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TECHNICAL MEMO

DATE: November 18, 2014

TO: Douglas Howie, P.E., Stormwater Engineer, Department of Ecology, Water Quality Program

FROM: Claire Jonson, P.E., Engineer III, Capital Services Unit (CSU)
Stormwater Services Section, Water and Land Resources Division (WLRD)
Department of Natural Resources and Parks (DNRP)

EDITED: Scott Miller, Engineer II, CSU, WLRD, DNRP

SUBJECT: Evans Creek Tributary 108 Basin Wide Retrofit Siting, Grant Number G1400026

Introduction

This technical memorandum is the submittal for the Evans Creek Tributary 108 Basin Wide Retrofit Siting, Grant Number G1400026, Task 4 – Modeled Design of Basin-wide Retrofit System. The deliverables for Task4 are a technical memo describing the methodology for prioritizing sites; a map of modeled system design showing the location of all retrofits facilities and low impact development best management practices (LID BMPs); and a spreadsheet summarizing the design specifics and planning level project costs for each site. I sent an email to you on January 16, 2014 to describe how the subcatchments of the Evans Creek Tributary 108 Basin were divided and the potential facility volumes based on area unit volume case study discussed in the King County, Juanita Creek Study, 2012[1]. The schematic of the HSPF model of the Evans Creek Tributary 108 Basin in predeveloped and mitigated condition is attached in Appendix A.

The Ecology 8% performance goal from the Juanita Creek Study was used to size the facilities for this project. This scenario modeled existing land use with a basin-wide retrofit utilizing a combination of bioretention sized per 2009 King County Surface Water Design Manual methodology applied to 80% of the total impervious area of the basin and detention ponds applied to all modeled overflows from the bioretention as well as all other unmitigated surfaces in the basin. The bioretention and detention pond combination were used to achieve the Washington State Department of Ecology proposed 8% standards. The 8% standard matches

[1] http://www.kingcounty.gov/environment/watersheds/cedar-river-lake-wa/documents/juanita-creek-stormwater-retrofit.aspx

post-developed flows to pre-developed flows for runoff events ranging from 8% of the 2 year storm to the 50 year runoff event assuming the predeveloped condition as forested.

Methodology for prioritizing sites

The methodology for prioritizing sites was derived from the North Kitsap County, LID Retrofit Project Implementation Plan, 2013[2]. King County DNRP staff located potential facility sites in the field on October 30 and November 16, 2013. These sites were then screened using the following physical and logistical criteria: availability of siting area in the right-of-way or in existing drainage facilities, site slope, amount of impervious surface in the site's catchment, how the project may meet multiple objectives and potential risks to the environment. Table 1 below shows the summary of level one assessment ranking criteria, possible scores, and sources.

Table 1 – Summary of Level One Assessment Ranking Criteria, Possible Scores, and Sources

Score	Criteria	Sources
Site Slopes		
1	Site slopes (X) > 10%	GIS (Appendix A) and field evaluation.
2	5% > X ≤ 10%	
3	X ≤ 5%	
Available Area		
0	No available area in existing drainage facilities or right of way.	GIS (Appendix A) and field evaluation.
1	Available area in the existing drainage facilities	
2	Available area in the right-of-way 8 feet ≤ x ≤ 10 feet	
3	Available area in the right-of-way 8 feet x ≥ 10 feet	
Effective Impervious Area (EIA) Managed		
1	Low	GIS (Appendix A) and field evaluation.
2	Medium	
3	High	
Meets Multiple Objectives		
1	Meeting one of the following: water quaility improvement, peak flow reduction, or local drainage improvement	GIS (Appendix A) and field evaluation.
2	Meeting two of the following: water quaility improvement, peak flow reduction, or local drainage improvement	
3	Meeting all of the following: water quaility improvement, peak flow reduction, and local drainage improvement	
Risk to the Environment		
1	Sites located within required setback zones for existing wells, steep slopes, critical areas, or pose a risk to existing structure or features	GIS (Appendix A) and field evaluation.
2	Sites located near the same features, but considered minor risk	
3	Site located outside of the same features	

[2] http://www.kitsapgov.com/sswm/pdf/NKLID_LID%20Plan%20(FINAL%20Dec%202013).pdf

The 26 subbasins were then scored with the level one assessment. Table 2 below shows how the 26 subbasin were scored using the level one assessment criteria.

Table 2. Level One Assessment Ranking Scores for the 26 Subbasins.

Subcatchment	Site Slopes	Available Area	Effective Impervious Area (EIA) Managed	Meets Multiple Objectives	Risk to the Environment	Total Level 1 Feasibility Score
A	2	0	1	3	1	7
B1	1	2	1	2	1	7
B2	1	3	3	2	3	12
C1	1	0	1	3	1	6
C2	1	0	1	2	1	5
C3	1	2	3	2	2	10
C4	2	3	3	2	3	13
C5	2	3	3	2	3	13
C6	2	3	3	2	3	13
C7	2	3	2	2	3	12
C8	2	0	2	2	1	7
D1	1	0	1	2	1	5
D2	1	3	3	2	2	11
D3	2	3	2	2	2	11
D4	1	1	2	3	2	9
D5	1	0	2	2	3	8
D6	1	2	2	2	3	10
D7	2	1	2	2	3	10
E1	1	0	1	2	1	5
E2	1	0	1	2	1	5
E3	1	1	3	2	3	10
E4	1	1	2	2	3	9
E5	1	1	2	2	3	9
E6	3	2	2	2	3	12
E7	2	2	2	2	3	11
E8	3	0	2	2	3	10

* E6 and E7 are upstream of E5 and are served by the same facility as E5.

The highest scores of total level one assessment of 12 and higher moved to the level two priority scoring. The subcatchments B2, C4, C5, C6, C7, and E6 moved to the level two priority scoring. See Appendix B for a map of the locations of the outfalls of the subcatchments B2, C4, C5, C6, C7, and E6.

The level two priority scoring is also derived from the North Kitsap County, LID Retrofit Project Implementation Plan, 2013. However, King County DNRP staff decided to move the utility coordination that was in the North Kitsap County, LID Retrofit Project Implementation Plan, 2013, level one assessment scoring to the level two priority scoring because utility coordination usually happens in the design phase of the project.

Level two prioritization was based on evaluation of six criteria, as follows:

- Water quality.
- Utility Coordination
- Drainage and local flooding improvement.
- Constructability.
- Operation and maintenance.
- Ease of funding.

Each criterion was scored on a scale of 0 (low) to 3 (high). The Water Quality scoring will be derived from the Benefit Calculation from Department of Ecology Phase I Municipal Stormwater Permit, Appendix 11, Pages 3 and 4. The Water Quality Benefit Calculation can be found at the following web address:
http://www.ecy.wa.gov/programs/wq/stormwater/municipal/phaseIpermit/phipermit.html

The Water Quality scoring was based on calculations for a basic wet pond, per King County 2009 King County Surface Water Design Manual page 6-70, because it is similar to bioretention. Because the subbasins do not have any existing water quality facilities, they all met the 80% TSS removal. Therefore, all of the subbasins scored for level two prioritization for water quality, received a score of 1. See Appendix B for Water Quality Benefit Calculations.

The remaining five criteria were evaluated qualitatively during three, one-hour-long workshops with King County DNRP staff. Table 3 summarizes the project level two criteria and possible scores.

Table 3 – Summary of Level Two Priority Ranking Criteria, Possible Scores, and Sources

Score	Criteria
Water Quality	
0	See discussion provided below in this Section
1	
2	
3	
Drainage & Local Flooding	
0	Project expected to provide no effect on existing drainage or local flooding problems
1	Project expected to provide some drainage improvement
2	Project expected to improve local drainage and reduce local flooding
3	Project helps address specific drainage or local flooding issues based on record of historical complaints
Utility Coordination	
1	Numerous potential utility conflicts
2	Moderate potential utility conflicts
3	Limited potential utility conflicts and/or good opportunity to coordinate retrofit with planned utility or roadway improvement projects.
Constructability	
0	Construction costs expected to exceed the project value; Potentially significant impacts to residents during construction
1	No major impacts to residents expected; Some utility conlicts may increase construction time/costs
2	No major impacts to residents expected; Construction not expected to be complicated by utility or other types of conflicts
3	No major impacts to residents expected; County crews can construct the project in approximately 2 weeks or less
Operation and Maintenance	
0	Long-term operation and maintenance of project is not feasible or cost effective
1	Project located outside of County-owned right-of-way and will require external O&M
2	Project may require purchase of new equipment, training staff, and/or allocation of additional budget to properly maintain the proposed retrofits
3	County has necessary equipment, staff experience, and budget allocated to maintain the proposed retrofits
Ease of Funding	
0	Expected cost of project exceeds value and/or funding is not available
1	Project funding depends on collaboration with tribes or other public agencies
2	Project not expected to be eligible for grant funding through Ecology's Stormwater LID Retrofit grant program
3	Project expected to be eligible and compete successfully for grant funding through Ecology's Stormwater LID Retrofit grant program

The utility maps from Puget Sound Energy gas and power and the Union Hill Water Association were reviewed for the utility coordination and constructability scoring and attached in Appendix B. Subbasin B2 lowest point near NE Union Hill Road and 205th Ave NE intersection, has gas and water lines nearby. Subbasin C4 lowest point could be in a King County owned parcel 8807300590. Subbasin C4 has only power lines nearby. Subbasin C5 lowest point is located at the end of NE 78th Street and has water lines nearby. Subbasin C6 lowest point can be located in King County owned parcel 8807300590, and has water lines nearby. Subbasin C7 lowest point is located near NE 78th Street and 208th Ave NE intersection, and has power and gas lines nearby.

Subbasin E6 lowest point is located near the intersection of NE 87th place and 217th Ave NE, and has water lines nearby.

The size of the subbasin detention ponds, impacts to residents during construction, and how much impervious surface the detention ponds treated were considered for constructability. The detention ponds were sized with WWHM2012 as trapezoidal ponds with 3 horizontal to 1 vertical side slopes. Construction costs were derived from the Development of a Stormwater Retrofit Plan for Water Resources Inventory Area 9, SUSTAIN Model Pilot Study, July 2013, page 27, the cost of $7.97 per cubic feet. Subbasin B2 lowest point is located on NE Union Hill Road which is a King County minor arterial road. Therefore, there could be potentially significant impacts to residents during construction. The Table 4 below shows the subcatchment, detention pond volume, impervious areas treated, construction costs, and construction costs divided by Impervious Area Treated

Table 4 –Subcatchment, Detention Pond Volume, Impervious Area Treated, Construction Costs, and Construction Costs Divided by Impervious Area Treated.

Subcatchment	Detention Pond Volume (cu-ft)	Impervious area treated (ac)	Construction Cost ($ - at $7.97 per cu-ft)	Construction Cost / Impervious Area Treated ($/ac)
B2	4,691.41	3.37	$37,390.55	$11,096.69
C4	5,545.19	1.59	$44,195.15	$27,873.26
C5	1,106.42	0.50	$8,818.20	$17,610.95
C6	1,441.84	0.68	$11,491.43	$16,969.38
C7	1,642.21	0.93	$13,088.43	$14,094.61
E6	1,746.76	2.03	$13,921.65	$6,854.07

King County WLRD has necessary equipment, staff experience, and budget allocated to maintain a proposed retrofit in the subbasins except subbasin B2. King County WLRD does not have Traffic Control equipment necessary to inspect detention facilities on minor arterial roads. Therefore, all the subbasins will receive a score of 3 for Operations and Maintenance, except for subbasin B2, which will receive a score of 2. Subbasins C6, C7, and E6 scored the highest in the level two priority ranking scores. All of the subbasins will be eligible to compete successfully for grant fuding throught Ecology's Stormwater LID Retrofit grant program. Therefore, all the subbasins will receive a score of 3. See Table 5 below for the level two priority ranking scores.

Table 5 –Level Two Priority Ranking Scores

Subcatchment	Water Quality	Drainage and Local Flooding	Utility Coordination	Constructability	Operation and Maintenance	Ease of Funding	Total
B2	1	1	1	0	2	3	8
C4	1	1	2	1	3	3	11
C5	1	1	2	2	3	3	12
C6	1	1	3	2	3	3	13
C7	1	1	1	1	3	3	10
E6	1	1	3	2	3	3	13

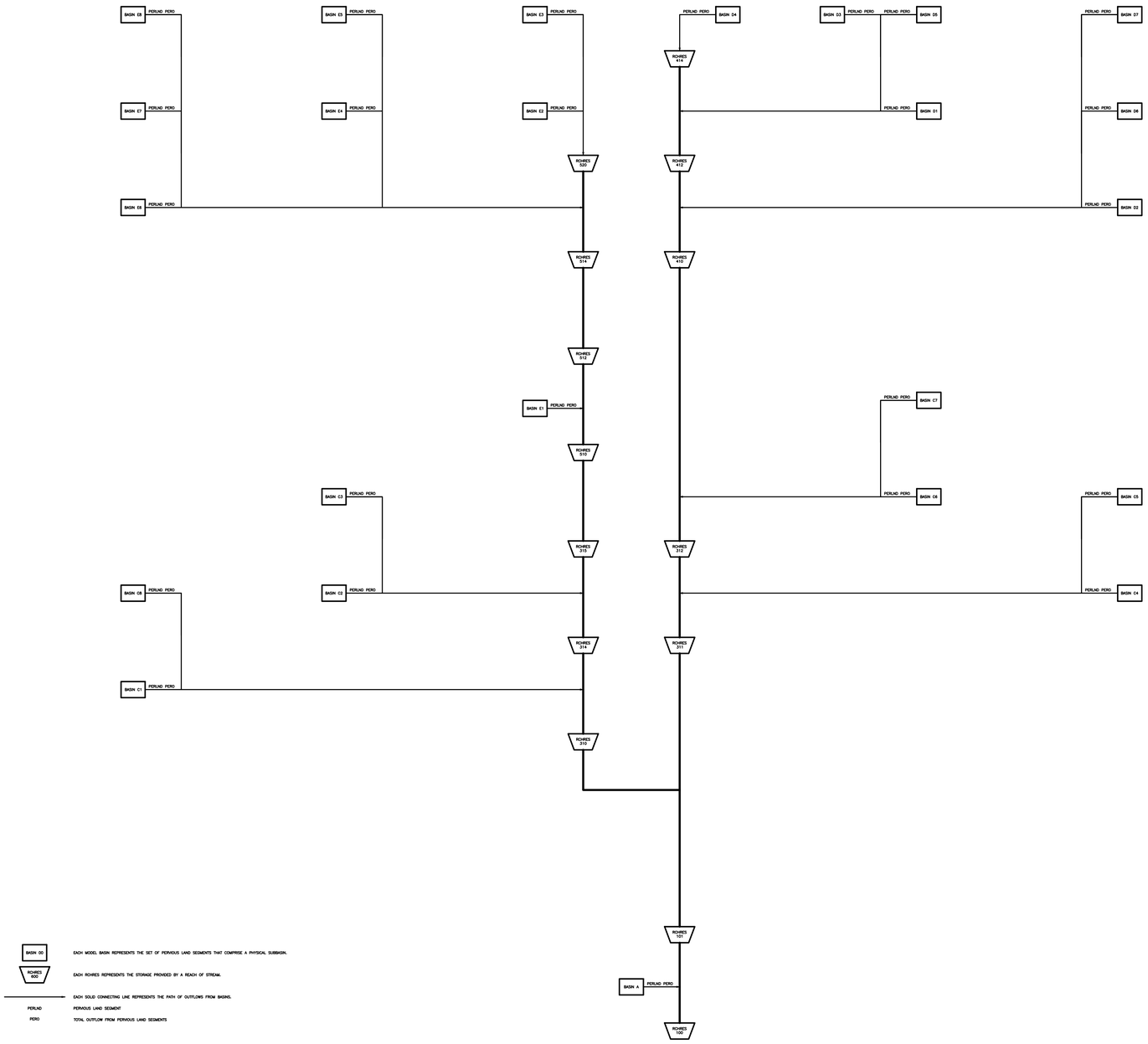
The three highest scoring subbasins are C5, C6, and E6 and are chosen for the three pre-design reports of the grant agreement.

Evans Creek Tributary 108 Basin Wide Retrofit Siting

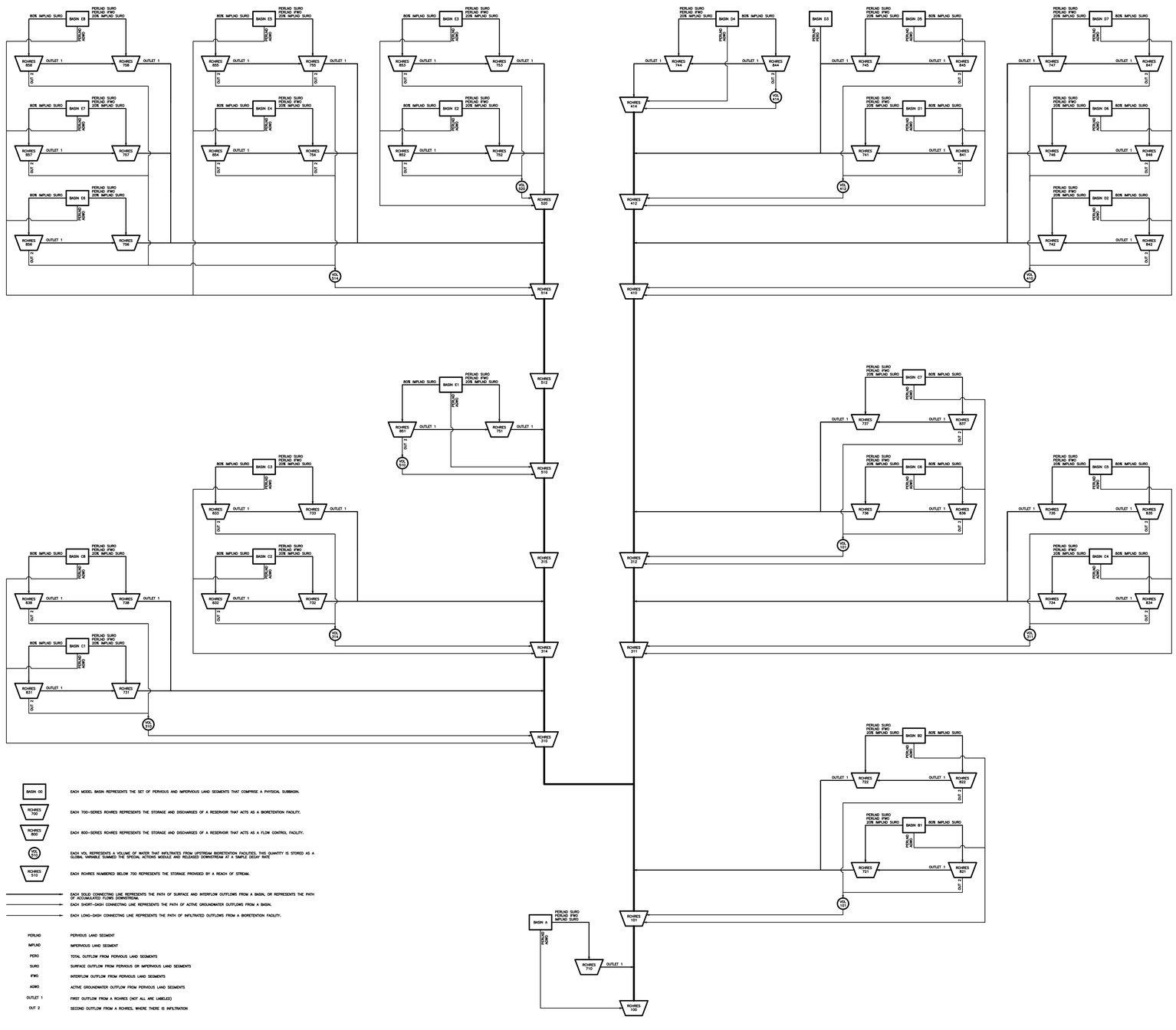
Grant No. G1400026

Appendix A

EVANS CREEK TRIBUTARY 108 PREDEVELOPED CONDITION HSPF MODEL SCHEMATIC



EVANS CREEK TRIBUTARY 108 MITIGATED CONDITION HSPF MODEL SCHEMATIC

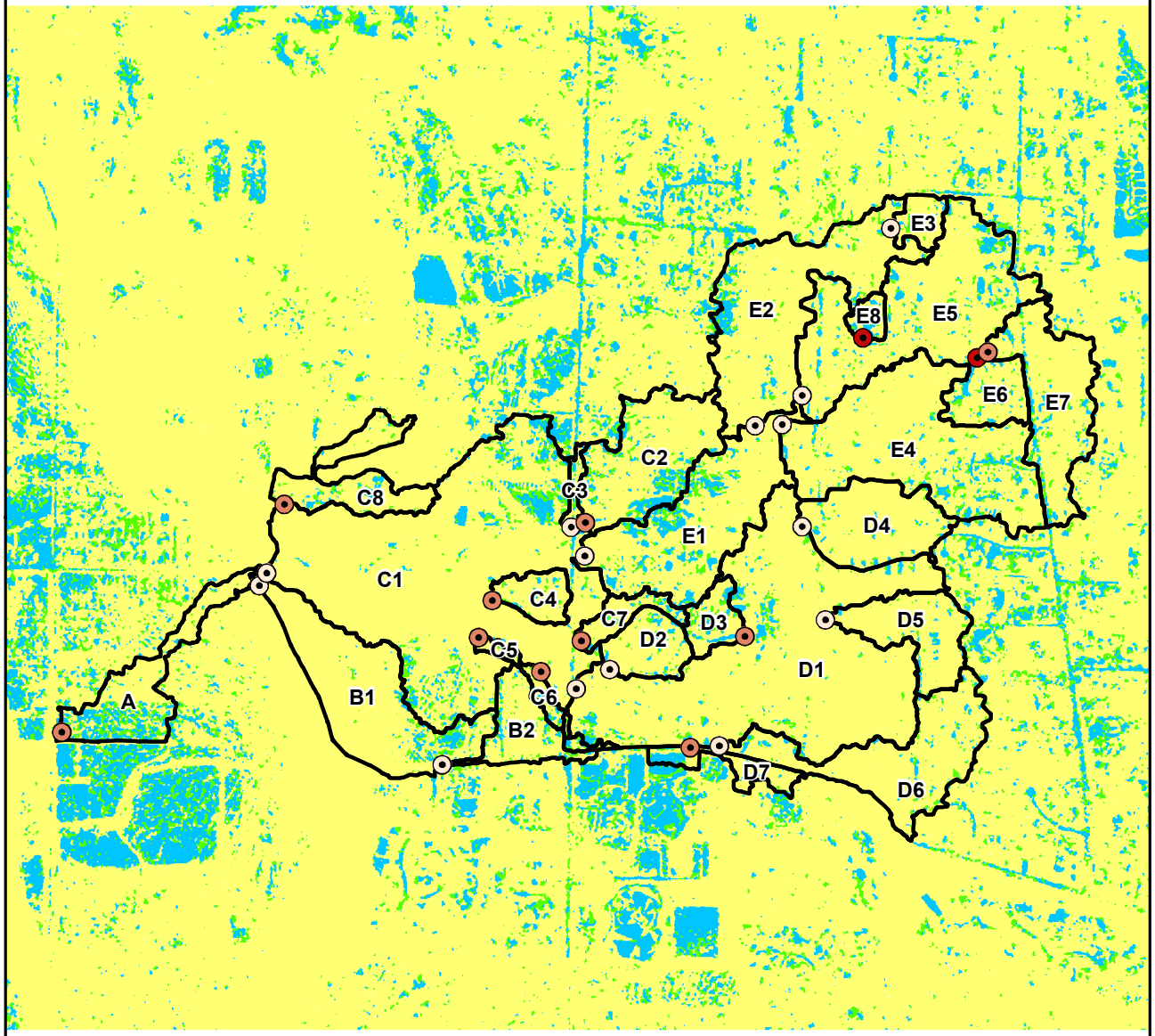


BASIN 00	EACH MODEL BASIN REPRESENTS THE SET OF PERVIOUS AND IMPERVIOUS LAND SEGMENTS THAT COMPRISE A PHYSICAL SUBBASIN.
ROHRES 700	EACH 700-SERIES ROHRES REPRESENTS THE STORAGE AND DISCHARGES OF A RESERVOIR THAT ACTS AS A BIORETENTION FACILITY.
ROHRES 800	EACH 800-SERIES ROHRES REPRESENTS THE STORAGE AND DISCHARGES OF A RESERVOIR THAT ACTS AS A FLOW CONTROL FACILITY.
VOL 101	EACH VOL REPRESENTS A VOLUME OF WATER THAT INFILTRATES FROM UPSTREAM BIORETENTION FACILITIES. THIS QUANTITY IS STORED AS A GLOBAL VARIABLE SUMMED THE SPECIAL ACTIONS MODULE AND RELEASED DOWNSTREAM AT A SIMPLE DECAY RATE
ROHRES 510	EACH ROHRES NUMBERED BELOW 700 REPRESENTS THE STORAGE PROVIDED BY A REACH OF STREAM.
———	EACH SOLID CONNECTING LINE REPRESENTS THE PATH OF SURFACE AND INTERFLOW OUTFLOWS FROM A BASIN, OR REPRESENTS THE PATH OF ACCUMULATED FLOWS DOWNSTREAM.
- - - -	EACH SHORT-DASH CONNECTING LINE REPRESENTS THE PATH OF ACTIVE GROUNDWATER OUTFLOWS FROM A BASIN.
— — —	EACH LONG-DASH CONNECTING LINE REPRESENTS THE PATH OF INFILTRATED OUTFLOWS FROM A BIORETENTION FACILITY.

PERLND	PERVIOUS LAND SEGMENT
IMPLND	IMPERVIOUS LAND SEGMENT
PERO	TOTAL OUTFLOW FROM PERVIOUS LAND SEGMENTS
SURO	SURFACE OUTFLOW FROM PERVIOUS OR IMPERVIOUS LAND SEGMENTS
IFWO	INTERFLOW OUTFLOW FROM PERVIOUS LAND SEGMENTS
AGWO	ACTIVE GROUNDWATER OUTFLOW FROM PERVIOUS LAND SEGMENTS
OUTLET 1	FIRST OUTFLOW FROM A ROHRES (NOT ALL ARE LABELED)
OUT 2	SECOND OUTFLOW FROM A ROHRES, WHERE THERE IS INFILTRATION

Evans Creek Tributary 108
Level 1 Site Prioritization

Site Slope Criterion



Subbasin

slope <= 3%

3% < slope <= 5%

slope > 5%

Facility Location Slope Score

1

2

3

0 220 440 660 Yards

N

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Evans Creek Retrofit Siting 1121161\GIS\E108_L1_SlopeScore.mxd

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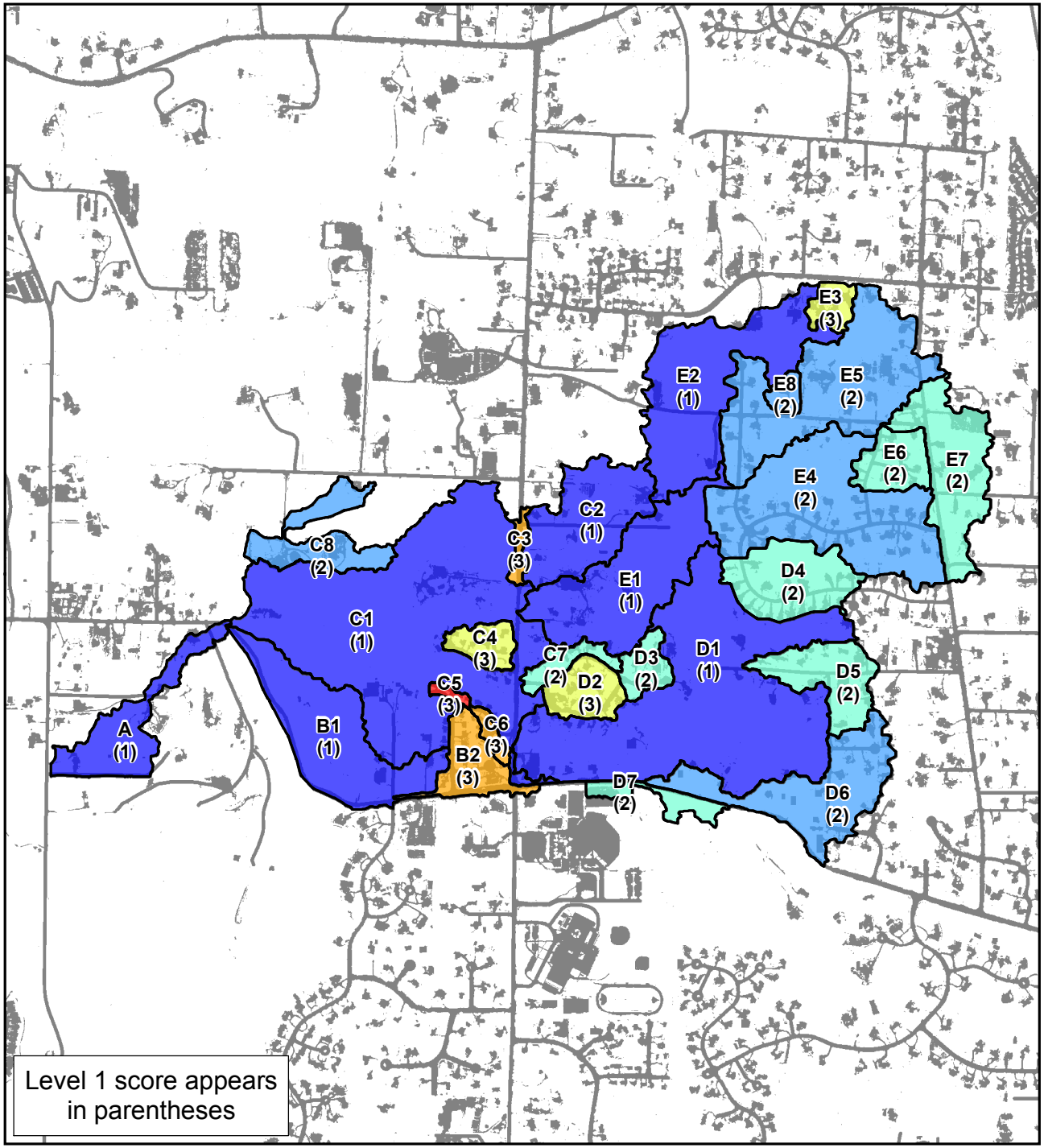
Evans Creek Tributary 108
Level 1 Site Prioritization

Impervious Surface Criterion

Impervious Percent of Subbasin

- 7.1% - 16.3%
- 16.4% - 25.6%
- 25.7% - 34.9%
- 35.0% - 44.1%
- 44.2% - 53.4%
- 53.5% - 62.7%
- Impervious and Impacted Areas



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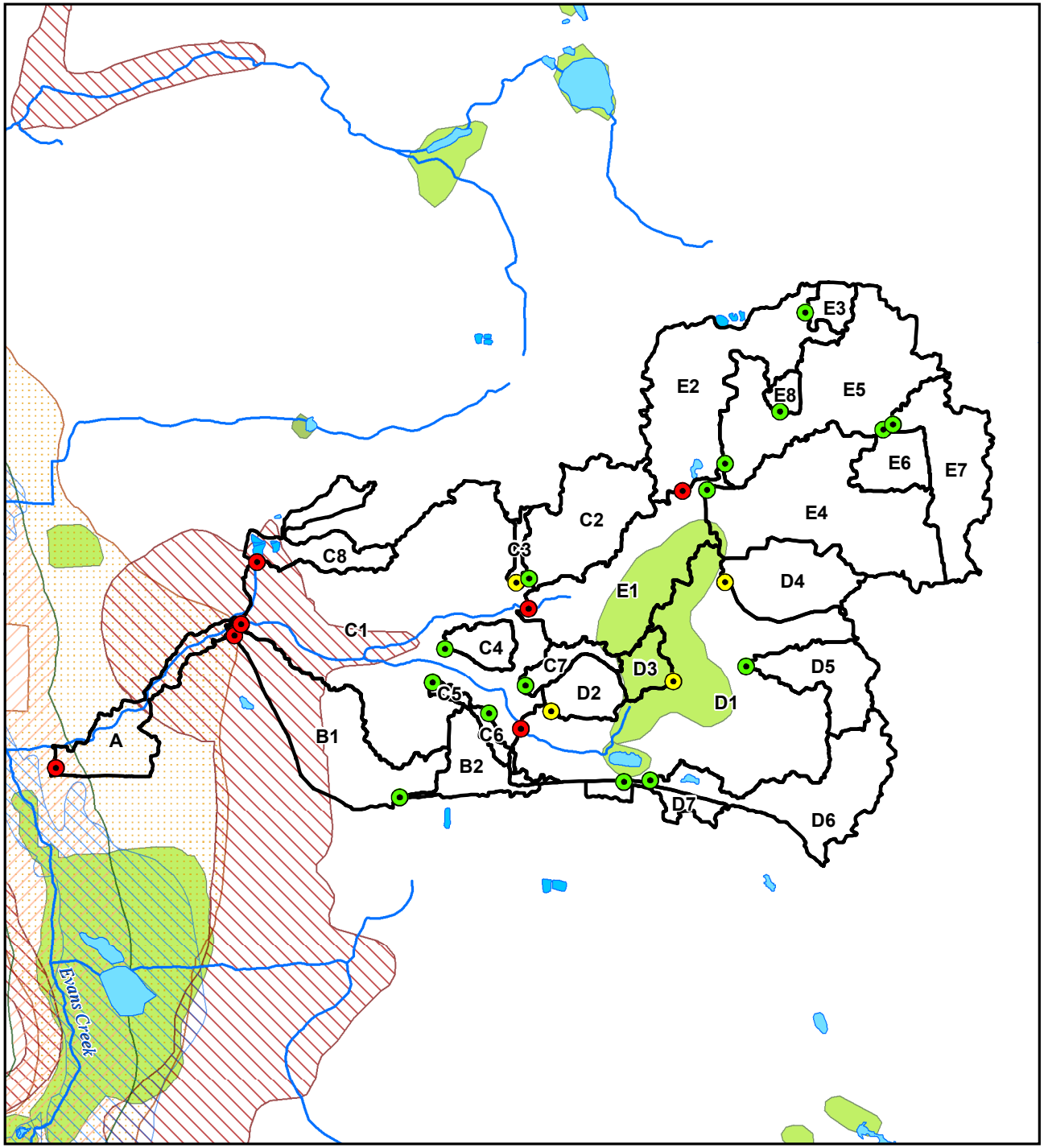

Evans Creek Tributary 108
Level 1 Site Prioritization

Risk to Environment Criterion

Subbasins

100-year floodplain

Chinook reach

Landslide hazard

Seismic hazard

Facility Location Environmental Score

1

2

3

0 220 440 660 Yards

N

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Evans Creek Retrofit Siting 1121161\GIS\E108_L1_EnvironmentCriteria.mxd

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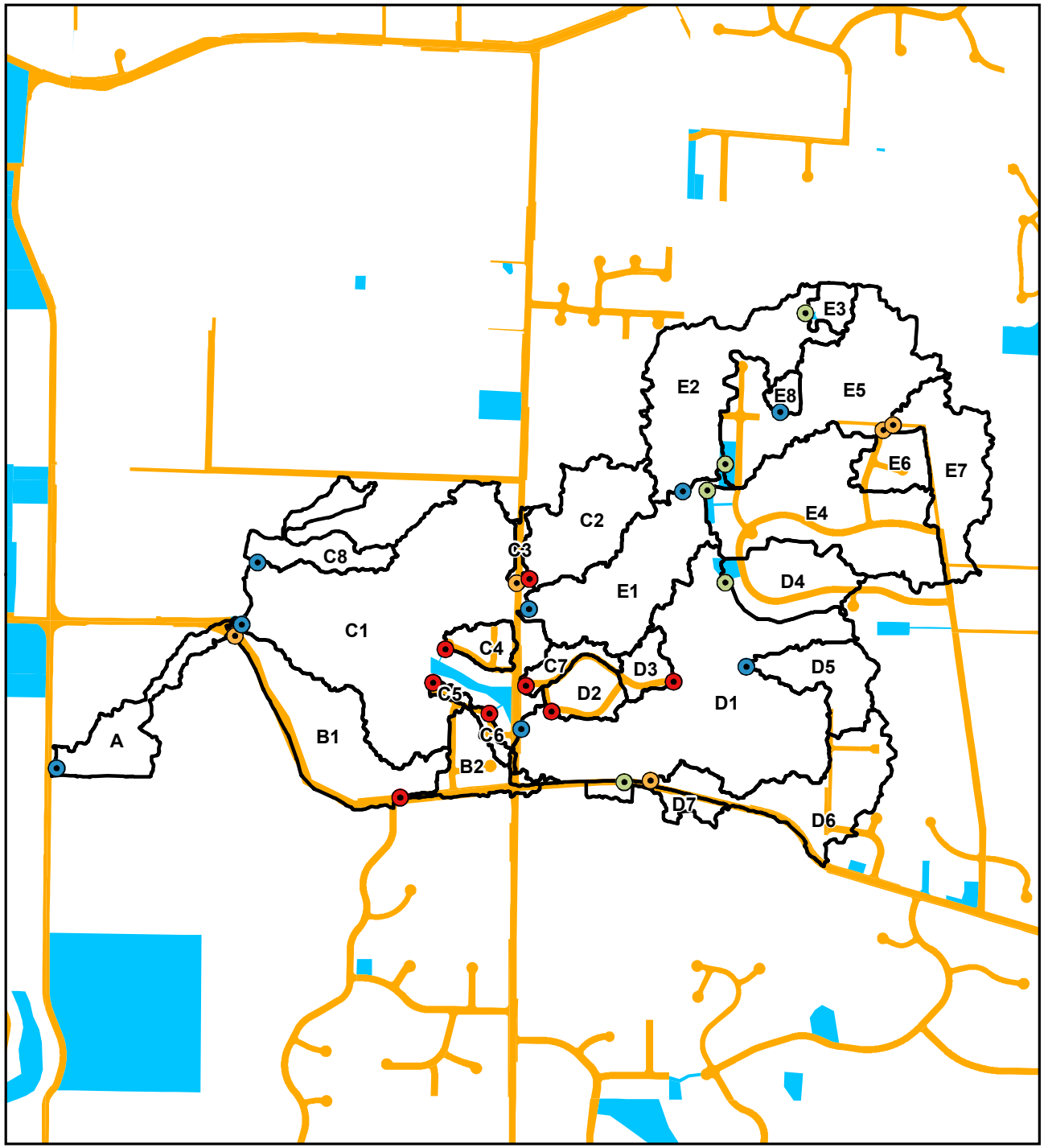

Evans Creek Tributary 108
Level 1 Site Prioritization

Available Area Criterion

Subbasins

Street Right-of-Way

Publicly Owned Lands

Facility Location Available Area Score

- 0
- 1
- 2
- 3

0 220 440 660 Yards

N

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Evans Creek Retrofit Siting 1121161\GIS\E108_L1_AvailableArea.mxd

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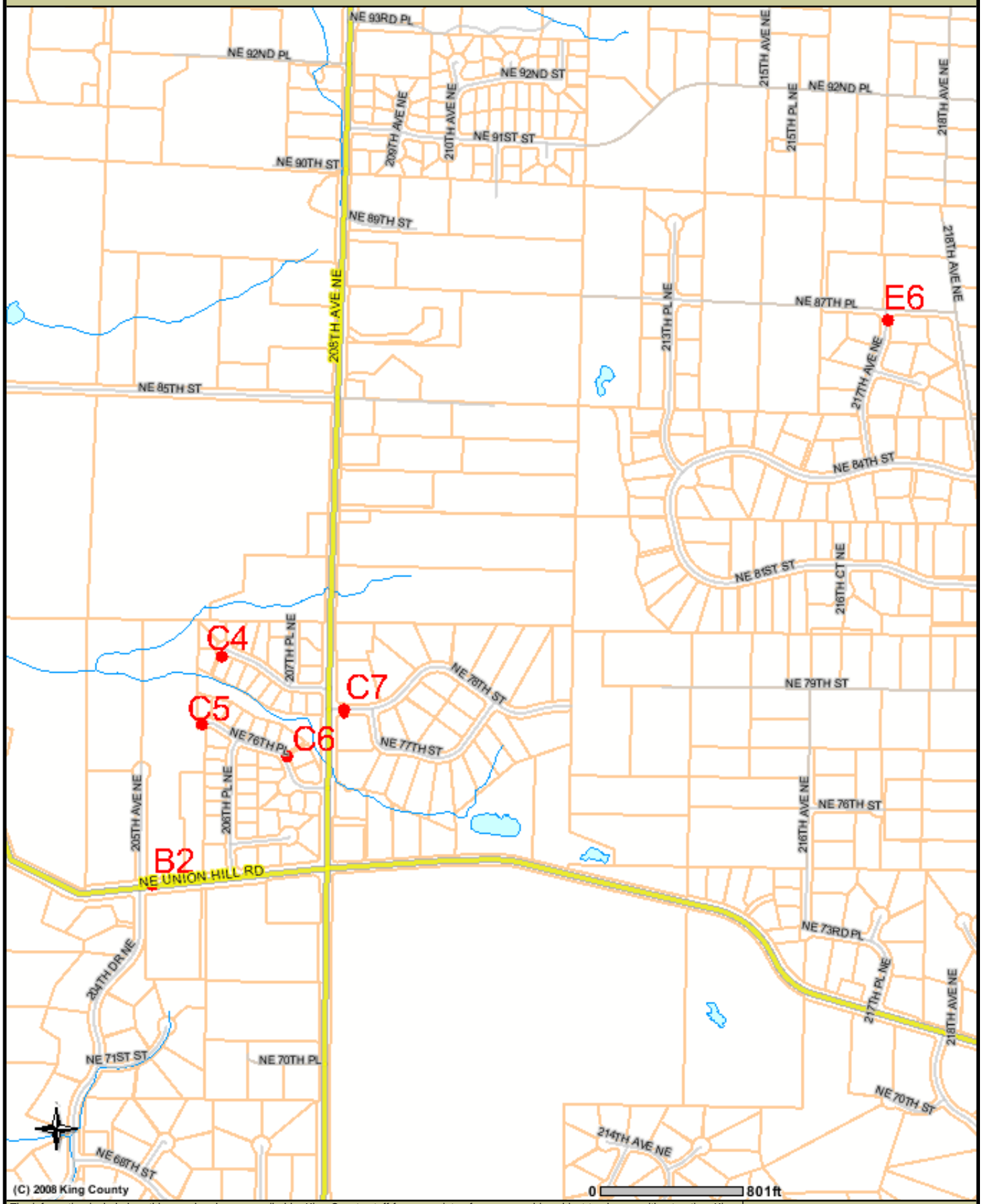
SubbasinID	Outfall POINT_X	Outfall POINT_Y	Flooding or Erosion Complaints / Comments
A	1333609.496	247441.3822	Flooding Drainage Complaints 90-0498 and 90-1442
B1	1335130.41	248573.3291	None
C1	1335187.132	248667.8666	Erosion Drainage Complaint 2011-0120
B2	1336543.069	247190.3814	None
C5	1336823.102	248172.696	None
C4	1336931.586	248458.055	None
C6	1337302.407	247909.4078	None
C8	1335323.537	249199.9771	None
C3	1337538.413	249024.4076	None
C4	1337649.157	249059.5217	None
E1	1337643.755	248800.2187	None
E2	1338960.772	249807.0806	None
E5	1339322.11	250043.3399	None
E4	1339164.604	249816.3456	None
E8	1339789.997	250485.7472	None
E3	1340007.726	251333.5017	None
E6	1340671.768	250330.7675	None
E7	1340755.99	250375.0197	None
C7	1337616.201	248143.6971	None
D2	1337835.033	247926.7198	None
D3	1338878.338	248181.3538	None
D4	1339320.403	249031.2731	Pond is dry but designed as wet pond. Drainage complaint 199-0278
D5	1339499.315	248308.012	None
D6	1338680.888	247335.4162	None
D7	1338456.296	247323.9963	None
D1	1337576.665	247777.7198	None

Evans Creek Tributary 108 Basin Wide Retrofit Siting

Grant No. G1400026

Appendix B

Appendix B - Map of Outfall Locations for Level 2



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Date: 11/13/2014 Source: King County iMAP - Property Information (http://www.metrokc.gov/GIS/iMAP)

King County

Appendix B - Map of Outfall Locations for Level 2

Legend

- County Boundary
- Mountain Peaks
- Highways
- Forest Production District Boundary
- Agricultural Production District Boundary
- Urban Growth Area Line
- Incorporated Area
- Streets
- (cont)
- Highway
- Arterials
- Local
- Lakes and Large Rivers
- Streams
- Tribal Lands
- Parcels
- Parks

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Date: 11/13/2014 Source: King County iMAP - Property Information (http://www.metrokc.gov/GIS/iMAP)

King County

Evans Creek Basin B2 BioRetention Retrofit

Water Quality Calculations Data Inputs By Dale Nelson, 8/25/2014

SWDM Section 6.4.1.1 - Basic Wetpond Calculations (p. 6-70)

Step 1:	Wetpool Volume Factor	Basin Water Quality Standard: Basic for Seola Creek									
		f =	3	(3 for Basic Wetpool, 4.5 for Large Wetpool or Enhanced Basic)							
Step 2:	Rainfall for mean annual storm (p. 6-70)	R =	0.039	ft							
Step 3:	Runoff from Mean Annual Storm	V_r =	$(0.9A_i + 0.25A_{tg} + 0.10A_{tf} + 0.01A_o) \times (R)$			(p. 6-72)					
	Area of impervious surface (effective)		A_i =	146,776	sf	=	3	acres	=	63.6	%
	Area of till soil covered with grass		A_{tg} =	73,467	sf	=	2	acres	=	31.8	%
	Area of till soil covered with forest		A_{tf} =	10,602	sf	=	0.243	acres	=	4.6	%
	Area of outwash soil covered with grass or forest		A_o =	0	sf	=	0	acres	=	0.0	%
	Runoff from Mean Annual Storm		V_r =	5910	cf	=	0.14	acre-ft			
Step 4:	Wetpool Volume	V_b =	$f V_r$ =	17729	cf	=	0.41	acre-ft			

Evaluation of TSS Removal Efficiency of the Retrofitted Wetpool Volume of B2 Pond

	Existing Pond	Retrofitted Pond*	Basic WQ Goal
	(acre-ft)		
Wetpool Volume, V_b =	0.00	0.41	7.26
Mean Annual Storm, V_r =	0.14	0.14	0.14
$x = V_b/V_r$ =	0.00	3.02	53.51
Removal Efficiency y = 0.2053ln(x) + 0.5687	0%	80%	80%

Three data points were used to generate a TSS efficiency curve using the the King County Surface Water Design Manual methodolgy and design criteria. Microsoft Excel was used to fit a curve to the 3 data points and generate the removal efficiency formula.

$x = V_b/V_r$	Removal Efficiency y = 0.2053ln(x) + 0.5687
3.00	80%
0.75	50%
0.10	10%

The TSS removal efficiency with a V_b/V_r of 3 was assumed to be 80% and so on. Efficiency is assumed to be zero as Vb/Vr goes to zero however the logarithmic function can only approach zero.

Evans Creek Basin C4 BioRetention Retrofit

Water Quality Calculations Data Inputs By Dale Nelson, 8/26/2014

SWDM Section 6.4.1.1 - Basic Wetpond Calculations (p. 6-70)

Step 1:	Wetpool Volume Factor	Basin Water Quality Standard: Basic for Seola Creek									
		f =	3	(3 for Basic Wetpool, 4.5 for Large Wetpool or Enhanced Basic)							
Step 2:	Rainfall for mean annual storm (p. 6-70)	R =	0.039	ft							
Step 3:	Runoff from Mean Annual Storm	V_r =	$(0.9A_i + 0.25A_{tg} + 0.10A_{tf} + 0.01A_o) \times (R)$			(p. 6-72)					
	Area of impervious surface (effective)		A_i =	69,068	sf	=	1.586	acres	=	38.0	%
	Area of till soil covered with grass		A_{tg} =	83,328	sf	=	2	acres	=	45.8	%
	Area of till soil covered with forest		A_{tf} =	29,504	sf	=	0.677	acres	=	16.2	%
	Area of outwash soil covered with grass or forest		A_o =	0	sf	=	0	acres	=	0.0	%
	Runoff from Mean Annual Storm		V_r =	3352	cf	=	0.08	acre-ft			
Step 4:	Wetpool Volume	V_b =	$f V_r$ =	10055	cf	=	0.23	acre-ft			

Evaluation of TSS Removal Efficiency of the Retrofitted Wetpool Volume of C4 Pond

	Existing Pond	Retrofitted Pond*	Basic WQ Goal
	(acre-ft)		
Wetpool Volume, V_b =	0.00	0.23	7.26
Mean Annual Storm, V_r =	0.08	0.08	0.08
$x = V_b/V_r$ =	0.00	2.99	94.35
Removal Efficiency $y = 0.2053\ln(x) + 0.5687$	0%	79%	80%

Three data points were used to generate a TSS efficiency curve using the the King County Surface Water Design Manual methodolgy and design criteria. Microsoft Excel was used to fit a curve to the 3 data points and generate the removal efficiency formula.

$x = V_b/V_r$	Removal Efficiency $y = 0.2053\ln(x) + 0.5687$
3.00	80%
0.75	50%
0.10	10%

The TSS removal efficiency with a V_b/V_r of 3 was assumed to be 80% and so on. Efficiency is assumed to be zero as Vb/Vr goes to zero however the logarithmic function can only approach zero.

Evans Creek Basin C5 BioRetention Retrofit

Water Quality Calculations Data Inputs By Dale Nelson, 8/25/2014

SWDM Section 6.4.1.1 - Basic Wetpond Calculations (p. 6-70)

Step 1: Wetpool Volume Factor

Basin Water Quality Standard: Basic for Seola Creek

f = 3 (3 for Basic Wetpool, 4.5 for Large Wetpool or Enhanced Basic)

Step 2: Rainfall for mean annual storm (p. 6-70) R = 0.039 ft

Step 3: Runoff from Mean Annual Storm $V_r = (0.9A_i + 0.25A_{tg} + 0.10A_{tf} + 0.01A_o) \times (R)$ (p. 6-72)

Area of impervious surface (effective)	A_i =	21,811	sf	=	0.501	acres	=	78.6	%
Area of till soil covered with grass	A_{tg} =	5,805	sf	=	0.133	acres	=	20.9	%
Area of till soil covered with forest	A_{tf} =	117	sf	=	0.003	acres	=	0.4	%
Area of outwash soil covered with grass or forest	A_o =	0	sf	=	0	acres	=	0.0	%
Runoff from Mean Annual Storm	V_r =	823	cf	=	0.019	acre-ft			

Step 4: Wetpool Volume $V_b = f V_r$ = 2468 cf = 0.057 acre-ft

Evaluation of TSS Removal Efficiency of the Retrofitted Wetpool Volume of C5 Pond

	Existing Pond	Retrofitted Pond*	Basic WQ Goal
	(acre-ft)		
Wetpool Volume, V_b =	0.00	0.06	7.26
Mean Annual Storm, V_r =	0.02	0.02	0.02
$x = V_b/V_r$ =	0.01	3.00	384.43
Removal Efficiency $y = 0.2053\ln(x) + 0.5687$	0%	79%	80%

Three data points were used to generate a TSS efficiency curve using the the King County Surface Water Design Manual methodolgy and design criteria. Microsoft Excel was used to fit a curve to the 3 data points and generate the removal efficiency formula.

$x = V_b/V_r$	Removal Efficiency $y = 0.2053\ln(x) + 0.5687$
3.00	80%
0.75	50%
0.10	10%

The TSS removal efficiency with a V_b/V_r of 3 was assumed to be 80% and so on. Efficiency is assumed to be zero as Vb/Vr goes to zero however the logarithmic function can only approach zero.

Evans Creek Basin C6 BioRetention Retrofit

Water Quality Calculations Data Inputs By Dale Nelson, 8/26/2014

SWDM Section 6.4.1.1 - Basic Wetpond Calculations (p. 6-70)

Step 1:	Wetpool Volume Factor	Basin Water Quality Standard: Basic for Seola Creek									
		f =	3	(3 for Basic Wetpool, 4.5 for Large Wetpool or Enhanced Basic)							
Step 2:	Rainfall for mean annual storm (p. 6-70)	R =	0.039	ft							
Step 3:	Runoff from Mean Annual Storm	V_r =	$(0.9A_i + 0.25A_{tg} + 0.10A_{tf} + 0.01A_o) \times (R)$			(p. 6-72)					
	Area of impervious surface (effective)		A_i =	29,498	sf	=	0.677	acres	=	46.4	%
	Area of till soil covered with grass		A_{tg} =	33,594	sf	=	1	acres	=	52.9	%
	Area of till soil covered with forest		A_{tf} =	439	sf	=	0.010	acres	=	0.7	%
	Area of outwash soil covered with grass or forest		A_o =	0	sf	=	0	acres	=	0.0	%
	Runoff from Mean Annual Storm		V_r =	1365	cf	=	0.03	acre-ft			
Step 4:	Wetpool Volume	V_b =	$f V_r$ =	4094	cf	=	0.09	acre-ft			

Evaluation of TSS Removal Efficiency of the Retrofitted Wetpool Volume of C6 Pond

	Existing Pond	Retrofitted Pond*	Basic WQ Goal
	(acre-ft)		
Wetpool Volume, V_b =	0.00	0.09	7.26
Mean Annual Storm, V_r =	0.03	0.03	0.03
$x = V_b/V_r$ =	0.00	2.87	231.74
Removal Efficiency $y = 0.2053\ln(x) + 0.5687$	0%	79%	80%

Three data points were used to generate a TSS efficiency curve using the the King County Surface Water Design Manual methodolgy and design criteria. Microsoft Excel was used to fit a curve to the 3 data points and generate the removal efficiency formula.

$x = V_b/V_r$	Removal Efficiency $y = 0.2053\ln(x) + 0.5687$
3.00	80%
0.75	50%
0.10	10%

The TSS removal efficiency with a V_b/V_r of 3 was assumed to be 80% and so on. Efficiency is assumed to be zero as Vb/Vr goes to zero however the logarithmic function can only approach zero.

Evans Creek Basin E6 BioRetention Retrofit

Water Quality Calculations Data Inputs By Dale Nelson, 8/26/2014

SWDM Section 6.4.1.1 - Basic Wetpond Calculations (p. 6-70)

Step 1:	Wetpool Volume Factor	Basin Water Quality Standard: Basic for Seola Creek									
		f =	3	(3 for Basic Wetpool, 4.5 for Large Wetpool or Enhanced Basic)							
Step 2:	Rainfall for mean annual storm (p. 6-70)	R =	0.039	ft							
Step 3:	Runoff from Mean Annual Storm	V_r =	$(0.9A_i + 0.25A_{tg} + 0.10A_{tf} + 0.01A_o) \times (R)$			(p. 6-72)					
	Area of impervious surface (effective)		A_i =	88,477	sf	=	2.031	acres	=	31.0	%
	Area of till soil covered with grass		A_{tg} =	0	sf	=	0	acres	=	0.0	%
	Area of till soil covered with forest		A_{tf} =	0	sf	=	0.000	acres	=	0.0	%
	Area of outwash soil covered with grass or forest		A_o =	196739	sf	=	4.52	acres	=	69.0	%
	Runoff from Mean Annual Storm		V_r =	3182	cf	=	0.07	acre-ft			
Step 4:	Wetpool Volume	V_b =	fV_r =	9547	cf	=	0.22	acre-ft			

Evaluation of TSS Removal Efficiency of the Retrofitted Wetpool Volume of E6 Pond

	Existing Pond	Retrofitted Pond*	Basic WQ Goal
	(acre-ft)		
Wetpool Volume, V_b =	0.00	0.22	7.26
Mean Annual Storm, V_r =	0.07	0.07	0.07
$x = V_b/V_r$ =	0.00	3.01	99.38
Removal Efficiency $y = 0.2053\ln(x) + 0.5687$	0%	80%	80%

Three data points were used to generate a TSS efficiency curve using the the King County Surface Water Design Manual methodolgy and design criteria. Microsoft Excel was used to fit a curve to the 3 data points and generate the removal efficiency formula.

$x = V_b/V_r$	Removal Efficiency $y = 0.2053\ln(x) + 0.5687$
3.00	80%
0.75	50%
0.10	10%

The TSS removal efficiency with a V_b/V_r of 3 was assumed to be 80% and so on. Efficiency is assumed to be zero as Vb/Vr goes to zero however the logarithmic function can only approach zero.