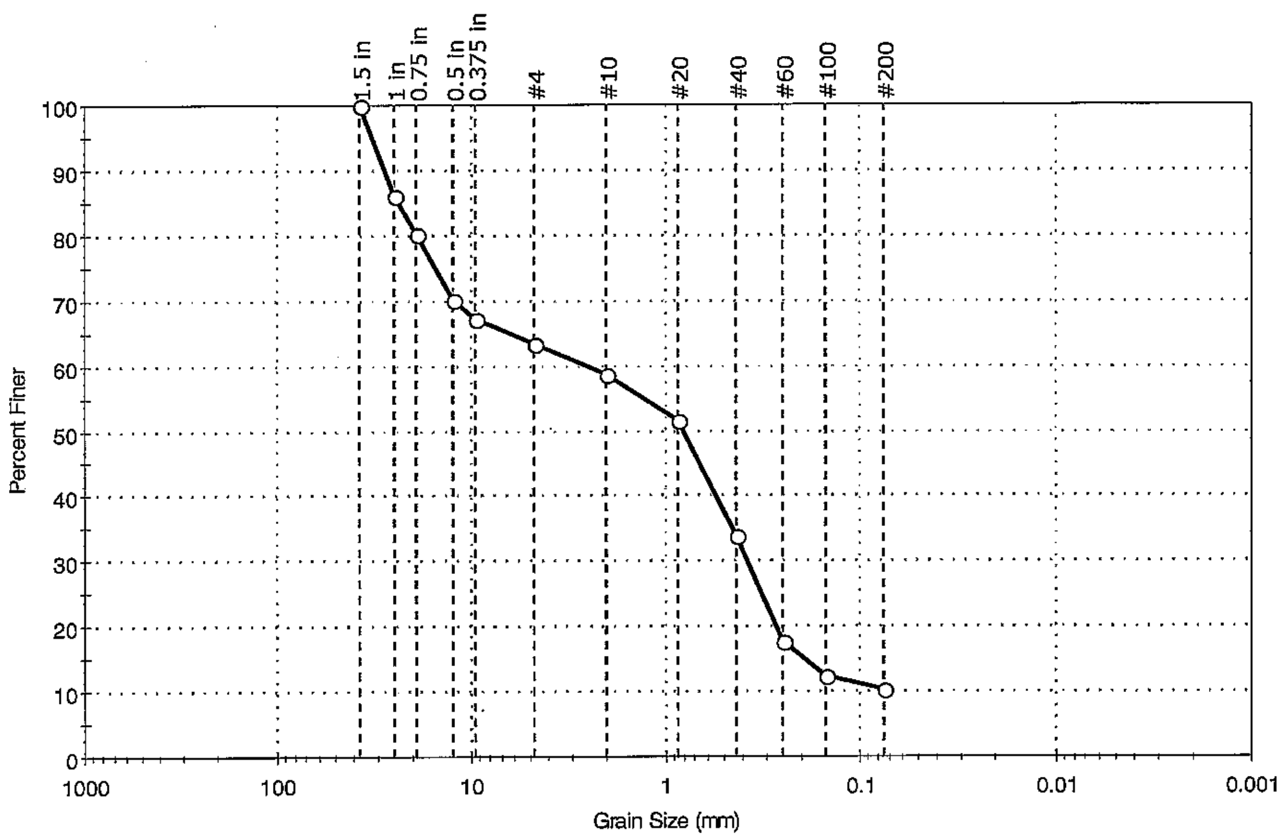
Client:	Ecology & Environment, Inc.		
Project:	10-08-0011		
Location:	---	Project No:	GTX-11124
Boring ID: SB-03	Sample Type: bag	Tested By:	jbr
Sample ID:---	Test Date: 09/14/11	Checked By:	jdt
Depth : 25	Test Id: 217171		

Test Comment: ---

Sample Description: Moist, yellowish brown sand with silt and gravel

Sample Comment: ---

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	36.5	53.1	10.4

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1.5 in	37.50	100		
1 in	25.00	86		
0.75 in	19.00	80		
0.5 in	12.50	70		
0.375 in	9.50	67		
#4	4.75	64		
#10	2.00	59		
#20	0.85	52		
#40	0.42	34		
#60	0.25	18		
#100	0.15	12		
#200	0.075	10		

Coefficients

D_{85} =23.7701 mm D_{30} =0.3742 mm

D_{60} =2.5118 mm D_{15} =0.1928 mm

D_{50} =0.7955 mm D_{10} =0.0660 mm

C_u =38.058 C_c =0.845

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

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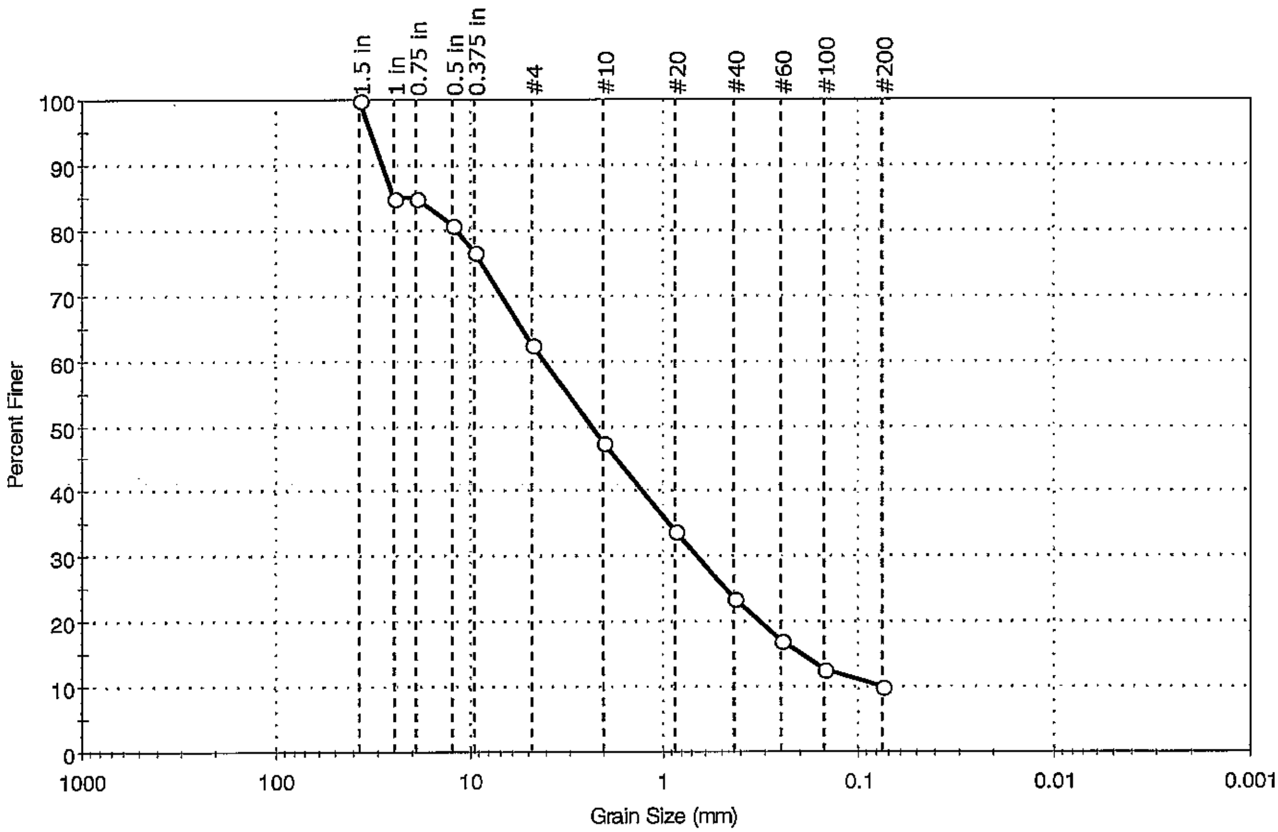
GeoTesting EXPRESS

Client:	Ecology & Environment, Inc.				
Project:	10-08-0011				
Location:	---			Project No:	GTX-11124
Boring ID: SB-03		Sample Type:	bag	Tested By:	jbr
Sample ID:---		Test Date:	09/14/11	Checked By:	jdt
Depth : 50		Test Id:	217172		
Test Comment:	---				
Sample Description:	Moist, brown sand with silt and gravel				
Sample Comment:	---				

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	37.4	52.7	9.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1.5 in	37.50	100		
1 in	25.00	85		
0.75 in	19.00	85		
0.5 in	12.50	81		
0.375 in	9.50	77		
#4	4.75	63		
#10	2.00	47		
#20	0.85	34		
#40	0.42	24		
#60	0.25	17		
#100	0.15	13		
#200	0.075	10		

Coefficients

D_{85} =25.0761 mm	D_{30} =0.6515 mm
D_{60} =4.0841 mm	D_{15} =0.1970 mm
D_{50} =2.3175 mm	D_{10} =0.0764 mm
C_u =53.457	C_c =1.360

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-a (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

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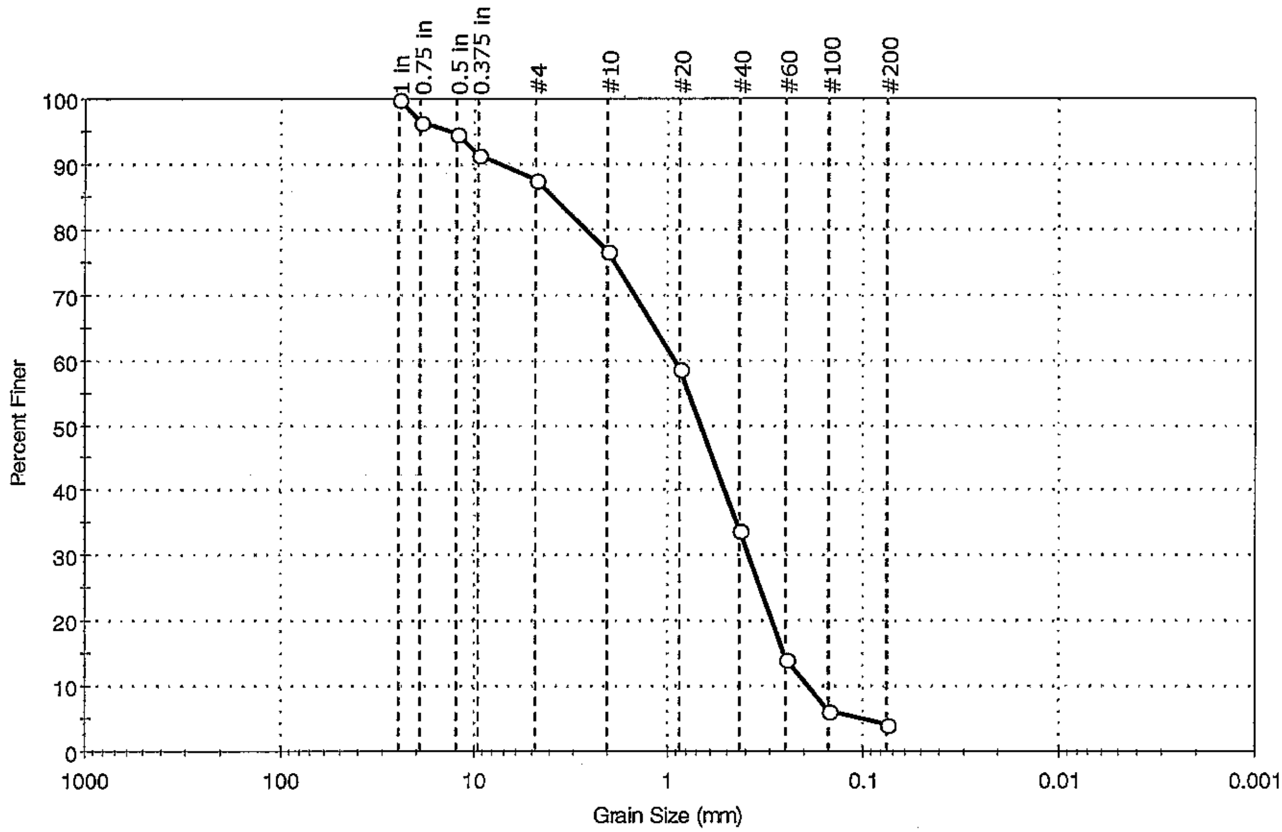
GeoTesting EXPRESS

Client:	Ecology & Environment, Inc.				
Project:	10-08-0011				
Location:	---			Project No:	GTX-11124
Boring ID: SB-04		Sample Type:	bag	Tested By:	jbr
Sample ID:---		Test Date:	09/14/11	Checked By:	jdt
Depth : 10		Test Id:	217173		
Test Comment:	---				
Sample Description:	Moist, brownish yellow sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	12.4	83.4	4.2

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 in	25.00	100		
0.75 in	19.00	96		
0.5 in	12.50	95		
0.375 in	9.50	91		
#4	4.75	88		
#10	2.00	77		
#20	0.85	59		
#40	0.42	34		
#60	0.25	14		
#100	0.15	6		
#200	0.075	4		

Coefficients

D_{85} =3.8405 mm D_{30} =0.3814 mm

D_{60} =0.8979 mm D_{15} =0.2548 mm

D_{50} =0.6639 mm D_{10} =0.1909 mm

C_u =4.704 C_c =0.849

Classification

ASTM Poorly graded sand (SP)

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

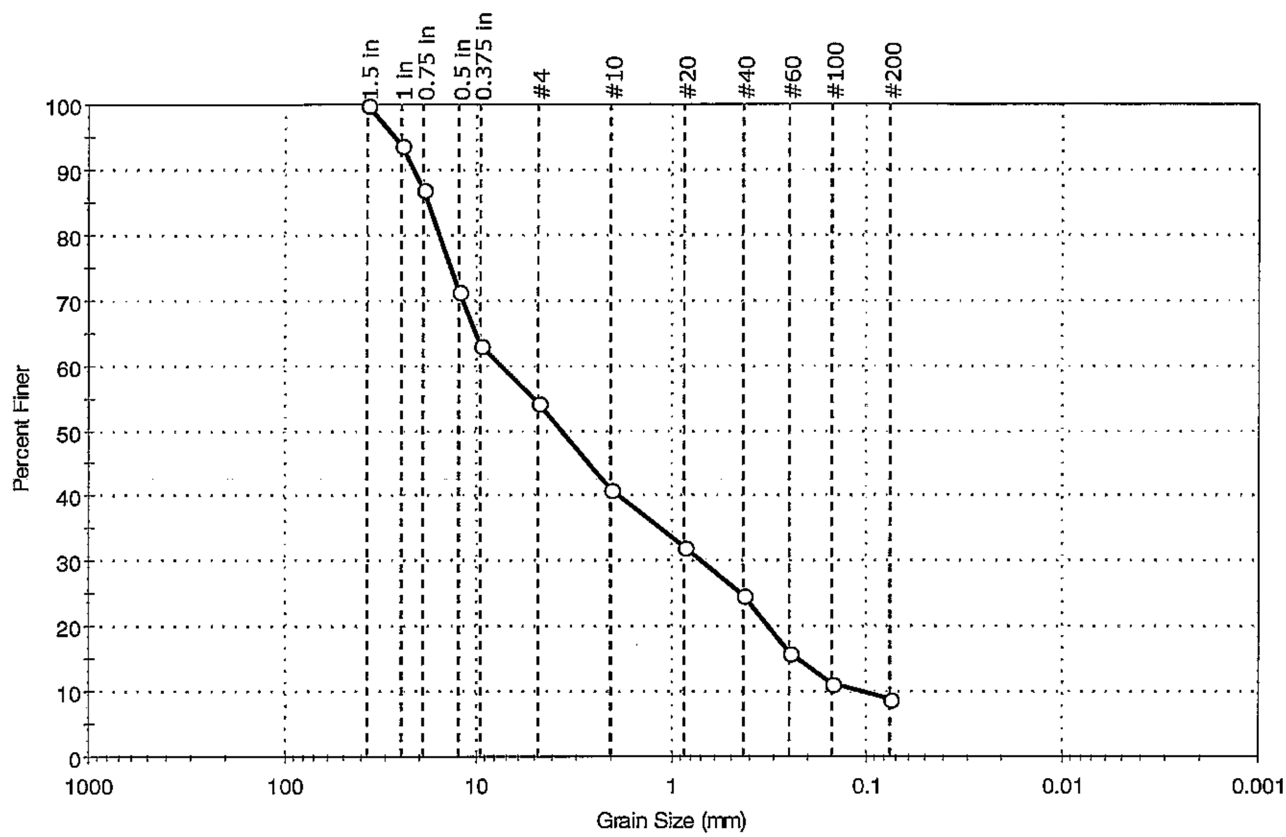
Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

GeoTesting EXPRESS

Client: Ecology & Environment, Inc.			
Project: 10-08-0011			
Location: ---		Project No:	GTX-11124
Boring ID: SB-05	Sample Type: bag	Tested By:	jbr
Sample ID:---	Test Date: 09/12/11	Checked By:	jdt
Depth : 20	Test Id: 217174		
Test Comment: ---			
Sample Description: Moist, brown gravel with silt and sand			
Sample Comment: ---			

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	45.8	45.4	8.8

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1.5 in	37.50	100		
1 in	25.00	94		
0.75 in	19.00	87		
0.5 in	12.50	71		
0.375 in	9.50	63		
#4	4.75	54		
#10	2.00	41		
#20	0.85	32		
#40	0.42	25		
#60	0.25	16		
#100	0.15	11		
#200	0.075	9		

Coefficients

D_{85} =17.9761 mm D_{30} =0.7003 mm

D_{60} =7.4095 mm D_{15} =0.2279 mm

D_{50} =3.5984 mm D_{10} =0.1081 mm

C_u =68.543 C_c =0.612

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-a (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

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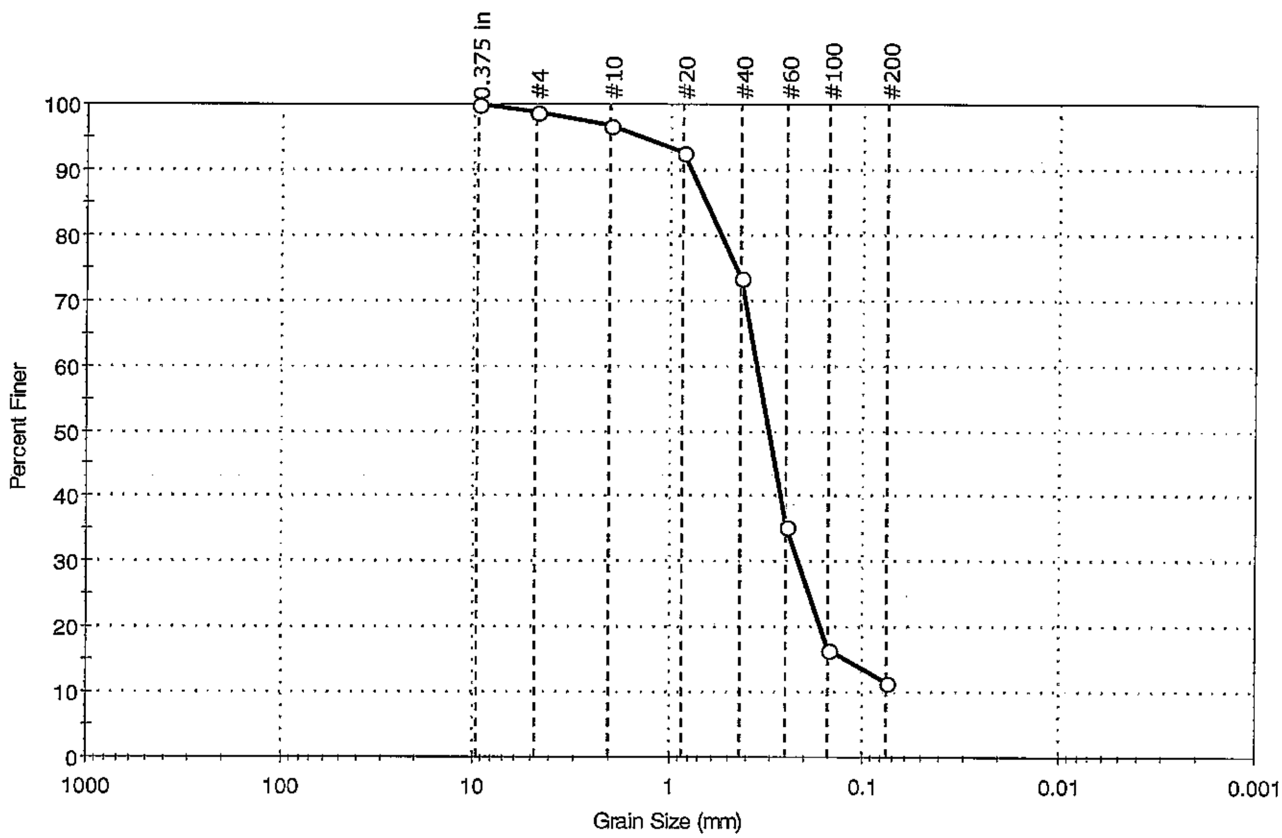
GeoTesting EXPRESS

Client: Ecology & Environment, Inc.			
Project: 10-08-0011			
Location: ---		Project No:	GTX-11124
Boring ID: SB-05	Sample Type: bag	Tested By:	jbr
Sample ID:---	Test Date: 09/14/11	Checked By:	jdt
Depth : 55	Test Id: 217175		
Test Comment: ---			
Sample Description: Moist, brown sand with silt			
Sample Comment: ---			

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	1.2	87.3	11.5

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	99		
#10	2.00	97		
#20	0.85	93		
#40	0.42	74		
#60	0.25	36		
#100	0.15	16		
#200	0.075	11		

Coefficients

D_{85} =0.6429 mm	D_{30} =0.2156 mm
D_{60} =0.3519 mm	D_{15} =0.1230 mm
D_{50} =0.3060 mm	D_{10} =0.0610 mm
C_u =5.769	C_c =2.165

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

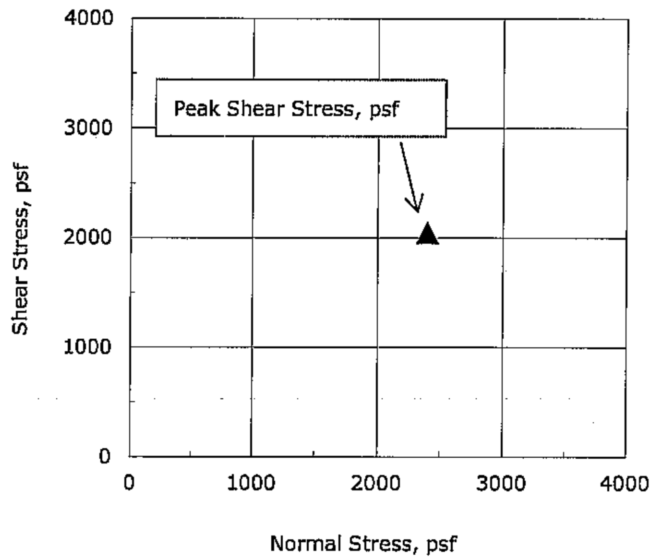
Sand/Gravel Particle Shape : ---

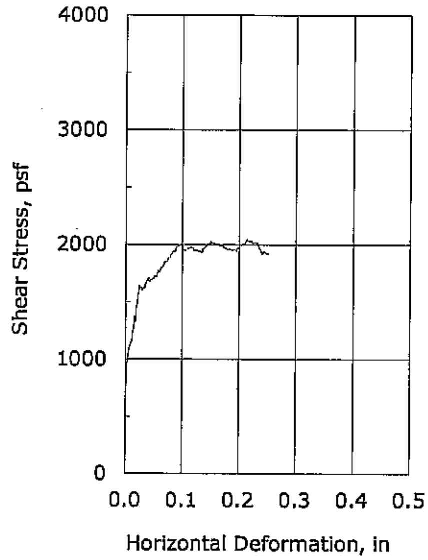
Sand/Gravel Hardness : ---

GeoTesting EXPRESS

Client:	Ecology & Environment, Inc.
Project Name:	10-08-0011
Project Location:	---
GTX #:	11124
Test Date:	9/12/2011
Tested By:	md
Checked By:	jdt
Boring ID:	SB-01
Sample ID:	---
Depth, ft:	20.5
Visual Description:	Dry, brown sand

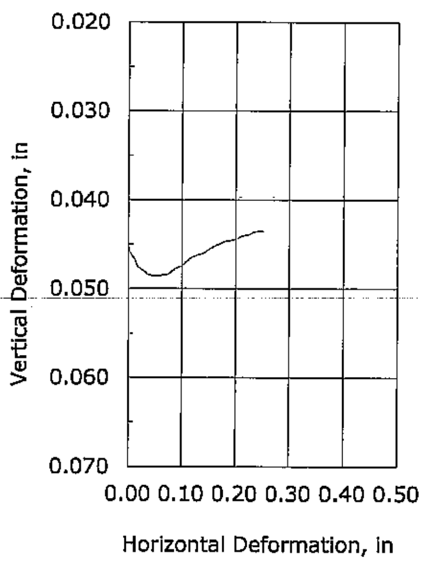
Direct Shear Test of Soils Under Consolidated Drained Conditions by ASTM D 3080-04





Test No.:	DS-4		
Initial Diameter, in	2.00		
Initial Height, in	1.00		
Initial Mass, grams	80.0		
Initial Dry Density, pcf	90.8		
Initial Moisture Content, %	6.7		
Initial Bulk Density, pcf	97		
Initial Degree of Saturation	21.7		
Initial Void Ratio	0.82		
Final Dry Density, pcf	95.0		
Final Moisture Content, %	26.3		
Final Bulk Density, pcf	120		
Normal Stress, psf	2400		
Maximum Shear Stress, psf	2044		
Shear Rate, in/min	0.004		

Sample Type:	tube
Estimated Specific Gravity:	2.65
Liquid Limit:	---
Plastic Limit:	---
Plasticity Index:	---
% Passing #200 sieve:	---
Soil Classification:	---
Group Symbol:	---



Notes: Moisture content obtained before shear from sample trimmings

Moisture Content determined by ASTM D 2216

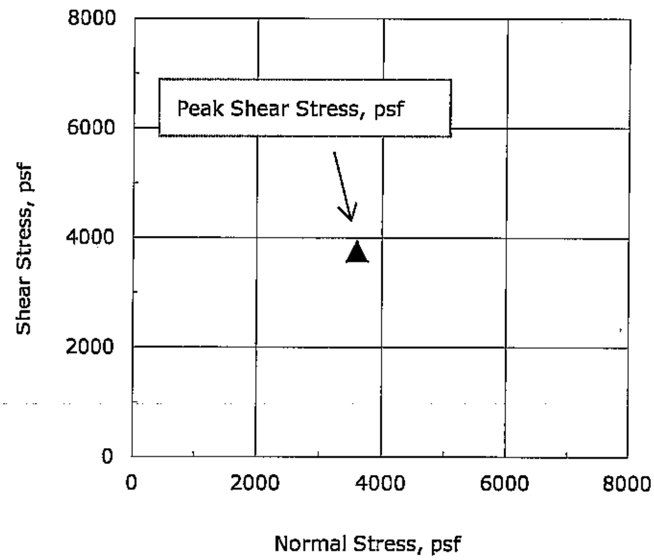
Values for cohesion and friction angle not presented because only one test point was requested. If zero cohesion is assumed, the approximate friction angle would be 40.4°.

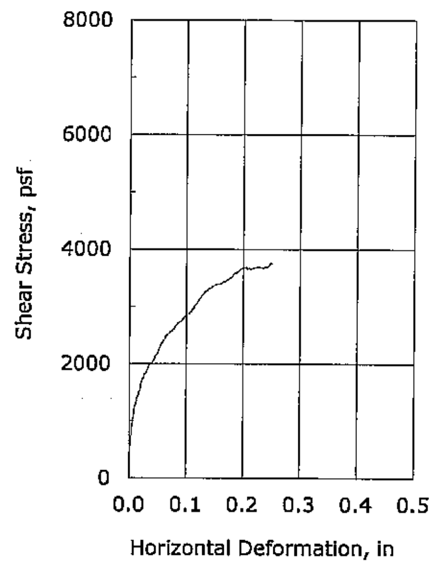
"---" indicates testing required to determine these values was not requested.

GeoTesting EXPRESS

Client:	Ecology & Environment, Inc.
Project Name:	10-08-0011
Project Location:	---
GTX #:	11124
Test Date:	9/12/2011
Tested By:	md
Checked By:	jdt
Boring ID:	SB-02
Sample ID:	---
Depth, ft:	30.5
Visual Description:	Dry, brown sand

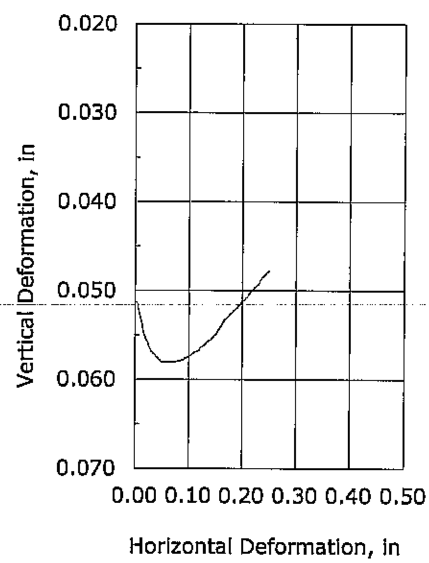
Direct Shear Test of Soils Under Consolidated Drained Conditions by ASTM D 3080-04





Test No.:	DS-5		
Initial Diameter, in	2.00		
Initial Height, in	1.00		
Initial Mass, grams	93.5		
Initial Dry Density, pcf	107.4		
Initial Moisture Content, %	5.5		
Initial Bulk Density, pcf	113		
Initial Degree of Saturation	27.1		
Initial Void Ratio	0.54		
Final Dry Density, pcf	113		
Final Moisture Content, %	18.0		
Final Bulk Density, pcf	133		
Normal Stress, psf	3600		
Maximum Shear Stress, psf	3755		
Shear Rate, in/min	0.004		

Sample Type:	tube
Estimated Specific Gravity:	2.65
Liquid Limit:	---
Plastic Limit:	---
Plasticity Index:	---
% Passing #200 sieve:	---
Soil Classification:	---
Group Symbol:	---



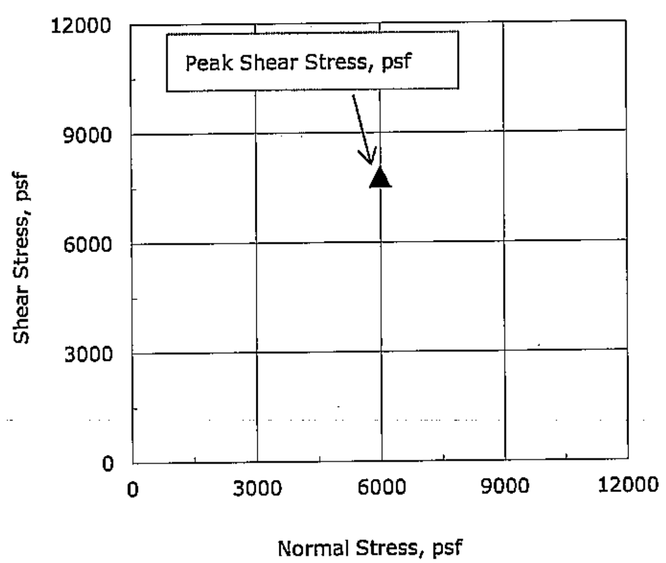
Notes: Moisture content obtained before shear from sample trimmings
Moisture Content determined by ASTM D 2216
Values for cohesion and friction angle not presented because only one test point was requested. If zero cohesion is assumed, the approximate friction angle would be 46.2°.

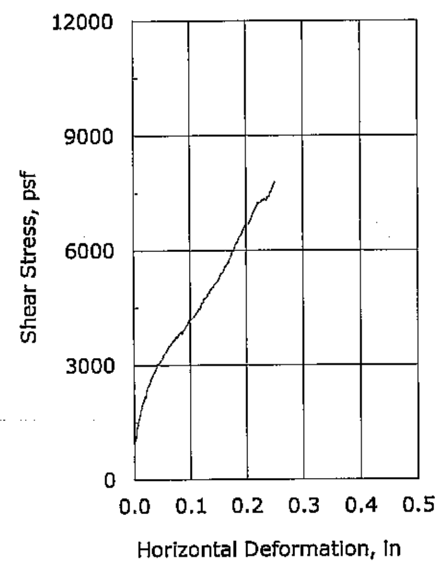
"---" indicates testing required to determine these values was not requested.

GeoTesting EXPRESS

Client:	Ecology & Environment, Inc.
Project Name:	10-08-0011
Project Location:	---
GTX #:	11124
Test Date:	9/13/2011
Tested By:	md
Checked By:	jdt
Boring ID:	SB-02
Sample ID:	---
Depth, ft:	50.5
Visual Description:	Dry, brown sand with gravel

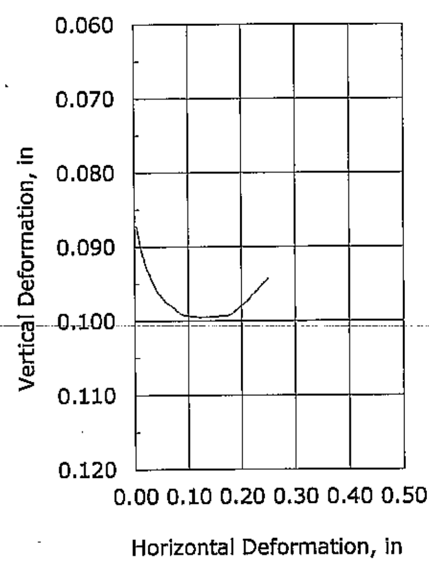
Direct Shear Test of Soils Under Consolidated Drained Conditions by ASTM D 3080-04





Test No.:	DS-6		
Initial Diameter, in	2.00		
Initial Height, in	1.00		
Initial Mass, grams	96.0		
Initial Dry Density, pcf	110		
Initial Moisture Content, %	6.0		
Initial Bulk Density, pcf	116		
Initial Degree of Saturation	31.4		
Initial Void Ratio	0.51		
Final Dry Density, pcf	121		
Final Moisture Content, %	13.3		
Final Bulk Density, pcf	137		
Normal Stress, psf	6000		
Maximum Shear Stress, psf	7794		
Shear Rate, in/min	0.004		

Sample Type:	tube
Estimated Specific Gravity:	2.65
Liquid Limit:	---
Plastic Limit:	---
Plasticity Index:	---
% Passing #200 sieve:	---
Soil Classification:	---
Group Symbol:	---



Notes: Moisture content obtained before shear from sample trimmings

Moisture Content determined by ASTM D 2216

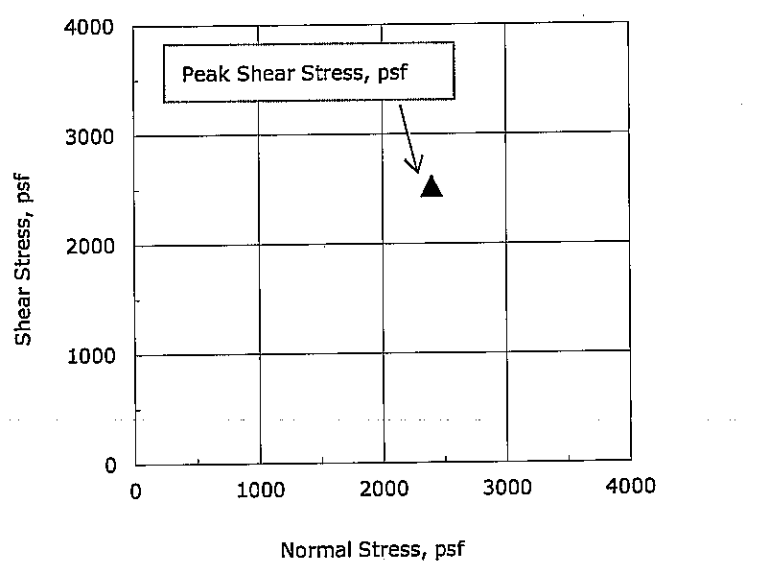
Values for cohesion and friction angle not presented because only one test point was requested. If zero cohesion is assumed, the approximate friction angle would be 52.4°.

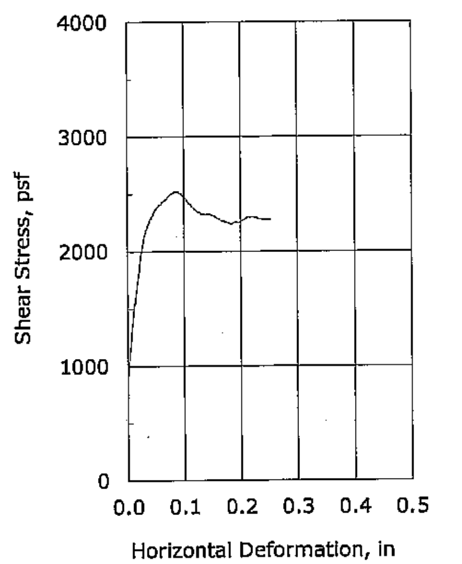
"---" indicates testing required to determine these values was not requested.

GeoTesting EXPRESS

Client:	Ecology & Environment, Inc.
Project Name:	10-08-0011
Project Location:	---
GTX #:	11124
Test Date:	9/9/2011
Tested By:	md
Checked By:	jdt
Boring ID:	SB-03
Sample ID:	---
Depth, ft:	20.5
Visual Description:	Moist, brown sand

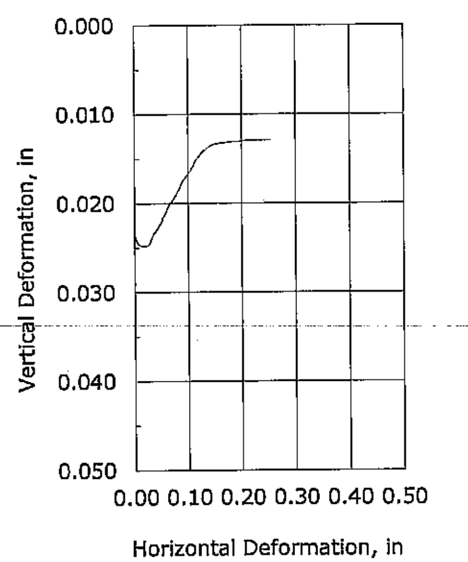
Direct Shear Test of Soils Under Consolidated Drained Conditions by ASTM D 3080-04





Test No.:	DS-3		
Initial Diameter, in	2.00		
Initial Height, in	1.00		
Initial Mass, grams	91.2		
Initial Dry Density, pcf	98.1		
Initial Moisture Content, %	12.8		
Initial Bulk Density, pcf	111		
Initial Degree of Saturation	49.4		
Initial Void Ratio	0.69		
Final Dry Density, pcf	99.4		
Final Moisture Content, %	22.9		
Final Bulk Density, pcf	122		
Normal Stress, psf	2401		
Maximum Shear Stress, psf	2522		
Shear Rate, in/min	0.004		

Sample Type:	tube
Estimated Specific Gravity:	2.65
Liquid Limit:	---
Plastic Limit:	---
Plasticity Index:	---
% Passing #200 sieve:	---
Soil Classification:	---
Group Symbol:	---



Notes: Moisture content obtained before shear from sample trimmings

Moisture Content determined by ASTM D 2216

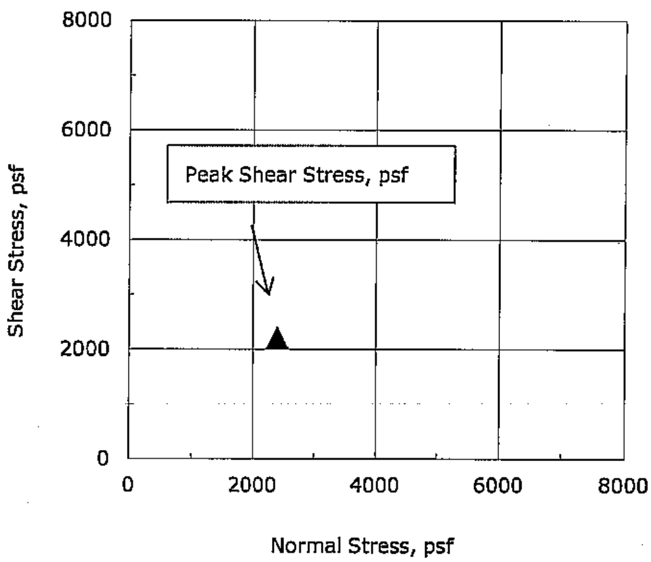
Values for cohesion and friction angle not presented because only one test point was requested. If zero cohesion is assumed, the approximate friction angle would be 46.4°.

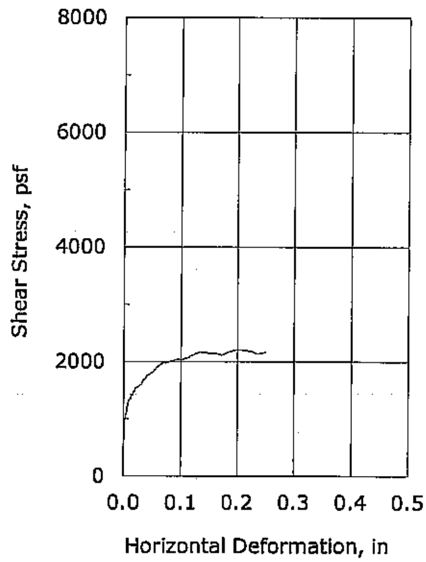
"---" indicates testing required to determine these values was not requested.

GeoTesting EXPRESS

Client:	Ecology & Environment, Inc.
Project Name:	10-08-0011
Project Location:	---
GTX #:	11124
Test Date:	9/14/2011
Tested By:	md
Checked By:	jdt
Boring ID:	SB-03
Sample ID:	---
Depth, ft:	21
Visual Description:	Moist, brown sand

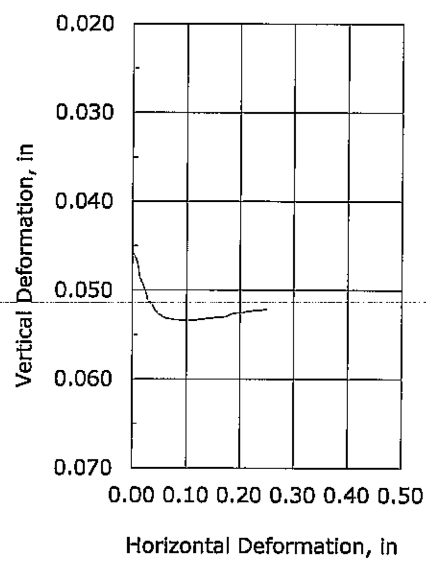
Direct Shear Test of Soils Under Consolidated Drained Conditions by ASTM D 3080-04





Test No.:	DS-7		
Initial Diameter, in	2.00		
Initial Height, in	1.00		
Initial Mass, grams	90.4		
Initial Dry Density, pcf	98.8		
Initial Moisture Content, %	10.9		
Initial Bulk Density, pcf	110		
Initial Degree of Saturation	42.8		
Initial Void Ratio	0.67		
Final Dry Density, pcf	104		
Final Moisture Content, %	19.4		
Final Bulk Density, pcf	124		
Normal Stress, psf	2400		
Maximum Shear Stress, psf	2210		
Shear Rate, in/min	0.004		

Sample Type:	tube
Estimated Specific Gravity:	2.65
Liquid Limit:	---
Plastic Limit:	---
Plasticity Index:	---
% Passing #200 sieve:	---
Soil Classification:	---
Group Symbol:	---



Notes: Moisture content obtained before shear from sample trimmings

Moisture Content determined by ASTM D 2216

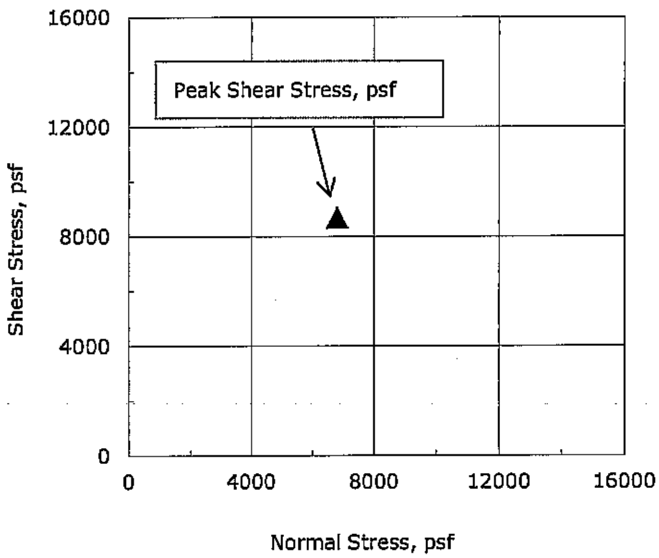
Values for cohesion and friction angle not presented because only one test point was requested. If zero cohesion is assumed, the approximate friction angle would be 42.6°.

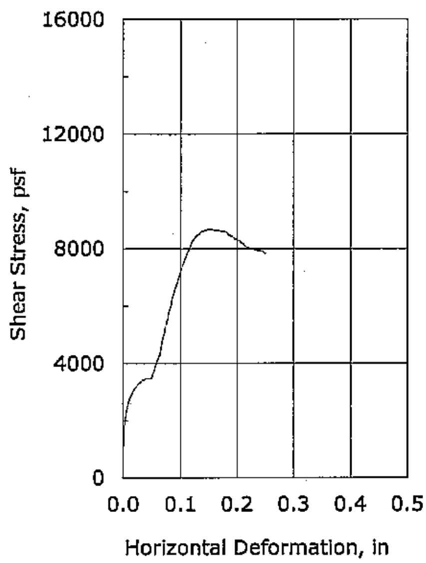
"---" indicates testing required to determine these values was not requested.

GeoTesting EXPRESS

Client:	Ecology & Environment, Inc.
Project Name:	10-08-0011
Project Location:	---
GTX #:	11124
Test Date:	9/8/2011
Tested By:	md
Checked By:	jdt
Boring ID:	SB-03
Sample ID:	---
Depth, ft:	57.5
Visual Description:	Moist, dark gray sand with gravel

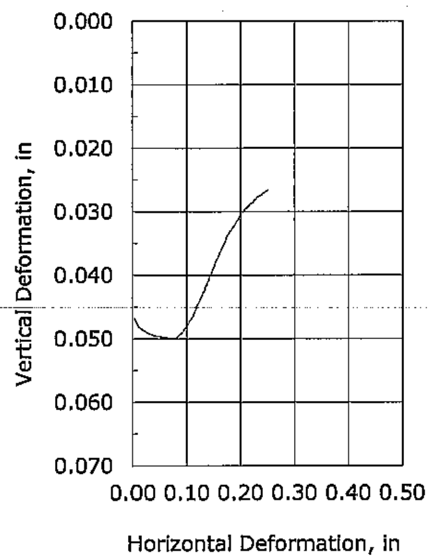
Direct Shear Test of Soils Under Consolidated Drained Conditions by ASTM D 3080-04





Test No.:	DS-1		
Initial Diameter, in	2.00		
Initial Height, in	1.00		
Initial Mass, grams	107		
Initial Dry Density, pcf	118		
Initial Moisture Content, %	10.2		
Initial Bulk Density, pcf	130		
Initial Degree of Saturation	67.3		
Initial Void Ratio	0.40		
Final Dry Density, pcf	121		
Final Moisture Content, %	17.4		
Final Bulk Density, pcf	142		
Normal Stress, psf	6800		
Maximum Shear Stress, psf	8687		
Shear Rate, in/min	0.004		

Sample Type:	tube
Estimated Specific Gravity:	2.70
Liquid Limit:	---
Plastic Limit:	---
Plasticity Index:	---
% Passing #200 sieve:	---
Soil Classification:	---
Group Symbol:	---



Notes: Moisture content obtained before shear from sample trimmings

Moisture Content determined by ASTM D 2216

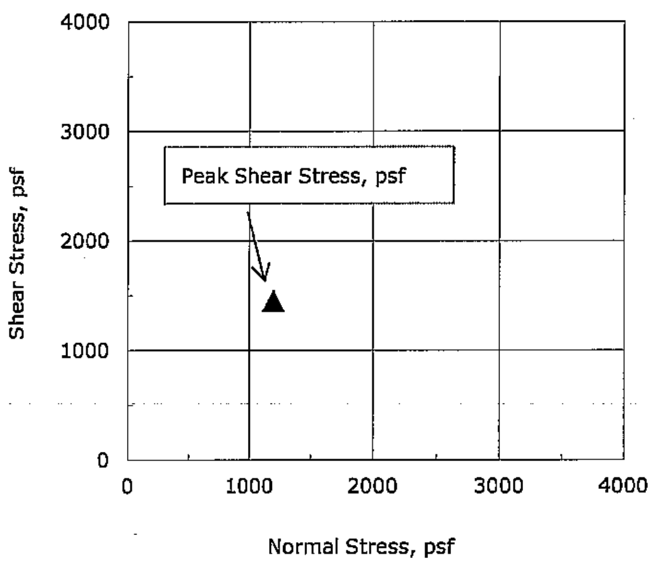
Values for cohesion and friction angle not presented because only one test point was requested. If zero cohesion is assumed, the approximate friction angle would be 51.9°.

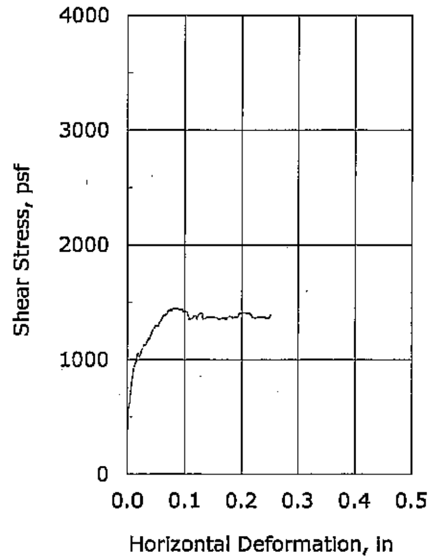
"---" indicates testing required to determine these values was not requested.

GeoTesting EXPRESS

Client:	Ecology & Environment, Inc.
Project Name:	10-08-0011
Project Location:	---
GTX #:	11124
Test Date:	9/16/2011
Tested By:	md
Checked By:	jdt
Boring ID:	SB-04
Sample ID:	---
Depth, ft:	10.5
Visual Description:	Moist, brown coarse sand and gravel

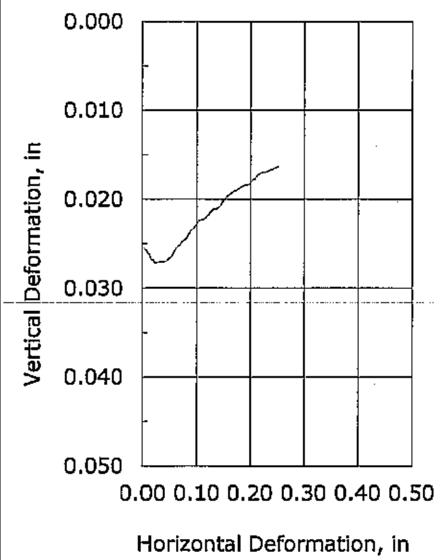
Direct Shear Test of Soils Under Consolidated Drained Conditions by ASTM D 3080-04





Test No.:	DS-9		
Initial Diameter, in	2.00		
Initial Height, in	1.00		
Initial Mass, grams	106.2		
Initial Dry Density, pcf	115		
Initial Moisture Content, %	12.3		
Initial Bulk Density, pcf	129		
Initial Degree of Saturation	73.8		
Initial Void Ratio	0.44		
Final Dry Density, pcf	117		
Final Moisture Content, %	16.3		
Final Bulk Density, pcf	136		
Normal Stress, psf	1201		
Maximum Shear Stress, psf	1452		
Shear Rate, in/min	0.004		

Sample Type:	tube
Estimated Specific Gravity:	2.65
Liquid Limit:	---
Plastic Limit:	---
Plasticity Index:	---
% Passing #200 sieve:	---
Soil Classification:	---
Group Symbol:	---



Notes: Moisture content obtained before shear from sample trimmings

Moisture Content determined by ASTM D 2216

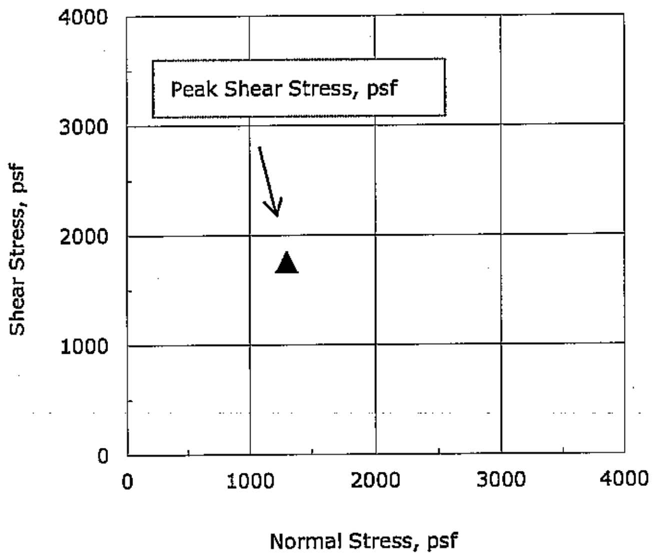
Values for cohesion and friction angle not presented because only one test point was requested. If zero cohesion is assumed, the approximate friction angle would be 50.4°.

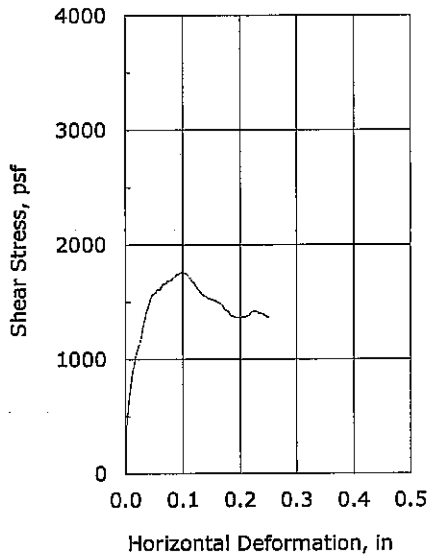
"---" indicates testing required to determine these values was not requested.

GeoTesting EXPRESS

Client:	Ecology & Environment, Inc.
Project Name:	10-08-0011
Project Location:	---
GTX #:	11124
Test Date:	9/9/2011
Tested By:	md
Checked By:	jdt
Boring ID:	SB-04
Sample ID:	---
Depth, ft:	11
Visual Description:	Moist, brown sand with clay

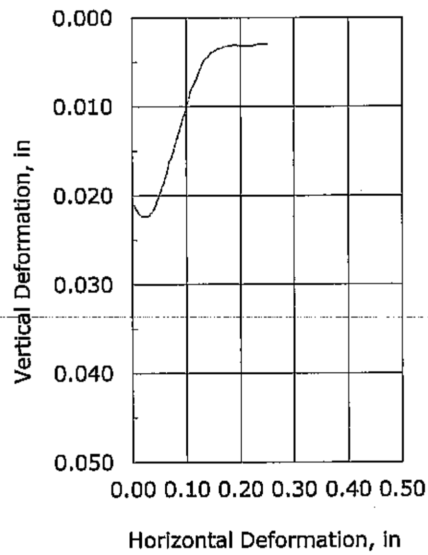
Direct Shear Test of Soils Under Consolidated Drained Conditions by ASTM D 3080-04





Test No.:	DS-2		
Initial Diameter, in	2.00		
Initial Height, in	1.00		
Initial Mass, grams	104		
Initial Dry Density, pcf	105		
Initial Moisture Content, %	20.3		
Initial Bulk Density, pcf	126		
Initial Degree of Saturation	90.0		
Initial Void Ratio	0.61		
Final Dry Density, pcf	105		
Final Moisture Content, %	26.0		
Final Bulk Density, pcf	132		
Normal Stress, psf	1300		
Maximum Shear Stress, psf	1756		
Shear Rate, in/min	0.004		

Sample Type:	tube
Estimated Specific Gravity:	2.70
Liquid Limit:	---
Plastic Limit:	---
Plasticity Index:	---
% Passing #200 sieve:	---
Soil Classification:	---
Group Symbol:	---



Notes: Moisture content obtained before shear from sample trimmings

Moisture Content determined by ASTM D 2216

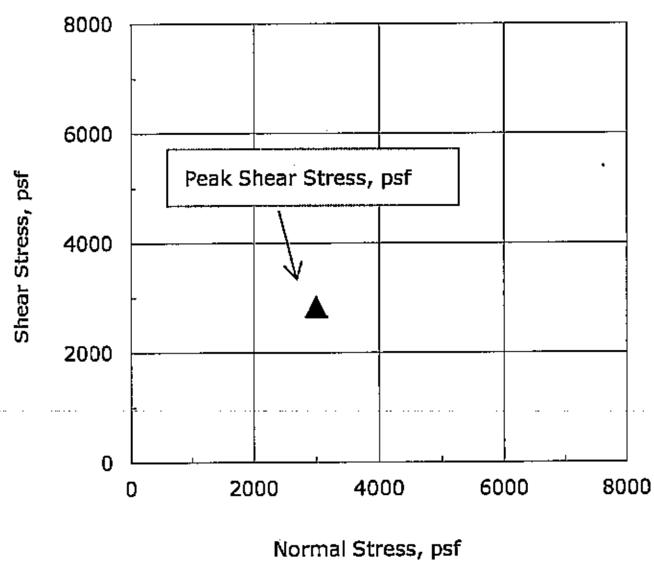
Values for cohesion and friction angle not presented because only one test point was requested. If zero cohesion is assumed, the approximate friction angle would be 53.5°.

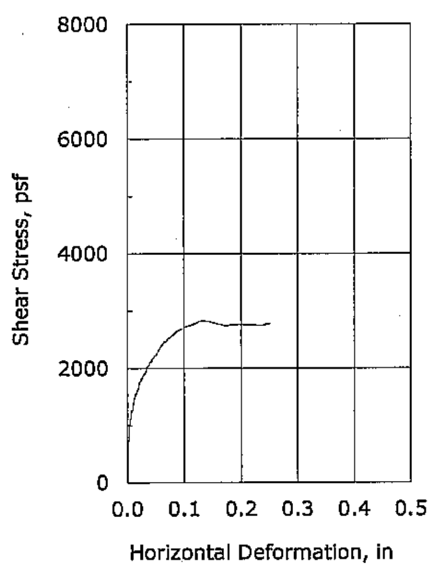
"---" indicates testing required to determine these values was not requested.

GeoTesting EXPRESS

Client:	Ecology & Environment, Inc.
Project Name:	10-08-0011
Project Location:	---
GTX #:	11124
Test Date:	9/14/2011
Tested By:	md
Checked By:	jdt
Boring ID:	SB-05
Sample ID:	---
Depth, ft:	25.5
Visual Description:	Moist, brown sand with gravel

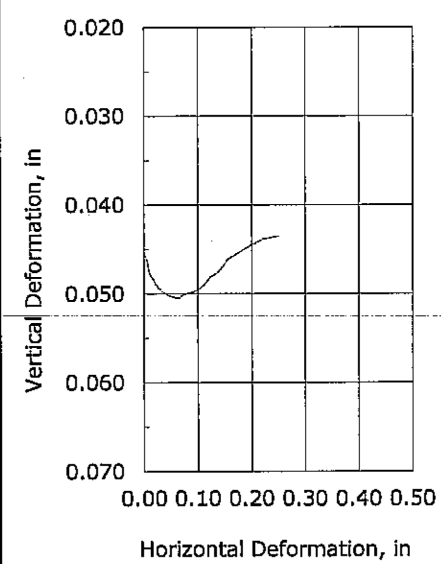
Direct Shear Test of Soils Under Consolidated Drained Conditions by ASTM D 3080-04





Test No.:	DS-8		
Initial Diameter, in	2.00		
Initial Height, in	1.00		
Initial Mass, grams	89.9		
Initial Dry Density, pcf	98.9		
Initial Moisture Content, %	10.2		
Initial Bulk Density, pcf	109		
Initial Degree of Saturation	40.2		
Initial Void Ratio	0.67		
Final Dry Density, pcf	103		
Final Moisture Content, %	22.6		
Final Bulk Density, pcf	127		
Normal Stress, psf	3000		
Maximum Shear Stress, psf	2833		
Shear Rate, in/min	0.004		

Sample Type:	tube
Estimated Specific Gravity:	2.65
Liquid Limit:	---
Plastic Limit:	---
Plasticity Index:	---
% Passing #200 sieve:	---
Soil Classification:	---
Group Symbol:	---



Notes: Moisture content obtained before shear from sample trimmings

Moisture Content determined by ASTM D 2216

Values for cohesion and friction angle not presented because only one test point was requested. If zero cohesion is assumed, the approximate friction angle would be 43.4°.

"---" indicates testing required to determine these values was not requested.

USEPA
DateShipped:
CarrierName:
AirbillNo:

CHAIN OF CUSTODY RECORD
Site #: 10GL
Contact Name: Tim Adair
Contact Phone: 503-248-5600

No: 10-081611-135111-0003
Cooler #:
Lab: GeoTesting Express
Lab Phone: 978-635-0424

Lab #	Sample #	Location	Analyses	Matrix	Collected	Numb Cont	Container	Preservative	MS/MSD
✓	SB01-20.5	SB01	Direct Shear	Soil	8/18/2011	1	sleeve		
✓	SB01-25	SB01	Grain Size	Soil	8/18/2011	1	bag		
✓	SB01-50 - 52	SB01	Grain Size	Soil	8/18/2011	1	bag		
✓	SB02-22	SB02	Grain Size	Soil	8/18/2011	1	bag		
✓	SB02-30.5	SB02	Direct Shear	Soil	8/18/2011	1	sleeve		
✓	SB02-55	SB02	Grain Size	Soil	8/18/2011	1	bag		
✓	SB03-20.5	SB03	Direct Shear	Soil	8/18/2011	1	sleeve		
✓	SB03-21	SB03	Direct Shear	Soil	8/18/201	1	sleeve		
✓	SB03-25	SB03	Grain Size	Soil	8/18/2011	1	bag		
✓	SB03-50	SB03	Grain Size	Soil	8/18/2011	1	bag		
✓	SB03-57.5	SB03	Direct Shear	Soil	8/18/2011	1	sleeve		
✓	SB04-10	SB04	Grain Size	Soil	8/18/2011	1	bag		
✓	SB04-10.5	SB04	Direct Shear	Soil	8/18/2011	1	sleeve		
✓	SB04-11	SB04	Direct Shear	Soil	8/18/2011	1	sleeve		
✓	SB05-20	SB05	Grain Size	Soil	8/18/2011	1	bag		
✓	SB05-25.5	SB05	Direct Shear	Soil	8/18/2011	1	sleeve		
✓	SB05-55	SB05	Grain Size	Soil	8/18/2011	1	bag		
✓	SB02-50.5	SB02	Direct Shear	Soil	8/18/2011	1	sleeve		

Special Instructions:

SAMPLES TRANSFERRED FROM
CHAIN OF CUSTODY #

Items/Reason	Relinquished by	Date	Received by	Date	Time	Items/Reason	Relinquished By	Date	Received by	Date	Time

GeoTesting EXPRESS

WARRANTY and LIABILITY

GeoTesting Express (GTX) warrants that all tests it performs are run in general accordance with the specified test procedures and accepted industry practice. GTX will correct or repeat any test that does not comply with this warranty. GTX has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

GTX may report engineering parameters that require us to interpret the test data. Such parameters are determined using accepted engineering procedures. However, GTX does not warrant that these parameters accurately reflect the true engineering properties of the *in situ* material. Responsibility for interpretation and use of the test data and these parameters for engineering and/or construction purposes rests solely with the user and not with GTX or any of its employees.

GTX's liability will be limited to correcting or repeating a test which fails our warranty. GTX's liability for damages to the Purchaser of testing services for any cause whatsoever shall be limited to the amount GTX received for the testing services. GTX will not be liable for any damages, or for any lost benefits or other consequential damages resulting from the use of these test results, even if GTX has been advised of the possibility of such damages. GTX will not be responsible for any liability of the Purchaser to any third party.

Commonly Used Symbols

A	pore pressure parameter for $\Delta\sigma_1 - \Delta\sigma_3$
B	pore pressure parameter for $\Delta\sigma_3$
CIU	isotropically consolidated undrained triaxial shear test
CR	compression ratio for one dimensional consolidation
C_c	coefficient of curvature, $(D_{30})^2 / (D_{10} \times D_{60})$
C_u	coefficient of uniformity, D_{60}/D_{10}
C_c	compression index for one dimensional consolidation
C_α	coefficient of secondary compression
c_v	coefficient of consolidation
c	cohesion intercept for total stresses
c'	cohesion intercept for effective stresses
D	diameter of specimen
D_{10}	diameter at which 10% of soil is finer
D_{15}	diameter at which 15% of soil is finer
D_{30}	diameter at which 30% of soil is finer
D_{50}	diameter at which 50% of soil is finer
D_{60}	diameter at which 60% of soil is finer
D_{85}	diameter at which 85% of soil is finer
d_{50}	displacement for 50% consolidation
d_{90}	displacement for 90% consolidation
d_{100}	displacement for 100% consolidation
E	Young's modulus
e	void ratio
e_c	void ratio after consolidation
e_o	initial void ratio
G	shear modulus
G_s	specific gravity of soil particles
H	height of specimen
PI	plasticity index
i	gradient
K_o	lateral stress ratio for one dimensional strain
k	permeability
LI	Liquidity Index
m_v	coefficient of volume change
n	porosity
PI	plasticity index
P_c	preconsolidation pressure
p	$(\sigma_1 + \sigma_3)/2$, $(\sigma_v + \sigma_h)/2$
p'	$(\sigma'_1 + \sigma'_3)/2$, $(\sigma'_v + \sigma'_h)/2$
p'_c	p' at consolidation
Q	quantity of flow
q	$(\sigma_1 - \sigma_3)/2$
q_f	q at failure
q_o, q_i	initial q
q_c	q at consolidation
S	degree of saturation
SL	shrinkage limit
s_u	undrained shear strength
T	time factor for consolidation
T	temperature
t	time
U, UC	unconfined compression test
UU, Q	unconsolidated undrained triaxial test
u_a	pore gas pressure
u_e	excess pore water pressure
u, u_w	pore water pressure
V	total volume
V_g	volume of gas
V_s	volume of solids
V_v	volume of voids
V_w	volume of water
V_o	initial volume
v	velocity
W	total weight
W_s	weight of solids
W_w	weight of water
w	water content
w_c	water content at consolidation
w_f	final water content
w_l	liquid limit
w_n	natural water content
w_p	plastic limit
w_s	shrinkage limit
w_o, w_i	initial water content
α	slope of q_f versus p_f
α'	slope of q_f versus p_f'
γ_t	total unit weight
γ_d	dry unit weight
γ_s	unit weight of solids
γ_w	unit weight of water
ε	strain
ε_{vol}	volume strain
ε_h, ε_v	horizontal strain, vertical strain
μ	Poisson's ratio, also viscosity
σ	normal stress
σ'	effective normal stress
σ_c, σ'_c	consolidation stress in isotropic stress system
σ_h, σ'_h	horizontal normal stress
σ_v, σ'_v	vertical normal stress
σ_1	major principal stress
σ_2	intermediate principal stress
σ_3	minor principal stress
τ	shear stress
φ	friction angle based on total stresses
φ'	friction angle based on effective stresses
φ'_r	residual friction angle
φ_{ult}	φ for ultimate strength

DRILLING LOG OF BORING NO. SB01

DATE DRILLED: 8/17/2011
LOGGED BY: Tim Adair
CHECKED BY: Tim Adair
DRILLING CONTRACTOR: Cascade Drilling
DRILLING METHOD: Hollow Stem Auger
COORDINATE REFERENCE SYSTEM: NAD 83

PROJECT NAME: Gorst Creek
PROJECT LOCATION: Kitsap County, Washington

EPA TASK MONITOR: Jeff Rodin
PROJECT #: 002233.0599
PROJ MGR: Jim Peterson

ELEVATION / DEPTH (feet)	USCS	GRAPHIC LOG	CONTACT DEPTH (feet)	SOIL DESCRIPTION	PHOTO IONIZATION DETECTOR READINGS (PPM)	FLAME IONIZATION DETECTOR READINGS (PPM)	COMMENTS
				Top of Ground Surface (GS) Elevation			This log is part of the report prepared for the named project and should be read together with that report for complete interpretation. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered.
5	SM		5	Silty Sand, fine to coarse sand with silt, trace fine to coarse gravel, trace cobbles, some metal, garbage fragments, plastic, etc., slightly moist			Using SPT and 140 lb slide auto-hammer for blow counts
10			10				
15			15				20/33/40 at 15'
20	SP		20	Silty Sand, fine to coarse sand, with fine to coarse, gravel, moist	40	25	Debris to ~18' BGS
25	SP-SM		25	Sand, fine to coarse sand, some silt, moist			
30			30				19/36/54 at 30'
35			35		5	6	
40			40	Sand, fine to coarse sand, trace silt, moist more coarse sand, increasing coarse sand and gravel	4	5	
45			45				27/37/41 at 45'
50			50		5	4	
55							
60			60				50 for 6" at 60'
65							
70							
75							
80							
85							
90	GP		90	Gravelly Sand, fine to coarse sand and fine to coarse gravel			Total Depth = 90', Boring backfilled with bentonite chips, hydrated and cement from 5' - 0' bgs.
95							
100							

ENE SOIL BORING GORST_CREEK_BORINGLOGS.GPJ E&E PORTLAND.GDT 1/18/12

ecology and environment, inc.
333 SW Fifth Avenue
Suite 608
Portland, OR 97204
Phone: 503-248-5600 Fax: 503-248-5577

DRILLING LOG OF BORING NO. SB02

DATE DRILLED: 8/17/2011
LOGGED BY: Tim Adair
CHECKED BY: Tim Adair
DRILLING CONTRACTOR: Cascade Drilling
DRILLING METHOD: Hollow Stem Auger
COORDINATE REFERENCE SYSTEM: NAD 83

PROJECT NAME: Gorst Creek
PROJECT LOCATION: Kitsap County, Washington

EPA TASK MONITOR: Jeff Rodin
PROJECT #: 002233.0599
PROJ MGR: Jim Peterson

ELEVATION	DEPTH (feet)	USCS	GRAPHIC LOG	CONTACT DEPTH (feet)	SOIL DESCRIPTION	PHOTO IONIZATION DETECTOR READINGS (PPM)	FLAME IONIZATION DETECTOR READINGS (PPM)	COMMENTS
					Top of Ground Surface (GS) Elevation			This log is part of the report prepared for the named project and should be read together with that report for complete interpretation. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered.
	5	SM			Landfill debris plus Silty Sand, fine to medium sand and fine to coarse gravel, moist, black 10YR2/1	3	2	Using SPT and 140 lb slide auto-hammer for low counts
	10					3	2	
	15	SP			Silty Sand, fine to coarse sand and fine to coarse gravel, some silt, moist, olive brown, 2.5Y4/4	1	1	20/37/46 at 15'
	20	SP-SM			Sand, fine to coarse coarse, moist, olive brown, 2.5Y4/3			
	25				Sand, fine to coarse coarse, moist, increasing coarseness, olive brown, 2.5Y4/3			
	30							50/50 for 6" at 30'
	35	GP			Sand, fine to coarse coarse, moist, olive brown, 2.5Y4/3, coarse gravel cobble in shoe			
	40				Gravelly Sand, fine to coarse sand and fine to coarse gravel			
	45				Gravelly Sand, fine to coarse sand and fine to coarse gravel, trace silt, moist, olive brown, 2.5Y4/4			50 for 5.5" at 45'
	50							
	55							
	60							Total Depth = 60', Boring backfilled with bentonite chips hydrated, and wet cement from 5' - 0' bgs.
	65							
	70							
	75							
	80							
	85							
	90							
	95							
	100							

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DRILLING LOG OF BORING NO. SB03

DATE DRILLED: 8/18/2011
LOGGED BY: Tim Adair
CHECKED BY: Tim Adair
DRILLING CONTRACTOR: Cascade Drilling
DRILLING METHOD: Hollow Stem Auger
COORDINATE REFERENCE SYSTEM: NAD 83

PROJECT NAME: Gorst Creek
PROJECT LOCATION: Kitsap County, Washington

EPA TASK MONITOR: Jeff Rodin
PROJECT #: 002233.0599
PROJ MGR: Jim Peterson

ELEVATION	DEPTH (feet)	USCS	GRAPHIC LOG	CONTACT DEPTH (feet)	SOIL DESCRIPTION	PHOTO IONIZATION DETECTOR READINGS (PPM)	FLAME IONIZATION DETECTOR READINGS (PPM)	COMMENTS
					Top of Ground Surface (GS) Elevation			This log is part of the report prepared for the named project and should be read together with that report for complete interpretation. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered.
	5	SM			Silty Sand, fine to coarse sand, trace fine to coarse gravel, debris, wood and landfill waste, moist, olive brown, 2.5Y4/4			Using SPT and 140 lb slide auto-hammer for blow counts, overburden contains landfill waste
	10					37	29	Still in waste black material (stained soil)
	15				Silty Sand, fine to coarse sand, trace fine to coarse gravel, debris, wood and landfill waste, moist, black, 10YR2/1	27	12	Waste to approximately 18' based on drilling conditions
	20	SP						
	25				Silty Sand, fine to coarse sand, moist, trace fine to coarse gravel	12	2	
	30	GP			Sand, fine to coarse sand, trace silt, moist, gray 2.5Y5/1, trace fine to coarse gravel, color change to dark yellowish brown 10YR4/6 at 22.5 ft			3/50 for 5" at 30'
	35							
	40							
	45				Sand, fine to coarse sand, trace silt, moist			50 for 4" at 45'
	50				Gravelly Sand, fine to coarse sand with fine to coarse gravel, trace silty, moist, dark yellowish brown 10YR3/6			
	55							50 for 3" at 55'
	60							
	65							
	70							
	75							
	80				Gravelly Sand, fine to coarse sand with fine to coarse gravel, trace silty, moist, dark yellowish brown 10YR3/6			Total Depth = 80', Boring backfilled with bentonite chips, hydrated, wet cement from 5' - 0' bgs.
	85							
	90							
	95							
	100							

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DRILLING LOG OF BORING NO. SB04

DATE DRILLED:	8/18/2011	PROJECT NAME:	Gorst Creek
LOGGED BY:	Tim Adair	PROJECT LOCATION:	Kitsap County, Washington
CHECKED BY:	Tim Adair	EPA TASK MONITOR:	Jeff Rodin
DRILLING CONTRACTOR:	Cascade Drilling	PROJECT #:	002233.0599
DRILLING METHOD:	Hollow Stem Auger	PROJ MGR:	Jim Peterson
COORDINATE REFERENCE SYSTEM:	NAD 83		

ELEVATION	DEPTH (feet)	USCS	GRAPHIC LOG	CONTACT DEPTH (feet)	SOIL DESCRIPTION	PHOTO IONIZATION DETECTOR READINGS (PPM)	FLAME IONIZATION DETECTOR READINGS (PPM)	COMMENTS
					Top of Ground Surface (GS) Elevation			This log is part of the report prepared for the named project and should be read together with that report for complete interpretation. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered.
	5	SP			Sand, fine to coarse grained some fine to coarse gravel, trace silt, wet, groundwater at 5'	0	0	Depth to water 5' 25/33/41 at 5' 18/30/39 at 10' Total Depth = 13', Boring backfilled with bentonite chips, hydrated, wet cement from 5' - 0' bgs.
	10							
	15							
	20							
	25							
	30							
	35							
	40							
	45							
	50							
	55							
	60							
	65							
	70							
	75							
	80							
	85							
	90							
	95							
	100							

ENE SOIL BORING GORST_CREEK_BORINGLOGS.GPJ E&E PORTLAND.GDT 1/18/12

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DRILLING LOG OF BORING NO. SB05

DATE DRILLED: 8/18/2011
LOGGED BY: Tim Adair
CHECKED BY: Tim Adair
DRILLING CONTRACTOR: Cascade Drilling
DRILLING METHOD: Hollow Stem Auger
COORDINATE REFERENCE SYSTEM: NAD 83

PROJECT NAME: Gorst Creek
PROJECT LOCATION: Kitsap County, Washington

EPA TASK MONITOR: Jeff Rodin
PROJECT #: 002233.0599
PROJ MGR: Jim Peterson

ELEVATION	DEPTH (feet)	USCS	GRAPHIC LOG	CONTACT DEPTH (feet)	SOIL DESCRIPTION	PHOTO IONIZATION DETECTOR READINGS (PPM)	FLAME IONIZATION DETECTOR READINGS (PPM)	COMMENTS
					Top of Ground Surface (GS) Elevation			This log is part of the report prepared for the named project and should be read together with that report for complete interpretation. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered.
	5	SM			Silty Sand, fine to coarse sand, some fine to coarse gravel some silt, cobbles, slightly moist, light yellowish brown, 10YR4/6			Using SPT and 140 lb slide auto-hammer for blow counts
	10	SP			Sand, fine to coarse trace silt, some fine to coarse gravel, slightly moist			Rounded gravel to 5' then more course sand
	15	SP-SM						26/26/50 for 6" at 15'
	20							
	25							40/50 for 6" at 25'
	30	GP			Gravelly Sand, fine to coarse trace silt, and fine to coarse gravel, slightly moist			
	35							31/50 for 6" at 35'
	40	SP			Gravelly Sand, fine to coarse sand and fine to coarse gravel, moist, light yellowish brown, 10YR4/6			40/5 for 6" at 40'
	45				Sand, fine to coarse, trace fine to coarse gravel, moist			50/50 for 2" at 45'
	50	SP-SM			Silty Sand, fine to coarse, trace fine to coarse gravel, moist			100 for 6" at 50'
	55							
	60							Total Depth = 61.5', Boring backfilled with bentonite chips, hydrated, wet cement from 5' - 0' bgs.
	65							
	70							
	75							
	80							
	85							
	90							
	95							
	100							

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C

STREAMLINED HUMAN HEALTH RISK EVALUATION

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Appendix C -- Gorst Creek Streamlined Human Health Risk Evaluation

C.1 Streamlined Human Health Evaluation

This section presents a streamlined human health risk evaluation (HHRE) for the Gorst Creek – Bremerton Auto Wrecking Landfill. The streamlined evaluation is intended to focus on the specific problem that the EE/CA for the site is addressing, which is to identify the scope of the removal action for the site. In a streamlined evaluation, the chemicals of potential concern (COPCs) for which actions may be taken are identified by defining potential exposure pathways and receptors, and comparing analyte concentrations to screening levels. Screening levels are conservative risk-based criteria consistent with the pathways and receptors identified. This evaluation was performed in accordance with federal guidance for assessing risks associated with non-time critical removal actions (USEPA 1993) and other applicable federal and state human health risk assessment guidance (USEPA 1989 and 2010a, Ecology 2007).

The HHRE is organized in the following sections:
Section C.1 describes site data that is included in the HHRE
Section C.2 presents the conceptual site model (CSM) for human health
Section C.3 describes the exposure pathways and receptors identified in the CSM
Section C.4 describes screening values used for the HHRE
Section C.5 compares site data with screening values and presents the results
Section C.7 discusses the uncertainties with the HHRE
Section C.8 presents a summary of the HHRE

C.2 Data Used for HHRE

Environmental media samples have been collected at the Gorst Creek Landfill site at different times beginning in 2000, then in 2003, and most recently in 2011. The quantitative portion of the HHRE is primarily based on the data collected during the July 2011 field investigation because these data represent current conditions. With one exception, historical data from the site hazard assessment (Hart Crowser 2000) and the integrated assessment (E & E 2004) were used primarily for field investigation planning purposes and to help develop the CSM described above. However, surface water samples were not collected during the 2011 field investigation due to the lack of water flow in Gorst Creek in the vicinity of the site. In this case, the historical surface water data were relied upon for the screening level comparison.

During the 2011 investigation, seven surface soil samples (LF01SS to LF07SS) were collected from the landfill surface (0 to 6 inches bgs), four sediment samples (GC01SD to GC04SD) were collected from Gorst Creek near the landfill, and one groundwater sample (SB04) was collected northwest of the landfill. Two of the sediment samples (GC01SD and GC02SD) were collected upstream from the landfill and two sediment samples (GC03SD and GC04SD) were collected downstream from the landfill. Samples collected during July 2011 were analyzed for metals, VOCs, SVOCs, PCBs, and pesticides. Sample location maps and additional information about sample collection and results are provided in Section 1.4.3.

For the HHRE, historical surface water data from November 2003 were used, including results from two samples collected from the site's probable points of entry (PPEs) and one background sample collected 0.3 mile upstream of the first PPE (E&E 2004). These surface water samples were analyzed for metals SVOCs, VOCs, and PCBs/pesticides (E&E 2004).

C.3 Human Health Conceptual Site Model

The human health CSM provides an overall picture of site conditions as they relate to the HHRE. The CSM is a tool used to identify the following:

- the primary source of contamination in the environment;
- how chemicals at the original point of release migrate through the environment;
- the types of human populations who might come into contact with contaminated media; and
- the potential exposure pathways that may occur for each population.

In risk assessment, exposure pathways are means by which chemicals move from the contaminated media to a point of contact by receptors. They describe the exposure medium (e.g., surface soil) and the exposure route (e.g., incidental ingestion). A complete exposure pathway must exist for exposure and subsequent risks to occur. If one or more of the aforementioned elements is missing, the exposure pathway is not considered complete and is not evaluated in the HHRE (USEPA 1989).

The CSM for the Gorst Creek Landfill site is provided in Figure 1-5. Based on local land use and zoning information, exposure scenarios evaluated in the HHRE include current and future residential, current and future worker, current and future trespasser, and current and future recreational. Human receptors at the Gorst Creek Landfill site could be exposed to chemicals through contact with surface soil, sediment, surface water, and groundwater. Potential routes of exposure include ingestion, dermal absorption, and inhalation. Descriptions of exposure pathways and receptors, including a summary of area land use and zoning, are provided in the following section.

C.4 Exposure Pathways and Receptors

Residential

A residential exposure scenario is included in the HHRE due to the proximity of current and potential future residential properties to the site. The population residing within a 1-mile radius of the site includes 1,027 people and within a 4-mile radius is 8,425 people (see Table C-1). Sunnyslope Elementary School is located within 1 mile of the site, and Pleasant Valley School is located within 3 miles of the site. No other schools or daycare facilities are located within 1 mile of the site (USGS 2011).

The landfill site and immediate properties to the northeast are zoned "business center" and are not occupied by residents. Adjoining land is zoned as incorporated city and rural residential (Kitsap County 2010a). The landfill site is bordered by an auto wrecking facility, a privately-owned Christmas tree plantation (Alpine Farms), McCormick Land Co., Washington State Department of Transportation property which contains a highway and easement corridors, and one private residential property. There are no other residential properties bordering the site. Kitsap County comprehensive land use planning indicates that the zoning will remain the same in the future for the site property and surrounding area (Kitsap County 2010b).

Two exposure pathways for residents were initially considered in the CSM: exposure to contaminants in groundwater and in onsite surface soil. Consumption of and dermal contact with groundwater as drinking water are considered potentially complete exposure pathways for residents because municipal and domestic wells are completed in aquifers in which site contaminants may have infiltrated. As discussed in Section 1.2.3, several aquifers are present in the region. While not all of the aquifers are used for drinking water purposes, all are available to be used as drinking water.

Table C-1 presents a tally of various drinking water wells located within a 4-mile radius of the Gorst Creek Landfill site. There are 587 domestic wells and 40 municipality wells serving a population of more than 8,400 people. The residential population relying on domestic wells is approximately 1,500 persons, which was determined by multiplying the number of domestic wells within 4 miles by the number of persons per Kitsap County household (USCB 2010 and 2011, WDOE 2011a).

Exposure to contaminants in onsite soil is not considered a complete pathway for residents. Access to the site is restricted to an easement through the adjacent Airport Auto Wrecking, Too facility. In addition, the future land use of the property is expected to remain industrial or commercial and therefore will not be occupied by residents. The site is not a desirable location for recreational purposes and residents are not expected to hike around the site. The majority of the site is covered with vegetation, limiting the potential for windblown soil and dust. While there may be small patches of exposed soil (i.e., with little or no vegetation), residential and school properties are located far enough from the site such that receptors would not likely have exposure to windblown soil and dust from the site.

Workers
A future worker scenario is evaluated in the HHRE because future land use plans at the site indicate that zoning will remain industrial and commercial. Therefore, if no cleanup action is taken at the site, workers onsite in the future may have contact with COPCs in soil via incidental ingestion, dermal contact, and particulate inhalation. A current worker scenario was also evaluated for workers on adjacent properties (i.e., Airport Auto Wrecking, Too facility) because workers may have limited exposure potential via windblown soil and dust from the site. Data for soil samples collected up to 0 to 6 inches bgs were included in the screening analysis due to potential erosion of surficial soil over time. VOCs were not detected during air monitoring; therefore, inhalation of volatiles was not evaluated as an exposure route.

Trespassers
A current trespasser scenario is evaluated in the HHRE because there are reported cases of individuals trespassing on the site for scrap metal. Although vehicular access to the site is restricted to an easement through the auto wrecking facility, the site is not fenced and access to pedestrians is not restricted. It is assumed that the site will be eventually developed in the future for industrial or commercial purposes (Kitsap County 2010b). Trespassers could have direct contact with contaminants in surface soil via incidental ingestion, dermal contact, and particulate inhalation. Data for soil samples collected 0 to 6 inches bgs were evaluated to account for contact with surface soil currently exposed as well as with soil that may be exposed over time due to natural erosion. VOCs were not detected during air monitoring; therefore, inhalation of volatiles was not evaluated as an exposure route.

Recreational Users
Current and future recreational scenarios are evaluated in the HHRE. As discussed in Section 1.3, contaminants from the landfill may be seeping into Gorst Creek. In addition, soil from the landfill may erode directly into the creek. Visitors to the area and residents have the potential for exposure via direct contact with surface water and sediment while wading in Gorst Creek. There is generally unrestricted access at various points along the creek, as well as a recreational park (Otto Jarstad Park) located within 4 miles downstream of the site. A tribal fishery is also located near the mouth of Gorst Creek, on Sinclair Inlet, approximately 3.7 miles downstream of the site. The fishery is supported by a tribal Chinook salmon fish-rearing facility, located on Gorst Creek approximately 2.7 miles downstream of the site and 1 mile upstream of the confluence with Sinclair Inlet (Zischke 2003). Fishing reportedly does not occur on Gorst Creek downstream of the site; rather, fish are harvested from Sinclair Inlet (Huff 2003). In addition, a golf course is located near the landfill site and Gorst Creek; however, it relies on City of Bremerton municipal water for irrigation and drinking water (Folk 2011).

C.5 Screening Values for the HHRE
The USEPA (1989) suggests that, at sites where a large number of chemicals are present, it can be useful to eliminate from further consideration those chemicals that represent a small contribution to risk. To accomplish this, site concentrations of chemicals are compared to numerical screening values. If the

maximum concentration of a chemical is above a screening value, the chemical is considered a COPC for the site. Generally, at sites where contaminant concentrations fall below screening levels, no further action or study is warranted for that COPC to ensure the protection of human health.

Several metrics are used for screening and selecting COPCs, including:

- Health-based screening values based on toxicological characteristics of each chemical;
- Comparison to background concentrations; and
- Evaluation of essential nutrients.

The sources of the screening levels selected for the HHRE are described below for each of the media of concern. The values for the screening levels are presented in Tables C-2 to C-5. Background concentration data were available for surface water and sediment samples, as described in the previous section, and are included in Tables C-2 to C-5 for comparison to detected concentrations.

The USEPA (1989) recommends removing chemicals from further consideration if they are considered "essential nutrients"; that is, naturally occurring chemicals essential to human life that are toxic only at very high doses. Essential nutrients are noted in Tables C-2 to C-5 and were eliminated from further consideration.

Soil
As shown in Table C-2, two primary sources of health-based screening levels are used for screening analyte concentrations reported for onsite soil. These sources include USEPA's Regional Screening Levels for Chemical Contaminants at Superfund Sites (RSLs) (USEPA 2011a) and Washington State Model Toxics Control Act (MTCA) Method A and Method C cleanup levels generated using the online Cleanup Levels and Risk Calculations (CLARC) database (Ecology 2011b). The USEPA RSLs are risk-based concentrations derived from standard risk equations that combine default reasonable maximum exposure (RME) assumptions with USEPA toxicity data. Exposure assumptions are for a full-time (8 hours per day) worker who may work both indoors and outdoors (i.e., composite worker) and may contact chemicals in soil via incidental ingestion, dermal absorption, or particulate inhalation (USEPA 2011b). Target risk levels in the equations are set to $1x10^{-6}$ (or one in one million) for carcinogenic chemicals and a hazard index of 1 for noncarcinogens. The screening levels are considered by the USEPA to be protective for humans (including sensitive groups) over a lifetime.

With the exception of arsenic, the MTCA cleanup levels are risk-based concentrations using the equations and default parameter values set forth in the MTCA Cleanup Regulation, Chapter 173-340 WAC. The lower of the Method A and Method C values was used for the screening. Exposure assumptions for both Method A and Method C cleanup levels are for a full-time (10 hours per day) adult worker who may contact chemicals in soil via incidental ingestion (Ecology 2005) under RME conditions. Method A has an additional component in which the cleanup levels are based on concentrations that are protective of soil leaching into groundwater. MTCA cleanup levels are set to a target risk level of $1x10^{-5}$ (or one in one hundred thousand) for carcinogens and a hazard index of 1 for noncarcinogens (Ecology 2005). For arsenic in soil, the MTCA cleanup level was calculated assuming direct contact and protection of groundwater for drinking water use, then adjusted to account for natural background levels determined for Washington State (Ecology 2007).

The industrial screening levels for workers are assumed to be sufficiently conservative to be adequately protective for the shorter exposure duration and frequency of a trespasser going onsite. Therefore, scenario-specific screening levels were not calculated for the trespasser scenario; rather, the worker exposure scenario values were used.

Groundwater

The health-based screening levels used for comparing groundwater concentrations are based on residential consumption of tap water because, as described in Section C.2, groundwater in the vicinity of the site is used for drinking water purposes. Three primary sources of screening levels are used in this evaluation. These sources include USEPA's RSLs for residential tap water (USEPA 2011a), USEPA Maximum Contaminant Levels (MCLs) (USEPA 2011c), and MTCA Method B cleanup levels calculated using the online CLARC database (Ecology 2011b). The USEPA RSLs are risk-based concentrations derived from standard risk equations that combine default RME assumptions with USEPA toxicity data. RSLs for tap water are based on exposure assumptions for a resident who consumes 2 liters of water per day and showers once per day. During a shower a resident may contact chemicals in the water via incidental ingestion, dermal contact, and volatile inhalation (USEPA 2011b). However, it should be noted that while the USEPA screening levels incorporate inhalation exposure in the equations, no volatiles have been detected in monitoring wells in the vicinity of the site. Target risk levels in the equations are set to 1×10^{-6} (or one in one million) for carcinogenic chemicals and a hazard index of 1 for noncarcinogens. The screening levels are considered by the USEPA to be protective for humans (including sensitive groups) over a lifetime.

MCLs are USEPA standards for public water systems and are developed under the National Primary Drinking Water Regulations per the Safe Drinking Water Act (SDWA). Under the SDWA, EPA sets legal limits on the levels of certain contaminants in the drinking water. The limits reflect both the level that protects human health and the level that water systems can achieve using the best available technology (USEPA 2011c).

The MTCA cleanup levels are risk-based concentrations using the equations and default parameter values set forth in the MTCA Cleanup Regulation, Chapter 173-340 WAC. Exposure assumptions are for a RME resident who may contact chemicals in groundwater via ingestion and dermal absorption (Ecology 2005). Under MTCA Method B, cleanup levels are set to a target risk level of 1E-05 for carcinogens and a hazard index of 1 for noncarcinogens (Ecology 2005).

Screening levels for groundwater are presented in Table C-3.

Sediment

Sources for sediment screening levels based on a recreational scenario are limited to the USEPA recreational RSLs, which account for either soil or sediment contact (USEPA 2011a). While the recreational RSLs are not available in USEPA generic tables as the residential and industrial RSLs are, they can be generated using the online RSL calculator. This calculator allows input of either default or site-specific exposure assumptions for incidental ingestion and dermal contact. To be efficient, the site analyte concentrations in sediment were initially compared to the soil RSLs for residential exposure (USEPA 2011a). Relying on these levels for sediment is a highly conservative approach because several exposure factors are significantly lower under the recreational scenario than they are for residential exposure. These parameters include, but are not limited to, the incidental ingestion rate, dermal contact time, and exposure frequency. If analyte concentrations exceeded the residential soil RSLs, then screening levels for recreational exposure were generated using the USEPA online RSL calculator.

Sediment concentrations were also compared to the maximum background level reported for two background samples collected upstream of the landfill. All screening values for sediment are presented in Table C-4.

Surface Water

As shown in Table C-5, sources for surface water screening levels based on a recreational scenario include the USEPA RSLs and the Ambient Water Quality Criteria (AWQC) for human health. Similar to the USEPA sediment RSLs, surface water RSLs must be generated using the online calculator and default or site-specific exposure assumptions. Exposure routes include incidental ingestion and dermal contact (USEPA 2011b). Human health AWQC are numeric values limiting the amount of chemicals present in surface water bodies and are published pursuant to the Clean Water Act (CWA). The criteria are designed to protect humans from recreational or subsistence exposure to chemicals in water and aquatic biota (e.g., fish). The values are based on the risk assessment of incidental water ingestion and consumption of aquatic organisms by individuals using a surface water body. Exposure parameters incorporated into the AWQC calculations include a water ingestion rate of 2 liters per day (L/day), a fish ingestion rate of 17.5 grams per day (g/day), a chemical-specific bioconcentration factor, and fraction of fish intake from contaminant source (USEPA 2002).

The surface water analyte concentrations were initially compared to the USEPA residential tapwater RSLs and AWQCs. If exceedances occurred, site-specific recreation surface water RSLs were calculated for the comparison. Given that fishing on Gorst Creek near the landfill site reportedly does not occur and a consumption water rate of 2 L/day for individuals recreating in the creek is highly unlikely, the screening values assumed for the surface water comparison are considered very conservative.

C.6 Screening Evaluation Results

This section presents the human health screening assessment of chemical concentrations in soil, groundwater, sediment, and surface water samples using the screening levels described above and maximum detected concentrations. If the maximum concentration of a chemical is above a screening value, the chemical is considered a COPC for the site. Generally, at sites where contaminant concentrations fall below screening and/or natural background levels, no further action or study is warranted to ensure the protection of human health.

The screening evaluations for soil, groundwater, sediment, and surface water are shown in Tables C-2 to C-5, respectively. Table C-6 provides a summary of all screening level exceedances and COPCs. The results for each medium are discussed below.

Soil

Of the chemicals detected in surface soil, only chromium had concentrations exceeding screening levels (Table C-2). Chromium was detected in all seven surface soil samples collected at total concentrations ranging from 19.6 to 47.8 mg/kg, with an average of 29.6 mg/kg. All samples exceeded the USEPA RSL and MTCA CUL for hexavalent chromium assuming an industrial/worker scenario (5.6 mg/kg and 19 mg/kg, respectively) but not for trivalent chromium (1.5E+06 mg/kg and 2,000 mg/kg, respectively). Magnitude of screening level exceedances ranged from 4 to 9 times the hexavalent chromium RSL and slight to 3 times the MTCA Method A CUL (Table C-6). Current site-specific background data are not available for comparison to site concentrations.

Site-specific speciation data for chromium are not available to determine the proportions of the various forms of chromium in site soil. Therefore, the screening level comparison in this HHRE does not provide a definitive picture of the COPC status of this metal at the site. While the total chromium concentrations found at the site are comparable to typical background levels (42 mg/kg state-wide, 48 mg/kg in the Puget Sound area) and trivalent chromium is the form predominantly found in natural background soils, chromium cannot be completely ruled out as a COPC given the previous use of and disposal of chromium-related products at the landfill. Hexavalent and trivalent chromium data would be needed to resolve the uncertainty. It should be noted that, as discussed in Section C.5, the USEPA RSLs are based on a target cancer risk level of $1x10^{-6}$ (USEPA 2011b). Increasing the target risk level to $1x10^{-5}$ increases the hexavalent chromium RSL ten-fold to 56 mg/kg. The maximum detected chromium concentration is lower than this level and would not be considered a COPC when assuming this higher target risk level. The MTCA Method A CUL is already based on this higher target risk level.

The essential nutrients that were eliminated from the list of soil COPCs include magnesium, calcium, potassium, and sodium. The concentrations of these minerals in site soil samples are well below levels associated with toxicity.

Groundwater

Three metals (arsenic, chromium, and cobalt) and two volatile organic compounds (chloroform and methyl tert-butyl ether [MTBE]) were identified as human health COPCs in groundwater (Table C-3). The concentrations for all five chemicals exceeded respective USEPA RSLs for residential tap water (As 0.045 ug/L, Cr 0.043 ug/L, Co 4.7 ug/L, chloroform 0.19 ug/L, and MTBE 12 ug/L) in the one sample collected in 2011 (Table C-3). The arsenic concentration was 44 times its RSL, chromium was over 300 times its RSL, and MTBE was 5 times its RSL (Table C-6). The concentrations for these three chemicals were 2 ug/L, 14.5 ug/L, and 55 ug/L, respectively. For chloroform (0.43 ug/L), the exceedance was slightly greater than two times and for cobalt only slightly higher (site concentration of 5.1 ug/L). In addition, the arsenic concentration (2 ug/L) was nearly two times the MTCA Method B cleanup level for a residential scenario. However, with the exception of colbalt and MTBE, which have no promulgated national standards, all chemical concentrations were well below the respective USEPA MCLs (Table C-3).

For MTBE, USEPA provides a drinking water health advisory range of 20 to 40 ug/L to prevent adverse taste and odor in the water (USEPA 1997). Studies have shown that concentrations in this range are several orders of magnitude lower than the range of exposure levels in which adverse health effects were observed in rodents (USEPA 1997). Advisories are for communities concerned with potential risk from exposure to chemicals for which no national regulations currently exist. Advisories are used only for guidance and are not mandatory standards for action. The MTBE concentration in groundwater (55 ug/L) was slightly above the upper end of the advisory range. Cobalt has no such advisory published.

Current background data for groundwater were not available for comparison. The essential nutrients that were eliminated from the list of groundwater COPCs include calcium, magnesium, potassium, and sodium. The concentrations of these minerals in site groundwater samples are well below levels associated with toxicity.

Sediment

Metals, PCBs, and VOCs were detected in the two sediment samples collected downstream of the site. With the exception of arsenic and the PCBs (Aroclor 1248, Aroclor 1254, and Aroclor 1260), concentrations of all detected analytes were below the USEPA RSLs for a residential scenario (Table C-4). The arsenic concentrations of 1.11 mg/kg and 1.73 mg/kg in the sediment samples exceeded the residential RSL by 3 to 4 times (0.39 mg/kg). However, these concentrations were below the site-specific background concentration of 2.42 mg/kg). The maximum Aroclor concentrations, ranging from 516 to 908 ug/kg, exceeded the Aroclor residential RSL by 2 to 4 times, as well as the site-specific background concentrations (Table C-6). However, USEPA's online RSL calculator generated recreational screening levels 10 times greater than those for the residential scenario by assuming a reduced exposure frequency of 35 days/year rather than 365 days/year (Table C-4). The lower value represents a RME number of days an individual might recreate in Gorst Creek given the maritime climate typical of Kitsap County (i.e., 7 days per month for 5 months). The arsenic sediment concentrations are 2 to 3 times lower than the recreational RSL. Similarly, the Aroclor sediment concentrations are 2 to 4 times lower than respective recreational RSLs. Therefore, arsenic and the Aroclors are not considered human health COPCs in sediment.

While several other chemicals in the downstream samples were detected above background levels, the concentrations of these chemicals were all well below screening levels (see Table C-4). No human health COPCs were identified for sediment.

Surface Water
Three metals (iron, manganese, and zinc) and one essential nutrient (calcium) were detected in the two surface water samples collected downstream of the site in 2003 (Table C-5). Concentrations of these metals were well below the respective USEPA residential tapwater RSLs and AWQC. Zinc was only slightly above the background level, and both iron and manganese were below background levels. Therefore, no COPCs in surface water for human health concerns were identified.

C.7 Uncertainties
Uncertainty is inherent in every step of the risk evaluation process. Significant sources of uncertainty in the HHRE include the following:

- The standard methodology for risk assessment relies on fixed input parameters in the equations used to calculate risk estimates, cleanup levels, or screening levels. These parameters are based on a considerable number of assumptions and do not characterize the variability inherent in a population or in environmental media concentrations.

- Screening criteria are based on published screening levels or standards, both of which tend to rely on conservative default assumptions. These assumptions are selected to represent a high-end estimate of exposure for an individual (i.e., RME) that is a conservative, or protective, estimate of actual exposures. Potential exposures may be less than estimated.

- The HHRE relied on maximum concentrations for comparison to screening levels due to the streamlined nature of the evaluation and the limited number of available data points. In the case of groundwater, the results for only one recent sample were available for screening. Not knowing the variability and distribution of concentrations within different areas of the groundwater introduces significant uncertainty in the screening results. Similarly, the sediment data set was limited to two samples and, while there were no exceedances, the small sample size introduces uncertainty into these results.

- For the HHRE, a conservative assumption was made that all of the chromium detected in surface soil samples was in the hexavalent form, which is considered carcinogenic. However, most of the chromium is likely to be in the trivalent form which is not carcinogenic and has a higher RSL. Speciation data to determine amounts of each form were not available.

- Surface water was not sampled in 2011 due to low water levels in the vicinity of the site. Therefore, the screening evaluation relied upon historical data which may not accurately reflect current conditions in Gorst Creek.

- The lack of background data for comparing to groundwater concentrations could lead to an assumption that screening level exceedances are due entirely to the landfill site. Given that the site is located in an industrial and commercial area, sources other than the landfill site are likely to be present.

C.8 HHRE Summary

The HHRE is a streamlined evaluation in which COPCs for the landfill site were identified by comparing site concentrations to screening levels. Screening levels included USEPA published and calculated risk-based concentrations, Washington State cleanup levels, and applicable standards.

Exposure scenarios evaluated in the HHRE include current and future residential, current and future worker, current and future trespasser, and current and future recreational. Human receptors at the Gorst Creek Landfill site could be exposed to chemicals through contact with surface soil, groundwater, sediment, and surface water. Routes of exposure include ingestion, dermal absorption, and inhalation. Screening levels were selected to be consistent with these exposure scenarios.

Screening levels were compared to maximum detected concentrations reported for surface soil, groundwater, and sediment samples collected in July and August 2011. Surface water samples were not collected at this time due to lack of water flow; therefore, historical data from 2003 were used in the HHRE. If the maximum concentration of a chemical was above a screening value, the chemical was considered a COPC for the site. Generally, at sites where contaminant concentrations fall below screening and/or natural background levels, no further action or study is warranted to ensure the protection of human health for that compound. Results of the screening level comparison are summarized in Table C-6 and are described as follows:

- The total chromium concentrations in all seven surface soil samples exceeded the USEPA industrial worker RSL for hexavalent chromium based on a cancer target risk level of $1x10^{-6}$; however, none of the total chromium concentrations exceeded the RSL for trivalent chromium. Trivalent chromium is the predominant form of chromium typically found in soil and the total chromium concentrations found are comparable to typical background levels. Modifying the target risk level to $1x10^{-5}$ in the RSL calculation results in no chromium exceedances of the hexavalent chromium RSL. It should be noted that Washington state MTCA cleanup levels assume a $1x10^{-5}$ target risk level in the calculations. Chromium is nominally a COPC for soil because no chromium speciation data is available and the total chromium concentrations exceed the RSL for hexavalent chromium. However, for the reasons stated, it is unlikely that chromium is actually a site-related COPC. No other chemicals in soil exceeded screening levels.

- Arsenic, chromium, cobalt, chloroform, and MTBE concentrations exceeded respective USEPA RSLs for residential tap water in the one sample collected in 2011. Arsenic also exceeded the MTCA Method B drinking water cleanup level. However, with the exception of cobalt and MTBE, which have no promulgated national standards, the other chemicals had concentrations that were well below the respective MCLs. The MTBE concentration is only slightly above USEPA's drinking water advisory concentration range. This range is only for guidance and not mandatory regulation. Cobalt has no such advisory.

- All chemicals detected in sediment and historical surface water samples had site concentrations below applicable screening levels.

C.9 References

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Table C-1. Number of Drinking Water Wells and Population Within a 4-Mile Radius of Gorst Creek Landfill Site

Distance Ring From Site	Household Population	Number of Domestic Wells	Domestic Well Population[a]	Number of Municipality Wells	Number of Other Wells[b]
0-0.25	9	0	0	1	0
0.25-0.5	184	1	3	0	2
0.5-1	834	30	77	10	0
1-2	1,006	109	279	14	3
2-3	2,994	116	297	9	3
3-4	3,398	331	847	6	1
Totals	8,425	587	1,503	40	9

[a]Well population = number wells in distance ring X 2.56 persons per Kitsap County household

[b]Other wells include Sunnyslope Water District, Sunnyslope Water Development, WSDOT, McCormick Woods Water Co., and Veterans Administration

Sources: USCB 2010 and 2011; WDOE 2011a

Table C-2. Surface Soil Human Health Screening Results for Samples Collected in July 2011, Gorst Creek - Bremerton Auto Wrecking Landfill.

Analyte[a]	Minimum Detect	Maximum Detect	FoD	Health-Based Screening Level Comparison				COPC?	Rationale
				USEPA RSL Industrial		MTCA CUL Industrial			
				Value	FoE	Value	FoE		
Metals (mg/kg)									
Aluminum	9160	19300	7/7	9.9E+05	0/7	3.5E+09	0/7	N	< SLs
Arsenic	1.25	10.1	7/7	1.6	0/7	20	0/7	N	< SLs
Barium	47.4	194	7/7	1.9E+05	0/7	7.0E+05	0/7	N	< SLs
Beryllium	0.132	0.269	7/7	2000	0/7	7000	0/7	N	< SLs
Cadmium	0.0942	3.24	7/7	800	0/7	NA	--	N	< SLs
Calcium	3150	14100	7/7	NA	--	NA	--	N	NUT
Chromium[b]	**19.6**	**47.8**	**7/7**	**5.6**	**7/7**	**19**	**7/7**	**Y**	**> SLs**
Cobalt	5.08	9.93	7/7	300	0/7	NA	--	N	< SLs
Copper	10.7	83.1	7/7	4.1E+04	0/7	1.4E+05	0/7	N	< SLs
Iron	9940	23500	7/7	7.2E+04	0/7	2.5E+06	0/7	N	< SLs
Lead	3.21	691	7/7	800	0/7	1000	0/7	N	< SLs
Mercury	0.00943	1.28	7/7	310	0/7	1100	0/7	N	< SLs
Magnesium	3170	5520	7/7	NA	--	NA	--	N	NUT
Manganese	168	654	7/7	2.3E+04	0/7	4.9E+05	0/7	N	< SLs
Nickel	21.8	44.8	7/7	2.0E+04	0/7	7.0E+04	0/7	N	< SLs
Potassium	382	868	7/7	NA	--	NA	--	N	NUT
Selenium	0.405	0.405	1/7	5100	0/7	1.8E+04	0/7	N	< SLs
Sodium	74.2	358	7/7	NA	--	NA	--	N	NUT
Zinc	31.1	836	7/7	3.1E+05	0/7	1.1E+06	0/7	N	< SLs
Volatile Organic Compounds (µg/kg)									
Acetone	5.12	30.3	3/7	6.3E+08	0/7	3.2E+09	0/7	N	< SLs
2-Butanone (MEK)	2.13	2.13	1/7	2.0E+08	0/7	2.1E+09	0/7	N	< SLs
Ethylbenzene	0.51	0.51	1/7	2.7E+04	0/7	6000	0/7	N	< SLs
4-Isopropyltoluene[c]	0.315	0.956	2/7	4.5E+07	0/7	7000	0/7	N	< SLs
m,p-Xylene	0.416	0.5	2/7	2.6E+06	0/7	7.0E+08	0/7	N	< SLs
Methylene chloride	4.18	4.18	1/7	5.3E+04	0/7	20	0/7	N	< SLs
Styrene	0.305	1.3	7/7	3.6E+07	0/7	7.0E+08	0/7	N	< SLs
Toluene	0.429	1.12	3/7	4.5E+07	0/7	7000	0/7	N	< SLs
Xylenes (total)	0.416	0.5	2/7	2.7E+06	0/7	9000	0/7	N	< SLs
Polychlorinated Biphenyls (PCBs) (µg/kg)									
Aroclor-1248	243	243	1/7	740	0/7	NA	--	N	Similar PCB <SL
Aroclor-1254	345	345	1/7	740	0/7	6.6E+04	0/7	N	< SLs
Aroclor-1260	136	171	1/7	740	0/7	6.6E+04	0/7	N	< SLs
Pesticides (µg/kg)									
alpha-BHC	25.2	25.2	1/7	2.7E+05	0/7	2.1E+04	0/7	N	< SLs
4,4'-DDD	6.37	6.37	1/7	7200	0/7	5.5E+05	0/7	N	< SLs
4,4'-DDT	9.1	89.9	3/7	700	0/7	4000	0/7	N	< SLs
endosulfan sulfate	42.1	42.1	1/7	3.7E+06	0/7	2.1E+07	0/7	N	< SLs
Polycyclic Aromatic Hydrocarbons (PAHs) (µg/kg)									
Anthracene	56.7	56.7	1/7	1.7E+08	0/7	1.1E+09	0/7	N	< SLs
Benzo(a)anthracene	151	164	2/7	2100	0/7	1.8E+05	0/7	N	< SLs
Benzo(a)pyrene	145	155	2/7	210	0/7	2000	0/7	N	< SLs
Benzo(b)fluoranthene	291	291	1/7	2100	0/7	1.8E+05	0/7	N	< SLs
Benzo(ghi)perylene	89.5	117	2/7	NA	0/7	NA	--	N	Similar PAH <SL
Chrysene	204	210	2/7	2.1E+05	0/7	1.8E+07	0/7	N	< SLs
Fluoranthene	250	254	2/7	2.2E+07	0/7	1.4E+08	0/7	N	< SLs
Fluorene	42.7	42.7	1/7	2.2E+07	0/7	1.4E+08	0/7	N	< SLs
Indeno(1,2,3-cd)pyrene	78.8	117	2/7	2.1E+06	0/7	1.8E+05	0/7	N	< SLs
Phenanthrene	91.1	409	2/7	NA	0/7	NA	--	N	Similar PAH <SL
Pyrene	351	425	2/7	1.7E+07	0/7	1.1E+08	0/7	N	< SLs
HPAH sum	218.15	1723.6	3/7	NA	0/7	NA	--	N	PAHs < SL
LPAH sum	326.9	672.6	2/7	NA	0/7	NA	--	N	PAHs < SL
Other Semivolatile Organic Compounds (µg/kg)									
bis(2-Ethylhexyl)phthalate	335	568	2/7	1.2E+05	0/7	9.4E+06	0/7	N	< SLs
Butylbenzylphthalate	1230	1230	1/7	9.1E+05	0/7	6.9E+07	0/7	N	< SLs

[a]Includes only analytes detected at least once in soil samples; bold type indicates chemical is a COPC

[b]In the absence of speciated site data for chromium, RSL and MTCA CUL are for hexavalent chromium (Cr VI) (see text). The RSL and MTCA CUL for trivalent chromium (Cr III) are 1.5E+06 mg/kg and 2,000 mg/kg, respectively.

[c]No specific screening levels are available for this chemical; therefore, the screening level for toluene was used as a substitute.

Key:
NA = not available
COPC = chemical of potential concern
CUL = cleanup level
FoD = frequency of detection (number of detects over total number of samples)
FoE = frequency of exceedence (number of samples that exceed screening level over total number of samples)
HPAH = high molecular weight PAH
LPAH = low molecular weight PAH
mg/kg = milligrams per kilogram
MTCA = Model Toxics Control Act (value is the lowest of Methods A and C)
NUT = considered essential nutrient for humans
PAH = polycyclic aromatic hydrocarbon
RSL = regional screening level
µg/kg = micrograms per kilogram
USEPA = United States Environmental Protection Agency
? = status as COPC uncertain
-- = not applicable

Table C-3. Groundwater Human Health Screening Results for Samples Collected in August 2011, Gorst Creek - Bremerton Auto Wrecking Landfill.

Analyte[a]	USEPA RSL Resident Tap	Res RSL FoE	USEPA MCL	MCL FoE	MTCA Method B CUL	MTCA FoE	Sample Results SB04 11080101 Northwest of Landfill Site	COPC?	Rationale
	Health-Based Screening Level Comparison								
Metals (µg/L)									
Aluminum	37000	0/1	NA	--	16000	0/1	8170	N	< SLs
Arsenic	**0.045**	**1/1**	10	0/1	**0.058**	**1/1**	**2**	**Y**	**>RSL & MTCA**
Barium	7300	0/1	2000	0/1	3200	0/1	112	N	< SLs
Beryllium	73	0/1	4	0/1	32	0/1	0.21	N	< SLs
Calcium	NA	--	NA	--	NA	--	4930	N	NUT
Chromium[b]	**0.031**	**1/1**	100	0/1	48	0/1	**14.5**	**Y**	**>RSL**
Cobalt	**4.7**	**1/1**	NA	--	NA	--	**5.1**	**Y**	**>RSL**
Copper	1500	0/1	1300	0/1	640	0/1	10	N	< SLs
Iron	26000	0/1	NA	--	11000	0/1	6850	N	< SLs
Lead	NA	--	15	0/1	NA	--	3.6	N	< SLs
Magnesium	NA	--	NA	--	NA	--	2590	N	NUT
Manganese	880	0/1	NA	--	2200	0/1	275	N	< SLs
Nickel	730	0/1	NA	--	320	0/1	16.4	N	< SLs
Potassium	NA	--	NA	--	NA	--	907	N	NUT
Sodium	NA	--	NA	--	NA	--	3590	N	NUT
Zinc	11000	0/1	NA	--	4800	0/1	14.9	N	< SLs
Semivolatile Organic Compounds (µg/L)									
bis(2-Ethylhexyl)phthalate	4.8	0/1	6	1/1	6.3	1/1	4.6	N	< SLs
Volatile Organic Compounds (µg/L)									
1,3,5-Trimethylbenzene	370	0/1	NA	--	80	0/1	2.9	N	< SLs
2-Butanone (MEK)	7100	0/1	NA	--	4800	0/1	12.1	N	< SLs
4-Methyl-2-pentanone (MIBK)	2000	0/1	NA	--	640	0/1	7.8	N	< SLs
Acetone	22000	0/1	NA	--	7200	0/1	959	N	< SLs
Chloroform	**0.19**	**1/1**	80	0/1	80	0/1	**0.43**	Y	**>RSL**
Methyl tert-butyl Ether (MTBE)	**12**	**1/1**	NA	--	NA	--	**55**	Y	**>RSL**

[a]Includes only analytes detected at least once in groundwater sample

[b]In the absence of speciated chromium data, RSL and MTCA CUL are for hexavalent chromium (Cr VI) (see text); MCL is for total chromium. Chromium III screening levels are 55,000 ug/L (RSL resident tap) and 24,000 ug/L (MTCA Method B).

-- = Not applicable
COPC = chemical of potential concern
CUL = cleanup level
FoE = frequency of exceedence (number of samples that exceed screening level over total number of samples)
MCL = maximum contaminant level
MTCA = Model Toxics Control Act
NA = Not available
NUT = essential nutrient for humans
µg/L = micrograms per liter
RSL = Regional Screening Level
USEPA = United States Environmental Protection Agency

Table C-4. Sediment Human Health Screening Results for Samples Collected in July 2011, Gorst Creek - Bremerton Auto Wrecking Landfill.

Analyte[a]	Health-Based Screening Level Comparison				Background Level Comparison		Site-Related Samples		COPC?	Rationale
	USEPA RSL Resident	Res RSL FoE	USEPA RSL Recreation[b]	Rec RSL FoE	Maximum Background Concentration	Background FoE	GC03SD 11070004 Between Landfill and Highway 3	GC04SD 11070003 Downstream from Highway 3		
Metals (mg/kg)										
Aluminum	77000	0/2	--	--	13400	0/2	12300	11200	N	< Res SL & Bckgrd
Arsenic	0.39	2/2	3.9	0/2	2.42	0/2	1.73	1.11	N	< Rec SL
Barium	15000	0/2	--	--	68.4	0/2	54.7	44.8	N	< Res SL & Bckgrd
Beryllium	160	0/2	--	--	0.197	0/2	0.168	0.181	N	< Res SL & Bckgrd
Cadmium	70	0/2	--	--	0.133	2/2	0.522	0.605	N	< Res SL
Calcium	NA	--	--	--	3130	0/2	3090	2860	N	NUT
Chromium	0.29	0/2	--	--	23.5	0/2	18.1	19.6	N	< Res SL & Bckgrd
Cobalt	23	0/2	--	--	16.9	0/2	5.53	6.13	N	< Res SL & Bckgrd
Copper	3100	0/2	--	--	9.94	0/2	38.5	30.5	N	< Res SL & Bckgrd
Iron	55000	0/2	--	--	17500	0/2	14600	14400	N	< Res SL & Bckgrd
Lead	400	0/2	--	--	4.57	0/2	35.3	25.5	N	< Res SL & Bckgrd
Magnesium	NA	--	--	--	4360	1/2	4050	4600	N	NUT
Manganese	1800	0/2	--	--	1160	0/2	239	237	N	< Res SL & Bckgrd
Mercury	23	0/2	--	--	0.0251	2/2	0.0593	0.0442	N	< SL
Nickel	1500	0/2	--	--	35.7	0/2	33.4	32.3	N	< Res SL & Bckgrd
Potassium	NA	--	--	--	334	2/2	426	419	N	NUT
Selenium	390	0/2	--	--	0.185	0/2	0.0467	0.00455	N	< Res SL & Bckgrd
Sodium	NA	--	--	--	123	0/2	94.4	113	N	NUT
Thallium	0.78	0/2	--	--	0.101	0/2	0.0449	0.0362	N	< Res SL & Bckgrd
Zinc	23000	0/2	--	--	41	2/2	130	115	N	< Res SL
Polychlorinated Biphenyls (µg/kg)										
Aroclor 1248	220	2/2	2200	0/2	ND	2/2	746	437	N	< Rec SL
Aroclor 1254	220	1/2	2200	0/2	ND	2/2	908	84	N	< Rec SL
Aroclor 1260	220	2/2	2200	0/2	7.2	2/2	516	248	N	< Rec SL
Volatile Organic Compounds (µg/kg)										
4-Isopropyltoluene[c]	5.0E+06	0/2	--	--	ND	1/2	ND	3.19	N	< Res SL
Acetone	6.1E+07	0/2	--	--	2.7	1/2	ND	3.85	N	< Res SL
Styrene	6.3E+06	0/2	--	--	ND	1/2	0.426	ND	N	< Res SL

[a]Includes only analytes detected at least once in sediment samples

[b]USEPA recreational (Rec) RSL was calculated only for analytes with sediment concentrations that exceeded the USEPA Residential RSL; the Rec RSL was calculated assuming an exposure frequency (EF) of 35 days/year or 1/10 of the residential EF (see text).

[c]No specific screening levels are available for this chemical; therefore, the screening level for toluene was used as a substitute.

Key:
- -- = Not applicable
- Bckgrd = background level
- COPC = chemical of potential concern
- FoE = frequency of exceedence (number of samples that exceed screening level over total number of samples)
- mg/kg = milligrams per kilogram
- NA = Not available
- ND = Non-detect
- NUT = essential nutrient for humans
- Rec = recreational
- Res = residential
- µg/kg = micrograms per kilogram
- USEPA RSL = United States Environmental Protection Agency Regional Screening Level

Table C-5. Surface Water Human Health Screening Results for Samples Collected in November 2003, Gorst Creek - Bremerton Auto Wrecking Landfill.

Analyte[a]	Health-Based Screening Level Comparison				Background Level Comparison		Site-Related Samples		COPC?	Rationale
	USEPA RSL Resident Tap	Res RSL FoE	USEPA AWQC	AWQC FoE	Background Concentration (BG02SW)	Background FoE	GC03SW 3464424 PPE1 Upstream	GC04SW 3464430 PPE2 Downstream		
Metals (µg/L)										
Calcium	NA	0/2	NA	--	1970	2/2	2060	6830	N	NUT
Iron	26000	0/2	300	0/2	270	0/2	30	31.2	N	< SLs & Bckgrd
Manganese	880	0/2	50	0/2	1703	0/2	3.1	11	N	< SLs & Bckgrd
Zinc	11000	0/2	7,400	0/2	21.8	2/2	23.5	31.5	N	< RSL & AWQC

[a]Includes only analytes detected at least once in surface water samples

Key:
-- = Not applicable
AWQC = ambient water quality criteria
Bckgrd = background level
COPC = chemical of potential concern
FoE = frequency of exceedence (number of samples that exceed screening level over total number of samples)
NA = Not available
NUT = essential nutrient for humans
PPE = probable points of entry
µg/L = micrograms per liter
USEPA RSL = United States Environmental Protection Agency Regional Screening Level

Table C-6. Summary of Human Health Risk Screening Results, Gorst Creek - Bremerton Auto Wrecking Landfill.

Chemical of Potential Concern (COPC)[a]	Minimum Detected Concentration	Maximum Detected Concentration	Screening Level Exceeded	Basis for Screening Level	Frequency of Exceedance	Magnitude of SL Exceedance[b]
Soil mg/kg						
Chromium	19.6	47.8	5.6	USEPA RSL Indus	7/7	9
Chromium	19.6	47.8	19	MTCA Method A	7/7	3
Groundwater ug/L						
Arsenic	2	2	0.045	USEPA RSL Res	1/1	44
Arsenic	2	2	0.058	MTCA Method B	1/1	34
Chromium	14.5	14.5	0.043	USEPA RSL Res	1/1	337
Chloroform	0.43	0.43	0.19	USEPA RSL Res	1/1	2
Methyl tert-butyl Ether (MTBE)	55	55	12	USEPA RSL Res	1/1	5
Sediment						
No Screening Exceedances						
Surface Water						
No Screening Exceedances						

[a]COPCs identified in screening assessment presented in Tables C-2 to C-5.

[b]Maximum detected concentration/screening level.

Key:
Indus = industrial soil
mg/kg = micrograms per kilogram
MTCA = Model Toxics Control Act
µg/L = micrograms per liter
Res = residential tap water
SL = screening level
USEPA RSL = United States Environmental Protection Agency Regional Screening Level

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D

STREAMLINED ECOLOGICAL RISK EVALUATION

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Appendix D -- Gorst Creek Streamlined Ecological Risk Evaluation

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Appendix B -- Streamlined Ecological Risk Evaluation

D.1 Introduction
This section presents a streamlined ecological risk evaluation for the Gorst Creek – Bremerton Auto Wrecking Landfill and portion of Gorst Creek near the landfill. The evaluation was undertaken to determine if contaminant concentrations in environmental media at and near the site pose an ecological risk and, if so, to aid in making risk-management decisions.

The methodology used in the streamlined ecological risk evaluation was generally consistent with United States Environmental Protection Agency (USEPA) and Washington State Department of Ecology (Ecology) guidance, including, but not limited to:

- *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* (USEPA 1993a)

- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA 1997);

- *Guidelines for Ecological Risk Assessment* (USEPA 1998);

- *Wildlife Exposure Factors Handbook* (USEPA 1993b);

- *Guidance for Developing Ecological Soil Screening Levels* (USEPA 2005a); and

- *Model Toxics Control Act Chapter 70.105D RCW and Cleanup Regulation Chapter 173-340 WAC* (Ecology 2007).

In addition to the above mentioned state and federal guidance documents, E & E also used publications from Oak Ridge National Laboratory (ORNL) and articles from the peer-reviewed literature, as appropriate.

The remainder of this section is organized as follows:

- Section D.2 provides a brief site description.

- Section D.3 presents the problem formulation for the streamlined ecological risk evaluation.

- Sections D.4 compares chemical concentrations in sediment and soil with risk-based screening levels for benthic invertebrates, terrestrial vegetation, soil invertebrates, and wildlife; presents the results of toxicity tests conducted with Gorst Creek sediment; and presents a supplemental risk evaluation for wildlife.

- Section D.5 identifies and discusses sources of uncertainty in the risk evaluation.

- Section D.6 presents a summary of the risk evaluation.

D.2 Site Description

D.2.1 Summary of Site History and Characteristics
The Gorst Creek – Bremerton Auto Wrecking Landfill is a closed landfill located in Kitsap County, Washington approximately 5 miles southwest of Port Orchard, 6 miles south-southwest of Bremerton, and

1.5 miles west of Gorst, Washington along the southwest side of Highway 3 (see Figure 1-1 for site location figure). The property began operating as a landfill in 1950 under the name of Ames Auto Wrecking. Beginning in 1980, the landfill operated under the name of Bremerton Auto Wrecking, Inc. until its closure in 1989 by the Kitsap County Health Department as a result of non-compliance with state and local solid-waste regulations. In addition to automotive debris, the landfill accepted waste from public dumping, occasional demolition debris contracts, and refuse from the Puget Sound Naval Shipyard, including a limited amount of medical waste from that facility (E & E 2003).

The landfill is a triangular-shaped parcel of 5.7 acres centered over 700 feet of the Gorst Creek ravine. The ravine was 60 to 80 feet deep at this location before being used as a landfill. Gorst Creek is located in the ravine and is conveyed under the landfill through a culvert that was constructed when landfill operations began in 1968. Presently, the top of the landfill is flush with the surrounding topography over much of the landfill surface and is overgrown with saplings, blackberry bushes, and other vegetation. The invasive Himalayan blackberry (*Rubus armeniacus* or *R. discolor*) is the predominant plant species on the landfill surface.

Gorst Creek is an intermittent stream in the site vicinity. During field work in July 2011, no surface water was present in the creek near the site. Downstream from the site, Gorst Creek becomes a perennial stream and flows for 3.7 miles to Sinclair Inlet, an arm of Puget Sound.

Additional information about site conditions and current and past use of the site is provided in Sections 1.2 and 1.3).

D.2.2 Species of Special Concern

E & E examined available information from the Washington Department of Fish and Wildlife (WDFW), Washington State Department of Natural Resources (WSDNR), United States Fish and Wildlife Service (USFWS), and National Oceanic and Atmospheric Administration (NOAA) regarding the presence of sensitive plant and animal species in the site vicinity. A summary of the information from these agencies is provided below.

The WDFW Priority Habitats and Species (PHS) database (WDFW 2011) indicated that the Coho salmon (*Oncorhynchus kisutch,* federally listed threatened) and coast-resident cutthroat trout (*O. clarki,* PHS listed) occur or migrate in Gorst Creek. The information in the PHS database suggests that these species may occur throughout Gorst Creek, including the portion of the creek near the site.

The WSDNR (2011) indicated that six rare plants species occur in Kitsap County: pink sand-verbena (*Abronia umbrellata* var. *brevifolia*, state-listed endangered); Vancouver ground-cone (*Boschniakia hookeri*, state-listed of potential concern); bog clubmoss (*Lycopodium inundata*, state-listed sensitive); western yellow oxalis (*Oxalis suksdorfii*, state-listed threatened); humped bladderwort (*Utricularia gibba*; state-listed of potential concern); and chain fern (*Woodwardia fimbriata*; state-listed sensitive). The Vancouver ground-cone, bog clubmoss, humped bladderwort, and chain fern were sited in west Kipsap County within approximately 10 miles of the site. However, none of these species were observed at the site during field activities in July 2011 and they would not be expected to occur there given their habitat requirements. Vancouver ground pine is a root parasite and typically is found growing in young forest stands near salt water. Associated tree species include western hemlock, western red cedar, Sitka spruce, and Douglas fir. Bog clubmoss, humped bladderwort, and chain fern prefer perennially wet habitats (bogs, lakeshores, etc.) that are not offered by the site.

The USFWS (2010) indicated that the bull trout (*Salvalinus confluentus*) – Coastal-Puget Sound Distinct Population Segment (DPS) and marbled murrelet (*Brachyramphus marmoratus*) are listed as threatened and endangered species, respectively, in Kitsap County. Also, the USFWS considers the yellow-billed cuckoo (*Coccyzus americanus*) as a candidate species in Kitsap County and 12 other animals as species of concern in Kipsap County, including: bald eagle (*Haliaeetus leucocephalus*), long-eared myotis *(Myotis evotis)*, long-legged myotis (*Myotis volans*), northern goshawk (*Accipiter gentilis*), northern sea otter (*Enhydra lutris kenyoni*), northwestern pond turtle (*Emys* (= *Clemmys*) *marmorata marmorata*), Pacific lamprey (*Lampetra tridentata*), Pacific Townsend's big-eared bat (*Corynorhinus townsendii townsendii*), peregrine falcon (*Falco peregrinus*), river lamprey (*Lampetra ayresi*), tailed frog (*Ascaphus truei*), and western toad (*Bufo boreas*). Some of these species (e.g., marbled murrelet, northern sea otter, and peregrine falcon) would not be expected to occur in the site vicinity given their habitat requirements. However, the possibility that the other mentioned-above species might occur in the site vicinity cannot be definitely ruled out, although none were observed during field work at the site in July 2011.

The National Marine Fisheries Service, a branch of NOAA, indentified the Puget Sound Chinook salmon (*O. tshawytscha*) evolutionarily significant unit (ESU) and Puget Sound steelhead (*O. mykiss*) DPS as federally threatened species in Puget Sound (NOAA 2011). Because Gorst Creek is a tributary of Puget Sound, the occurrence of these species in Gorst Creek cannot be definitely ruled out.

D.3 Problem Formulation

Problem formulation is the first step in the ecological risk assessment process and identifies the goals, breadth, and focus of the assessment (USEPA 1997, 1998). The problem formulation step identifies site-related contaminants (i.e., stressors), potential ecological receptors, and potential exposure pathways. A conceptual model is then developed to summarize the relationship between stressors and receptors. Lastly, assessment endpoints and measures (previously called measurement endpoints) are developed to guide the remaining steps of the risk assessment process. The problem formulation and conceptual site model (CSM) for the Gorst Creek – Bremerton Auto Wrecking Landfill site are presented below.

D.3.1 Contaminant Sources and Migration Pathways

In addition to automotive debris, the Gorst Creek – Bremerton Auto Wrecking Landfill accepted waste from public dumping, occasional demolition debris contracts, and refuse from the Puget Sound Naval Shipyard, including a limited amount of medical waste from that facility (E & E 2003). The landfill is estimated to contain 150,000 cubic yards of waste (E & E 2003, 2004) from these sources. The landfill is not capped. In March 1997, after a significant storm event (7.3 inches in a 24-hour period), Gorst Creek backed up on the upstream side of the landfill and overtopped the surface of the landfill, causing a portion of the northwest slope of the landfill to fail and wash into Gorst Creek. In January 2002, after another significant storm event, Gorst Creek again backed up and overtopped the landfill, resulting in another (smaller) slope failure. Landfill debris was again released to Gorst Creek. Other less significant releases may have taken place over the past 15 years. Gorst Creek backs up behind the landfill during periods of heavy precipitation because a portion of the culvert beneath the landfill has collapsed (E & E 2004).

D.3.2 Site-Related Chemicals

Chemicals detected in soil, sediment, and surface water in past site investigations included metals, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and pesticides (E & E 2003, 2004). Based on these investigations, DDT, DDE, and PCBs (Aroclor 1254) in sediment in Gorst Creek downstream from the site appeared to be of greatest concern from an ecological standpoint; sediment concentrations of these chemicals exceeded their respective probable effect concentration (PEC, MacDonald et al. 2000), indicating that the concentrations were great enough to adversely effect benthic invertebrates. These chemicals also were detected in surface and subsurface soil from the site, suggesting that the landfill is a source to the creek.

D.3.3 Ecological Receptors

The following ecological receptor groups have the potential to be affected by site-related contaminants at the site:

- Terrestrial plants and soil invertebrates living on the landfill surface;

- Mammals, birds, and reptiles that use the landfill surface and Gorst Creek near the landfill to satisfy there food and habitat needs; and

- Benthic invertebrates, fish, amphibians, and other aquatic organisms in Gorst Creek near the landfill.

D.3.4 Ecological Conceptual Site Model

Potential receptors and exposure pathways are summarized in the site conceptual model shown in Figure 1-6. Terrestrial plants and soil invertebrates on the landfill surface may be exposed to site-related chemicals by direct contact with contaminated soil. Birds, mammals, and reptiles that use the site may be exposed to site-related chemicals by incidental ingestion of contaminated soil, consumption of contaminated prey, and consumption of contaminated water. Direct contact with contaminated media also is a potential exposure pathway for wildlife, but is considered insignificant due to the protection provided by their external coverings (i.e., fur, feathers, and scales). Amphibians, benthic invertebrates, and fish in Gorst Creek near the site may be affected by direct contact with contaminated water and sediment, ingestion of contaminated water and sediment, and through the food chain, although not all of these exposure pathways are equally significant. Direct contact with sediment typically is considered a minor exposure pathway for fish, amphibians, and many other aquatic organisms (e.g., zooplankton and phytoplankton).

D.3.5 Assessment Endpoints and Measures

Assessment endpoints are expressions of the ecological resources that are to be protected (USEPA 1997). An assessment endpoint consists of an ecological entity and a characteristic of the entity that is important to protect. According to USEPA (1998), assessment endpoints do not represent a desired achievement or goal, and should not contain words such as protect or restore, or indicate a direction for change such as loss or increase. Assessment endpoints are distinguished from management goals by their neutrality (USEPA 1998).

Measurements used to evaluate risks to the assessment endpoints are termed “measures” and may include measures of effect (e.g., results of sediment toxicity tests), measures of exposure (e.g., chemical concentrations in soil) and/or measures of ecosystem and receptor characteristics (e.g., habitat characteristics or water quality conditions) (USEPA 1998). Based on the site ecology, potential site-related contaminants, and preliminary conceptual model, the ecological resources potentially at risk at the site include populations of plants, soil invertebrates, mammals, birds, reptiles, fish, amphibians, and benthic invertebrates that use the landfill surface and/or Gorst Creek near the landfill. The assessment endpoints and measures for these receptor groups are listed in Table D-1.

D.3.6 Data Used in Risk Evaluation

The streamlined ecological risk evaluation is based on soil and sediment data collected in July 2011. In July 2011, seven surface soil samples (LF01SS to LF07SS) were collected from the landfill surface and four sediment samples (GC01SD to GC04SD) were collected from Gorst Creek near the landfill. Two sediment samples (GC01CD and GC02SD) were collected upstream from the landfill and two sediment samples (GC03SD and GC04SD) were collected downstream from the landfill. Sample location maps are provided in Section 1.4.2 and E & E (2011). The samples were analyzed for metals, VOCs, SVOCs, PCBs, and pesticides. In addition, sediment samples were analyzed for toxicity to benthic invertebrates using USEPA (2000) and ASTM (1993) protocols. Surface water samples were not collected in July 2011 because the creek was dry in the site vicinity at that time. Historical data from Hart Crowser (2000) and E & E (2004) were deemed to not reflect current site conditions and therefore were not used in the ecological risk evaluation.

D.4 Ecological Risk Evaluation

The ecological risk evaluation is presented under four main headings, one each for the principal assessment endpoints being evaluated: (1) benthic invertebrates; (2) terrestrial vegetation; (3) soil invertebrates; and (4) wildlife. Fish and other aquatic organisms exposed to surface water in Gorst Creek could not be evaluated in the current assessment because no surface water was present in the creek near the site at the time of sampling (July 2011).

D.4.1 Benthic Macroinvertebrates

Two approaches were used to evaluate risks to benthic macroinvertebrates in Gorst Creek (see Table D-1): (1) sediment chemical concentrations compared with screening levels for effects on freshwater benthic macroinvertebrates and (2) toxicity tests with Gorst Creek sediment. These two measures are discussed in turn below.

D.4.1.1 Sediment Chemical Concentrations Compared with Screening Levels

Chemical concentrations in Gorst Creek sediment were compared with Threshold Effect Concentrations (TECs) and Probable Effect Concentrations (PECs) from MacDonald et al. (2000). Concentrations less than the TEC are assumed to be nontoxic to benthic macroinvertebrates, while those greater than the PEC often are associated with adverse effects. Samples with chemical concentrations between the TEC and PEC are neither predicted to be toxic or nontoxic (i.e., the screening levels are not intended to provide guidance within this concentration range). If a TEC was not available for a particular chemical, an alternate screening level that was analogous to the TEC was taken from Mac Donald et al. (1999). The sediment data from July 2011 are presented and compared with screening levels in Table D-2. Aroclor 1248 and 1254 marginally exceeded the PEC in one of two sediment samples collected downstream from the landfill. No other chemicals in sediment exceeded the available PECs. Overall, the sediment screening results suggest that only levels of PCBs in sediment downstream from landfill are likely to be great enough to adversely affect benthic macroinvertebrates.

D.4.1.2 Sediment Toxicity Tests

Two different sediment bioassays were conducted with Gorst Creek sediment: (1) 10-day survival and growth test with *Chironomus dilutus* (midge) and (2) 28-day survival and growth test with *Hyalella azteca* (amphipod). The tests were conducted by Northwest Aquatic Sciences (NAS) following USEPA (2000) and ASTM (1993) protocols. Full test reports from NAS are included in Appendix A. Table D-3 provides a summary of the results. No effects on survival were observed in either test. Three samples (GC01SD, GC03SD, and GC04SD) showed reduced midge growth and two samples (GC01SD and GC03SD) showed reduced amphipod growth compared with clean control sediment. One of the samples that resulted in reduced growth was collected upstream from the landfill. The sample with the lowest midge and amphipod growth (GC03SD, see Table D-3) was collected downstream from the landfill and contained the greatest concentrations of Aroclor 1248 and 1254 (see Table D-2).

D.4.2 Terrestrial Vegetation

Potential risks to terrestrial vegetation from chemicals in soil were evaluated by comparing soil chemical concentrations with ecological soil screening levels for effects on plant survival, growth, or reproduction from USEPA (2005a, e-g, 2007a-e), Efroymson et al. (1997), or Alloway (1984). The results of the comparisons are shown in Table D-4. Copper, lead, manganese, mercury, nickel, and zinc concentrations in soil exceeded the available screening levels and therefore may be great enough to affect plant growth, reproduction, or survival in some areas of the landfill surface.

D.4.3 Soil Invertebrates

Potential risks to soil invertebrates from chemicals in soil were evaluated by comparing soil chemical concentrations with ecological soil screening levels for effects on earthworm survival, growth, or reproduction from USEPA (2005c-e, g, 2007a-e). The results of the comparisons are shown in Table D-4. Copper, manganese and zinc concentrations in soil exceeded the available screening levels and therefore may be great enough to adversely affect growth, reproduction, or survival of soil invertebrates in some areas of the landfill surface. However, both copper and manganese exceeded their respective screening level in only one sample, suggesting that potential impacts to soil invertebrates from these metals are limited in extent.

D.4.4 Wildlife

Two approaches were used to evaluate risks to wildlife at the site (see Table D-1): (1) comparing soil chemical concentrations with screening levels for effects on wildlife and (2) estimating an ingested chemical dose for comparison with a toxicity reference value (hazard quotient [HQ] method). These two measures are discussed in turn below.

D.4.4.1 Surface Soil Chemical Concentrations Compared with Screening Levels

Potential risks to terrestrial wildlife were evaluated by comparing soil chemical concentrations with ecological soil screening levels (Eco-SSLs) for effects on wildlife. Most of the available wildlife screening levels are based on exposure scenarios with wildlife species that consume soil invertebrates, such as the woodcock and shrew, but a few are based on other wildlife species. For example, the mammalian and avian Eco-SSLs for nickel are based on scenarios with a weasel (carnivore) and dove (herbivore). The results of the comparisons are shown in Table D-4. Soil concentrations of cadmium, chromium, copper, lead, zinc, DDT, and high molecular weight PAHs exceeded the available screening levels and therefore may be great enough to adversely affect growth, reproduction, or survival of wildlife on the landfill.

Unfortunately, soil screening levels for terrestrial wildlife are not available for some metals and most organic compounds. Also, sediment screening levels for effects on wildlife are not available. Hence, comparing chemical concentrations with screening levels does not provide a complete assessment of potential wildlife risks. To address this shortcoming, screening-level exposure estimates and HQs were calculated for four representative wildlife species using maximum detected concentrations of chemicals in surface soil and sediment. Details are provided in the following section.

D.4.4.2 Wildlife Risk Evaluation

This section presents an evaluation of potential risks to wildlife at the Gorst Creek – Bremerton Auto Wrecking site. The evaluation was performed in accordance with state, federal, and other available guidance for ecological risk assessment (e.g., USEPA 1997, 1998, 2005a; Sample *et al.* 1996). The wildlife risk evaluation consists of three parts: (1) exposure assessment, (2) ecological effects assessment, and (3) risk characterization. The exposure assessment estimates wildlife exposure to site-related chemicals using measured concentrations of chemicals in environmental media and exposure parameters for the chosen receptor species. The ecological effects assessment summarizes the potential toxic effects of site-related chemicals on wildlife by selecting a toxicity reference value for each chemical for each receptor. The risk characterization combines the results of the exposure and ecological effects assessments to provide an estimate of potential risk to wildlife at the site.

D.4.4.2.1 Exposure Assessment

This section discusses potential wildlife exposures to chemicals at the site. Potential receptors and exposure pathways were generally discussed in Section D.3.3 and identified in the ecological conceptual site model (see Figure 1-6). This section describes specific wildlife exposure scenarios that will be evaluated in the assessment; estimates of concentrations of chemicals in soil, sediment, and prey; and quantifies exposure.

D.4.4.2.1.1 Wildlife Exposure Scenarios and Pathways

Four wildlife species representing different functional groups were selected as receptors for the assessment: (1) American robin (*Turdus migratorius*); (2) masked shrew (*Sorex cinereus*); (3) barn swallow (*Hirundo rustica*); (4) raccoon (*Procyon lotor*). The robin and shrew have relatively small home ranges and could derive a large portion of their food and habitat requirements from the site. In addition, both the robin and shrew feed extensively on soil invertebrates, such as earthworms, and therefore are often highly exposed to contaminants in soil. The raccoon is an omnivorous mammal that often forages in aquatic habitats. Given its foraging behavior, the raccoon is likely to use Gorst Creek near the landfill, where it may be exposed to site-related chemicals in water, sediment, and prey. Lastly, the barn swallow is an insectivorous songbird that readily consumes emergent aquatic insects in riparian settings. The barn swallow also may be exposed to chemicals in sediment while collecting mud for nest building.

For these four wildlife receptors, this assessment evaluates exposure from incidental ingestion of contaminated soil or sediment and consumption of contaminated prey. Exposure through drinking was not quantitatively evaluated because consumption of surface water typically accounts for only a small fraction of the total chemical exposure for wildlife. This results from the fact that chemicals occur in soil, sediment, and biota at much greater concentrations (part per million concentration range) than in surface water (part per billion concentration range). Direct contact with contaminated media is considered an insignificant route of exposure for wildlife due to the protection provided by fur and feathers and therefore was not quantitatively evaluated. A summary of important life-history characteristics of the chosen receptor species is provided below.

American Robin – The American robin is a common resident of open areas, woodland edges, and early successional habitats (USEPA 1993b). The makeup of the diet varies seasonally, with invertebrates making up the majority of food items during the spring and early summer. During this time, robins feed on the ground, searching the soil and leaf litter for invertebrates, such as earthworms. Robins establish small territories during the breeding season, and potentially could reside entirely within the area provided by the site. Northern populations typically winter in southern locations.

Masked Shrew – The masked shrew is the most common shrew in moist forests, open country, and brush in the northern United States and throughout Canada and Alaska (USEPA 1993b). It feeds primarily on invertebrates, including insects, earthworms, slugs, and snails. Vertebrates and plants typically make up a minor component of the diet. The species is active year-round. Shrews have a small home range (USEPA 1993b); therefore, the masked shrew could reside entirely within the area provided by the site.

Raccoon – The raccoon is the most abundant and widespread medium-sized omnivore in North America. Raccoons are found near virtually every aquatic habitat (USEPA 1993b). They also are common in suburban residential areas and cultivated and abandoned farmlands. Raccoons use surface water bodies for both drinking and foraging. The raccoon is an omnivore and opportunistic feeder. They feed primarily on fleshy fruits, nuts, acorns, and corn, but also eat grain, insects, frogs, crayfish, eggs, and virtually any animal and vegetable matter. The proportion of the diet depends on location and season, although plant material is usually a more important component of the diet than animal material. Typically, it is only in the spring and early summer that raccoons eat more animal than plant material. The size of a raccoon's home range depends on several factors, including its sex and age, habitat quality, food sources, and season. Values from a few hectares to more than a few thousand hectares have been reported, although home ranges of several hundred hectares appear to be most common (USEPA 1993b). Raccoons may forage in Gorst Creek near the site.

Barn Swallow – The barn swallow is an insectivorous songbird that readily consumes emergent aquatic insects in stream and lake settings (Bent 1963). The barn swallow was conservatively assumed to feed entirely on emergent (adult forms) of aquatic insects from Gorst Creek. Barn swallows also could be exposed to chemicals in creek sediment while collecting mud for nest building. Barn swallows reside in the Puget Sound area from mid-April to mid-October (Wahl 1995).

D.4.4.2.1.2 Wildlife Exposure Calculations

The total chemical exposure for wildlife was calculated as the sum of exposures from diet and incidental soil or sediment ingestion. As noted above, chemical exposure from surface-water consumption was not quantitatively evaluated. Dietary exposure is calculated by multiplying the chemical concentration in each food item by its fraction of the total diet and summing the contribution from each item. This sum is then multiplied by the receptor's site use factor (SUF), exposure duration (ED), and ingestion rate (IR), and divided by the receptor's body weight (BW), as shown in the following equation:

$$EE_{diet} = ([(C_1 \text{ x } F_1) + (C_2 \text{ x } F_2) + ... (C_n \text{ x } F_n)] \text{ x SUF x ED x IR})/BW$$

where:

EE_{diet} = Estimated exposure from diet (mg/kg-day);
C_n = Chemical concentration in food item *n* (mg/kg dry weight);
F_n = Fraction of diet represented by food item *n*;
SUF = Site use factor (unitless);
ED = Exposure duration (unitless), equal to fraction of year spent at site;
IR = Ingestion rate of receptor (kg/day dry weight); and
BW = Body weight of receptor (kg).

The site use factor (SUF) indicates the portion of an animal's home range represented by the site. If the home range is larger than the site, the SUF equals the site area divided by the home range area. If the site area is greater than or equal to the home range, the SUF is equal to 1. Exposure duration (ED) is the percentage of the year spent in the site area by the receptor species. Home-range size, IR, and BW for the robin, shrew, swallow, and raccoon were taken from USEPA (1993b), Sample and Suter (1994), and Sample *et al.* (1996). The values are presented in Table X-5. Critical exposure assumptions are described in the following section.

Wildlife exposure to chemicals through incidental ingestion of soil/sediment is estimated in a manner similar to dietary exposure. Specifically, the soil/sediment chemical concentration is multiplied by the soil/sediment IR and then multiplied by the SUF and ED and divided by BW. Soil/sediment ingestion estimates for the receptor species were taken from Sample and Suter (1994), Sample *et al.* (1996), and Beyer et al. (1994). The values are presented in Table X-5.

The total exposure for a receptor is the sum of exposure from diet and soil/sediment ingestion, as represented by the following equation:

$$EE_{total} = EE_{diet} + EE_{soil/sediment}$$

where:

EE_{total} = Total exposure (mg/kg-day);
EE_{diet} = Estimated exposure from diet (mg/kg-day);
$EE_{soil/sediment}$ = Estimated exposure from soil/sediment ingestion (mg/kg-day).

D.4.4.2.1.3 Screening-Level Exposure Assumptions

Diet -- The robin and shrew were conservatively assumed to prey entirely on earthworms. Earthworms were chosen as a representative prey item for these receptors because earthworms typically are abundant in surface soil, are important in the diets of shrews and robins, and have been well studied compared with other groups of soil invertebrates. The diet of the swallow was conservatively assumed to consist entirely of emergent aquatic insects from Gorst Creek. Swallows often prey on midges, mayflies, and other emergent aquatic insects. The diet of the raccoon was conservatively assumed to consist entirely of crayfish from Gorst Creek. Crayfish were chosen as a representative aquatic prey species for the raccoon because they typically are abundant in small streams and are readily eaten by raccoons (USEPA 1993b). Table D-5 summarizes the assumed diets. Contaminant levels in earthworms, benthic invertebrates, and crayfish were estimated as described below.

Site Use Factor (SUF) and Exposure Duration (ED) -- To provide a conservative estimate of exposure to site-related chemicals, the SUF and ED were assumed to be 1 for all receptors. That is, the site was assumed to be a closed system and the shrew, robin, swallow, and raccoon were assumed to derive all of their food and habitat requirements from the landfill or Gorst Creek near the landfill. For this assessment, the robin and shrew were assumed to forage exclusively on the landfill surface and the swallow and raccoon were assumed to forage exclusively along Gorst Creek near the landfill. These assumptions are highly conservative and often are used in screening-level risk calculations to avoid overlooking chemicals that may be of concern for wildlife (USEPA 1997).

D.4.4.2.1.4 Exposure Point Concentrations

Soil – Maximum surface soil chemical concentrations were used as the exposure point concentrations (EPCs) to estimate exposure for the robin and shrew. The soil EPCs were used for two purposes: (1) to estimate exposure from incidental soil ingestion; and (2) to model chemical concentrations in earthworms, the assumed prey for the shrew and robin. Soil EPCs are listed in Table D-6.

Earthworms – Chemical concentrations in earthworms were modeled from the soil EPCs using soil-to-earthworm bioaccumulation factors (BAFs) and uptake equations from USEPA (2005a) and Sample *et al.* (1998). If a BAF or uptake equation was not available, a soil-to-earthworm uptake factor of 1 was assumed (i.e., earthworm chemical concentration was set equal to the soil chemical concentration). Table D-6 lists the soil-to-earthworm uptake factors and equations and earthworm EPCs used in the assessment.

Sediment – The maximum detected concentration was used to estimate wildlife exposure to chemicals in sediment. The sediment EPCs were used for two purposes: (1) to estimate exposure from incidental sediment ingestion for the swallow and raccoon; and (2) to model chemical concentrations in benthic invertebrates and crayfish, the assumed prey of the swallow and raccoon, respectively. Sediment EPCs are listed in Table D-7.

Benthic Invertebrates – Chemical concentrations in benthic invertebrates, including crayfish, were modeled from the sediment EPC using biota-sediment accumulation factor (BSAFs) and equations developed by Bechtel Jacobs (1998). For metals not addressed by Bechtel Jacobs (1998), a BSAF of 1 was assumed (i.e., the prey chemical concentration was set equal to the sediment EPC). The benthic invertebrate EPCs are listed in Table D-7.

D.4.4.2.2 Ecological Effects Assessment
No observed adverse effect levels (NOAELs) and lowest observed adverse effect levels (LOAELs) for chemicals of interest were taken from USEPA (2008, 2007a to g, 2005b to f) and Sample *et al.* (1996). The values and sources are listed in Table D-8. The NOAELs and LOAELs were not scaled for

differences in body weight between the test species and wildlife receptors being evaluated because this practice is no longer considered appropriate (Allard et al. 2009). Therefore, information on test-species body weight is not included in Table D-8.

D.4.4.2.3 Wildlife Risk Characterization

The potential risks posed by site-related chemicals were determined by calculating a hazard quotient (HQ) for each contaminant for each endpoint species. The HQ was determined by dividing the total exposure (EE_{total}) by the NOAEL or LOAEL, as shown in the following equations:

$$HQ\text{-}NOAEL = EE_{total}/NOAEL$$

$$HQ\text{-}LOAEL = EE_{total}/LOAEL$$

For a given receptor and chemical, a HQ-NOAEL greater than 1 indicates that the estimated exposure exceeds the highest dose at which no adverse effect was observed. Such a result does not necessarily imply that the receptor is at risk, especially if the HQ-NOAEL is only marginally above 1. An HQ-LOAEL greater than 1 suggests that a chronic adverse affect is possible to an individual receptor, assuming that the estimated exposure for that receptor is accurate. Tables D-9 to D-12 list the estimated exposures from food and soil/sediment ingestion, total exposure, and HQs for the robin, shrew, swallow, and raccoon.

D.4.4.2.3.1 Terrestrial Wildlife Risks

Aroclor 1254, cadmium, chromium, copper, lead, nickel, and zinc were predicted to pose a potential risk to the American robin (see Table D-9). Cadmium, copper, lead, nickel and zinc were predicted to pose a potential risk to the masked shrew (see Table D-10). Lead appears to pose the greatest potential risks for both receptors based on the magnitude of the HQs (HQ-LOAEL of 20 for the American robin and 5.9 for the masked shrew).

D.4.4.2.3.2 Aquatic-Dependent Wildlife Risks

Aroclor 1248, 1254, and 1260 and copper and manganese were predicted to pose a potential risk to the barn swallow (see Table D-11). Aroclor 1248 and 1254 and manganese were predicted to pose a potential risk to the raccoon (see Table D-12). Except for the HQ-NOAELs for the Aroclors for the swallow, the HQs for the chemicals posing a potential risk to the swallow and raccoon were only marginally above 1.

As noted above, the exposure estimates and risks in Tables D-9 to D-11 are based on maximum chemical concentrations in surface soil or sediment and the assumption that all four receptors forage only at the site on a year-round basis. The following section examines the sensitivity of the exposure estimates and risks to changes in these assumptions

D.4.4.2.4 Effect of Exposure Duration, Site Use Factor, and Exposure Point Concentration on Wildlife Risks

To provide a more realistic evaluation of risks to wildlife, the SUF, ED, and EPCs were changed as follows:

- For the robin and swallow, the ED was changed from 1.0 to 0.5 to account for the migratory behavior of these species.

- For the robin and shrew, the 95% upper confidence limit (UCL) on the average chemical concentration in soil was used as the soil EPC. ProUCL Version 4 software was used to calculate UCLs for surface soil using data for the seven surface soils samples collected in July 2011. It was not possible to revise the sediment EPCs for the swallow and raccoon because only four sediment samples were collected in July 2011, too few to support calculation of a UCL.

- For the swallow, the exposure estimates and risks were recalculated assuming that the swallow only forages on emergent aquatic insects from Gorst Creek near the site when the creek contains water, which was assumed to be 50% of the time between mid-April and mid-October.

- For the raccoon, the exposure estimates and risks were recalculated based on a more realistic SUF of 0.0003. This SUF is based on the approximate area of the Gorst Creek ravine near the site (0.2 ha) divided by the average home range size for this receptor (630 ha; USEPA 1993b).

Table D-13 illustrates the effects of these changes on the HQs for these receptors (only chemicals with HQs greater than 1 in Tables D-9 to D-12 are included in Table D-13). The following points are noteworthy:

- No chemicals are predicted to pose a risk to the raccoon when receptor-specific estimates of the SUF and ED are used.

- For the barn swallow, only Arcolor 1254 remains as a COPC; however, because the HQ-NOAEL for Aroclor 1254 is only marginally greater than 1, and because the HQ-LOAEL is much less than 1, it seems unlikely that Aroclor 1254 poses an actual risk to this receptor.

- For the American robin, cadmium, lead, and zinc remain as COPCs. However, because the HQ-NOAEL for cadmium only marginally exceeds 1, is seems unlikely that cadmium poses an actual risk to the robin.

- For the masked shrew, cadmium, lead, nickel, and zinc remain as COPCs.

The recalculated HQs in Table D-13 are referred to as "moderately conservative" because they still incorporate several conservative assumptions. For example, the recalculated HQs for the robin and shrew both assume a SUF of 1, which implies that these receptors forage only on the landfill surface. In all likelihood, these receptors probably forage more often on nearby areas with better natural habitat. Also, the recalculated HQs for the swallow and raccoon are based on maximum detected chemical concentrations in sediment because a UCL cannot be calculated from four samples, as noted above.

The final HQ results in Table D-13 (moderately conservative case) differ from the screening results for wildlife in Table D-4 in several noteworthy ways;

- The final HQ results in Table D-13 do not predict a potential risk to terrestrial wildlife from chromium, DDT, and high molecular weight PAHs in soil, whereas the screening results in Table D-4 do.

- The final HQ results in Table D-13 suggest that PCBs may be a concern for terrestrial wildlife. The screening results in Table D-4 are inconclusive for PCBs because an ecological soil screening level for PCBs for wildlife is not available.

- The final HQ results in Table D-13 suggest that aquatic-dependent wildlife (swallow and raccoon) are unlikely to be at risk from chemicals in Gorst Creek sediment. The screening results in Table D-4 are inconclusive for aquatic-dependent wildlife because sediment screening levels for effects on wildlife are not available.

In general, the HQ approach for evaluating risks to wildlife is more thorough and flexible than the simple screening approach used in Table D-4 because it allows one to examine a wider range of potential receptors, a greater number of chemicals, and the sensitivity of the risk estimates to the assumptions used. For these reasons, the wildlife risk results based on the HQ approach will be given priority over those based on simple screening when drawing conclusions about potential ecological risks to wildlife at the site.

D.5 Uncertainties

Significant sources of uncertainty in this ecological risk assessment include the following:

- **Bioavailability –** The bioavailability of chemicals in environmental media at the site is poorly understood. To be conservative, it was assumed that 100% of the chemicals in soil and sediment were bioavailable to all ecological receptors. If bioavailability is less than 100%, which seems likely, the potential risks to all categories of ecological receptors would be correspondingly lower.

- **Reliability of Soil Benchmarks –** Many of the available soil screening benchmarks for plants and soil invertebrates (i.e. earthworms) were developed from laboratory studies in which chemical solutions were added to clean soil to arrive at a range of test concentrations. In such studies, the added chemicals are highly bioavailable. Comparing total chemical concentrations in field samples to solution-based soil benchmarks is conservative and likely results in an overestimation of risk. For aluminum, USEPA (2003) has deemed that such a comparison is inappropriate.

- **Availability of Soil Benchmarks –** As indicated in Tables D-2 and D-4, screening benchmarks are not available for all chemicals in all media. For example, soil screening benchmarks for plants and soil fauna are not available for many volatile and semivolatile organic compounds and pesticides. Hence, risks to certain receptor groups from certain chemicals could not be evaluated.

- **Chemicals in Surface Water –** Recent data for chemicals in surface water are not available because no surface water was present in Gorst Creek near the site July 2011.

- **Chemicals in Wildlife Prey –** Food-chain transfer of chemicals at the site is poorly understood. The potential risks to wildlife at the site are largely driven by estimated concentrations of chemicals in wildlife prey. For this assessment, prey concentrations were estimated from measured soil and sediment concentrations using uptake factors from the literature. Or, if a literature-based uptake factor was not available, it was assumed that the prey concentration was the same as the soil or sediment concentration. The uncertainty associated with this approach often is high because a number of site-specific factors affect food-chain transfer of chemicals. In general, the uptake factors used in this assessment are intended to provide a conservative estimate of chemicals in wildlife prey and are likely to result in an overestimation of risk.

- **Wildlife Diet –** Uncertainty may result from the assumptions made about the diets of the wildlife receptors evaluated in this assessment. For the shrew and robin, the assumption of a diet consisting entirely of earthworms is conservative. In addition to earthworms, shrews consume other invertebrates (i.e. slugs, snails, centipedes, and various insects), fungi, plant materials, and small mammals (USEPA 1993b). Similarly, robins also consume other invertebrates (i.e., spiders, sowbugs, and various insects) and plant materials (USEPA 1993b). These foods are less intimately associated with the soil matrix than earthworms, and thus accumulate lesser amounts of soil contamination. The diet assumed for the shrew and robin in this assessment likely overestimates exposure and risks from chemicals in soil. The diet assumed for the raccoon (100% crayfish from Gorst Creek) also is highly conservative. Raccoons typically consume a considerable amount of plant material.

- **Chemical Concentrations in Environmental Media –** For sediment, the small sample size (4 samples) necessitated use of the maximum detected concentration to estimate wildlife risks. Although a larger sample size was available for surface soil (7 samples), the distribution of the data for some chemicals (e.g., lead) necessitated using the maximum detected concentration to estimate wildlife risks. Use of the maximum lead soil concentration in the wildlife risk evaluation likely resulted in an overestimate of potential risks to terrestrial wildlife from lead.

D.6 Summary

The assessment endpoints for this risk evaluation were stated in Table D-1 and include: terrestrial vegetation, soil invertebrates, wildlife, benthic invertebrates, and fish and other aquatic organisms exposed to surface water. Table D-14 provides a summary of the chemical that may pose a potential risk to these assessment endpoints. The following points are noteworthy.

- **Terrestrial Vegetation –** Potential risks to terrestrial plants on the landfill surface were evaluated by comparing soil chemical concentrations to screening benchmarks for effects on plant survival, growth, or reproduction. Based on these comparisons, copper, lead, manganese, mercury, nickel, and zinc in soil may pose a potential risk to terrestrial plants in some areas of the landfill surface.

- **Soil Invertebrates –** Potential risks to soil invertebrates on the landfill surface were evaluated by comparing soil chemical concentrations to screening benchmarks for effects on survival, growth, or reproduction or earthworms. Based on these comparisons, copper, manganese and zinc in soil may pose a potential risk to soil invertebrates in some areas of the landfill surface. Potential risks from copper and manganese are restricted to a single location, whereas the risks from zinc appear to be more widespread.

- **Birds and Mammals –** Based on food-chain modeling, cadmium, lead, nickel, and zinc in soil are likely to pose a risk to song birds and small mammals that feed extensively on soil invertebrates, such as the American robin and masked shrew. Risks to aquatic-dependent wildlife that may forage in Gorst Creek near the site appear to be minimal. This conclusion is based on the result that no LOAEL-based HQs exceeded the critical value of 1.0 for the swallow or raccoon.

- **Benthic Invertebrates –** Potential risks to benthic macroinvertebrates were evaluated by comparing sediment chemical concentrations with sediment screening levels and by conducting toxicity tests with Gorst Creek sediment. The sediment screening results suggest that levels of PCBs in sediment downstream from landfill are great enough to adversely affect benthic macroinvertebrates. The sediment toxicity tests found no effects on survival of laboratory-reared organisms (midge larvae and amphipods) in Gorst Creek sediment. However, three sediment samples showed reduced midge growth and two samples showed reduced amphipod growth compared with clean control sediment. The sample with the lowest midge and amphipod growth (GC03SD) contained the greatest concentrations of Aroclor 1248 and 1254. This sample was collected downstream from the landfill and upstream from Highway 3

- **Fish, Amphibian, and Other Aquatic Organisms Exposed to Surface Water –** No surface water samples were collected in July 2011 because Gorst Creek near the landfill was dry. Hence, potential risks to this assessment endpoint from site-related chemicals were not evaluated.

Overall, this evaluation identified potential risks to several ecological receptor groups using the landfill surface or Gorst Creek near the landfill. On the landfill surface, terrestrial plants, soil invertebrates, and wildlife (songbird and small mammals) may be at risk from high levels of metals in soil; cadmium, lead, nickel, and zinc pose the greatest potential risks. In Gorst Creek downstream from the landfill, sediment PCB levels are great enough to reduce growth of benthic macroinvertebrates. Birds and mammals using the creek are unlikely to be adversely affected by current levels of chemicals in sediment.

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Table D-1. Assessment Endpoints and Measures for Gorst Creek - Bremerton Auto Wrecking Landfill Streamlined Ecological Risk Evaluation.

Assessment Endpoint	Risk Question	Measure Selected for Streamlined Ecological Risk Evaluation	Analysis Approach
Terrestrial Vegetation			
Survival, growth, and reproduction or terrestrial plants	Are levels of contaminants in surface soil from the site greater than benchmarks for effects on survival, growth, or reproduction of terrestrial plants?	Chemical concentrations in soil.	Compare soil chemical concentrations with literature-based toxicity thresholds.
Soil Invertebrates			
Survival, growth, and reproduction or soil invertebrates	Are levels of contaminants in surface soil from the site greater than benchmarks for effects on survival, growth, or reproduction of soil invertebrates?	Chemical concentrations in soil.	Compare soil chemical concentrations with literature-based toxicity thresholds.
Birds			
Survival, growth, and reproduction or birds	Are levels of contaminants in surface soil from the site greater than benchmarks for the survival, growth, or reproduction of birds?	Chemical concentrations in soil.	Compare soil chemical concentrations with literature-based toxicity thresholds.
	Does the daily dose of chemicals received by birds from consumption of prey and other media at the site exceed TRVs for survival, growth, or reproduction of birds?	Chemical concentration in surface water, sediment, soil, and modeled or measured tissue concentrations in prey species.	Modeled dose from diet, surface water ingestion, and incidental ingestion of soil or sediment compared with literature-based TRVs.
Mammals			
Survival, growth, and reproduction or mammals	Are levels of contaminants in surface soil from the site greater than benchmarks for the survival, growth, or reproduction of mammals?	Chemical concentrations in soil.	Compare soil chemical concentrations with literature-based toxicity thresholds.
	Does the daily dose of chemicals received by mammals from consumption of prey and other media at the site exceed TRVs for survival, growth, or reproduction of mammals?	Chemical concentration in surface water, sediment, soil, and modeled or measured tissue concentrations in prey species.	Modeled dose from diet, surface water ingestion, and incidental ingestion of soil or sediment compared with literature-based TRVs.
Reptiles			
Survival, growth, and reproduction or reptiles	None. Quantitative methods for evaluating the toxicity of contaminants to reptiles are poorly developed.	None.	None.
Benthic Invertebrates			
Survival, growth, and reproduction or benthic invertebrates	Are levels of contaminants in sediment from Gorst Creek greater than sediment benchmarks for survival, growth, or reproduction of benthic invertebrates?	Chemical concentrations in sediment.	Compare sediment chemical concentrations with literature-based toxicity thresholds.
	Are survival and growth of benthic invertebrates exposed to sediment downstream from the Gorst Creek landfill significantly lower than those exposed to reference sediments?	Survival and growth of benthic invertebrates in laboratory toxicity tests.	Compare survival and growth of laboratory-reared benthic invertebrates in sediment collected upstream and downstream from the Gorst Creek Landfill. Use growth and survival tests with the freshwater amphipod (*Hyalella azteca*) and midge (*Chironomus dilutus*).
Fish, Amphibians, and Other Aquatic Biota			
Survival, growth, and reproduction or fish, amphibians, and other aquatic biota	Are levels of contaminants in surface water from Gorst Creek greater than water quality criteria and standards for protection of aquatic life?	Chemical concentrations in surface water.	Compare surface water chemical concentrations with federal and state water quality criteria and standards.

Key:
TRVs = toxicity reference values

Table D-2. Gorst Creek Sediment Ecological Screening Results (July 2011 Samples).

Analyte[a]	Sediment Screening Levels			Sample Number, Location, and Concentration			
				GC01SD	GC02SD	GC03SD	GC04SD
				11070002	11070001	11070004	11070003
	TEC	PEC	Other[b]	150 feet Upstream from Landfill (background)	50 feet Upstream from Landfill	Between Landfill and Highway 3	Downstream from Highway 3
Metals (mg/kg)							
Aluminum	--	--	58,000	11900	13400	12300	11200
Arsenic	9.8	33	--	2.03	2.42	1.73	1.11
Barium	--	--	--	43.6	68.4	54.7	44.8
Beryllium	--	--	--	0.119	0.197	0.168	0.181
Cadmium	1	4.98	--	0.111	0.133	0.522	0.605
Calcium	--	--	--	3100	3130	3090	2860
Chromium	43.4	111	--	22.5	23.5	18.1	19.6
Cobalt	--	--	50	7.32	16.9	5.53	6.13
Copper	31.6	149	--	9.94	8.94	38.5	30.5
Iron	--	--	21,200	16600	17500	14600	14400
Lead	35.8	128	--	2.57	4.57	35.3	25.5
Magnesium	--	--	--	4360	3540	4050	4600
Manganese	--	--	460	505	1160	239	237
Mercury	0.18	1.06	--	0.0251	0.00713	0.0593	0.0442
Nickel	22.7	48.6	--	29.6	35.7	33.4	32.3
Potassium	--	--	--	334	281	426	419
Sodium	--	--	--	123	88.5	94.4	113
Zinc	121	459	--	35.4	41	130	115
Semivolatile Organic Compounds (µg/kg)							
All compounds	--	--	--	ND	ND	ND	ND
Polychlorinated Biphenyls (µg/kg)							
Aroclor 1248	60	676	--	ND	ND	**746**	437
Aroclor 1256	60	676	--	ND	ND	**908**	84
Aroclor 1260	60	676	--	ND	7.2	516	248
Pesticides (µg/kg)							
All compounds	--	--	--	ND	ND	ND	ND
Volatile Organic Compounds (µg/kg)[c]							
4-Isopropyltoluene	--	--	--	ND	ND	ND	3.19
Acetone	--	--	--	2.7	ND	ND	3.85
Styrene	--	--	--	ND	ND	0.426	ND

Key:

-- = Not available or not applicable
ND = Non-detect
PEC = Probable effect concentration (MacDonald et al. 2000)
TEC = Threshold effect concentration (MacDonald et al. 2000)
Value = Exceeds TEC or other benchmark.
Value = Exceeds PEC. Adverse effect likely.

Notes:

a = Detected chemicals only are listed.
b = From MacDonald et al. (1999); screening level analogous to TEC.
c = VOCs do not accumulate in sediment; hence, sediment benchmarks typically are not available for VOCs.

Table D-3. Gorst Creek Sediment Bioassay Results (July 2011 Samples).

E & E Sample ID	Laboratory Sample ID	Sample Location	10-day *Chironomus dilutus* (Midge) Test Results				28-day *Hyalella azteca* (Amphipod) Test Results			
			% Mortality (mean ± s.d.)	Significantly Different than Control ($p < 0.05$)?	Average ash free dry weight per midge (mg) (mean ± s.d.)	Significantly Different than Control ($p < 0.05$)?	% Mortality (mean ± s.d.)	Significantly Different than Control ($p < 0.05$)?	Average ash free dry weight per amphipod (mg) (mean ± s.d.)	Significantly Different than Control ($p < 0.05$)?
Control	--	Clean control sediment.	15.0 ± 5.3	--	0.85 ± 0.13	--	5.0 ± 10.7	--	0.50 ± 0.08	--
CG01SD[a]	11070002	150 ft upstream from landfill.	16.3 ± 5.2	No	0.73 ± 0.11	Yes	11.3 ± 9.9	No	0.40 ± 0.06	Yes
GC02SD	11070001	50 ft upstream from landfill.	28.8 ± 19.6	No	0.81 ± 0.18	No	3.8 ± 5.2	No	0.52 ± 0.07	No
GC03SD	11070004	Between landfill and Highway 3.	11.4 ± 6.4	No	0.59 ± 0.10	Yes	3.8 ± 5.2	No	0.33 ± 0.04	Yes
GC04SD	11070003	Downstream from Highway 3.	13.8 ± 11.9	No	0.71 ± 0.09	Yes	6.3 ± 7.4	No	0.50 ± 0.12	No

Key:

ft = feet

p = probability

s.d. = standard deviation

Note: a = Site-specific background sample.

Table D-4. Surface Soil Ecological Screening Results for Samples Collected in July 2011, Gorst Creek - Bremerton Auto Wrecking Landfill.

Analyte[a]	Minimum Detect	Maximum Detect	FoD	Ecological Benchmarks for Soil and Frequency of Exceedance								COPC?	Rationale[d]
				Plant[b]		Soil Invert.[c]		Bird[c]		Mammal[c]			
				Value	FoE	Value	FoE	Value	FoE	Value	FoE		
Metals (mg/kg)													
Aluminum	9160	19300	7/7	--	--	--	--	--	--	--	--	No	MSC
Arsenic	1.25	10.1	7/7	18	0/7	--	--	43	0/7	46	0/7	No	< SL
Barium	47.4	194	7/7	--	--	330	0/7	--	--	2000	0/7	No	< SL
Beryllium	0.132	0.269	7/7	--	--	40	0/7	--	--	21	0/7	No	< SL
Cadmium	0.0942	3.24	7/7	32	0/7	140	0/7	0.77	3/7	0.36	5/7	Yes	SL-W
Calcium	3150	14100	7/7	--	--	--	--	--	--	--	--	No	NUT
Chromium	19.6	47.8	7/7	75	0/7	--	--	26	3/7	34	1/7	Yes	SL-W
Cobalt	5.08	9.93	7/7	13	0/7	--	--	120	0/7	230	0/7	No	< SL
Copper	10.7	83.1	7/7	70	1/7	80	1/7	28	3/7	49	1/7	Yes	SL-P, SL-I, SL-W
Iron	9940	23500	7/7	--	--	--	--	--	--	--	--	No	MSC
Lead	3.21	691	7/7	120	2/7	1700	0/7	11	6/7	56	3/7	Yes	SL-P, SL-W
Mercury	0.00943	1.28	7/7	0.3	2/7	--	--	--	--	--	--	Yes	SL-P
Magnesium	3170	5520	7/7	--	--	--	--	--	--	--	--	No	NUT
Manganese	168	654	7/7	220	6/7	450	1/7	4300	0/7	4000	0/7	Yes	SL-P, SL-I
Nickel	21.8	44.8	7/7	38	3/7	280	0/7	210	0/7	130	0/7	Yes	SL-P
Potassium	382	868	7/7	--	--	--	--	--	--	--	--	No	NUT
Selenium	0.405	0.405	1/7	0.52	0/7	4.1	0/7	1.2	0/7	0.63	0/7	No	< SL
Sodium	74.2	358	7/7	--	--	--	--	--	--	--	--	No	NUT
Thallium	--	--	0/7	1	0/7	--	--	--	--	--	--	No	< SL
Zinc	31.1	836	7/7	160	4/7	120	4/7	46	6/7	79	5/7	Yes	SL-W
Volatile Organic Compounds (µg/kg)													
Acetone	5.12	30.3	3/7	--	--	--	--	--	--	--	--	?	NSL
2-Butanone (MEK)	2.13	2.13	1/7	--	--	--	--	--	--	--	--	?	NSL
Ethylbenzene	0.51	0.51	1/7	--	--	--	--	--	--	--	--	?	NSL
4-Isopropyltoluene	0.315	0.956	2/7	--	--	--	--	--	--	--	--	?	NSL
m,p-Xylene	0.416	0.5	2/7	--	--	--	--	--	--	--	--	?	NSL
Methylene chloride	4.18	4.18	1/7	--	--	--	--	--	--	--	--	?	NSL
Styrene	0.305	1.3	7/7	300000	0/7	--	--	--	--	--	--	No	< SL
Toluene	0.429	1.12	3/7	200000	0/7	--	--	--	--	--	--	No	< SL
Xylenes (total)	0.416	0.5	2/7	--	--	--	--	--	--	--	--	?	NSL
Polychlorinated Biphenyls (PCBs) (µg/kg)													
Aroclor-1248	243	243	1/7	40000	0/7	--	--	--	--	--	--	No	< SL
Aroclor-1254	345	345	1/7	40000	0/7	--	--	--	--	--	--	No	< SL
Aroclor-1260	136	171	1/7	40000	0/7	--	--	--	--	--	--	No	< SL
Pesticides (µg/kg)													
alpha-BHC	25.2	25.2	1/7	--	--	--	--	--	--	--	--	?	NSL
4,4'-DDD	6.37	6.37	1/7	--	--	--	--	93	0/7	21	0/7	No	< SL
4,4'-DDT	9.1	89.9	3/7	--	--	--	--	93	0/7	21	1/7	Yes	SL-W
endosulfan sulfate	42.1	42.1	1/7	--	--	--	--	--	--	--	--	?	NSL
Polycyclic Aromatic Hydrocarbons (PAHs) (µg/kg)													
HPAH sum	218.15	1723.6	3/7	--	--	18000	0/7	--	--	1100	2/7	Yes	SL-W
LPAH sum	326.9	672.6	2/7	--	--	29000	0/7	--	--	100000	0/7	No	< SL
Other Semivolatile Organic Compounds (µg/kg)													
bis(2-Ethylhexyl)phthalate	335	568	2/7	--	--	--	--	--	--	--	--	?	NSL
Butylbenzylphthalate	1230	1230	1/7	--	--	--	--	--	--	--	--	?	NSL

Key:
- -- (double dash) = not available or not applicable
- COPC = chemical of potential concern
- Eco-SSL = Ecological Soil Screening Level
- FoD = frequency of detection (number of detects over total number of samples)
- FoE = frequency of exceedence (number of samples that exceed screening level over total number of samples)
- HPAH = high molecular weight PAH
- LPAH = low molecular weight PAH
- mg/kg = milligrams per kilogram
- PAH = polycyclic aromatic hydrocarbon
- µg/kg = micrograms per kilogram
- ? = status as COPC uncertain
- Value / Value (shaded) = exceeds screening value

Notes:
- a = Detected chemicals only are listed.
- b = Eco-SSLs (www.epa.gov/ecotox/ecossl/), except for chromium, which is from Alloway (1984), and mercury, thallium, styrene, toluene, and PCBs, which are from Efroymson et al. (1997).
- c = Eco-SSLs (www.epa.gov/ecotox/ecossl/).
- d = Rationale codes.
  - For Yes: SL-I = soil invertebrate screening level exceeded.
    SL-P = plant screening level exceeded.
    SL-W = wildlife screening level exceeded.
  - For No: < SL = less than screening level
    MSC = Major soil constituent (of low toxicity; Gough et al. 1979, USEPA 2003).
    NUT = Essential nutrient (USEPA 1989).
  - For ?: NSL = no screening level

Table D-5. Exposure Parameters for Wildlife Species, Gorst Creek - Bremerton Auto Wrecking Landfill Site.

Species	Dietary Composition		Soil or Sediment Ingestion (kg/d) dry	Home Range (ha)	Fraction Soil in Dry Diet	Food Ingestion Rate (kg/d) wet	Percent Water in Diet	Food Ingestion Rate (kg/d) dry	Body Weight (kg wet)
	Earthworms	Aquatic Invertebrates							
Terrestrial Invertivores									
American Robin[a]	100%		0.00019	0.42	0.104	0.093	80%	0.0186	0.077
Masked Shrew[b]	100%		0.00023	0.39	0.13	0.009	80%	0.0018	0.015
Aquatic-Dependent Invertivore									
Barn Swallow[c]		100%	0.00006	0.5	0.02	0.012	75%	0.003	0.0159
Raccoon[d]		100%	0.027	630	0.094	1.1	75%	0.283	5.3

Notes:

a - Diet of 100% earthworms assumed. Home range size, food ingestion (wet), and body mass taken without modification from Sample and Suter (1994). Soil ingestion of 10.4% (of dry diet) assumed based on data from Beyer et al. (1994) for American woodcock.

b - Diet of 100% earthworms assumed. Home-range size, food ingestion (wet), and body mass are for short-tailed shrew and were taken without modification from Sample and Sutter (1994). Soil ingestion of 13% (of dry diet) based on data from Talmage and Walton (1993) as cited in Sample and Suter (1994) .

c - Diet of 100% emergent aquatic insects assumed. Body weight and food ingestion from Sample et al. (1996) for rough-winged swallow (*Stelgidopteryx serripennis*). Soil intake assumed to be 2% of dry food ingestion. Home range of 0.5 ha assumed. Exposure duration based on observations in Wahl (1995).

d - Diet of 100% crayfish assumed. Home range and body weigh from (USEPA 1993b). Food ingestion (dry) calculated from allometric equations presented in Sample et al. (1996). Soil ingestion of 9.4% (of dry diet) based on Beyer et al. (1994).

Table D-6. Surface Soil and Earthworm Exposure Point Concentrations for American Robin and Masked Shrew, Gorst Creek - Bremerton Auto Wrecking Landfill.

Analyte[a]	Minimum Detected Value	Maximum Detected Value	Frequency of Detection	Soil EPC	BAF[b]	Earthworm EPC
Polychlorinated Biphenyls (µg/kg)						
Aroclor-1248	243	243	1/7	243	See note c	597
Aroclor-1254	345	345	1/7	345	See note c	962
Aroclor-1260	136	171	1/7	171	See note c	370
Metals (mg/kg)						
Arsenic	1.25	10.1	7/7	10.1	See note c	1.24
Barium	47.4	194	7/7	194	0.091	17.7
Beryllium	0.132	0.269	7/7	0.269	0.045	0.012
Cadmium	0.0942	3.24	7/7	3.24	See note c	21.1
Chromium	19.6	47.8	7/7	47.8	0.306	14.6
Cobalt	5.08	9.93	7/7	9.93	0.122	1.21
Copper	10.7	83.1	7/7	83.1	0.515	42.8
Lead	3.21	691	7/7	691	See note c	157
Manganese	168	654	7/7	654	See note c	37.1
Mercury	0.00943	1.28	7/7	1.28	See note c	0.52
Nickel	21.8	44.8	7/7	44.8	1.059	47.4
Selenium	0.405	0.405	1/7	0.405	See note c	0.48
Zinc	31.1	836	7/7	836	See note c	777
Volatile Organic Compounds (µg/kg)						
Acetone	5.12	30.3	3/7	30.3	1	30.3
2-Butanone (MEK)	2.13	2.13	1/7	2.13	1	2.13
Ethylbenzene	0.51	0.51	1/7	0.51	1	0.51
4-Isopropyltoluene	0.315	0.956	2/7	0.956	1	0.96
m,p-Xylene	0.416	0.5	2/7	0.5	1	0.5
Methylene chloride	4.18	4.18	1/7	4.18	1	4.18
Styrene	0.305	1.3	7/7	1.3	1	1.3
Toluene	0.429	1.12	3/7	1.12	1	1.12
Xylenes (total)	0.416	0.5	2/7	0.5	1	0.5
Pesticides (µg/kg)						
alpha-BHC	25.2	25.2	1/7	25.2	1	25.2
4,4'-DDD	6.37	6.37	1/7	6.37	See note c	11.6
4,4'-DDT	9.1	89.9	3/7	89.9	See note c	417
Endosulfan sulfate	42.1	42.1	1/7	42.1	1	42.1
Polycyclic Aromatic Hydrocarbons (µg/kg)						
HPAH sum	218	1724	3/7	1724	2.6	4481
LPAH sum	327	673	2/7	673	3.0	2045
Other Semivolatile Organic Compounds (µg/kg)						
Bis(2-ethylhexyl)phthalate	335	568	2/7	568	1	568
Butylbenzylphthalate	1230	1230	1/7	1230	1	1230

Key:

BAF = Bioaccumulation factor

EPC = Exposure Point Concentration

HPAH = high molecular weight PAH

LPAH = low molecular weigjht PAH

PAH = polycyclic aromatic hydrocarbon

mg/kg = milligrams per kilogram

µg/kg = micrograms per kilogram

Notes:

a. Detected chemicals only are listed. Essential nutrients (calcium, iron, magnesium, sodium, and potassium) and major soil constitutes (aluminum) were excluded from the evaluation as per USEPA guidance (USEPA 1989, 2003).

b. Soil-to-earthworm BAFs from USEPA (2005a), except for nickel, which is from Sample et al. (1998). BAF of 1 assumed for chemicals not addressed by USEPA (2005a) or Sample et al. (1998).

c. Soil-to-earthworm uptake equation from USEPA (2005a) used to calculate earthworm EPC.

Table D-7. Sediment and Benthic Invertebrate Exposure Point Concentrations for Barn Swallow and Raccoon, Gorst Creek - Bremerton Auto Wrecking Landfill.

Analyte[a]	Minimum Detected value	Maximum Detected value	Frequency of Detection	Sediment EPC	BSAF[b]	Benthic Invertebrate EPC
Polychlorinated Biphenyls (µg/kg)						
Aroclor-1248	437	746	2/4	746	4.67	3,484
Aroclor-1254	84	908	2/4	908	4.67	4,240
Aroclor-1260	7.2	516	3/4	516	4.67	2,410
Metals (mg/kg)						
Arsenic	1.11	2.42	4/4	2.42	See note c	1.0
Barium	43.6	68.4	4/4	68.4	1	68
Beryllium	0.119	0.197	4/4	0.197	1	0.20
Cadmium	0.111	0.605	4/4	0.605	See note c	0.8
Chromium	18.1	23.5	4/4	23.5	See note c	5.1
Cobalt	5.53	16.9	4/4	16.9	1	16.9
Copper	8.94	38.5	4/4	38.5	See note c	33.9
Lead	2.57	35.5	4/4	35.5	See note c	2.9
Manganese	237	1,160	4/4	1,160	1	1,160
Mercury	0.00713	0.0593	4/4	0.0593	1.136	0.067
Nickel	29.6	35.7	4/4	35.7	0.486	17.4
Zinc	35.4	130	4/4	130	See note c	174
Volatile Organic Compounds (µg/kg)						
Acetone	2.7	3.85	2/4	3.85	1	3.85
4-Isopropyltoluene	3.19	3.19	1/4	3.19	1	3.19
Styrene	0.426	0.426	1/4	0.426	1	0.43

Key:

BSAF = Biota Sediment Accumulation Factor

EPC = Exposure Point Concentration

mg/kg = milligrams per kilogram

µg/kg = micrograms per kilogram

Notes:

a. Detected chemicals only are listed. Essential nutrients (calcium, iron, magnesium, sodium, and potassium) and major soil constitutes (aluminum) were excluded from the evaluation as per USEPA guidance (USEPA 1989, 2003).

b. From Bechtel Jacobs (1998). BSAF of 1 assumed for chemicals not addressed by Bechtel Jacobs (1998)

c. Sediment-to-benthic invertebrate uptake equation from Bechtel Jacobs (1998) used to calculate benthic invert. EPC.

Table D-8. Toxicity Reference Values for Birds and Mammals.

Analyte	Wildlife Class	NOAEL (mg/kg-day)	Critical Effect	LOAEL (mg/kg-day)	Critical Effect	Reference and Comments
Polychlorinated Biphenyls						
Aroclors 1254	Birds	0.18	Reproduction	1.8	Reproduction	Sample et al. (1996) for Aroclor 1254.
	Mammals	0.14	Reproduction	0.69	Reproduction	Sample et al. (1996) for Aroclor 1254 effects on mink.
Metals						
Arsenic	Birds	2.24	Reproduction	3.55	Growth	USEPA(2005b). Lowest NOAEL for growth, reproduction, or survival from nine laboratory toxicity studies. Lowest LOAEL for growth, reproduction, or survival greater than selected NOAEL.
	Mammals	1.04	Growth	1.66	Growth	USEPA (2005b). Highest bounded NOAEL for growth, reproduction, or survival less than lowest bounded LOAEL for growth, reproduction, or survival from 62 laboratory toxicity studies.
Barium	Birds	20.8	Survival	41.7	Survival	Sample et al. (1996).
	Mammals	51.8	Reproduction, growth, and survival	121	Growth and survival	USEPA (2005c). Geometric mean NOAEL for growth, reproduction, and survival from 12 laboratory toxicity studies. Lowest bounded LOAEL for reproduction, growth, or survival greater than geometric mean NOAEL.
Beryllium	Birds	na	na	na	na	na
	Mammals	0.532	Survival	na	na	USEPA (2005d). Lowest NOAEL for growth, reproduction, or survival from four laboratory toxicity studies.
Cadmium	Birds	1.47	Reproduction, growth, and survival	2.37	Reproduction	USEPA (2005e). Geometric mean NOAEL for growth, reproduction, and survival from 49 laboratory toxicity studies. Lowest bounded LOAEL for growth, reproduction, or survival greater than geometric mean NOAEL.
	Mammals	0.77	Growth	1	Growth	USEPA (2005e). Highest bounded NOAEL (0.77 mg/kg-d) for reproduction, growth, or survival less than the lowest bounded LOAEL (1.0 mg/kg-d) from 141 laboratory toxicity studies.
Chromium	Birds	2.66	Reproduction, growth, and survival	2.78	Survival	USEPA (2008). Geometric mean NOAEL for growth, reproduction, and survival from 17 laboratory toxicity studies. Lowest bounded LOAEL for reproduction, growth, or survival greater than geometric mean NOAEL.
	Mammals	9.24	Reproduction and growth	na	na	USEPA (2008). Geometric mean NOAEL for reproduction and growth from 10 studies with trivalent chromium.
Cobalt	Birds	7.61	Growth	7.8	Growth	USEPA (2005f). Geometric mean NOAEL for growth from 10 toxicity studies. Lowest bounded LOAEL for growth or reproduction greater than geometric mean NOAEL.
	Mammals	7.33	Reproduction and Growth	10.9	Reproduction	USEPA (2005f). Geometric mean NOAEL for reproduction and growth based on 21 laboratory toxicity studies. Lowest bounded LOAEL for growth or reproduction greater than geometric mean NOAEL.
Copper	Birds	4.05	Reproduction	4.68	Growth	USEPA (2007a). Highest bounded NOAEL for reproduction, growth, or survival (4.05 mg/kg-day) lower than the lowest bounded LOAEL for reproduction, growth, or survival (4.68 mg/kg-day).
	Mammals	5.6	Reproduction	6.79	Growth	USEPA (2007a). Highest bounded NOAEL for reproduction, growth, or survival (5.6 mg/kg-day) lower than the lowest bounded LOAEL for reproduction, growth, or survival (6.79 mg/kg-day).
Lead	Birds	1.63	Reproduction	1.94	Reproduction	USEPA (2005g). Highest bounded NOAEL (1.63 mg/kg-d) for growth, reproduction, or survival lower than the lowest bounded LOAEL (1.94 mg/kg-d) for growth, reproduction, or survival based on 57 laboratory toxicity studies.
	Mammals	4.7	Growth	5	Growth	USEPA (2005g). Highest bounded NOAEL (4.7 mg/kg-d) for growth, reproduction, or survival lower than the lowest bounded LOAEL (5 mg/kg-d) for growth, reproduction, or survival based on 220 laboratory toxicity studies.
Manganese	Birds	179	Reproduction and Growth	348	Growth	USEPA (2007b). Geometric mean NOAEL for reproduction and growth. Lowest bounded LOAEL for reproduction or growth greater than geometric mean NOAEL.
	Mammals	51.5	Reproduction and Growth	65	Growth	USEPA (2007b). Geometric mean NOAEL for reproduction and growth. Lowest bounded LOAEL for reproduction or growth greater than geometric mean NOAEL.

Table D-8. Toxicity Reference Values for Birds and Mammals.

Analyte	Wildlife Class	NOAEL (mg/kg-day)	Critical Effect	LOAEL (mg/kg-day)	Critical Effect	Reference and Comments
Mercury	Birds	0.45	Reproduction	0.9	Reproduction	Sample et al. (1996).
	Mammals	13.2	Reproduction and survival	na	na	Sample et al. (1996).
Nickel	Birds	6.71	Growth and survival	11.5	Growth	USEPA (2007c). Geometric mean NOAEL for reproduction and growth. Lowest bounded LOAEL for reproduction or growth greater than geometric mean NOAEL.
	Mammals	1.7	Reproduction	2.71	Reproduction	USEPA (2007c). Highest bounded NOAEL for reproduction, growth, or survival below lowest bounded LOAEL for reproduction, growth, or survival.
Selenium	Birds	0.291	Survival	0.368	Reproduction	USEPA (2007d). Highest bounded NOAEL for reproduction, growth, or survival below lowest bounded LOAEL for reproduction, growth, or survival.
	Mammals	0.143	Growth	0.145	Reproduction	USEPA (2007d). Highest bounded NOAEL for reproduction, growth, or survival below lowest bounded LOAEL for reproduction, growth, or survival.
Zinc	Birds	66.1	Reproduction and Growth	66.5	Reproduction	USEPA (2007e). Geometric mean NOAEL for reproduction and growth. Lowest bounded LOAEL for reproduction or growth greater than geometric mean NOAEL.
	Mammals	75.4	Reproduction and Growth	75.9	Reproduction	USEPA (2007e). Geometric mean NOAEL for reproduction and growth. Lowest bounded LOAEL for reproduction or growth greater than geometric mean NOAEL.
Volatile Organic Compounds						
Acetone	Birds	na	na	na	na	na
	Mammals	10	Kidney damage	50	Kidney damage	Sample et al. (1996).
2-Butanone (MEK)	Birds	na	na	na	na	na
	Mammals	1771	Reproduction	4571	Reproduction	Sample et al. (1996).
Ethylbenzene	Birds	na	na	na	na	na
	Mammals	na	na	na	na	na
4-Isopropyltoluene	Birds	na	na	na	na	na
	Mammals	na	na	na	na	na
m,p-Xylene	Birds	na	na	na	na	na
	Mammals	2.1	Reproduction	2.6	Reproduction	Sample et al. (1996), for xylene (mixed isomers).
Methylene chloride	Birds	na	na	na	na	na
	Mammals	5.85	Liver histology	50	Liver histology	Sample et al. (1996).
Styrene	Birds	na	na	na	na	na
	Mammals	na	na	na	na	na
Toluene	Birds	na	na	na	na	na
	Mammals	26	Reproduction	260	Reproduction	Sample et al. (1996).
Xylenes (total)	Birds	na	na	na	na	na
	Mammals	2.1	Reproduction	2.6	Reproduction	Sample et al. (1996), for xylene (mixed isomers).
Pesticides						
DDT and metabolites	Birds	0.227	Growth	0.281	Reproduction	USEPA (2007f). Highest bounded NOAEL below the lowest bounded LOAEL for reproduction, growth, or survival.
	Mammals	0.147	Reproduction	0.247	Reproduction	
Alpha-BHC	Birds	0.56	Reproduction	2.25	Reproduction	Sample et al. (1996) for BHC mixed isomers.
	Mammals	0.014	Reproduction	0.14	Reproduction	Sample et al. (1996) for BHC mixed isomers.
Endosulfan Sulfate	Birds	11.1	Reproduction	na	na	NYSDEC (2002).
	Mammals	0.15	na	na	na	NYSDEC (2002).
Polycyclic Aromatic Hydrocarbons						
LPAHs	Birds	na	na	na	na	na
	Mammals	65.6	Growth	110	Growth	USEPA (2007g). Highest bounded NOAEL (65.5 mg/kg-d) below the lowest bounded LOAEL (110 mg/kg-d) for reproduction, growth, or survival.
HPAHs	Birds	2	Growth	20	Growth	USEPA (2007g); from Appendix 5.2A for European starling.
	Mammals	0.615	Survival	3.07	Survival	USEPA (2007g). Highest bounded NOAEL (0.615 mg/kg-day) below the lowest bounded LOAEL (3.07 mg/kg-day) for reproduction, growth, or survival.

Table D-8. Toxicity Reference Values for Birds and Mammals.

Analyte	Wildlife Class	NOAEL (mg/kg-day)	Critical Effect	LOAEL (mg/kg-day)	Critical Effect	Reference and Comments
Other Semivolatile Organic Compounds						
Bis(2-ethylhexyl)phthalate	Birds	1.11	Reproduction	na	na	Sample et al. (1996).
	Mammals	18.33	Reproduction	183.3	Reproduction	Sample et al. (1996).
Butyl Benzyl Phthalate	Birds	na	na	na	na	na
	Mammals	na	na	na	na	na

Key:
DDT = dichlorodiphenyltrichloroethane
HPAH = high molecular weight PAH
LOAEL = lowest observed adverse effect level
LPAH = low molecular weight PAH
MEK = methyl ethyl ketone
mg/kg/day = milligrams per kilogram per day
na = no available
NOAEL = no observed adverse effect level
NYSDEC = New York State Department of Environmental Conservation
TRV = toxicity reference value

Table D-9. American Robin Exposure Estimates and Hazard Quotients, Gorst Creek - Bremerton Auto Wrecking Landfill.

Analyte[a]	Soil EPC[b]	EE-soil (mg/kg/d)	EE-diet (mg/kg/d)	EE-total (mg/kg/d)	NOAEL (mg/kg/d)	LOAEL (mg/kg/d)	HQ-NOAEL	HQ-LOAEL
Polychlorinated Biphenyls								
Aroclor-1248	243	0.001	0.14	0.14	0.18	1.8	0.8	0.08
Aroclor-1254	345	0.001	0.23	0.23	0.18	1.8	1.3	0.13
Aroclor-1260	171	0.0004	0.09	0.09	0.18	1.8	0.5	0.05
Metals								
Arsenic	10.1	0.025	0.30	0.32	2.24	3.55	0.14	0.09
Barium	194	0.479	4.26	4.74	20.8	41.7	0.23	0.11
Beryllium	0.269	0.001	0.003	0.004	NA	NA	NA	NA
Cadmium	3.24	0.008	5.09	5.10	1.47	2.37	3.5	2.2
Chromium	47.8	0.118	3.53	3.65	2.66	2.78	1.4	1.3
Cobalt	9.93	0.025	0.29	0.32	7.61	7.8	0.042	0.041
Copper	83.1	0.205	10.34	10.54	4.05	4.68	2.6	2.3
Lead	691	1.705	38.00	39.71	1.63	1.94	24	20
Manganese	654	1.614	8.95	10.57	179	348	0.06	0.03
Mercury	1.28	0.003	0.13	0.13	0.45	0.9	0.29	0.14
Nickel	44.8	0.111	11.46	11.57	6.71	11.5	1.7	1.0
Selenium	0.405	0.001	0.12	0.12	0.291	0.368	0.40	0.32
Zinc	836	2.063	187.79	189.86	66.1	66.5	2.87	2.85
Volatile Organic Compounds								
Acetone	30.3	7.5E-05	7.3E-03	7.4E-03	NA	NA	NA	NA
2-Butanone (MEK)	2.13	5.3E-06	5.1E-04	5.2E-04	NA	NA	NA	NA
Ethylbenzene	0.51	1.3E-06	1.2E-04	1.2E-04	NA	NA	NA	NA
4-Isopropyltoluene	0.956	2.4E-06	2.3E-04	2.3E-04	NA	NA	NA	NA
m,p-Xylene	0.5	1.2E-06	1.2E-04	1.2E-04	NA	NA	NA	NA
Methylene chloride	4.18	1.0E-05	1.0E-03	1.0E-03	NA	NA	NA	NA
Styrene	1.3	3.2E-06	3.1E-04	3.2E-04	NA	NA	NA	NA
Toluene	1.12	2.8E-06	2.7E-04	2.7E-04	NA	NA	NA	NA
Xylenes (total)	0.5	1.2E-06	1.2E-04	1.2E-04	NA	NA	NA	NA
Pesticides								
alpha-BHC	25.2	6.2E-05	6.1E-03	6.1E-03	0.56	2.25	0.011	0.003
4,4'-DDD	6.37	1.6E-05	2.8E-03	2.8E-03	0.227	0.281	0.012	0.010
4,4'-DDT	89.9	2.2E-04	1.0E-01	1.0E-01	0.227	0.281	0.44	0.36
Endosulfan sulfate	42.1	1.0E-04	1.0E-02	1.0E-02	11.1	NA	0.001	NA
Polycyclic Aromatic Hydrocarbons								
HPAH sum	1723.6	0.004	1.08	1.09	2	20	0.54	0.05
LPAH sum	672.6	0.002	0.49	0.50	NA	NA	NA	NA
Other Semivolatile Organic Compounds								
Bis(2-Ethylhexyl)phthalate	335	0.001	0.14	0.14	1.11	NA	0.12	NA
Butylbenzylphthalate	1230	0.003	0.30	0.30	NA	NA	NA	NA

Key:
EE-diet = estimated chemical exposure from diet
EE-soil = estimated chemical exposure from incidental soil ingestion
EE-total = total chemical exposure
EPC = exposure point concentration
HPAH = high molecular weight PAH
HQ = hazard quotient
LOAEL = lowest observed adverse effect level
LPAH = low molecular weight PAH
NOAEL = no observed adverse effect level
mg/kg = Milligrams per kilogram
mg/kg/day = Milligrams per kilogram per day
μg/kg = micrograms per kilogram
NA = Not available
Grey shading = HQ exceeds 1.0

Note:
a = Chemicals detected in surface soil are listed. Essential nutrients (calcium, iron, magnesium, sodium, and potassium) and major soil constitutes (aluminum) were excluded from the evaluation as per USEPA guidance (USEPA 1989, 2003).
b = mg/kg for metals. μg/kg for other analytes.

Table D-10. Masked Shrew Exposure Estimates and Hazard Quotients, Gorst Creek - Bremerton Auto Wrecking Landfill.

Analyte[a]	Soil EPC [b]	EE-soil (mg/kg/d)	EE-diet (mg/kg/d)	EE-total (mg/kg/d)	NOAEL (mg/kg/d)	LOAEL (mg/kg/d)	HQ-NOAEL	HQ-LOAEL
Polychlorinated Biphenyls								
Aroclor-1248	243	0.004	0.07	0.08	0.14	0.69	0.54	0.11
Aroclor-1254	345	0.005	0.12	0.12	0.14	0.69	0.86	0.18
Aroclor-1260	171	0.003	0.04	0.05	0.14	0.69	0.34	0.07
Metals								
Arsenic	10.1	0.15	0.15	0.30	1.04	1.66	0.29	0.18
Barium	194	2.97	2.12	5.09	51.8	121	0.10	0.04
Beryllium	0.269	0.004	0.001	0.01	0.532	NA	0.01	NA
Cadmium	3.24	0.050	2.53	2.58	0.77	1	3.4	2.6
Chromium	47.8	0.73	1.76	2.49	9.24	NA	0.27	NA
Cobalt	9.93	0.15	0.15	0.30	7.33	10.9	0.041	0.027
Copper	83.1	1.27	5.14	6.41	5.6	6.79	1.1	0.94
Lead	691	10.6	18.9	29.5	4.7	5	6.3	5.9
Manganese	654	10.0	4.4	14.5	51.5	65	0.28	0.22
Mercury	1.28	0.020	0.062	0.08	13.2	NA	0.006	NA
Nickel	44.8	0.687	5.69	6.38	1.7	2.71	3.8	2.4
Selenium	0.405	0.006	0.057	0.06	0.143	0.145	0.44	0.44
Zinc	836	12.8	93.3	106.1	75.4	75.9	1.41	1.40
Volatile Organic Compounds								
Acetone	30.3	4.6E-04	3.6E-03	4.1E-03	10	50	4.1E-04	8.2E-05
2-Butanone (MEK)	2.13	3.3E-05	2.6E-04	2.9E-04	1771	4571	1.6E-07	6.3E-08
Ethylbenzene	0.51	7.8E-06	6.1E-05	6.9E-05	NA	NA	NA	NA
4-Isopropyltoluene	0.956	1.5E-05	1.1E-04	1.3E-04	NA	NA	NA	NA
m,p-Xylene	0.5	7.7E-06	6.0E-05	6.8E-05	2.1	2.6	3.2E-05	2.6E-05
Methylene chloride	4.18	6.4E-05	5.0E-04	5.7E-04	5.85	50	9.7E-05	1.1E-05
Styrene	1.3	2.0E-05	1.6E-04	1.8E-04	NA	NA	NA	NA
Toluene	1.12	1.7E-05	1.3E-04	1.5E-04	26	260	5.8E-06	5.8E-07
Xylenes (total)	0.5	7.7E-06	6.0E-05	6.8E-05	2.1	2.6	3.2E-05	2.6E-05
Pesticides								
alpha-BHC	25.2	3.9E-04	3.0E-03	3.4E-03	0.014	0.14	0.24	0.02
4,4'-DDD	6.37	9.8E-05	1.4E-03	1.5E-03	0.147	0.247	0.01	0.01
4,4'-DDT	89.9	1.4E-03	5.0E-02	5.1E-02	0.147	0.247	0.35	0.21
Endosulfan sulfate	42.1	6.5E-04	5.1E-03	5.7E-03	0.15	NA	0.04	NA
Polycyclic Aromatic Hydrocarbons								
HPAH sum	1723.6	0.026	0.54	0.56	0.615	3.07	0.92	0.18
LPAH sum	672.6	0.010	0.25	0.26	65.6	110	0.004	0.002
Other Semivolatile Organic Compounds								
Bis(2-Ethylhexyl)phthalate	335	0.005	0.07	0.07	18.33	183.3	0.004	0.0004
Butylbenzylphthalate	1230	0.019	0.15	0.17	NA	NA	NA	NA

Key:
EE-diet = estimated chemical exposure from diet
EE-soil = estimated chemical exposure from incidental soil ingestion
EE-total = total chemical exposure
EPC = exposure point concentration
HPAH = high molecular weight PAH
HQ = hazard quotient
LOAEL = lowest observed adverse effect level
LPAH = low molecular weight PAH
NOAEL = no observed adverse effect level
mg/kg = milligrams per kilogram
mg/kg/day = milligrams per kilogram per day
μg/kg = micrograms per kilogram
NA = not available
Grey shading = HQ exceeds 1.0

Note:
a = Chemicals detected in surface soil are listed. Essential nutrients (calcium, iron, magnesium, sodium, and potassium) and major soil constitutes (aluminum) were excluded from the evaluation as per USEPA guidance (USEPA 1989, 2003).
b = mg/kg for metals. μg/kg for other analytes.

Table D-11. Swallow Exposure Estimates and Hazard Quotients, Gorst Creek - Bremerton Auto Wrecking Landfill.

Analyte[a]	Sediment EPC[b]	EE-sediment (mg/kg/d)	EE-diet (mg/kg/d)	EE-total (mg/kg/d)	NOAEL (mg/kg/d)	LOAEL (mg/kg/d)	HQ-NOAEL	HQ-LOAEL
Polychlorinated Biphenyls								
Aroclor-1248	746	2.8E-03	0.66	0.66	0.18	1.8	3.7	0.37
Aroclor-1254	908	3.4E-03	0.80	0.80	0.18	1.8	4.5	0.45
Aroclor-1260	516	1.9E-03	0.45	0.46	0.18	1.8	2.5	0.25
Metals								
Arsenic	2.42	0.01	0.19	0.20	2.24	3.55	0.088	0.055
Barium	68.4	0.26	12.9	13.2	20.8	41.7	0.63	0.32
Beryllium	0.197	0.001	0.04	0.04	NA	NA	NA	NA
Cadmium	0.605	0.002	0.15	0.15	1.47	2.37	0.10	0.06
Chromium	23.5	0.09	0.97	1.06	2.66	2.78	0.40	0.38
Cobalt	16.9	0.06	3.19	3.25	7.61	7.8	0.43	0.42
Copper	38.5	0.15	6.39	6.54	4.05	4.68	1.6	1.4
Lead	35.5	0.13	0.55	0.69	1.63	1.94	0.42	0.35
Manganese	1,160	4.38	219	223	179	348	1.2	0.64
Mercury	0.0593	0.0002	0.013	0.013	0.45	0.9	0.029	0.014
Nickel	35.7	0.13	3.3	3.4	6.71	11.5	0.51	0.30
Zinc	130	0.49	32.8	33.3	66.1	66.5	0.50	0.50
Volatile Organic Compounds								
Acetone	3.85	1.5E-05	7.3E-04	7.4E-04	NA	NA	NA	NA
4-Isopropyltoluene	3.19	1.2E-05	6.0E-04	6.1E-04	NA	NA	NA	NA
Styrene	0.426	1.6E-06	8.0E-05	8.2E-05	NA	NA	NA	NA

Key:

EE-diet = estimated chemical exposure from diet

EE-sediment = estimated chemical exposure from incidental sediment ingestion

EE-total = total chemical exposure

EPC = exposure point concentration

HQ = hazard quotient

LOAEL = lowest observed adverse effect level

NOAEL = no observed adverse effect level

mg/kg = milligrams per kilogram

mg/kg/day = milligrams per kilogram per day

µg/kg = micrograms per kilogram

NA = Not available

Grey shading = HQ exceed 1.0

Note:

a = Chemicals detected in sediment are listed. Essential nutrients (calcium, iron, magnesium, sodium, and potassium) and major soil /sediment constitutes (aluminum) were excluded from the evaluation as per USEPA guidance (USEPA 1989, 2003).

b = mg/kg for metals. µg/kg for other analytes.

Table D-12. Raccoon Exposure Estimates and Hazard Quotients, Gorst Creek - Bremerton Auto Wrecking Landfill.

Analyte[a]	Sediment EPC[b]	EE-sediment (mg/kg/d)	EE-diet (mg/kg/d)	EE-total (mg/kg/d)	NOAEL (mg/kg/d)	LOAEL (mg/kg/d)	HQ-NOAEL	HQ-LOAEL
Polychlorinated Biphenyls								
Aroclor-1248	746	0.004	0.19	0.19	0.14	0.69	1.36	0.28
Aroclor-1254	908	0.005	0.23	0.23	0.14	0.69	1.65	0.33
Aroclor-1260	516	0.003	0.13	0.13	0.14	0.69	0.94	0.19
Metals								
Arsenic	2.42	0.012	0.053	0.065	1.04	1.66	0.06	0.04
Barium	68.4	0.348	3.7	4.0	51.8	121	0.08	0.03
Beryllium	0.197	0.001	0.011	0.01	0.532	NA	0.02	NA
Cadmium	0.605	0.003	0.041	0.04	0.77	1	0.06	0.04
Chromium	23.5	0.120	0.274	0.39	9.24	NA	0.04	NA
Cobalt	16.9	0.086	0.902	0.99	7.33	10.9	0.13	0.09
Copper	38.5	0.196	1.808	2.00	5.6	5.79	0.36	0.35
Lead	35.5	0.181	0.156	0.34	4.7	5	0.07	0.07
Manganese	1,160	5.9	62	68	51.5	65	1.32	1.04
Mercury	0.0593	0.0003	0.004	0.00	13.2	NA	0.0003	NA
Nickel	35.7	0.182	0.926	1.11	1.7	2.71	0.65	0.41
Zinc	130	0.662	9.273	9.94	75.4	75.9	0.13	0.13
Volatile Organic Compounds								
Acetone	3.85	2.0E-05	2.1E-04	2.3E-04	10	50	2.3E-05	4.5E-06
4-Isopropyltoluene	3.19	1.6E-05	1.7E-04	1.9E-04	NA	NA	NA	NA
Styrene	0.426	2.2E-06	2.3E-05	2.5E-05	NA	NA	NA	NA

Key:

EE-diet = estimated chemical exposure from diet

EE-sediment = estimated chemical exposure from incidental sediment ingestion

EE-total = total chemical exposure

EPC = exposure point concentration

HQ = hazard quotient

LOAEL = lowest observed adverse effect level

NOAEL = no observed adverse effect level

mg/kg = milligrams per kilogram

mg/kg/day = milligrams per kilogram per day

µg/kg = micrograms per kilogram

NA = Not available

Grey shading = HQ > 1

Note:

a = Chemicals detected in sediment are listed. Essential nutrients (calcium, iron, magnesium, sodium, and potassium) and major soil/sediment constitutes (aluminum) were excluded from the evaluation as per USEPA guidance (USEPA 1989, 2003).

b = mg/kg for metals. µg/kg for other analytes.

Table D-13. Effect of Exposure Duration, Site Use, and Exposure Point Concentration on Wildlife Hazard Quotients.

Analyte	Highly Conservative Case[a]					Moderately Conservative Case					
	SUF	ED	EPC Max.[b] (mg/kg)	HQ-NOAEL	HQ-LOAEL	SUF	ED	EPC (ProUCL Recommendation) Value	EPC (ProUCL Recommendation) Basis	HQ-NOAEL	HQ-LOAEL
American Robin											
Aroclor 1254	1	1	0.345	1.3	0.13	1	0.5	345	Maximum concentration	0.65	0.07
Cadmium	1	1	3.24	3.5	2.2	1	0.5	2.36	95% Approximate gamma UCL	1.4	0.85
Chromium	1	1	47.8	1.4	1.3	1	0.5	36.6	95% Student's-t UCL	0.55	0.51
Copper	1	1	83.1	2.6	2.3	1	0.5	55.9	95% Approximate gamma UCL	0.90	0.75
Lead	1	1	691	24	20	1	0.5	691	Maximum concentration	12	10
Nickel	1	1	44.8	1.7	1.0	1	0.5	40.5	95% Student's-t UCL	0.8	0.46
Zinc	1	1	836	2.87	2.85	1	0.5	527	95% Student's-t UCL	1.23	1.23
Masked Shrew											
Cadmium	1	1	3.24	3.4	2.6	1	1	2.36	95% Approximate gamma UCL	2.6	2.0
Copper	1	1	83.1	1.1	0.94	1	1	55.9	95% Approximate gamma UCL	0.8	0.6
Lead	1	1	691	6.3	5.9	1	1	691	Maximum concentration	6.3	5.9
Nickel	1	1	44.8	3.8	2.4	1	1	40.5	95% Student's-t UCL	3.4	2.1
Zinc	1	1	836	1.41	1.40	1	1	527	95% Student's-t UCL	1.17	1.16
Barn Swallow											
Aroclor 1248	1	1	0.746	3.7	0.5	0.5	0.5	0.746	Maximum concentration	0.93	0.13
Aroclor 1254	1	1	0.908	4.5	0.45	0.5	0.5	0.908	Maximum concentration	1.1	0.11
Aroclor 1260	1	1	0.516	2.5	0.25	0.5	0.5	0.516	Maximum concentration	0.63	0.06
Copper	1	1	38.5	1.6	1.4	0.5	0.5	38.5	Maximum concentration	0.40	0.35
Manganese	1	1	1160	1.2	0.64	0.5	0.5	1160	Maximum concentration	0.30	0.16
Raccoon											
Aroclor 1248	1	1	0.746	1.4	0.28	0.0003	1	0.746	Maximum concentration	0.0004	0.0001
Aroclor 1254	1	1	0.908	1.7	0.33	0.0003	1	0.908	Maximum concentration	0.0005	0.0001
Manganese	1	1	1160	1.3	1.04	0.0003	1	1160	Maximum concentration	0.0004	0.0003

Notes:

a = Robin, shrew, swallow, and raccoon HQs from Tables X-9 to X-12, respectively.

b = Maximum soil concentration for robin and shrew. Maximum sediment concentration for swallow and raccoon.

Key:

ED = exposure duration (i.e. fraction of year spent at site)

EPC = exposure point concentration

HQ = hazard quotient

LOAEL = lowest observed adverse effect level

NOAEL = no observed adverse effect level

SUF = site use factor (i.e. fraction of receptor's home range represented by the site).

UCL = upper confidence limit

Table D-14. Summary of Chemicals Exceeding Screening Levels or Toxicity Reference Values, Gorst Creek - Bremerton Auto Wrecking Site.

	Environmental Medium and Receptor Group						
	Soil				Sediment		
		Soil	Wildlife[d]			Wildlife[f]	
Analyte[a]	Plants[b]	Fauna[c]	NOAEL	LOAEL	Benthos[e]	NOAEL	LOAEL
Polychlorinated Biphenyls							
Aroclor 1248					X	X	
Aroclor 1254			X		X	X	
Aroclor 1260					X	X	
Metals							
Arsenic							
Barium							
Beryllium							
Cadmium			X	X			
Chromium			X	X			
Cobalt							
Copper	X	X	X	X	X	X	X
Lead	X		X	X			
Manganese	X	X			X	X	X
Mercury	X						
Nickel	X		X	X	X		
Selenium							
Zinc	X	X	X	X	X		
Volatile Organic Compounds							
Acetone							
2-Butanone (MEK)							
Ethylbenzene							
4-Isopropyltoluene							
m,p-Xylene							
Methylene chloride							
Styrene							
Toluene							
Xylenes (total)							
Pesticides							
alpha-BHC							
4,4'-DDD							
4,4'-DDT							
Endosulfan sulfate							
Polycyclic Aromatic Hydrocarbons							
HPAH sum							
LPAH sum							
Other Semivolatile Organic Compounds							
Bis(2-ethylhexyl)phthalate							
Butylbenzylphthalate							

Key:
HPAH = high molecular weight PAH
LOAEL = Lowest observed adverse effect
LPAH = low molecular weight PAH
MEK = methyl ethyl ketone
NOAEL = No observed adverse effect level
TRV = toxicity reference value
X = screening level exceeded or HQ > 1.
X = Likely chemical of concern for wildlife (see Table X-13 and Section X.4.5.1.4) or benthos (see Section X.4.1.2).

Notes:
a = Chemicals detected in soil or sediment are listed.
b - Based on comparing soil chemical concentrations with soil screening levels for plants (see Table X-4).
c - Based on comparing soil chemical concentrations with soil screening levels for earthworms (see Table X-4).
d - Based on modeled exposure estimates for the American robin and masked shrew (see Tables X-9 and X-10).
e - Based on comparing chemical concentrations in sediment with sediment screening levels (see Table X-2).
f - Based on modeled exposure estimates for the barn swallow and raccoon (see Tables X-11 and X-12).

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E

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

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Standard, Requirement, Criterion, or Limitation	Citation	Description	ARAR/TBC
Chemical Specific			
Federal			
Clean Water Act 40 (Federal Water Pollution Control Act; as amended)	33 USC §§ 1251- 1387 40 CFR 129	Toxic Pollutant Effluent Standards	Relevant and appropriate
Federal Safe Drinking Water Act	42 USC 300f et seq. 40 CFR 141, 143	Defines Maximum Contaminant Levels for drinking water	Applicable
EPA Regional Screening Levels	EPA 2011	Chemical-specific risk-based concentrations derived from standard risk equations for soil, groundwater, surface water, and sediment.	To be considered
Ambient Water Quality Criteria (AWQC)	33 USC Sec. 304; http://water.epa.gov/scitech/swguidance/standards/current/index.cfm	Published pursuant to the Clean Water Act, numeric values limiting the amount of chemicals present in surface water bodies	To be considered
Ecological Soil Screening Levels	EPA 2005a, 2005 e-g, 2007a-e	Includes chemical-specific ecological soil screening levels	To be considered
State			
State of Washington ARARs Model Toxics Control Act	RCW 70.105D Chapter 173-340 WAC	Identifies procedures for establishing cleanup levels for groundwater, surface water, sediments, and soil	Applicable
Water quality standards for surface waters of the state of Washington	RCW 90.48 Chapter 173-201A WAC	Establishes water quality standards for surface waters of the state of Washington consistent with public health and public enjoyment of the waters and the propagation and protection of fish, shellfish, and wildlife	Applicable
State Water Pollution Control Act, State Water Resources Act of 1971	RCW 90.54 Chapter 173-200 WAC	Establishes ground water quality standards and applies to all ground waters of the state that occur in a saturated zone or stratum beneath the surface of land or below a surface water body	Applicable
Other			
Ecological Soil Screening Levels	Efroymson et al. (1997), or Alloway (1984)	critical soil levels and potential concern for effects for terrestrial plants.	To be considered
Ecological Sediment Screening Levels	MacDonald et al. 2000 MacDonald et al. 1999	Threshold Effect Concentrations (TECs) and Probable Effect Concentrations (PECs) Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems	To be considered
Action Specific			
Federal			
Federal Resource Conservation and Recovery Act (RCRA)	42 USC 6902 et seq. 40 CFR 261 et seq.	Defines hazardous waste management requirements. Applies to management of hazardous/dangerous waste. If wastes are removed from the disposal areas, they will be managed in accordance with these requirements.	Relevant and appropriate (State is authorized for RCRA)
Federal Endangered Species Act (1973)	16 USC 1531 et seq. 50 CFR 200, 402	Establishes program to conserve and protect threatened or endangered species.	Applicable to the site for listed and proposed to be listed threatened or endangered species and their habitat areas which will, or could, be impacted by removal action.
Federal Water Pollution Control Act (a.k.a. Clean Water Act), National Pollutant Discharge Elimination System (NPDES)	33 USC Sec. 303, 304 40 CFR Part 122, 125	Establishes State permit program for discharge of pollutants and wastewater to surface waters. Requires all known, available, and reasonable methods of treatment (AKART). Applies to discharge of extracted, treated groundwater to surface water.	Applicable for any point source discharge of pollutants to surface water, including storm water runoff at the site.

Standard, Requirement, Criterion, or Limitation	Citation	Description	ARAR/TBC
Federal Water Pollution Control Act (a.k.a. Clean Water Act)	33 USC 1251-1387 33 CFR 320-330 40 CFR 230	Establishes permit program for activities performed within 200 ft. of shorelines. Applies to construction of outfall for discharge of treated groundwater to surface water.	Applicable
Toxic Substances Control Act	15 U.S.C § 2601 et seq.	Provides requirements for reporting, record-keeping, testing, and disposal of certain chemical substances and/or mixtures, including polychlorinated biphenyls [PCB]s.	Applicable if PCB concentrations exceed specific thresholds
Clean Air Act, 42 USC s/s 7401 et seq. (1970)	40 CFR Parts 61 and 63	Part 61- National Emission Standards for Hazardous Air Pollutants. Part 63 - National Emission Standards for Hazardous Air Pollutants for Source Categories.	Applicable
U.S. Fish and Wildlife Coordination Act	16 USC 661 et seq.	Prohibits water pollution with any substance deleterious to fish, plant life, or bird life. Discharges to surface water controlled through state NPDES program. However, discharges to surface water may require a consultation with the United States Fish and Wildlife Service.	Applicable if threatened or endangered species could be impacted by the response action.
Migratory Bird Treaty Act (MBTA)	16 USC § 703 et seq	Makes it unlawful to "hunt, take, capture, kill" or take various other actions adversely affecting a broad range of migratory birds, including tundra swans, hawks, falcons, songbirds, without prior approval by the U.S. Fish and Wildlife Service. (See 50 CFR 10.13 for the list of birds protected under the MBTA.) Under the MBTA, permits may be issued for take (e.g., for research) or killing of migratory birds (e.g., hunting licenses). The mortality of migratory birds due to ingestion of contaminated sediment is not a permitted take under the MBTA.	Applicable for protecting migratory bird species identified. The selected removal action to be carried out in a manner that avoids the taking or killing of protected migratory bird species, including individual birds or their nests or eggs.
Archaeological Resources Protection Act	16 USC § 470aa et seq.; 43 CFR Part 7	Prohibits the unauthorized disturbance of archaeological resources on public or Indian lands. Archaeological resources are "any material remains of past human life and activities which are of archaeological interest," including pottery, baskets, tools, and human skeletal remains. The unauthorized removal of archaeological resources from public or Indian lands is prohibited without a permit, and any archaeological investigations at a site must be conducted by a professional archeologist.	Applicable for the conduct of any selected response actions that may result in ground disturbance.
American Indian Religious Freedom Act	42 USC § 1996 et seq	The American Indian Religious Freedom Act and implementing regulations are intended to protect Native American religious, ceremonial, and burial sites, and the free practice of religions by Native American groups. The requirements of this Act must be followed if sacred sites graves are discovered in the course of ground-disturbing activities.	Potentially applicable to a site where response actions involve disturbance/alteration of the ground and/or site terrain.
Native American Graves Protection and Repatriation Act	25 USC § 3001 et seq 43 CFR Part 10 25 USC 3001 et seq. 43 CFR 10	Intended to protect Native American graves from desecration through the removal and trafficking of human remains and "cultural items" including funerary and sacred objects. The requirements of this Act must be followed when graves are discovered or ground-disturbing activities encounter Native American burial sites.	Potentially applicable to a site where response actions involve disturbance/alteration of the ground and/or site terrain.
State			
Model Toxics Control Act	RCW 70.105D.090 WAC 173-340	Establishes administrative processes and standards to identify, investigate, and clean up facilities where hazardous substances have come to be located. Applies to any facility (including landfills) where hazardous substance releases to the environment have been confirmed. Also specifies application of cleanup levels.	Applicable

Standard, Requirement, Criterion, or Limitation	Citation	Description	ARAR/TBC
State Minimum Functional Standards for Solid Waste Handling	WAC 173-304	Defines requirements for solid waste management and disposal facilities. Applies to closure of solid waste landfill, including capping, installation of gas system, and environmental monitoring.	Does not apply if dangerous wastes are present.
State Hazardous Waste Management Act (HWMA)	RCW 70.105	Defines threshold levels and criteria to determine whether materials are hazardous/ dangerous wastes. Applies to designation, handling, and disposal of wastes. Treatment residuals meeting these criteria will be handled and disposed of in accordance with regulatory requirements	Applicable
State Dangerous Waste Regulations	WAC 173-303-140 WAC	Defines pre-treatment and land disposal restrictions for certain wastes. Applies to disposal of hazardous/dangerous wastes off-site. Wastes probably will not require additional treatment or be subject to restrictions.	Applicable if any waste is disposed off site.
State Hydraulics Act	RCW 75.20 Chapter 220-110 WAC	Establishes permit program under Dept. of Wildlife/ Fisheries for projects that may change natural flow of "waters of the state." Applies to discharge of treated groundwater to surface water (additional flow to creek is a "change").	Applicable
State Clean Air Act: Source Registration, Emissions Limits, Air Quality Standards	RCW 70.94 Chapter 173-400 WAC	Establishes state approved program for source registration and fee payment to restrict emissions, use of BACT, and ensures compliance with air quality standards. Applies to installing or operating source having emissions to atmosphere. Alternatives emitting contaminants to atmosphere will comply with substantive requirements of these regulations.	Applicable
Location Specific			
Local			
Kitsap County Local Development Ordinances	KCC Title 12	Local codes for construction activities including storm water related management. Planned construction must meet the requirements of the applicable ordinances.	To be considered
Kitsap County Board of Health	Ordinance 2010-1	Adoption of the full text of WAC 173-250 by the Kitsap County Board of Health. Applies to landfills in the county. It is rules and regulations that govern the handling, storage, collection, transportation, treatment, utilization, processing and final disposal of all solid waste within Kitsap County.	To be considered

Key:
ARAR = applicable or relevant and appropriate requirement
TBC = to be considered

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F

HYDROLOGIC AND HYDRAULIC CALCULATIONS

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APPENDIX F

This appendix includes the hydrologic and hydraulic calculations used in the preliminary design of the alternatives identified for evaluation under the Gorst Landfill EECA. Peak flow rates was calculated based on the Santa Barbara Urban Hydrograph Method as required by local and state design guidelines for storm water conveyance systems. Precipitation depths used to predict peak flows were estimated from spreadsheet hyetographs provided by Washington State Department of Ecology (WSDOE) under Technical Note 3. All assumptions should be noted as such in the calculations. Maps showing the estimated drainage basin and the precipitation travel routes used in the hydrologic calculations are also provided at the end of this appendix. Time of concentration calculations are based on the National Resouce Conservation Service (NRCS) Technical Release 55 (TR-55) method which presents simplified procedures to calculate storm runoff volume.

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2 YEAR PEAK FLOW ESTIMATE

Site:	Gorst Creek		Return Period year	Duration hour	
	Rainfall:	3.04 in.	2	24	

Time Increment: 10 minutes   w: 0.0344

w = Time increment / (2 * Time of Concentration + Time Increment)

	Area		CN	S	0.2 S
Pervious Area:	300.00	acres	68	4.71	0.94
Impervious Area:	0.00	acres	89	1.24	0.25
Total Area:	300.00	acres			
Time of Concentration:	140.1	minutes			
	2.34	hours			

Qmax= 12.3 cfs

Column

1	2	3	4	5	6	7	8	9	10	11	12	13
					PERVIOUS		IMPERVIOUS					
Time Increment	Time (minutes)	Rainfall Distribu-tion (fraction)	Incre-mental Rainfall (inches)	Accum. Rainfall (inches)	Accum. Rainfall (inches)	Increm. Runoff (inches)	Accum. Rainfall (inches)	Increm. Runoff (inches)	Total Runoff (inches)	Instant Flowrate (cfs)	Design Flowrate (cfs)	Design Flowrate with Tail (cfs)
1	0	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
2	10	0.0040	0.012	0.012	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
3	20	0.0040	0.012	0.024	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
4	30	0.0040	0.012	0.036	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
5	40	0.0040	0.012	0.049	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
6	50	0.0040	0.012	0.061	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
7	60	0.0040	0.012	0.073	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
8	70	0.0040	0.012	0.085	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
9	80	0.0040	0.012	0.097	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
10	90	0.0040	0.012	0.109	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
11	100	0.0040	0.012	0.122	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
12	110	0.0040	0.012	0.134	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
13	120	0.0050	0.015	0.149	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
14	130	0.0050	0.015	0.164	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
15	140	0.0050	0.015	0.179	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
16	150	0.0050	0.015	0.195	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
17	160	0.0050	0.015	0.210	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
18	170	0.0050	0.015	0.225	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
19	180	0.0060	0.018	0.243	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
20	190	0.0060	0.018	0.261	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
21	200	0.0060	0.018	0.280	0.000	0.000	0.001	0.001	0.000	0.0	0.0	0.0
22	210	0.0060	0.018	0.298	0.000	0.000	0.002	0.001	0.000	0.0	0.0	0.0
23	220	0.0060	0.018	0.316	0.000	0.000	0.004	0.002	0.000	0.0	0.0	0.0
24	230	0.0060	0.018	0.334	0.000	0.000	0.006	0.002	0.000	0.0	0.0	0.0
25	240	0.0070	0.021	0.356	0.000	0.000	0.009	0.003	0.000	0.0	0.0	0.0
26	250	0.0070	0.021	0.377	0.000	0.000	0.012	0.004	0.000	0.0	0.0	0.0
27	260	0.0070	0.021	0.398	0.000	0.000	0.016	0.004	0.000	0.0	0.0	0.0
28	270	0.0070	0.021	0.420	0.000	0.000	0.021	0.005	0.000	0.0	0.0	0.0
29	280	0.0070	0.021	0.441	0.000	0.000	0.026	0.005	0.000	0.0	0.0	0.0
30	290	0.0070	0.021	0.462	0.000	0.000	0.032	0.006	0.000	0.0	0.0	0.0
31	300	0.0080	0.024	0.486	0.000	0.000	0.039	0.007	0.000	0.0	0.0	0.0
32	310	0.0080	0.024	0.511	0.000	0.000	0.046	0.008	0.000	0.0	0.0	0.0
33	320	0.0080	0.024	0.535	0.000	0.000	0.054	0.008	0.000	0.0	0.0	0.0
34	330	0.0080	0.024	0.559	0.000	0.000	0.063	0.009	0.000	0.0	0.0	0.0
35	340	0.0080	0.024	0.584	0.000	0.000	0.072	0.009	0.000	0.0	0.0	0.0
36	350	0.0080	0.024	0.608	0.000	0.000	0.082	0.010	0.000	0.0	0.0	0.0
37	360	0.0100	0.030	0.638	0.000	0.000	0.094	0.013	0.000	0.0	0.0	0.0
38	370	0.0100	0.030	0.669	0.000	0.000	0.107	0.013	0.000	0.0	0.0	0.0
39	380	0.0100	0.030	0.699	0.000	0.000	0.121	0.014	0.000	0.0	0.0	0.0
40	390	0.0100	0.030	0.730	0.000	0.000	0.135	0.014	0.000	0.0	0.0	0.0
41	400	0.0100	0.030	0.760	0.000	0.000	0.150	0.015	0.000	0.0	0.0	0.0
42	410	0.0130	0.040	0.800	0.000	0.000	0.171	0.020	0.000	0.0	0.0	0.0
43	420	0.0130	0.040	0.839	0.000	0.000	0.192	0.021	0.000	0.0	0.0	0.0
44	430	0.0130	0.040	0.879	0.000	0.000	0.213	0.022	0.000	0.0	0.0	0.0
45	440	0.0180	0.055	0.933	0.000	0.000	0.245	0.031	0.000	0.0	0.0	0.0
46	450	0.0180	0.055	0.988	0.000	0.000	0.278	0.033	0.000	0.8	0.0	0.0
47	460	0.0340	0.103	1.091	0.005	0.004	0.343	0.065	0.004	7.6	0.3	0.3
48	470	0.0540	0.164	1.256	0.020	0.015	0.453	0.110	0.015	27.3	1.5	1.5
49	480	0.0270	0.082	1.338	0.031	0.011	0.511	0.058	0.011	20.2	3.0	3.0
50	490	0.0180	0.055	1.392	0.039	0.009	0.551	0.040	0.009	15.7	4.1	4.1
51	500	0.0130	0.040	1.432	0.046	0.007	0.580	0.029	0.007	12.5	4.7	4.7
52	510	0.0130	0.040	1.471	0.054	0.007	0.609	0.029	0.007	13.3	5.3	5.3
53	520	0.0130	0.040	1.511	0.062	0.008	0.639	0.030	0.008	14.2	5.9	5.9
54	530	0.0090	0.027	1.538	0.067	0.006	0.660	0.021	0.006	10.3	6.3	6.3
55	540	0.0090	0.027	1.566	0.073	0.006	0.680	0.021	0.006	10.8	6.6	6.6
56	550	0.0090	0.027	1.593	0.079	0.006	0.702	0.021	0.006	11.2	6.9	6.9
57	560	0.0090	0.027	1.620	0.086	0.006	0.723	0.021	0.006	11.5	7.2	7.2
58	570	0.0090	0.027	1.648	0.092	0.007	0.744	0.021	0.007	11.9	7.5	7.5
59	580	0.0090	0.027	1.675	0.099	0.007	0.765	0.021	0.007	12.3	7.9	7.9
60	590	0.0090	0.027	1.702	0.106	0.007	0.787	0.022	0.007	12.7	8.2	8.2
61	600	0.0090	0.027	1.730	0.113	0.007	0.809	0.022	0.007	13.0	8.5	8.5
62	610	0.0090	0.027	1.757	0.121	0.007	0.830	0.022	0.007	13.4	8.8	8.8
63	620	0.0090	0.027	1.784	0.128	0.008	0.852	0.022	0.008	13.8	9.2	9.2
64	630	0.0090	0.027	1.812	0.136	0.008	0.874	0.022	0.008	14.1	9.5	9.5
65	640	0.0090	0.027	1.839	0.144	0.008	0.896	0.022	0.008	14.5	9.8	9.8
66	650	0.0090	0.027	1.867	0.152	0.008	0.918	0.022	0.008	14.8	10.1	10.1
67	660	0.0070	0.021	1.888	0.159	0.006	0.936	0.017	0.006	11.8	10.4	10.4
68	670	0.0070	0.021	1.909	0.165	0.007	0.953	0.017	0.007	12.0	10.5	10.5
69	680	0.0070	0.021	1.930	0.172	0.007	0.971	0.017	0.007	12.2	10.6	10.6
70	690	0.0070	0.021	1.952	0.179	0.007	0.988	0.017	0.007	12.4	10.7	10.7
71	700	0.0070	0.021	1.973	0.186	0.007	1.006	0.018	0.007	12.5	10.8	10.8
72	710	0.0070	0.021	1.994	0.193	0.007	1.023	0.018	0.007	12.7	10.9	10.9

73	720	0.0070	0.021	2.016	0.200	0.007	1.041	0.018	0.007	12.9	11.1	11.1
74	730	0.0070	0.021	2.037	0.207	0.007	1.059	0.018	0.007	13.1	11.2	11.2
75	740	0.0070	0.021	2.058	0.214	0.007	1.076	0.018	0.007	13.3	11.3	11.3
76	750	0.0070	0.021	2.079	0.222	0.007	1.094	0.018	0.007	13.5	11.5	11.5
77	760	0.0070	0.021	2.101	0.229	0.008	1.112	0.018	0.008	13.7	11.6	11.6
78	770	0.0070	0.021	2.122	0.237	0.008	1.130	0.018	0.008	13.9	11.8	11.8
79	780	0.0060	0.018	2.140	0.243	0.007	1.145	0.015	0.007	12.0	11.9	11.9
80	790	0.0060	0.018	2.158	0.250	0.007	1.161	0.015	0.007	12.1	11.9	11.9
81	800	0.0060	0.018	2.177	0.257	0.007	1.176	0.015	0.007	12.3	11.9	11.9
82	810	0.0060	0.018	2.195	0.264	0.007	1.192	0.015	0.007	12.4	11.9	11.9
83	820	0.0060	0.018	2.213	0.271	0.007	1.207	0.016	0.007	12.5	12.0	12.0
84	830	0.0060	0.018	2.231	0.278	0.007	1.223	0.016	0.007	12.7	12.0	12.0
85	840	0.0060	0.018	2.250	0.285	0.007	1.238	0.016	0.007	12.8	12.1	12.1
86	850	0.0060	0.018	2.268	0.292	0.007	1.254	0.016	0.007	12.9	12.1	12.1
87	860	0.0060	0.018	2.286	0.299	0.007	1.269	0.016	0.007	13.0	12.2	12.2
88	870	0.0060	0.018	2.304	0.306	0.007	1.285	0.016	0.007	13.1	12.2	12.2
89	880	0.0060	0.018	2.323	0.313	0.007	1.301	0.016	0.007	13.3	12.3	12.3
90	890	0.0050	0.015	2.338	0.320	0.006	1.314	0.013	0.006	11.1	12.3	12.3
91	900	0.0050	0.015	2.353	0.326	0.006	1.327	0.013	0.006	11.2	12.2	12.2
92	910	0.0050	0.015	2.368	0.332	0.006	1.340	0.013	0.006	11.3	12.1	12.1
93	920	0.0050	0.015	2.383	0.338	0.006	1.353	0.013	0.006	11.4	12.1	12.1
94	930	0.0050	0.015	2.399	0.345	0.006	1.366	0.013	0.006	11.5	12.0	12.0
95	940	0.0050	0.015	2.414	0.351	0.006	1.380	0.013	0.006	11.5	12.0	12.0
96	950	0.0050	0.015	2.429	0.357	0.006	1.393	0.013	0.006	11.6	12.0	12.0
97	960	0.0050	0.015	2.444	0.364	0.006	1.406	0.013	0.006	11.7	12.0	12.0
98	970	0.0050	0.015	2.459	0.370	0.006	1.419	0.013	0.006	11.8	11.9	11.9
99	980	0.0050	0.015	2.475	0.377	0.007	1.432	0.013	0.007	11.9	11.9	11.9
100	990	0.0050	0.015	2.490	0.383	0.007	1.446	0.013	0.007	11.9	11.9	11.9
101	1,000	0.0050	0.015	2.505	0.390	0.007	1.459	0.013	0.007	12.0	11.9	11.9
102	1,010	0.0040	0.012	2.517	0.395	0.005	1.470	0.011	0.005	9.7	11.9	11.9
103	1,020	0.0040	0.012	2.529	0.401	0.005	1.480	0.011	0.005	9.7	11.7	11.7
104	1,030	0.0040	0.012	2.541	0.406	0.005	1.491	0.011	0.005	9.8	11.6	11.6
105	1,040	0.0040	0.012	2.554	0.411	0.005	1.502	0.011	0.005	9.8	11.4	11.4
106	1,050	0.0040	0.012	2.566	0.417	0.005	1.512	0.011	0.005	9.9	11.3	11.3
107	1,060	0.0040	0.012	2.578	0.422	0.005	1.523	0.011	0.005	9.9	11.2	11.2
108	1,070	0.0040	0.012	2.590	0.428	0.005	1.534	0.011	0.005	9.9	11.1	11.1
109	1,080	0.0040	0.012	2.602	0.433	0.006	1.544	0.011	0.006	10.0	11.1	11.1
110	1,090	0.0040	0.012	2.614	0.439	0.006	1.555	0.011	0.006	10.0	11.0	11.0
111	1,100	0.0040	0.012	2.627	0.444	0.006	1.566	0.011	0.006	10.1	10.9	10.9
112	1,110	0.0040	0.012	2.639	0.450	0.006	1.577	0.011	0.006	10.1	10.9	10.9
113	1,120	0.0040	0.012	2.651	0.456	0.006	1.587	0.011	0.006	10.2	10.8	10.8
114	1,130	0.0040	0.012	2.663	0.461	0.006	1.598	0.011	0.006	10.2	10.8	10.8
115	1,140	0.0040	0.012	2.675	0.467	0.006	1.609	0.011	0.006	10.3	10.7	10.7
116	1,150	0.0040	0.012	2.687	0.473	0.006	1.620	0.011	0.006	10.3	10.7	10.7
117	1,160	0.0040	0.012	2.700	0.478	0.006	1.631	0.011	0.006	10.4	10.7	10.7
118	1,170	0.0040	0.012	2.712	0.484	0.006	1.641	0.011	0.006	10.4	10.7	10.7
119	1,180	0.0040	0.012	2.724	0.490	0.006	1.652	0.011	0.006	10.4	10.6	10.6
120	1,190	0.0040	0.012	2.736	0.496	0.006	1.663	0.011	0.006	10.5	10.6	10.6
121	1,200	0.0040	0.012	2.748	0.501	0.006	1.674	0.011	0.006	10.5	10.6	10.6
122	1,210	0.0040	0.012	2.760	0.507	0.006	1.685	0.011	0.006	10.6	10.6	10.6
123	1,220	0.0040	0.012	2.772	0.513	0.006	1.695	0.011	0.006	10.6	10.6	10.6
124	1,230	0.0040	0.012	2.785	0.519	0.006	1.706	0.011	0.006	10.7	10.6	10.6
125	1,240	0.0040	0.012	2.797	0.525	0.006	1.717	0.011	0.006	10.7	10.6	10.6
126	1,250	0.0040	0.012	2.809	0.531	0.006	1.728	0.011	0.006	10.7	10.6	10.6
127	1,260	0.0040	0.012	2.821	0.537	0.006	1.739	0.011	0.006	10.8	10.6	10.6
128	1,270	0.0040	0.012	2.833	0.543	0.006	1.750	0.011	0.006	10.8	10.6	10.6
129	1,280	0.0040	0.012	2.845	0.549	0.006	1.761	0.011	0.006	10.9	10.7	10.7
130	1,290	0.0040	0.012	2.858	0.555	0.006	1.772	0.011	0.006	10.9	10.7	10.7
131	1,300	0.0040	0.012	2.870	0.561	0.006	1.783	0.011	0.006	10.9	10.7	10.7
132	1,310	0.0040	0.012	2.882	0.567	0.006	1.793	0.011	0.006	11.0	10.7	10.7
133	1,320	0.0040	0.012	2.894	0.573	0.006	1.804	0.011	0.006	11.0	10.7	10.7
134	1,330	0.0040	0.012	2.906	0.579	0.006	1.815	0.011	0.006	11.1	10.8	10.8
135	1,340	0.0040	0.012	2.918	0.585	0.006	1.826	0.011	0.006	11.1	10.8	10.8
136	1,350	0.0040	0.012	2.931	0.591	0.006	1.837	0.011	0.006	11.1	10.8	10.8
137	1,360	0.0040	0.012	2.943	0.597	0.006	1.848	0.011	0.006	11.2	10.8	10.8
138	1,370	0.0040	0.012	2.955	0.603	0.006	1.859	0.011	0.006	11.2	10.9	10.9
139	1,380	0.0040	0.012	2.967	0.610	0.006	1.870	0.011	0.006	11.3	10.9	10.9
140	1,390	0.0040	0.012	2.979	0.616	0.006	1.881	0.011	0.006	11.3	10.9	10.9
141	1,400	0.0040	0.012	2.991	0.622	0.006	1.892	0.011	0.006	11.3	10.9	10.9
142	1,410	0.0040	0.012	3.004	0.628	0.006	1.903	0.011	0.006	11.4	11.0	11.0
143	1,420	0.0040	0.012	3.016	0.635	0.006	1.914	0.011	0.006	11.4	11.0	11.0
144	1,430	0.0040	0.012	3.028	0.641	0.006	1.925	0.011	0.006	11.5	11.0	11.0
145	1,440	0.0040	0.0122	3.040	0.647	0.006	1.936	0.011	0.006	11.5	11.1	11.1
	Total:	1.0000	3.0400			0.6474		1.9360	0.6474			
							Max:	**12.3**				

Cumulative Runoff at Period 145	0.56	inches	Start Flow	11.1
Unaccounted Runoff	0.09	inches	End Flow	-0.3
	17,440.85	sec	Flow Dec./per	0.4
	290.68	min		
	29.07	periods		
	30	periods		
	0.5619	Total Runoff		

Column	Description
1	Time Increment
2	Time (min)
3	Type IA Storm Distibution
4	Column 3 * Precipitation
5	Accumulated Sum of Column 4
6	If P<0.2S then 0, else (Column 5 - 0.2 * S)/(Column 5 +0.8 * S)
7	Column 6 of the present step - Column 6 of the previous step
8	Same as Column 6, except Impervious Area Calculations
9	Column 8 of the present step - Column 8 of the previous step
10	PerviousArea/TotalArea*Column 7 + ImperviousArea/TotalArea*Column 9
11	(60.5 * Column 10 * TotalArea)/Time Increment
12	Column 12 of previous step + w * ((Column 11 of previous step + column 11 of present step) - (2 * Column 12 of previous step))

10 YEAR PEAK FLOW ESTIMATE

				Return Period year	Duration hour
Site:	Gorst Creek				
		Rainfall:	4.53 in.	10	24

Time Increment: 10 minutes w: 0.0344

w = Time increment / (2 * Time of Concentration + Time Increment)

	Area		CN	S	0.2 S
Pervious Area:	300.00	acres	68	4.71	0.94
Impervious Area:	0.00	acres	89	1.24	0.25
Total Area:	300.00	acres			
Time of Concentration:	140.1	minutes			
	2.34	hours			

Qmax= 30.2 cfs

Column

1	2	3	4	5	6	7	8	9	10	11	12	13
					PERVIOUS		IMPERVIOUS					
Time Increment	Time (minutes)	Rainfall Distribu-tion (fraction)	Incre-mental Rainfall (inches)	Accum. Rainfall (inches)	Accum. Rainfall (inches)	Increm. Runoff (inches)	Accum. Rainfall (inches)	Increm. Runoff (inches)	Total Runoff (inches)	Instant Flowrate (cfs)	Design Flowrate (cfs)	Design Flowrate with Tail (cfs)
1	0	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
2	10	0.0040	0.018	0.018	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
3	20	0.0040	0.018	0.036	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
4	30	0.0040	0.018	0.054	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
5	40	0.0040	0.018	0.072	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
6	50	0.0040	0.018	0.091	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
7	60	0.0040	0.018	0.109	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
8	70	0.0040	0.018	0.127	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
9	80	0.0040	0.018	0.145	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
10	90	0.0040	0.018	0.163	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
11	100	0.0040	0.018	0.181	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
12	110	0.0040	0.018	0.199	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
13	120	0.0050	0.023	0.222	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
14	130	0.0050	0.023	0.245	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
15	140	0.0050	0.023	0.267	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
16	150	0.0050	0.023	0.290	0.000	0.000	0.001	0.001	0.000	0.0	0.0	0.0
17	160	0.0050	0.023	0.313	0.000	0.000	0.003	0.002	0.000	0.0	0.0	0.0
18	170	0.0050	0.023	0.335	0.000	0.000	0.006	0.003	0.000	0.0	0.0	0.0
19	180	0.0060	0.027	0.362	0.000	0.000	0.010	0.004	0.000	0.0	0.0	0.0
20	190	0.0060	0.027	0.390	0.000	0.000	0.015	0.005	0.000	0.0	0.0	0.0
21	200	0.0060	0.027	0.417	0.000	0.000	0.020	0.006	0.000	0.0	0.0	0.0
22	210	0.0060	0.027	0.444	0.000	0.000	0.027	0.007	0.000	0.0	0.0	0.0
23	220	0.0060	0.027	0.471	0.000	0.000	0.034	0.007	0.000	0.0	0.0	0.0
24	230	0.0060	0.027	0.498	0.000	0.000	0.042	0.008	0.000	0.0	0.0	0.0
25	240	0.0070	0.032	0.530	0.000	0.000	0.053	0.010	0.000	0.0	0.0	0.0
26	250	0.0070	0.032	0.562	0.000	0.000	0.064	0.011	0.000	0.0	0.0	0.0
27	260	0.0070	0.032	0.593	0.000	0.000	0.076	0.012	0.000	0.0	0.0	0.0
28	270	0.0070	0.032	0.625	0.000	0.000	0.089	0.013	0.000	0.0	0.0	0.0
29	280	0.0070	0.032	0.657	0.000	0.000	0.102	0.013	0.000	0.0	0.0	0.0
30	290	0.0070	0.032	0.689	0.000	0.000	0.116	0.014	0.000	0.0	0.0	0.0
31	300	0.0080	0.036	0.725	0.000	0.000	0.133	0.017	0.000	0.0	0.0	0.0
32	310	0.0080	0.036	0.761	0.000	0.000	0.151	0.018	0.000	0.0	0.0	0.0
33	320	0.0080	0.036	0.797	0.000	0.000	0.169	0.019	0.000	0.0	0.0	0.0
34	330	0.0080	0.036	0.834	0.000	0.000	0.189	0.019	0.000	0.0	0.0	0.0
35	340	0.0080	0.036	0.870	0.000	0.000	0.209	0.020	0.000	0.0	0.0	0.0
36	350	0.0080	0.036	0.906	0.000	0.000	0.229	0.021	0.000	0.0	0.0	0.0
37	360	0.0100	0.045	0.951	0.000	0.000	0.256	0.026	0.000	0.0	0.0	0.0
38	370	0.0100	0.045	0.997	0.001	0.001	0.283	0.027	0.001	1.1	0.0	0.0
39	380	0.0100	0.045	1.042	0.002	0.001	0.311	0.028	0.001	2.7	0.2	0.2
40	390	0.0100	0.045	1.087	0.004	0.002	0.340	0.029	0.002	4.1	0.4	0.4
41	400	0.0100	0.045	1.133	0.007	0.003	0.369	0.030	0.003	5.6	0.7	0.7
42	410	0.0130	0.059	1.191	0.013	0.005	0.409	0.039	0.005	9.4	1.2	1.2
43	420	0.0130	0.059	1.250	0.019	0.006	0.449	0.040	0.006	11.7	1.8	1.8
44	430	0.0130	0.059	1.309	0.027	0.008	0.491	0.041	0.008	13.9	2.6	2.6
45	440	0.0180	0.082	1.391	0.039	0.013	0.550	0.059	0.013	22.7	3.6	3.6
46	450	0.0180	0.082	1.472	0.054	0.015	0.610	0.060	0.015	26.6	5.1	5.1
47	460	0.0340	0.154	1.626	0.087	0.033	0.727	0.117	0.033	60.3	7.7	7.7
48	470	0.0540	0.245	1.871	0.153	0.066	0.922	0.195	0.066	120.4	13.4	13.4
49	480	0.0270	0.122	1.993	0.192	0.039	1.022	0.100	0.039	70.5	19.1	19.1
50	490	0.0180	0.082	2.075	0.220	0.028	1.090	0.068	0.028	50.5	21.9	21.9
51	500	0.0130	0.059	2.134	0.241	0.021	1.140	0.049	0.021	38.2	23.5	23.5
52	510	0.0130	0.059	2.193	0.263	0.022	1.190	0.050	0.022	39.5	24.5	24.5
53	520	0.0130	0.059	2.251	0.285	0.023	1.240	0.050	0.023	40.8	25.6	25.6
54	530	0.0090	0.041	2.292	0.301	0.016	1.275	0.035	0.016	29.0	26.3	26.3
55	540	0.0090	0.041	2.333	0.318	0.016	1.310	0.035	0.016	29.6	26.5	26.5
56	550	0.0090	0.041	2.374	0.334	0.017	1.345	0.035	0.017	30.2	26.7	26.7
57	560	0.0090	0.041	2.414	0.351	0.017	1.380	0.035	0.017	30.8	27.0	27.0
58	570	0.0090	0.041	2.455	0.369	0.017	1.416	0.035	0.017	31.4	27.2	27.2
59	580	0.0090	0.041	2.496	0.386	0.018	1.451	0.036	0.018	31.9	27.6	27.6
60	590	0.0090	0.041	2.537	0.404	0.018	1.487	0.036	0.018	32.5	27.9	27.9
61	600	0.0090	0.041	2.578	0.422	0.018	1.523	0.036	0.018	33.0	28.2	28.2
62	610	0.0090	0.041	2.618	0.441	0.018	1.559	0.036	0.018	33.5	28.6	28.6
63	620	0.0090	0.041	2.659	0.459	0.019	1.595	0.036	0.019	34.0	28.9	28.9
64	630	0.0090	0.041	2.700	0.478	0.019	1.631	0.036	0.019	34.5	29.3	29.3
65	640	0.0090	0.041	2.741	0.498	0.019	1.667	0.036	0.019	35.0	29.7	29.7
66	650	0.0090	0.041	2.781	0.517	0.020	1.703	0.036	0.020	35.5	30.0	30.0
67	660	0.0070	0.032	2.813	0.533	0.015	1.732	0.028	0.015	28.0	30.2	30.2
68	670	0.0070	0.032	2.845	0.548	0.016	1.760	0.028	0.016	28.2	30.0	30.0
69	680	0.0070	0.032	2.877	0.564	0.016	1.789	0.028	0.016	28.5	29.9	29.9
70	690	0.0070	0.032	2.908	0.580	0.016	1.817	0.028	0.016	28.8	29.8	29.8
71	700	0.0070	0.032	2.940	0.596	0.016	1.846	0.029	0.016	29.1	29.8	29.8
72	710	0.0070	0.032	2.972	0.612	0.016	1.874	0.029	0.016	29.3	29.7	29.7

73	720	0.0070	0.032	3.003	0.628	0.016	1.903	0.029	0.016	29.6	29.7	29.7
74	730	0.0070	0.032	3.035	0.645	0.016	1.932	0.029	0.016	29.9	29.7	29.7
75	740	0.0070	0.032	3.067	0.661	0.017	1.960	0.029	0.017	30.1	29.7	29.7
76	750	0.0070	0.032	3.099	0.678	0.017	1.989	0.029	0.017	30.4	29.8	29.8
77	760	0.0070	0.032	3.130	0.695	0.017	2.018	0.029	0.017	30.6	29.8	29.8
78	770	0.0070	0.032	3.162	0.712	0.017	2.047	0.029	0.017	30.9	29.9	29.9
79	780	0.0060	0.027	3.189	0.727	0.015	2.072	0.025	0.015	26.7	29.8	29.8
80	790	0.0060	0.027	3.216	0.741	0.015	2.096	0.025	0.015	26.8	29.6	29.6
81	800	0.0060	0.027	3.243	0.756	0.015	2.121	0.025	0.015	27.0	29.4	29.4
82	810	0.0060	0.027	3.271	0.771	0.015	2.146	0.025	0.015	27.2	29.2	29.2
83	820	0.0060	0.027	3.298	0.786	0.015	2.171	0.025	0.015	27.3	29.1	29.1
84	830	0.0060	0.027	3.325	0.802	0.015	2.196	0.025	0.015	27.5	29.0	29.0
85	840	0.0060	0.027	3.352	0.817	0.015	2.221	0.025	0.015	27.7	28.9	28.9
86	850	0.0060	0.027	3.379	0.832	0.015	2.246	0.025	0.015	27.8	28.8	28.8
87	860	0.0060	0.027	3.407	0.848	0.015	2.271	0.025	0.015	28.0	28.8	28.8
88	870	0.0060	0.027	3.434	0.863	0.016	2.296	0.025	0.016	28.2	28.7	28.7
89	880	0.0060	0.027	3.461	0.879	0.016	2.321	0.025	0.016	28.3	28.7	28.7
90	890	0.0050	0.023	3.484	0.892	0.013	2.342	0.021	0.013	23.7	28.5	28.5
91	900	0.0050	0.023	3.506	0.905	0.013	2.363	0.021	0.013	23.8	28.2	28.2
92	910	0.0050	0.023	3.529	0.918	0.013	2.384	0.021	0.013	23.9	27.9	27.9
93	920	0.0050	0.023	3.552	0.931	0.013	2.405	0.021	0.013	24.0	27.6	27.6
94	930	0.0050	0.023	3.574	0.945	0.013	2.426	0.021	0.013	24.2	27.4	27.4
95	940	0.0050	0.023	3.597	0.958	0.013	2.447	0.021	0.013	24.3	27.1	27.1
96	950	0.0050	0.023	3.619	0.971	0.013	2.468	0.021	0.013	24.4	27.0	27.0
97	960	0.0050	0.023	3.642	0.985	0.013	2.489	0.021	0.013	24.5	26.8	26.8
98	970	0.0050	0.023	3.665	0.998	0.014	2.510	0.021	0.014	24.6	26.6	26.6
99	980	0.0050	0.023	3.687	1.012	0.014	2.531	0.021	0.014	24.7	26.5	26.5
100	990	0.0050	0.023	3.710	1.026	0.014	2.552	0.021	0.014	24.8	26.4	26.4
101	1,000	0.0050	0.023	3.733	1.039	0.014	2.573	0.021	0.014	24.9	26.3	26.3
102	1,010	0.0040	0.018	3.751	1.050	0.011	2.590	0.017	0.011	20.0	26.0	26.0
103	1,020	0.0040	0.018	3.769	1.061	0.011	2.607	0.017	0.011	20.0	25.6	25.6
104	1,030	0.0040	0.018	3.787	1.072	0.011	2.624	0.017	0.011	20.1	25.2	25.2
105	1,040	0.0040	0.018	3.805	1.084	0.011	2.641	0.017	0.011	20.1	24.8	24.8
106	1,050	0.0040	0.018	3.823	1.095	0.011	2.658	0.017	0.011	20.2	24.5	24.5
107	1,060	0.0040	0.018	3.841	1.106	0.011	2.675	0.017	0.011	20.3	24.2	24.2
108	1,070	0.0040	0.018	3.860	1.117	0.011	2.691	0.017	0.011	20.3	24.0	24.0
109	1,080	0.0040	0.018	3.878	1.128	0.011	2.708	0.017	0.011	20.4	23.7	23.7
110	1,090	0.0040	0.018	3.896	1.140	0.011	2.725	0.017	0.011	20.4	23.5	23.5
111	1,100	0.0040	0.018	3.914	1.151	0.011	2.742	0.017	0.011	20.5	23.3	23.3
112	1,110	0.0040	0.018	3.932	1.162	0.011	2.759	0.017	0.011	20.6	23.1	23.1
113	1,120	0.0040	0.018	3.950	1.174	0.011	2.776	0.017	0.011	20.6	22.9	22.9
114	1,130	0.0040	0.018	3.968	1.185	0.011	2.793	0.017	0.011	20.7	22.8	22.8
115	1,140	0.0040	0.018	3.986	1.196	0.011	2.810	0.017	0.011	20.7	22.6	22.6
116	1,150	0.0040	0.018	4.005	1.208	0.011	2.827	0.017	0.011	20.8	22.5	22.5
117	1,160	0.0040	0.018	4.023	1.219	0.011	2.844	0.017	0.011	20.8	22.4	22.4
118	1,170	0.0040	0.018	4.041	1.231	0.012	2.861	0.017	0.012	20.9	22.3	22.3
119	1,180	0.0040	0.018	4.059	1.242	0.012	2.878	0.017	0.012	21.0	22.2	22.2
120	1,190	0.0040	0.018	4.077	1.254	0.012	2.895	0.017	0.012	21.0	22.1	22.1
121	1,200	0.0040	0.018	4.095	1.266	0.012	2.912	0.017	0.012	21.1	22.0	22.0
122	1,210	0.0040	0.018	4.113	1.277	0.012	2.930	0.017	0.012	21.1	22.0	22.0
123	1,220	0.0040	0.018	4.131	1.289	0.012	2.947	0.017	0.012	21.2	21.9	21.9
124	1,230	0.0040	0.018	4.149	1.301	0.012	2.964	0.017	0.012	21.2	21.9	21.9
125	1,240	0.0040	0.018	4.168	1.312	0.012	2.981	0.017	0.012	21.3	21.8	21.8
126	1,250	0.0040	0.018	4.186	1.324	0.012	2.998	0.017	0.012	21.3	21.8	21.8
127	1,260	0.0040	0.018	4.204	1.336	0.012	3.015	0.017	0.012	21.4	21.8	21.8
128	1,270	0.0040	0.018	4.222	1.348	0.012	3.032	0.017	0.012	21.4	21.7	21.7
129	1,280	0.0040	0.018	4.240	1.360	0.012	3.049	0.017	0.012	21.5	21.7	21.7
130	1,290	0.0040	0.018	4.258	1.371	0.012	3.066	0.017	0.012	21.5	21.7	21.7
131	1,300	0.0040	0.018	4.276	1.383	0.012	3.083	0.017	0.012	21.6	21.7	21.7
132	1,310	0.0040	0.018	4.294	1.395	0.012	3.100	0.017	0.012	21.6	21.7	21.7
133	1,320	0.0040	0.018	4.313	1.407	0.012	3.118	0.017	0.012	21.7	21.7	21.7
134	1,330	0.0040	0.018	4.331	1.419	0.012	3.135	0.017	0.012	21.7	21.7	21.7
135	1,340	0.0040	0.018	4.349	1.431	0.012	3.152	0.017	0.012	21.8	21.7	21.7
136	1,350	0.0040	0.018	4.367	1.443	0.012	3.169	0.017	0.012	21.8	21.7	21.7
137	1,360	0.0040	0.018	4.385	1.455	0.012	3.186	0.017	0.012	21.9	21.7	21.7
138	1,370	0.0040	0.018	4.403	1.467	0.012	3.203	0.017	0.012	21.9	21.7	21.7
139	1,380	0.0040	0.018	4.421	1.479	0.012	3.220	0.017	0.012	22.0	21.7	21.7
140	1,390	0.0040	0.018	4.439	1.492	0.012	3.238	0.017	0.012	22.0	21.8	21.8
141	1,400	0.0040	0.018	4.458	1.504	0.012	3.255	0.017	0.012	22.1	21.8	21.8
142	1,410	0.0040	0.018	4.476	1.516	0.012	3.272	0.017	0.012	22.1	21.8	21.8
143	1,420	0.0040	0.018	4.494	1.528	0.012	3.289	0.017	0.012	22.2	21.8	21.8
144	1,430	0.0040	0.018	4.512	1.540	0.012	3.306	0.017	0.012	22.2	21.9	21.9
145	1,440	0.0040	0.0181	4.530	1.553	0.012	3.324	0.017	0.012	22.3	21.9	21.9
	Total:	1.0000	4.5300			1.5528		3.3237	1.5528			
							Max:	**30.2**				

Cumulative Runoff at Period 145	1.38	inches	Start Flow	21.9
Unaccounted Runoff	0.18	inches	End Flow	-0.7
	17,427.85	sec	Flow Dec./per	0.8
	290.46	min		
	29.05	periods		
	30	periods		
	1.3837	Total Runoff		

Column	Description
1	Time Increment
2	Time (min)
3	Type IA Storm Distibution
4	Column 3 * Precipitation
5	Accumulated Sum of Column 4
6	If P<0.2S then 0, else (Column 5 - 0.2 * S)/(Column 5 +0.8 * S)
7	Column 6 of the present step - Column 6 of the previous step
8	Same as Column 6, except Impervious Area Calculations
9	Column 8 of the present step - Column 8 of the previous step
10	PerviousArea/TotalArea*Column 7 + ImperviousArea/TotalArea*Column 9
11	(60.5 * Column 10 * TotalArea)/Time Increment
12	Column 12 of previous step + w * ((Column 11 of previous step + column 11 of present step) - (2 * Column 12 of previous step))

25 YEAR PEAK FLOW ESTIMATE

						Return Period year	Duration hour
Site:	Gorst Creek						
		Rainfall:	5.20	in.		25	24

Time Increment: 10 minutes   w: 0.0344

w = Time increment / (2 * Time of Concentration + Time Increment)

	Area		CN	S	0.2 S
Pervious Area:	300.00	acres	68	4.71	0.94
Impervious Area:	0.00	acres	89	1.24	0.25
Total Area:	300.00	acres			
Time of Concentration:	140.1	minutes			
	2.34	hours			

Qmax= 40.7 cfs

Column

1	2	3	4	5	6	7	8	9	10	11	12	13
					PERVIOUS		IMPERVIOUS					
Time Increment	Time (minutes)	Rainfall Distribu-tion (fraction)	Incre-mental Rainfall (inches)	Accum. Rainfall (inches)	Accum. Rainfall (inches)	Increm. Runoff (inches)	Accum. Rainfall (inches)	Increm. Runoff (inches)	Total Runoff (inches)	Instant Flowrate (cfs)	Design Flowrate (cfs)	Design Flowrate with Tail (cfs)
1	0	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
2	10	0.0040	0.021	0.021	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
3	20	0.0040	0.021	0.042	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
4	30	0.0040	0.021	0.062	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
5	40	0.0040	0.021	0.083	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
6	50	0.0040	0.021	0.104	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
7	60	0.0040	0.021	0.125	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
8	70	0.0040	0.021	0.146	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
9	80	0.0040	0.021	0.166	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
10	90	0.0040	0.021	0.187	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
11	100	0.0040	0.021	0.208	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
12	110	0.0040	0.021	0.229	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
13	120	0.0050	0.026	0.255	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
14	130	0.0050	0.026	0.281	0.000	0.000	0.001	0.001	0.000	0.0	0.0	0.0
15	140	0.0050	0.026	0.307	0.000	0.000	0.003	0.002	0.000	0.0	0.0	0.0
16	150	0.0050	0.026	0.333	0.000	0.000	0.006	0.003	0.000	0.0	0.0	0.0
17	160	0.0050	0.026	0.359	0.000	0.000	0.009	0.004	0.000	0.0	0.0	0.0
18	170	0.0050	0.026	0.385	0.000	0.000	0.014	0.005	0.000	0.0	0.0	0.0
19	180	0.0060	0.031	0.416	0.000	0.000	0.020	0.006	0.000	0.0	0.0	0.0
20	190	0.0060	0.031	0.447	0.000	0.000	0.028	0.008	0.000	0.0	0.0	0.0
21	200	0.0060	0.031	0.478	0.000	0.000	0.036	0.009	0.000	0.0	0.0	0.0
22	210	0.0060	0.031	0.510	0.000	0.000	0.046	0.010	0.000	0.0	0.0	0.0
23	220	0.0060	0.031	0.541	0.000	0.000	0.056	0.010	0.000	0.0	0.0	0.0
24	230	0.0060	0.031	0.572	0.000	0.000	0.068	0.011	0.000	0.0	0.0	0.0
25	240	0.0070	0.036	0.608	0.000	0.000	0.082	0.014	0.000	0.0	0.0	0.0
26	250	0.0070	0.036	0.645	0.000	0.000	0.097	0.015	0.000	0.0	0.0	0.0
27	260	0.0070	0.036	0.681	0.000	0.000	0.113	0.016	0.000	0.0	0.0	0.0
28	270	0.0070	0.036	0.718	0.000	0.000	0.130	0.017	0.000	0.0	0.0	0.0
29	280	0.0070	0.036	0.754	0.000	0.000	0.147	0.018	0.000	0.0	0.0	0.0
30	290	0.0070	0.036	0.790	0.000	0.000	0.166	0.018	0.000	0.0	0.0	0.0
31	300	0.0080	0.042	0.832	0.000	0.000	0.188	0.022	0.000	0.0	0.0	0.0
32	310	0.0080	0.042	0.874	0.000	0.000	0.211	0.023	0.000	0.0	0.0	0.0
33	320	0.0080	0.042	0.915	0.000	0.000	0.234	0.024	0.000	0.0	0.0	0.0
34	330	0.0080	0.042	0.957	0.000	0.000	0.259	0.024	0.000	0.1	0.0	0.0
35	340	0.0080	0.042	0.998	0.001	0.001	0.284	0.025	0.001	1.2	0.0	0.0
36	350	0.0080	0.042	1.040	0.002	0.001	0.310	0.026	0.001	2.4	0.2	0.2
37	360	0.0100	0.052	1.092	0.005	0.003	0.343	0.033	0.003	4.8	0.4	0.4
38	370	0.0100	0.052	1.144	0.008	0.004	0.377	0.034	0.004	6.7	0.8	0.8
39	380	0.0100	0.052	1.196	0.013	0.005	0.412	0.035	0.005	8.5	1.2	1.2
40	390	0.0100	0.052	1.248	0.019	0.006	0.448	0.036	0.006	10.3	1.8	1.8
41	400	0.0100	0.052	1.300	0.025	0.007	0.484	0.036	0.007	12.1	2.5	2.5
42	410	0.0130	0.068	1.368	0.035	0.010	0.533	0.048	0.010	18.2	3.3	3.3
43	420	0.0130	0.068	1.435	0.047	0.012	0.582	0.050	0.012	20.9	4.4	4.4
44	430	0.0130	0.068	1.503	0.060	0.013	0.633	0.051	0.013	23.5	5.7	5.7
45	440	0.0180	0.094	1.596	0.080	0.020	0.704	0.071	0.020	36.7	7.3	7.3
46	450	0.0180	0.094	1.690	0.103	0.023	0.777	0.073	0.023	41.2	9.5	9.5
47	460	0.0340	0.177	1.867	0.152	0.049	0.919	0.141	0.049	89.6	13.4	13.4
48	470	0.0540	0.281	2.148	0.246	0.094	1.152	0.233	0.094	170.7	21.4	21.4
49	480	0.0270	0.140	2.288	0.300	0.054	1.271	0.120	0.054	97.1	29.2	29.2
50	490	0.0180	0.094	2.382	0.338	0.038	1.352	0.081	0.038	68.8	32.9	32.9
51	500	0.0130	0.068	2.449	0.366	0.028	1.410	0.059	0.028	51.6	34.8	34.8
52	510	0.0130	0.068	2.517	0.395	0.029	1.469	0.059	0.029	53.1	36.0	36.0
53	520	0.0130	0.068	2.584	0.425	0.030	1.529	0.059	0.030	54.6	37.2	37.2
54	530	0.0090	0.047	2.631	0.447	0.021	1.570	0.041	0.021	38.6	37.8	37.8
55	540	0.0090	0.047	2.678	0.468	0.022	1.611	0.041	0.022	39.3	37.9	37.9
56	550	0.0090	0.047	2.725	0.490	0.022	1.653	0.042	0.022	40.0	38.0	38.0
57	560	0.0090	0.047	2.772	0.513	0.022	1.695	0.042	0.022	40.6	38.2	38.2
58	570	0.0090	0.047	2.818	0.535	0.023	1.736	0.042	0.023	41.2	38.4	38.4
59	580	0.0090	0.047	2.865	0.558	0.023	1.778	0.042	0.023	41.8	38.6	38.6
60	590	0.0090	0.047	2.912	0.582	0.023	1.820	0.042	0.023	42.4	38.8	38.8
61	600	0.0090	0.047	2.959	0.605	0.024	1.863	0.042	0.024	43.0	39.1	39.1
62	610	0.0090	0.047	3.006	0.629	0.024	1.905	0.042	0.024	43.6	39.4	39.4
63	620	0.0090	0.047	3.052	0.654	0.024	1.947	0.042	0.024	44.2	39.7	39.7
64	630	0.0090	0.047	3.099	0.678	0.025	1.990	0.042	0.025	44.7	40.0	40.0
65	640	0.0090	0.047	3.146	0.703	0.025	2.032	0.043	0.025	45.3	40.4	40.4
66	650	0.0090	0.047	3.193	0.729	0.025	2.075	0.043	0.025	45.8	40.7	40.7
67	660	0.0070	0.036	3.229	0.749	0.020	2.108	0.033	0.020	36.0	40.7	40.7
68	670	0.0070	0.036	3.266	0.769	0.020	2.142	0.033	0.020	36.3	40.4	40.4
69	680	0.0070	0.036	3.302	0.789	0.020	2.175	0.033	0.020	36.6	40.2	40.2
70	690	0.0070	0.036	3.338	0.809	0.020	2.208	0.033	0.020	36.9	39.9	39.9
71	700	0.0070	0.036	3.375	0.830	0.021	2.242	0.033	0.021	37.2	39.7	39.7
72	710	0.0070	0.036	3.411	0.850	0.021	2.275	0.034	0.021	37.5	39.6	39.6

73	720	0.0070	0.036	3.448	0.871	0.021	2.309	0.034	0.021	37.8	39.4	39.4
74	730	0.0070	0.036	3.484	0.892	0.021	2.342	0.034	0.021	38.1	39.3	39.3
75	740	0.0070	0.036	3.520	0.913	0.021	2.376	0.034	0.021	38.4	39.3	39.3
76	750	0.0070	0.036	3.557	0.934	0.021	2.410	0.034	0.021	38.6	39.2	39.2
77	760	0.0070	0.036	3.593	0.956	0.021	2.443	0.034	0.021	38.9	39.2	39.2
78	770	0.0070	0.036	3.630	0.977	0.022	2.477	0.034	0.022	39.2	39.2	39.2
79	780	0.0060	0.031	3.661	0.996	0.019	2.506	0.029	0.019	33.8	39.0	39.0
80	790	0.0060	0.031	3.692	1.015	0.019	2.535	0.029	0.019	34.0	38.6	38.6
81	800	0.0060	0.031	3.723	1.034	0.019	2.564	0.029	0.019	34.2	38.3	38.3
82	810	0.0060	0.031	3.754	1.053	0.019	2.593	0.029	0.019	34.4	38.0	38.0
83	820	0.0060	0.031	3.786	1.072	0.019	2.622	0.029	0.019	34.5	37.8	37.8
84	830	0.0060	0.031	3.817	1.091	0.019	2.652	0.029	0.019	34.7	37.6	37.6
85	840	0.0060	0.031	3.848	1.110	0.019	2.681	0.029	0.019	34.9	37.4	37.4
86	850	0.0060	0.031	3.879	1.129	0.019	2.710	0.029	0.019	35.1	37.2	37.2
87	860	0.0060	0.031	3.910	1.149	0.019	2.739	0.029	0.019	35.3	37.1	37.1
88	870	0.0060	0.031	3.942	1.168	0.020	2.768	0.029	0.020	35.4	37.0	37.0
89	880	0.0060	0.031	3.973	1.188	0.020	2.798	0.029	0.020	35.6	36.9	36.9
90	890	0.0050	0.026	3.999	1.204	0.016	2.822	0.024	0.016	29.8	36.6	36.6
91	900	0.0050	0.026	4.025	1.221	0.016	2.846	0.024	0.016	29.9	36.1	36.1
92	910	0.0050	0.026	4.051	1.237	0.017	2.871	0.024	0.017	30.0	35.7	35.7
93	920	0.0050	0.026	4.077	1.254	0.017	2.895	0.024	0.017	30.1	35.3	35.3
94	930	0.0050	0.026	4.103	1.271	0.017	2.920	0.024	0.017	30.3	34.9	34.9
95	940	0.0050	0.026	4.129	1.287	0.017	2.944	0.024	0.017	30.4	34.6	34.6
96	950	0.0050	0.026	4.155	1.304	0.017	2.969	0.024	0.017	30.5	34.3	34.3
97	960	0.0050	0.026	4.181	1.321	0.017	2.993	0.025	0.017	30.6	34.1	34.1
98	970	0.0050	0.026	4.207	1.338	0.017	3.018	0.025	0.017	30.7	33.8	33.8
99	980	0.0050	0.026	4.233	1.355	0.017	3.042	0.025	0.017	30.8	33.6	33.6
100	990	0.0050	0.026	4.259	1.372	0.017	3.067	0.025	0.017	30.9	33.4	33.4
101	1,000	0.0050	0.026	4.285	1.389	0.017	3.091	0.025	0.017	31.0	33.3	33.3
102	1,010	0.0040	0.021	4.306	1.403	0.014	3.111	0.020	0.014	24.9	32.9	32.9
103	1,020	0.0040	0.021	4.326	1.416	0.014	3.131	0.020	0.014	24.9	32.3	32.3
104	1,030	0.0040	0.021	4.347	1.430	0.014	3.150	0.020	0.014	25.0	31.8	31.8
105	1,040	0.0040	0.021	4.368	1.444	0.014	3.170	0.020	0.014	25.1	31.4	31.4
106	1,050	0.0040	0.021	4.389	1.458	0.014	3.190	0.020	0.014	25.1	30.9	30.9
107	1,060	0.0040	0.021	4.410	1.472	0.014	3.209	0.020	0.014	25.2	30.5	30.5
108	1,070	0.0040	0.021	4.430	1.486	0.014	3.229	0.020	0.014	25.3	30.2	30.2
109	1,080	0.0040	0.021	4.451	1.500	0.014	3.249	0.020	0.014	25.3	29.8	29.8
110	1,090	0.0040	0.021	4.472	1.514	0.014	3.269	0.020	0.014	25.4	29.5	29.5
111	1,100	0.0040	0.021	4.493	1.528	0.014	3.288	0.020	0.014	25.5	29.2	29.2
112	1,110	0.0040	0.021	4.514	1.542	0.014	3.308	0.020	0.014	25.5	29.0	29.0
113	1,120	0.0040	0.021	4.534	1.556	0.014	3.328	0.020	0.014	25.6	28.8	28.8
114	1,130	0.0040	0.021	4.555	1.570	0.014	3.348	0.020	0.014	25.6	28.5	28.5
115	1,140	0.0040	0.021	4.576	1.584	0.014	3.367	0.020	0.014	25.7	28.3	28.3
116	1,150	0.0040	0.021	4.597	1.598	0.014	3.387	0.020	0.014	25.8	28.2	28.2
117	1,160	0.0040	0.021	4.618	1.612	0.014	3.407	0.020	0.014	25.8	28.0	28.0
118	1,170	0.0040	0.021	4.638	1.627	0.014	3.427	0.020	0.014	25.9	27.9	27.9
119	1,180	0.0040	0.021	4.659	1.641	0.014	3.447	0.020	0.014	25.9	27.7	27.7
120	1,190	0.0040	0.021	4.680	1.655	0.014	3.466	0.020	0.014	26.0	27.6	27.6
121	1,200	0.0040	0.021	4.701	1.670	0.014	3.486	0.020	0.014	26.1	27.5	27.5
122	1,210	0.0040	0.021	4.722	1.684	0.014	3.506	0.020	0.014	26.1	27.4	27.4
123	1,220	0.0040	0.021	4.742	1.698	0.014	3.526	0.020	0.014	26.2	27.3	27.3
124	1,230	0.0040	0.021	4.763	1.713	0.014	3.546	0.020	0.014	26.2	27.2	27.2
125	1,240	0.0040	0.021	4.784	1.727	0.014	3.565	0.020	0.014	26.3	27.2	27.2
126	1,250	0.0040	0.021	4.805	1.742	0.015	3.585	0.020	0.015	26.3	27.1	27.1
127	1,260	0.0040	0.021	4.826	1.756	0.015	3.605	0.020	0.015	26.4	27.1	27.1
128	1,270	0.0040	0.021	4.846	1.771	0.015	3.625	0.020	0.015	26.5	27.0	27.0
129	1,280	0.0040	0.021	4.867	1.786	0.015	3.645	0.020	0.015	26.5	27.0	27.0
130	1,290	0.0040	0.021	4.888	1.800	0.015	3.665	0.020	0.015	26.6	26.9	26.9
131	1,300	0.0040	0.021	4.909	1.815	0.015	3.685	0.020	0.015	26.6	26.9	26.9
132	1,310	0.0040	0.021	4.930	1.830	0.015	3.705	0.020	0.015	26.7	26.9	26.9
133	1,320	0.0040	0.021	4.950	1.844	0.015	3.724	0.020	0.015	26.7	26.9	26.9
134	1,330	0.0040	0.021	4.971	1.859	0.015	3.744	0.020	0.015	26.8	26.9	26.9
135	1,340	0.0040	0.021	4.992	1.874	0.015	3.764	0.020	0.015	26.8	26.9	26.9
136	1,350	0.0040	0.021	5.013	1.889	0.015	3.784	0.020	0.015	26.9	26.9	26.9
137	1,360	0.0040	0.021	5.034	1.904	0.015	3.804	0.020	0.015	26.9	26.9	26.9
138	1,370	0.0040	0.021	5.054	1.918	0.015	3.824	0.020	0.015	27.0	26.9	26.9
139	1,380	0.0040	0.021	5.075	1.933	0.015	3.844	0.020	0.015	27.0	26.9	26.9
140	1,390	0.0040	0.021	5.096	1.948	0.015	3.864	0.020	0.015	27.1	26.9	26.9
141	1,400	0.0040	0.021	5.117	1.963	0.015	3.884	0.020	0.015	27.1	26.9	26.9
142	1,410	0.0040	0.021	5.138	1.978	0.015	3.904	0.020	0.015	27.2	26.9	26.9
143	1,420	0.0040	0.021	5.158	1.993	0.015	3.924	0.020	0.015	27.2	26.9	26.9
144	1,430	0.0040	0.021	5.179	2.008	0.015	3.944	0.020	0.015	27.3	27.0	27.0
145	1,440	0.0040	0.0208	5.200	2.023	0.015	3.964	0.020	0.015	27.3	27.0	27.0
	Total:	1.0000	5.2000			2.0232		3.9637	2.0232			

Max: **40.7**

Cumulative Runoff at Period 145 1.81 inches

Unaccounted Runoff 0.22 inches

17,424.51 sec

290.41 min

29.04 periods

30 periods

1.8147 Total Runoff

Start Flow 27.0

End Flow -0.9

Flow Dec./per 0.9

Column	Description
1	Time Increment
2	Time (min)
3	Type IA Storm Distibution
4	Column 3 * Precipitation
5	Accumulated Sum of Column 4
6	If P<0.2S then 0, else (Column 5 - 0.2 * S)/(Column 5 +0.8 * S)
7	Column 6 of the present step - Column 6 of the previous step
8	Same as Column 6, except Impervious Area Calculations
9	Column 8 of the present step - Column 8 of the previous step
10	PerviousArea/TotalArea*Column 7 + ImperviousArea/TotalArea*Column 9
11	(60.5 * Column 10 * TotalArea)/Time Increment
12	Column 12 of previous step + w * ((Column 11 of previous step + column 11 of present step) - (2 * Column 12 of previous step))

100 YEAR PEAK FLOW ESTIMATE

				Return Period year	Duration hour
Site:	Gorst Creek				
		Rainfall:	6.17 in.	100	24

Time Increment: 10 minutes

w: 0.0344

w = Time increment / (2 * Time of Concentration + Time Increment)

	Area		CN	S	0.2 S
Pervious Area:	300.00	acres	68	4.71	0.94
Impervious Area:	0.00	acres	89	1.24	0.25
Total Area:	300.00	acres			
Time of Concentration:	140.1	minutes			
	2.34	hours			

Qmax= 57.5 cfs

Column

1	2	3	4	5	6	7	8	9	10	11	12	13
					PERVIOUS		IMPERVIOUS					
Time Increment	Time (minutes)	Rainfall Distribu-tion (fraction)	Incre-mental Rainfall (inches)	Accum. Rainfall (inches)	Accum. Rainfall (inches)	Increm. Runoff (inches)	Accum. Rainfall (inches)	Increm. Runoff (inches)	Total Runoff (inches)	Instant Flowrate (cfs)	Design Flowrate (cfs)	Design Flowrate with Tail (cfs)
1	0	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
2	10	0.0040	0.025	0.025	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
3	20	0.0040	0.025	0.049	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
4	30	0.0040	0.025	0.074	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
5	40	0.0040	0.025	0.099	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
6	50	0.0040	0.025	0.123	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
7	60	0.0040	0.025	0.148	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
8	70	0.0040	0.025	0.173	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
9	80	0.0040	0.025	0.197	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
10	90	0.0040	0.025	0.222	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
11	100	0.0040	0.025	0.247	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
12	110	0.0040	0.025	0.271	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
13	120	0.0050	0.031	0.302	0.000	0.000	0.002	0.002	0.000	0.0	0.0	0.0
14	130	0.0050	0.031	0.333	0.000	0.000	0.006	0.003	0.000	0.0	0.0	0.0
15	140	0.0050	0.031	0.364	0.000	0.000	0.010	0.004	0.000	0.0	0.0	0.0
16	150	0.0050	0.031	0.395	0.000	0.000	0.016	0.006	0.000	0.0	0.0	0.0
17	160	0.0050	0.031	0.426	0.000	0.000	0.023	0.007	0.000	0.0	0.0	0.0
18	170	0.0050	0.031	0.457	0.000	0.000	0.030	0.008	0.000	0.0	0.0	0.0
19	180	0.0060	0.037	0.494	0.000	0.000	0.041	0.011	0.000	0.0	0.0	0.0
20	190	0.0060	0.037	0.531	0.000	0.000	0.053	0.012	0.000	0.0	0.0	0.0
21	200	0.0060	0.037	0.568	0.000	0.000	0.066	0.013	0.000	0.0	0.0	0.0
22	210	0.0060	0.037	0.605	0.000	0.000	0.080	0.014	0.000	0.0	0.0	0.0
23	220	0.0060	0.037	0.642	0.000	0.000	0.095	0.015	0.000	0.0	0.0	0.0
24	230	0.0060	0.037	0.679	0.000	0.000	0.112	0.016	0.000	0.0	0.0	0.0
25	240	0.0070	0.043	0.722	0.000	0.000	0.132	0.020	0.000	0.0	0.0	0.0
26	250	0.0070	0.043	0.765	0.000	0.000	0.153	0.021	0.000	0.0	0.0	0.0
27	260	0.0070	0.043	0.808	0.000	0.000	0.175	0.022	0.000	0.0	0.0	0.0
28	270	0.0070	0.043	0.851	0.000	0.000	0.198	0.023	0.000	0.0	0.0	0.0
29	280	0.0070	0.043	0.895	0.000	0.000	0.223	0.024	0.000	0.0	0.0	0.0
30	290	0.0070	0.043	0.938	0.000	0.000	0.248	0.025	0.000	0.0	0.0	0.0
31	300	0.0080	0.049	0.987	0.000	0.000	0.277	0.030	0.000	0.8	0.0	0.0
32	310	0.0080	0.049	1.037	0.002	0.001	0.308	0.031	0.001	2.6	0.1	0.1
33	320	0.0080	0.049	1.086	0.004	0.002	0.339	0.031	0.002	4.4	0.4	0.4
34	330	0.0080	0.049	1.135	0.008	0.003	0.371	0.032	0.003	6.1	0.7	0.7
35	340	0.0080	0.049	1.185	0.012	0.004	0.404	0.033	0.004	7.8	1.1	1.1
36	350	0.0080	0.049	1.234	0.017	0.005	0.438	0.034	0.005	9.4	1.7	1.7
37	360	0.0100	0.062	1.296	0.025	0.008	0.481	0.043	0.008	13.9	2.3	2.3
38	370	0.0100	0.062	1.357	0.034	0.009	0.525	0.044	0.009	16.3	3.2	3.2
39	380	0.0100	0.062	1.419	0.044	0.010	0.570	0.045	0.010	18.6	4.2	4.2
40	390	0.0100	0.062	1.481	0.056	0.011	0.616	0.046	0.011	20.8	5.3	5.3
41	400	0.0100	0.062	1.543	0.068	0.013	0.663	0.047	0.013	22.9	6.4	6.4
42	410	0.0130	0.080	1.623	0.086	0.018	0.725	0.062	0.018	32.8	7.9	7.9
43	420	0.0130	0.080	1.703	0.106	0.020	0.787	0.063	0.020	36.1	9.7	9.7
44	430	0.0130	0.080	1.783	0.128	0.022	0.851	0.064	0.022	39.3	11.7	11.7
45	440	0.0180	0.111	1.894	0.160	0.033	0.941	0.090	0.033	59.4	14.2	14.2
46	450	0.0180	0.111	2.005	0.196	0.036	1.032	0.091	0.036	64.9	17.5	17.5
47	460	0.0340	0.210	2.215	0.271	0.075	1.209	0.176	0.075	136.4	23.3	23.3
48	470	0.0540	0.333	2.548	0.409	0.138	1.497	0.288	0.138	250.0	35.0	35.0
49	480	0.0270	0.167	2.715	0.485	0.076	1.644	0.147	0.076	138.7	46.0	46.0
50	490	0.0180	0.111	2.826	0.539	0.053	1.743	0.099	0.053	97.0	50.9	50.9
51	500	0.0130	0.080	2.906	0.579	0.040	1.815	0.072	0.040	72.3	53.2	53.2
52	510	0.0130	0.080	2.986	0.620	0.041	1.887	0.072	0.041	74.0	54.6	54.6
53	520	0.0130	0.080	3.066	0.661	0.042	1.960	0.073	0.042	75.7	56.0	56.0
54	530	0.0090	0.056	3.122	0.691	0.029	2.010	0.050	0.029	53.3	56.6	56.6
55	540	0.0090	0.056	3.178	0.720	0.030	2.061	0.051	0.030	54.1	56.4	56.4
56	550	0.0090	0.056	3.233	0.751	0.030	2.112	0.051	0.030	54.8	56.3	56.3
57	560	0.0090	0.056	3.289	0.781	0.031	2.163	0.051	0.031	55.6	56.2	56.2
58	570	0.0090	0.056	3.344	0.812	0.031	2.214	0.051	0.031	56.3	56.2	56.2
59	580	0.0090	0.056	3.400	0.844	0.031	2.265	0.051	0.031	57.0	56.2	56.2
60	590	0.0090	0.056	3.455	0.875	0.032	2.316	0.051	0.032	57.6	56.3	56.3
61	600	0.0090	0.056	3.511	0.908	0.032	2.367	0.051	0.032	58.3	56.4	56.4
62	610	0.0090	0.056	3.566	0.940	0.032	2.418	0.051	0.032	58.9	56.5	56.5
63	620	0.0090	0.056	3.622	0.973	0.033	2.470	0.051	0.033	59.6	56.7	56.7
64	630	0.0090	0.056	3.677	1.006	0.033	2.522	0.052	0.033	60.2	56.9	56.9
65	640	0.0090	0.056	3.733	1.039	0.033	2.573	0.052	0.033	60.8	57.2	57.2
66	650	0.0090	0.056	3.788	1.073	0.034	2.625	0.052	0.034	61.4	57.5	57.5
67	660	0.0070	0.043	3.832	1.100	0.027	2.665	0.040	0.027	48.1	57.3	57.3
68	670	0.0070	0.043	3.875	1.127	0.027	2.706	0.040	0.027	48.5	56.7	56.7
69	680	0.0070	0.043	3.918	1.153	0.027	2.746	0.040	0.027	48.8	56.1	56.1
70	690	0.0070	0.043	3.961	1.180	0.027	2.787	0.040	0.027	49.1	55.6	55.6
71	700	0.0070	0.043	4.004	1.208	0.027	2.827	0.041	0.027	49.5	55.2	55.2
72	710	0.0070	0.043	4.048	1.235	0.027	2.868	0.041	0.027	49.8	54.8	54.8

73	720	0.0070	0.043	4.091	1.263	0.028	2.908	0.041	0.028	50.1	54.5	54.5
74	730	0.0070	0.043	4.134	1.291	0.028	2.949	0.041	0.028	50.4	54.2	54.2
75	740	0.0070	0.043	4.177	1.318	0.028	2.990	0.041	0.028	50.7	53.9	53.9
76	750	0.0070	0.043	4.220	1.347	0.028	3.030	0.041	0.028	51.0	53.7	53.7
77	760	0.0070	0.043	4.263	1.375	0.028	3.071	0.041	0.028	51.3	53.5	53.5
78	770	0.0070	0.043	4.307	1.403	0.028	3.112	0.041	0.028	51.6	53.4	53.4
79	780	0.0060	0.037	4.344	1.428	0.024	3.147	0.035	0.024	44.5	53.0	53.0
80	790	0.0060	0.037	4.381	1.452	0.025	3.182	0.035	0.025	44.7	52.4	52.4
81	800	0.0060	0.037	4.418	1.477	0.025	3.217	0.035	0.025	44.9	51.9	51.9
82	810	0.0060	0.037	4.455	1.502	0.025	3.252	0.035	0.025	45.1	51.4	51.4
83	820	0.0060	0.037	4.492	1.527	0.025	3.287	0.035	0.025	45.3	51.0	51.0
84	830	0.0060	0.037	4.529	1.552	0.025	3.322	0.035	0.025	45.5	50.6	50.6
85	840	0.0060	0.037	4.566	1.577	0.025	3.358	0.035	0.025	45.7	50.3	50.3
86	850	0.0060	0.037	4.603	1.602	0.025	3.393	0.035	0.025	45.8	50.0	50.0
87	860	0.0060	0.037	4.640	1.628	0.025	3.428	0.035	0.025	46.0	49.7	49.7
88	870	0.0060	0.037	4.677	1.653	0.025	3.463	0.035	0.025	46.2	49.4	49.4
89	880	0.0060	0.037	4.714	1.679	0.026	3.499	0.035	0.026	46.4	49.2	49.2
90	890	0.0050	0.031	4.745	1.700	0.021	3.528	0.029	0.021	38.8	48.8	48.8
91	900	0.0050	0.031	4.776	1.722	0.021	3.557	0.029	0.021	38.9	48.1	48.1
92	910	0.0050	0.031	4.806	1.743	0.022	3.587	0.029	0.022	39.1	47.5	47.5
93	920	0.0050	0.031	4.837	1.765	0.022	3.616	0.029	0.022	39.2	46.9	46.9
94	930	0.0050	0.031	4.868	1.786	0.022	3.646	0.029	0.022	39.3	46.4	46.4
95	940	0.0050	0.031	4.899	1.808	0.022	3.675	0.029	0.022	39.4	45.9	45.9
96	950	0.0050	0.031	4.930	1.830	0.022	3.705	0.029	0.022	39.5	45.4	45.4
97	960	0.0050	0.031	4.961	1.852	0.022	3.734	0.030	0.022	39.6	45.0	45.0
98	970	0.0050	0.031	4.992	1.874	0.022	3.764	0.030	0.022	39.8	44.7	44.7
99	980	0.0050	0.031	5.022	1.896	0.022	3.793	0.030	0.022	39.9	44.3	44.3
100	990	0.0050	0.031	5.053	1.918	0.022	3.823	0.030	0.022	40.0	44.0	44.0
101	1,000	0.0050	0.031	5.084	1.940	0.022	3.852	0.030	0.022	40.1	43.7	43.7
102	1,010	0.0040	0.025	5.109	1.957	0.018	3.876	0.024	0.018	32.2	43.2	43.2
103	1,020	0.0040	0.025	5.133	1.975	0.018	3.900	0.024	0.018	32.2	42.5	42.5
104	1,030	0.0040	0.025	5.158	1.993	0.018	3.923	0.024	0.018	32.3	41.8	41.8
105	1,040	0.0040	0.025	5.183	2.011	0.018	3.947	0.024	0.018	32.4	41.1	41.1
106	1,050	0.0040	0.025	5.207	2.029	0.018	3.971	0.024	0.018	32.4	40.5	40.5
107	1,060	0.0040	0.025	5.232	2.047	0.018	3.995	0.024	0.018	32.5	40.0	40.0
108	1,070	0.0040	0.025	5.257	2.064	0.018	4.018	0.024	0.018	32.6	39.4	39.4
109	1,080	0.0040	0.025	5.282	2.082	0.018	4.042	0.024	0.018	32.6	39.0	39.0
110	1,090	0.0040	0.025	5.306	2.100	0.018	4.066	0.024	0.018	32.7	38.5	38.5
111	1,100	0.0040	0.025	5.331	2.119	0.018	4.089	0.024	0.018	32.8	38.1	38.1
112	1,110	0.0040	0.025	5.356	2.137	0.018	4.113	0.024	0.018	32.8	37.8	37.8
113	1,120	0.0040	0.025	5.380	2.155	0.018	4.137	0.024	0.018	32.9	37.4	37.4
114	1,130	0.0040	0.025	5.405	2.173	0.018	4.161	0.024	0.018	33.0	37.1	37.1
115	1,140	0.0040	0.025	5.430	2.191	0.018	4.184	0.024	0.018	33.0	36.8	36.8
116	1,150	0.0040	0.025	5.454	2.209	0.018	4.208	0.024	0.018	33.1	36.6	36.6
117	1,160	0.0040	0.025	5.479	2.228	0.018	4.232	0.024	0.018	33.2	36.3	36.3
118	1,170	0.0040	0.025	5.504	2.246	0.018	4.256	0.024	0.018	33.2	36.1	36.1
119	1,180	0.0040	0.025	5.528	2.264	0.018	4.280	0.024	0.018	33.3	35.9	35.9
120	1,190	0.0040	0.025	5.553	2.283	0.018	4.303	0.024	0.018	33.3	35.7	35.7
121	1,200	0.0040	0.025	5.578	2.301	0.018	4.327	0.024	0.018	33.4	35.6	35.6
122	1,210	0.0040	0.025	5.602	2.319	0.018	4.351	0.024	0.018	33.5	35.4	35.4
123	1,220	0.0040	0.025	5.627	2.338	0.018	4.375	0.024	0.018	33.5	35.3	35.3
124	1,230	0.0040	0.025	5.652	2.356	0.018	4.399	0.024	0.018	33.6	35.2	35.2
125	1,240	0.0040	0.025	5.676	2.375	0.019	4.422	0.024	0.019	33.6	35.1	35.1
126	1,250	0.0040	0.025	5.701	2.394	0.019	4.446	0.024	0.019	33.7	35.0	35.0
127	1,260	0.0040	0.025	5.726	2.412	0.019	4.470	0.024	0.019	33.8	34.9	34.9
128	1,270	0.0040	0.025	5.750	2.431	0.019	4.494	0.024	0.019	33.8	34.8	34.8
129	1,280	0.0040	0.025	5.775	2.449	0.019	4.518	0.024	0.019	33.9	34.7	34.7
130	1,290	0.0040	0.025	5.800	2.468	0.019	4.542	0.024	0.019	33.9	34.7	34.7
131	1,300	0.0040	0.025	5.824	2.487	0.019	4.566	0.024	0.019	34.0	34.6	34.6
132	1,310	0.0040	0.025	5.849	2.506	0.019	4.589	0.024	0.019	34.0	34.6	34.6
133	1,320	0.0040	0.025	5.874	2.524	0.019	4.613	0.024	0.019	34.1	34.6	34.6
134	1,330	0.0040	0.025	5.899	2.543	0.019	4.637	0.024	0.019	34.1	34.5	34.5
135	1,340	0.0040	0.025	5.923	2.562	0.019	4.661	0.024	0.019	34.2	34.5	34.5
136	1,350	0.0040	0.025	5.948	2.581	0.019	4.685	0.024	0.019	34.3	34.5	34.5
137	1,360	0.0040	0.025	5.973	2.600	0.019	4.709	0.024	0.019	34.3	34.5	34.5
138	1,370	0.0040	0.025	5.997	2.619	0.019	4.733	0.024	0.019	34.4	34.5	34.5
139	1,380	0.0040	0.025	6.022	2.638	0.019	4.757	0.024	0.019	34.4	34.5	34.5
140	1,390	0.0040	0.025	6.047	2.657	0.019	4.781	0.024	0.019	34.5	34.5	34.5
141	1,400	0.0040	0.025	6.071	2.676	0.019	4.805	0.024	0.019	34.5	34.5	34.5
142	1,410	0.0040	0.025	6.096	2.695	0.019	4.828	0.024	0.019	34.6	34.5	34.5
143	1,420	0.0040	0.025	6.121	2.714	0.019	4.852	0.024	0.019	34.6	34.5	34.5
144	1,430	0.0040	0.025	6.145	2.733	0.019	4.876	0.024	0.019	34.7	34.5	34.5
145	1,440	0.0040	0.0247	6.170	2.752	0.019	4.900	0.024	0.019	34.7	34.5	34.5
	Total:	1.0000	6.1700			2.7520		4.9002	2.7520			

Max: **57.5**

Cumulative Runoff at Period 145 2.48 inches

Unaccounted Runoff 0.28 inches

17,420.94 sec

290.35 min

29.03 periods

30 periods

2.4856 Total Runoff

Start Flow 34.5

End Flow -1.1

Flow Dec./per 1.2

Column	Description
1	Time Increment
2	Time (min)
3	Type IA Storm Distibution
4	Column 3 * Precipitation
5	Accumulated Sum of Column 4
6	If P<0.2S then 0, else (Column 5 - 0.2 * S)/(Column 5 +0.8 * S)
7	Column 6 of the present step - Column 6 of the previous step
8	Same as Column 6, except Impervious Area Calculations
9	Column 8 of the present step - Column 8 of the previous step
10	PerviousArea/TotalArea*Column 7 + ImperviousArea/TotalArea*Column 9
11	(60.5 * Column 10 * TotalArea)/Time Increment
12	Column 12 of previous step + w * ((Column 11 of previous step + column 11 of present step) - (2 * Column 12 of previous step))

500 YEAR PEAK FLOW ESTIMATE

Site: Gorst Creek

Rainfall: 7.28 in.

Return Period (year): 500

Duration (hour): 24

Time Increment: 10 minutes

w: 0.0344

w = Time increment / (2 * Time of Concentration + Time Increment)

	Area		CN	S	0.2 S
Pervious Area:	300.00	acres	68	4.71	0.94
Impervious Area:	0.00	acres	89	1.24	0.25
Total Area:	300.00	acres			

Time of Concentration: 140.1 minutes

2.34 hours

Qmax= 80.2 cfs

Column

1	2	3	4	5	6	7	8	9	10	11	12	13
					PERVIOUS		IMPERVIOUS					
Time Increment	Time (minutes)	Rainfall Distribu-tion (fraction)	Incre-mental Rainfall (inches)	Accum. Rainfall (inches)	Accum. Rainfall (inches)	Increm. Runoff (inches)	Accum. Rainfall (inches)	Increm. Runoff (inches)	Total Runoff (inches)	Instant Flowrate (cfs)	Design Flowrate (cfs)	Design Flowrate with Tail (cfs)
1	0	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
2	10	0.0040	0.029	0.029	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
3	20	0.0040	0.029	0.058	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
4	30	0.0040	0.029	0.087	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
5	40	0.0040	0.029	0.116	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
6	50	0.0040	0.029	0.146	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
7	60	0.0040	0.029	0.175	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
8	70	0.0040	0.029	0.204	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
9	80	0.0040	0.029	0.233	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
10	90	0.0040	0.029	0.262	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
11	100	0.0040	0.029	0.291	0.000	0.000	0.002	0.001	0.000	0.0	0.0	0.0
12	110	0.0040	0.029	0.320	0.000	0.000	0.004	0.003	0.000	0.0	0.0	0.0
13	120	0.0050	0.036	0.357	0.000	0.000	0.009	0.005	0.000	0.0	0.0	0.0
14	130	0.0050	0.036	0.393	0.000	0.000	0.015	0.006	0.000	0.0	0.0	0.0
15	140	0.0050	0.036	0.430	0.000	0.000	0.023	0.008	0.000	0.0	0.0	0.0
16	150	0.0050	0.036	0.466	0.000	0.000	0.033	0.009	0.000	0.0	0.0	0.0
17	160	0.0050	0.036	0.502	0.000	0.000	0.044	0.011	0.000	0.0	0.0	0.0
18	170	0.0050	0.036	0.539	0.000	0.000	0.056	0.012	0.000	0.0	0.0	0.0
19	180	0.0060	0.044	0.582	0.000	0.000	0.072	0.016	0.000	0.0	0.0	0.0
20	190	0.0060	0.044	0.626	0.000	0.000	0.089	0.017	0.000	0.0	0.0	0.0
21	200	0.0060	0.044	0.670	0.000	0.000	0.108	0.019	0.000	0.0	0.0	0.0
22	210	0.0060	0.044	0.713	0.000	0.000	0.128	0.020	0.000	0.0	0.0	0.0
23	220	0.0060	0.044	0.757	0.000	0.000	0.149	0.021	0.000	0.0	0.0	0.0
24	230	0.0060	0.044	0.801	0.000	0.000	0.171	0.022	0.000	0.0	0.0	0.0
25	240	0.0070	0.051	0.852	0.000	0.000	0.199	0.027	0.000	0.0	0.0	0.0
26	250	0.0070	0.051	0.903	0.000	0.000	0.227	0.029	0.000	0.0	0.0	0.0
27	260	0.0070	0.051	0.954	0.000	0.000	0.257	0.030	0.000	0.1	0.0	0.0
28	270	0.0070	0.051	1.005	0.001	0.001	0.288	0.031	0.001	1.5	0.1	0.1
29	280	0.0070	0.051	1.056	0.003	0.002	0.320	0.032	0.002	3.4	0.2	0.2
30	290	0.0070	0.051	1.107	0.006	0.003	0.352	0.033	0.003	5.3	0.5	0.5
31	300	0.0080	0.058	1.165	0.010	0.005	0.391	0.039	0.005	8.2	0.9	0.9
32	310	0.0080	0.058	1.223	0.016	0.006	0.431	0.040	0.006	10.5	1.5	1.5
33	320	0.0080	0.058	1.281	0.023	0.007	0.471	0.041	0.007	12.7	2.2	2.2
34	330	0.0080	0.058	1.340	0.031	0.008	0.512	0.041	0.008	14.8	3.0	3.0
35	340	0.0080	0.058	1.398	0.040	0.009	0.555	0.042	0.009	16.9	3.9	3.9
36	350	0.0080	0.058	1.456	0.051	0.010	0.598	0.043	0.010	18.9	4.9	4.9
37	360	0.0100	0.073	1.529	0.065	0.014	0.652	0.055	0.014	26.3	6.1	6.1
38	370	0.0100	0.073	1.602	0.081	0.016	0.708	0.056	0.016	29.1	7.6	7.6
39	380	0.0100	0.073	1.674	0.099	0.018	0.765	0.057	0.018	31.9	9.1	9.1
40	390	0.0100	0.073	1.747	0.118	0.019	0.822	0.058	0.019	34.5	10.8	10.8
41	400	0.0100	0.073	1.820	0.138	0.020	0.881	0.058	0.020	37.1	12.5	12.5
42	410	0.0130	0.095	1.915	0.167	0.029	0.958	0.077	0.029	51.8	14.7	14.7
43	420	0.0130	0.095	2.009	0.198	0.031	1.036	0.078	0.031	55.8	17.4	17.4
44	430	0.0130	0.095	2.104	0.230	0.033	1.115	0.079	0.033	59.5	20.2	20.2
45	440	0.0180	0.131	2.235	0.279	0.049	1.226	0.111	0.049	88.2	23.9	23.9
46	450	0.0180	0.131	2.366	0.331	0.052	1.338	0.113	0.052	94.6	28.5	28.5
47	460	0.0340	0.248	2.614	0.438	0.107	1.554	0.216	0.107	194.8	36.5	36.5
48	470	0.0540	0.393	3.007	0.630	0.192	1.906	0.351	0.192	347.7	52.7	52.7
49	480	0.0270	0.197	3.203	0.734	0.104	2.084	0.179	0.104	189.3	67.6	67.6
50	490	0.0180	0.131	3.334	0.807	0.072	2.204	0.120	0.072	131.4	74.0	74.0
51	500	0.0130	0.095	3.429	0.860	0.054	2.292	0.087	0.054	97.3	76.8	76.8
52	510	0.0130	0.095	3.524	0.915	0.055	2.379	0.087	0.055	99.2	78.2	78.2
53	520	0.0130	0.095	3.618	0.971	0.056	2.467	0.088	0.056	101.1	79.7	79.7
54	530	0.0090	0.066	3.684	1.010	0.039	2.527	0.061	0.039	71.0	80.2	80.2
55	540	0.0090	0.066	3.749	1.049	0.040	2.588	0.061	0.040	71.9	79.6	79.6
56	550	0.0090	0.066	3.815	1.089	0.040	2.650	0.061	0.040	72.7	79.1	79.1
57	560	0.0090	0.066	3.880	1.130	0.040	2.711	0.061	0.040	73.5	78.7	78.7
58	570	0.0090	0.066	3.946	1.171	0.041	2.772	0.061	0.041	74.2	78.3	78.3
59	580	0.0090	0.066	4.011	1.212	0.041	2.834	0.061	0.041	75.0	78.1	78.1
60	590	0.0090	0.066	4.077	1.254	0.042	2.895	0.062	0.042	75.7	77.9	77.9
61	600	0.0090	0.066	4.142	1.296	0.042	2.957	0.062	0.042	76.4	77.8	77.8
62	610	0.0090	0.066	4.208	1.338	0.043	3.019	0.062	0.043	77.1	77.7	77.7
63	620	0.0090	0.066	4.273	1.381	0.043	3.081	0.062	0.043	77.8	77.7	77.7
64	630	0.0090	0.066	4.339	1.425	0.043	3.142	0.062	0.043	78.5	77.7	77.7
65	640	0.0090	0.066	4.404	1.468	0.044	3.204	0.062	0.044	79.1	77.8	77.8
66	650	0.0090	0.066	4.470	1.512	0.044	3.267	0.062	0.044	79.8	77.9	77.9
67	660	0.0070	0.051	4.521	1.547	0.034	3.315	0.048	0.034	62.5	77.4	77.4
68	670	0.0070	0.051	4.572	1.581	0.035	3.363	0.048	0.035	62.8	76.4	76.4
69	680	0.0070	0.051	4.623	1.616	0.035	3.412	0.048	0.035	63.2	75.5	75.5
70	690	0.0070	0.051	4.674	1.651	0.035	3.460	0.049	0.035	63.6	74.7	74.7
71	700	0.0070	0.051	4.725	1.686	0.035	3.509	0.049	0.035	63.9	73.9	73.9
72	710	0.0070	0.051	4.776	1.722	0.035	3.558	0.049	0.035	64.2	73.2	73.2

73	720	0.0070	0.051	4.827	1.757	0.036	3.606	0.049	0.036	64.6	72.6	72.6
74	730	0.0070	0.051	4.878	1.793	0.036	3.655	0.049	0.036	64.9	72.1	72.1
75	740	0.0070	0.051	4.929	1.829	0.036	3.704	0.049	0.036	65.2	71.6	71.6
76	750	0.0070	0.051	4.980	1.865	0.036	3.752	0.049	0.036	65.5	71.2	71.2
77	760	0.0070	0.051	5.030	1.901	0.036	3.801	0.049	0.036	65.9	70.8	70.8
78	770	0.0070	0.051	5.081	1.938	0.036	3.850	0.049	0.036	66.2	70.5	70.5
79	780	0.0060	0.044	5.125	1.969	0.031	3.892	0.042	0.031	57.0	69.8	69.8
80	790	0.0060	0.044	5.169	2.001	0.031	3.934	0.042	0.031	57.2	69.0	69.0
81	800	0.0060	0.044	5.212	2.032	0.032	3.976	0.042	0.032	57.4	68.2	68.2
82	810	0.0060	0.044	5.256	2.064	0.032	4.018	0.042	0.032	57.6	67.4	67.4
83	820	0.0060	0.044	5.300	2.096	0.032	4.060	0.042	0.032	57.8	66.8	66.8
84	830	0.0060	0.044	5.344	2.128	0.032	4.102	0.042	0.032	58.0	66.1	66.1
85	840	0.0060	0.044	5.387	2.160	0.032	4.144	0.042	0.032	58.2	65.6	65.6
86	850	0.0060	0.044	5.431	2.192	0.032	4.186	0.042	0.032	58.4	65.1	65.1
87	860	0.0060	0.044	5.475	2.224	0.032	4.228	0.042	0.032	58.6	64.6	64.6
88	870	0.0060	0.044	5.518	2.257	0.032	4.270	0.042	0.032	58.8	64.2	64.2
89	880	0.0060	0.044	5.562	2.289	0.033	4.312	0.042	0.033	59.0	63.9	63.9
90	890	0.0050	0.036	5.598	2.316	0.027	4.347	0.035	0.027	49.3	63.2	63.2
91	900	0.0050	0.036	5.635	2.344	0.027	4.382	0.035	0.027	49.4	62.2	62.2
92	910	0.0050	0.036	5.671	2.371	0.027	4.417	0.035	0.027	49.6	61.4	61.4
93	920	0.0050	0.036	5.708	2.398	0.027	4.452	0.035	0.027	49.7	60.6	60.6
94	930	0.0050	0.036	5.744	2.426	0.027	4.488	0.035	0.027	49.8	59.8	59.8
95	940	0.0050	0.036	5.780	2.453	0.028	4.523	0.035	0.028	49.9	59.1	59.1
96	950	0.0050	0.036	5.817	2.481	0.028	4.558	0.035	0.028	50.1	58.5	58.5
97	960	0.0050	0.036	5.853	2.509	0.028	4.593	0.035	0.028	50.2	57.9	57.9
98	970	0.0050	0.036	5.890	2.536	0.028	4.628	0.035	0.028	50.3	57.4	57.4
99	980	0.0050	0.036	5.926	2.564	0.028	4.664	0.035	0.028	50.4	56.9	56.9
100	990	0.0050	0.036	5.962	2.592	0.028	4.699	0.035	0.028	50.5	56.5	56.5
101	1,000	0.0050	0.036	5.999	2.620	0.028	4.734	0.035	0.028	50.7	56.1	56.1
102	1,010	0.0040	0.029	6.028	2.642	0.022	4.762	0.028	0.022	40.6	55.3	55.3
103	1,020	0.0040	0.029	6.057	2.665	0.022	4.791	0.028	0.022	40.7	54.3	54.3
104	1,030	0.0040	0.029	6.086	2.687	0.022	4.819	0.028	0.022	40.8	53.4	53.4
105	1,040	0.0040	0.029	6.115	2.710	0.022	4.847	0.028	0.022	40.8	52.5	52.5
106	1,050	0.0040	0.029	6.144	2.732	0.023	4.875	0.028	0.023	40.9	51.7	51.7
107	1,060	0.0040	0.029	6.173	2.755	0.023	4.904	0.028	0.023	41.0	51.0	51.0
108	1,070	0.0040	0.029	6.203	2.777	0.023	4.932	0.028	0.023	41.0	50.3	50.3
109	1,080	0.0040	0.029	6.232	2.800	0.023	4.960	0.028	0.023	41.1	49.7	49.7
110	1,090	0.0040	0.029	6.261	2.823	0.023	4.988	0.028	0.023	41.2	49.1	49.1
111	1,100	0.0040	0.029	6.290	2.845	0.023	5.017	0.028	0.023	41.2	48.5	48.5
112	1,110	0.0040	0.029	6.319	2.868	0.023	5.045	0.028	0.023	41.3	48.0	48.0
113	1,120	0.0040	0.029	6.348	2.891	0.023	5.073	0.028	0.023	41.4	47.6	47.6
114	1,130	0.0040	0.029	6.377	2.914	0.023	5.102	0.028	0.023	41.4	47.1	47.1
115	1,140	0.0040	0.029	6.406	2.937	0.023	5.130	0.028	0.023	41.5	46.8	46.8
116	1,150	0.0040	0.029	6.436	2.960	0.023	5.158	0.028	0.023	41.6	46.4	46.4
117	1,160	0.0040	0.029	6.465	2.982	0.023	5.186	0.028	0.023	41.6	46.1	46.1
118	1,170	0.0040	0.029	6.494	3.005	0.023	5.215	0.028	0.023	41.7	45.8	45.8
119	1,180	0.0040	0.029	6.523	3.028	0.023	5.243	0.028	0.023	41.8	45.5	45.5
120	1,190	0.0040	0.029	6.552	3.051	0.023	5.271	0.028	0.023	41.8	45.2	45.2
121	1,200	0.0040	0.029	6.581	3.075	0.023	5.300	0.028	0.023	41.9	45.0	45.0
122	1,210	0.0040	0.029	6.610	3.098	0.023	5.328	0.028	0.023	41.9	44.8	44.8
123	1,220	0.0040	0.029	6.639	3.121	0.023	5.356	0.028	0.023	42.0	44.6	44.6
124	1,230	0.0040	0.029	6.668	3.144	0.023	5.385	0.028	0.023	42.1	44.4	44.4
125	1,240	0.0040	0.029	6.698	3.167	0.023	5.413	0.028	0.023	42.1	44.3	44.3
126	1,250	0.0040	0.029	6.727	3.190	0.023	5.442	0.028	0.023	42.2	44.1	44.1
127	1,260	0.0040	0.029	6.756	3.214	0.023	5.470	0.028	0.023	42.2	44.0	44.0
128	1,270	0.0040	0.029	6.785	3.237	0.023	5.498	0.028	0.023	42.3	43.9	43.9
129	1,280	0.0040	0.029	6.814	3.260	0.023	5.527	0.028	0.023	42.4	43.8	43.8
130	1,290	0.0040	0.029	6.843	3.284	0.023	5.555	0.028	0.023	42.4	43.7	43.7
131	1,300	0.0040	0.029	6.872	3.307	0.023	5.583	0.028	0.023	42.5	43.6	43.6
132	1,310	0.0040	0.029	6.901	3.331	0.023	5.612	0.028	0.023	42.5	43.5	43.5
133	1,320	0.0040	0.029	6.931	3.354	0.023	5.640	0.028	0.023	42.6	43.4	43.4
134	1,330	0.0040	0.029	6.960	3.378	0.023	5.669	0.028	0.023	42.6	43.4	43.4
135	1,340	0.0040	0.029	6.989	3.401	0.024	5.697	0.028	0.024	42.7	43.3	43.3
136	1,350	0.0040	0.029	7.018	3.425	0.024	5.726	0.028	0.024	42.8	43.3	43.3
137	1,360	0.0040	0.029	7.047	3.448	0.024	5.754	0.028	0.024	42.8	43.3	43.3
138	1,370	0.0040	0.029	7.076	3.472	0.024	5.782	0.028	0.024	42.9	43.2	43.2
139	1,380	0.0040	0.029	7.105	3.496	0.024	5.811	0.028	0.024	42.9	43.2	43.2
140	1,390	0.0040	0.029	7.134	3.519	0.024	5.839	0.028	0.024	43.0	43.2	43.2
141	1,400	0.0040	0.029	7.164	3.543	0.024	5.868	0.028	0.024	43.0	43.2	43.2
142	1,410	0.0040	0.029	7.193	3.567	0.024	5.896	0.028	0.024	43.1	43.2	43.2
143	1,420	0.0040	0.029	7.222	3.590	0.024	5.925	0.028	0.024	43.1	43.2	43.2
144	1,430	0.0040	0.029	7.251	3.614	0.024	5.953	0.028	0.024	43.2	43.2	43.2
145	1,440	0.0040	0.0291	7.280	3.638	0.024	5.982	0.028	0.024	43.2	43.2	43.2
	Total:	1.0000	7.2800			3.6380		5.9816	3.6380			

Max:	**80.2**			
Cumulative Runoff at Period 145	3.29	inches	Start Flow	43.2
Unaccounted Runoff	0.35	inches	End Flow	-1.4
	17,417.99	sec	Flow Dec./per	1.5
	290.30	min		
	29.03	periods		
	30	periods		
	3.3047	Total Runoff		

Column	Description
1	Time Increment
2	Time (min)
3	Type IA Storm Distibution
4	Column 3 * Precipitation
5	Accumulated Sum of Column 4
6	If P<0.2S then 0, else (Column 5 - 0.2 * S)/(Column 5 +0.8 * S)
7	Column 6 of the present step - Column 6 of the previous step
8	Same as Column 6, except Impervious Area Calculations
9	Column 8 of the present step - Column 8 of the previous step
10	PerviousArea/TotalArea*Column 7 + ImperviousArea/TotalArea*Column 9
11	(60.5 * Column 10 * TotalArea)/Time Increment
12	Column 12 of previous step + w * ((Column 11 of previous step + column 11 of present step) - (2 * Column 12 of previous step))

100,000 YEAR PEAK FLOW ESTIMATE

		Return Period year	Duration hour
Site: Gorst Creek	Rainfall: 10.82 in.	100,000	24

Time Increment: 10 minutes

w: 0.0344

w = Time increment / (2 * Time of Concentration + Time Increment)

	Area		CN	S	0.2 S
Pervious Area:	300.00	acres	68	4.71	0.94
Impervious Area:	0.00	acres	89	1.24	0.25
Total Area:	300.00	acres			

Time of Concentration: 140.1 minutes, 2.34 hours

Qmax= 165.2 cfs

Column

1	2	3	4	5	6	7	8	9	10	11	12	13
					PERVIOUS		IMPERVIOUS					
Time Increment	Time (minutes)	Rainfall Distribu-tion (fraction)	Incre-mental Rainfall (inches)	Accum. Rainfall (inches)	Accum. Rainfall (inches)	Increm. Runoff (inches)	Accum. Rainfall (inches)	Increm. Runoff (inches)	Total Runoff (inches)	Instant Flowrate (cfs)	Design Flowrate (cfs)	Design Flowrate with Tail (cfs)
1	0	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
2	10	0.0040	0.043	0.043	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
3	20	0.0040	0.043	0.087	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
4	30	0.0040	0.043	0.130	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
5	40	0.0040	0.043	0.173	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
6	50	0.0040	0.043	0.216	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
7	60	0.0040	0.043	0.260	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
8	70	0.0040	0.043	0.303	0.000	0.000	0.002	0.002	0.000	0.0	0.0	0.0
9	80	0.0040	0.043	0.346	0.000	0.000	0.007	0.005	0.000	0.0	0.0	0.0
10	90	0.0040	0.043	0.390	0.000	0.000	0.015	0.007	0.000	0.0	0.0	0.0
11	100	0.0040	0.043	0.433	0.000	0.000	0.024	0.010	0.000	0.0	0.0	0.0
12	110	0.0040	0.043	0.476	0.000	0.000	0.036	0.012	0.000	0.0	0.0	0.0
13	120	0.0050	0.054	0.530	0.000	0.000	0.053	0.017	0.000	0.0	0.0	0.0
14	130	0.0050	0.054	0.584	0.000	0.000	0.072	0.020	0.000	0.0	0.0	0.0
15	140	0.0050	0.054	0.638	0.000	0.000	0.094	0.022	0.000	0.0	0.0	0.0
16	150	0.0050	0.054	0.692	0.000	0.000	0.118	0.024	0.000	0.0	0.0	0.0
17	160	0.0050	0.054	0.747	0.000	0.000	0.144	0.026	0.000	0.0	0.0	0.0
18	170	0.0050	0.054	0.801	0.000	0.000	0.171	0.027	0.000	0.0	0.0	0.0
19	180	0.0060	0.065	0.866	0.000	0.000	0.206	0.035	0.000	0.0	0.0	0.0
20	190	0.0060	0.065	0.931	0.000	0.000	0.243	0.037	0.000	0.0	0.0	0.0
21	200	0.0060	0.065	0.995	0.001	0.001	0.282	0.039	0.001	1.1	0.0	0.0
22	210	0.0060	0.065	1.060	0.003	0.002	0.323	0.041	0.002	4.2	0.2	0.2
23	220	0.0060	0.065	1.125	0.007	0.004	0.365	0.042	0.004	7.2	0.6	0.6
24	230	0.0060	0.065	1.190	0.013	0.006	0.408	0.043	0.006	10.1	1.2	1.2
25	240	0.0070	0.076	1.266	0.021	0.008	0.460	0.052	0.008	15.3	2.0	2.0
26	250	0.0070	0.076	1.342	0.031	0.010	0.514	0.054	0.010	19.0	3.0	3.0
27	260	0.0070	0.076	1.417	0.044	0.012	0.569	0.055	0.012	22.4	4.2	4.2
28	270	0.0070	0.076	1.493	0.058	0.014	0.625	0.056	0.014	25.7	5.6	5.6
29	280	0.0070	0.076	1.569	0.074	0.016	0.683	0.058	0.016	28.9	7.1	7.1
30	290	0.0070	0.076	1.645	0.091	0.018	0.742	0.059	0.018	32.0	8.7	8.7
31	300	0.0080	0.087	1.731	0.114	0.022	0.810	0.068	0.022	40.1	10.6	10.6
32	310	0.0080	0.087	1.818	0.138	0.024	0.879	0.069	0.024	43.7	12.7	12.7
33	320	0.0080	0.087	1.904	0.164	0.026	0.949	0.070	0.026	47.2	15.0	15.0
34	330	0.0080	0.087	1.991	0.191	0.028	1.020	0.071	0.028	50.5	17.3	17.3
35	340	0.0080	0.087	2.077	0.221	0.030	1.092	0.072	0.030	53.6	19.7	19.7
36	350	0.0080	0.087	2.164	0.252	0.031	1.165	0.073	0.031	56.7	22.2	22.2
37	360	0.0100	0.108	2.272	0.293	0.041	1.257	0.092	0.041	74.9	25.2	25.2
38	370	0.0100	0.108	2.380	0.337	0.044	1.351	0.093	0.044	79.2	28.7	28.7
39	380	0.0100	0.108	2.489	0.383	0.046	1.445	0.094	0.046	83.2	32.3	32.3
40	390	0.0100	0.108	2.597	0.431	0.048	1.540	0.095	0.048	87.1	36.0	36.0
41	400	0.0100	0.108	2.705	0.481	0.050	1.635	0.096	0.050	90.7	39.6	39.6
42	410	0.0130	0.141	2.846	0.549	0.068	1.761	0.125	0.068	123.1	44.3	44.3
43	420	0.0130	0.141	2.986	0.620	0.071	1.887	0.127	0.071	128.6	49.9	49.9
44	430	0.0130	0.141	3.127	0.693	0.074	2.015	0.128	0.074	133.8	55.5	55.5
45	440	0.0180	0.195	3.322	0.800	0.106	2.193	0.178	0.106	193.2	62.9	62.9
46	450	0.0180	0.195	3.517	0.911	0.111	2.372	0.179	0.111	201.8	72.2	72.2
47	460	0.0340	0.368	3.884	1.132	0.222	2.715	0.342	0.222	402.2	88.0	88.0
48	470	0.0540	0.584	4.469	1.511	0.379	3.265	0.551	0.379	687.6	119.5	119.5
49	480	0.0270	0.292	4.761	1.711	0.200	3.543	0.278	0.200	363.0	147.5	147.5
50	490	0.0180	0.195	4.956	1.848	0.137	3.729	0.186	0.137	248.2	158.4	158.4
51	500	0.0130	0.141	5.096	1.948	0.100	3.864	0.135	0.100	182.1	162.3	162.3
52	510	0.0130	0.141	5.237	2.050	0.102	3.999	0.135	0.102	184.4	163.7	163.7
53	520	0.0130	0.141	5.378	2.153	0.103	4.134	0.135	0.103	186.6	165.2	165.2
54	530	0.0090	0.097	5.475	2.225	0.072	4.228	0.094	0.072	130.4	164.8	164.8
55	540	0.0090	0.097	5.572	2.297	0.072	4.322	0.094	0.072	131.4	162.4	162.4
56	550	0.0090	0.097	5.670	2.370	0.073	4.416	0.094	0.073	132.3	160.3	160.3
57	560	0.0090	0.097	5.767	2.443	0.073	4.510	0.094	0.073	133.2	158.4	158.4
58	570	0.0090	0.097	5.864	2.517	0.074	4.604	0.094	0.074	134.1	156.7	156.7
59	580	0.0090	0.097	5.962	2.592	0.074	4.698	0.094	0.074	135.0	155.2	155.2
60	590	0.0090	0.097	6.059	2.666	0.075	4.793	0.094	0.075	135.8	153.8	153.8
61	600	0.0090	0.097	6.157	2.742	0.075	4.887	0.094	0.075	136.6	152.6	152.6
62	610	0.0090	0.097	6.254	2.817	0.076	4.982	0.095	0.076	137.4	151.5	151.5
63	620	0.0090	0.097	6.351	2.893	0.076	5.076	0.095	0.076	138.1	150.6	150.6
64	630	0.0090	0.097	6.449	2.970	0.077	5.171	0.095	0.077	138.9	149.7	149.7
65	640	0.0090	0.097	6.546	3.047	0.077	5.266	0.095	0.077	139.6	149.0	149.0
66	650	0.0090	0.097	6.643	3.124	0.077	5.360	0.095	0.077	140.3	148.4	148.4
67	660	0.0070	0.076	6.719	3.184	0.060	5.434	0.074	0.060	109.6	146.8	146.8
68	670	0.0070	0.076	6.795	3.245	0.061	5.508	0.074	0.061	110.0	144.2	144.2
69	680	0.0070	0.076	6.871	3.306	0.061	5.582	0.074	0.061	110.4	141.9	141.9
70	690	0.0070	0.076	6.946	3.367	0.061	5.656	0.074	0.061	110.7	139.7	139.7
71	700	0.0070	0.076	7.022	3.428	0.061	5.730	0.074	0.061	111.1	137.7	137.7
72	710	0.0070	0.076	7.098	3.490	0.061	5.804	0.074	0.061	111.5	135.9	135.9

73	720	0.0070	0.076	7.174	3.551	0.062	5.878	0.074	0.062	111.8	134.2	134.2
74	730	0.0070	0.076	7.249	3.613	0.062	5.952	0.074	0.062	112.2	132.7	132.7
75	740	0.0070	0.076	7.325	3.675	0.062	6.026	0.074	0.062	112.5	131.3	131.3
76	750	0.0070	0.076	7.401	3.737	0.062	6.100	0.074	0.062	112.9	130.0	130.0
77	760	0.0070	0.076	7.477	3.800	0.062	6.174	0.074	0.062	113.2	128.9	128.9
78	770	0.0070	0.076	7.552	3.862	0.063	6.248	0.074	0.063	113.5	127.8	127.8
79	780	0.0060	0.065	7.617	3.916	0.054	6.312	0.064	0.054	97.6	126.3	126.3
80	790	0.0060	0.065	7.682	3.970	0.054	6.375	0.064	0.054	97.8	124.3	124.3
81	800	0.0060	0.065	7.747	4.024	0.054	6.439	0.064	0.054	98.0	122.5	122.5
82	810	0.0060	0.065	7.812	4.078	0.054	6.502	0.064	0.054	98.3	120.8	120.8
83	820	0.0060	0.065	7.877	4.132	0.054	6.566	0.064	0.054	98.5	119.3	119.3
84	830	0.0060	0.065	7.942	4.187	0.054	6.630	0.064	0.054	98.7	117.8	117.8
85	840	0.0060	0.065	8.007	4.241	0.054	6.693	0.064	0.054	98.9	116.5	116.5
86	850	0.0060	0.065	8.072	4.296	0.055	6.757	0.064	0.055	99.1	115.3	115.3
87	860	0.0060	0.065	8.137	4.350	0.055	6.821	0.064	0.055	99.3	114.2	114.2
88	870	0.0060	0.065	8.202	4.405	0.055	6.885	0.064	0.055	99.5	113.2	113.2
89	880	0.0060	0.065	8.266	4.460	0.055	6.948	0.064	0.055	99.7	112.2	112.2
90	890	0.0050	0.054	8.321	4.506	0.046	7.002	0.053	0.046	83.2	110.8	110.8
91	900	0.0050	0.054	8.375	4.552	0.046	7.055	0.053	0.046	83.4	108.9	108.9
92	910	0.0050	0.054	8.429	4.598	0.046	7.108	0.053	0.046	83.5	107.2	107.2
93	920	0.0050	0.054	8.483	4.644	0.046	7.161	0.053	0.046	83.6	105.5	105.5
94	930	0.0050	0.054	8.537	4.690	0.046	7.214	0.053	0.046	83.8	104.0	104.0
95	940	0.0050	0.054	8.591	4.736	0.046	7.267	0.053	0.046	83.9	102.6	102.6
96	950	0.0050	0.054	8.645	4.783	0.046	7.321	0.053	0.046	84.0	101.4	101.4
97	960	0.0050	0.054	8.699	4.829	0.046	7.374	0.053	0.046	84.1	100.2	100.2
98	970	0.0050	0.054	8.753	4.875	0.046	7.427	0.053	0.046	84.3	99.1	99.1
99	980	0.0050	0.054	8.807	4.922	0.046	7.480	0.053	0.046	84.4	98.0	98.0
100	990	0.0050	0.054	8.862	4.968	0.047	7.534	0.053	0.047	84.5	97.1	97.1
101	1,000	0.0050	0.054	8.916	5.015	0.047	7.587	0.053	0.047	84.6	96.2	96.2
102	1,010	0.0040	0.043	8.959	5.052	0.037	7.629	0.043	0.037	67.8	94.9	94.9
103	1,020	0.0040	0.043	9.002	5.090	0.037	7.672	0.043	0.037	67.8	93.0	93.0
104	1,030	0.0040	0.043	9.046	5.127	0.037	7.715	0.043	0.037	67.9	91.3	91.3
105	1,040	0.0040	0.043	9.089	5.165	0.037	7.757	0.043	0.037	68.0	89.7	89.7
106	1,050	0.0040	0.043	9.132	5.202	0.037	7.800	0.043	0.037	68.1	88.2	88.2
107	1,060	0.0040	0.043	9.175	5.240	0.038	7.843	0.043	0.038	68.1	86.8	86.8
108	1,070	0.0040	0.043	9.219	5.277	0.038	7.885	0.043	0.038	68.2	85.5	85.5
109	1,080	0.0040	0.043	9.262	5.315	0.038	7.928	0.043	0.038	68.3	84.3	84.3
110	1,090	0.0040	0.043	9.305	5.353	0.038	7.970	0.043	0.038	68.3	83.2	83.2
111	1,100	0.0040	0.043	9.348	5.390	0.038	8.013	0.043	0.038	68.4	82.2	82.2
112	1,110	0.0040	0.043	9.392	5.428	0.038	8.056	0.043	0.038	68.5	81.2	81.2
113	1,120	0.0040	0.043	9.435	5.466	0.038	8.098	0.043	0.038	68.5	80.4	80.4
114	1,130	0.0040	0.043	9.478	5.503	0.038	8.141	0.043	0.038	68.6	79.6	79.6
115	1,140	0.0040	0.043	9.522	5.541	0.038	8.184	0.043	0.038	68.7	78.8	78.8
116	1,150	0.0040	0.043	9.565	5.579	0.038	8.226	0.043	0.038	68.7	78.1	78.1
117	1,160	0.0040	0.043	9.608	5.617	0.038	8.269	0.043	0.038	68.8	77.5	77.5
118	1,170	0.0040	0.043	9.651	5.655	0.038	8.312	0.043	0.038	68.9	76.9	76.9
119	1,180	0.0040	0.043	9.695	5.693	0.038	8.355	0.043	0.038	68.9	76.3	76.3
120	1,190	0.0040	0.043	9.738	5.731	0.038	8.397	0.043	0.038	69.0	75.8	75.8
121	1,200	0.0040	0.043	9.781	5.769	0.038	8.440	0.043	0.038	69.0	75.3	75.3
122	1,210	0.0040	0.043	9.825	5.807	0.038	8.483	0.043	0.038	69.1	74.9	74.9
123	1,220	0.0040	0.043	9.868	5.845	0.038	8.525	0.043	0.038	69.2	74.5	74.5
124	1,230	0.0040	0.043	9.911	5.883	0.038	8.568	0.043	0.038	69.2	74.1	74.1
125	1,240	0.0040	0.043	9.954	5.922	0.038	8.611	0.043	0.038	69.3	73.8	73.8
126	1,250	0.0040	0.043	9.998	5.960	0.038	8.654	0.043	0.038	69.3	73.5	73.5
127	1,260	0.0040	0.043	10.041	5.998	0.038	8.696	0.043	0.038	69.4	73.2	73.2
128	1,270	0.0040	0.043	10.084	6.036	0.038	8.739	0.043	0.038	69.5	73.0	73.0
129	1,280	0.0040	0.043	10.128	6.075	0.038	8.782	0.043	0.038	69.5	72.7	72.7
130	1,290	0.0040	0.043	10.171	6.113	0.038	8.825	0.043	0.038	69.6	72.5	72.5
131	1,300	0.0040	0.043	10.214	6.151	0.038	8.867	0.043	0.038	69.6	72.3	72.3
132	1,310	0.0040	0.043	10.257	6.190	0.038	8.910	0.043	0.038	69.7	72.1	72.1
133	1,320	0.0040	0.043	10.301	6.228	0.038	8.953	0.043	0.038	69.7	71.9	71.9
134	1,330	0.0040	0.043	10.344	6.266	0.038	8.996	0.043	0.038	69.8	71.8	71.8
135	1,340	0.0040	0.043	10.387	6.305	0.038	9.038	0.043	0.038	69.8	71.7	71.7
136	1,350	0.0040	0.043	10.430	6.343	0.039	9.081	0.043	0.039	69.9	71.5	71.5
137	1,360	0.0040	0.043	10.474	6.382	0.039	9.124	0.043	0.039	69.9	71.4	71.4
138	1,370	0.0040	0.043	10.517	6.421	0.039	9.167	0.043	0.039	70.0	71.3	71.3
139	1,380	0.0040	0.043	10.560	6.459	0.039	9.209	0.043	0.039	70.1	71.2	71.2
140	1,390	0.0040	0.043	10.604	6.498	0.039	9.252	0.043	0.039	70.1	71.2	71.2
141	1,400	0.0040	0.043	10.647	6.536	0.039	9.295	0.043	0.039	70.2	71.1	71.1
142	1,410	0.0040	0.043	10.690	6.575	0.039	9.338	0.043	0.039	70.2	71.0	71.0
143	1,420	0.0040	0.043	10.733	6.614	0.039	9.381	0.043	0.039	70.3	71.0	71.0
144	1,430	0.0040	0.043	10.777	6.653	0.039	9.423	0.043	0.039	70.3	70.9	70.9
145	1,440	0.0040	0.0433	10.820	6.691	0.039	9.466	0.043	0.039	70.4	70.9	70.9
	Total:	1.0000	10.8200			6.6913		9.4662	6.6913			

Max:	**165.2**			
Cumulative Runoff at Period 145	6.12	inches	Start Flow	70.9
Unaccounted Runoff	0.57	inches	End Flow	-2.3
	17,412.60	sec	Flow Dec./per	2.4
	290.21	min		
	29.02	periods		
	30	periods		
	6.1442	Total Runoff		

Column	Description
1	Time Increment
2	Time (min)
3	Type IA Storm Distibution
4	Column 3 * Precipitation
5	Accumulated Sum of Column 4
6	If P<0.2S then 0, else (Column 5 - 0.2 * S)/(Column 5 +0.8 * S)
7	Column 6 of the present step - Column 6 of the previous step
8	Same as Column 6, except Impervious Area Calculations
9	Column 8 of the present step - Column 8 of the previous step
10	PerviousArea/TotalArea*Column 7 + ImperviousArea/TotalArea*Column 9
11	(60.5 * Column 10 * TotalArea)/Time Increment
12	Column 12 of previous step + w * ((Column 11 of previous step + column 11 of present step) - (2 * Column 12 of previous step))

1,000,000 YEAR PEAK FLOW ESTIMATE

Site: Gorst Creek		Return Period year	Duration hour	
Rainfall:	12.31 in.	1,000,000	24	

Time Increment: 10 minutes   w: 0.0344

w = Time increment / (2 * Time of Concentration + Time Increment)

	Area		CN	S	0.2 S
Pervious Area:	300.00	acres	68	4.71	0.94
Impervious Area:	0.00	acres	89	1.24	0.25
Total Area:	300.00	acres			

Time of Concentration: 140.1 minutes / 2.34 hours

Qmax= 203.9 cfs

Column

1	2	3	4	5	6	7	8	9	10	11	12	13
					PERVIOUS		IMPERVIOUS					
Time Increment	Time (minutes)	Rainfall Distribution (fraction)	Incremental Rainfall (inches)	Accum. Rainfall (inches)	Accum. Rainfall (inches)	Increm. Runoff (inches)	Accum. Rainfall (inches)	Increm. Runoff (inches)	Total Runoff (inches)	Instant Flowrate (cfs)	Design Flowrate (cfs)	Design Flowrate with Tail (cfs)
1	0	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
2	10	0.0040	0.049	0.049	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
3	20	0.0040	0.049	0.098	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
4	30	0.0040	0.049	0.148	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
5	40	0.0040	0.049	0.197	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
6	50	0.0040	0.049	0.246	0.000	0.000	0.000	0.000	0.000	0.0	0.0	0.0
7	60	0.0040	0.049	0.295	0.000	0.000	0.002	0.002	0.000	0.0	0.0	0.0
8	70	0.0040	0.049	0.345	0.000	0.000	0.007	0.005	0.000	0.0	0.0	0.0
9	80	0.0040	0.049	0.394	0.000	0.000	0.016	0.008	0.000	0.0	0.0	0.0
10	90	0.0040	0.049	0.443	0.000	0.000	0.027	0.011	0.000	0.0	0.0	0.0
11	100	0.0040	0.049	0.492	0.000	0.000	0.041	0.014	0.000	0.0	0.0	0.0
12	110	0.0040	0.049	0.542	0.000	0.000	0.057	0.016	0.000	0.0	0.0	0.0
13	120	0.0050	0.062	0.603	0.000	0.000	0.080	0.023	0.000	0.0	0.0	0.0
14	130	0.0050	0.062	0.665	0.000	0.000	0.105	0.026	0.000	0.0	0.0	0.0
15	140	0.0050	0.062	0.726	0.000	0.000	0.134	0.028	0.000	0.0	0.0	0.0
16	150	0.0050	0.062	0.788	0.000	0.000	0.165	0.031	0.000	0.0	0.0	0.0
17	160	0.0050	0.062	0.849	0.000	0.000	0.197	0.033	0.000	0.0	0.0	0.0
18	170	0.0050	0.062	0.911	0.000	0.000	0.232	0.035	0.000	0.0	0.0	0.0
19	180	0.0060	0.074	0.985	0.000	0.000	0.276	0.044	0.000	0.7	0.0	0.0
20	190	0.0060	0.074	1.059	0.003	0.002	0.322	0.046	0.002	4.5	0.2	0.2
21	200	0.0060	0.074	1.133	0.007	0.005	0.369	0.048	0.005	8.4	0.6	0.6
22	210	0.0060	0.074	1.206	0.014	0.007	0.419	0.050	0.007	12.1	1.3	1.3
23	220	0.0060	0.074	1.280	0.023	0.009	0.470	0.051	0.009	15.7	2.2	2.2
24	230	0.0060	0.074	1.354	0.033	0.011	0.523	0.053	0.011	19.1	3.2	3.2
25	240	0.0070	0.086	1.440	0.048	0.015	0.586	0.063	0.015	26.4	4.6	4.6
26	250	0.0070	0.086	1.526	0.065	0.017	0.651	0.065	0.017	30.6	6.2	6.2
27	260	0.0070	0.086	1.613	0.084	0.019	0.717	0.066	0.019	34.7	8.0	8.0
28	270	0.0070	0.086	1.699	0.105	0.021	0.784	0.067	0.021	38.5	10.0	10.0
29	280	0.0070	0.086	1.785	0.128	0.023	0.853	0.069	0.023	42.2	12.1	12.1
30	290	0.0070	0.086	1.871	0.153	0.025	0.922	0.070	0.025	45.7	14.3	14.3
31	300	0.0080	0.098	1.970	0.184	0.031	1.003	0.081	0.031	56.3	16.8	16.8
32	310	0.0080	0.098	2.068	0.218	0.033	1.085	0.082	0.033	60.4	19.7	19.7
33	320	0.0080	0.098	2.167	0.253	0.035	1.168	0.083	0.035	64.3	22.6	22.6
34	330	0.0080	0.098	2.265	0.291	0.038	1.251	0.084	0.038	68.1	25.6	25.6
35	340	0.0080	0.098	2.364	0.330	0.039	1.336	0.085	0.039	71.6	28.7	28.7
36	350	0.0080	0.098	2.462	0.371	0.041	1.422	0.085	0.041	75.0	31.7	31.7
37	360	0.0100	0.123	2.585	0.426	0.054	1.529	0.108	0.054	98.3	35.5	35.5
38	370	0.0100	0.123	2.708	0.482	0.057	1.638	0.109	0.057	103.0	40.0	40.0
39	380	0.0100	0.123	2.831	0.542	0.059	1.748	0.110	0.059	107.5	44.5	44.5
40	390	0.0100	0.123	2.954	0.603	0.062	1.859	0.111	0.062	111.8	49.0	49.0
41	400	0.0100	0.123	3.078	0.667	0.064	1.970	0.111	0.064	115.8	53.5	53.5
42	410	0.0130	0.160	3.238	0.753	0.086	2.116	0.146	0.086	156.2	59.1	59.1
43	420	0.0130	0.160	3.398	0.842	0.089	2.263	0.147	0.089	162.2	66.0	66.0
44	430	0.0130	0.160	3.558	0.935	0.092	2.410	0.148	0.092	167.8	72.9	72.9
45	440	0.0180	0.222	3.779	1.068	0.133	2.616	0.206	0.133	240.9	81.9	81.9
46	450	0.0180	0.222	4.001	1.205	0.138	2.824	0.207	0.138	250.1	93.2	93.2
47	460	0.0340	0.419	4.419	1.478	0.273	3.219	0.395	0.273	494.9	112.4	112.4
48	470	0.0540	0.665	5.084	1.940	0.461	3.852	0.634	0.461	837.6	150.6	150.6
49	480	0.0270	0.332	5.416	2.181	0.242	4.172	0.319	0.242	438.8	184.2	184.2
50	490	0.0180	0.222	5.638	2.346	0.165	4.385	0.214	0.165	299.0	196.9	196.9
51	500	0.0130	0.160	5.798	2.467	0.121	4.540	0.155	0.121	218.9	201.2	201.2
52	510	0.0130	0.160	5.958	2.589	0.122	4.695	0.155	0.122	221.3	202.5	202.5
53	520	0.0130	0.160	6.118	2.712	0.123	4.850	0.155	0.123	223.5	203.9	203.9
54	530	0.0090	0.111	6.229	2.798	0.086	4.957	0.107	0.086	156.0	202.9	202.9
55	540	0.0090	0.111	6.340	2.884	0.086	5.065	0.108	0.086	157.0	199.7	199.7
56	550	0.0090	0.111	6.450	2.971	0.087	5.173	0.108	0.087	157.9	196.8	196.8
57	560	0.0090	0.111	6.561	3.059	0.088	5.280	0.108	0.088	158.9	194.1	194.1
58	570	0.0090	0.111	6.672	3.147	0.088	5.388	0.108	0.088	159.8	191.7	191.7
59	580	0.0090	0.111	6.783	3.235	0.089	5.496	0.108	0.089	160.6	189.6	189.6
60	590	0.0090	0.111	6.894	3.324	0.089	5.604	0.108	0.089	161.5	187.6	187.6
61	600	0.0090	0.111	7.004	3.414	0.089	5.712	0.108	0.089	162.3	185.8	185.8
62	610	0.0090	0.111	7.115	3.504	0.090	5.821	0.108	0.090	163.1	184.2	184.2
63	620	0.0090	0.111	7.226	3.594	0.090	5.929	0.108	0.090	163.8	182.8	182.8
64	630	0.0090	0.111	7.337	3.685	0.091	6.037	0.108	0.091	164.6	181.5	181.5
65	640	0.0090	0.111	7.448	3.776	0.091	6.145	0.108	0.091	165.3	180.4	180.4
66	650	0.0090	0.111	7.558	3.867	0.091	6.254	0.108	0.091	166.0	179.4	179.4
67	660	0.0070	0.086	7.645	3.938	0.071	6.338	0.084	0.071	129.6	177.2	177.2
68	670	0.0070	0.086	7.731	4.010	0.072	6.423	0.084	0.072	130.0	173.9	173.9
69	680	0.0070	0.086	7.817	4.082	0.072	6.507	0.084	0.072	130.4	170.9	170.9
70	690	0.0070	0.086	7.903	4.154	0.072	6.592	0.084	0.072	130.8	168.1	168.1
71	700	0.0070	0.086	7.989	4.226	0.072	6.676	0.085	0.072	131.1	165.6	165.6
72	710	0.0070	0.086	8.075	4.299	0.072	6.761	0.085	0.072	131.5	163.2	163.2

73	720	0.0070	0.086	8.162	4.371	0.073	6.845	0.085	0.073	131.9	161.0	161.0
74	730	0.0070	0.086	8.248	4.444	0.073	6.930	0.085	0.073	132.2	159.0	159.0
75	740	0.0070	0.086	8.334	4.517	0.073	7.015	0.085	0.073	132.6	157.2	157.2
76	750	0.0070	0.086	8.420	4.590	0.073	7.099	0.085	0.073	132.9	155.5	155.5
77	760	0.0070	0.086	8.506	4.664	0.073	7.184	0.085	0.073	133.2	154.0	154.0
78	770	0.0070	0.086	8.592	4.737	0.074	7.269	0.085	0.074	133.6	152.6	152.6
79	780	0.0060	0.074	8.666	4.801	0.063	7.341	0.073	0.063	114.7	150.6	150.6
80	790	0.0060	0.074	8.740	4.864	0.063	7.414	0.073	0.063	115.0	148.1	148.1
81	800	0.0060	0.074	8.814	4.927	0.063	7.487	0.073	0.063	115.2	145.9	145.9
82	810	0.0060	0.074	8.888	4.991	0.064	7.559	0.073	0.064	115.4	143.8	143.8
83	820	0.0060	0.074	8.962	5.055	0.064	7.632	0.073	0.064	115.6	141.8	141.8
84	830	0.0060	0.074	9.036	5.119	0.064	7.705	0.073	0.064	115.8	140.0	140.0
85	840	0.0060	0.074	9.109	5.182	0.064	7.778	0.073	0.064	116.0	138.4	138.4
86	850	0.0060	0.074	9.183	5.247	0.064	7.850	0.073	0.064	116.2	136.8	136.8
87	860	0.0060	0.074	9.257	5.311	0.064	7.923	0.073	0.064	116.4	135.4	135.4
88	870	0.0060	0.074	9.331	5.375	0.064	7.996	0.073	0.064	116.6	134.1	134.1
89	880	0.0060	0.074	9.405	5.439	0.064	8.069	0.073	0.064	116.8	132.9	132.9
90	890	0.0050	0.062	9.466	5.493	0.054	8.129	0.061	0.054	97.5	131.1	131.1
91	900	0.0050	0.062	9.528	5.547	0.054	8.190	0.061	0.054	97.6	128.8	128.8
92	910	0.0050	0.062	9.589	5.601	0.054	8.251	0.061	0.054	97.8	126.7	126.7
93	920	0.0050	0.062	9.651	5.655	0.054	8.311	0.061	0.054	97.9	124.7	124.7
94	930	0.0050	0.062	9.713	5.709	0.054	8.372	0.061	0.054	98.0	122.9	122.9
95	940	0.0050	0.062	9.774	5.763	0.054	8.433	0.061	0.054	98.2	121.1	121.1
96	950	0.0050	0.062	9.836	5.817	0.054	8.494	0.061	0.054	98.3	119.6	119.6
97	960	0.0050	0.062	9.897	5.871	0.054	8.554	0.061	0.054	98.4	118.1	118.1
98	970	0.0050	0.062	9.959	5.925	0.054	8.615	0.061	0.054	98.5	116.8	116.8
99	980	0.0050	0.062	10.020	5.980	0.054	8.676	0.061	0.054	98.6	115.5	115.5
100	990	0.0050	0.062	10.082	6.034	0.054	8.737	0.061	0.054	98.8	114.3	114.3
101	1,000	0.0050	0.062	10.143	6.089	0.054	8.798	0.061	0.054	98.9	113.3	113.3
102	1,010	0.0040	0.049	10.193	6.132	0.044	8.846	0.049	0.044	79.2	111.6	111.6
103	1,020	0.0040	0.049	10.242	6.176	0.044	8.895	0.049	0.044	79.2	109.4	109.4
104	1,030	0.0040	0.049	10.291	6.220	0.044	8.943	0.049	0.044	79.3	107.3	107.3
105	1,040	0.0040	0.049	10.340	6.263	0.044	8.992	0.049	0.044	79.4	105.4	105.4
106	1,050	0.0040	0.049	10.390	6.307	0.044	9.041	0.049	0.044	79.5	103.6	103.6
107	1,060	0.0040	0.049	10.439	6.351	0.044	9.089	0.049	0.044	79.5	101.9	101.9
108	1,070	0.0040	0.049	10.488	6.395	0.044	9.138	0.049	0.044	79.6	100.4	100.4
109	1,080	0.0040	0.049	10.537	6.439	0.044	9.187	0.049	0.044	79.7	99.0	99.0
110	1,090	0.0040	0.049	10.587	6.483	0.044	9.235	0.049	0.044	79.7	97.6	97.6
111	1,100	0.0040	0.049	10.636	6.527	0.044	9.284	0.049	0.044	79.8	96.4	96.4
112	1,110	0.0040	0.049	10.685	6.571	0.044	9.333	0.049	0.044	79.9	95.3	95.3
113	1,120	0.0040	0.049	10.734	6.615	0.044	9.381	0.049	0.044	79.9	94.2	94.2
114	1,130	0.0040	0.049	10.784	6.659	0.044	9.430	0.049	0.044	80.0	93.2	93.2
115	1,140	0.0040	0.049	10.833	6.703	0.044	9.479	0.049	0.044	80.1	92.3	92.3
116	1,150	0.0040	0.049	10.882	6.747	0.044	9.528	0.049	0.044	80.1	91.5	91.5
117	1,160	0.0040	0.049	10.931	6.791	0.044	9.576	0.049	0.044	80.2	90.7	90.7
118	1,170	0.0040	0.049	10.981	6.835	0.044	9.625	0.049	0.044	80.2	90.0	90.0
119	1,180	0.0040	0.049	11.030	6.880	0.044	9.674	0.049	0.044	80.3	89.3	89.3
120	1,190	0.0040	0.049	11.079	6.924	0.044	9.722	0.049	0.044	80.4	88.7	88.7
121	1,200	0.0040	0.049	11.128	6.968	0.044	9.771	0.049	0.044	80.4	88.1	88.1
122	1,210	0.0040	0.049	11.177	7.012	0.044	9.820	0.049	0.044	80.5	87.6	87.6
123	1,220	0.0040	0.049	11.227	7.057	0.044	9.869	0.049	0.044	80.5	87.1	87.1
124	1,230	0.0040	0.049	11.276	7.101	0.044	9.917	0.049	0.044	80.6	86.6	86.6
125	1,240	0.0040	0.049	11.325	7.146	0.044	9.966	0.049	0.044	80.7	86.2	86.2
126	1,250	0.0040	0.049	11.374	7.190	0.044	10.015	0.049	0.044	80.7	85.8	85.8
127	1,260	0.0040	0.049	11.424	7.235	0.044	10.064	0.049	0.044	80.8	85.5	85.5
128	1,270	0.0040	0.049	11.473	7.279	0.045	10.112	0.049	0.045	80.8	85.2	85.2
129	1,280	0.0040	0.049	11.522	7.324	0.045	10.161	0.049	0.045	80.9	84.9	84.9
130	1,290	0.0040	0.049	11.571	7.368	0.045	10.210	0.049	0.045	80.9	84.6	84.6
131	1,300	0.0040	0.049	11.621	7.413	0.045	10.259	0.049	0.045	81.0	84.3	84.3
132	1,310	0.0040	0.049	11.670	7.458	0.045	10.307	0.049	0.045	81.0	84.1	84.1
133	1,320	0.0040	0.049	11.719	7.502	0.045	10.356	0.049	0.045	81.1	83.9	83.9
134	1,330	0.0040	0.049	11.768	7.547	0.045	10.405	0.049	0.045	81.1	83.7	83.7
135	1,340	0.0040	0.049	11.818	7.592	0.045	10.454	0.049	0.045	81.2	83.5	83.5
136	1,350	0.0040	0.049	11.867	7.636	0.045	10.503	0.049	0.045	81.2	83.4	83.4
137	1,360	0.0040	0.049	11.916	7.681	0.045	10.551	0.049	0.045	81.3	83.2	83.2
138	1,370	0.0040	0.049	11.965	7.726	0.045	10.600	0.049	0.045	81.3	83.1	83.1
139	1,380	0.0040	0.049	12.015	7.771	0.045	10.649	0.049	0.045	81.4	83.0	83.0
140	1,390	0.0040	0.049	12.064	7.816	0.045	10.698	0.049	0.045	81.4	82.9	82.9
141	1,400	0.0040	0.049	12.113	7.861	0.045	10.746	0.049	0.045	81.5	82.8	82.8
142	1,410	0.0040	0.049	12.162	7.906	0.045	10.795	0.049	0.045	81.5	82.7	82.7
143	1,420	0.0040	0.049	12.212	7.951	0.045	10.844	0.049	0.045	81.6	82.6	82.6
144	1,430	0.0040	0.049	12.261	7.996	0.045	10.893	0.049	0.045	81.6	82.5	82.5
145	1,440	0.0040	0.0492	12.310	8.041	0.045	10.942	0.049	0.045	81.7	82.5	82.5
	Total:	1.0000	12.3100			8.0406		10.9417	8.0406			
							Max:	**203.9**				

Cumulative Runoff at Period 145	7.38 inches	Start Flow	82.5
Unaccounted Runoff	0.66 inches	End Flow	-2.7
	17,411.27 sec	Flow Dec./per	2.8
	290.19 min		
	29.02 periods		
	30 periods		
	7.4039 Total Runoff		

Column	Description
1	Time Increment
2	Time (min)
3	Type IA Storm Distibution
4	Column 3 * Precipitation
5	Accumulated Sum of Column 4
6	If P<0.2S then 0, else (Column 5 - 0.2 * S)/(Column 5 +0.8 * S)
7	Column 6 of the present step - Column 6 of the previous step
8	Same as Column 6, except Impervious Area Calculations
9	Column 8 of the present step - Column 8 of the previous step
10	PerviousArea/TotalArea*Column 7 + ImperviousArea/TotalArea*Column 9
11	(60.5 * Column 10 * TotalArea)/Time Increment
12	Column 12 of previous step + w * ((Column 11 of previous step + column 11 of present step) - (2 * Column 12 of previous step))

PRECIPITATION DATA

The magnitude of the precipitation depth used in the design storm is dependent upon the design step selected to meet the required design/performance goal for the project. Since there is a high downstream hazard potential and severe water quality degradation potential, a design step of 6 was selected (Design Steps range from 1 to 8). This corresponds to a 1,000,000 year storm. Procedures describes in Technical Note 3, Design Storm Construction were used to calculate the rainfall amount associated with a 1,000,000 year 24 hours storm, and a 100,000 year 6 hour storm. Rainfall amounts were multiplied by a safetly factor of 15%. Documents used to perform the calcuations include: (1) Dam Safety Guidelines Part IV: Dam Design and Construction; (2) Technical Note 2, Selection of Design/Performance Goals for Critical Project Elements; and (3) Technical Note 3, Design Storm Construction.

Equation 1 (from Technical Note 3)

$X_i = X_{bar}(1+K_iC_v)$

X_i	Precipitation estimate for selected Annual Exceedance Probability (AEP)
X_{bar}	At site mean for duration of interest
K_i	Frequency factor for the KAPPA distribution for the regional value of L-skewness (r_3) and the selected AEP
C_v	Regional value of the coefficient of variation

Equation 2 (from Technical Note 3)

$X_{bar} = [0.88*X_{2p}]/[1+(K_2*C_v)]$

X_{2p}	2 year partial duration value from NOAA 2 for the duration of interest
X_{bar}	At site mean for duration of interest
K_2	Frequency factor for the 2 year event (appendix B Tables B1 and B2)
C_v	Regional value of the coefficient of variation for the geographic location and duration of intersest (Figure 5a and 5b)

Mean Annual Precipitation (MAP) of geographic location = 50 to 60 inches (55 inches)

Variable	Values (24 hour)	Values (6 hour)	Reference
X_i	11.27	4.44	Equation 1, Tech Note 3
X_{bar}	2.78	1.29	Equation 2, Tech Note 3
K_i	10.17	9.81	From Appendix B, Table B1, Tech Note 3, Desgin Step 6
C_v	0.30	0.25	From Figure 5a and 5b, Tech Note 3
X_{2p}	3.00	1.40	From NOAA Atlas 2
K_2	-0.17	-0.17	From Appendix B, Table B1, Tech Note 3
r_3	0.18	0.18	From Figure 6a and 6b, Tech Note 3

24 hour Design Precipitation (P_d) = X_i * 1.15

P_d **12.96** inches

6 hour Design Precipitation (P_d) = X_i * 1.15

P_d **5.10** inches

Precipitation Depths calculated from WSDOE Technical Note 3 Rainfall Calculator Spreasheets:

24 hour						1000 YR		10000 YR		100000 YR		1000000 YR	
Frequency	2 YR	10 YR	25 YR	100 YR	500 YR	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6	STEP 7	STEP 8	PMP
X_i	2.64	3.94	4.52	5.37	6.33	6.74	7.41	8.08	8.75	9.40	10.05	10.70	20.00
Pd	**3.04**	**4.53**	**5.20**	**6.17**	**7.28**	**7.75**	**8.53**	**9.29**	**10.06**	**10.82**	**11.56**	**12.31**	**23.00**

6 hour													
X_i		1.77	2.02	2.41	2.88	3.09	3.45	3.83	4.22	4.64	5.07	5.52	11.50
Pd		2.04	2.33	2.77	3.31	3.55	3.97	4.41	4.86	5.34	5.83	6.35	13.23

Reference: Washington Statd Department of Ecology, Technical Note 3: Design Storm Construction.
Available online at: http://www.ecy.wa.gov/programs/wr/dams/GuidanceDocs_ne.html

TIME OF CONCENTRATION ESTIMATE

Equations:

Overland Flow
Tc = (0.007*(nL)^0.8)/((P24^0.5)*(S^0.4))
max L= 300 based on NRCS TR-55 definitions

Sheet Flow
Tc=L/(3600*K*S^0.5)
where K = 16.13 for unpaved and 20.32 for paved

Waterway Flow
Tc = L/(V*3600)

Tc1= 1.34 hour

Variables	Value	Unit	Description
n	0.8		Woods - Dense Under brush
L	300	feet	Topographic map
P24	3	inches	2 year, 24 hour Figure 25 NOAA Atlas 2
S	0.0289	ft/ft	20 feet/693 feet

Tc2= 0.17 hour

Variables	Value	Unit	Description
n	0.8		Woods - Dense Under brush
L	1393	feet	Topographic map
P24	3	inches	2 year, 24 hour Figure 25 NOAA Atlas 2
S	0.02	ft/ft	20 feet/ 1000 feet

Elevation	Length	Area	Slope	Velocity	Time Sec	Time Min
460	2832.00	Ill defined stream	0.007062	1.25	2266	38
440	612.00	Ill defined stream	0.03268	2.85	215	4
420	500.00	stream	0.04	3.2	156	3
400	570.00	stream	0.035088	3	190	3
380	465.00	stream	0.043011	3.3	141	2
360	85.00	stream	0.235294	5.75	15	0

Tc3= 50 minutes total
0.8 hours total

Velocities taken from TR-55 Figure 3-1 (June 1986 Version)
Elevations and slope determined from GIS database

Tctotal 2.34 hour
140.14 minute

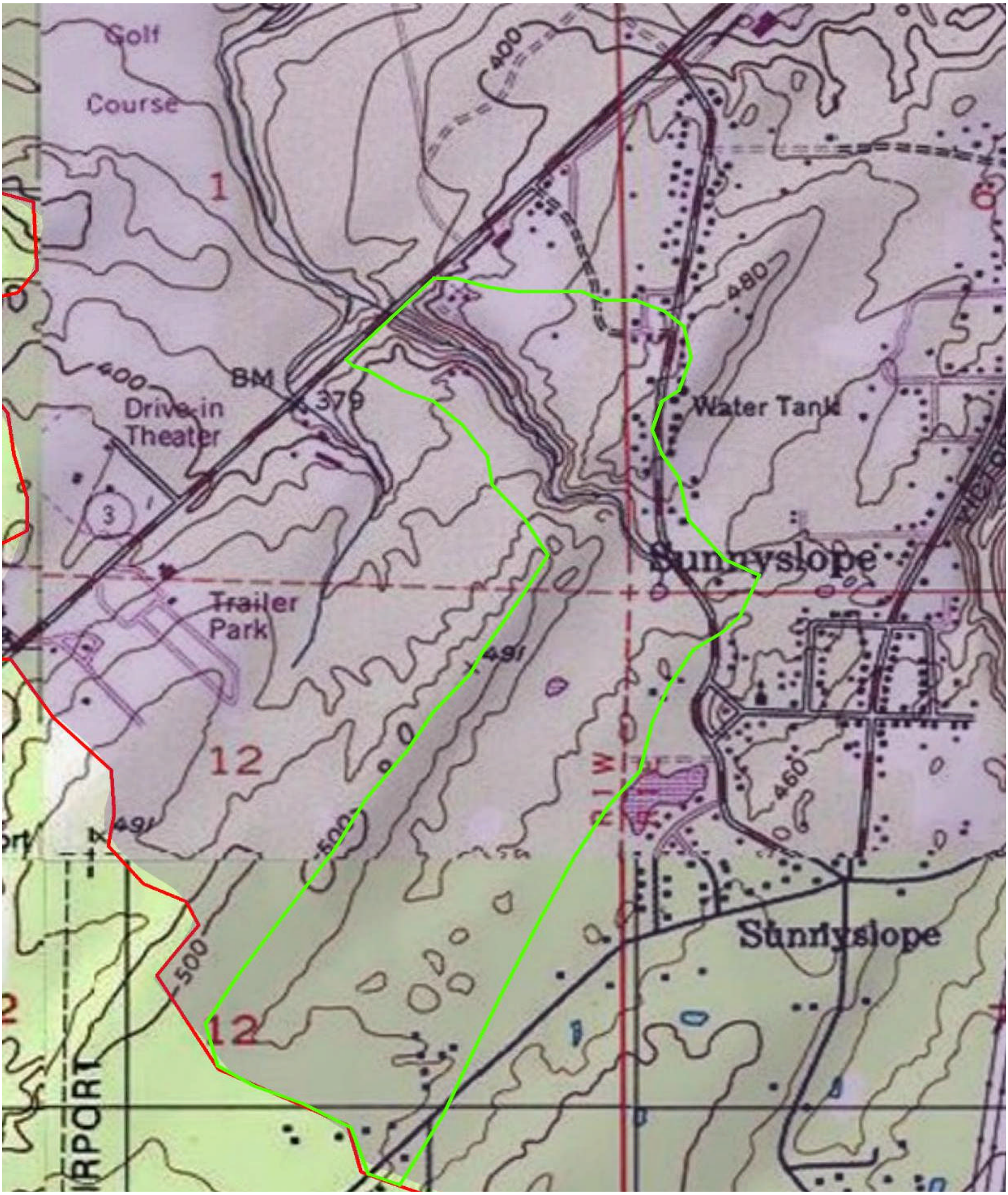
CURVE NUMBER ESTIMATE

Assumptions:
n = woods - dense underbrush

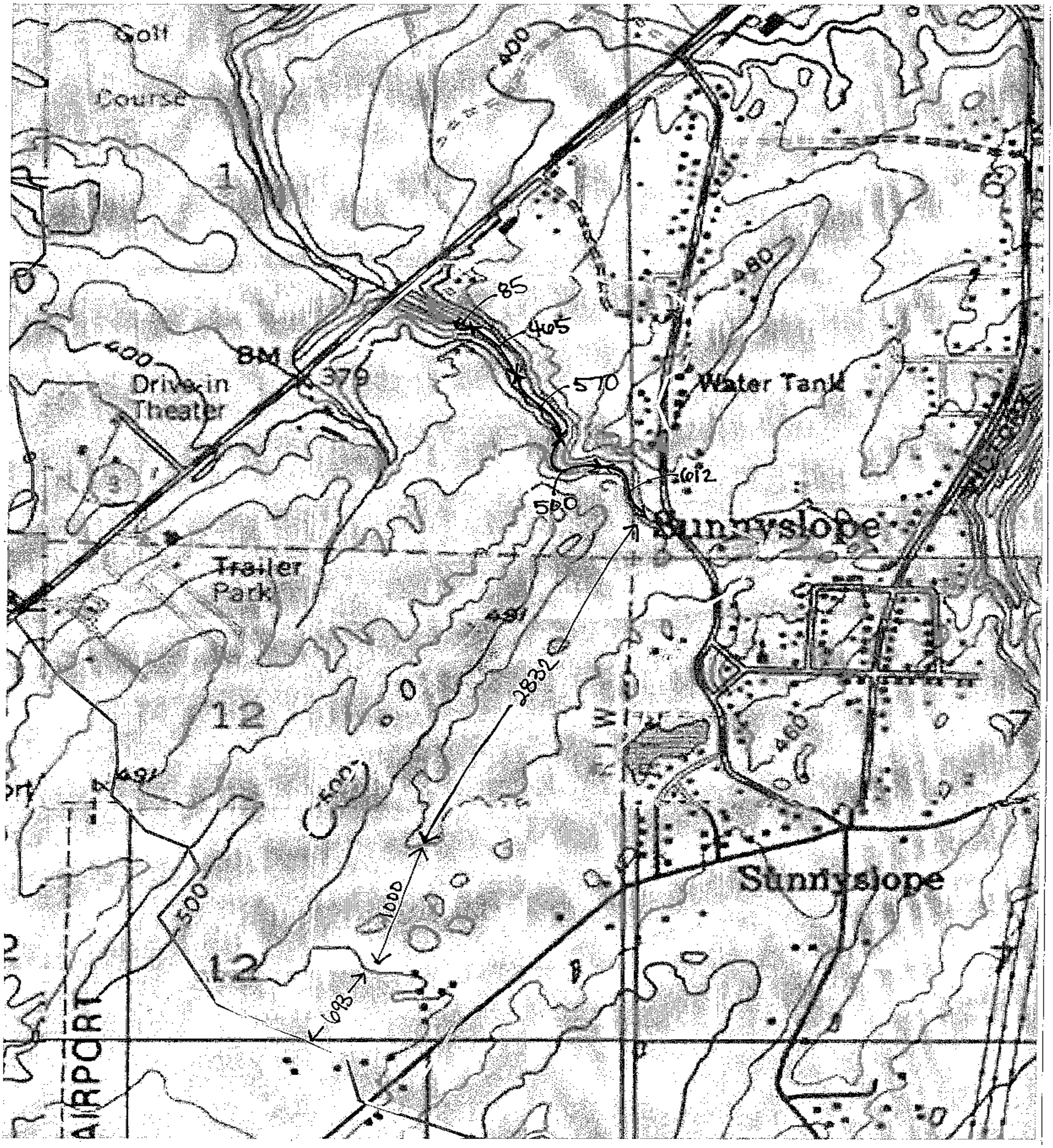
CN = 30 Woods (good condition), soil group A
CN = 70 Woods (good condition), soil group C

Soil Group A = 12.33 acres
Soil Group C = 196.67 acres

weighted curve number
68.00



GORST CREEK DRAINAGE BASIN



Time of Concentration Distance Measurements

The following worksheets compute normal depth for a circular pipe section

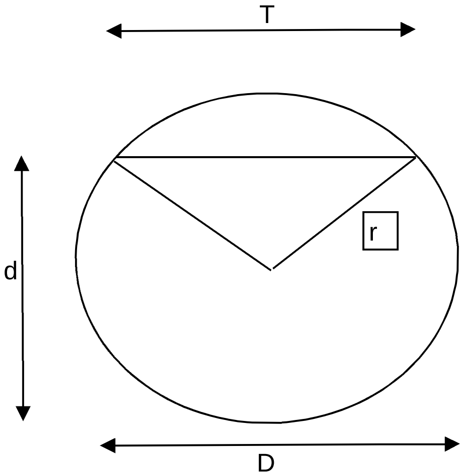
The worksheets use the SOLVER routine in Excel.
The worksheets are protected to prevent a user from inadvertently
changing the underlying formulae. I did not use a password,
so a user can go to the tools menu and click protection.
After you run either sheet, the protection will be turned on
automatically.

Highlighted cells are not protected and are for input.

* ** *
* These worksheets will not work unless you do the following for *
* EACH computer that will run the worksheets. It need be done *
* only once for each computer. *
* Start Excel *
* Click the <View> menu *
* Click the <Toolbars> menu *
* Click <Visual Basic>, so a check mark is next to it. *
* A toolbar should appear somewhere on the worksheet *
* One of the icons on the toolbar looks like a piece of *
* paper covered by a plumber's helper. When the mouse *
* cursor passes over this icon, it should say *
* "Visual Basic Editor". *
* Click the <Visual Basic Editor> icon. *
* The Excel window disappears and is replaced by the *
* editor window. *
* Click the <Tools> menu *
* Click the <References> menu *
* Click the box next to "SOLVER" to put a check mark *
* in it. *
* Click OK button *
* Close the Visual Basic window by clicking the X in *
* the upper right hand corner. *
* DONE *
* ** *

PRELIMINARY PIPE DESIGN

PIPE LOCATION: 1



Number of Culverts =	1	Total Q =	80.20	cfs	500 Year Peak Flow	
D	32	inches =	2.67	ft		
n	0.014				Assume concrete pipe	
Schannel	0.0326	ft/ft				

Q target	80.20	cfs	Q crit	46.78 cfs			Percent Full
d	2.27	ft	d-.01	2.26	0.8*D	2.13	
T	1.90	ft			0.8*D-d	-0.13	85.0%
r	1.33	ft					

			Area at midpoint	2.79	sq ft	
			D-d	0.4	ft	deg
Area	5.06	sq ft	alpha	1.5908	radians	91.15
P	6.26	ft	Area Sector	1.41	sq ft	
R	0.81	ft	Area Triangle	0.89	sq ft	
A*R(2/3)	4.3919					
Qactual	84.17	cfs				
Qt - Qa	-3.97	cfs				
V	16.64	fps				

Using Manning's Equation the calcualtions show that the actual flow rate (Qa) for a 32 inch pipe installed at the site is greater than the estimated 500 year peak flow rate indicating that the selected pipe size will contain up to the 500 year peak flow rate at 85% capacity without causing backup behind the dam

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G

COST TABLES

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Table G-1
Alternative 2 - Gorst Ravine Restoration
Gorst Creek Landfill Engineering Evaluation/Cost Analysis

Direct Capital Costs					
Item Description	**Quantity**	**Unit**	**Cost/Unit**	**Cost**	**Reference** [14]
Field Overhead and Oversight	6	month			
Superintendent	24	week	$2,950.00	$70,800	01 31 13.20 0260
Clerk	24	week	$630.00	$15,120	01 31 13.20 0010
Portable toilet	6	month	$177.00	$1,062	01 54 33.40 6410
Field Office Expenses	6	month	$220.00	$1,320	01 52 13.40 0100
Equipment Mobilization	4	each	$425.00	$1,700	01 54 36.50 0100
Equipment Demobilization	4	each	$425.00	$1,700	01 54 36.50 0100
Dust Control	60	day	$1,775.00	$106,500	31 23 23.20 2510
Air Monitoring Instrument Rental	6	month	$3,405.00	$20,430	Vendor Quote
Air Sampling - Summa	48	each	$275.00	$13,200	Estimate
Clear and Grub Light Vegetation [1]	5	acre	$6,100.00	$29,280	31 11 10.10 0160
Excavation [2]	150,000	c.y.	$3.37	$505,253	31 23 16.42 0250
Material Transportation [3]	195,000	c.y.	$12.75	$2,486,250	31 23 23.20 9514
Grading	348,480	s.f	$0.02	$8,518	31 22 16.10 3310
Waste Disposal [4]	180,000	ton	$117.82	$21,207,600	Vendor Quote
Hazardous Waste Disposal [5]	18,000	ton	$150.22	$2,703,960	Vendor Quote
Seeding, Mulching, and Fertilizing	348,480	s.f.	$0.04	$15,507	32 92 19.14 4600
Haul Road - subgrade preparation	30,000	s.f.	$0.02	$733	31 22 16.10 3310
Haul Road - gravel base course	30,000	s.f.	$1.16	$34,667	32 11 23.23 0400
Haul Road Maintenance [6]	24	day	$1,125.00	$27,000	31 23 23.20 2600
Riprap from off-site	500	c.y.	$62.50	$31,250	31 37 13.10 0100
Place Riprap	675	ton	$37.00	$24,975	31 37 13.10 0370
Pump/Discharge System [7]					
Sump hole construction	4,000	c.f.	$2.46	$9,840	31 23 19.20 1600
12" pipe	1,200	l.f.	$50.00	$60,000	31 23 19.20 1700
Pump rental	6	month	$11,100.00	$66,600	01 54 33.70 1600
Subtotal Direct Capital Costs [8]				***$27,443,265***	
Contingency Allowance (20%)				$5,488,653	
Total Direct Capital Costs (rounded to nearest $10,000)				$32,930,000	
Indirect Capital Costs					
Engineering and Design (1%)				$329,300	
Home Office Administration, Legal Fees, and License/Permit Costs (2%)				$658,600	
3rd Party Construction Oversight (0.5%)				$164,650	
Total Indirect Capital Costs (rounded to nearest $10,000)				***$1,150,000***	
Total Alternative Cost (rounded to nearest $10,000)				**$34,080,000**	

Table G-2
Cost Analysis, Alternative 3
Gorst Creek Re-Alignment
Draft Engineering Evaluation/Cost Analysis
Gorst Creek Landfill

Direct Capital Costs					
Item Description	**Quantity**	**Unit**	**Cost/Unit**	**Cost**	**Reference** [14]
Field Overhead and Oversight	9	month			
Superintendent	36	week	$2,950.00	$106,200	01 31 13.20 0260
Clerk	36	week	$630.00	$22,680	01 31 13.20 0010
Portable toilet	9	month	$177.00	$1,593	01 54 33.40 6410
Field Office Expenses	9	month	$220.00	$1,980	01 52 13.40 0100
Equipment Mobilization	6	each	$425.00	$2,550	01 54 36.50 0100
Equipment Demobilization	6	each	$425.00	$2,550	01 54 36.50 0100
Clear and Grub Light Vegetation	4	acre	$6,100.00	$25,986	31 11 10.10 0160
Clear Heavy Vegetation [1]	10.74	acre	$20,750	$222,855	31 11 10.10 0260
Excavation of Overburden [9]	508,000	c.y.	$2.32	$1,180,084	31 23 16.42 0250
Material Hauling Onsite[10]	1,733	c.y.	$2.39	$4,143	31 23 23.20 0014
Material Hauling Offsite [11]	658,667	c.y.	$7.05	$4,643,600	31 23 23.20 9068
Seeding, Mulching, and Fertilizing	511,394	s.f.	$0.04	$22,757	32 92 19.14 4600
Haul Road - subgrade preparation	30,000	s.f.	$0.02	$733	31 22 16.10 3310
Haul Road - gravel base course	30,000	s.f.	$1.16	$34,667	32 11 23.23 0400
Haul Road Maintenance [6]	36	day	$1,125.00	$40,500	31 23 23.20 2600
Riprap from off-site	500	c.y.	$62.50	$31,250	31 37 13.10 0100
Place Riprap	675	ton	$37.00	$24,975	31 37 13.10 0370
General Cap Maintenance					
Crew/Equipment	1	week	$17,412	$17,412	Crew B-3C, 01 54 36.5 0020
Material Hauling Offsite [3]	30	c.y.	$12.75	$383	31 23 23.20 9514
Waste Disposal [4]	20	ton	$117.82	$2,356	Vendor Quote
Import Soil for Surface Restoration	774	c.y.	$12.50	$9,675	Vendor Quote
Material Hauling Onsite [10]	774	c.y.	$2.39	$1,851	31 23 23.20 0014
Seeding, Mulching, and Fertilizing	52,272	s.f.	$0.04	$2,091	32 92 19.14 4600
Pump/Discharge System [7]					
Sump hole construction	4,000	c.f.	$2.46	$9,840	31 23 19.20 1600
12" pipe	1,200	l.f.	$50.00	$60,000	31 23 19.20 1700
Pump rental	9	month	$11,100.00	$99,900	01 54 33.70 1600
Subtotal Direct Capital Costs [12]				***$6,572,610***	
Contingency Allowance (20%)				$1,314,522	
Total Direct Capital Costs (rounded to nearest $10,000)				$7,890,000	
Indirect Capital Costs					
Engineering and Design (4%)				$315,600	
Home Office Administration, Legal Fees, and License/Permit Costs (2%)				$157,800	
3rd Party Construction Oversight (2%)				$157,800	
Total Indirect Capital Costs (rounded to nearest $10,000)				***$630,000***	
Total Alternative Cost (rounded to nearest $10,000)				**$8,520,000**	

Table G-3
Alternative 4 - Microtunneling/Pipe Jacking
Gorst Creek Landfill Engineering Evaluation/Cost Analysis

Direct Capital Costs					
Item Description	**Quantity**	**Unit**	**Cost/Unit**	**Cost**	**Reference** [14]
Field Overhead and Oversight	3	month			
Superintendent	12	week	$2,950.00	$35,400	01 31 13.20 0260
Clerk	12	week	$630.00	$7,560	01 31 13.20 0010
Portable toilet	3	month	$177.00	$531	01 54 33.40 6410
Field Office Expenses	3	month	$220.00	$660	01 52 13.40 0100
Equipment Mobilization	1	each	$425.00	$425	01 54 36.50 0100
Equipment Demobilization	1	each	$425.00	$425	01 54 36.50 0100
Clear and Grub Light Vegetation	2	acre	$6,100.00	$12,200	31 11 10.10 0160
Haul Road - subgrade preparation	30,000	s.f.	$0.02	$733	31 22 16.10 3310
Haul Road - gravel base course	30,000	s.f.	$0.60	$18,000	32 11 23.23 0370
Staging Pad - Subgrade Preparation	10,000	s.f.	$0.02	$244	31 22 16.10 3310
Staging Pad - Gravel Base Course	10,000	s.f.	$1.16	$11,556	32 11 23.23 0400
Microtunneling	880	l.f.	$1,100	$968,000	33 05 23.19 0100
Rent Microtunneling Machine	1	mo	$97,000	$97,000	33 05 23.19 1000
Operating Technician	20	day	$650	$13,000	33 05 29.13 1010
Microtunnel Equip. Mobe/Demobe	1	job	$241,000	$241,000	33 05 23.19 1100
Excavate Pit and Creek Channel	5,300	c.y.	$5.55	$29,415	31 23 16.13 1300
Shoring	1,600	s.f.	$33	$52,800	31 41 16.10 1500
36" Reinforced Concrete Pipe	880	l.f.	$119	$104,720	33 41 13.60 2060
Material Hauling Onsite [10]	1,733	c.y.	$2.39	$4,143	31 23 23.20 0014
Seeding, Mulching, and Fertilizing	174,240	s.f.	$0.04	$7,754	32 92 19.14 4600
Riprap from off-site	74	c.y.	$62.50	$4,630	31 37 13.10 0100
Place Riprap	100	ton	$37.00	$3,700	31 37 13.10 0370
General Cap Maintenance					
Crew/Equipment	1	week	$17,412	$17,412	Crew B-3C, 01 54 36.5 0020
Material Hauling Offsite [3]	30	c.y.	$12.75	$383	31 23 23.20 9514
Waste Disposal [4]	20	ton	$117.82	$2,356	Vendor Quote
Import Soil for Surface Restoration	774	c.y.	$12.50	$9,675	Vendor Quote
Material Hauling Onsite [10]	774	c.y.	$2.39	$1,851	31 23 23.20 0014
Seeding, Mulching, and Fertilizing	52,272	s.f.	$0.04	$2,091	32 92 19.14 4600
Pump/Discharge System [7]					
Sump hole construction	4,000	c.f.	$2.46	$9,840	31 23 19.20 1600
12" pipe	1,200	l.f.	$50.00	$60,000	31 23 19.20 1700
Pump rental	3	month	$11,100.00	$33,300	01 54 33.70 1600
Subtotal Direct Capital Costs [13]				***$1,750,803***	
Contingency Allowance (20%)				$350,161	
Total Direct Capital Costs (rounded to nearest $10,000)				$2,100,000	
Indirect Capital Costs					
Engineering and Design (20%)				$350,161	
Home Office Administration, Legal Fees, and License/Permit Costs (2%)				$87,540	
3rd Party Construction Oversight (5%)				$87,540	
Total Indirect Capital Costs (rounded to nearest $10,000)				***$530,000***	
Total Alternative Cost (rounded to nearest $10,000)				**$2,630,000**	

Key:

l.s. = Lump sum.
c.f. = Cubic feet.
c.y. = Cubic yard.
l.f. = Linear foot.
s.f. = Square foot.

Notes:

[1] Some felled trees from adjacent area will be recovered and saved for erosion control in restored creek channel.
[2] Hydraulic excavator with 1.5 c.y. bucket loading directly to trucks utilizing Level C protection.
[3] Using 18 c.y. trucks with 50 mph average, 50 mile cycle, and 25 minute wait at disposal facility. Assumed swell factor of 1.3 for landfill waste.
[4] Assumed as automobile wrecking waste and some municipal solid waste at 1.2 tons/cy for landfill debris.
[5] Assumed 10% of total disposal material would be disposed of as hazardous waste. Medical waste may also be potentially encountered.
[6] Assumed 20% of work days would be needed for haul road maintenance.
[7] Pump/discharge system will consist of a temporary diversion dam, pumps, and piping to allow the creekflow to bypass the landfill.
[8] Costs are based on two excavators and 30 on-road trucks with a project length of 6 months.
[9] Volume of overburdern was caluculated in AutoCad utilizing July 2011 survey data.
[10] For landfill surface repairs using 8 c.y. trucks with 15 mph average, 0.5 mile cycle. Assumed swell factor of 1.3 for soil.
[11] For beneficial use of soil using 18 c.y. trucks with 35 mph average, 20 mile cycle, and 15 minute wait. Assumed swell factor of 1.3 for landfill waste.
[12] Costs are based on four excavators and 30 on-road trucks with a project length of 9 months.
[13] Costs are based on one backhoe and one truck with a project length of 3 months.
[14] References are vendor quotes, estimates based on similar projects, or RS Means 2011 Cost Data. RS Means cost references are expressed in the format XX XX XX.XX XXXX.