Cedar River Municipal Watershed
Road Surface Erosion Monitoring Study Plan
Draft of 2-11-08

Introduction

Responsible resource stewardship, particularly the protection of water quality, is of primary importance for the City of Seattle in establishing policies and guidelines to efficiently and effectively manage the land and water within the Cedar River Municipal Watershed. As an integral part of watershed management, the City of Seattle has developed an ecosystem-based, multiple species Habitat Conservation Plan (HCP) for the Cedar River Municipal Watershed under Section 10 of the Endangered Species Act (ESA). The City's HCP was developed to offset any harm caused to individual listed and selected unlisted species by promoting conservation of populations as a whole. The plan specifies conservation objectives, provides for protection and restoration of both aquatic and terrestrial ecosystems, utilizes ecological monitoring and research to support adaptive management, includes mitigation for adverse impacts, and incorporates public participation during implementation. Federal approval of the HCP occurred on April 21, 2000.

The objectives for the road network relevant to the strategies for the Aquatic and Riparian Ecosystem are to improve and protect stream and riparian ecosystems. The program is designed to: 1) Reduce the road network to what is needed for watershed management under conditions of no timber harvest for commercial purposes; 2) Minimize sediment delivery to streams from roads; 3) Improve drainage patterns that have been altered by roads; 4) Reestablish fish passage, where economically and technically feasible, between significant amounts of upstream and downstream aquatic habitats, where these connections are interrupted by roads; and 5) track changes in sediment delivery to the aquatic system as a result of all road work.

A great deal of effort and money is expended maintaining, improving and decommissioning roads within the Cedar River Municipal Watershed. While relying heavily on our comprehensive road inventory and predictions about sediment delivery using output from the Washington Road Surface Erosion Model (WARSEM) to prioritize road work and track improvements, the accuracy of these predictions has not been assessed, resulting in a significant source of uncertainty as to the effectiveness of our roads program at achieving one of our most fundamental objectives. Road surface erosion and delivery data collected under this Study Plan are intended to quantify the actual amount of sediment produced from roads in the watershed as well as the effectiveness of road improvements at reducing road-generated sediment delivery to streams.

Goals

The goal of this study plan is to measure road surface erosion and delivery from a representative sub-set of roads in the Cedar River Municipal Watershed to help calibrate the WARSEM road surface erosion production and delivery estimates to conditions in the watershed.

Previous Research

Road surface erosion is controlled by the characteristics of the road itself as well as the climate, traffic use, and underlying geology. Measurements of forest road surface erosion and the influence of different road characteristics on erosion and delivery have been undertaken throughout the United States since the 1960's (a comprehensive discussion of previous work is available in Appendices A and C of the WARSEM manual, Dubé et. al 2004). WARSEM estimates road erosion and delivery based on road length, width, age, surfacing, traffic, gradient, cutslope height and cover, rainfall, geology, and distance from a stream. The influence of several of these factors on erosion is fairly well constrained by available research (e.g., road gradient, cutslope cover, road age). Other variables either show differing responses between studies, or have fewer measurements (e.g., traffic, geology, climate, surfacing, delivery). Based on the confidence in each of the factors, as well as specific data needs in the Cedar River Municipal Watershed, critical questions were formulated for this study.

Critical Questions

A number of critical questions were developed to help guide the selection and quantity of road sampling locations. A summary of samples required to support answers to these questions is included in Table 1. Where sample site characteristics allow, data collected at a single site may provide information for more than one critical question.

Note that the categories listed in Table 1 (as well as data in Figures 1, 2, and 3) are based on road inventory data collected in 2005. Road improvements such as changes to surfacing and addition of drainage structures have taken place on approximately 60 miles (10%) or roads since that time.

Critical Question 1: How accurate are the WARSEM estimates of road surface erosion in the Cedar River Municipal Watershed?

Justification: The WARSEM model results are being used to estimate road surface erosion from the road network in the Cedar River Municipal Watershed. The model is an empirical model, based on road erosion research from watersheds across the United States (Dubé et. al 2004). Road surface erosion estimates using WARSEM are suspected to overestimate actual road surface erosion. Since model predictions are an important tool for tracking progress and gauging success in reducing sediment loads from the road network, calibration of these estimates will enable SPU management to more confidently evaluate the overall benefit of this expensive work on water quality.

Scope of Study: The primary road attributes that control sediment production are: traffic/grading (disturbance); surfacing/ditch condition; road area (length/width); and gradient. It is recommended to hold road area constant (study segments would be similar lengths; 200-300 feet based on the average length of direct delivery segments in the watershed) and sample erosion from roads with the following characteristics (see Table 1 and Figures 1, 2 and 3):

- Traffic – occasional, light, moderate, moderately high
- Surfacing – Crushed rock, Borrow, Native blocky-coarse, Native blocky medium-fine, Native fine
- Gradient – 2-3%, 5-7%, 10-12%

Table 1. Potential Sample Site Characteristics and Recommended Sample Size (initial proposal)

<table>
<tr><th>Traffic</th><th>Surfacing</th><th>Gradient</th><th>Total</th><th>Notes</th></tr>
<tr><td colspan="5">Critical Questions 1, 4, and 6</td></tr>
<tr><td rowspan="4">Occasional</td><td>Borrow</td><td>2-3%, 5-7%</td><td>5</td><td>Could reduce number of samples since these are likely small producers (but 80% of total road length in watershed)</td></tr>
<tr><td>Native blocky/coarse</td><td>2-3%, 5-7%</td><td>5</td><td></td></tr>
<tr><td>Native Medium/fine</td><td>2-3%, 5-7%</td><td>5</td><td rowspan="2"></td></tr>
<tr><td>Native fine</td><td>5-7%, 10-12%</td><td>5</td></tr>
<tr><td rowspan="2">Light</td><td>Borrow</td><td>5-7%</td><td>5</td><td></td></tr>
<tr><td>Native Medium/fine</td><td>5-7%</td><td>5</td><td></td></tr>
<tr><td rowspan="2">Moderate</td><td>Borrow</td><td>2-3%</td><td>5</td><td rowspan="3">These are likely largest producers</td></tr>
<tr><td>Crushed</td><td>2-3%</td><td>5</td></tr>
<tr><td>Moderately High</td><td>Crushed</td><td>2-3%, 7%</td><td>5</td></tr>
<tr><td colspan="5">Critical Question 3</td></tr>
<tr><td colspan="3">Either select segments from Critical Question (CQ)1 and monitor for an additional 2-3 years, or add paired BMP segments to initial study</td><td>None
(or 8-10)</td><td></td></tr>
<tr><td colspan="5">Critical Question 5</td></tr>
<tr><td colspan="3">Select low use segments from CQ1 in areas that will have special projects in 2010-2011</td><td>None</td><td></td></tr>
<tr><td colspan="5">Critical Question 7</td></tr>
<tr><td colspan="2">Select 5 of highest predicted segments to monitor; these are longer lengths – would test difference in length of segment (is adding culverts to break up lengths helpful?)</td><td>10-15%</td><td>5</td><td></td></tr>
</table>

Total Segments: 50 (60 if additional sites are needed for QC3)

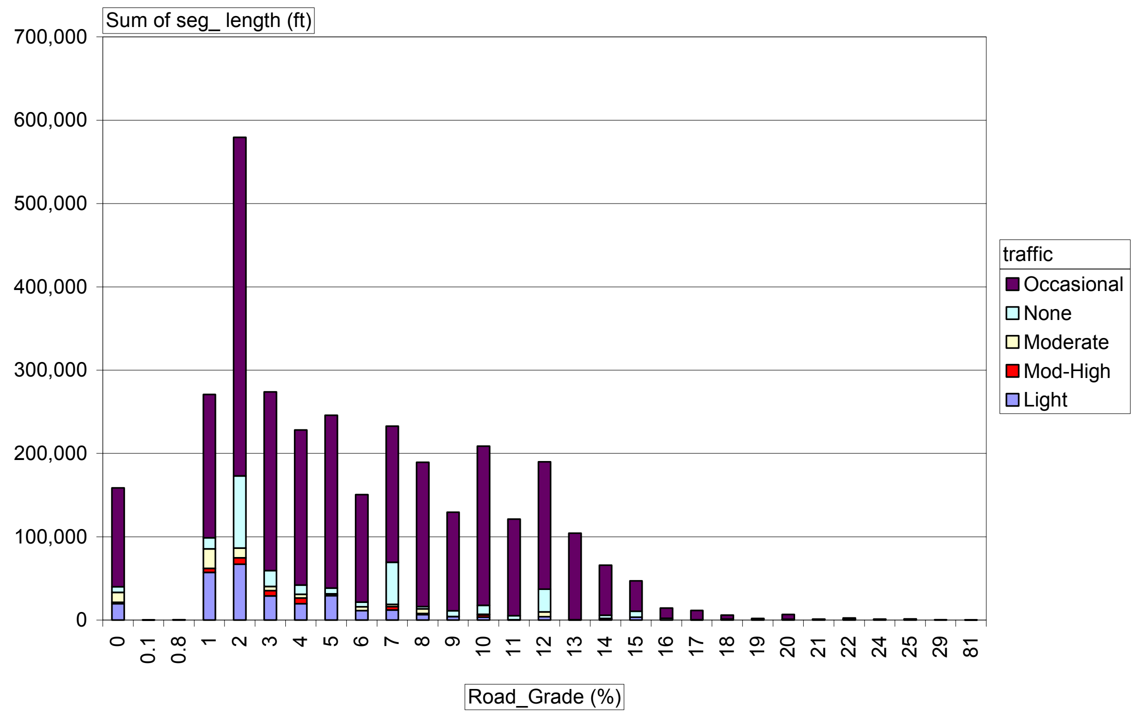

Figure 1. Total length of roads in Cedar River Municipal Watershed by traffic and road gradient.

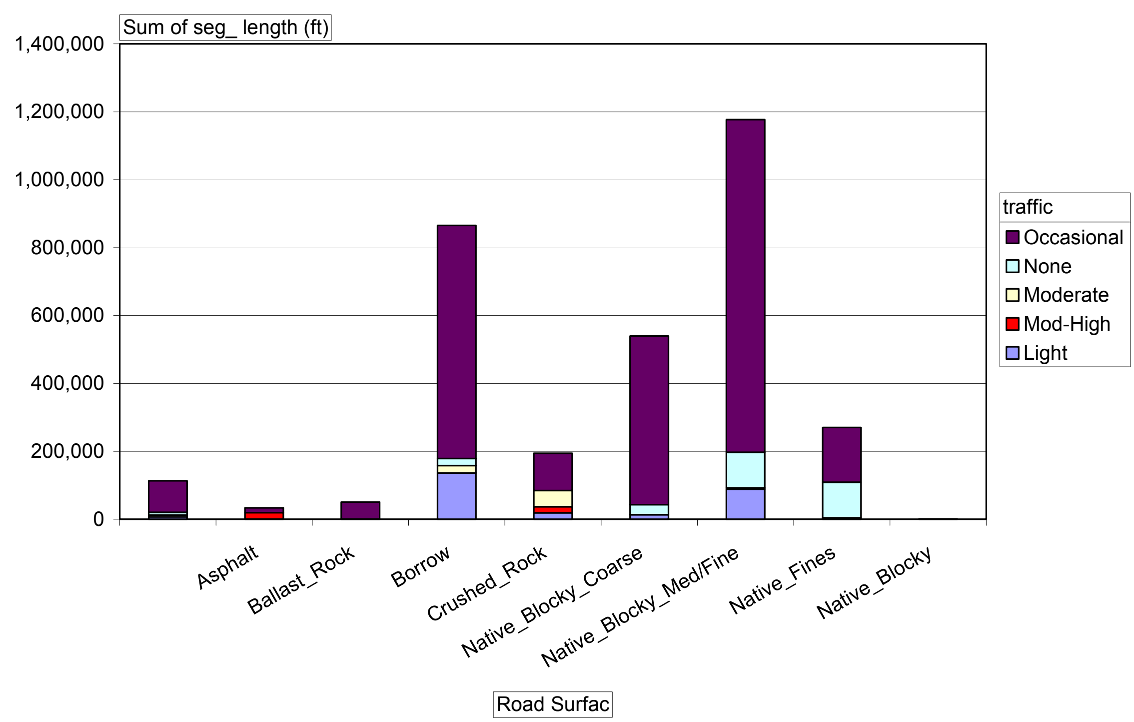

Figure 2. Total length of roads in Cedar River Municipal Watershed by traffic and surfacing *(Note: based on 2005 inventory; 100/200 roads – light native blocky – are now crushed surfacing)*

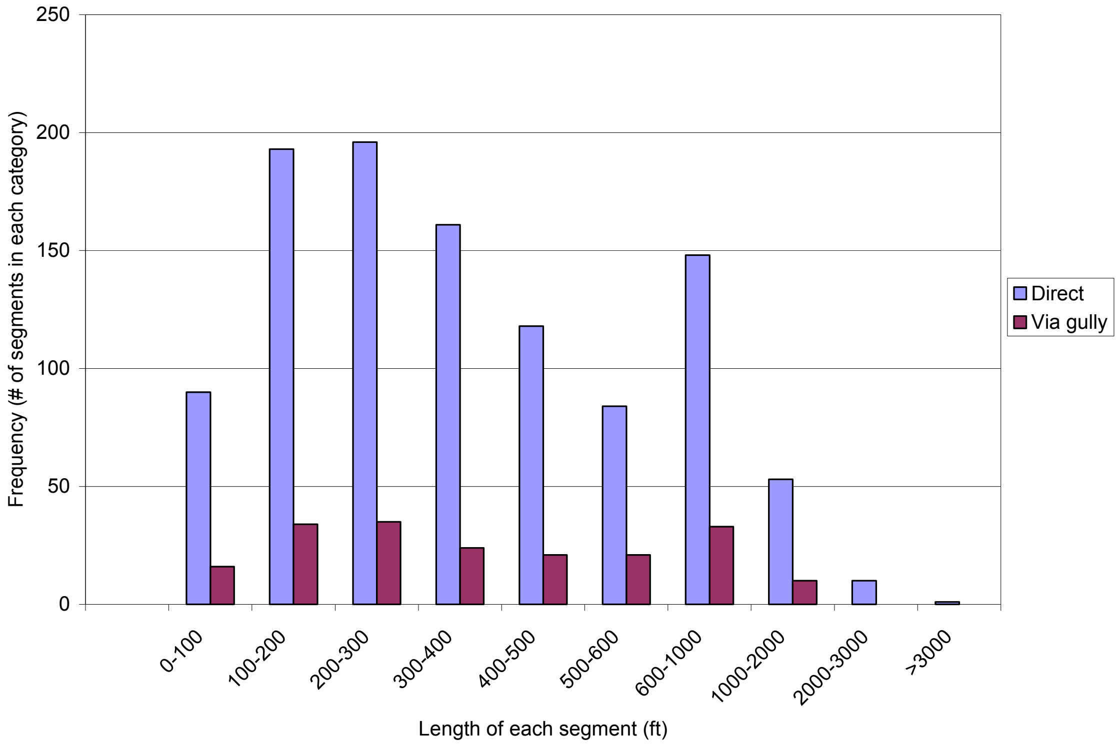

Figure 3. Length of direct delivery and direct via gully road <u>segments</u> in Cedar River Municipal Watershed.

Critical Question 2: How accurate are the WARSEM predictions of delivery of eroded sediments in the Cedar River Municipal Watershed?

Justification: The WARSEM model uses data from a road research study in Idaho to estimate the distance sediment can be transported from the outlet of a culvert (Ketcheson and Megahan 1996). The Idaho study site conditions were different than those in the Cedar Watershed (Idaho – sandy soil, Cedar – finer-grained soil, different precipitation patterns and intensities). Improving our understanding of the distances and associated site characteristics where sediment delivery across the forest floor occurs will greatly improve our confidence in sediment predictions and the implementation of future road improvements designed to reduce sediment delivery to streams.

Scope of Study: The proposed study method would be to install filter fabric structures (similar to silt fences) to catch runoff at varying distances below culvert outfalls and at dispersed runoff sites. This study would require 35 sample sites monitored over 3 years (5 sites each – 10, 25, 50, 100, 200 ft from outfall and 10 and 20 ft from dispersed sites). Sites would be visually checked twice/year to determine if road sediment reaches filter structure.

Critical Question 3: What is the actual reduction of road surface erosion due to road work in the Cedar River Municipal Watershed? **Justification:** A great deal of effort has and will continue to be expended to reduce sediment input from roads in the watershed. A measure of the success of this effort is important to help determine the cost effectiveness of these actions.

Common expensive measures used to address this issue include surfacing (gravel), grading, ditching/cleaning, armoring ditches, addition of culverts, vegetation management, and installation of silt fencing.

Scope of Study: Sampling the effectiveness of BMPs requires either a paired segment study (one segment without BMP, another similar one with the BMP) or monitoring of a single segment without the BMP for several years, adding the BMP, and monitoring the segment with the BMP for several years. Recommended BMPs to measure are:

- Adding gravel
- Grading
- Ditching/cleaning
- Armoring ditches

If time is a critical factor (want to know the answer sooner), 8 additional monitoring stations (2 for each BMP) could be added to selected segments adjacent to those in Table 1. If time is not as critical, 8-10 of the segments from Table 1 could be chosen to monitor for 2 years under existing conditions, then BMPS could be added and monitored for 2-3 additional years.

Critical Question 4: How much sediment is produced from low traffic roads in the CRW**Justification:** One important objective of road decommissioning work in the CRW is the reduction of sediment delivering from nonessential roads. Understanding the amount of road surface erosion produced from these roads will inform our prioritization, enabling us to more confidently identify and prioritize roads where significant sediment delivery to streams and wetlands is occurring. **Scope of Study:** A measure of sediment production from low use roads is included in Critical Question 1.

Critical Question 5: How much sediment is produced from road use/alterations associated with temporary, project-related effects (e.g., thinning operations)

Justification: Temporary changes in traffic patterns and road maintenance and reconstruction are associated with special projects such as thinning operations in the watershed. Disturbance associated with special projects generally last less than one year and will continue at various locations in the future. These temporary changes likely result in a temporary increase in sediment production from the affected areas. Research in other locations suggests the temporary increases from only changes in traffic use return to normal levels in a short period of time (days to weeks; Reid 1982), but increases from road reconstruction take 2-3 years to return to pre-disturbance levels (Ketcheson et. al 1999, Luce and Black 1999, Grace 1999, Swift 1984, Dryness 1975, Megahan 1974, Megahan and Kidd 1972).

Scope of Study: The most cost-effective way to address this question would be to find a location where thinning/road reconstruction efforts are planned for 2010-2011 adjacent to current low traffic roads. Road segments would be monitored for 2 years under low use conditions (Critical Question 1 and 4), continue to be monitored during the thinning/reconstruction efforts, and for 2-3 years following this work (total time 5-6 years). This would provide information on low use road erosion rates, changes due to temporary disturbance, length of time to recover, and, if BMPs are planned (Critical Question 3), the effectiveness of these measures (assuming several sites are left with no BMPs). These sites could be included in Critical Question 1 and 3 estimates (segments selected from Table 1).

Critical Question 6: How much sediment is produced and delivered from high use roads adjacent to key water features?

Justification: Traffic use, particularly during wet weather, has been shown to greatly increase sediment production from road surfaces. Several high use roads are located adjacent to waterways in the Cedar River Municipal Watershed with a high likelihood of delivery of the sediment to water bodies. A measure of the amount of sediment produced by these roads would provide information on the importance of controlling sediment from these roads.

Scope of Study: A measure of sediment production from high use roads is included in Critical Question 1. Delivery is included in Critical Question 2.

Critical Question 7: Do the road segments WARSEM predicted to be the highest sediment producers actually produce large quantities of sediment?

Justification: The top 20 WARSEM-predicted road segments have the following characteristics: direct/direct via gully delivery, long segment lengths (500-2,500 feet), native surfacing (all but 2), high gradient (7-20%), and varying traffic rates.

Scope of Study: Directly sampling the predicted high sediment producers is a great goal. However, the long lengths (most over 800 feet long) would preclude them from being part of the "constant length" pool of study segments discussed in Critical Question 1. It would be worthwhile to visit several of these in the field to determine if it would be feasible (space for sampling equipment?) to monitor 2-3 of these segments. If so, it would add 2-3 additional monitoring stations for 3 years.

Methods

Different researchers have measured road surface erosion using a number of methods through the years. Two separate data collection methodologies are proposed for the current study:

- Road surface erosion sampling using a settling tank (with optional tipping bucket at select plots) based on Black and Luce (2007)
- Sediment delivery distance sampling using silt fence traps set at pre-determined distances downslope of selected road segments (Robichaud and Brown 2002).

Electronic versions of both methodologies are provided separately that include implementation details, materials lists, and sampling techniques. The two techniques are summarized below.

Road Surface Erosion Sampling

Road surface erosion sampling will measure the amount of sediment produced from road segments. Black and Luce (2007 Draft) have developed a cost-effective method for measuring surface erosion using a bordered road erosion plot, a settling tank, and an optional tipping bucket/flow sampling device. The advantages to this methodology are that it is comparatively low cost, requires only periodic checking (annually if only the settling tank is used; monthly data downloads for the tipping bucket device), and collected data is comparable to other data that is being collected in the Pacific Northwest using the same equipment.

Road segments to be measured are isolated from other road segments by the use of constructed wood/rubber waterbars that direct runoff from the measured road segment into the ditchline. A ditch diversion structure directs the runoff into a 6” corrugated plastic pipe that carries water under the road and flows into a steel settling tank on the downslope side of the road (alternatively, an existing culvert can be used to divert water under road). The coarse sediment (and some fraction of the fine-grained silt and clay) settle and remain in the tank. If information on fine-grained sediment is important, water that spills out of the tank can be directed into a tipping bucket flow monitor attached to a datalogger that records runoff volume and takes a sub-sample of runoff to estimate suspended sediment concentration. Estimated cost per sample to install and monitor a road segment for 3 years is $5,200 without the tipping bucket, or $12,100 with the tipping bucket option (note: costs for tipping buckets assume SPU shop fabrication. Costs with pre-made tipping bucket are $10,390.)

Delivery Distance

In addition to sediment production, road models estimate the percent of eroded sediment that is delivered to a stream or water body based on the distance between the road runoff point (e.g., culvert outfall) and the stream. The WARSEM model assumes that 35% of the sediment produced from a road segment located between 1-100 feet from a stream is delivered to a stream, and 10% of the sediment is delivered from segments located between 101-200 feet from a stream. These estimates are based on research in the Idaho batholith (sandy soils, sparse vegetation) and likely overestimate delivery in the Cedar watershed with its dense vegetation that helps trap sediment traveling across the forest floor.

Installation of silt fence sediment traps on hillsides downslope of road segments is proposed to measure how far road sediment is transported from a road. Silt fence methodologies are described in Robichaud and Brown (2002). In order to measure sediment transport distances, silt fence traps would be installed 10, 25, 50, 100, 200 ft downslope from culvert outfalls, and 10 and 20 ft downslope from dispersed sites (e.g., outsloped road segments). Robichaud and Brown recommend a minimum of 5 replicates per site, resulting in 35 total sites. Silt fence locations would be visited twice/year to determine if any sediment is collecting at them. If so, sediment would be collected and weighed to determine quantity reach the silt fence. Estimated cost for installing and monitoring a silt fence location for 3 years is $1,240.

Estimated Project Cost

An estimate of total project cost was made based on total number of samples to answer all critical questions listed in Table and estimated costs to install and monitor sample locations for three years (Table 2, Scenario 1).

Scenario 2 (Table 2) includes all plots listed in Table 1, but only 5 tipping bucket plots (which would be used to extrapolate percent fines overflowing the settling basins in the other 45 erosion samples – would introduce some error by extrapolating).

Scenario 3 (Table 2) reduces the number of sample sites on occasional traffic roads from 20 to 12 and includes 5 tipping bucket plots. The 5 sites on WARSEM-estimated highest yield road segments (QC 7) are also dropped in scenario 3 since the reason these road segments have the highest yields are primarily due to the fact that they are very long (would get same amount by adding together several shorter segments). The reasoning behind reducing the number of sample sites on occasional traffic roads is that these likely produce very little sediment (although they account for 80% of the road length in the watershed).

Table 2. Estimated Sampling Costs

Scenario 1. All sample sites listed in Table 1

Sampling Method	Number of plots	Cost/plot	Total
Road Erosion Plots, no tipping bucket	25	$5,160.45	$113,976.00
Road Erosion Plots, with tipping bucket	25	$12,109.28	$302,731.88
Silt fence plots	35	$ 1,243.00	$ 43,505.00
TOTAL	50 + 35		$ 475,248.13

Scenario 2. All sample sites listed in Table 1; only 5 tipping buckets

Sampling Method	Number of plots	Cost/plot	Total
Road Erosion Plots, no tipping bucket	45	$ 5,160.45	$ 232,220.25
Road Erosion Plots, with tipping bucket	5	$12,109.28	$ 60,546.38
Silt fence plots	35	$ 1,243.00	$ 43,505.00
TOTAL	50 + 35		$ 336,271.63

Scenario 3. Fewer occasional traffic road sites (9); does not address QC 7, 5 tipping buckets

Sampling Method	Number of plots	Cost/plot	Total
Road Erosion Plots, no tipping bucket	32	$ 5,160.45	$ 165,134.40
Road Erosion Plots, with tipping bucket	5	$12,109.28	$ 60,546.38
Silt fence plots	35	$ 1,243.00	$ 43,505.00
TOTAL	37 + 35		$ 269,185.78

Proposed Pilot Project

Given the large overall expense and difficulty predicting installation costs, an initial smaller-scale study is proposed to help refine project costs as well as provide a means to gain familiarity with the construction and installation of monitoring equipment. The pilot project would include both the road erosion plot and silt fence monitoring locations and would be aimed at calibrating the WARSEM erosion estimates (QC1, QC2) and estimating the effectiveness of the road erosion reduction strategies most commonly employed in the watershed (surfacing and installing culverts to reduce delivery, QC 4).

Table 3 lists proposed pilot project sample site locations in relation to the Critical Questions. Road erosion plot sample site locations were chosen to answer Critical Questions 1, 4, and 6 across most traffic levels. The Moderately High traffic level was dropped since most of these segments are on the Kerriston Road which is not owned by SPU. Note also that Light traffic, Native medium/fine surfacing category from Table 1 and Figure 2 have been revised to crushed surfacing in Table 3 since these segments are primarily along the 100 and 200 road systems which have been re-surfaced since the 2005 road inventory.

Table 3. Potential Sample Site Characteristics and Recommended Sample Size for Pilot Project

<table>
<tr><th>Traffic</th><th>Surfacing</th><th>Gradient</th><th>Total</th><th>Notes</th></tr>
<tr><td colspan="5">Critical Questions 1, 4, and 6</td></tr>
<tr><td rowspan="4">Occasional</td><td>Borrow</td><td>5-7%</td><td>3</td><td rowspan="4">Effects of gradient are well documented in literature, so concentrate most samples in 5-7% gradient range if possible</td></tr>
<tr><td>Native blocky/coarse</td><td>5-7%</td><td>2</td></tr>
<tr><td>Native Medium/fine</td><td>5-7%</td><td>3 (1 w/ tipping bucket)</td></tr>
<tr><td>Native fine</td><td>5-7% or 10-12%</td><td>0</td></tr>
<tr><td rowspan="3">Light</td><td>Borrow</td><td>5-7%</td><td>3</td><td></td></tr>
<tr><td>Crushed</td><td>2-3%</td><td>2 (1 w/ Tipping bucket)</td><td>Would like to install one station each on the 100 and 200 road since these deliver directly to lake</td></tr>
<tr><td>Native blocky/coarse</td><td>2-3%</td><td>1</td><td></td></tr>
<tr><td rowspan="2">Moderate</td><td>Borrow</td><td>2-3%</td><td rowspan="2">2</td><td rowspan="2"></td></tr>
<tr><td>Crushed</td><td>2-3%</td></tr>
<tr><td>Moderately High</td><td>Crushed</td><td>2-3%, 7%</td><td>0</td><td>Majority of this category is Kerriston Road – not owned by SPU</td></tr>
<tr><td colspan="3">Additional silt fence monitoring sites at the 8 occasional use road sites</td><td>8</td><td>Install on road segments adjacent to erosion plots</td></tr>
<tr><td colspan="5">Critical Question 3</td></tr>
<tr><td colspan="3">Either select segments from Critical Question (CQ)1 and monitor for an additional 2-3 years, or add paired BMP segments to initial study</td><td>None</td><td></td></tr>
<tr><td colspan="5">Critical Question 5</td></tr>
<tr><td colspan="3">Select low use segments from CQ1 in areas that will have special projects in 2010-2011</td><td>None</td><td>If possible, select Occasional use roads from QC 1 that will have higher traffic levels in year 2 or 3 of pilot study</td></tr>
<tr><td colspan="5">Critical Question 7</td></tr>
<tr><td colspan="3">Select 5 of highest predicted segments to monitor; these are longer lengths – would test difference in length of segment (is adding culverts to break up lengths helpful?)</td><td>None</td><td></td></tr>
<tr><td colspan="5">Critical Question 2</td></tr>
<tr><td colspan="3">Silt fence monitoring sites</td><td>12</td><td></td></tr>
</table>

Total Segments: Road Erosion Plots - 16 (3 w/tipping buckets); Silt fence plots - 12

Since the effects of gradient on erosion are fairly well document in the literature (Dubé et al. 2004), and a check of 2-3% gradient occasional use roads in the field showed that many of these roads are on grade (not enough side slope to place settling tanks), concentrating on the 5-7% gradient road segments for sample locations is recommended. The exception is the 100 and 200 road systems (light traffic use category). These roads are low gradient (1-3%) but many segments are located adjacent to the reservoir with adequate sideslope gradient and space to install settling basins.

The 12 silt fence monitoring sites chosen to address Critical Question 2 will also provide information on the effectiveness of adding culverts to break up road segments and reduce delivery by directing road runoff to the forest floor.

Occasional use roads account for the majority of roads in the Cedar River Watershed (Figure 2). However, based on the WARSEM model, erosion measurements on roads in other areas, and observations of the lack of sediment in ditchlines along occasional use roads in the Cedar River Watershed, it is likely that these roads produce little sediment. Half of the sediment monitoring plots with settling tanks are proposed to be installed on occasional use roads. Since installation and monitoring of the settling tanks is somewhat expensive, it is proposed that silt fence sediment traps be installed at culvert outfalls at road segments adjacent to the settling tank plots. Assuming that all else (slope, geology, traffic, surfacing) would be equal between adjacent segments, this will allow us to compare methods and test whether or not the most cost-effective silt fences could be employed to collect data along occasional use roads.

The estimated 2008 installation costs for the pilot project are listed in Table 4 along with total costs for 3 years of data collection.

Table 4. Estimated Costs for Proposed Pilot Project

Sampling Method	**Number of plots**	**Cost/plot (installation only)**	**Cost in 2008**	**Total Costs (3-year data collection and analysis)**
Road Erosion Plots, no tipping bucket	13	$2,910.75	$37,840	$50,798
Road Erosion Plots, w/pre-made tipping bucket	3	$4,063.75	$12,191	$22,310
Silt fences at erosion stations	8	$494.50	$3,956	$7,148
Silt fences for delivery distance	5	$494.50	$2,472	$4,468
TOTAL	16 erosion, 12 silt fence		$56,459	$84,724

Note: placing traffic counters (SPU already owns several) along several of the higher use road segments selected for monitoring would provide site-specific information on traffic levels. It is possible that some traffic counters will be deployed in the watershed for other purposes and may be on roads being monitored for sediment.

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Swift, L.W. Jr., 1984. Gravel and grass surfacing reduces soil loss from mountain roads. Forestry Science, Vol. 30, pp.657-670.

Sediment Tank Installation Sites

Road	Site No.	Location	Slope	Pipe needed? (Yes/No	Constructed Water Bars or Driveable Dips?	Berm needed?	WB Lengths (2x6 w/ conveyor belt)	Misc. hardware needed?	Timing and Other issues?	Status
21	OBw1	Top: Culvert 21-6-C Bottom: Before CMP 21-6-B	7 %	No	2 Driveable dips	Yes (outside berm – approx. half the length)	Na		Install after 21 road decom work completed	√ Tank Installed (8-13) ☐ Berms ☐ WBs
22	OBw2	Top: Approx 10ft south of 21 rd junction Bottom: 308 feet down gradient	5 %	No	1 driveable dip (at bottom); don't need one at top	Yes (outside berm – entire length)	Na		Install after upper half of 21 road decom. work completed.	√ Tank Installed (8-16) ☐ Berms ☐ Driveable dips
18	OBw3	Top: just north of CMP 18-17	4%	No	2 driveable dips	Yes (outside berm)	Na		Need to plug ditch and add WB at top of segment;	☐ Sediment Tank ☐ Berms ☐ Driveable dips or WBs ☐ Plug top of ditch
810	OBC1 (420' long)	Top: CMP 810-14 Bottom: 300' above CMP 13		No	2 Driveable dips; tie dip into ditch	Yes- Entire outside edge	Na		Not GPS'd	√ Tank (Installed on 10-2-08 and partially connected; fully connected on 11-6-08) ☐ Berms √ Driveable dips
800	OBC2 (505 ft long)	Top: CMP 800-6 Bottom: 100' above 800-810 jct	11%	No	2 WB's: Upper:30 Lower: 25	Yes – entire outside edge	Upper: 16, 14 Lower: 14, 9		Not GPS'd. Upper dip is also bottom of DD_1(silt fence)	√ Sediment Tank (installed on 10-30-08; connected on 11-03-08) ☐ Berms

Road	Site No.	Location	Slope	Pipe needed? (Yes/No	Constructed Water Bars or Driveable Dips?	Berm needed?	WB Lengths (2x6 w/ conveyor belt)	Misc. hardware needed?	Timing and Other issues?	Status
										√ WBs (same date)
200	OBM1	Top: just below CMP (?) Bottom: just before CMP 200-99	5-6 %	No	2 WB's: Upper: 25 Lower: 27	Yes –Both sides- entire length	Upper: 12, 12 Lower: 12, 12		Don't tie in to ditch	√ Sediment Tank (Installed on 10-31-08 and fully connected on 11-5-08 ☐ Berms √ WBs (same date)
210	OBM2	Top: at CMP 20-2 Bottom: before 200 rd jct	7 %	No	2 Driveable dips	Yes- Entire outside edge	Na		Install tank in ditch line and rock weirs in ditch below tank	√ Sediment Tank (Installed on 11-04-08 and fully connected on 11-6-08) ☐ Berms √ Driveable dips (same date)
800	OBM3	Top: 200 ft upgrade of cmp 800-17 Bottom: just above 800-17	6 %	No	2 Driveable Dips	Yes- Inside edge	Na			√ Sediment Tank (installed on 10-29-08; connected on 11-03-08) ☐ Berms √ WBs (same date)
10	LBw1	Top: at break in hill (500 feet SE of 20 jct) Bottom: before sag point	4 %	No	WB: **1 x 24 ft**; tie WB into ditch	Yes – outside edge	**~~14~~, 12, ~~9~~, 10**			☐ Sediment Tank (connected on 12-1-08) ☐ Ditch inlet structure still needs work ☐ Berms ☐ WB

Road	Site No.	Location	Slope	Pipe needed? (Yes/No	Constructed Water Bars or Driveable Dips?	Berm needed?	WB Lengths (2x6 w/ conveyor belt)	Misc. hardware needed?	Timing and Other issues?	Status
61	LBw2	Top: Approx 400ft downgrade of 61.5 rd	7 %	No	2 WB's: Upper WB is **V-shaped (11 & 14 ft lengths**); Lower WB **(24 ft);** plug ditch at top of segment just below upper WB	Yes- Inside only	Upper: ~~14~~**, 12**, 10 Lower: 12, 12		Install tank in ditch line; 400 ft seg. length	☐ Sediment Tank ☐ Berms ☐ WBs ☐ Plug upper end of ditch
100-300	LBM1	Top: Break in slope	4%	No	**WB's 1 X 22 ft**	Yes- Outside edge	~~12~~**, 10**, 10		Install tank in ditch line	√ Sediment Tank- Installed on 11-7-08 and mostly connected; completed connection on 11-14-08 ☐ Berms √ WB (same date)
70	LBw3	Top: WB below switchback Bottom: just before 70-6 culvert	5%	No	2 WB's: Lower WB is **26 ft**; Upper WB is **22 ft** long); plug ditch at top of segment just below upper WB	Yes- Both edges (entire length)	Lower: 16, 10 Upper: ~~12~~**, 10**, 10		Low traffic day	√ Sediment Tank (Installed on 11-19-08; connected on….) ☐ Berms √ WBs (same date)
50	LCr1	Top: Crest of hill Bottom: Unmarked CMP (approx 1000ft east of 59 rd jct)	11%	Need 24ft of 4 or 6" pipe for ditch under powerline	Install **V-shaped WB (17 & 12 ft** lengths); need to plug inboard ditch and tie WB into cutslope	Yes – inside edge above WB	16 (still needs to be built) , ~~12~~**, 10**	4 feet of 12" plastic pipe (to pipe ditch water into tank)	Low traffic day; good site for tipping bucket	√ Sediment Tank (connected on 12-1-08) ☐ Berms √ 6" diam pipe √ Ditch inlet structure √ WB

Road	Site No.	Location	Slope	Pipe needed? (Yes/No	Constructed Water Bars or Driveable Dips?	Berm needed?	WB Lengths (2x6 w/ conveyor belt)	Misc. hardware needed?	Timing and Other issues?	Status
100	LCr2	Top: Approx. 300 west of CMP (slope break) Bottom: at 100-30-0-0	2%	No	Install **V-shaped WB (16 & 15 ft** lengths)	No	16, 14	Todd will need to line both ditches w/ plastic)	Low traffic day	√ Sediment Tank – Installed on 11-15-08; not yet connected ☐ Berms √ WBs (same date)
100	MCr1	Top: 620 ft above bottom culvert Bottom: CMP 100-4-3	5 %	No	Install **V-shaped WB's: Lower WB (15, 22ft); Upper WB (16 & 14 ft lengths)**	Yes- outside edge	Lower: 14, 10, 12 Upper: 16, 14	Might place 12" X40 'long plastic pipe inside exsting 24" metal pipe	Low traffic day; **use large, shallow tank & tipping bucket**	√ Sediment Tank – Installed on 11-15-08; ☐ Berms √ WBs (same date)
50	MCr2	Top: Crest of hill Bottom: CMP 50-32	6%	No	Install **V-shaped WB: 16 & 20 ft lengths**	Yes (both sides – lower half of inboard side)	~~**16**~~**, 10, 10**, 10, 10	Todd will line culvert intake w/ plastic	Low traffic day	☐ Sediment Tank ☐ Berms ☐ WBs

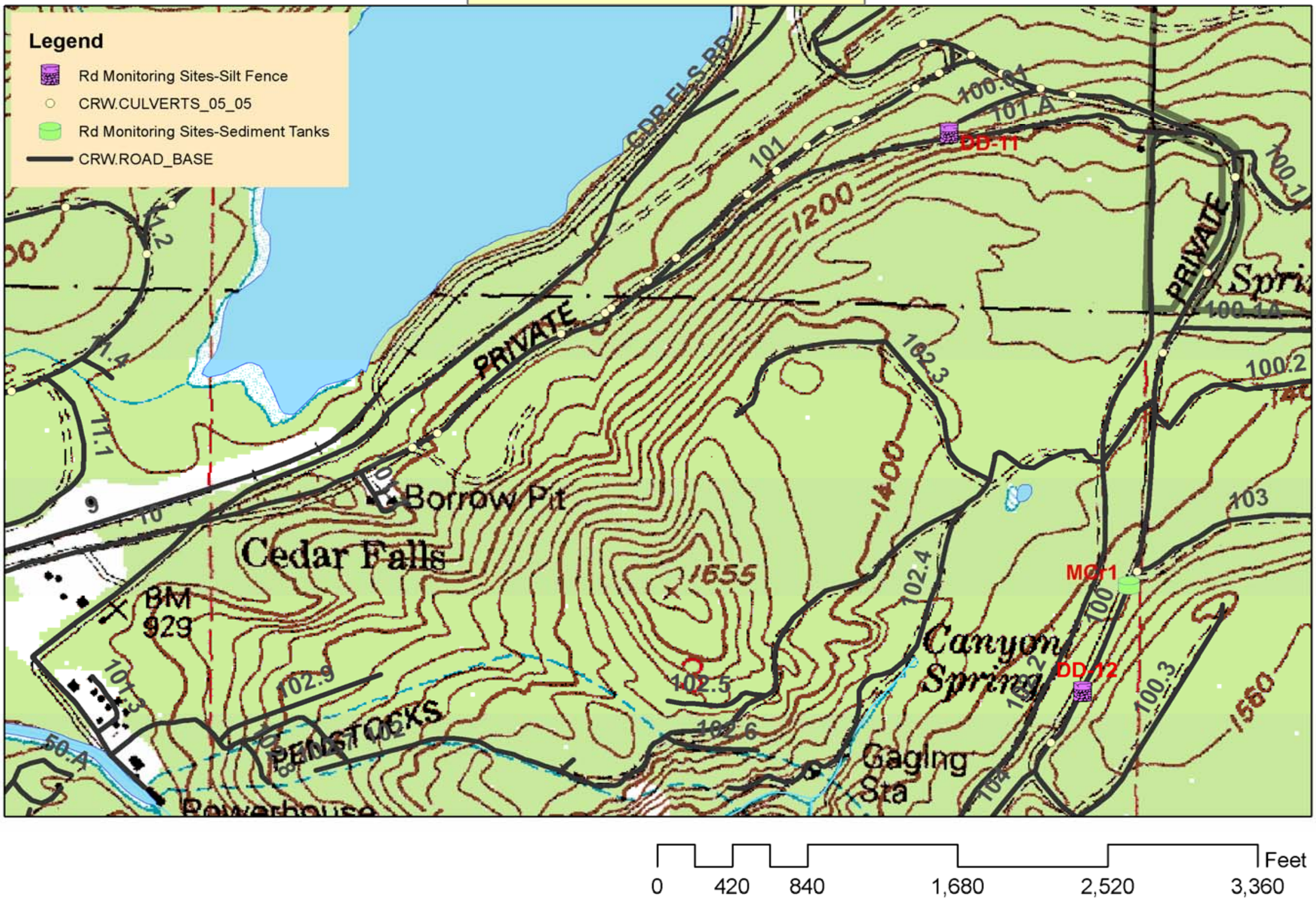
Silt Fence Sites (with Rubber Water Bars) -All Silt Fences Installed on 11-3 and 11-4-08 by NW Erosion Control

Road	Site No.	Distance of Silt Fence from Edge of Road	New Site ID	Location	Site Characteristics	WB Lengths (2x6 w/ conveyor belt) (Values shown in Bold still need to be constructed)	Construction Notes
800	DD-01	10	DD10-1	Starts at top of OBC2	About 275 ‘ in length (slight rise beyond 50’)	Already accounted for in Sediment Tank Table WB installed on 10-30-08	Install WB (30) between stakes; create outside berm; same WB used for top of OBC2
800	DD-02	100	DD100-1	Immediately above DD-1	Even steeper slope below road (potential 100’ site)	9, 12 WB installed on 10-31-08	Install WB (21) between stakes ; create outside berm up to 800-7 culvert
810	DD-03	25	DD25-1	Top is 30’ below 810-12. Bottom is 735’ above 810-11	Approx 60% open slopes w/ rocky soils.	Na	Construct very shallow driveable dips (tie both dips into ditch); create berm (entire outside edge)
800	DD-04	50	DD50-1	Bottom is 185’ above 800-2	Approx 50% slopes; open forested floor	14, 10 WB installed on 10-31-08	Install WB (25) between stakes; create outside berm below switchback
800	DD-05	50	DD50-2	Immediately below DD-4. Between CMP 1 and 2	Fairly gentle slopes (25’, possibly up to 100’)	10, 10 WB installed on 10-31-08	Install WB (20) between stakes; create berm- outside edge
200	DD-6	10	DD10-2	466’ above 200-95;	Max silt fence	14, 14	Install **WB (27 ft)**

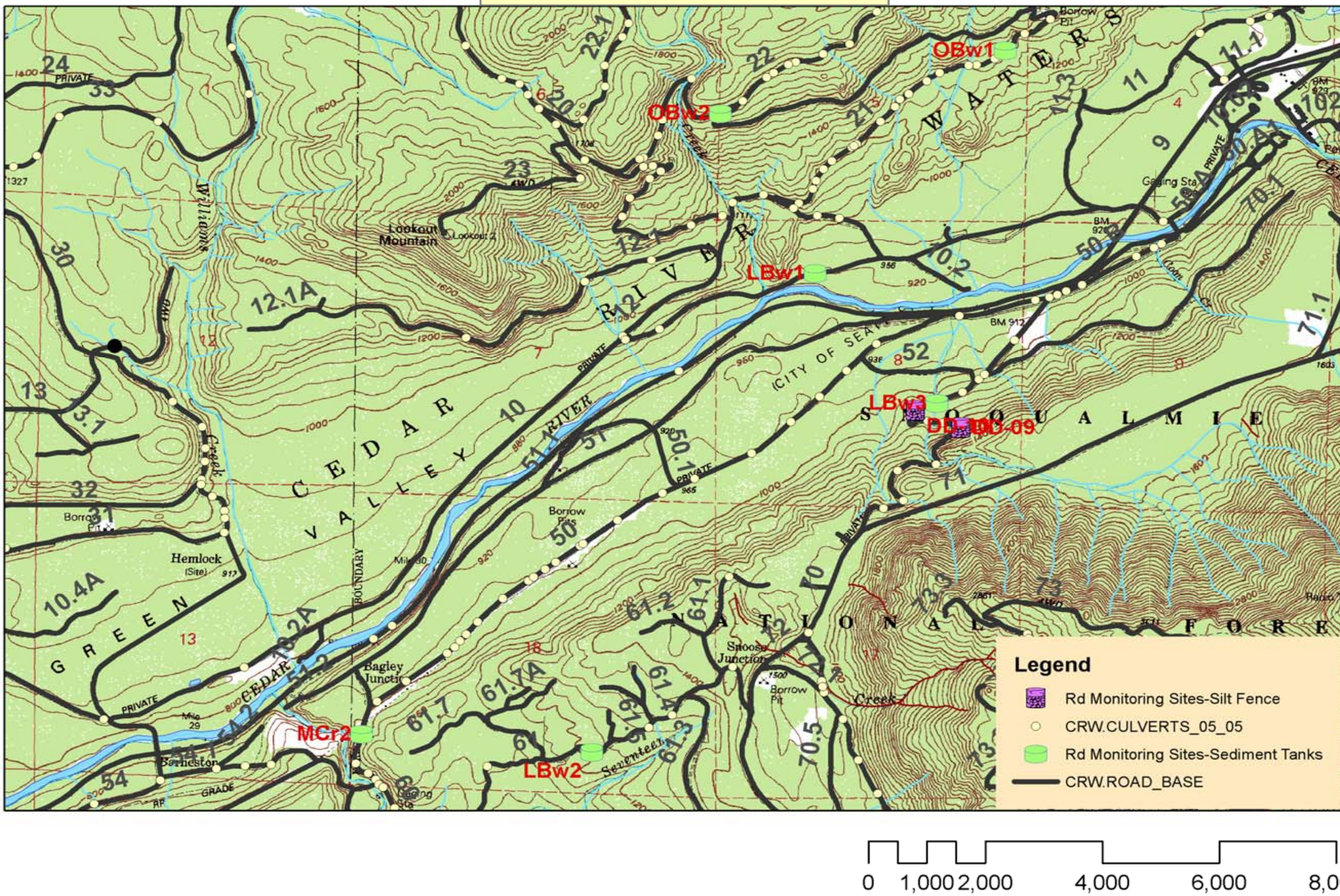
Road	Site No.	Distance of Silt Fence from Edge of Road	New Site ID	Location	Site Characteristics	WB Lengths (2x6 w/ conveyor belt) (Values shown in Bold still need to be constructed)	Construction Notes
				1100 feet below 200-96	distance 25ft	WB installed on 11-4-08	between stakes; create berm-both sides below bend in road
200	DD-7	25	DD25-2	200 near CMP 94	Open forest- no shrubs	14, 12 WB installed on 11-4-08	Install **WB (25 ft)** between stakes; do not tie WB into ditch; create berm- both sides for 200 ft
200	DD-8	100	DD100-2	Just below switchback	Pretty open up to 10 to 25 ft	16, 14 WB installed on 10-31-08	Install **WB (30 ft)** between stakes; create berm- both sides above switchback for 200 ft
70	DD-9	100	DD100-3	Just above middle switchback	Pretty open up to 100ft	**~~12~~, 10**, **~~12~~, 14** (needs to be built) WB installed on 11-18-08	Need a **23ft WB**; Do not tie WB into ditch; berm outside edge for 200’
70	DD-10	50	DD50-3	70 road near cmp 6		Already accounted for in Sediment Tank Table WB installed on 11-18-08	No additional WB’s needed; berm both edges upto switchback
101A	DD-11	10	DD10-3	101 below upper junction w/ 100 road	Sword fern and conifers; dense fern up to 100ft	**~~14~~, 16, ~~12~~, 10** WB installed on 11-8-08	Install WB **(25 ft)** between stakes; tie WB into ditch/ cutslope;
100	DD-	25	DD25-3	100rd above MCr1	Sword fern;	Already accounted	Berm outside edge up

Road	**Site No.**	**Distance of Silt Fence from Edge of Road**	**New Site ID**	**Location**	**Site Characteristics**	**WB Lengths (2x6 w/ conveyor belt) (Values shown in Bold still need to be constructed)**	**Construction Notes**
	12				mature conifer	for in Sediment Tank Table (WB installed on 11-15-08)	to curve in road. Cut through outside berm at WB

Road Monitoring Sites

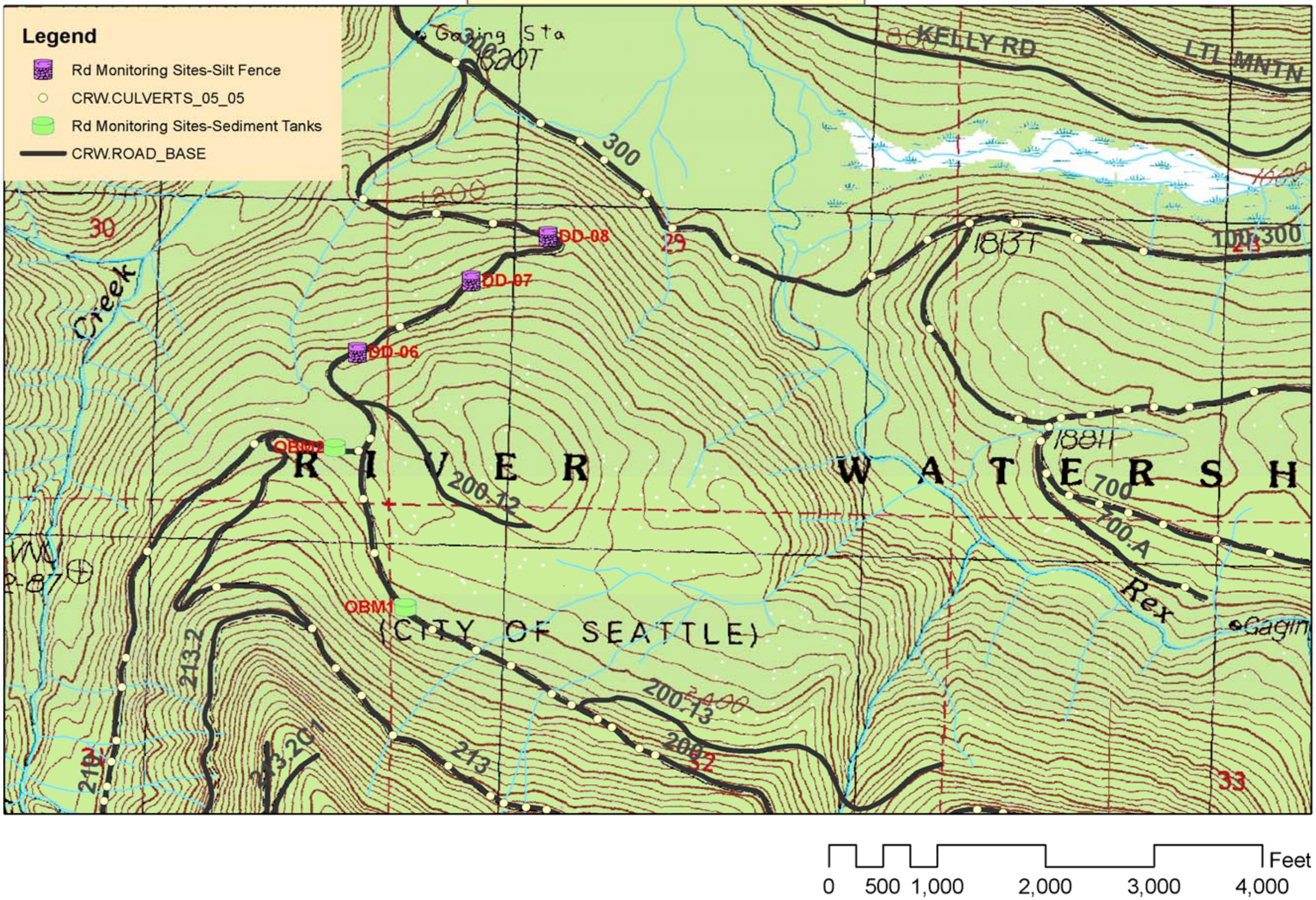


Road Monitoring Sites



Road Monitoring Sites

Road Monitoring Sites



Road Monitoring Sites