COMPREHENSIVE BASIN REVIEW AND WATERCOURSE MONITORING

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Need for the Basin Review

This Comprehensive Basin Review (Basin Review) examines the City of Mercer Island's Storm and Surface Water Utility programs, focusing on capital needs, capital priorities, and utility policies. The need for this engineering and planning effort has increased in recent years for several reasons including:

- The need for a predictable long term Capital Improvement Program (CIP). The City has solved many of the more severe and well known watercourse/ravine problems since the creation of the Stormwater Utility in 1995. The City needs to identify where remaining problems are the worst, in particular the ravine erosion problems, and address these problems with future CIPs.
- The need for a standardized prioritization method so that when problems are identified, corrective actions can be ranked in a logical and consistent manner. This prioritization method should be simple, defensible, flexible, and easy to reproduce over time as new projects arise or additional information becomes available.
- The need for formalizing certain drainage policies that the City staff have historically used but have not been formally documented. Formalizing these policies will help define what is included in the CIP as well as manage day-to-day operation of the program.
- The need for a drainage system condition monitoring program to provide current information with which to reassess future CIP prioritization. For example, some erosion problems may worsen quickly while others are slowly worsening (e.g., those that have eroded down to hard pan and are less resistant to further erosion).

General System Description

Mercer Island is divided into four basins (north, south, east and west) and approximately 85 sub-basins (shown on Figure E-1 below). Within each sub-basin, storm water runoff is collected in some combination of public and/or private lateral and trunk storm drains, streets, gutters, and ditches and then conveyed to the Island's watercourses. The watercourses flow downslope through occasional roadway culvert crossings to Lake Washington. Many of the watercourses are located in ravines. The storm and surface water systems also include underground detention systems and stormwater treatment systems (for large parking lots such as at the Community Center). In addition, the City has also constructed a few high-flow bypass pipelines that convey high storm runoff around a ravine erosion problem area while allowing base flows to remain in the watercourse.

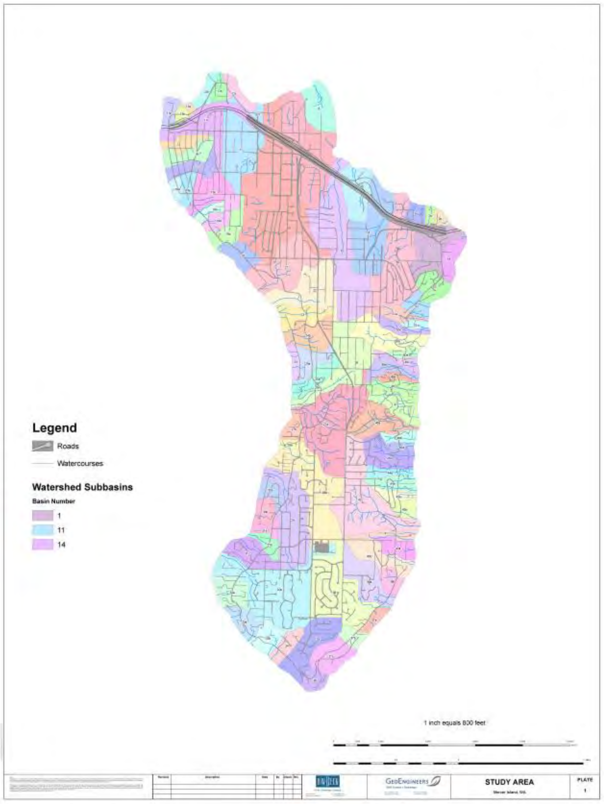

Figure E-1 Mercer Island Subbasins

There are many types of surface water problems that were generally found. While there do not appear to be any major recurrent flooding problems that result in significant property damage, there are pipe system problems that result in localized minor flooding during heavy rains. These involve both private and public substandard drainage systems that were installed long ago and which are either undersized, subject to root intrusion, inadequately maintained, or generally are in poor condition.

Several ravine watercourses are susceptible to streambank erosion and channel downcutting. Channel and streambank erosion occur where flow velocities are high and along sections in which the underlying geologic soils are more susceptible to erosion. Erosion in watercourses can result in environmental degradation, risks of damage to public and private property, and downstream sedimentation. The City has historically constructed capital improvements to address some of the worst ravine erosion problem areas.

Phased Basin Review Approach

Implementation of the Basin Review was conducted in a two-phased approach. Phase 1 included a high-level problem identification analysis and was based on a combination of interviews with City staff, review of previous documents, review and assessment of LiDAR-based topographic information, and very limited field reconnaissance. The problem identification was considered high level because it did not include detailed hydrologic or hydraulic modeling or extensive field investigations. The objective of the planning-level problem identification was to determine through a “desk top” exercise, the areas with high potential for drainage and erosion problems. Doing so allowed more efficient and cost effective direction of field work and investigation in Phase 2 to those areas as being the most severe. The Phase 1 work focused on ravine erosion problems along watercourses as well as drainage system (i.e., pipes and ditches) problems. Investigations to identify wetland, water quality, or fish habitat/passage problems were not included in this work.

The Phase 1 LiDAR analysis involved using good quality LiDAR (Light Detention and Ranging) topographic dataset obtained from Mercer Island’s GIS. The objective of this analysis was to predict the susceptibility to erosion of any particular section of stream channel. Some of the factors that were considered in the analysis include stream gradient (slope), underlying geology, historical areas of erosion and landslide. These and other factors were quantified to determine an overall susceptibility ranking, which was categorized as “high”, “moderate”, or “low”.

Phase 1 also included an initial ravine erosion monitoring program. The City identified three specific erosion problem sites for periodic monitoring. The sites are located in sub-basins 26, 29, and 32b. The monitoring included taking measurements of the channel, and documenting how and where the measurements were taken. Future measurements can be taken in similar manner and the rate of erosion can be evaluated. Subsequently, as part of the Phase 2 effort, the Phase 1 sites were revisited in January 2006 and features were remeasured. During the course of the Phase 2 field investigations, several new locations were also identified that should be considered for future monitoring sites. Table 3-2 in the report (also presented below) lists these sites as well as the priority for implementation considering the observed severity of the problems.

Table 3-2
Recommended New Monitoring Sites

Problem No.	Suggested Priority for Implementation of Monitoring based on Field Investigations
45b.3	1
49b.4	2
29.2	3
52.1	4
51a.1	5
4.2	6
46.3	7
42.1	8
42.1a	9
42.3	10
42.2	11
46a.4	12
42.4	13
27a.3	14
46.2	15
49b.2	16
4.1	17

One of the main objectives of the Phase 2 effort was to carry the Phase 1 problem identification work forward and develop specific capital improvement projects (CIPs). There was insufficient budget available to investigate all of the Phase 1 projects in more detail, therefore the scope of the effort needed to be limited. For erosion-type problems, field investigations and problem solutions were conducted on those erosion problems categorized in Phase 1 as “high”. For drainage system problems, additional investigations (most often including TV’ing of pipe sections) were conducted on the systems of higher concern as determined by City staff. For these problems, solutions and conceptual cost estimates were developed.

In addition to this work, Phase 2 also included policy review and CIP prioritization. The policy review included working with the City’s Utility Board to formalize five of the most important policy areas selected by the City.

Basin Review Results and Conclusions

The major results include development of Capital Improvement Projects (CIPs), development of a CIP prioritization method, ranking of proposed CIPs using the prioritization method, and formalization of certain storm water policies. These results are discussed below.

Capital Improvement Projects

For both erosion and drainage system problems, "Project Summaries" were developed (in Appendix G). The "Project Summary" includes the following information:

- Sub-basin number, project number and title
- Problem description and a representative photo
- CIP description
- Related projects, if any
- Planning-level cost estimate
- Simple plan view graphic showing location and extent of CIP

Twenty seven (27) erosion CIP Summaries and six drainage CIP Summaries were developed. The planning level cost estimates include 30 percent contingency and an allowance for indirect cost such as surveying, design and permitting. The total cost for completing all of the CIPs is estimated to be approximately $6.4 million. The total cost for completing the erosion CIPs is $5.2 million and the total cost for completing the drainage CIPs is $1.2 million. Note that the cost for these watercourse erosion projects are only for solving problems identified in Phase 1 as "high". Additional future analysis of the problems identified in Phase 1 as "moderate" will result in additional projects. There were 40 locations where potential erosion problems in the "moderate" category were identified.

In general, these solutions should be considered preliminary for the purpose of estimating capital costs and defining priorities. As further investigations and design work proceeds on individual projects (such as field surveying and flow analysis), refinements to the projects and their estimated construction costs should be expected.

CIP Prioritization

The Basin Review team, City staff, and the City's Utility Board discussed criteria for prioritization of CIPs. With a documented process in place, it is possible to more clearly and objectively describe the merits of a particular project, and to explain and document to ratepayers and elected officials why one project gets built before another. Also, having this documented process will help to ensure that priorities are established in a consistent manner from year to year. The prioritization program includes a prioritization model in spreadsheet form. The model uses weighted evaluation criteria. The result is an effective model that scores how well the CIPs meet the criteria and gives an overall ranking or prioritization.

The criteria that were evaluated for each CIP project include the following:

- Magnitude of the problem (To help define the magnitude of problems, this criterion was further subdivided into separate criteria for risk to health and safety, risk to property, rate of degradation/project urgency, and the flows or size of the drainage area)
- Impact to water quality and stream habitat
- Cost effectiveness
- Special opportunity
- Reduction in maintenance and operation costs
- Neighborhood advocacy/complaints
- Permitting effort
- Overall project cost

The spreadsheet model is set up to automatically update the ranking when the scoring is modified. In this way, the City can update the prioritization as more information about problems becomes available or other problems arise. Using the prioritization method, a 6-year CIP implementation schedule was developed.

Six-Year Stormwater CIP (2007-2012)

	Estimated Cost (in thousands)					
Description	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Medium/Large Basin Improvements						
Parkwood WC Stabil., trail improvement, and sewer replacement (45b.3)	$444					
Lakeview Highlands (29.1)	$95	$864				
Sub-Basin 26 Ph. 2 (26.1)		$50	$50	$961		
Basin Improvements/Conveyance System Replacement						
4905 EMW 18" culvert repl.(D47.1)	$243					
24" pipe replacement SE 65th St. btwn. 8010 and 8020 (D29.2)			$92			
7625 WMW culvert repl. (D32a.2)			$25			
EMW culvert replacements			$15	$185		
WMW culvert replacements				$15	$185	
Conveyance System Replacement 63rd Ave. SE from SE 24th St. to SE 27th St. (D15.4)						$585
Sub-basin 46a Ph. 2 conveyance				$15	$185	
Watercourse/Conveyance System Condition Assessments	$30		$30		$30	
4700 91st Ave. SE (Sub-Basin 49b.4)					$25	$175
4300 EMW WC Stabil. (Sub-Basin 52.1)					$10	$95
Neighborhood Drainage Improvements						
Annual Improvements	$50	$50	$60	$60	$70	$70
Total Per Year	**$862**	**$964**	**$272**	**$1,236**	**$505**	**$925**

Program Policies

The Basin Review documented and formalized several longstanding informal policies through discussion, input and review by the City's Utility Board. These formalized policies help define what is included in the CIP as well as manage day-to-day operation of the City's stormwater program.

The key policy issues that were identified with City staff and evaluated include:

- CIP prioritization
- Erosion, easements, and regulatory compliance
- Fee-in-lieu of detention
- Maintenance easements for storm water facilities on private property
- Filling of roadside ditches

The specific recommendations are discussed in Section 6.

Additional Recommendations

In addition to the results described above, additional recommendations are included concerning future field evaluations and monitoring. The City should continue and expand erosion problem monitoring to provide additional data that can be input into the prioritization model and to make decisions on CIP implementation.

The City should continue to investigate drainage systems (summarized on Table 5-4) to identify and correct problems. Special emphasis should be placed on inspection and monitoring of the East Mercer Way and West Mercer Way culverts because these are critical structures.

Finally, the City should continue investigation of erosion problems categorized as "moderate" in Phase 1 (shown on Plate 3 and Table 4-1). Due to limited resources, only the "high" category problems were investigated as part of this project, but as additional resources become available, the City should continue investigations of other ravines noted as having susceptibility for erosion.

Section 1
INTRODUCTION

1.1 Purpose

This Comprehensive Basin Review (Basin Review) examines the City of Mercer Island's Storm and Surface Water Utility programs, focusing on capital needs, capital priorities, and utility policies. The need for this engineering and planning effort has increased in recent years for several reasons including:

- The need for a predictable long term Capital Improvement Program (CIP). The City has solved many of the more severe and well known watercourse/ravine problems since the creation of the Stormwater Utility in 1995. The City needs to identify where remaining problems are the worst, in particular the ravine erosion problems, and address these problems with future CIPs.
- The need for a standardized prioritization method so that when problems are identified, corrective actions can be ranked in a logical and consistent manner. This prioritization method should be simple, defensible, flexible, and easy to reproduce over time as new projects arise or additional information becomes available.
- The need for formalizing certain drainage policies that the City staff have historically used but have not been formally documented. Formalizing these policies will help define what is included in the CIP as well as manage day-to-day operation of the program.
- The need for a drainage system condition monitoring program to provide current information with which to reassess future CIP prioritization. For example, some erosion problems may worsen quickly while others are slowly worsening (e.g., those that have eroded down to hard pan and are less resistant to further erosion).

The Basin Review is intended to provide guidance for erosion and drainage system CIP planning over the next ten to twenty years, and to provide the City with the prioritization tools and methods for use when updating the prioritization of CIPs.

The Watercourse Monitoring elements of the project are intended to identify and implement approaches to physical monitoring of selected ravines suspected of ongoing erosion problems. In this way, data can be collected to assess the rate at which erosion problems are becoming worse. This can provide valuable information for determining CIP priorities.

1.2 Scope

Implementation of the Basin Review and Watercourse Monitoring was conducted in a two-phased approach. Phase 1 was completed in December 2004 ("Comprehensive Basin Review and Watercourse Monitoring – Phase 1", R.W. Beck, December 2004). Phase 1 is documented within this report in Sections 2, 3, and 4. Phase 1 included data review, conducting interviews with City staff and a LiDAR/GIS mapping assessment (described in detail in Section 3) with limited field work to identify and characterize drainage problems as well as provide initial investigations toward the watercourse monitoring. Phase 1 also included the development of planning level cost estimates to solve these problems. The focus of the Phase I work was on drainage system and watercourse (ravine) erosion problems for the development of CIP projects. Erosion problems identified in Phase 1 were classified into three categories: "high", "moderate", and "low". Investigations to identify wetland, water quality, or fish habitat/passage problems were not included in this work.

The Phase 2 effort is also summarized in this report in Sections 5, 6, and 7. Phase 2 included supplemental field and technical work to more specifically define the type and extent of the improvements and the costs for the erosion CIP projects in the "high" category in Phase 1. Phase 2 also included the identification of drainage system CIPs to the extent that information was available based on City-conducted conveyance system (pipe/culvert) inspections and "TV'ing" to assess the condition of the several systems identified as potential problems in Phase 1. The available data was used to recommend appropriate drainage system CIPs where possible. Investigations to identify wetland, water quality, or fish habitat/passage problems were not included in the Phase 2 work.

In addition to this work, Phase 2 also included policy review and CIP prioritization. The policy review included working with the City's Utility Board to formalize five of the most important policy areas selected by the City.

Section 2
STUDY AREA DESCRIPTION

2.1 Drainage System

Mercer Island is divided into four basins (north, south, east and west) and approximately 85 subbasins[1]. Within each subbasin, storm water runoff is collected in some combination of public and/or private lateral and trunk storm drains, streets, gutters, and ditches and then conveyed to the Island's watercourses. The watercourses flow downslope through occasional roadway culvert crossings to Lake Washington. Many of the watercourses are located in ravines. The storm and surface water systems also include underground detention systems and stormwater treatment systems (for large parking lots such as at the Community Center). In addition, the City has also constructed a few high-flow bypass pipelines that convey high storm runoff around a ravine erosion problem area while allowing base flows to remain in the watercourse. The storm and surface systems also include detention basins and energy control structures.

Many areas of the island were developed before stormwater controls were implemented which has resulted in increases in the volume of stormwater runoff and peak flow rates to watercourses.

2.2 Geology

Geology is a major factor in determining the nature of the Mercer Island drainage basins. Like most of Puget Sound, the geology of Mercer Island is dominated by glacially-derived sediments. In the following paragraphs, the geology of the island will be described beginning from the oldest unit and going to the most recent unit.

Prior to the last phase of glaciation, fine grained silt was deposited, forming a dense, erosion-resistant, low permeability unit which probably underlies the island. This unit is called the Transitional beds (Qtb) because it was deposited in a transitional time between phases of glaciation. As an abbreviation Q is used to denote the Quaternary Period and tb is used to denote Transitional beds. This unit is present on the west and southeast shorelines of the island (Plate 2).

As the glaciers advanced from the north during the Vashon glaciation, sand and gravel were deposited over the Transitional beds. This unit is called advance outwash (Qva or Quaternary Vashon advance outwash). Although this unit was overridden by the glaciers and can stand vertically, it is susceptible to erosion and created many of the

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[1] There are 54 numbered subbasins, some of which have multiple designations (i.e., 39a, 39b, etc.), for a total of 85.

erosion problems on the island. Furthermore, since it overlays the low permeability Transitional beds, advance outwash tends to collect groundwater and be subject to slope movement. Many of the slides on the island lie at the base of the advance outwash.

The material laid down directly under the glacier is till (Qvt). This unit forms a rolling cap which covers the top ¾ of the island and consists of a dense mixture of silt, sand and gravel. Because of its content and density is relatively resistant to erosion and sliding.

As the glaciers retreated, deposits of sand and gravel (Qvr) were laid down. This surface unit is present on the east shoreline and parts of the commercial district and is susceptible to erosion. Other mapped units include alluvium (Qyal) and modified soil/fill (m). These two units cover small areas.
Plate 2 shows the geology, landslide areas, watercourses, and major roads on Mercer Island.

Section 3
PHASE 1 PROBLEM IDENTIFICATION AND RESULTS

This section contains a description of the methodologies used in the problem identification for Phase 1 as well as the approach to watercourse monitoring. This section also contains a summary of the problems identification results.

3.1 General Methodology

Drainage system and ravine erosion problem identification was conducted at a high-level for the Phase 1 analysis and was based on a combination of interviewing City staff, review of previous documents, LiDAR review and assessment, and limited field reconnaissance. The problem identification was considered high level because it did not include detailed hydrologic or hydraulic modeling or extensive field investigations. The objective of the planning-level problem identification was to determine the areas with high potential for drainage and erosion problems. Doing so provided multiple benefits. First, this information was later used to focus a more detailed evaluation of problem areas in Phase 2 to those problems that are more severe. Second, the information was used to estimate order of magnitude costs for capital improvements. Third, the information was used to evaluate policy decisions on where to focus the funding of the City's stormwater program, such as whether the City should correct all know erosion problems or focus on the most severe.

This work focused on ravine erosion problems along watercourses as well as drainage system (i.e., system of pipes and ditches) problems. Investigations to identify wetland, water quality, or fish habitat/passage problems were not included in this work.

3.2 Interviews with City Staff

Interviews were conducted with current and former City maintenance staff (Jerry Judd and Jerry Meier) at two meetings. The interviews were conducted to collect unpublished information and to compile information regarding current and past erosion and drainage system problems. The following paragraph provides a general description of the information gathered. Specific information about individual problems is included in Table 3-3 for erosion problems and Table 3-4 for drainage system problems.

There are many types of surface water problems that were generally found within the City. While there do not appear to be any major recurrent flooding problems that result in significant property damage, there are pipe system problems that result in localized minor flooding problems. These include both private and public substandard drainage systems that were installed long ago and which are either undersized, subject to root intrusion, may not be well maintained, or generally are in poor condition. In many cases private drainage systems are not well-maintained, and this can cause problems for the private systems as well as for the upstream public systems. In some cases, the private property owner may not be aware that problems exist within the private system. Some areas lack a formal drainage system, and in other areas, trashracks and culverts become clogged with debris, leaves and sediment. Furthermore, as a result of undersized drainage system components, the velocities in culverts or watercourses may be high and cause erosion. Steep channels throughout the City are susceptible to erosion and downcutting. Headcutting and sloughing also occur within the channels. Channel and streambank erosion occur where velocities are high. Bank failure and sediment deposition were also identified as problems throughout the City.

Following large storm events, City maintenance staff routinely discover new problems that need to be addressed.

3.3 Data Review

The City provided available drainage and utility documents for review. Several documents were provided that date back to the mid 1970s when comprehensive stormwater planning first began at the City. In more recent years, the City has conducted separate subbasin plans. These subbasin plans provided the most detailed account of drainage problems and were the focus of the data review. They included:

- Drainage Basin Evaluation - Basin 21 (Channel Stabilization Downstream of West Mercer Way), Harding Lawson Associates for City of Mercer Island, July 1998, Technical Memorandum.
- Drainage Basin Evaluation - Basin 26 (West Basin), CH2M Hill for City of Mercer Island, December 3, 2003, Technical Memorandum.
- Basin 29 Watercourse Stabilization and Rehabilitation - Preliminary Engineering Report. City of Mercer Island. February 2000. CH2M Hill. Draft Report.
- Basin 29 High Flow Bypass Pipeline and Stream Restoration, Final Design Report. CH2M Hill for City of Mercer Island. June 2001.
- Basin #32B - Drainage Basin Study, The McAndrews Group, Ltd., for the City of Mercer Island, November 2000.
- Basin #42 - Drainage Basin Study, The McAndrews Group, Ltd., for the City of Mercer Island, December 2000.
- Drainage Basin Evaluation - Basin 45b (East Basin), CH2M Hill for City of Mercer Island, December 9, 2003, Technical Memorandum.

3.4 LiDAR and GIS Ravine Analysis

3.4.1 Background and Data Sources

The City has benefited in this Ravine Analysis from the availability of a good quality LiDAR (Light Detection and Ranging) dataset obtained from King County and the Puget Sound Regional Council. The LiDAR was used to generate several derivative layers that support the analysis, including hydrographic flow direction, hill-shading, slope gradients and slope curvature. The analysis was also facilitated by several key GIS layers provided by the City's GIS coordinator which showed:

1. the City's stormwater conveyance system (originally an AutoCAD file);
2. impervious surfaces;
3. watercourses;
4. culverts and pipes;
5. historic landslides (where known); and
6. building footprints.

3.4.2 Analysis Objective

The objective of this analysis was to predict the susceptibility to erosion of any particular section of stream channel and to quantify that susceptibility as "high", "moderate", or "low". In order to do this, team geologists developed a predictive formula that considers a number of critical physical factors that contribute to the erosion process in the ravines. This was done by dividing each factor into categories and assigning a weight (or score) for each category. For example, the category of "Landslide in vicinity" was assigned a "yes" category with a weight of 5 and a "no" category with a weight of 0. The relative weights between categories were assigned by professional judgment of team geologists and from some sensitivity analysis. An additional factor was included that took into account known erosion problems area based on City staff input. These factors were then quantified to determine an overall susceptibility ranking.

3.4.3 Susceptibility Factors

The areas of potential erosion problems, as well as their severity, were identified using LiDAR and GIS information without performing significant field reconnaissance of the Island.

The key factors deemed to most influence the degree and susceptibility to erosion, and their relative importance (weighting) are tabulated below:

Table 3-1
Susceptibility Factor Weighting

Factor	Description	Categories	Weighting
Permeability	The City provided a layer showing areas of impermeability. No erosion takes place in these areas.	Yes No	1 0
Known areas of erosion	Areas known by the City to suffer from erosion.	Yes No	5 0
Geology	Main geological units from Dept. of Natural Recourses.	Till Outwash Transitional beds	2 10 5
Landslide in vicinity	Areas of landslide with a 50' zone. Contributes a weight of 5 if intersected by a stream.	Yes No	5 0
Degree of slope (stream gradient)	Gradient of the stream as determined by calculation from LiDAR data.	<15 15-30 30-40 >40	0 2 5 7
Degree of curvature	Rate of change of the gradient (slope of the slope).	+1 +2	2 5
Outfalls	If onto outwash units, 5; transitional beds, 3. No consideration for condition of outfall.	If yes Outwash Transitional Beds	5 3
Knickpoints	Identified as short, sharp gradients in the stream of greater than 100%.	Yes No	35 0

3.4.4 Detailed Methodology

The methodology applied to derive the measure of a stream channel's susceptibility to erosion comprised a sequence of steps using multiple GIS data layers, some of which already existed, and some of which were derived through this analysis. Those sequential steps are summarized below:

1. The Puget Sound Regional Council's LiDAR raw elevation data set was interpolated to a 3-foot-square grid covering the entirety of Mercer Island to create a digital terrain model (DTM). According to the PSLC statement accompanying the data, the mapping has vertical accuracy on the order of one foot. Locally (i.e., within isolated areas within the data), the data may be of poorer quality. In areas of dense vegetation, LiDAR ground data points may be further apart than the 3-foot-square grid resolution used for this study, and consequently the surface interpolated between the points may be more uneven

than represented by the surface model. Despite these caveats, the data remains a very good source of elevation data for a study of this kind.

2. A combination of two data sets was required to create a master layer that showed the watercourses which are subject to erosion, and that was used to tabulate the various erosion factors. First, the island's hydrography was derived from the DTM derived in the step described above. This layer was then compared with a second layer, the City's stormwater conveyance system layer. The hydrography was modified appropriately where stormwater is piped or conveyed by other than watercourses. The resulting layer is the master layer used to evaluate erosion susceptibility factors.
3. Landslide data were compiled as a combination of documented historic landslide events provided by the City and areas of subject to landslides, as interpreted by a geologist from the DTM.
4. Slopes (channel and land gradients) were derived from the DTM.
5. Curvature was derived from the DTM.
6. The outfall layer was created to represent the downstream end of road culverts for the ravine watercourses. Only those culverts relevant to the ravine watercourses were represented.
7. By definition, a knickpoint is an interruption or break in slope; especially an abrupt change in the longitudinal profile of a watercourse. For the knickpoint layer in this study, a threshold of 200 percent over a minimum horizontal distance of about 12 feet was initially used to try to define those places along a creek bed where it is likely subject to more aggressive erosion. However, at this threshold, no areas were identified. As a second attempt, at a threshold of 100 percent over a minimum horizontal distance of about 12 feet was used. The resulting analysis showed numerous areas along a creek bed where it is likely subject to more aggressive erosion. These inflection points were derived from the slope layer. Visual observation of the DTM and review of the gradients suggests that additional knickpoints exist along some streams but, because they did not meet the 100 percent steepness threshold over this length, they were not identified in the analysis. This assertion is supported by observation of the slope model and the failure of the stream to reduce its gradient profile to the local norm. The explanations for this can be that: (a) the stream has encountered a particularly resistant layer and cannot easily cut back further, or; (b) it has encountered a unit tends to stand tall until undercut and then collapses (like the till). This latter type represents an active erosion point of potential concern. Knickpoints were given a stand-alone weighting of the maximum (35) to ensure they were included as "high" erosion areas, even if other factors did not put them in that category. Some refinement in the slope/distance threshold may improve the knickpoint identification.
8. The final analysis with these combined data sets involved superimposing each of the layers shown on Table 3-1 above and attributing creeks with their numerical values (weightings). This involved summing the weighted values

for each factor along the line of each watercourse to arrive at the numerical totals along the line of the watercourse (which are symbolized on Plate 3). The values are cumulative so that the higher the value, the more susceptible to erosion is that section of the watercourse. The impervious surface GIS layer was used to negate all values where erosion is deemed unlikely. The result is that the numerical classification applies only to drainages on pervious surfaces.

9. Results are classified into the categories “high”, “moderate”, and “low” based approximately on standard deviations from the mean:

	Category	Score
>X+2s	High	> 30
X+1s – X+2s	Moderate	18 – 29
>X+1s	Low	< 18

Those creek sections included in the “High” category are identified on the map as separate clusters which are grouped based on proximity. They are labeled on the map using a numbering convention that uses the basin number as a prefix, followed by a period separator, followed by sequentially numbered suffix to designate separate groupings. Numbering begins at the downstream end of the mainstem and progresses upstream, then following with any tributaries, again progressing sequentially from the downstream end. In some cases, the cluster may include some sections of “Moderate” susceptibility, for example, if a short section of “Moderate” susceptibility lies between two “High” susceptibility clusters.

It should be noted that geology has a large influence on the streambed susceptibility to erosion. The spatial resolution of the Department of Natural Resource’s digital geology map is at a small, regional scale. Based on our field reconnaissance, the accuracy and resolution of the geology can be improved by re-interpreting the location of geological contacts relative to the topography. This refinement would likely result in additional watercourse sections being classified as “high”.

3.5 Watercourse Condition Monitoring

3.5.1 Baseline Field Monitoring

During Phase 1, the City identified three specific erosion problem sites for periodic monitoring. The sites are located in subbasins 26, 29, and 32b. Two members of the project team, a geomorphologist from GeoEngineers and a hydraulic engineer from R. W. Beck, visited the three sites on November 16, 2004, to evaluate the erosion problems. A monitoring plan was then developed for each site. Each monitoring plan was developed to meet the following objectives:

1. Define the problem explicitly.
2. Recommend appropriate tasks and measurements to document the progress or change of the problem.

3. Choose a method that allows City staff to perform the future monitoring without additional training.
4. Comparison of baseline and future monitoring results is intended to provide evidence as to whether or not the problem is worsening.

The monitoring plans for each site are presented in separate memoranda in Appendix C-1. Each memorandum includes a discussion of the following information:

1. Description of the specific erosion problem being monitored.
2. Site location and access.
3. A description of the measurement locations and other specifics regarding the measurements.
4. The locations of fixed nails and pins.
5. Guidelines for interpreting future monitoring observations and measurements.
6. Photographs of each site including close-ups of important features.
7. Two sketch maps for the site: a plan view and an oblique view map showing locations of baseline measurements and photo reference numbers.

Subsequently, as part of the Phase 2 effort, the sites were revisited in January and October 2006 and features were remeasured. The monitoring measurements and results for each site are presented in Appendix C-2. The second and third sets of results are presented in tabular form that can be added to for future measurements.

During the course of the Phase 2 field investigations, several new locations were also identified that should be considered for future monitoring sites. These sites are listed on Table 3-2 and were generally selected because the erosion problems tended to be more severe and/or it appeared the area was more actively eroding. Table 3-2 also provides a recommended priority of these sites based on these same considerations.

Table 3-2
Recommended New Monitoring Sites

Problem No.	Suggested Priority for Implementation of Monitoring based on Field Investigations
45b.3	1
49b.4	2
29.2	3
52.1	4
51a.1	5
4.2	6
46.3	7
42.1	8
42.1a	9
42.3	10
42.2	11
46a.4	12
42.4	13
27a.3	14
46.2	15
49b.2	16
4.1	17

Sites Already Being Monitored

Problem No.
26.1
29.1
32.5

3.5.2 LiDAR Monitoring

The 2002 LiDAR Digital Elevation Model (DEM) provides good baseline topography over the whole of the island and, in particular the ravines. Future comparison of a LiDAR DEM map against the 2002 baseline DEM could provide an effective means for detecting changes in the ravine slopes, and watercourses. Using two separate LiDAR images, GIS routines can be developed that compare and identify locations where changes of a certain specified vertical distance (e.g., one foot) have occurred. This could provide helpful data in evaluation erosion activity.

While future LiDAR monitoring can be very efficient because it is an in-office digital exercise as opposed to field work, some caution should be exercised. While the field work performed in Phase 2 of this study found general concurrence with the Phase 1 LiDAR analysis, there were also deviations where field observations showed erosion either more or less severe and/or the extent of problem locations was varied. New geologic mapping will be available in 2006 that will increase the reliability of future LiDAR analysis. In summary, the City should weigh the cost of future LiDAR analysis with what could be accomplished in field observations.

3.6 Watercourse Erosion Problems

The LiDAR and GIS ravine analysis identified potential erosion problems within basins. As described earlier in this section, the problems are defined primarily by assigning various weighting values to features/characteristics in GIS data layers such as geology, slope gradient, topographic curvature (inclination), known landslides, culverts, and drainage outfalls.

The watercourse erosion problems identified in this analysis are shown on Plate 3 and listed on Table 3-3. Each problem is assigned a unique number which starts with the subbasin number and then is followed by a problem number. Problems are numbered sequentially within each subbasin. The table shows the tabulation of the susceptibility factors, as well as problem type and length. The erosion problems identified by the analysis are grouped into five categories which are listed on Table 3-3: 1) streambed knickpoints, 2) outfall erosion, 3) landsliding exacerbated by streambank erosion, 4) landsliding driven by external factors (unstable slopes, road cuts, ground water seeps in granular slope soils), and 5) streambed and bank erosion. Descriptions of these erosion categories are:

- A **streambed knickpoint** is a vertical step with a plunge pool scoured in the streambed. As water cascades over the lip of the knickpoint, the plunge pool, and the face of the step erode further, causing upstream retreat of the face. Knickpoints typically form in channels underlain by erosion-sensitive soils, such as advance outwash. However, they can form in virtually any soil type including those more resistant to erosion such as till and transitional beds. Unless mitigated, the upstream propagation of the knickpoint will result in systemic lowering of the channel floor.
- The **outfall erosion** category refers primarily to road culverts, although the category can also pertain to stormwater pipe outfalls. Erosion at outfalls typically occurs in two scenarios: 1) confined flows exiting the culvert at high velocities, and 2) improperly designed or constructed culverts and pipes. For both scenarios, outfall erosion typically includes formation of a plunge pool immediately downstream of the outlet, severe bank erosion and possibly channel widening. Where bank erosion is severe, destabilization of the ravine can occur, resulting in small to moderate landslides depending on the extent of the bank erosion. The outfall erosion category does not include non-culvert storm outfalls. Review of the available Mercer Island drainage system

mapping indicates that few stormwater pipe systems outfall onto ravine slope soils above the ravine watercourse. In actuality, there are likely several drainage systems, particularly smaller ones such as individual house roof leaders that discharge to the upper portion of a ravine that can be a source of erosion.

- **Landslides** identified on Mercer Island fall into two major types: 1) relatively small, shallow failures caused by localized stream bank erosion, and 2) large failures caused by regional conditions. Type 1 landslides are caused, and/or exacerbated by streambank erosion, which effectively removes toe support of lower ravine slope soils. These failures contribute sediment to the stream, which is typically deposited downstream of the landslide. Depending on downstream channel conditions, the deposited sediment may cause aggradation of the streambed. Aggradation typically results in decreased channel flow area, which in turn can cause increased frequency of flooding. In addition to flooding, channel floor aggradation can cause moderate to severe stream bank erosion and channel widening. Type 1 landslides are included as candidates for CIP projects (see Section 4).

  Type 2 landslides are driven by regional scale conditions such as unstable soils, ground water seepage, and mechanical disturbances that destabilize ravine slopes (e.g., road cuts and improper discharge of stormwater runoff). These features are typically large, and can involve entire sections of a ravine. The movement of Type 2 landslides into a stream channel typically results in the diversion of the channel around the slide and severe erosion along the opposite bank. Similar to the Type 1 slides, eroded sediment is subject to downstream transport and deposition. Type 2 landslides are not included in the CIP project development at this time.

- **Streambed and bank erosion** within most streams on the island is caused by a combination of factors including geology and soil type, channel gradient, and increased peak flows resulting from urbanization and previous stormwater control practices. The erosion is most notable in drainages dominated by glacial outwash soils. However, erosion-resistant transitional beds are also subject to erosion, particularly in densely developed basins. Streambed erosion identified in the analysis typically reflects potential channel downcutting.

High and moderate erosion potential problems are shown on Plates 3 and 4. High erosion potential areas include several types of erosion problems: channel headcutting, outfall erosion, landsliding exacerbated by streambank erosion, and landslides. A representative example of a high erosion potential problem area is that provided at the monitoring site in subbasin 26, where an approximately 6-foot-high knickpoint is migrating upstream. As the knickpoint moves upstream, it leaves behind a wider, deeply incised channel. Moderate erosion potential areas typically consist of streambank and channel incision erosion. Moderate erosion potential areas include stream sections with outwash soils and channel gradients from 1 to 3 percent.

3.7 Drainage System Problems

Table 3-4 lists the drainage system problems (or drainage systems of concern/substandard) identified by current and former City staff. These problems are also shown on Plate 4. Drainage problems are numbered sequentially within each basin. Each problem is assigned a unique number which is preceded by a "D", followed by the subbasin number, and then a problem number. The "D" is used to distinguish drainage problems from erosion problems. This plate also includes the watercourse erosion problems as described in Section 3.6.

Some of the problems listed on this table and shown on the figure are twenty-five (25) "hot spots" which were identified by City staff as areas that require attention during storm events in order to prevent flooding. These are listed as a general problem on Table 3-4. An example, of a "hot spot" would be a drainage system inlet where the inlet (or inlet grates) has been more historically susceptible to becoming clogged with leaves and/or other debris if left unattended during a major storm.

Section 4
PHASE 1 PRELIMINARY CAPITAL PROJECTS IDENTIFICATION

4.1 General Approach

This section describes the identification of preliminary Capital Improvements Projects based on the identified problems in Section 3. As a part of the Phase 1 work, the CIPs are organized by groups represented by broad categories of improvements. As only a few of the problem areas were visited in the field as part of this phase, the type, extent, and cost of solutions are considered order-of-magnitude level. Planning level cost estimates were developed for each of the categories. As previously discussed, this information was later useful during Phase 2 to evaluate policy decisions on where to focus funding of the City's stormwater program and to provide a starting point from which problems should be investigated in more detail. In Section 5, Phase 2 builds on Phase 1 work and provides individual CIP descriptions and project costs for selected projects.

4.2 CIP Project Categories

The solution categories developed generally take into account the type of problem, potential severity, and appropriate groupings of problems. Groupings of problems to be addressed by a CIP were chosen to reflect the proximity of the problems as well as how the City could implement a project with consideration of severity. For example, if a severe erosion problem area is located immediately upstream or downstream of a short, moderate erosion problem area, it was assumed that the moderate problem area would be included in the solution. In these situations, the problem area is dominated by the severe erosion problem area. One reason to consider it this way is that once access to the site is obtained, it makes sense to solve both problem areas. However, if there was a small section of severe erosion adjacent to a lengthy section of moderate erosion (i.e., the watercourse system was dominated by moderate versus severe problems), solving these problems was defined as two separate CIPs (one project for the severe erosion area and the other project for the moderate erosion area). This is due in part to the possibility that the City may only be able afford to correct severe problems and it is desirable to keep track of the dominant conditions separately.

Four broad CIP Project categories include:

1. Drainage system investigations (e.g., TV). City staff reported many systems as systems of concern and/or substandard. More specific information about each system is necessary to determine the action necessary to ensure proper system performance. For example, some pipe systems may simply require

maintenance, some may require repair or replacement in the near term (e.g. 6-years), and some may be in better condition and not need replacement or need replacement in a longer term (6-years to 20-years). It is assumed that all pipe systems that were identified as a system of concern by the City will require some level of investigation to evaluate pipe conditions and therefore, will be TV'd and investigated. The data collected can be used to prioritize the drainage system replacements in the future.

2. Drainage system replacement. Drainage system replacement includes complete replacement of a drainage conveyance system identified by City staff as a system of concern. It is assumed that all systems identified by the City as problems or systems of concern will likely need to be replaced within the next 20 years even though it is likely many of these will not need replacement within the next 6 years.
3. High potential erosion. This includes correcting erosion problems that were dominated by areas with high erosion potential. The type of solution to correct the different types of erosion problems is discussed below.
4. Moderate potential erosion. This includes correcting erosion problems that were dominated by areas with moderate erosion potential. The type of solution to correct the different types of erosion problems is discussed below.

4.3 Phase 1 Cost Estimates

Generalized cost estimates were developed for the above categories during the Phase 1 effort. Phase 1 cost estimates are considered planning level and are not site-specific. Cost estimates were based on the Consultant's experiences with similar type projects and include a 40 percent construction contingency and 45 percent for planning, permitting, design, administration, and construction administration. For some CIP categories, different cost estimates were developed to more closely represent costs that would be commensurate with the type of solution. The breakdown is as follows:

1. Drainage system investigations. A cost of $4 per lineal foot (LF) of system was used. Cost includes pipe TV'ing and field investigations. A minimum cost of $800 was used for very short systems.
2. Drainage system replacement. Costs were based on LF of system. Cost estimates were developed for three categories. Simple, Complex and/or Larger Diameter systems, and ravine culvert replacement. Costs for simple systems ($400/LF) were based on pipe replacement of up to 18-inch-diameter pipes. Cost for complex systems was based on a ratio of 1.5 to the simple systems and $600/LF was used. This latter category would be used for systems known to be complex, deep, or larger in diameter. The ravine culvert category would be typically for culvert replacements for crossings of East or West Mercer Road. These are deep, large, may require headwalls, may be required to provide fish passage, and possibly other additional features than a pipe system replacement. A cost of $1800/LF was used.

3. Erosion. Several categories were used as follows:
    a) Correcting a Knickpoint with Difficult Access. A cost of $80,000 per each was used. Difficult access means that construction would be done by highline, large mobile crane, or hard labor (for small projects). Helicopter work would probably not be feasible in most areas.
    b) Correcting a Knickpoint with Vehicle Access. A cost of $30,000 per each was used. Vehicle access would allow normal construction equipment to be used with minimal road building.
    c) Instream Stabilization with Difficult Access. Construction methods include those described under Knickpoints. Most erosion restoration work on Mercer Island falls within this category. The cost per LF was estimated to be $1,800.
    d) Instream Stabilization with Vehicle Access. This occurs where vehicular access is likely to be feasible based on the slope and proximity to a street or driveway. The cost per LF was estimated to be $1400.
    e) High Flow Bypass. This option would be used very selectively for the most severe erosion problems that are difficult to access, construction feasibility problems, or where instream solutions would not work (like general landslide hazard area). The cost per LF was estimated to be $800.

    The Washington State Habitat Manager at the Washington Department of Fish and Wildlife (WDFW) was contacted to discuss acceptable solutions for erosion problems. The Habitat Manager indicated a preference that watercourse erosion problems be addressed by instream stabilization measures including such features as rock check dams, log check dams, boulders, rootwads, banks stabilization with plantings and bioengineering techniques. When asked about the use of high flow bypasses as an alternatives to instream stabilization, particularly in areas of severely restricted access, the habitat manager said that while they can be considered, there is some concern over the long-term sustainability with this approach, citing problems that other jurisdictions have encountered (e.g., City of Bellevue). Two situations where high flow bypasses would be considered more favorably were:

    - Where upstream urban storm runoff can be diverted at its sources (e.g., at the end of a piped drainage system outfall prior to entering a natural watercourse) and can be routed to Lake Washington without returning high flows to the watercourse.
    - For bypasses that involve diversion away from a natural watercourse or back into a watercourse, it is preferable to include stream enhancement of the affected watercourse along with any high flow bypass solutions in order to ensure that the channel

capacity is maintained and to protect the stream in the event that the bypass fails.

f) Pipe Outfall Erosion. This was estimated to be $16,000 per site. The cost was based on providing fish passage although it is recognized that few fish reside in the watercourses.

4.4 Phase 1 CIP Project Summary

Tables 4-1 and 4-2 summarize the CIP projects identified in the Phase 1 analysis for erosion problems and drainage system (piped) problems respectively. Again, the methodology used for the identification of erosion problems is approximate so this list of CIP erosion projects represents a list of “potential” erosion projects. In fact, during Phase 2, some of the identified problems were visited in the field and determined not to be a problem. Similarly, the drainage system problems identified by City staff are a good indication that the identified drainage system problems should be investigated. However, it is not certain that each system will need to be replaced. Therefore these drainage system CIPs should also be considered “potential” projects. Individual projects for both erosion and drainage system problems were later refined during Phase 2.

The total cost for completing all of the potential CIPs identified in Phase 1 is estimated to be approximately $42 million of which approximately 60 percent is for CIPs to solve moderate erosion problems. The total cost for completing all of the “High” category erosion problems is $4.6 million. The total cost for completing all of the “Moderate” erosion category problems is $24.4 million. The total cost for the drainage system CIPs is $12.6 million.

Table 4-1 includes some information on the proximity of house structures to erosion problems. This can be one factor in considering the risk of property damage due to continued erosion.

Table 4-2 also distinguishes which CIP solutions solve private drainage system problems. The indication of which systems are “private” is preliminary and should be reviewed by City staff. As previously noted, City staff report that new problems are often identified following a major storm event. Therefore, it is likely that within a 20-year planning horizon, additional problems and projects will be identified.

In general these planning level cost estimates reflect the projected cost to correct all “potential” drainage system and ravine erosion problems. As noted above, some of the projects evaluated further in Phase 2 were determined to be small enough as to not warrant a solution.

Section 5
PHASES 2 and 3 CAPITAL PROJECTS IDENTIFICATION

5.1 General Approach

One of the main objectives of the Phase 2 effort was to carry the Phase 1 problem identification work forward and develop specific capital improvement projects (CIPs). There was insufficient budget available to investigate all of the Phase 1 projects in more detail, therefore the scope of the effort needed to be limited. For erosion-type problems, field investigations and problem solutions were conducted on those erosion problems categorized in Phase 1 as “high”. For drainage system problems, additional investigations (most often including TV’ing of pipe sections) were conducted on the systems of higher concern as determined by City staff. For these problems, solutions and conceptual cost estimates were developed.

5.2 Field Investigations for Erosion Problems

Field reviews were performed for the problems identified as “high” erosion potential areas during the Phase 1 effort shown on Table 3-3. City staff also identified a few additional erosion problems along other watercourses which were also investigated in Phases 2 and 3. These watercourses generally included Phase 1 erosion problems that were identified as “moderate” problems. However, the City staff had concerns about these systems because of either prior observations or prior citizen complaints. In general, the field reconnaissance included:

- Observing the nature, extent (problem limits) and severity of the problem.
- Observing site constraints, and other issues to identify the type of solution that will be appropriate for the problem area.
- Collecting other data about the problems areas considering information that is also used for prioritizing problems.

The site visits were conducted by a senior engineer with over 20 years of experience solving erosion problems. Site visits were made to 33 ravines and 89 problems were evaluated. Through the field reconnaissance, some new problems within these ravines were identified and considered severe enough to warrant a CIP. At the same time, some of the Phase 1 erosion problems were found to be small enough as to not warrant a solution. Several of the Phase 1 “high” erosion problems were eliminated.

The field investigations for erosion problems are summarized on Table 5-1 based on the detailed field investigation forms which are included in Appendix E. At each site, several parameters were evaluated, as shown on the table and field forms. These parameters include:

- Site Conditions
    1. Geology
    2. Approximate flow on the day of the investigation (estimated by “eye”)
    3. Approximate channel gradient
    4. Approximate tributary area
    5. Bank vegetation type and quality
    6. Condition of aquatic habitat
    7. Proximity to drainage outfalls
    8. Location and apparent rate of erosion (i.e., bed, left or right bank, headcut)
- Risks
    1. Public versus private
    2. Whether unsafe conditions exist
    3. Bank and upper slope stability
    4. Landslide potential
    5. Sediment source
    6. Risk to habitat
    7. Risk to health and safety, property, home, other structures, private road or driveway, infrastructure, public road
    8. Proximity to homes at risk
- Solutions
    1. Construction access difficulties
    2. Potential reduction in O&M costs
    3. Restoration of construction access
    4. Conceptual solution
    5. Whether or not the site is a potential monitoring location

5.3 General Description of Solutions for Erosion Problems

Based on the field observations about the nature of erosion problems, there were eight general types of solutions that were identified as needed to solve erosion problems. These types of general solutions are briefly discussed below. In addition, the cost estimates (described later in this section and included in Appendix G) were developed for each CIP project. These detailed cost estimates provide additional detail about needed features for each project. Table 5-5 summarizes all of the proposed CIP projects and their respective costs.

In general these solutions should be considered preliminary for the purpose of estimating capital costs and defining priorities. As further investigations and design work proceeds on individual projects, refinements to the projects should be expected.

5.3.1 Outfall Protection

The outfall protection solution consists of a riprap pad and was considered when erosion occurs at a culvert or pipe outfall or other discharge point. Although angular quarry rock is normally used, rounded river rock could be used to create a more natural appearance. Rock pads do not provide fish passage.

5.3.2 Storm Drain Extension

This solution was proposed where it was practical and necessary to extend a pipeline but where the aquatic habitat was poor or non-existent. An example is where a storm drain discharges halfway down a steep slope toward a ravine.

5.3.3 Bypass Pipe

A bypass pipe solution would typically consist of a butt-fused HDPE pipeline (forming a single continuous length) with a manhole and buried concrete anchor block at the upstream end. These were proposed in reaches with severe erosion where pipes outlet onto steep channels having no fish habitat. An example of this is a pipe outlet at the top of a steep bank that slopes to a ravine watercourse.

5.3.4 Check Dams

Check dams were considered as a solution to channel erosion problems where the aquatic habitat is poor or fair, where the channel has a maximum gradient of about 10 percent, and where the banks are relatively stable. Rock check dams were assumed for cost estimating although log check dams could also be installed. In many cases, check dams were proposed to replace existing sand bag and geotextile dams that had been previously installed as a temporary solution.

5.3.5 Boulder Cascades

Boulder cascades were considered as a solution to channel erosion problems where the aquatic habitat is poor or fair, and the channel gradient is greater than 10 percent. These reaches are too steep to effectively use check dams. The intent of boulder cascades is to use large rounded rock to simulate a steep headwater stream.

5.3.6 Channel Stabilization

Channel stabilization was considered as a solution to channel erosion problems where check dams alone could not solve the problems, and where habitat potential was limited. Most often channel stabilization is selected over check dams in areas having bank instability. For the purpose of this study, channel stabilization was assumed to include less habitat improvement work and would be appropriate where potential aquatic habitat is limited. It would be less costly per linear foot than stream restoration.

5.3.7 Stream Restoration

As stated above, the stream restoration solution is similar to the channel stabilization solution. Stream restoration was assumed to require more habitat work and would have dual goals of reducing erosion and improving habitat. Stream restoration would be slightly more costly per linear foot than channel stabilization due to more planting and stream structures.

5.3.8 Hand-Constructed Stream Restoration

Hand-constructed stream restoration is similar to the stream restoration solution and was only considered in reaches where access with conventional and compact equipment is not practical, would cause excessive damage, or where the work was limited in magnitude. The work is limited to materials that can be carried manually or with very small machines. The cost of this solution is relatively high.

5.4 Permitting for Erosion Problems

Table 5-2 summarizes the permits that may be required for each of the erosion CIP solutions. The table also identifies special studies that could be necessary, and notes permits that require long lead times. Depending on the amount of work to be done inside of a wetland boundary, or below the ordinary high water mark, a Corps of Engineers (COE) nationwide permit may be required. This permit requirement would trigger the need for an Endangered Species Act (ESA) review, which requires the preparation of a Biological Assessment (BA). The COE permit could also trigger a Department of Ecology 401 Water Quality Certification review.

An ESA review and the requirement of a BA may also be triggered if the project is constructed using federal funding. A Hydraulic Permit Approval (HPA) from the Washington State Department of Fish and Wildlife will be required for projects that disturb any stream (defined as waters of the state) within its ordinary high water line. A SEPA checklist will be required for all projects. Additionally, local permits, such as a clearing/grading or right of way (ROW) use permits, may be required for projects.

5.5 Drainage Problems and CIP Projects

City maintenance crews conducted conveyance system inspections and "TV" investigations to assess the condition of selected segments of the City's drainage system. The investigated systems were selected by City staff and include many of the systems identified as problem areas during Phase 1, as well as a few additional systems not identified during Phase 1, but considered as systems of concern. Because of budget/resource limitations, not all of the systems identified in Phase 1 could be investigated. A summary of the areas that were investigated/TV'd is included in Table 5-3. The summary table was assembled following a meeting between R.W. Beck and City staff to review the information collected during the TV'ing. This table is also included in Appendix F, along with the summary forms that were filled out during the work. The table includes a summary of the observations by the TV consultant and City staff, and then one of three conclusions for each system. The three possible conclusions for each system investigated are:

- Not a problem – The system appears to be fully functioning with no or minimal maintenance needs.
- Not a major problem, but additional investigation and/or maintenance are required - For these systems, maintenance is needed (for example, if significant root intrusion is interfering with the flow area) and/or additional investigation is required to determine if the system is functioning. Additional investigations area often required for systems needing maintenance because the TV camera could not completely evaluate the pipe segment because it could not get past some obstacle, such as a root.
- Problem and CIP identified – These included systems problems that went beyond routine maintenance needs and required a capital improvement. Examples are severely damaged pipe, or where pipe joints have become severely separated.

There are many areas within the City where additional investigation and/or maintenance is required and these areas are listed on Table 5-4. The list was compiled from the TV inspections identified in Table 5-3 and from those systems identified in Phase 1 as systems of concern that were not investigated as part of Phase 2 because of limited resources. One of the most important recommendations for future studies is to investigate the condition of all culvert crossings of East and West Mercer Way not investigated as part of this study. These culverts represent critical components of the drainage system because failure of these culverts can affect the City's main arterials.

Through this process, six CIPs were identified to address drainage system problems. These six problems, their proposed solutions, and their estimated costs are summarized on Table 5-5.

The CIP solutions for the drainage system problems primarily include culvert or pipe replacement. Most of the pipe/culvert replacements can be done using traditional open cut/shoring techniques. In one case, pipe bursting methods are recommended for a pipe replacement across East Mercer Way due to high traffic volumes and depths of embankment.

5.6 Capital Improvement Projects for Erosion and Drainage Problems

Preliminary CIP projects were developed for the erosion problems visited as described in this section, and for the drainage problems identified with input from City staff. In addition to the data collected in the field, prior basin plan information was incorporated as appropriate for the erosion problems. A "Project Summary" was developed for each CIP and these are included in Appendix G. The "Project Summary" includes the following information:

- Basin number, project number and title
- Problem description and a representative photo (if available)
- CIP project description
- Related projects, if any
- Planning level cost estimate
- Simple plan view graphic showing location and extent of CIP

There are 26 erosion CIP Project Summaries and six drainage CIP Project Summaries. Some erosion CIPs address more than one problem identified in the Phase 1 analysis (for example, where there are two or more problems located close together along the same watercourse and one proposed project can fix both problems). In some cases, it is noted on the Project Summary if another CIP project should be completed prior to another.

The planning level cost estimates are for the total cost of the project. The estimates include consideration for special access requirements, erosion and sediment control, traffic control, mobilization, 30 percent contingency, and state sales tax. The cost estimates also include the following indirect costs: surveying and design, permitting, construction engineering and administration, and easement/land acquisition administration. For all easement acquisition, it is assumed that the only cost is administrative and that there is no cost to acquire the easement. Table 5-5 summarizes all of the proposed CIP projects and their respective costs.

The total cost for completing all of the CIPs is estimated to be approximately $10.8 million. The total cost for completing all of the erosion CIPs is $9.6 million and the total cost for completing all of the drainage CIPs is $1.2 million. Additional future analysis of the problems identified as "moderate" will result in additional projects.

Section 6
STORMWATER PROGRAM POLICIES

6.1 Overview of Stormwater Program Policies

In order to formalize some of the more important stormwater program policies for the City, issues associated with these policies were reviewed and input was solicited from the City's Utility Board. Formalized policies will help define what is included in the CIP as well as manage day-to-day operation of the program. The goals of this process also included having stormwater policies that support the delivery of consistent services that the community desires and can afford and that support compliance with regulatory requirements.

The key policy issues that were identified with City staff and evaluated include:

- CIP prioritization
- Erosion, easements, and regulatory compliance
- Fee-in-lieu of detention
- Maintenance easements for stormwater facilities on private property
- Filling of roadside ditches

This work did not include comparing the City's existing stormwater program with what is necessary to be in compliance with the pending regulatory requirements, such as NPDES Phase II, because the regulations are not yet fully defined.

6.2 Recommended Policy Changes

For the selected policy issues, this Section describes the City's current practices and provides discussion and recommendations toward defining and documenting these policies, based on the study conducted with R.W. Beck, City staff, and the City's Utility Board.

6.2.1 CIP Prioritization

The City currently constructs surface water capital projects on a pay-as-you-go basis as funds are available through the Storm and Surface Water Utility and attempts to construct the highest priority projects first. Projects are generally categorized into one of three types: large projects, spot improvement projects, and neighborhood projects. Large projects are typically $150,000 to $500,000 and are associated with watercourse restoration. Spot improvement projects are typically $50,000 to $150,000 and are associated with watercourse restoration. Neighborhood projects are typically within the City right-of-way and are associated with catch basin and/or pipe installation/replacement.

Many factors can affect the order in which projects are constructed. For example, a less expensive project may be built before a more expensive project because of the limited funds available. In addition, the City attempts to balance its capital expenditures across the City's geographic areas, so that if the two most severe problems are near each other, the City may construct just one of them while building other projects in other areas.

The project team, City staff, and the City's Utility Board discussed options for prioritization and it was recommended that the City formalize a prioritization process. With a documented process in place, it is possible to more clearly describe the merits of a particular project, and to explain and document to ratepayers and elected officials why one project gets built before another. Also, having this documented process will help to ensure that priorities are established in a consistent manner from year to year.

Working with City staff and the City's Utility Board, the project team developed two components of a prioritization program. The first element is a prioritization process flow chart that helps decide whether or not the City should implement a project. For example, some problems that are entirely on private property where no public drainage contributes to the problem should not be addressed using public funds. This process diagram can be used to screen out projects such as this. The process diagram is shown on Figure 6-1. The process is also designed to consider the timing of permits needed for a project and the ability to obtain private easements where needed. The second element of the prioritization program is a prioritization model (or spreadsheet). A prioritization model was developed that ranks projects according to several scored criteria such as magnitude of the problem and cost effectiveness, as well as several other criteria. The detailed prioritization model and results is presented in Section 7.

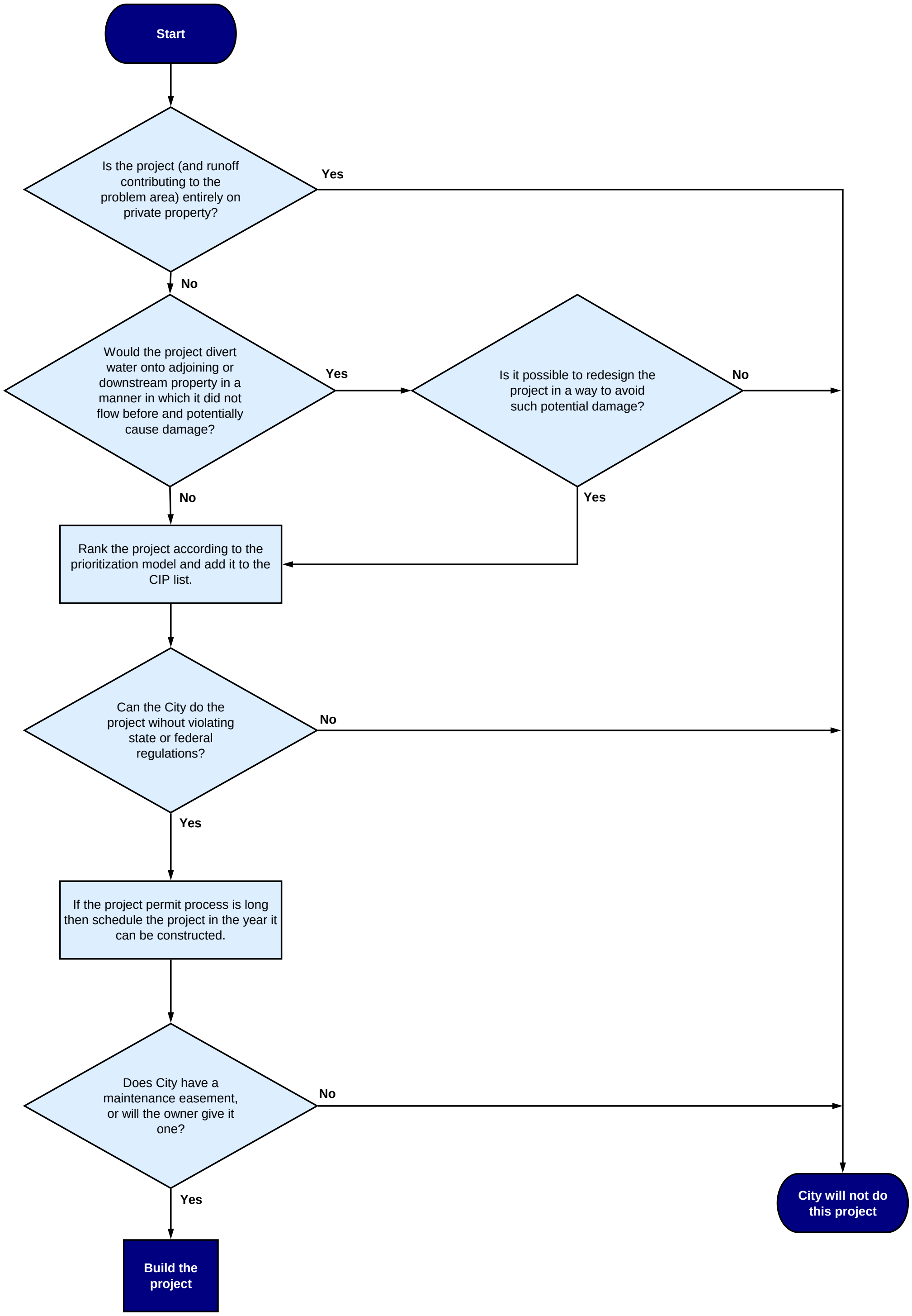

Figure 6-1
CIP Prioritization Process

6.2.2 Erosion, Easements, and Regulatory Compliance

There area a number of legal type issues the City is faced with when dealing with erosion problems which are most often on private property within ravines. Legal issues were discussed with the City staff, the City legal staff, and the City's Utility Board. The following paragraphs describe the main conclusions of these discussions:

- When implementing stormwater and erosion projects, any legal risks need to be reviewed on a case-by-case basis by the City.
- Where new development is adjacent to watercourses, proactively seeking easements during development review to allow future access to streams for CIP projects does not require the City to take over responsibility for correcting future problems in perpetuity because of the availability of the easement. The rights associated with the ownership of an easement do not extend to complete assumption of liability. The City is not responsible for drainage systems (pipes, ravines, watercourses) on private property that convey drainage from uphill City streets and private properties. There can be exceptions to this on a case-by-case basis.
- Any state or federal regulations implicated by a particular project must be given careful scrutiny and necessary permits must be obtained in order to avoid any regulatory compliance problems.
- The City should review the legal risks of potential CIP projects on a case-by-case basis and ensure that the project complies with any applicable state or federal regulations.

6.2.3 Fee-in-Lieu of Detention

Mercer Island City Code (section 15.11.030.A) currently allows private property owners to pay a fee-in-lieu of detention "when authorized by the City Engineer." The code states that the City Engineer will disallow a fee-in-lieu proposal "if, in the opinion of the City Engineer, undetained runoff from the development may materially adversely exacerbate an existing problem." However, the City previously had no written policy that explains how the City Engineer makes this decision.

The City Engineer currently considers many factors such as the location of the development within the subbasin, the magnitude of development, downstream drainage system conditions, the expected increase in stormwater runoff, etc. This practice has worked well, but it was concluded that these factors need to be documented as a part of this effort.

Based on the recommendations of the study with City staff and the City's Utility Board, the City developed the following set of review criteria to help guide decision-making on application of the fee-in-lieu of detention:

- The existence of known drainage system problems downstream of the project site, especially in a ravine/watercourse and whether they are worsening.

- The timing of future capital improvements planned in the ravine/watercourse and the benefit of applying fee-in-lieu monies toward the CIP compared to on-site detention.
- The history of landslides or instability in or along the downstream ravine/watercourse.
- The relative longitudinal slope, soil conditions, and peak flows in the ravine/watercourse. This is used as an indicator of potential erosion as well as how “flashy” the stormwater response is due to level of imperviousness in the subbasin. This is not quantified, but based rather on general observations and any historical knowledge.
- History of litigation regarding flooding or erosion in the subbasin.
- The extent to which the development increases peak flows into the system. Developments that either do not increase peak flows or where good downstream conditions exist are favorable candidates for fee-in-lieu of detention.
- Subbasin size, the project location within the subbasin, and the overall level of development in the basin. Detention in the lowest segments of the subbasin typically does not provide the same benefit as in the upper portions.

When the fee-in-lieu is determined to be an acceptable alternative to providing detention, the property owner’s civil engineer will still need to perform an analysis of the downstream system for one quarter mile to confirm that there are no capacity problems. If a problem is identified, the property owner will either need to correct the problem in addition to paying the fee-in-lieu or forego the fee and provide stormwater detention on the project site.

6.2.4 Maintenance Easements

The surface water system that falls within the jurisdiction of the Storm and Surface Water Utility includes the entire system within the city, both public and private. The system consists of naturally existing ravine watercourses and constructed pipes, culverts and channels. The “City or public drainage system” means those elements of the storm and surface water system within the City that are located on property owned by the City or within the public right-of-way, or are located on property on which the City has an easement. Some portions of the surface water system flow over private property for which there is not an easement. This type of system is referred to as a “private system.”

There are many of these private systems within the City. For private systems (where the City does not have an easement), the City is not responsible for the system operation nor does it have any rights to perform maintenance, improvements, or access the property. It is recognized that these private systems sometimes convey upstream runoff that includes public areas (such as roads). A malfunction of the system (such as plugging or pipe failure) could not only cause damage to the private property itself, but upstream or downstream properties. Therefore, in some cases where public drainage flows through private property, there may be some public benefit for the City to obtain maintenance easements to ensure that the system is reliable.

Following are some situations where obtaining a drainage easement may be desirable:

- The City would like to construct a capital project that results in public benefit, such as a watercourse stabilization project.
- The City would like to obtain an easement for future maintenance and/or replacement of a currently private system that conveys public drainage and it is in the public's interest to ensure that adequate maintenance is performed.
- When the City is reviewing a development proposal for a property with a private system that conveys public runoff and it is in the best public interest to obtain an easement.

It is not necessary to obtain drainage easements for all private systems. Therefore, the City should consider these situations on a case-by-case basis.

Based on the input from the City staff and the City's Utility Board, it is recommended that before the City performs maintenance or rehabilitation of systems on private property, the City obtain a maintenance easement from the property owner. This will allow the City to access the site and maintain the system. If an easement is not provided, the City should not work on the system. This requirement for an easement is also reflected in the CIP prioritization process shown on Figure 6-1.

It is also recommended that the City consider obtaining easements at the time a private property starts the permit process for development or redevelopment.

Note that these two recommendations do not include emergency projects, such as where a drainage problem caused by a recent storm poses an immediate danger. If there is an emergency, the City may need to access private property.

The following should be considered for obtaining an easement in accordance with either of the recommendations above:

- Obtaining an easement for a drainage system by the utility would provide a public benefit.
- Necessary and appropriate property rights are offered by the property owner at no monetary cost. Restoring property after completion of project improvements such as landscaping may be considered.
- That the system/facility substantially meets current engineering standards, as determined by the utility, or is brought up to current engineering standards by the owner or the City as part of a capital project.
- That there is access for utility maintenance.
- That the utility has adequate resources to maintain the facility.

6.2.5 Filling of Roadside Ditches

Many of the City's streets have roadside ditches and no pedestrian paths or shoulders. Private property owners often request that the City replace roadside ditches with piped systems. In considering these requests, the City must look at a number of factors, including:

- The desire of private property owners to have more parking or landscaping in front of their property.
- The safety of cyclists and pedestrians on narrow roadways.
- Water quality treatment provided by vegetated ditches.
- Water quantity control by allowing some infiltration (groundwater recharge) compared to piped systems.

On arterials that do not have much shoulder space, such as East Mercer Way, the City has piped ditches to provide additional space for bicycles and pedestrians. On residential streets with low traffic volumes, the water quality of runoff is likely better than arterials and other high traffic volume streets. Because the water quality on these streets is better, the water quality benefit of grassy ditches may be less compared to high traffic volume streets.

When the City has approved the filling of neighborhood ditches, it historically has also provided assistance. Property owners pay the cost of materials (pipe and backfill), and the City contributes the labor needed to install the materials and fill the ditch.

Based on input from the City's Utility Board, the City developed a set of criteria shown on Table 6-1 in order to help guide decision-making on preserving ditches. The decision to fill an existing ditch will be based on the type of street, whether it has a shoulder, and the water quality/quantity benefits provided. In addition, consideration of the water quality/quantity benefits should consider the basin conditions (e.g., whether there are erosion, flooding, or water quality problems and its location in the basin). Generally, on arterial streets with shoulders, existing ditches should be retained for their water quality/quantity benefits. For arterials without sufficient shoulders, safety is likely a higher priority than the water quality/quantity benefit of ditches. It is recognized that this table is simplified and the City may take other factors not listed here into consideration when determining whether to allow filling of a ditch. Note that no category is included for commercial areas because most of these areas do not have ditches.

Table 6-1. Ditch Filling Policy by Street Type

Type of Street	Roadside Ditch Filling Policy
Arterial[1] with shoulder	Generally not allowed in order to maintain the water quality/quantity benefits. In some locations, the safety of bicyclists and pedestrians may outweigh water quality/quantity benefits.
Arterial[1] w/o shoulder	Generally allowed.
Residential Street	Generally allowed unless in a basin that is subject to downstream water quality/quantity problems where continued filling of ditches in the basin will worsen current conditions.

[1] Arterial roads as defined in the Comprehensive Land Use Plan

In addition, in situations where ditch filling is allowed and it is requested by a property owner, the City will provide the labor and the property owner will purchase the materials. All costs associated with filling ditches when part of a development or redevelopment shall be solely the responsibility of the property owner.

Section 7
CIP PRIORITIZATION

7.1 Approach

As discussed in Section 6, the project team, City staff, and City's Utility Board worked together to develop a prioritization process or method. The process includes using evaluation criteria, weighing the relative importance of each evaluation criterion, and assessing the identified projects with respect to how well they meet each of the evaluation criteria. The result is a simple spreadsheet model that includes weighted criteria, scoring of the CIPs as to how well they meet the criteria and an overall ranking or prioritization. The scoring of individual projects was developed with City input to provide a prioritized ranking. The spreadsheet is further described in this section.

7.2 Criteria and Evaluation

The criteria that were evaluated for each CIP include the following:

- Magnitude of the problem (To help define the magnitude of problems, this criterion was further subdivided into separate criteria for risk to health and safety, risk to property, rate of degradation/project urgency, and the flows or size of the drainage area)
- Impact to water quality and stream habitat
- Cost effectiveness
- Special opportunity
- Reduction in maintenance and operation costs
- Neighborhood advocacy/complaints
- Permitting effort
- Overall project cost

Each of these criteria are defined and assigned a weighting factor on Table 7-1. The weighting factors range from 1 to 5 and were determined during meetings with City staff and the City's Utility Board. For each criterion, the projects were evaluated in terms of severity level. The definitions for each severity level are also defined on Table 7-1. The severity for each criteria is evaluated on a scale of 0 (none) to 3 (high). For each CIP project, all criteria are evaluated and scored according to severity. The total severity score for each project is the sum of the severity score times the weighting factor for each criterion.

Scoring for both erosion and drainage system CIPs was developed with input from the City. The prioritization results are presented in Table 7-1 for erosion problems and in Table 7-2 for drainage system problems. The projects with the highest scores reflect the highest priority projects and the projects are arranged from left to right. The spreadsheet model is set up to automatically update the ranking when the scoring is modified. In this way, the City can update the prioritization as more information about problems becomes available. A digital copy of the prioritization models is included in Appendix D for the City's future use.

7.3 Summary of Program Recommendations

The following paragraphs present a summary of the recommendations developed during the course of this study. These recommendations reflect City input as well as input received during City's Utility Board meetings.

1. Use the prioritization method developed to rank and implement projects.
2. Continue and expand erosion problem monitoring to provide additional data that can be input into the prioritization model and help the City make decisions on CIP implementation.
3. Continue to investigate drainage systems as summarized on Table 5-4 to identify and fix drainage system problems. Special emphasis should be placed on inspection and monitoring of the East Mercer Way and West Mercer Way culverts because these are critical structures.
4. The City should apply the formalized policies as presented in Section 6.
5. Continue investigation of erosion problems categorized as "medium" in Phase 1 and shown on Plate 3 and Table 4-1. Due to limited resources, only the "high" category problems were investigated as part of this study, but as additional resources become available, the City should continue investigations.

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Date: June 10, 2012

To: Patrick Yamashita, P.E.
City of Mercer Island

From: Jack Bjork, P.E. and Eliza Ghitis
Cardno Entrix, Inc.

RE: **Supplemental Ravine Erosion Assessment**

1.0 INTRODUCTION

In 2006, R. W. Beck, Inc. (R. W. Beck) prepared a Comprehensive Basin Review and Watercourse Monitoring Report (Basin Review) for the City of Mercer Island Storm and Surface Water Utility (the City). A major element of the Basin Review was the identification of ravine erosion problems and capital improvement projects (CIPs) that addressed these problems. The problem identification phase of the 2006 Basin Review classified erosion problems into three categories: Severe, Moderate, and Minor. Due to budget limitations, the focus of the work was limited to those erosion problems classified as Severe. Field assessments were conducted and CIP solutions were developed for the 28 severe sites in 2006.

Field work to investigate the magnitude of problems classified as Moderate was beyond the scope of the 2006 work but was begun in 2008. RW Beck completed the investigation of 16 additional problems in 2008 as part of a Supplemental Ravine Erosion Assessment (SREA). In 2010, the City engaged ENTRIX, Inc. (now Cardno ENTRIX) to conduct analyses and develop CIPs in an SREA for 12 of the erosion problems classified as Moderate in the 2006 Basin Review.

In 2011 and 2012, Cardno ENTRIX revisited 21 of problem sites with the following objectives:

1. To build on the 2006 Basin Review, 2008 SREA and 2010 SREA by conducting field investigations, performing analyses, and developing CIPs for the erosion problems that were classified as Moderate in the 2006 Basin Review.

2. To update the CIP prioritization model initially developed for the 2006 Basin Review. The model was developed after identifying key policy-based evaluation criteria, weighing the relative importance of each criterion, and assessing the identified projects with respect to how well they met each of the evaluation criteria. The spreadsheet model provided the City with an overall project ranking for prioritization.

This technical memorandum describes the work conducted in 2011 and 2012. It includes a discussion of the analysis completed and a series of tables, figures, and project data that have been integrated into the Master Copy notebook of the 2006 Basin Review and 2008 and 2010 supplements. These tables, figures, and data were included in the notebook as Attachments 1 through 11 to replace existing information or to be added as new information. Table 3 of this memo explains each attachment and all attachments are also included in digital format as a disc in Appendix D-3. This memorandum was added to the Basin Review notebook as Appendix I-3.

2.0 SCOPE OF WORK

The scope of work for the 2012 Supplemental Ravine Erosion Assessment is summarized as follows:

- Selection of Moderate erosion problems for field reconnaissance based on input from the City and an office assessment of the potential for erosion problems in new and previously investigated sites.
- Field reconnaissance for the selected Moderate problems, including the following activities:
    - Collection of the data used for prioritizing the problem sites;
    - Establishment of problem limits; and
    - Evaluation of site constraints and other issues relevant to the type of solution appropriate for the problem area.
- Completion of CIP Project Summary sheets and cost estimates (based on the 2006 Basin Review) for 21 problem sites which were combined into 16 CIPs.
- Updating the CIP prioritization spreadsheet model developed during the Basin Review for the 2011-2012 CIPs.
- This technical memorandum documenting the supplemental work.

3.0 ANALYSIS AND RESULTS

3.1 Erosion Problem Selection

The Cardno ENTRIX team reviewed problem sites previously identified in the 2006 Basin Review and the 2008 and 2010 SREAs for potential field investigation. Based on available mapping information, drainage area, watercourse slope, historical problems, and proximity to homes or roads, 21 problem sites were identified in collaboration with the City. These sites are included in Attachment 1 (which replaced Table 5-1 in the Basin Review notebook).

Those problems not selected for field investigation for this phase could be investigated under future phases by the City. These problems are summarized below in Table 2.

Table 2: Problems Not Investigated

Site Number	Preliminary CIP Priority	Severity Ranking (from 2006 Basin Review)
10.4	High	--
22.1	High	Moderate
24a.1	High	--
27a.1	None	Severe
27a.10	High	--
34.1	High	--
39a.2	High	Moderate
51a.1	High	Moderate

3.2 Field Investigations

Field evaluations were performed for the 21 problem sites listed in Table 5-1 (Attachment 1). The field investigations were done in a manner consistent with the prior work efforts, as described in Section 5.2 of the Basin Review. In general, the field reconnaissance included the following tasks:

- Observation of the nature, extent and severity of the problem;
- Identification of site constraints and other issues influencing the type of solution applicable to the problem; and
- Collection of data relevant to the CIP prioritization criteria (see Section 5 below).

The site visits were conducted by Jack Bjork, P.E., a senior engineer with over 20 years of experience solving erosion problems, and geomorphologists, Michael Ericsson and Eliza Ghitis. A summary of the field results is included in Attachment 1 to this memo (Table 5-1 of the Basin Review Master Copy). The data forms and drawings collected in the field investigations are included in Attachment 7 of this memo and Appendix E of the Basin Review Master Copy. Additional photographs of each problem area are included in Attachment 9 and Appendix H of the Basin Review.

While a small number of the 21 erosion problem sites visited in 2011 and 2012 showed no change, several showed signs of high risk from erosion. The watercourse in Site 4.2 is scouring and undercutting the toe of a large, mapped landslide, posing a long term risk to Gallager Hill Road. A gabion wall at the toe of Gallagher Hill Road is failing as well. Further investigation and solutions should be developed immediately to reduce risk to the road. In Site 27a.11, a 6 to 7 foot headcut has retreated approximately 10 feet into erodible material since 2010. The headcut is approximately 75 feet form a private residence. The right bank has retreated approximately 4 feet and the left bank has also eroded back where a tree failed. At Site 46a.6 erosion of the south bank presents moderate risk to a private residence that is 7 feet from the channel. The resident noted in 2011 that the channel has incised approximately 4 feet over the past 18 years, but no significant change observed between 2008 and 2011 surveys. Also of note is Site 49b.1, where work was already done by the city--future CIP will involve simple maintenance that can be done by City crews.

3.3 Ravine Monitoring

As part of the 2006 Basin Review, three sites had been established for the purpose of monitoring the changing nature of erosion problems. For example, some erosion problems may worsen quickly while others are slowly worsening. Three sites were monitored in the 2008 SREA: 23.2, 49b.4 and 32b.1, located in subbasins 23, 49b and 32b, respectively. In 2010, the SREA re-occupied the cross sections to assess changes. The 2011-2012 update did not include monitoring of the these sites in order to focus resources on the assessment of more problem sites.

Four sites from the 2010 SREA appeared to have accelerated rates of erosion. The sites listed in Table 2 could be used as future monitoring sites.

Table 2: Potential Erosion Monitoring Sites

Site Number	Preliminary Rank Moderate/Low
24a.1	Moderate
27a.11	Moderate
46b.2	Moderate
47.3	Moderate

4.0 CIP DEVELOPMENT

Based on the information gathered during the field reconnaissance, preliminary CIPs were developed for the problem sites based on the approach and format of the 2006 Basin Review. Project Summaries were prepared for the CIPs and included in Attachment 8 and Appendix G of the Basin Review. The location of the CIPs is presented in Attachment 3 of this memo and Figure 5-1 in the Basin Review.

Each Project Summary includes the following information:

- Sub-basin number, project number and title;
- Problem description and a representative photograph;
- CIP description;
- Related projects (if any);
- Planning-level cost estimate; and
- Plan view showing location and extent of the project.

Data in the field investigation forms presented in Attachment 7 and Appendix E of the Basin Review may provide additional information that could prove useful to future project designers.

The cost estimates for the sites visited in 2011 and 2012 were calculated from original unit prices from 2006 and 2008. The estimated project costs were escalated by 5% from 2006 to 2008 and again by 5% from 2008 to 2010. The sales tax for the 2010 cost estimates was also increased from 8.8% to 9.5%. The 2011/2012 costs were calculated as 80% of the 2010 costs based on construction costs for several projects that have since been completed. These costs updates are presented in Table 7-1, CIP Prioritization in Attachment 4 of this memo and Section 7 of the Basin Review.

Several sites re-visited for the 2011-2012 review were combined together for CIPs based on proximity and logistics of construction access as noted in Table 2. Site 27a.3 was not selected for a 2011-2012 update, but was combined with 27a.11 because the two sites are directly adjacent to each other on the same watercourse.

Table 2: 2011-2012 Erosion Projects Update Summary

Project	Previous Visit	Jan 2011 CIP Priority	2012 Total Project Score	2006/2008 Cost (Thousands)	2012 Cost (80% 2010 Cost)	Jan 2011 CIP Construction Date	2011/2012 Conclusion
4.2/4.3C/4.4	Yes	High	43	$364	$314	2013	Bed and bank erosion near Gallagher Hill Rd; gabion wall failing
6.4/6.5	Yes	NA	41	NA	$484	NA	Bank erosion in South Luther Burbank Open Space
23.2	No	High	38	$284	$239	2013	Slow retreat of headcuts
27a.3/27a.11	Yes	High	42	$207	$179	2014	Rapid erosion and headcut retreat in yard
27a.6	Yes	High	42	$54	$48	2013	No change
29.2	Yes	High	42	$115	$101	2014	Headcut toward road
32b.1/32b.2	Yes	None	29	$93	$82	None	No change
42.1/42.1A	Yes	High	40	$322	$284	2015	Bank erosion and potential failure of large check dam; small check dams failing, but ok
45b.1	Yes	High	38	$179	$158	2015	Bank erosion, repair rock check dam
46a.3	Yes	2nd	39	$109	$99*	2015	Toe erosion of landslide mass contributing fine sediment
46a.4	Yes	NA	25	$99	$87	NA	Flow reduced by 53rd St. project, minor problem now
46a.6	Yes	High	48	$53	$45	2013	No change
49b.1	Yes	High	34	NA	$12	2014	Maintenance to place 3-4 CY rock
49b.4	Yes	High	40	$195	$172	2017	Slow to moderate downcutting at outlet
50b.4	No	New	24	NA	$38	New	Resident request, 2 minor problems
52.1	Yes	High	43	$105	$93	2014	Rapid erosion

5.0 UPDATED CIP PRIORITIZATION

The new and updated CIPs developed for supplemental assessment were incorporated into the 2006 Basin Review prioritization ranking spreadsheet previously updated in the 2008 and 2012 SREAs. The evaluation criteria followed the previous versions and included the following:

- Magnitude of the problem. To help define the magnitude of problem, this criterion was further subdivided into separate criteria for risk to health and safety, risk to property, rate of degradation/project urgency, and the size of the drainage area;
- Impact to water quality and stream habitat;
- Cost effectiveness;
- Special opportunity (e.g. giving a project additional credit if there was a risk that an opportunity to do the project may be lost, such as unique funding source or land availability);
- Reduction in maintenance and operation costs;
- Neighborhood advocacy/complaints;
- Permitting effort; and
- Overall project cost.

The spreadsheet model is set up to automatically update the ranking when the scoring is modified. In this way, the City can update the prioritization as more information about problems becomes available or as other problems arise. The updated CIP prioritization table is contained in Attachment 7 (which replaced Table 7-1 in the Basin Review notebook). In Table 7-1, costs estimated in 2010 were reduced by 20% to reflect costs in 2012 dollars and the costs originally estimated in 2006 and 2008 were reduced by 11.8 and 16 percent, respectively. Detailed cost estimating forms in the 2006 Basin Review and SREA Project Summaries for sites not re-visited were not changed and do not include the adjustment.

6.0 DIGITAL FILES

The tables, text, figures and prioritization model are contained within a CD included in Attachment 6 (which was added as Appendix D-2 of the Basin Review notebook).

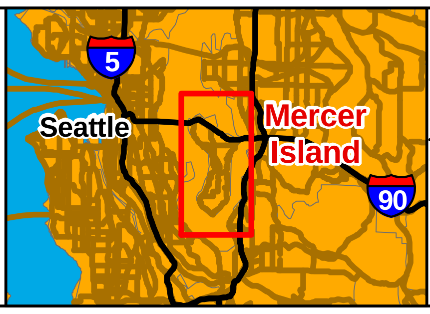
7.0 ATTACHMENTS

The attachments produced for this supplement are listed in Table 3.

Table 3 Summary of Attachments

Attachment	Location in Basin Review	Description	Action Updated
Attachment 1	Table 5-1	Summary of Field Investigations for Erosion Problems	Replaced Table 5-1 in Section 5
Attachment 2	Table 5-5	CIP Summary	Replaced Table 5-5 in Section 5
Attachment 3	Figure 5-1	CIP Project Locations map	Replaced Figure 5-1 in Section 5
Attachment 4	Table 7-1	Erosion CIP Prioritization	Replaced Table 7-1 in Section 7
Attachment 5	Appendix D	Supplement Digital Appendix	Added as Appendix D-3
Attachment 6	Appendix E	Field Investigation Forms for 2011/2012 Erosion Problem Areas	Added and integrated into Appendix E
Attachment 7	Appendix G	2011-2012 Erosion Project Summaries	Added and integrated into Appendix G
Attachment 8	Appendix H	2011-2012 Additional Field Photos	Added and integrated into Appendix H
Attachment 9	Appendix I	June 2012 Supplemental Ravine Erosion Assessment Memo	Added as Appendix I-3
Attachment 10	2012 Digital Report	DVD of Basin Review and updates	Insert with 2012 Memo at back of Appendices
Miscellaneous	-Replace covers on Volume I and II on outside, title sheet and spines -Replace Table of Contents and insert into Volume I -Replace Certification Page		-Replaced covers in Volume I (Main Report) and Volume II (Appendices) -Replace Table of Contents in Main Report -Replace Certification Page in Main Report

- ● Erosion Projects
- 🟨 Drainage Projects
- — Streams
- ▭ Stormwater Basins
- — Roads



Mercer Island
Ravine Investigation

Figure 5-1
CIP Project Locations

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fx (206) 269-0098

www.cardnoentrix.com

Coordinate System:
NAD 1983 Washington State Plane N feet

Updated April 6, 2012

PROJECT SUMMARY SHEET

Basin No.: 4

Project No: 4.2 (upstream), 4.3C (downstream), and 4.4 (west bank tributary in middle reach)

Project Title: **Bypass Pipes along West Side of Gallagher Hill Road, 30 LF of Channel Stabilization, and Raise and Re-create 100 LF of Watercourse within Gallagher Hill Open Space.**

Problem Description: In Project 4.2, flow is scouring and undercutting toe of large, mapped slide downstream of storm drain outlet. This is long term risk to Gallager Hill Road as well. Two other storm drain outlets contribute flow.

In addition to bed and bank erosion observed, at the downstream end of the gabion wall at the toe of Gallagher Hill Road is failing. Rock from the wall is displaced downslope all the way to the channel. Further investigation and solutions should be developed immediately to reduce risk to the road. It is likely that erosion at the downstream drain outlet discharging directly onto the slope is contributing to undermining the wall. See Appendix E for a field sketch of the problem area.

A majority of the main stem of the water course located in an undeveloped ravine within Gallagher Hill Open Space is either piped or only experiencing minor erosion. A total of about 30 LF of problematic bank erosion exists in a 300 LF reach designated as Reach 4.3C. The lower end of the reach is located 100 feet upstream of the intake that conveys flows under I-90. Bank erosion can be characterized as moderate, with a 1 foot drop upstream of the outlet and an 8 foot by 10 foot scour pool at the outlet.

Small tributary in Project 4.4 with limited collection area is incising in sandy soil creating undercut and vertical banks up to 5 feet deep.

Project Description: The preferred approach to Project 4.2 based upon the 2011 field reconnaissance includes installing manholes, anchor blocks, and 12-inch butt-fused HDPE pipes along 100 feet of water course and 40 feet at two side drainage systems to stop erosion of slide toe. Additional investigations are recommended for this problem with considerations of other alternatives and seeking input from WDFW. Other options could be considered, such as installation of rock check structures on the two side drainages discharging directly onto the slope, relocation of the lower 30-40 feet of the channel away from the road, and fill of the upper half of the channel to buttress the slide with additional toe protection and rock check structures. The cost estimate is based on the bypass pipes with 12-inch pipe.

Project 4.3C consists of channel stabilization in selected sites totaling 30 LF within a 300 LF reach and Project 4.4 will raise and re-create 100 LF of watercourse by filling channel with streambed gravel, boulders and logs.

Related Projects None

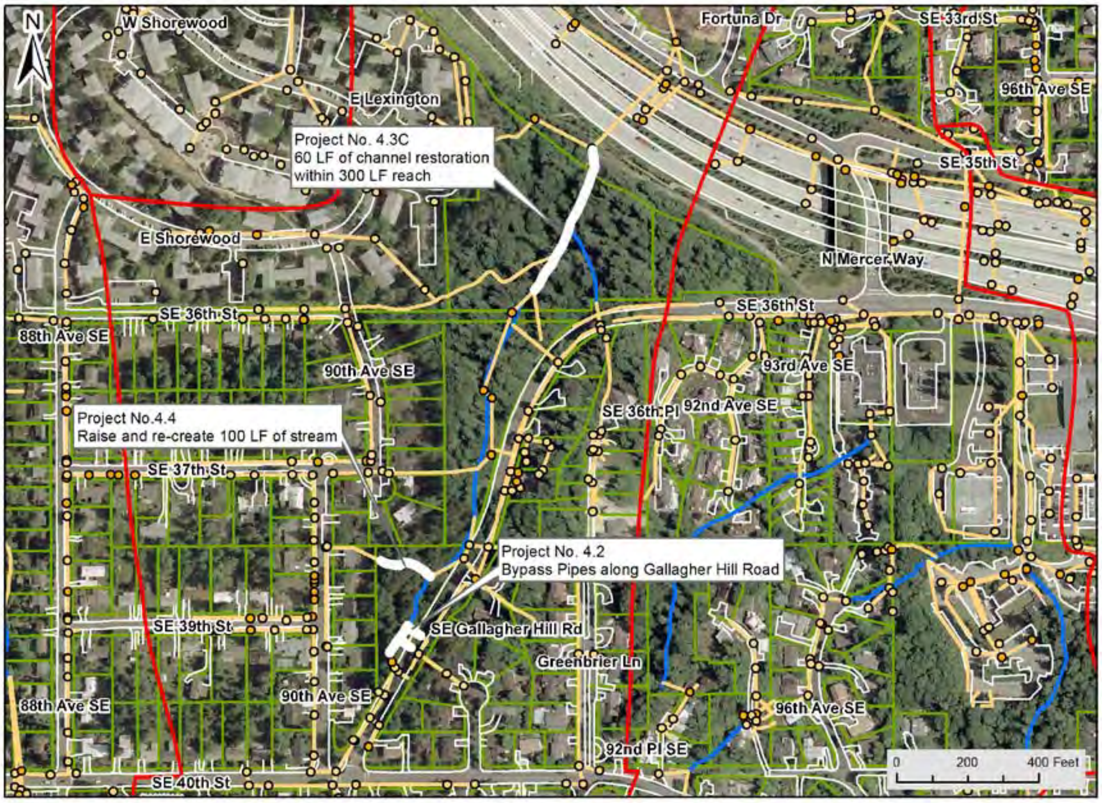
Estimated Project Cost: $314,000 (2012 Revision)

Project 4.2: Looking Downstream at Outlet 9/24/2005

Project 4.2: Failing Gabion Wall 12/22/2011

4.3C: Looking Upstream at Bank Erosion at a Stream Bend 3/13/2008

Project 4.4: Looking Upstream 3/13/2008



Project No. 4.3C
60 LF of channel restoration
within 300 LF reach

Project No.4.4
Raise and re-create 100 LF of stream

Project No. 4.2
Bypass Pipes along Gallagher Hill Road

Project Location Map

PROJECT SUMMARY SHEET

Basin No.: 6

Project No: 6.4 (west branch) and 6.5 (main stem)

Project Title: **280 LF Stream Restoration along main channel and 450’ 12” piping in west branch along South Luther Burbank Open Space**

Problem Description: Flow is scouring and undercutting toe of slope along west branch of watercourse (Project 6.4) within South Luther Burbank Open Space through a 500 LF section upstream of confluence with main stem of watercourse. The upper 280 LF of channel needs to be stabilized because the watercourse has incised about 5 feet through soft gray silt creating slides on the south slope and over-steepened banks.

Main stem (Project 6.5) along Shorewood Apts. was stabilized in the 1990s. Many of the stabilization measures have been undermined. In 2011, 9 of the 20 log weirs installed in 1998 have failed and more may fail with continued erosion. The channel is incised 2 to 5 feet into the cobble, gravel and clay beds. Failing vertical slopes are seen in numerous locations along the left bank mainly comprised of sand and gravel. Approximately 1,800 LF of channel needs to be repaired or stabilized.

See Appendix E for field map of project areas; 2011 visit made by Natural Systems Design and 2008 visit made by RW Beck.

Project Description: On main stem (Project 6.5), repair or replace 20 log weirs and stabilize in-channel log jams. Reinforce undercutting banks with boulders/logs at toe or catch/fill structures. Reduce scour in plunge pools with boulders/cobble. On west branch (Project 6.4), 450 feet of 12” pipe to reduce bank erosion and stabilize the hill slopes.

Related Projects Phase I – constructed in 1990s along Shorewood Apts.
Phase II – constructed in 2011 upstream of Shorewood Apts.

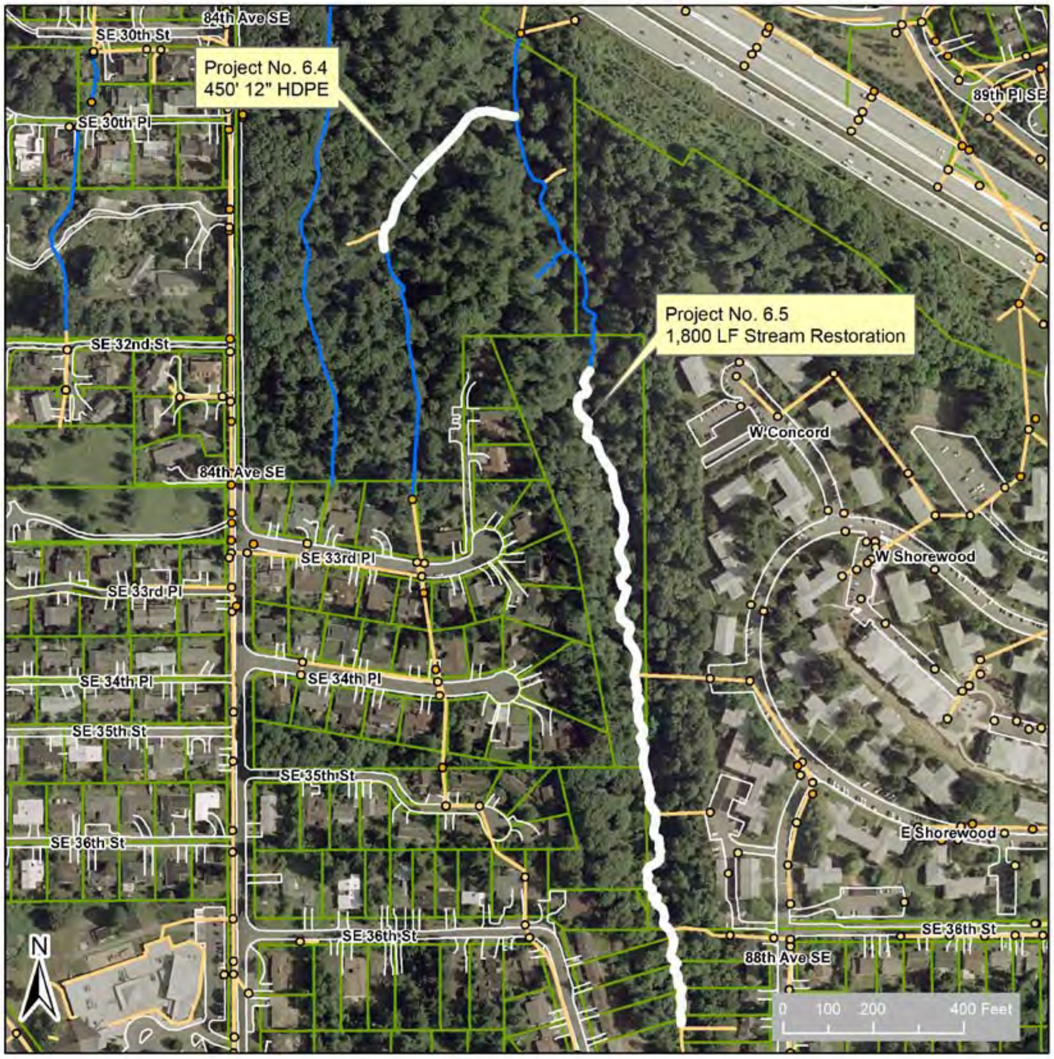
Estimated Project Cost: $484,000 (2011 estimate)

Project 6.4: Looking Upstream 3/26/2008

Project 6.5: Eroding bank 31+70 2/15/2011

Project 6.5: Failed Log Weir Station 33+20 2/15/2011

Project 6.5: Station 38+25 2/15/2011



Project No. 6.4
450' 12" HDPE

Project No. 6.5
1,800 LF Stream Restoration

Project Location Map

PROJECT SUMMARY SHEET

Basin No.: 23

Project No: 23.2

Project Title: **250 LF of Channel stabilization downstream of West Mercer Way.**

Problem Description: A watercourse reach extends 840 LF from West Mercer Way to Forest Avenue. The upper 250 LF needs to be stabilized to protect residence at 4323 West Mercer Way. This subreach has a gradient of 5 to 10% with numerous 2 to 10-foot high headcuts. The watercourse has incised up to 15 feet into medium dense tan silty sand and colluvium. The silt is stiff and resistant to erosion and the colluvium is up to 10 feet thick and subject to sliding. Two slope failures visible including one below the residence. While no additional sliding was seen in 2011, the more easterly slide is undercut approximately 3 feet along most of its length. If a 2 foot DBH maple below this slope fails, additional erosion is expected. Roof drain from the residence is broken and discharging onto slope; this pipe has not yet been fixed. A 5-foot headcut at Station 0+50 is in slow retreat. No other changes were seen since 2008. Additional geotechnical investigation of this subreach warranted. Additional erosional and slope stability problems exist downstream (see log in field notes) but do not currently affect human infrastructure.

Project Description: 250 LF of channel stabilization consisting of regrading and filling channel to re-create stream. Install boulder cascade at 10 foot headcut at station 2+00 and extend beyond headcut.

Related Projects About 120 LF of timber retaining wall at 4320 Forest Avenue is failing and will need to be replaced by property owner. Some watercourse stabilization warranted in this subreach as well.

Estimated Project Cost: $239,000 (2012 revision)

Looking Downstream 3/28/2008

Headcut at Station 2+00 with 10 Foot Drop 3/9/2012

2 Foot DBH Maple on Right Bank 03/9/2012

Project No. 23.2
250 LF of channel stabilization

Project Location Map

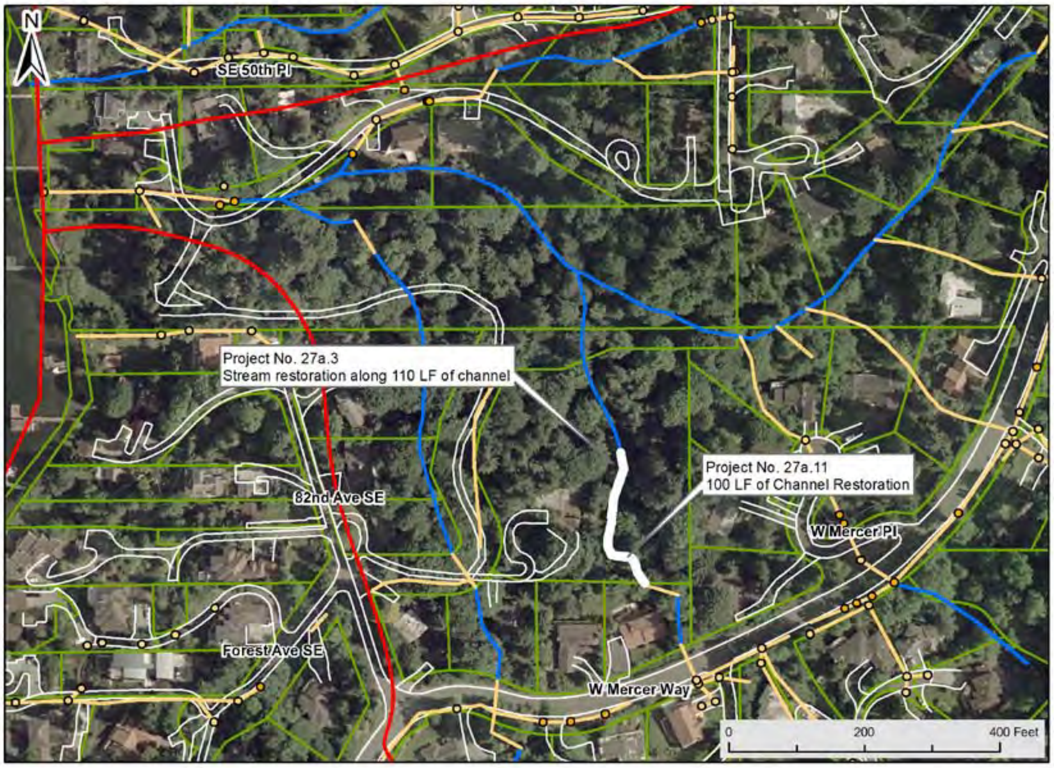
PROJECT SUMMARY SHEET

Basin No.:	27a
Project No:	27a.3 (downstream) and 27a.11 (upstream)
Project Title:	**100 LF of Channel Restoration and Stream Restoration of Incised Channel East of 82nd Avenue SE and North of West Mercer Way**
Problem Description:	In Project 27a.3, a small channel is deeply incised for about 110 feet. The channel has a bottom width of 3 to 4 feet, a depth of 4 to 7 feet and near vertical banks comprised of glacial till. Headcuts of 4 and 5 feet high also occur. The rate of erosion is moderate. In Project 27a.11, 80-100 LF of incised channel with steep 8-10 foot banks is cutting through erodible material: loose silty sand in the top 3 feet overlying moderately dense silty sand. The 6-7 foot headcut has retreated approximately 10 feet since 2010. The right bank has retreated approximately 4 feet and the left bank has eroded back where a tree failed. Minor erosion is also occurring from the culvert below West Mercer Way. See Appendix E for a field sketch of the problem areas.
Project Description:	Project 27a.3: Stream restoration and lay back the top of the banks in undeveloped ravine area. Project 27a.11: Fill channel with rock and recreate water course.
Related Projects	None
Estimated Project Cost:	$179,000 (2012 revision)

Project 27a.3: Looking Downstream - 9/28/2006

Project 27a.11: Looking Upstream 03/17/2010

Project 27a.11: Looking Upstream 03/09/2012



Project Location Map

PROJECT SUMMARY SHEET

Basin No.:	27a
Project No:	27a.6
Project Title:	**Boulder Cascade to Replace Timber Dam in 5200 Block north of West Mercer Way**
Problem Description:	4-foot high dam of 6 by 6 timbers and geotextile is falling over. If it were to fail it would release about 20 to 50 CY of stored sediment. No significant change was seen from 2006 to 2012; the timbers were mostly sound and no further displacement was visible. Sanitary sewer line crossing downstream of dam is not at risk.
Project Description:	Construct 40 feet of boulder cascade to replace timber dam using power wheelbarrow to reach area with limited access.
Related Projects	None
Estimated Project Cost:	$48,000 (2012 revision)

Looking Upstream at Failing Timber Dam 9/28/2006

Looking Upstream at Failing Timber Dam 3/9/2012

Project No. 27a.6
Install 40LF of boulder cascade along channel.

Project Location Map

PROJECT SUMMARY SHEET

Basin No.:	29
Project No:	29.2
Project Title:	**140 LF butt-fused HDPE pipe on west side of West Mercer Way in 6100 block**
Problem Description:	Very steep channel has created a 15 foot headcut and incised into the east bank of the main stem of the creek. The headcut has retreated about 5 feet since 2005. The small, narrow channel is up to 12 feet deep and rapidly eroding. See Appendix E for a field sketch of the problem area.
Project Description:	Butt-fused HDPE bypass pipe from West Mercer Way down the steep bank to the ravine bottom, a distance of 140 feet. New manhole and anchor near the street. All flow will be conveyed in the pipe.
Related Projects	None
Estimated Project Cost:	$101,000 (2012 revision)

Looking at 10’ Incised channel 12/14/2005

Outfall of 12” reinforced concrete pipe under West Mercer Way 03/09/2012

Project No. 29.2
Install 140 LF of 12-inch bypass pipe.

Project Location Map

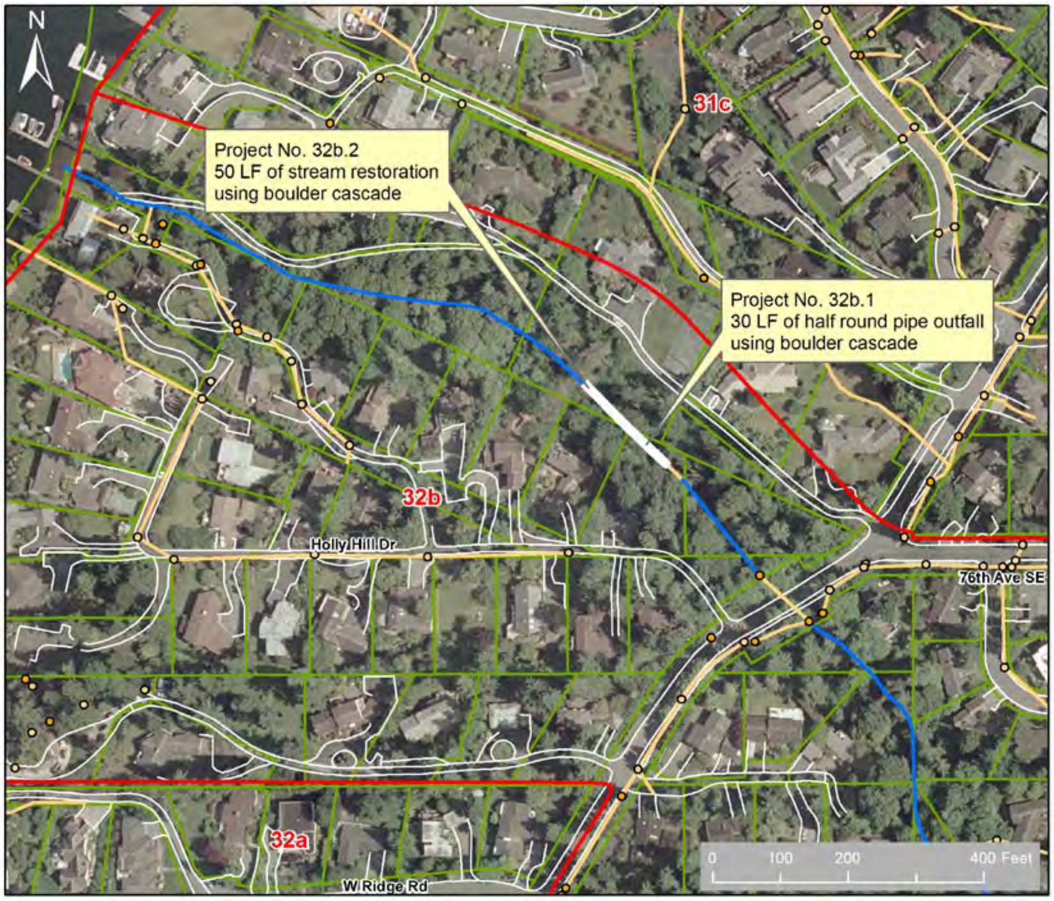
PROJECT SUMMARY SHEET

Basin No.:	32
Project No:	32b.1 (upstream) and 32b.2 (downstream)
Project Title:	**30 LF of Boulder Cascade for Protection of Outfall for Half Round Pipe and Headcut in Incised Stream Channel South of Meadow Lane and West of West Mercer Way**
Problem Description:	In Project 32b.1, the channel drops 3 to 5 vertical feet over 15 to 20 linear feet below the outlet of a 48 inch diameter, half round CMP conveyance pipe. Although channel appeared to be scouring vertically and horizontally below the culvert outlet, very little change was seen between 2006 and 2012. Local ravine water is also flowing along the underside of the half round pipe. Banks are steep, unvegetated, composed of very dense silt. Channel bottom lacks any substrate and consists of smooth, very dense silt. Approximately 80 feet downstream of the CMP is Project 32b.2, a 7 foot deep headcut through very dense silt. Below headcut, the channel is highly incised with vertical, unvegetated banks. Channel bottom also has little loose substrate, and consists of very dense silt. No change in this section in 6 years.
Project Description:	In Project 32b.1 construct approximately 30 linear feet of boulder cascade for outfall protection below half round pipe outlet and in Project 32b.2 install 50 linear feet of boulder cascade at headcut downstream. Regrade upper banks and replace invasive plants with native vegetation.
Related Projects	None
Estimated Project Cost:	$82,000 (2012 revision)

Looking upstream (32b.1) 10/20/2006

Looking upstream at previous photo (32b.1) 03/09/2012

Looking Upstream (32b.2) 10/20/2006



Project No. 32b.2
50 LF of stream restoration
using boulder cascade

Project No. 32b.1
30 LF of half round pipe outfall
using boulder cascade

Project Location Map

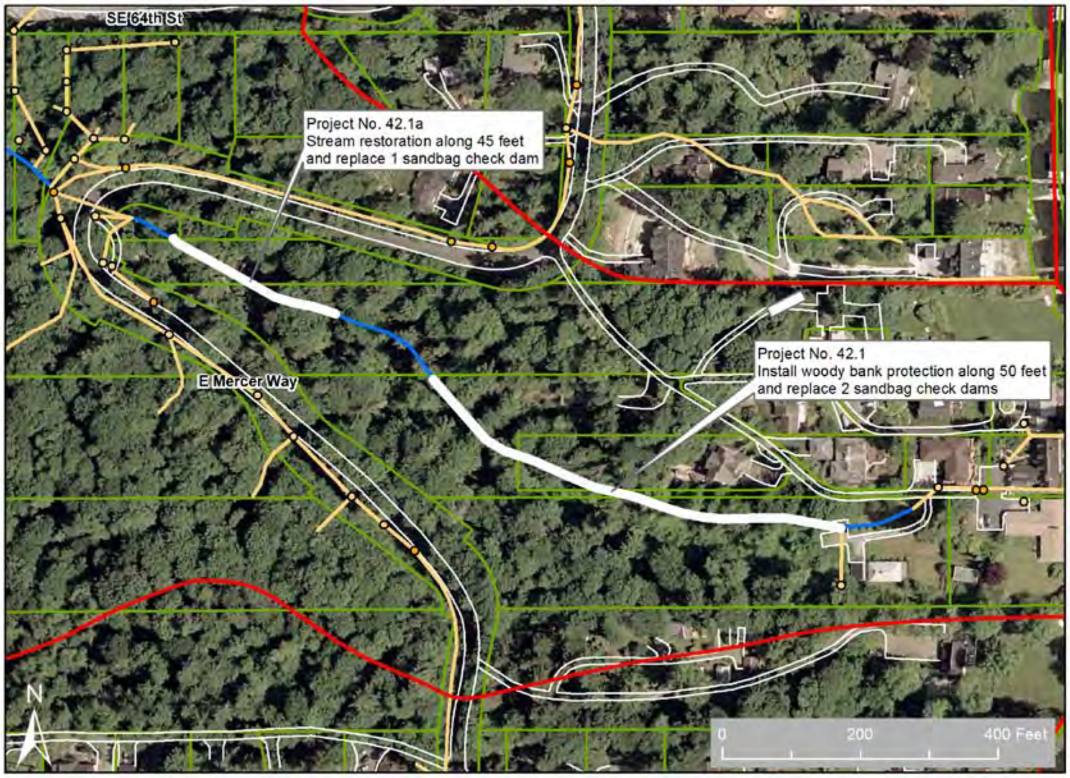
PROJECT SUMMARY SHEET

Basin No.:	42
Project No:	42.1a (upstream) and 42.1 (downstream)
Project Title:	**Install Large Woody Debris for Bank Protection and Stream Restoration Along 95 LF of Bank and Replace 3 Failing Sandbag Check Dams with Rock Check Dams or Rock Vortex Weirs Where Failure Poses a Risk.**
Problem Description:	About 14 sandbag and geotextile check dams were installed at 20 to 100 feet intervals as temporary protection of these reaches. The dams are up to 4 feet high and most are beginning to fail. While there is a large amount of fine grained sand behind the dams and in the channel, in some cases the failure will not increase the risk of erosion. On the downstream end of the reach (Project 42.1), a 30 foot long sandbag check dam with a 4 foot drop and 1.5 foot plunge pool is showing failure with erosion on both banks into blue-grey silt overlain with 2 feet of soils. Failure of this structure would release a large amount of fine sediment. Another check dam in the downstream end with a 2 foot drop and 3 foot plunge pool may fail by undercutting. Bank erosion is also occurring in several locations. One eroding bank of loose soils on the right bank measures 8 feet high and 30 feet long; another measures 4 to 5 feet high and 15 feet long, and another 50 feet of 7 foot high bank is eroding. In addition, a 2 to 3 foot high debris jam at the upstream end of the reach (Project 42.1a) could fail. The south bank appears to be slide material and much of the riparian area would be considered wetlands. Not mapped by the Watershed Company as having potential fish use. See Appendix E for a field sketch of the problem area.
Project Description:	Replace failing sandbag check dams that pose a risk to increase erosion with rock check dams or rock vortex weirs. Check dams are less expensive but rock vortex weirs may be needed to provide fish passage. Also provide bank protection and stream restoration along about 95 feet of bank. Stream restoration would include logs/large woody debris, boulders, bank regrading and planting.
Related Projects	None
Estimated Project Cost:	$284,000 (2012 revision)

Looking Upstream at 3' High Sandbag and Geotextile Dam 9/28/2005

Looking Upstream 3/3/2006

Downstream end of eroding right bank, 7 feet high and 50 feet long, with undercut and separated pipe directly in front of engineer 03/09/2012.



Project No. 42.1a
Stream restoration along 45 feet
and replace 1 sandbag check dam

Project No. 42.1
Install woody bank protection along 50 feet
and replace 2 sandbag check dams

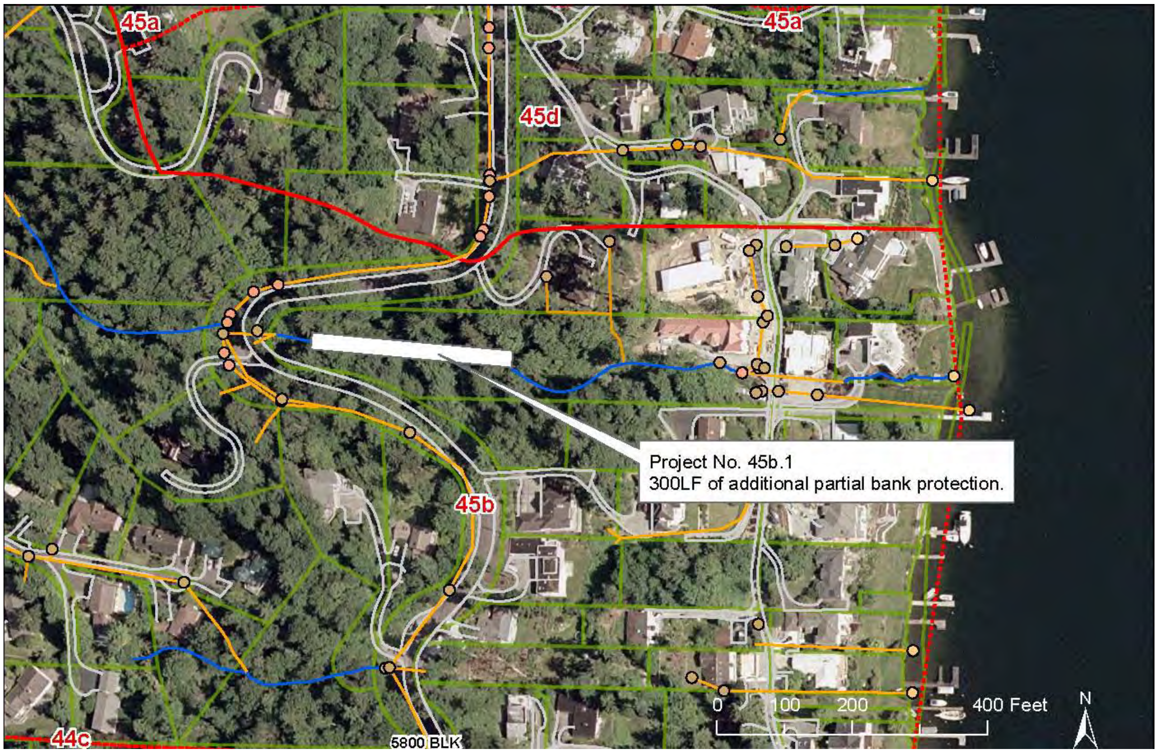
Project Location Map

PROJECT SUMMARY SHEET

Basin No.:	45b
Project No:	45b.1
Project Title:	**Partial Stream Restoration along 300 feet near East Mercer Way in 5600 Block.**
Problem Description:	Existing quarry spall check dams are relatively effective but some repairs and bank protection needed. Erosion creates downstream deposition and potential for failure of East Mercer Way from undermining adjacent steep slopes.
Project Description:	Partial stream restoration along 300 feet of channel involving repairs and additions to existing check dams as well as habitat friendly bank protection.
Related Projects	None
Estimated Project Cost:	$158,000 (2012 revision)

Looking Upstream at Recent Bank Erosion 12/22/2011

Looking Upstream 12/8/2005



Project No. 45b.1
300LF of additional partial bank protection.

Project Location Map

PROJECT SUMMARY SHEET

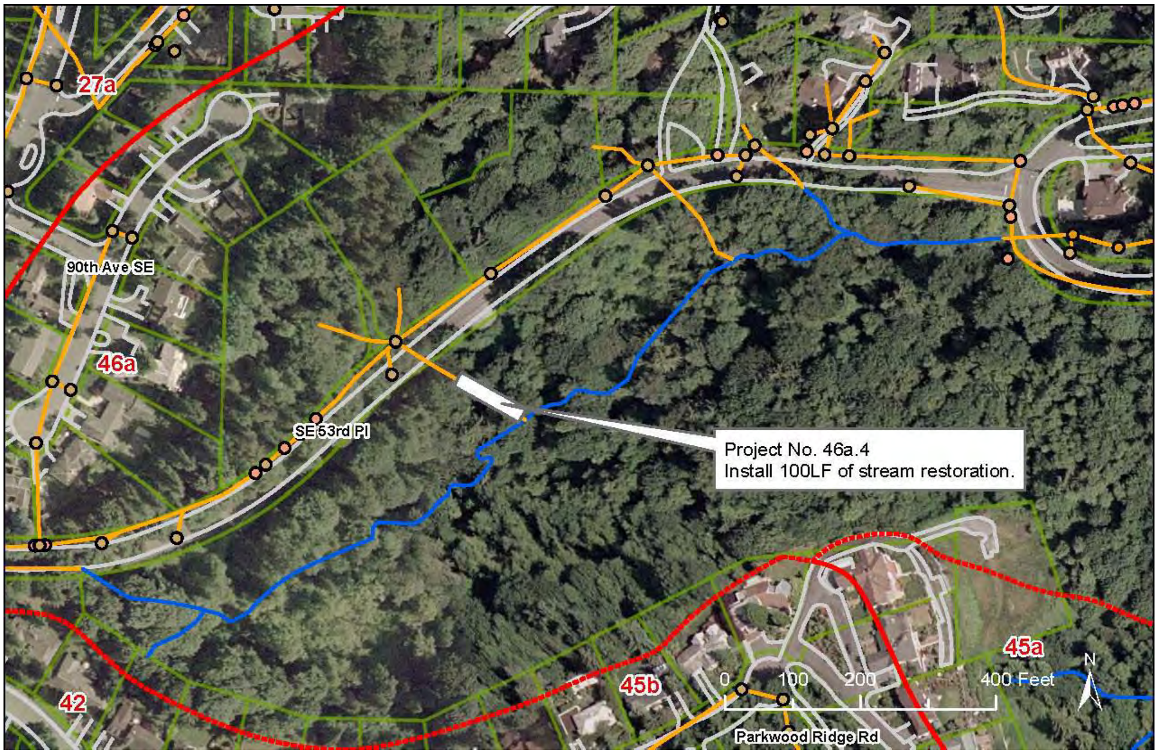
Basin No.:	46a
Project No:	46a.3
Project Title:	**Install 250 Feet of 24-inch Corrugated Polyethylene Pipe in Channel to Stop Slope Movement near SE 53rd Place.**
Problem Description:	Large scale slope movement into creek is pinching channel along 250-foot reach. Creek erosion of toe and fill south of street may be contributing to slope movement. This maybe a large source of sediment. The slope and much of the contributing area is mapped as a slide. Recent slope failures documented during 2011 survey primarily at the toe of the slope where the stream is eroding. Monitoring of the slide is warranted.
Project Description:	Install 250 feet of 24-inch CPEP along channel. Environmental and permitting concerns may be significant. Additional investigation should be done to determine if another alternative (rock lining and removal of fill at the top of the slope along the road) would stabilize the slope. Since SE 53rd Place work completed (see below), any additional work needed at Project 46a.3 could potentially be completed by City of Mercer Island maintenance staff. See Appendix E for field map.
Related Projects	City completed improvements to the drainage system in SE 53rd Place to reduce direct runoff into problem area. All tributaries north of SE 53rd Place now drain directly into system along the north side of road and discharge back into the mainstem channel at the downstream end at East Mercer Way. This bypass has been successful in reducing flows within the problematic reach and reducing erosion of the slope where culverts discharged directly onto the slope. Sediment detention pond present at downstream end at East Mercer Way. Maintenance records should be reviewed to determine if erosion has been mitigated following new project.
Estimated Project Cost:	$99,000 (2012 revision)

Recent Slope Toe Failure from Bank Erosion 12/22/2011

Project Location Map

PROJECT SUMMARY SHEET

Basin No.:	46a
Project No:	46a.4
Project Title:	**Stream restoration along 100 feet of channel near 53rd Place**
Problem Description:	Downstream of pipe outlet, channel is downcutting along 100 feet of soft fill and slide material. This tributary stream is located south of 53rd Place on city open space.
Project Description:	Stream restoration along 100 feet to stabilize soft bed and banks. Since SE 53rd Place work completed (see below), any additional work could potentially be completed by city maintenance staff.
Related Projects	City completed improvements to the drainage system in SE 53rd Place to reduce direct runoff into problem area. All tributaries north of SE 53rd Place now drain directly into system along the north side of road and discharge back into the mainstem channel at the downstream end at East Mercer Way. This bypass has been successful in reducing flows within the problematic reach and reducing erosion of the slope where culverts discharged directly onto the slope. Sediment detention pond present at downstream end at East Mercer Way. Maintenance records should be reviewed to determine if erosion has been mitigated following new project.
Estimated Project Cost:	$87,000 (2012 revision)



Project Location Map

PROJECT SUMMARY SHEET

Basin No.:	46a
Project No:	46a.6
Project Title:	**Relocate Watercourse and Protect Bank for 30 LF.**
Problem Description:	Some stabilization work previously completed on this reach in the 1990s (check dams). Erosion of south bank presents moderate risk to residence at 5325 Butterworth Road despite wood pilings and some rock bank toe protection. Older piles on downstream end have significant rot. Resident noted in 2011 that the channel has incised approximately 4 feet over the past 18 years. The channel is currently 7 feet from the residence. No significant change observed between 2008 and 2011 surveys.
Project Description:	Relocate watercourse toward Butterworth Road and protect bank for 30 LF.
Related Projects	None
Estimated Project Cost:	$45,000 (2012 revision)

Looking Downstream at Residence 3/31/2008

Project No. 46a.6
30LF of Channel relocation and bank protection
at 5325 Butterworth

Project Location Map

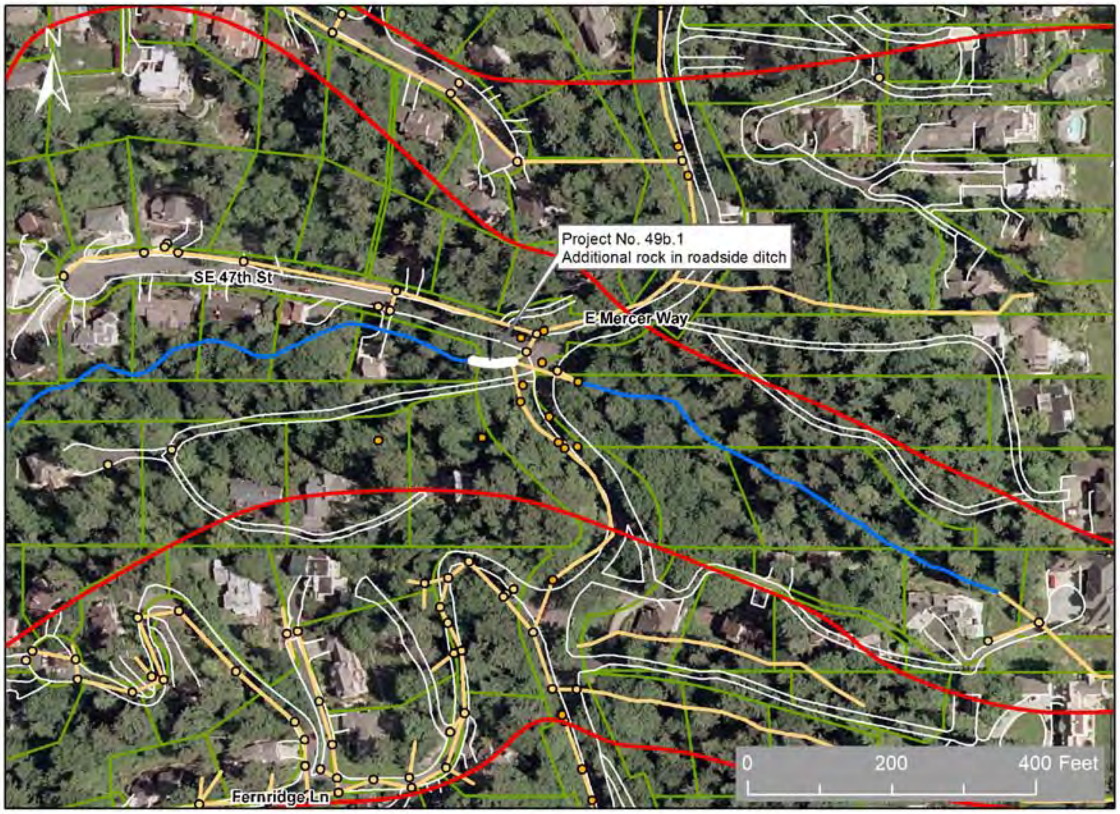
PROJECT SUMMARY SHEET

Basin No.:	49b
Project No:	49b.1
Project Title:	**Additional Rock in Roadside Ditch**
Problem Description:	Pipe system outlet from East Mercer Way and SE 47th Street discharges onto East Mercer Way embankment eroding a deep channel and 2 foot drop at outlet. Pipe outlet is also partially crushed, but functional. Channel is lined with quarry spalls ranging from 3-8 inches (at B-axis) See Appendix E for a field sketch of the problem area.
Project Description:	Add 3 to 5 cubic yards of riprap or rock minimum 6-8 inches diameter (existing quarry spalls are too small). Work can be done by City maintenance crews.
Related Projects	None
Estimated Project Cost:	$12,000 (2012 revision)

Erosion at Pipe Outlet (pipe crushed) 12/8/2005

Erosion at Pipe Outlet, same location as above 03/09/2012

Looking toward East Mercer Way with outfall from road at upper left and culvert draining slope behind camera 03/09/2012



Project Location Map

Problem 4.2

Problem 4.2

Problem 4.2

Problem 6.4/6.5

Problem 6.4/6.5

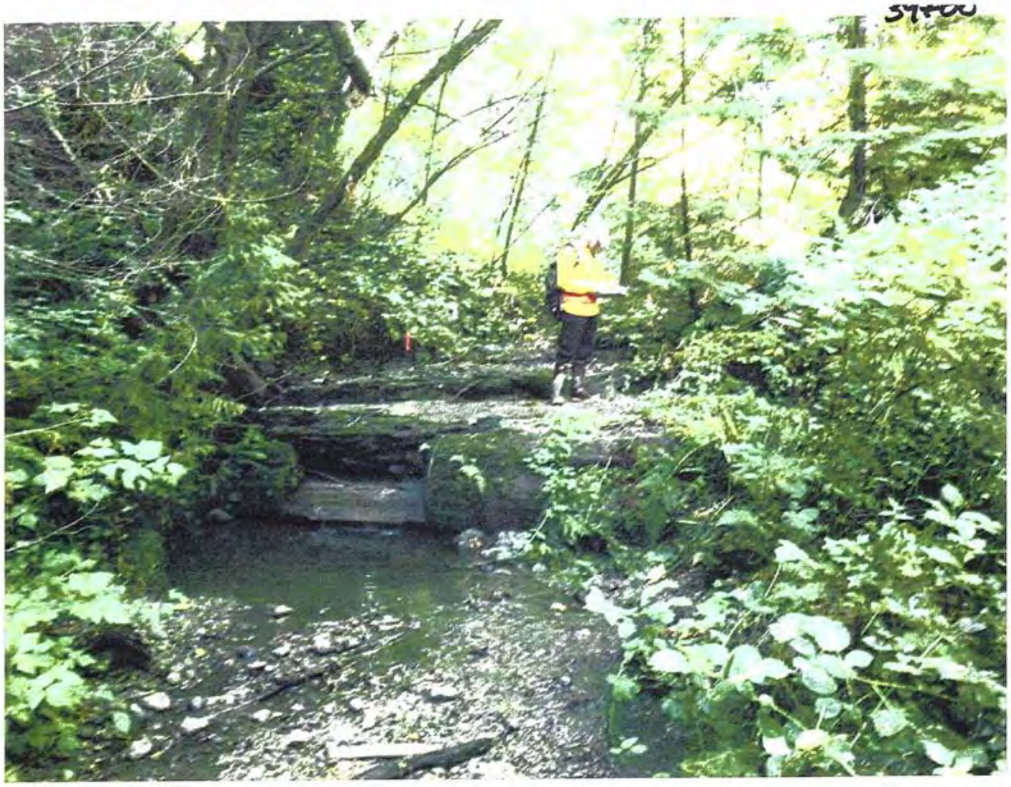
Problem 6.4/6.5

Problem 6.4/6.5

Problem 6.4/6.5

Problem 6.4/6.5

Problem 6.4/6.5



Problem 6.4/6.5

Problem 6.4/6.5

Problem 6.4/6.5

Problem 6.4/6.5

Problem 23.2

Problem 23.2

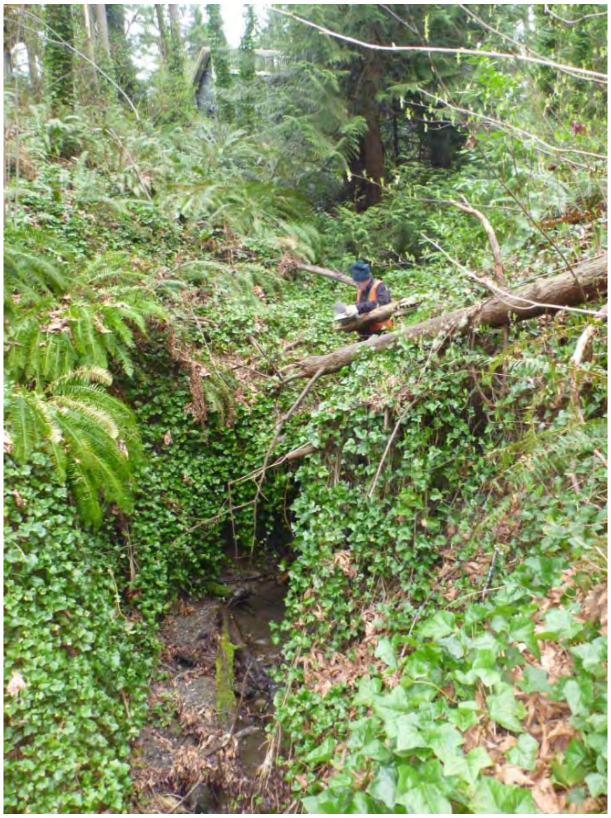
Problem 23.2

Problem 23.2

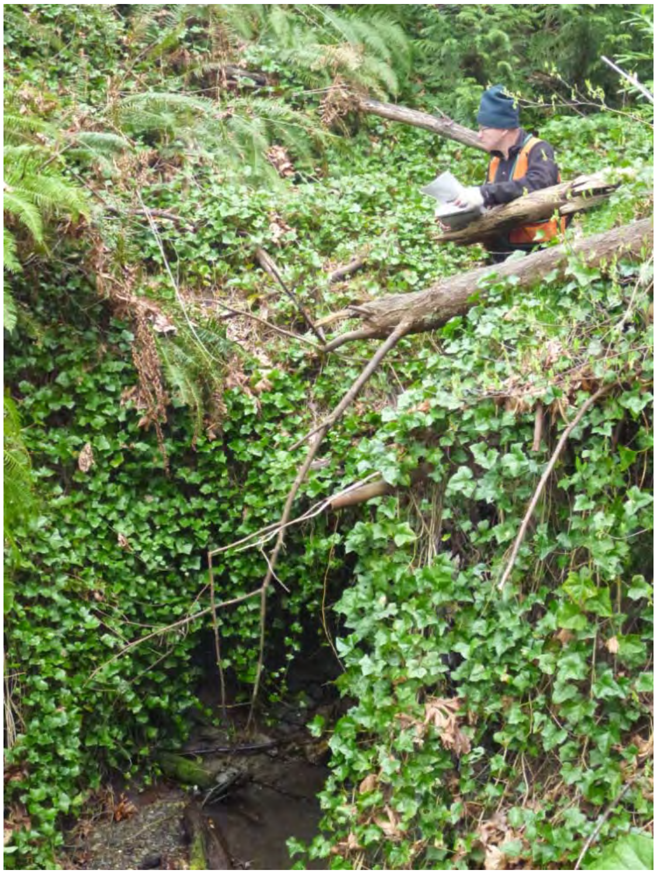
Problem 23.2

Problem 23.2

Problem 23.2



Problem 23.2



Problem 23.2

Problem 23.2

Problem 23.2

Problem 23.2

Problem 27a.6

Problem 27a.6

Problem 27a.6

Problem 27a.11

Problem 27a.11

Problem 27a.11

Problem 29.2

Problem 29.2

Problem 32b.1

Problem 32b.1

Problem 32b.2

Problem 32b.2

Problem 42.1/42.1A

Problem 42.1/42.1A

Problem 42.1/42.1A

Problem 42.1/42.1A

Problem 42.1/42.1A

Problem 42.1/42.1A

Problem 42.1/42.1A

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Problem 42.1/42.1A

Problem 42.1/42.1A

Problem 42.1/42.1A

Problem 42.1/42.1A

Problem 42.1/42.1A

Problem 45b.1

Problem 45b.1

Problem 45b.1

Problem 46a.3

Problem 46a.3

Problem 46a.6

Problem 46a.6

Problem 49b.1

Problem 49b.1

Problem 49b.1

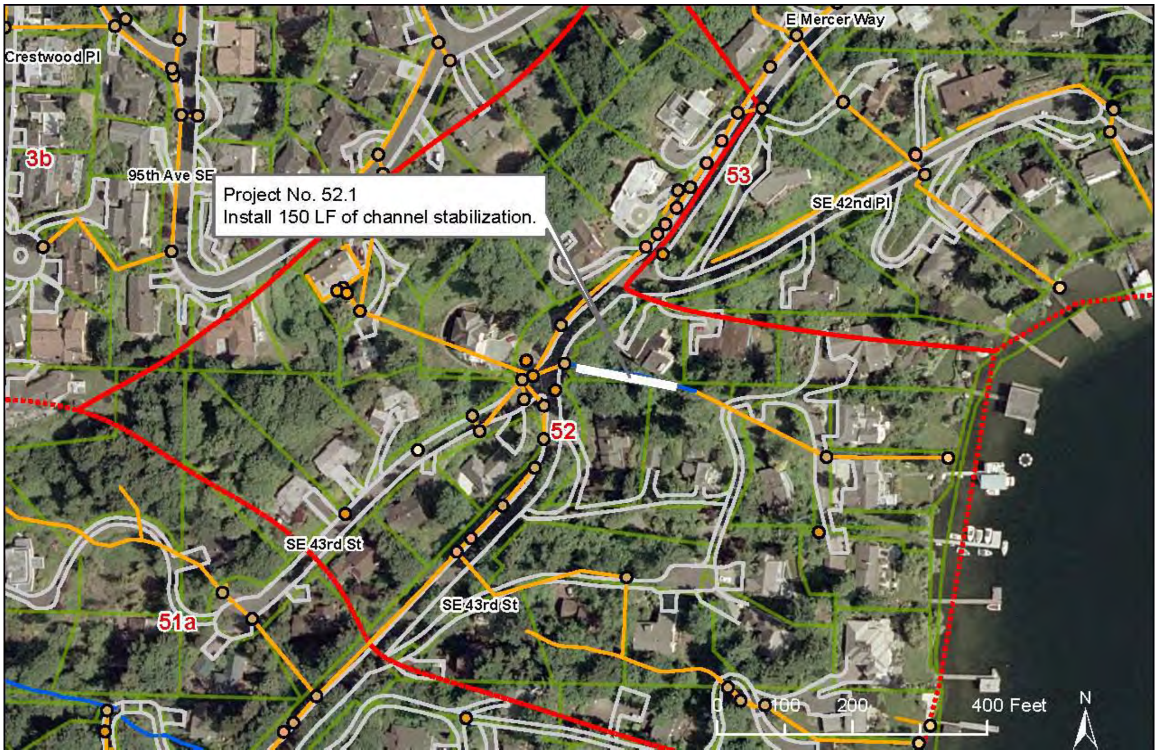
PROJECT SUMMARY SHEET

Basin No.:	52
Project No:	52.1
Project Title:	**150 feet of Channel Stabilization on Downstream Side of East Mercer Way in 4300 Block**
Problem Description:	Rapid bed erosion, bank erosion, East Mercer Way embankment erosion, and headcuts in a small channel with a bottom width of 2 to 6 feet and a depth of 2 to 8 feet on downstream side of East Mercer Way. Bed and banks consist of erodible poorly sorted, unconsolidated sand and gravel and fill. See Appendix E for field sketch of problem area.
Project Description:	Installation of channel stabilization on 150 feet of this small water course.
Related Projects	None
Estimated Project Cost:	$93,000 (2012 revision)

Looking Upstream 12/14/2005

Looking Downstream at Poorly Sorted, Unconsolidated Sand to Very Coarse Gravel 3/9/2012

Steep Silty Sand 8’ High Banks from Right Bank 3/9/2012



Project No. 52.1
Install 150 LF of channel stabilization.

Project Location Map

Problem 49b.4

Problem 49b.4

Problem 49b.4

Problem 50b.4-Reach A

Problem 50b.4-Reach A

Problem 50b.4-Reach B

Problem 50b.4-Reach C

Problem 50b.4-Reach C

Problem 50b.4-Reach D

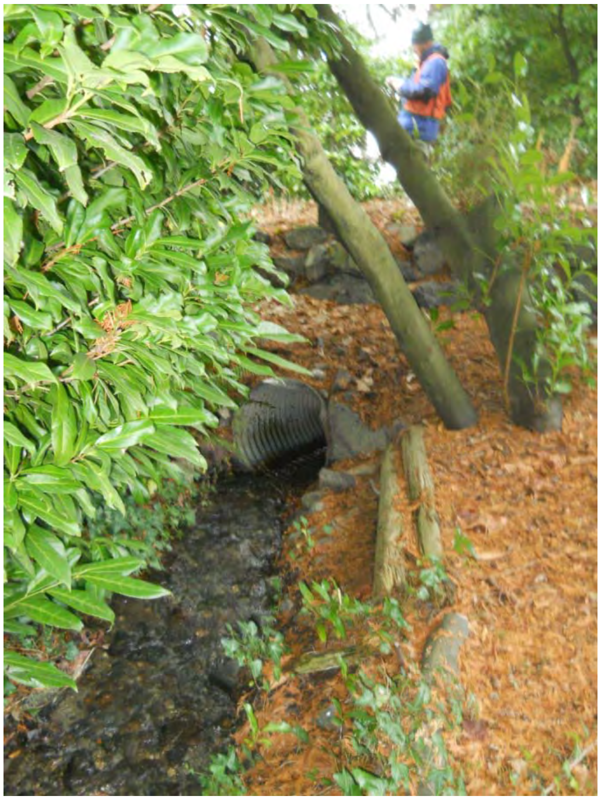
Problem 50b.4-Reach D

Problem 50b.4-Reach E

Problem 50b.4-Reach E

Problem 50b.4-Reach E

Problem 50b.4-Reach E



Problem 50b.4-Reach F

Problem 50b.4-Reach F

Problem 50b.4-Reach G

Problem 52.1

Problem 52.1

Problem 52.1

Problem 52.1

Problem 52.1

Problem 52.1

Problem 52.1

Mercer Island Comprensive Drainage Plan- Field Reconnaissance

Subbasin 4A **Problem No.** 4.2 By: J. Bjork 12/22/2011

Site Conditions

Geology: Qtb Qva Qvt Qvr Colluvium fill Undetermined slide

Flow Today: _____gpm ____cfs **Approx. Channel Gradient** 0-1% 2-5% 5-10%>10%

Bank Vegetation type: Native Invasive Landscaped

Bank Vegetation quality: Excellent Good Fair Poor

Aquatic Habitat: Excellent Good Fair Poor None

Proximity to Drainage Outfalls: ___ ft. up/downstream ________________" CMP RCP PVC CPEP

Erosion of: bed left bank right bank headcut ________________

Apparent rate of Erosion: stable Slow change Moderate change Rapid change

Risks (Check Applicable)

	None	Private	Public	Creates Unsafe Condition
Bank Stability				
Upper Slope Stability				
Landslide				
Sediment source				
Habitat destruction				
Threatens home				
Threatens other structure				
Threatens private road/driveway				
Threatens infrastructure				
Threatens public road				

Risk to Homes:	**Horiz (ft)**	**Vert (ft)**	**Address**	**Apparent Hazard**
No risk_____				Low Med High
				Low Med High

Solutions

Construction Access:	yes	No	
			Conventional Equipment to site
			Conventional Equipment down ravine
			Conventional Equipment to top of ravine
			Crane (less than 200')
			Cable Way (straight line)
			Small equipment
			Chute/skid

Potential Reduction in O&M costs None Small Moderate Significant

Restoration of construction access: Native Landscaped ___________LF

Concept:

Outfall protection ___________LF

Bypass Pipe ___________LF

Check dams ___________LF

Channel restoration ___________LF

Stream restoration ___________LF

Other ________________________

no change since 2010 survey. downstream end of gabion wall is failing

possible solutions: rock check structure for side channels

- lower half may need to relocate lower 20-40' away from road

- upper half; fill channel (? [illegible] slide) or pipe

Potential Monitoring Site: Yes No

Mercer Island Comprensive Drainage Plan- Field Reconnaissance

Subbasin 4 **Problem No.** 3c By: J. Bjork 12 / 22 / 01

Site Conditions

Geology: Qtb Qva Qvt Qvr Colluvium fill Undetermined slide

Flow Today: ____gpm ____cfs **Approx. Channel Gradient** 0-1% 2-5% 5-10%>10%

Bank Vegetation type: Native Invasive Landscaped

Bank Vegetation quality: Excellent Good Fair Poor

Aquatic Habitat: Excellent Good Fair Poor None

Proximity to Drainage Outfalls: ___ ft. up/downstream ________________" CMP RCP PVC CPEP

Erosion of: bed left bank right bank headcut ________________

Apparent rate of Erosion: stable Slow change Moderate change Rapid change

Risks (Check Applicable)

	None	Private	Public	Creates Unsafe Condition
Bank Stability				
Upper Slope Stability				
Landslide				
Sediment source				
Habitat destruction				
Threatens home				
Threatens other structure				
Threatens private road/driveway				
Threatens infrastructure				
Threatens public road				

Risk to Homes:	**Horiz (ft)**	**Vert (ft)**	**Address**	**Apparent Hazard**
No risk_____				Low Med High
				Low Med High

Solutions

	yes	No	
Construction Access:			Conventional Equipment to site
			Conventional Equipment down ravine
			Conventional Equipment to top of ravine
			Crane (less than 200')
			Cable Way (straight line)
			Small equipment
			Chute/skid

Potential Reduction in O&M costs None Small Moderate Significant

Restoration of construction access: Native Landscaped ____________LF

Concept:

Outfall protection ____________LF

Bypass Pipe ____________LF

Check dams ____________LF

Channel restoration ____________LF

Stream restoration ____________LF

Other ________________________________

1' drop at US outlets 8'x10' Scour pool @ outlet

Potential Monitoring Site: Yes No

Mercer Island Comprensive Drainage Plan- Field Reconnaissance

Subbasin 4 **Problem No.** 4 By: J. Bjork 12/22/11

Site Conditions

Geology: Qtb Qva Qvt Qvr Colluvium fill Undetermined slide

Flow Today: _____ gpm ____ cfs **Approx. Channel Gradient** 0-1% 2-5% 5-10%>10%

Bank Vegetation type: Native Invasive Landscaped

Bank Vegetation quality: Excellent Good Fair Poor

Aquatic Habitat: Excellent Good Fair Poor None

Proximity to Drainage Outfalls: ____ ft. up/downstream ____________________" CMP RCP PVC CPEP

Erosion of: bed left bank right bank headcut ____________________

Apparent rate of Erosion: stable Slow change Moderate change Rapid change

Risks (Check Applicable)

	None	**Private**	**Public**	**Creates Unsafe Condition**
Bank Stability				
Upper Slope Stability				
Landslide				
Sediment source				
Habitat destruction				
Threatens home				
Threatens other structure				
Threatens private road/driveway				
Threatens infrastructure				
Threatens public road				

Risk to Homes:	**Horiz (ft)**	**Vert (ft)**	**Address**	**Apparent Hazard**
No risk_____				Low Med High
				Low Med High

Solutions

	yes	No	
Construction Access:			Conventional Equipment to site
			Conventional Equipment down ravine
			Conventional Equipment to top of ravine
			Crane (less than 200')
			Cable Way (straight line)
			Small equipment
			Chute/skid

Potential Reduction in O&M costs None Small Moderate Significant

Restoration of construction access: Native Landscaped ____________LF

Concept:

Outfall protection ____________LF

Bypass Pipe ____________LF

Check dams ____________LF

Channel restoration ____________LF

Stream restoration ____________LF

Other ____________________________

No change from 2010 survey

Potential Monitoring Site: Yes No

Mercer Island Comprensive Drainage Plan- Field Reconnaissance

Subbasin 6 **Problem No.** 6.4 UPDATED (6.4 + 6.5) **By:** F. Gu/ NSD 2/15/2011 → SEPT. 2011 3 VISITS

± 1800 LF

Site Conditions

Geology: Qtb [✓ Qva] Qvt Qvr Colluvium fill Undetermined slide

Flow Today: ____ gpm 1 cfs **Approx. Channel Gradient** 0-1% [✓ 2-5%] 5-10% >10%

Bank Vegetation type: [✓ Native] [✓ Invasive] Landscaped

Bank Vegetation quality: Excellent Good [✓ Fair] [✓ Poor]

Aquatic Habitat: Excellent [✓ Good] Fair Poor None

Proximity to Drainage Outfalls: 1800 ft. up/[✓ downstream] TYPE II @ I-90 " CMP RCP PVC CPEP

Erosion of: [✓ bed] [✓ left bank] [✓ right bank] headcut

Apparent rate of Erosion: stable Slow change Moderate change [✓ Rapid change]

Risks (Check Applicable)

	None	Private	Public	Creates Unsafe Condition
Bank Stability		✓		
Upper Slope Stability	✓			
Landslide		✓		
Sediment source		✓	✓	
Habitat destruction		✓		
Threatens home	✓			
Threatens other structure	✓			
Threatens private road/driveway	✓			
Threatens infrastructure	✓			
Threatens public road	✓			

Risk to Homes: Horiz (ft) Vert (ft) Address Apparent Hazard

No risk____ Low Med High

Low Med High

Solutions

	yes	No	
Construction Access:		✓	Conventional Equipment to site
		✓	Conventional Equipment down ravine
		✓	Conventional Equipment to top of ravine
	?		Crane (less than 200')
	✓		Cable Way (straight line)
	✓		Small equipment
	?		Chute/skid

Potential Reduction in O&M costs None Small [✓ Moderate] Significant

Restoration of construction access: [✓ Native] Landscaped 500-1000 LF

Concept:

Outfall protection ______ LF

Bypass Pipe ______ LF

Check dams ______ LF

Channel restoration ______ LF

Stream restoration ______ LF

Other STABILIZE BANKS AND BED BY HAND-BUILD METHODS,
TRANSPORT MATERIALS BY WAY OF ZIPLINE AND/OR BY FOOT.
REPAIR & REPLACE APPROXIMATELY 20 FAILED LOG WEIRS THAT WERE BUILT IN 1998.
PLACE BOULDERS/COBBLE IN PLUNGE POOLS. PLUG UNDERMINED AREA WITH ADDITIONAL LOGS/ROCKS
WDFW SUPPORTS PIPING W. BRANCH OF WATERCOURSE

Potential Monitoring Site: [✓ Yes] No

10/25/2011

Sub-Basin 6 - Area 2

No.	STA		Field Notes	Recommended Fix
1	🟨 2450		Failing vertical slope LB. Sand/gravel. 40ft long, 10ft tall. Incised channel 2ft, cobble/gravel. Aspect STA 25+00	
2	🟨 2700	🟪 ****	Failed log weir, 3ft drop. Massive failed slope LB, 40ft long, 20ft tall. Large (3ft-6ft DBH) trees. Above slope (5-maple, fir, cedar (3)). Incised channel 5ft deep downstream of weir. End-run LB - likely triggered toe failure of LB.	
3	🟦 2775		Functioning log weir, but continued drop scour could undermine.	Place boulders/cobble in plunge pool to reduce/eliminate scour
4	🟨 2830		Eroding LB, 6-10ft vertical sand/clay.	Place toe boulders and/or catch/fill structure
5	🟦 2875		Log weir, 3ft drop. End-run LB. Functioning, but potentially soon to fail. End-run RB.	
6	🟦 2920		Functioning log weir, but continued drop scour could undermine.	Place boulders/cobble in plunge pool to reduce/eliminate scour
7	🟪 2980		Recently/barely failed log weir - continued "jet" scour will further undermine.	Plug undermined area w/additional logs/rock. Place boulders/cobble in plunge pool to reduce/eliminate scour.
8	🟨 3060	****	Massive failed slope LB, 40ft long, 20ft tall. Multiple downed trees.	
9	🟩 3120	++++	Template jam. In-channel, 3ft drop, stable.	
10	🟨 3170	🟪	Failing RB 40ft long - center. Failed weir, 3ft drop, scour behind RB toe logs for 10ft.	
11	🟩 3200	++++	Template jam. In-channel, small drop, holding back 4ft of sediment.	
12	🟨 3275		Destabilized bank logs. Incised channel 3ft. Vertical clay bank. Aspect flag 18+00.	
13	🟨 3320	🟪	Failed log weir. Incised 4ft. In-channel jam at 33+30. Stabilized 2ft of upstream fill. Failed DS bank log along RB. SD incised channel 3ft. Bank log LB, RB US. Vertical US LB w/bank log at toe - appears stable.	Stabilize in-channel jam at 33+30 to make into catch/fill structure.
14	🟦 3400		1ft drop in bed over historic bed log. Aspect flag 17+00.	Place boulders/cobble in plunge pool to reduce/eliminate scour
15	🟦 3420		Log weir 2ft drop. Large sand bar upstream. Stable (generally). May underscour at weir north. In-channel downstream logs providing down-channel stability for 80% of weir.	Place boulders/cobble in plunge pool to reduce/eliminate scour
16	🟪 3500	🟨	Failed log wier. Double-notched. Channel incising 3ft-4ft upstream to 35+20 and downstream to 34+00 and beyond. Storm drain (10-inch) at upstream side of weir. 4-man rock US. Minor end-run along RB. Active slumping LB.	
17	🟦 3520		In-channel jam. 3ft drop. Some destabilizing on LB.	Stabilize jam - reinforce left bank to prevent continued destabilization.
18	🟦 3560		Log weir. Less than 1ft drop. End-run along LB.	Place boulders/cobble in plunge pool to reduce/eliminate scour. Stabilize end-run along LB.
19	🟨 3580		LB steep shoulder (?) and vertical clay face.	Place layers of large boulders at toe of left bank to minimize toe scour.
20	🟪 3650		Failing log weir. 4ft drop. Upstream double bank logs. Proceeding for 50ft.	Place boulders/cobble in plunge pool to reduce/eliminate scour. Place similar to rock bed control structure, but at surface to gradually step (4H:1V) from log weir to streambed.
21	🟦 3675		Destabilized rock stop, 1.5ft drop. Bank logs both sides.	Build up rock stop at end of bank/toe logs and use area between bank/toe logs as catch/fill structure.
22	🟨 3700		LB slide area (Aspect flag). Bank logs both sides. Channel downcut as much as 2ft.	
23	🟨 3725		Bottom of 75ft long cascade/trench/chute. Clay bottom. Incised but fairly stable. Bank logs perched 3ft above streambed along RB.	Supplement with additional large boulders to dissipate energy and fill-in undercut banks. ?Possibly remove unsightly green geotextile fabric?
24	🟦 3860		Log weir. Stable. Top of cascade.	Reinforce log weir/jam. Place boulders/cobble in plunge pool to reduce/eliminate scour. Stabilize end-run along LB and RB.
25	🟪 3900		Failing log weir. 4ft drop. End-run on RB and LB. 30ft sediment wedge.	Reinforce log weir/jam. Place boulders/cobble in plunge pool to reduce/eliminate scour. Stabilize end-run along LB and RB.
26	🟪 4020	🟨	Bottom end of section. Failed log step and bank log. 4ft drop. Slump LB 20ft.	
27	🟪 4050		Failing log step. End-run RB. 4ft drop.	Place boulders/cobble in plunge pool to reduce/eliminate scour. Stabilize end-run along RB.

Legend

🟨 = Failed slope
🟪 = Failing or failed log weir
🟦 = Functioning log weir
🟩 = Template functioning log grade control or jam

CALL 48 HOURS BEFORE YOU DIG
1-800-424-5555
NORTHWEST UTILITIES NOTIFICATION CENTER

0 50 100
SCALE IN FEET

Natural Systems Design
P.O. Box 15609
Seattle, WA 98115

NAME OR INITIALS AND DATE	
DESIGNED	
CHECKED	
DRAWN	
CHECKED	
DATE	MARCH 2011

CITY OF MERCER ISLAND

SUB-BASIN 6 - WATERCOURSE STABILIZATION PROJECT

GPS WATERCOURSE ALIGNMENT

SHEET 1 OF 3

0 50 100
SCALE IN FEET

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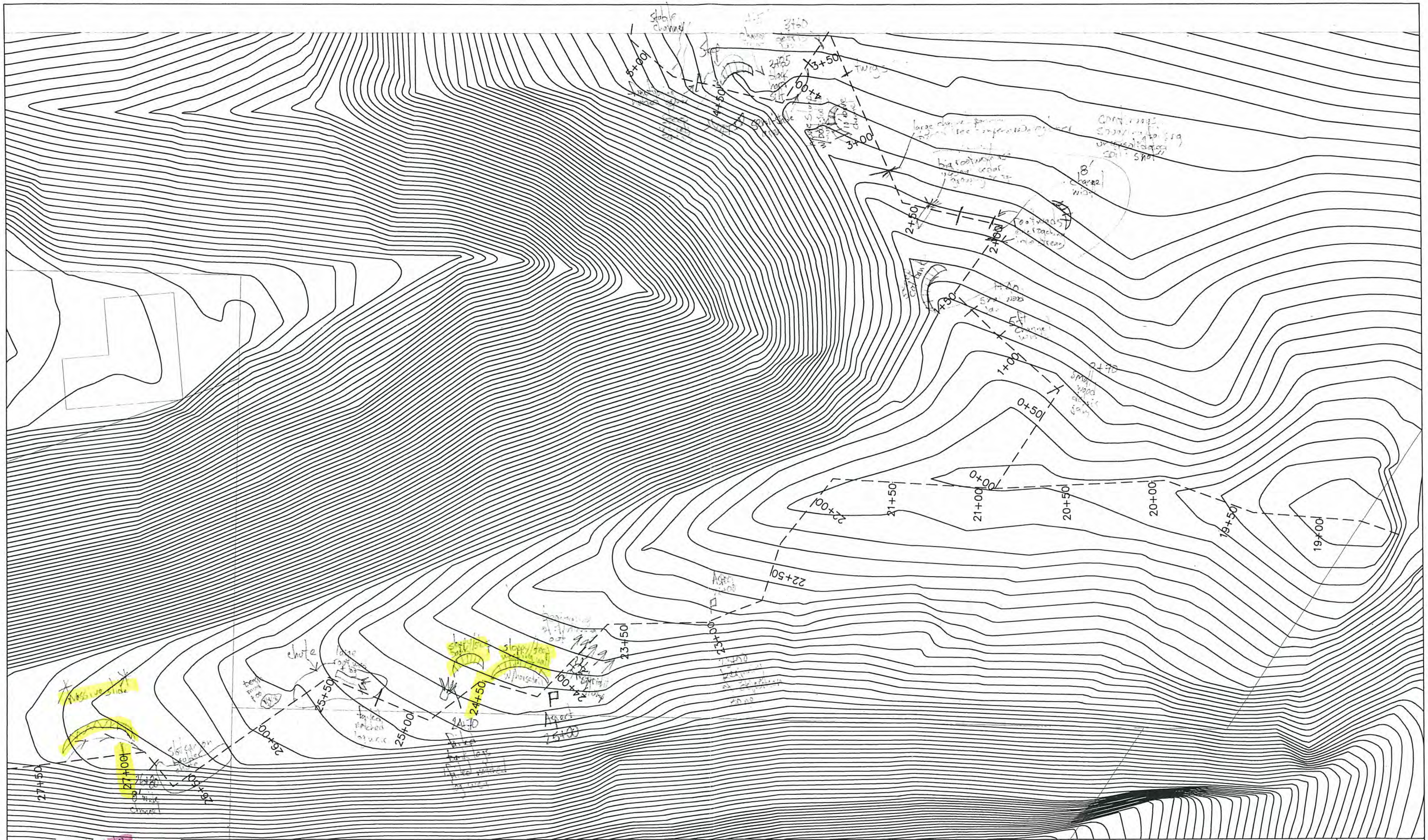
DATE MARCH 2011

CITY OF MERCER ISLAND

SUB-BASIN 6 - WATERCOURSE STABILIZATION PROJECT

GPS WATERCOURSE ALIGNMENT

SHEET 2 OF 3



not reached top
likely plugged then
end run on left bank
which except see
t canyon slope wise

0 50 100
SCALE IN FEET

CALL 48 HOURS
BEFORE YOU DIG
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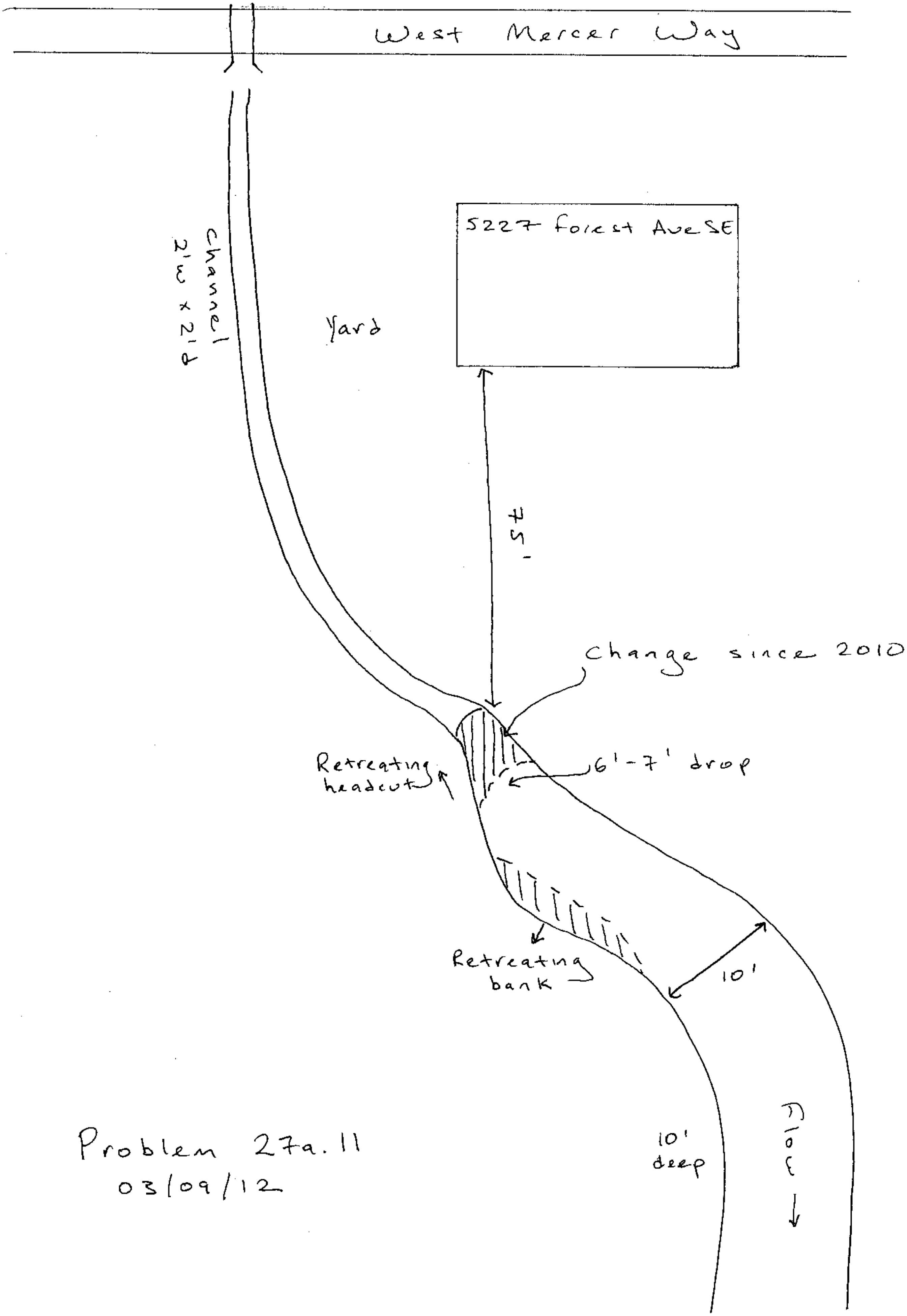
CHECKED	
DATE	MARCH 2011

CITY OF
MERCER ISLAND

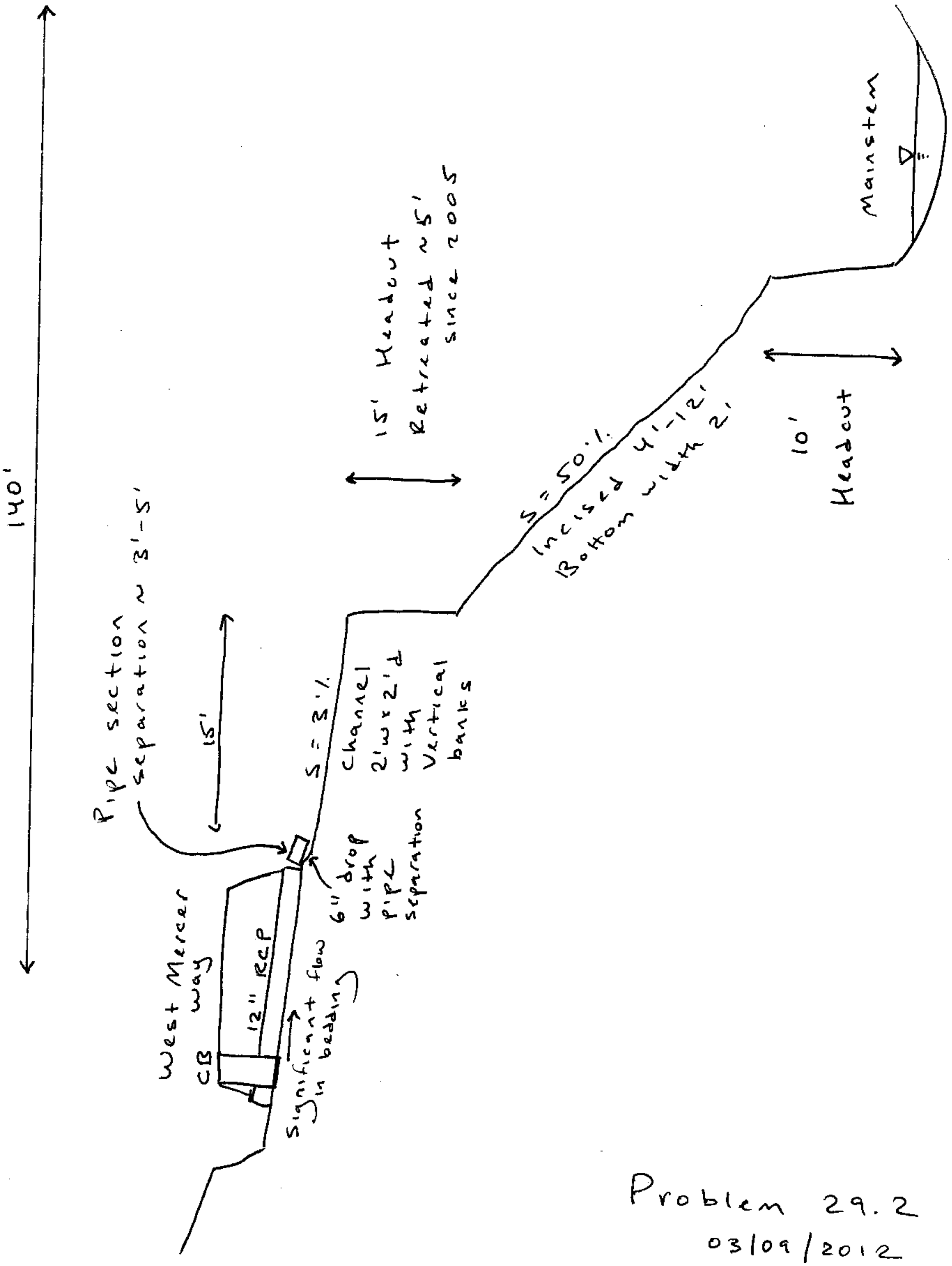
SUB-BASIN 6 - WATERCOURSE
STABILIZATION PROJECT

GPS WATERCOURSE ALIGNMENT

SHEET
3
OF
3



Problem 27a.11
03/09/12



Problem 29.2
03/09/2012

Sub-basin: 32b
Problem No.: 32b.1 and 32b.2
West Mercer Way Downstream to Meadow Lane
By: J. Bjork
Date: 3/9/2012

Station (ft)	Observations	Recommended Work
-1+00	36" culvert outlet under West Mercer Way	
0+50	Large angular rock and quarry spalls stabilized creek. Bed materials very compact sandy till. No problem.	
1+15	1' drop and metal plate entrance to half round CMP 5' ϕ. Has series of 1' drops	
2+01	End 10' of pipe section no longer attached but bed material is very dense sandy till. No change in 6 years.	
2+11	End CMP.	
	RB failure 2 ' deep X 20' L X 15' (max) high.	
	Monitoring section unchanged since 2008.	
2+90	7' drop. Very dense tan silt with debris jam. No significant change since 2006.	
3+34	Channel incision 10' in very dense tan silt, erosion resistant.	

Mercer Island Comprensive Drainage Plan- Field Reconnaissance

Subbasin 42 **Problem No.** ~~42.1A~~ 42.1 and 42.1a **By:** J. Bjork 3/3/06 3/9/12 Re-visit changes noted.

Site Conditions

Geology: [✓ Qtb] [✓ Qva] Qvt [✓ Qvr] Colluvium fill Undetermined [✓ slide]

Flow Today: ____gpm 1/2 cfs **Approx. Channel Gradient** 0-1% [✓ 2-5%] 5-10% >10%

Bank Vegetation type: [✓ Native] [✓ Invasive] Landscaped

Bank Vegetation quality: Excellent [✓ Good] Fair Poor

Aquatic Habitat: Excellent [✓ Good] Fair Poor

Proximity to Drainage Outfalls: ___ ft. up/downstream None " CMP RCP PVC CPEP

Erosion of: bed [✓ left bank] [✓ right bank] headcut

Apparent rate of Erosion: stable Slow change [✓ Moderate change] Rapid change

Risks (Check Applicable)

	None	Private	Public	Creates Unsafe Condition
Bank Stability		✓		
Upper Slope Stability	✓	✓		
Landslide	✓			
Sediment source		✓		
Habitat destruction		✓		
Threatens home	✓			
Threatens other structure	✓			
Threatens private road/driveway	✓			
Threatens infrastructure	✓			
Threatens public road	✓			

Risk to Homes: **Horiz (ft)** **Vert (ft)** **Address** **Apparent Hazard**

No risk ✓

Low Med High

Low Med High

Solutions

Construction Access:

yes	No	
✓	✓	Conventional Equipment to site
✓	✓	Conventional Equipment ~~down~~ up ravine
	✓	Conventional Equipment to top of ravine
	✓	Crane (less than 200')
✓		Cable Way (straight line)
✓		Small equipment
✓		Chute/skid

Potential Reduction in O&M costs None Small [✓ Moderate] Significant

Restoration of construction access: [✓ Native] Landscaped 200 LF

Concept:

Outfall protection ____ LF

Bypass Pipe ____ LF

Check dams 2 EA LF

Channel restoration ____ LF

Stream restoration 60 LF

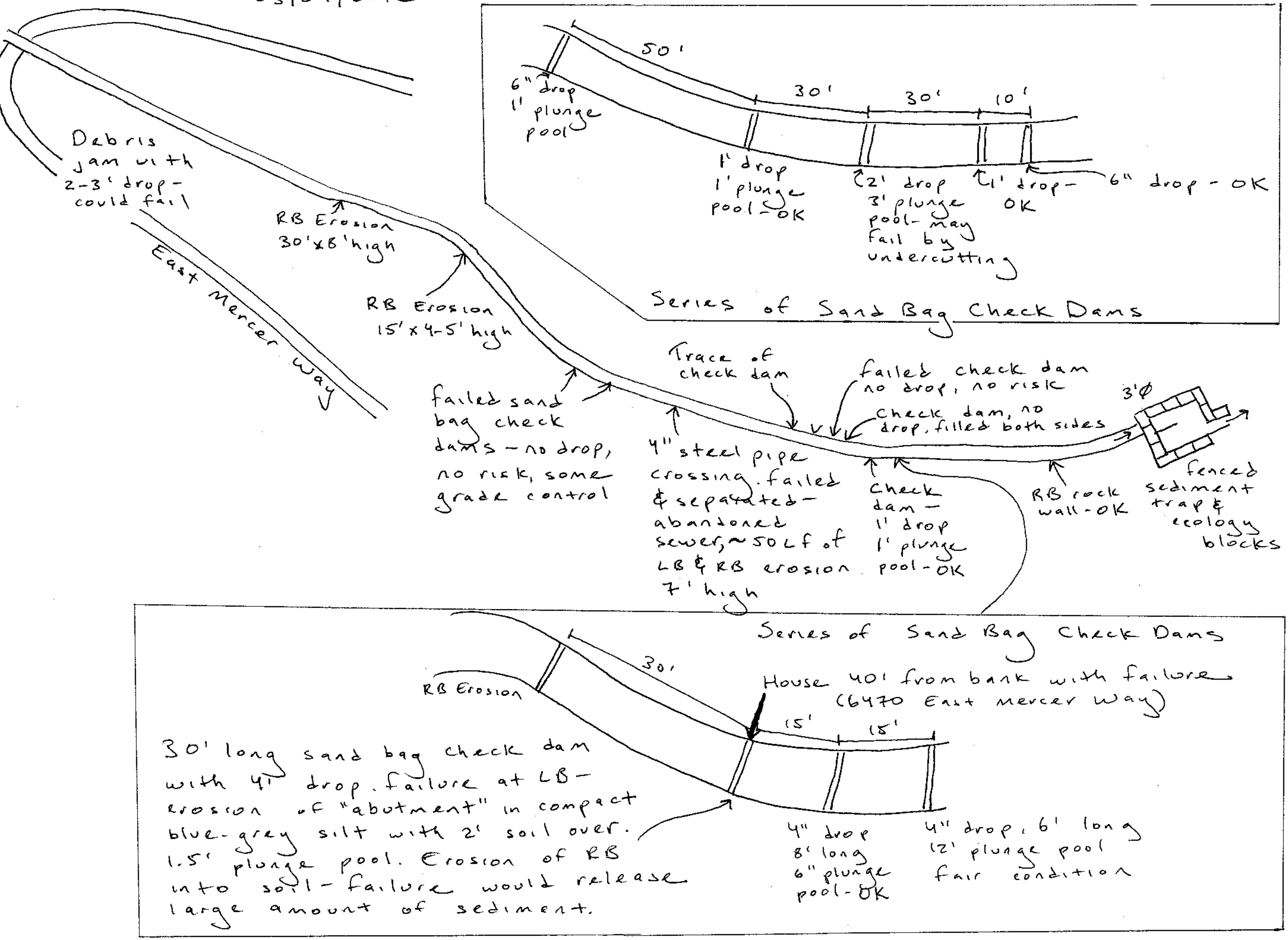
Other

Sand bag bank protection and check dam is failing. Right bank has some areas of erosion. Areas are intermittant. Sand bag check dam 3' high

Gabion lining US of 42.1A is OK

Potential Monitoring Site: [✓ Yes] No

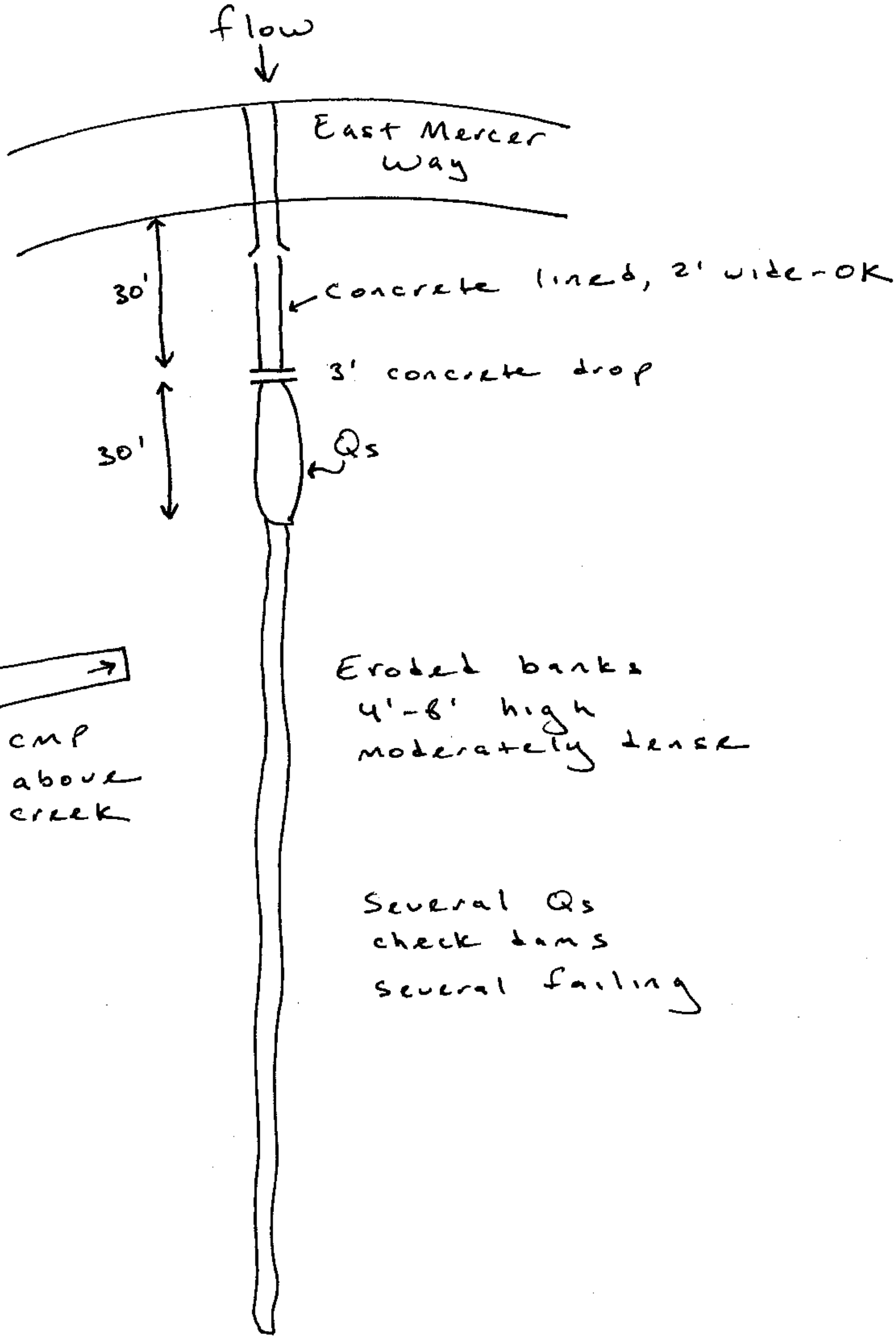
Problem 42.1 and 42.1A
03/09/2012



30' long sand bag check dam with 4' drop. failure at LB - erosion of "abutment" in compact blue-grey silt with 2' soil over. 1.5' plunge pool. Erosion of RB into soil - failure would release large amount of sediment.

Problem 45b.1
12/22/2011

A little worse -
by events since
2008?



Concrete lined, 2' wide - OK

3' concrete drop

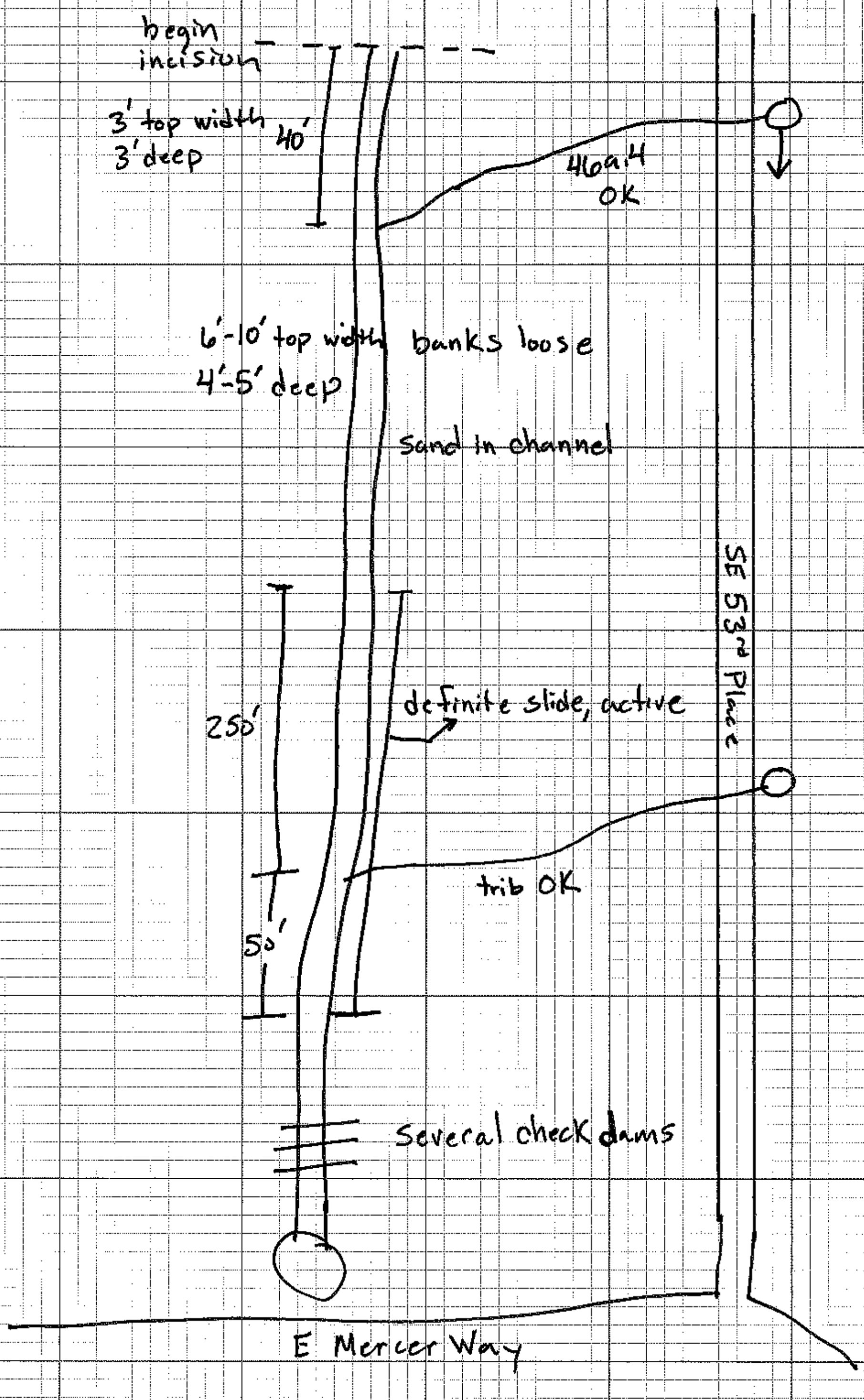
Eroded banks
4'-8' high
moderately dense

Several Qs
check dams
several failing

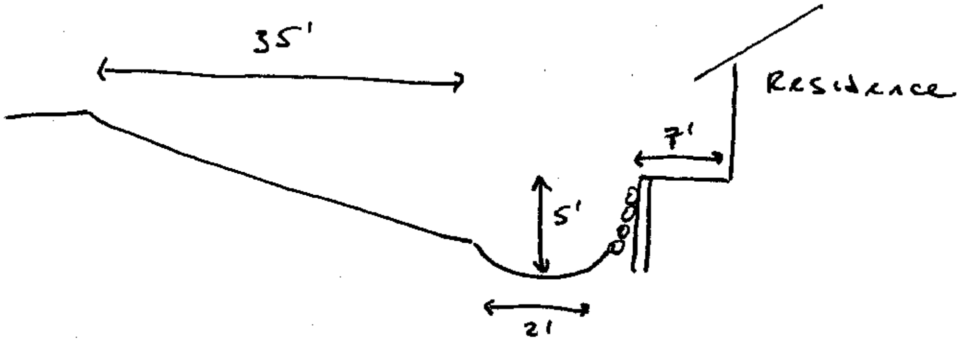
5638 East
Mercer Way

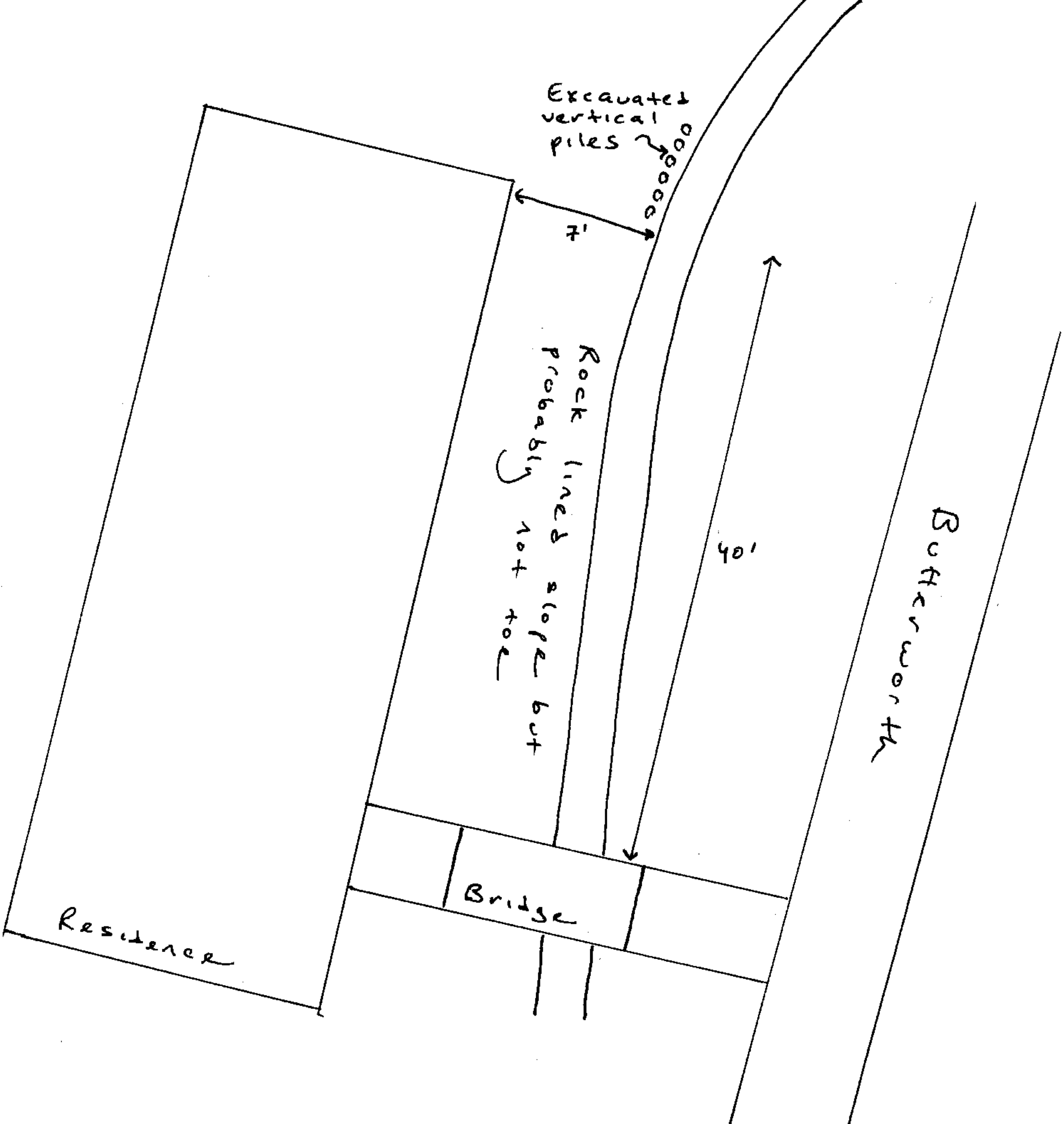
Needs
geotech

BY JB	DATE 12/22/11	SUBJECT 46a.3	SHEET NO. OF
CHECKED BY	DATE		PROJECT NO.

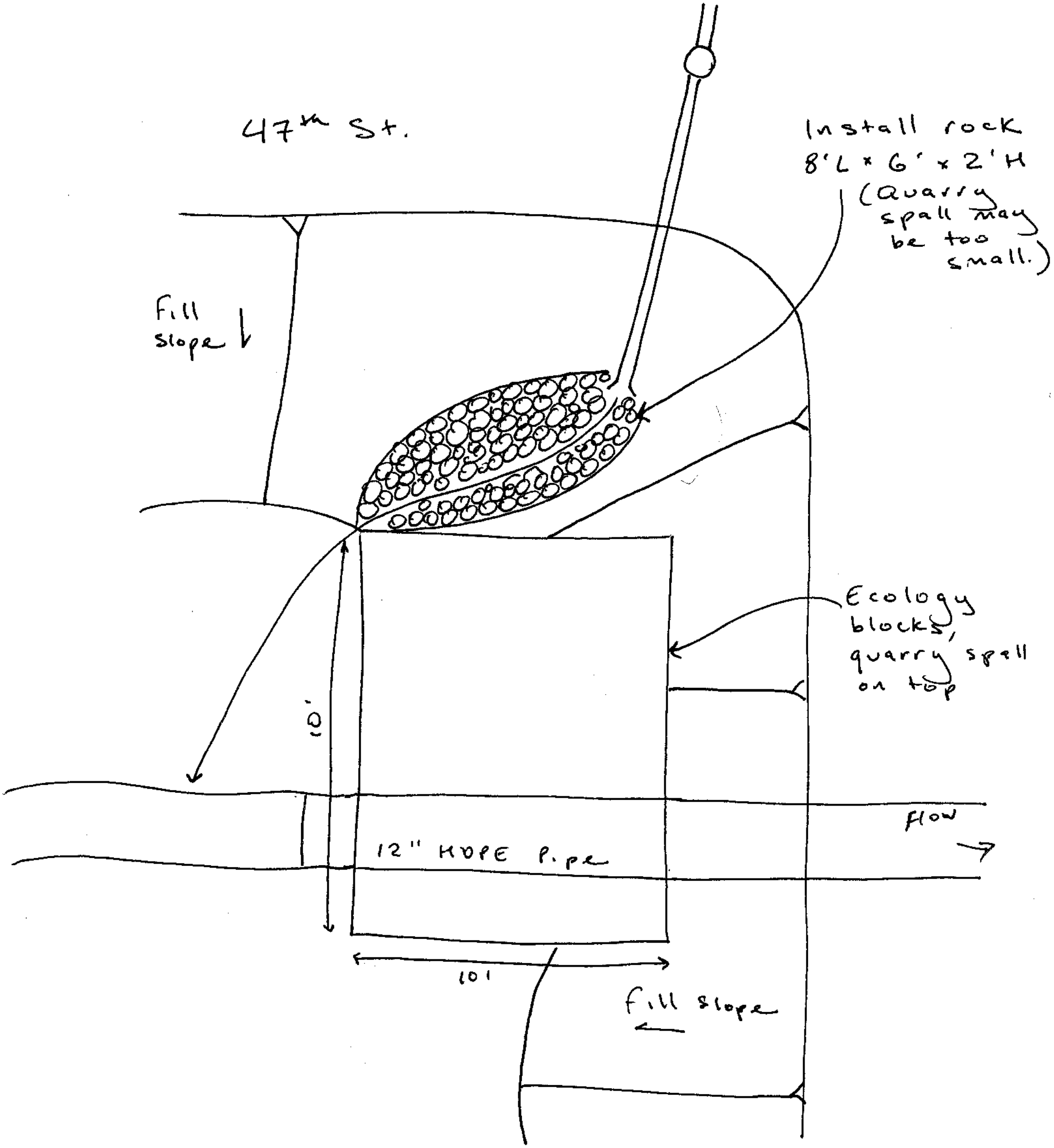


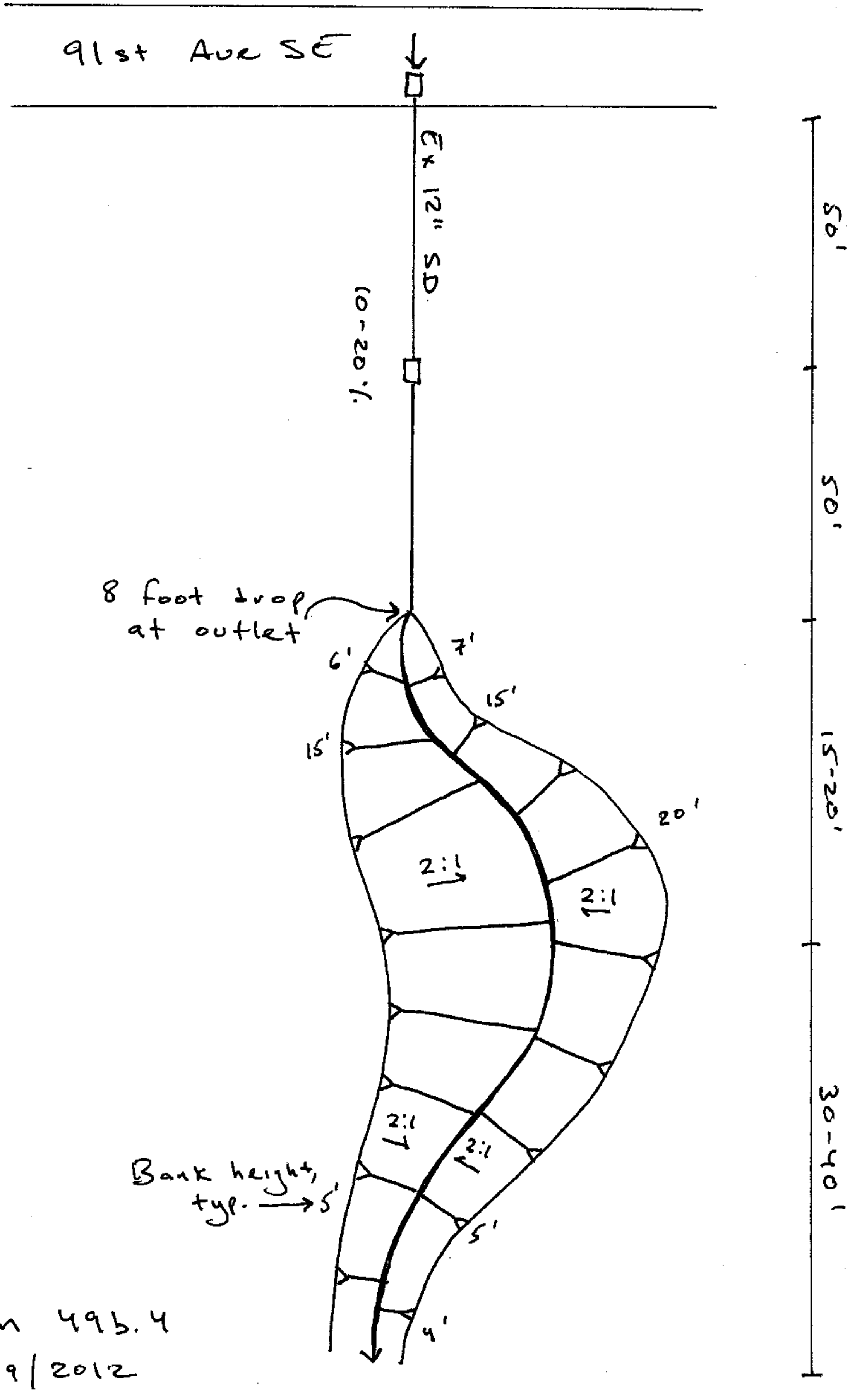
Problem 46a.6
12/22/2011





Problem 49b.1 03/09/2012





Problem 49b.4
03/09/2012

Mercer Island Comprensive Drainage Plan- Field Reconnaissance

Subbasin 50 **Problem No.** 64 By: J. Bjork 12/22/11
M. Ericsson

Site Conditions

Geology: Qtb [✓ Qva] Qvt Qvr Colluvium fill Undetermined slide
Flow Today: 200-300 gpm 1/2 cfs **Approx. Channel Gradient** 0-1% [✓ 2-5%] 5-10% >10%
Bank Vegetation type: [✓ Native] [✓ Invasive] [✓ Landscaped]
Bank Vegetation quality: Excellent [✓ Good] Fair Poor
Aquatic Habitat: Excellent [✓ Good] Fair Poor None
Proximity to Drainage Outfalls: 50 ft. [✓ up]/downstream to Sub. 1 " CMP RCP PVC CPEP
Erosion of: bed [✓ left bank right bank] headcut
Apparent rate of Erosion: stable [✓ Slow change] Moderate change Rapid change

Risks (Check Applicable)

	None	Private	Public	Creates Unsafe Condition
Bank Stability		X		
Upper Slope Stability	X			
Landslide	X			
Sediment source	X			
Habitat destruction	X			
Threatens home	X			
Threatens other structure	X			
Threatens private road/driveway		X		
Threatens infrastructure		X		
Threatens public road	X			

Risk to Homes:	**Horiz (ft)**	**Vert (ft)**	**Address**	**Apparent Hazard**
No risk X				Low Med High
				Low Med High

Solutions

Construction Access:	yes	No	
	X		Conventional Equipment to site
			Conventional Equipment down ravine
			Conventional Equipment to top of ravine
			Crane (less than 200')
			Cable Way (straight line)
			Small equipment
			Chute/skid

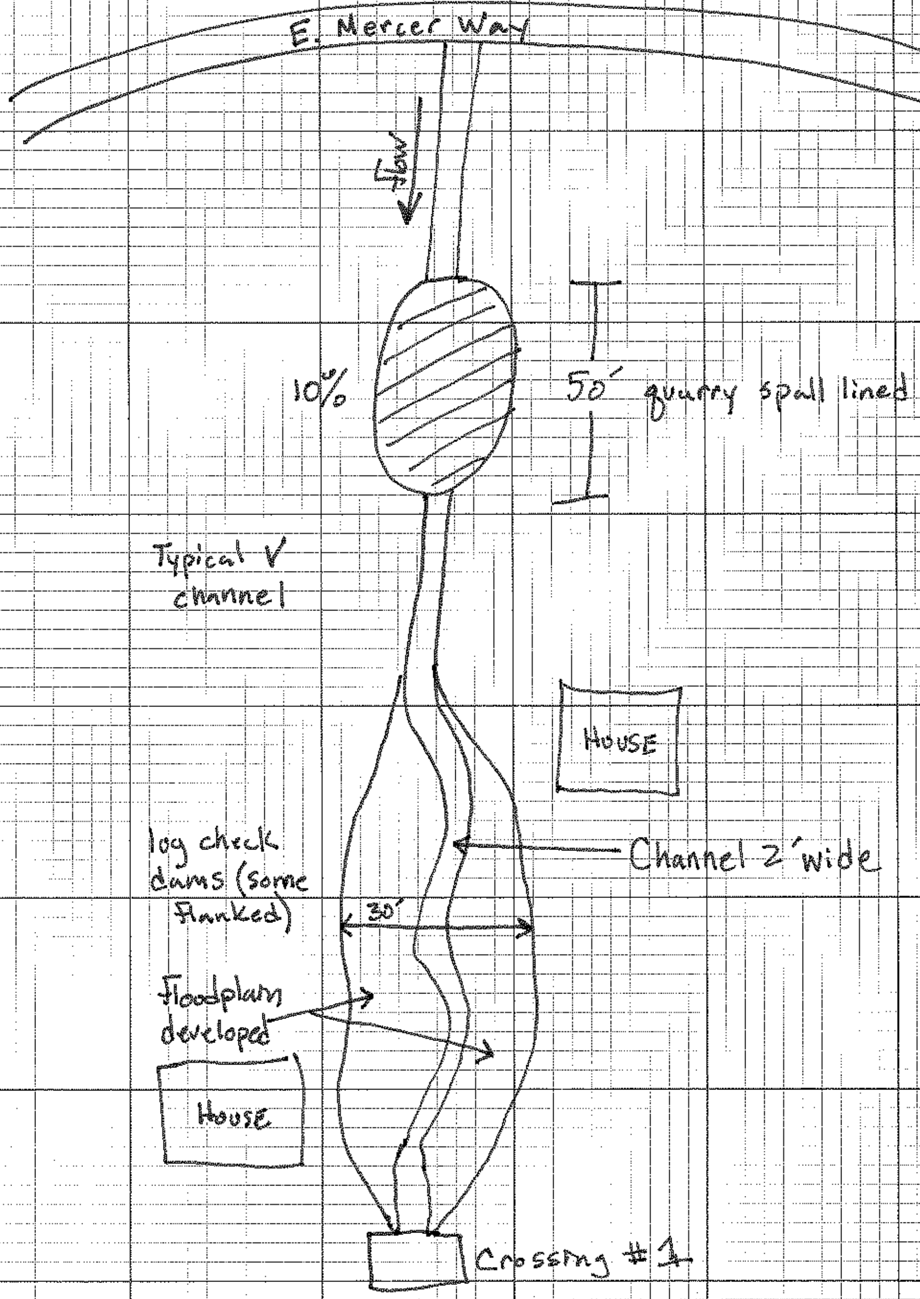
Potential Reduction in O&M costs [✓ None] Small Moderate Significant
Restoration of construction access: Native [✓ Landscaped] LF

Concept:
Outfall protection 20-30 LF ↘ check dam
Bypass Pipe LF
Check dams 5 LF
Channel restoration LF
Stream restoration LF
Other

outlet at bridge 4 (Ferncroft Rd) unstable rock protection
failed concrete weir

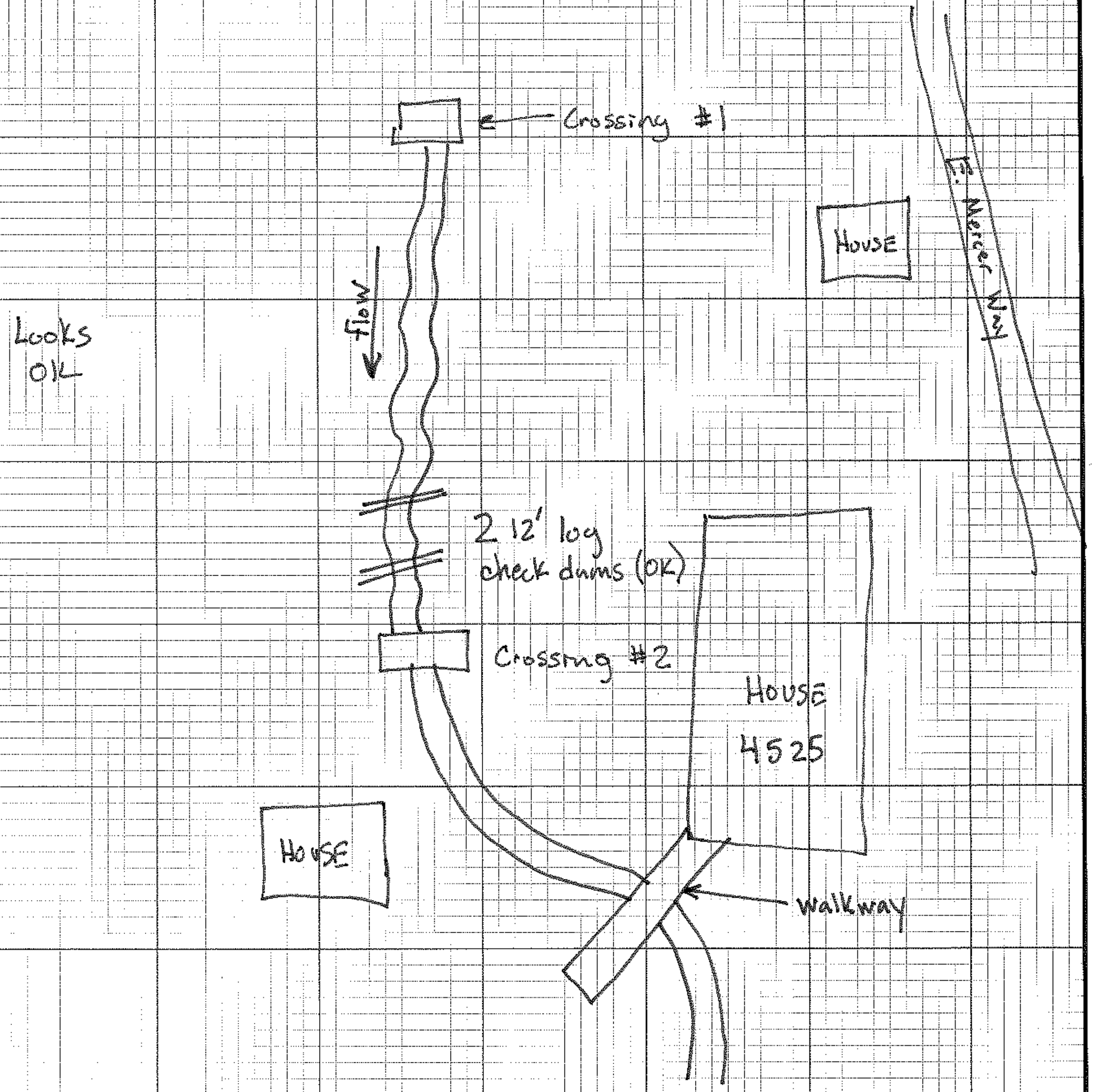
Potential Monitoring Site: Yes [✓ No]

BY JB
DATE 12/22/11
SUBJECT 506.4
Reach A (upstream end)
SHEET NO. 1 OF 7
CHECKED BY
DATE
PROJECT NO.

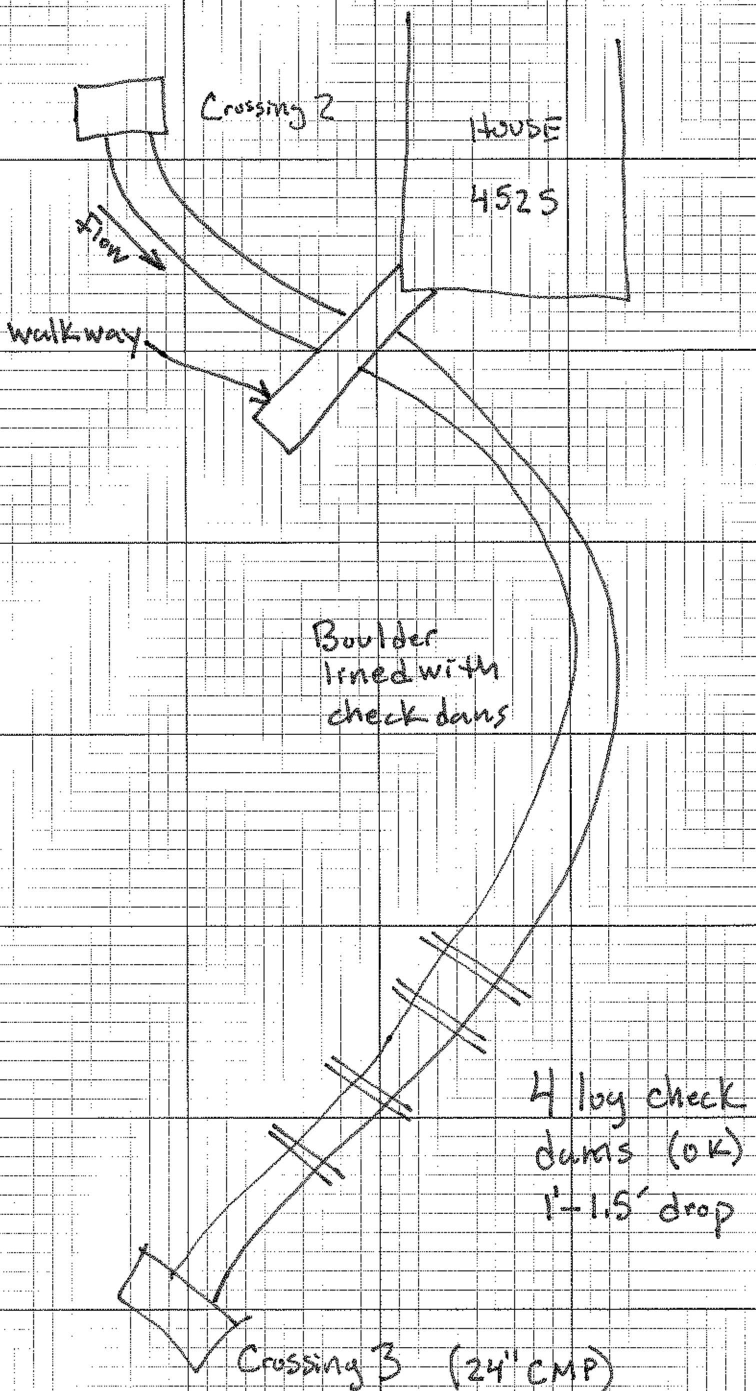


Looks OK

BY JB	DATE 12/22/11	SUBJECT 506.4	SHEET NO. 2 OF 7
CHECKED BY	DATE	Reach B	PROJECT NO.



BY JB	DATE 12/22/11	SUBJECT 506.4	SHEET NO. 3 OF 7
CHECKED BY	DATE	Reach C	PROJECT NO.



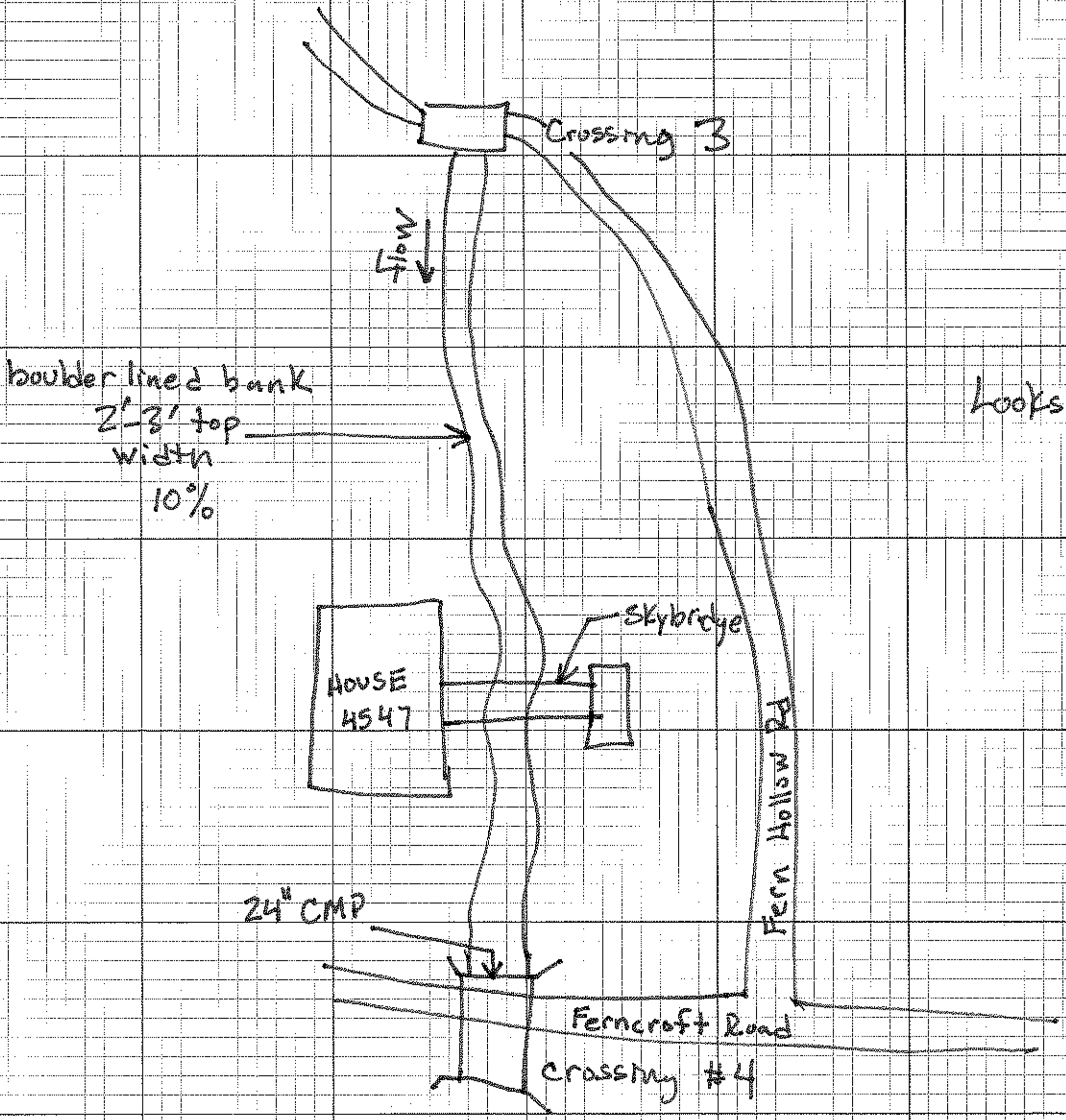
Looks OK

Boulder lined with check dams

4 log check dams (OK) 1'-1.5' drop

ENTRIX
Down to Earth. Down to Business.™

BY JB	DATE 12/22/11	SUBJECT 506.4	SHEET NO. 4 OF 7
CHECKED BY	DATE	Reach D	PROJECT NO.



Looks OK

ENTRIX

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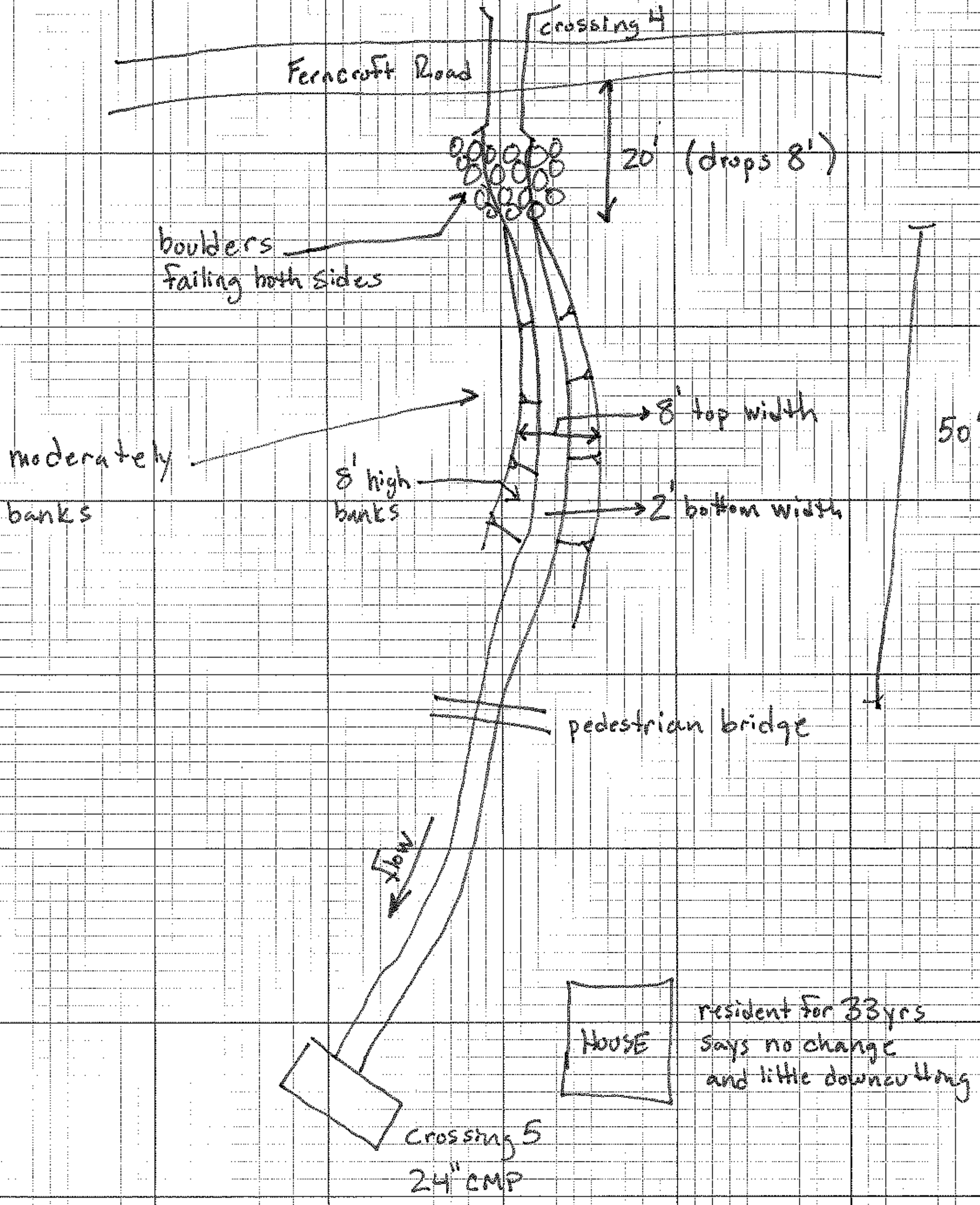
BY JB	DATE 12/22/11	SUBJECT 506.4	SHEET NO. 5 OF 7
CHECKED BY	DATE	Reach E	PROJECT NO.



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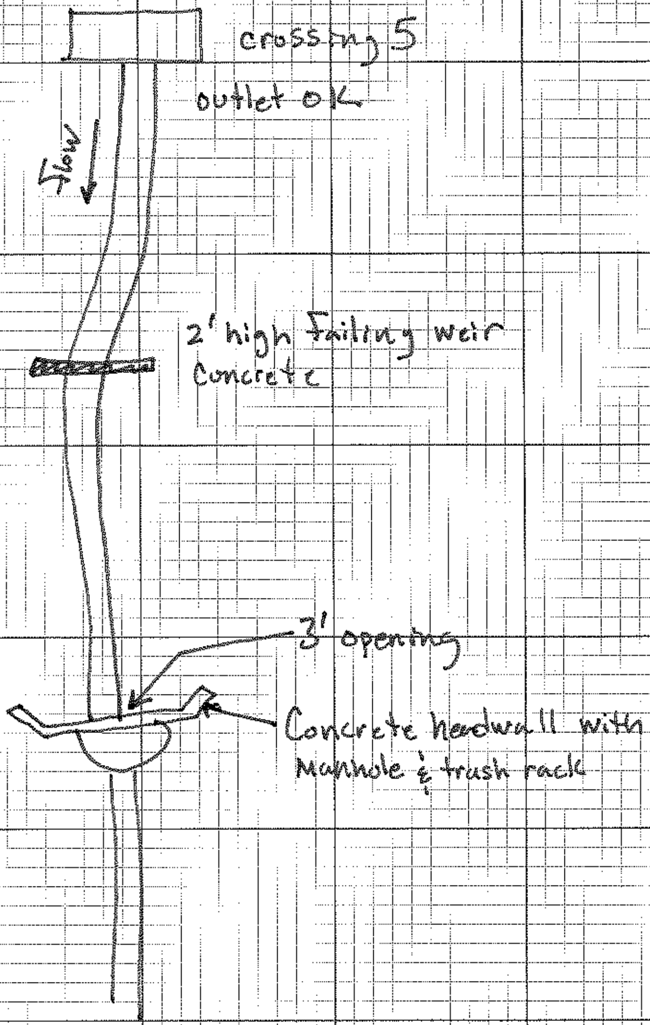
BY	DATE	SUBJECT	SHEET
JB	12/22/11	506.4	NO. 6 OF 7
CHECKED BY	DATE	Reach F	PROJECT NO.



ENTRIX

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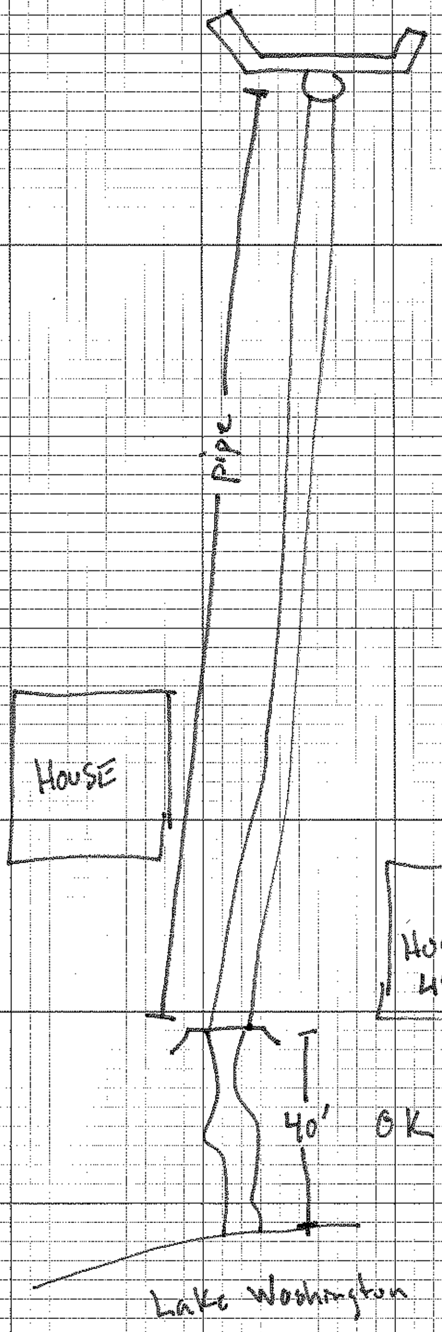
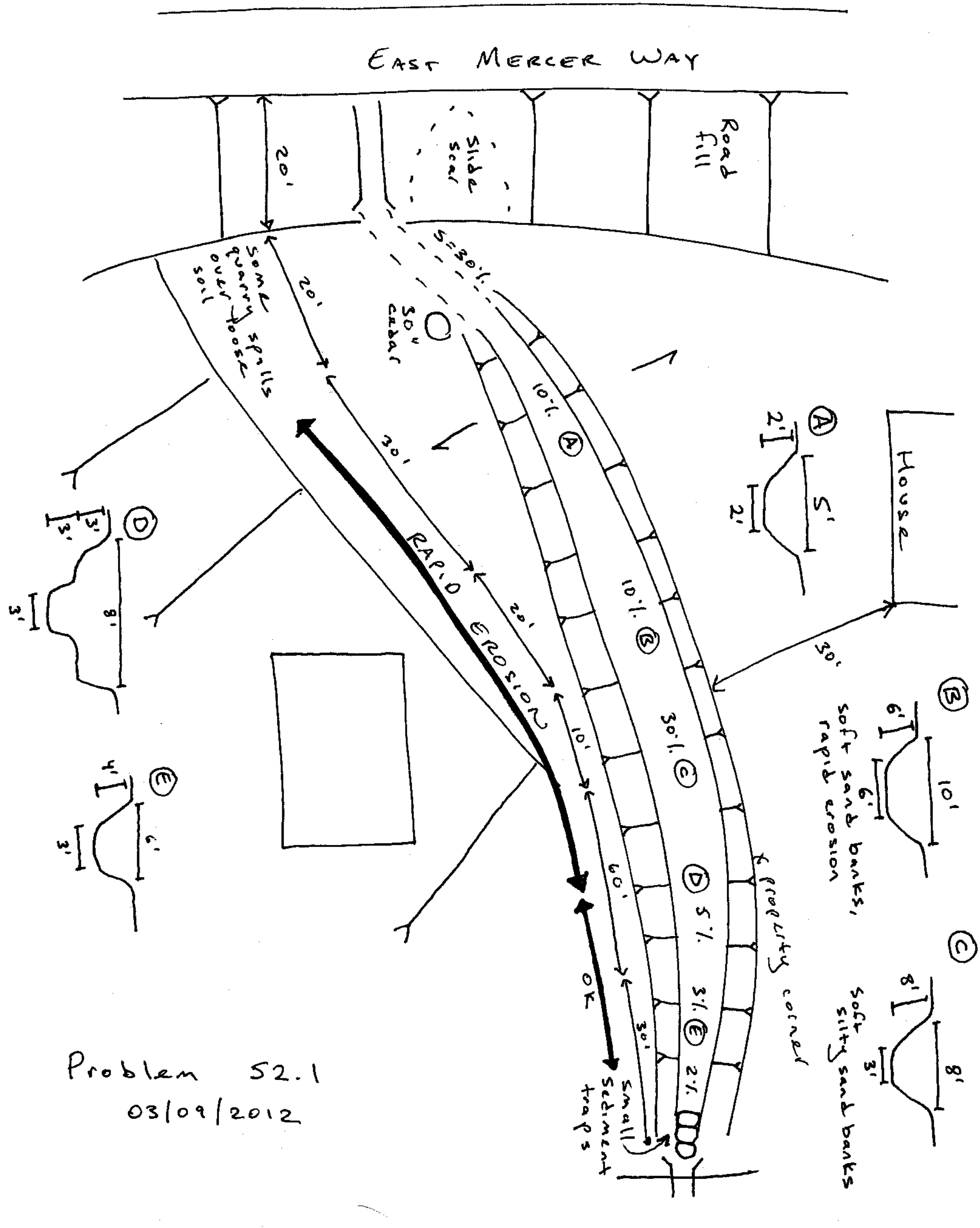
BY	DATE	SUBJECT	SHEET
		506.4	NO. 7 OF 7
CHECKED BY	DATE		PROJECT NO.
		Reach G	





Problem 52.1
03/09/2012

PROJECT SUMMARY SHEET

Basin No.:	49b
Project No:	49b.4
Project Title:	**Butt-fused HDPE Pipeline on Stream Stabilization East of 91st Avenue SE in 4700 Block**
Problem Description:	Large scale, severe erosion of 1,000 CY at an existing 12-inch storm drainage outlet in 47th Open Space near a primitive trail. The outlet drops 8 feet at invert into a steep channel in semi-consolidated sandy silt. Channel incision is about 100 feet long and the depth varies from 5 to 25 feet. Slope material above 5 feet is loose colluvium. This site is likely not a natural watercourse, but developed from erosion of storm water drainage. Change since 2005 has been slow to moderate. The steep channel gradient creates high risk of long-term erosion and downcutting. See Appendix E for a field sketch of the problem area.
Project Description:	Two alternatives are considered for this problem. The first is to install 12-inch-diameter HDPE pipeline with manhole energy dissipator at the downstream end. Under this alternative it may be desirable to fill the erosion scar. The second alternative is stream stabilization through reconstruction of 100 feet of channel. It is recommended the City get input from WDFW prior to selecting the preferred alternative. The cost estimate is based on the HDPE pipeline alternative.
Related Projects	None
Estimated Project Cost:	$172,000 (2012 revision)

Looking Upstream at Upper Half of Erosion Problem 12/14/2005

Looking Upstream at Total 25’ Vertical Drop 03/09/2012

Project No. 49b.4
Install 100 LF butt-fused HDPE pipe with energy dissipator or channel stabilization.

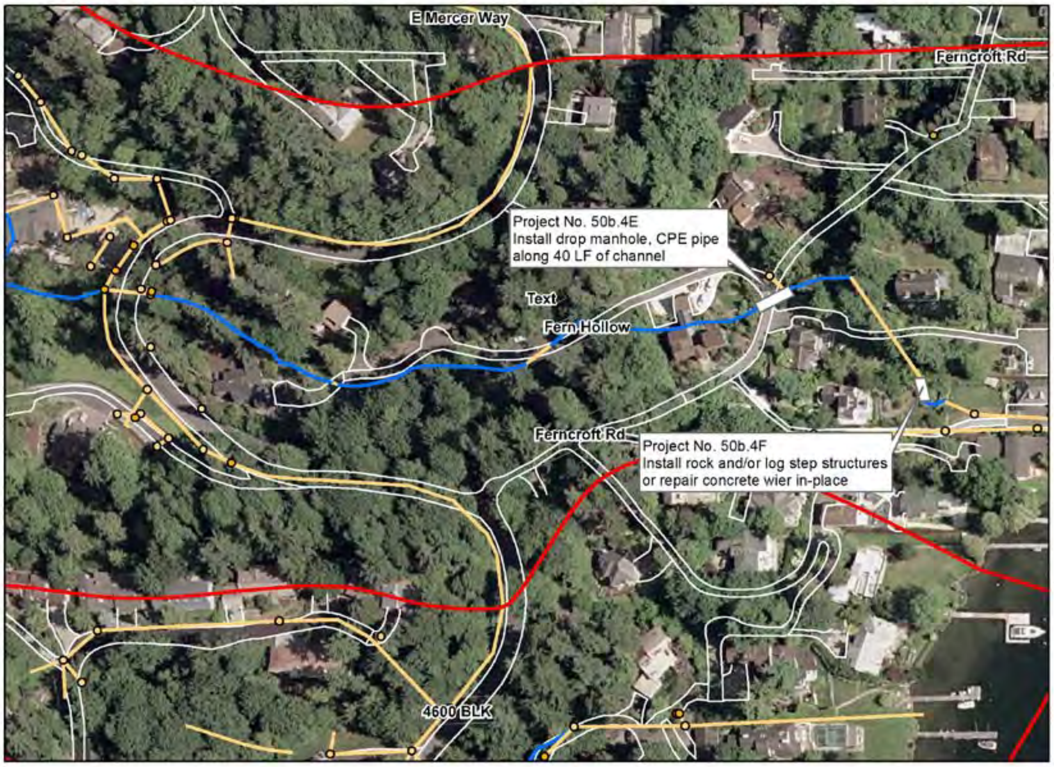
Project Location Map

PROJECT SUMMARY SHEET

Basin No.:	50b
Project No:	50b.4E (upstream) and 50b.4F (downstream)
Project Title:	**Install Drop Manhole and CPE Pipe along 40 LF of Channel and Install rock and/or log step structures or Repair Concrete Weir In Place**
Problem Description:	Downstream of Ferncroft Road at culvert outlet bank protection is failing. At the culvert outlet the channel drops approximately 8 feet along 20 LF of channel. Boulders placed along both banks are dislodged and falling into channel. In 50b.4F, approximately 2 foot high concrete weir has failed and is inclined downstream. See Appendix E for field sketches of problem areas.
Project Description:	In 50b.4E, the preferred approach includes installation of a drop manhole and CPE pipe along 40 LF of channel to stop erosion of banks at culvert outlet. Significant environmental and permitting concerns are likely with this approach. Alternate solutions include repair rock bank protection in-place and anchor into slope, or replace with gabion or other retaining wall. In 50b.4F, the preferred approach includes replacement of the weir using a short series of rock or log step structures. An alternate approach would be to repair the existing weir in place.
Related Projects	None
Estimated Project Cost:	$ 38,000 (2012 estimate)

Project 50b.4E: Looking Upstream at Failing Bank Protection at Outlet 12/22/2011

Project 50b.4F: Looking Upstream at Failed Concrete Weir 12/22/2011



Project No. 50b.4E
Install drop manhole, CPE pipe
along 40 LF of channel

Project No. 50b.4F
Install rock and/or log step structures
or repair concrete wier in-place

Project Location Map