SKAGIT RIVER HYDROELECTRIC PROJECT

NO. 553

SETTLEMENT AGREEMENT

CONCERNING

EROSION CONTROL

BETWEEN

THE CITY OF SEATTLE

AND THE

U.S. DEPARTMENT OF THE INTERIOR,
NATIONAL PARK SERVICE

APRIL 1991

ORIGINAL

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FEDERAL ENERGY REGULATORY COMMISSION

SETTLEMENT AGREEMENT
CONCERNING
EROSION CONTROL,
INCORPORATING THE
EROSION CONTROL PLAN

1.0 PARTIES

This Settlement Agreement Concerning Erosion Control (Agreement), incorporating the Skagit River Hydroelectric Project Erosion Control Plan (Erosion Control Plan), is entered into this 24th day of April, 1991, by and between the City of Seattle, City Light Department (the City) and the U.S. Department of the Interior, National Park Service. Together the City and the National Park Service are referred to as the "Parties". The Skagit River Hydroelectric Project is referred to as the "Project".

2.0 GENERAL PROVISIONS

2.1 PURPOSE AND INTENT

This Agreement establishes the City's obligations relating to soils and slope stability affected by the Skagit Project, as currently constructed. It also establishes the National Park Service's obligations to support this Agreement, and to submit it to the Federal Energy Regulatory Commission (FERC) as its recommendations relating to said soils resources under any applicable provisions of the Federal Power Act (including without limitation Sections 10(a), 10(j), and 4(e) thereof). The U.S. Forest Service agrees that this Agreement constitutes its preferred recommendation under Section 7(a) of the Wild and Scenic Rivers Act.

2.1.1 Resolution of Issues

This Agreement resolves all issues related to the effects on soils and slope stability of the Project, as currently constructed, except for those erosion control requirements identified in the archaeological portion of the Settlement Agreement Concerning Cultural Resources (Archaeological

and Historic Resources), for the period October 28, 1977, through the duration of this Agreement. This includes resolution of the effects of the absence of flows in the Gorge bypass reach. It shall be submitted to the FERC for incorporation into the new license for the Project and shall be enforceable as an article thereof. The Parties agree that incorporation and enforcement as a license condition is a material provision of this Agreement.

2.1.2 Stipulation of Adequacy

The Parties stipulate that this Agreement constitutes adequate soils protection and compensation for the erosion impacts of the Project, as currently constructed, for the period October 28, 1977, through the duration of this Agreement.

2.1.3 Release and Waiver of Claims

For the period October 28, 1977, through the duration of this Agreement, the National Park Service, its successors and assigns hereby releases, waives, and discharges the City, its successors, and assigns from any and all claims, demands, actions and causes of action of any kind (claims) arising during that period from the effects of the Project, as currently constructed, on soils and slope stability, so long as the City performs its obligations under this Agreement. This release does not waive claims that may arise from the negligent or intentional misconduct of the City in the operation of the Project.

2.1.4 Compliance with Laws and Effect on Rights

Nothing in this Agreement precludes the City or the National Park Service from complying with their obligations under the National Environmental Policy Act (NEPA), the Endangered Species Act, the Federal Power Act, the Wild and Scenic Rivers Act, or any other laws applicable to the Project. This Agreement shall not affect the rights of either Party except as expressly covered in this Agreement.

Nothing in this Agreement or in the plans, memoranda, procedures or other actions taken to further the purposes of this Agreement shall reduce or otherwise impair access to and exercise of implied or explicit Indian rights, including hunting, fishing and gathering rights; nor shall anything in this Agreement be construed as limiting, waiving or otherwise impairing whatever money damages claims the Tribes may have arising out of the construction and operation of the current Project outside the term of this Agreement.

2.1.5 Integrated Agreement

All previous communications between the Parties, either verbal or written, with reference to the subject matter of this Agreement are superseded by the terms and provisions of this Agreement, and, once executed, this Agreement and its companion documents constitute the entire agreement between the Parties.

2.1.6 Assignment

This Agreement shall be binding on and inure to the benefit of the Parties and their successors and assigns.

2.1.7 Authority

Each Party to this Agreement represents and acknowledges that it has the full legal authority to execute this Agreement and shall be fully bound by its terms.

2.2 OBLIGATIONS OF THE PARTIES

2.2.1 The City's Obligations

2.2.1.1 Compliance and Submittal

By entering into this Agreement, the City agrees to comply with all of the terms of this Agreement, including the payment of monies and the funding of activities specified herein. The City further agrees to submit this Agreement, including the Erosion Control Plan, to the FERC as its proposed measures relating to the soil resources affected by the Project as required by applicable provisions of federal and state law, including without limitation the Federal Power Act.

2.2.1.2 Additional Staffing

The City shall assign adequate professional environmental staff to implement this Agreement. This shall include establishment of two new environmental staff positions with expertise in fisheries, wildlife, recreation, visual quality, cultural resources, and erosion control. One staff position shall be dedicated primarily to implementation of the Anadromous Fish Flow Plan and the Anadromous and Resident Fish Non-Flow Plan. The second staff position shall be dedicated primarily to implementation of the wildlife, recreation/aesthetics, and cultural resource agreements and this Agreement.

2.2.2 The National Park Service's Obligations

2.2.2.1 Support for Project Relicense

The National Park Service agrees to support the expeditious issuance of a new license to the City for the Project, as currently constructed, which is consistent with the provisions of this Agreement and which includes the Agreement as an article. This support shall include reasonable effort to expedite the NEPA process. The Parties shall file comments on any draft EA or EIS developed by the FERC in the relicensing proceedings for this Project and shall support the measures defined by this Agreement as the preferred action. The Parties shall exchange drafts of their respective comments prior to submittal to the FERC and consult with each other to ensure that the comments are consistent with this Agreement.

2.2.2.2 Erosion Control Recommendations

The National Park Service shall submit this Agreement to the FERC as its recommendations for control of erosion impacts of the Project under any applicable provision of the Federal Power Act (including without limitation Sections 10(a), 10(j), and 4(e) thereof). The U.S. Forest Service agrees that this Agreement constitutes its preferred recommendation under Section 7(a) of the Wild and Scenic Rivers Act.

2.2.2.3 Gorge Bypass Reach

The National Park Service agrees that this Agreement incorporating the Erosion Control Plan obviates any need for flow releases in the Gorge bypass reach for erosion control purposes. The National Park Service shall support all efforts by the City to either retain its existing water quality certificate issued by the State of Washington, Department of Ecology (WDOE) on October 27, 1977, or, in the alternative, to obtain a new water quality certificate consistent with the terms and conditions of this Agreement, including the absence of flows in the Gorge bypass reach. In the event efforts are made to reclassify the Gorge bypass reach from a Class AA water to another Class water under WDOE regulations, the National Park Service shall not oppose this action and shall, at a minimum, provide written comments not opposing this action to the WDOE. Should the City be required to release flows in the Gorge bypass reach at any time before the issuance of a new FERC license and for any reason, this Agreement shall be voidable at the option of the City. Should the City be required to release flows in the Gorge bypass reach at any time after the issuance of a new FERC license and for any reason, this Agreement shall give rise to an immediate right of the City to petition the FERC to reconsider or reopen applicable license provisions to reconsider all resource provisions including those for soils in light of such requirement. Under such circumstances, the City's efforts to initiate a proceeding before the FERC to reconsider or reopen shall not be opposed by the National Park Service; the Parties may, however, differ in their respective positions in such a proceeding.

2.2.3 The Parties' Obligations

2.2.3.1 Cooperation Between Parties

The Parties shall cooperate in conducting and participating in studies and other actions provided for in this Agreement and shall provide assistance in obtaining any approvals or permits that may be required for implementation of this Agreement.

2.2.3.2 Support of Agreement

The Parties agree to join in the filing of an Offer of Settlement with the FERC based upon this Agreement and to request that the FERC issue appropriate orders approving this Agreement. Both Parties shall refrain from seeking judicial review of the FERC's approval of this Agreement. It is expressly agreed by the Parties that this Agreement shall be submitted to the FERC as a unit and that any material modification of its terms, approval of less than the entire Agreement, or addition of material terms by the FERC shall make the Agreement voidable at the option of any Party.

2.3 EFFECTIVE DATE AND DURATION

2.3.1 Execution and Effective Date

This Agreement shall take effect upon the effective date of a license issued by the FERC consistent with this Agreement, provided that Sections 2.5.2 and 6.1.1 obligate the City to specific monetary commitments prior to the effective date; these early obligations take effect upon the submittal to the FERC by the Parties of an Offer of Settlement pursuant to Section 2.2.3.2. If the FERC issues a new license inconsistent with this Agreement and if either Party appeals, the Agreement shall not go into effect. The Parties retain the right to appeal the issuance of a license in whole or in part if unacceptable provisions are added, including stay of any provision.

2.3.2 Duration

This Agreement, together with any subsequent modifications, shall remain in effect for the term of the new FERC license period for the Project, which includes the term(s) of any annual license(s) that may be issued after the foregoing new license has expired. This includes ongoing operations and maintenance expenses that shall continue to be funded for the duration of this Agreement.

2.4 COORDINATED IMPLEMENTATION AND SEVERABILITY

2.4.1 Across Forum Coordination

It is understood and agreed by the Parties that similar settlement agreements are being executed between the City, the National Park Service, and other intervenors (not party to this Settlement Agreement) in the Project relicensing proceedings concerning other resources affected by continuing Project operations. These other settlement agreements and mitigation and enhancement plans include:

Fisheries—Fisheries Settlement Agreement, incorporating the Anadromous Fish Flow Plan and the Anadromous and Resident Fish Non-Flow Plan;

Wildlife—Settlement Agreement Concerning Wildlife, incorporating the Wildlife Habitat Protection and Management Plan;

Recreation and Aesthetics—Settlement Agreement on Recreation and Aesthetics (including the Recreation Plan and the Visual Quality Mitigation Plan);

Cultural Resources—Settlement Agreement Concerning Cultural Resources (Archaeological and Historic Resources), incorporating the Cultural Resources Mitigation and Management Plan, which includes the historic and archaeological resources mitigation and management plans;

Traditional Cultural Resources—Settlement Agreement Concerning Traditional Cultural Properties, incorporating the Traditional Cultural Properties Mitigation Plan.

2.4.2 Annual Meeting

The City shall host an annual meeting of the Intervenors to facilitate coordination of implementation of the various settlement agreements. The National Park Service agrees to cooperate in across forum coordination as necessary and appropriate to further effective program implementation.

2.5 MONETARY FIGURES

2.5.1 Adjustments For Inflation/Deflation

All dollar amounts listed in this Agreement are defined as 1990 dollars and shall be adjusted annually for inflation or deflation by using the revised Consumer Price Index (CPI-U) for All Urban Consumers as published by the United States Department of Labor for the Seattle Metropolitan area. The indices used shall be those published for the last half of 1990, and for subsequent years, the last half of the calendar year preceding that in which a payment or expenditure is to be made. Indexing of items in this Agreement shall continue until the year of actual payment, unless otherwise provided in this Agreement. The percentage of change from the earlier index to the later index shall be multiplied by the amount specified in this Agreement and the result added to or subtracted from that amount to arrive at the total payment or expenditure. Should the CPI-U index not be available, the Parties agree to negotiate another statistical basis for determining annual changes in the City's monetary commitments.

2.5.2 Time Basis For Payments and Obligations

Payments and obligations by the City for this Agreement shall be made and met on a license-year basis. License years are based on the date of the FERC order issuing a new license for the Project; however, unless specifically provided otherwise in this Agreement, the City's monetary obligations do not become payable until the license becomes effective (see Section 2.3). The City shall make the 1991 interim payment to the National Park Service as provided in Section 6.1.1 of this Agreement as soon as practicable after the Parties submit this Agreement to the FERC pursuant to Section 2.2.3.2. The City shall make the 1992 and 1993 interim payments to the National Park Service as provided in Section 6.1.1 of this Agreement. The City shall make monies due in license year one available at the time they are needed as soon as possible after the license becomes effective. In subsequent license years, the City shall make payments to the National Park Service for the implementation of specific Erosion Control Plan projects at the time they are needed. Monies required to be paid to or on behalf of the National Park Service for non-project specific purposes shall be paid on the last day of each license year. If the license becomes effective during a season critical for implementation, it may be impossible to implement a particular program element that year. Therefore, the Parties agree that implementation of such elements may not occur until the license year following its stated schedule in this Agreement and the Erosion Control Plan. Agreed upon rescheduling of projects solely as a result of seasonal considerations shall not be considered a license compliance violation.

2.6 FORCE MAJEURE

The City shall not be liable or responsible for failure to perform or for delay in performance because of any cause or event or circumstance of Force Majeure. For purposes of this Agreement, Force Majeure is any cause or event beyond the City's reasonable control. This may include, but is not limited to, fire, flood, mechanical failure or accidents that could not reasonably have been avoided by the City, strike or other labor disruption, act of God, act of any governmental authority or of the Parties, embargo, fuel or energy unavailability (ancillary to, but not including, basic power generation), wrecks or unavoidable delays in transportation, and inability to obtain necessary labor, materials or manufacturing facilities from generally recognized sources in the applicable industry, or communications systems breakdowns, or for any other reason beyond the City's control. The City shall make all reasonable efforts to resume performance promptly once the Force Majeure is eliminated.

2.7 DESIGNATED CONTACTS

2.7.1 Contact Persons

For purposes of implementing this Agreement, the Parties agree that the following individuals shall be designated by each to be the primary contact persons. The initial contact person for the City is:

Superintendent
Seattle City Light
1015 Third Avenue
Seattle, WA 98104-1198
(206) 684-3200

and the initial contact person for the National Park Service is:

Superintendent
North Cascades National Park Service Complex
2105 Highway 20
Sedro Woolley, WA 98284
(206) 856-5700

Notification of a change in a contact person must be made in writing and delivered to the other contact person.

2.7.2 Notices

All written notices to be given pursuant to this Agreement shall be mailed by first class mail or overnight express service, postage prepaid, to each Party at the addresses listed above or such subsequent address as a Party shall identify by written notice to the other Party. Notices shall be deemed to be given five (5) working days after the date of mailing.

2.8 REOPENER AND MODIFICATION

2.8.1 Use of Reopener Clause in License

Notwithstanding any other provision of this Agreement, either Party may at any time invoke or rely on any reopener clause(s) in the license for the Project in order to request the imposition by the FERC of different or modified measures for erosion control. Any provision of this Agreement that might be read to limit or preclude either Party from raising any relevant material issue of fact or law in reopening or to otherwise conflict with reopening (e.g., Sections 2.1, 2.1.1, 2.1.2, 2.1.3, 2.1.4, and 2.2.2.2) shall be inoperative to the extent of any such limitation, preclusion or conflict.

2.8.2 Modification

Before invoking any reopener clause under Section 2.8.1, a Party shall request the other Party to commence negotiations for a period of up to 90 days to modify the terms and conditions of this Agreement in whole or in part. Any such modification shall be subject to FERC approval, except that the Parties may agree to implement on an interim basis, pending FERC approval, any measure not requiring prior FERC approval.

2.8.3 Burden of Proof

In any action under Section 2.8, the petitioning Party shall have the burden of proof.

2.8.4 Effect of Reopener Proceedings

The Parties shall continue to implement this Agreement pending final resolution of any modification sought from the FERC, or until the relief sought becomes effective by operation of law, or unless otherwise agreed. At the time of petitioning the FERC under Section 2.8.1, nothing shall prevent either Party from requesting the imposition of different or modified measures, from bringing any cause of action in any appropriate forum, or from taking other actions relating to any issue or matter addressed by this Agreement.

2.9 PROJECT MODIFICATIONS (HIGH ROSS)

2.9.1 Project Modifications

This Agreement applies to the Project excluding High Ross or any modified High Ross construction. It does not address mitigation for the effects of raising Ross Dam. In the event the City decides to consider raising Ross Dam, separate provision will be made for additional mitigation. The Parties shall initiate discussions regarding mitigation of erosion impacts according to the following procedures.

2.9.2 Notice

The City shall notify the National Park Service of its decision to consider raising Ross Dam at least thirty months before construction would commence.

2.9.3 Consultation

At the same time, the City shall commence consultation on necessary soils studies and possible erosion control measures.

2.9.4 Resolution

At least 180 days before construction would commence, the City shall either agree with the National Park Service on modifications to this Agreement, or remaining disputes over erosion control measures may proceed as described in Section 3.0 at the option of either Party.

2.9.5 Mitigation Criteria

Mitigation for the effects on soils, if any, of raising Ross Dam shall be based on criteria developed through any necessary soils studies that are conducted at the time that the City decides to consider raising Ross Dam.

2.9.6 Preservation of Rights

Nothing in this Agreement shall preclude the National Park Service from challenging the construction of High Ross, including disputed mitigation, in any proceeding. The mitigation procedures set out in this Section are not exclusive and need not be commenced or exhausted prior to such challenges.

3.0 DISPUTE RESOLUTION

3.1 REFERRAL OF DISPUTES

Any dispute between the Parties solely concerning asserted non-compliance with the terms of this Agreement shall be referred to technical representatives of the contact persons identified in Section 2.7. The technical representatives shall meet as soon as possible after written notification of a dispute by either Party. Decisions of the technical representatives must be unanimous. In the event that the technical representatives cannot resolve the dispute within thirty (30) days after first meeting on said dispute, the City shall give notice of such failure to the National Park Service.

3.2 OPTIONAL POLICY REVIEW

The Parties may, at their option prior to elevating an issue to the FERC, convene an in-person or telephone conference of policy-level administrators should technical level representatives fail to resolve a dispute under Section 3.1. Either Party through its designated contact in Section 2.7 may invoke optional policy review by contacting the other Party's designated contact and arranging a suitable conference. Decisions by unanimous consent shall bind both Parties. The policy-level representatives may by unanimous consent agree to binding arbitration or mediation subject to rules as they determine appropriate. In the event that the policy-level representatives cannot resolve the dispute within fifteen (15) days, the matter may be taken to the next level.

3.3 FERC REVIEW

In the event that disputes are not resolved at the first two levels of dispute resolution, either party may refer the matter to the FERC for resolution pursuant to the FERC's Rules of Practice and Procedure.

3.4 NON-COMPLIANCE

Notwithstanding any other provision of this Agreement, either Party may seek relief arising solely from non-compliance with this Agreement by the other Party.

4.0 ROSS LAKE OPERATIONS

4.1 REFILL AFTER APRIL 15

The City shall fill Ross Lake as early and as full as possible after April 15 each year, subject to adequate runoff, anadromous fisheries protection flows (specified in the Skagit River Anadromous Fish Flow Plan), flood protection, minimized spill, and firm power generation needs. Subject to the above constraints and hydrologic conditions permitting, the City shall achieve full pool by July 31 each year.

4.2 FULL POOL THROUGH LABOR DAY

The City shall hold Ross Lake as close to full pool as possible through Labor Day weekend, subject to adequate runoff, anadromous fisheries protection flows (specified in the Skagit River Anadromous Fish Flow Plan), flood protection, minimized spill, and firm power generation needs.

4.3 OVERDRAFT YEARS

In any overdraft year (i.e., in those years in which Ross Lake is drafted below the energy content curve), the City shall bring the Ross Lake level up to the Variable Energy Content Curve (VECC)

no later than March 31, subject to adequate runoff, anadromous fisheries protection flows (specified in the Skagit River Anadromous Fish Flow Plan), flood protection, minimized spill, and firm power generation needs.

5.0 EROSION CONTROL RESPONSIBILITIES OF THE CITY

As the licensee for the Project, the City shall oversee the implementation of this Agreement, providing funding for its implementation, and bear final responsibility for the implementation of the Erosion Control Plan. The City shall construct greenhouse facilities and institute a plant propagation program for the primary purpose of supplying plant stock for erosion control sites. The goal of the City shall be to complete the greenhouse facilities and have the plant propagation program fully operational by the end of the third year of the new license. As much as practical, the City shall use the guidelines listed in Section 2.5 of the Erosion Control Plan in the design, maintenance, and rehabilitation of Project roads. The City shall also implement the additional erosion control measures as specified in Section 2.6 of the Erosion Control Plan.

The City shall be the lead for all erosion control work other than biotechnical slope protection measures at the Project road sites specified in the Erosion Control Plan in accordance with the schedule set forth in Table 5-1 and at new Project road sites identified in accordance with Section 11.0 of this Agreement. Project road sites are identified in Table 5-1 by location number prefaced by the letter "R." In doing erosion control work at new Project road sites, the City shall follow the guidelines in Section 2.5 of the Erosion Control Plan. The City's responsibilities at Project road sites shall include grading and site preparation for vegetation work that will be done by the National Park Service.

6.0 FUNDING RESPONSIBILITIES OF THE CITY

The City shall provide funding for the purpose of implementing all of the erosion control activities pursuant to this Agreement (see Figure 6-1). The City shall provide a maximum of $845,000 to the National Park Service for work during the pre-license years and the first nine license years at the sites identified in the Erosion Control Plan as described below (see Sections 6.1, 6.1.1, and 6.1.2). The City shall provide a maximum of $500,000 to the National Park Service for maintenance of erosion control measures, installation of erosion control measures at new sites, and, if necessary, completion of work at the sites in the Erosion Control Plan as described below (see Section 6.2). The City shall separately fund and implement construction of greenhouse facilities and institution of a plant propagation program to supply stock for erosion sites as described below (see Section 6.3).

Table 5-1. Site protection priority and schedule.

Project Year (City's Obligations)[1/]	Site Name[2/]	Site Priority	Comments
Year 1 ($124,676)	One-time equipment purchase[3/]		
	One-month backhoe (lease)[4/]		
	W-124 ($6,868) [5/]	H	
	R-17 ($21,128)	H	Road site
Year 2 ($122,364)	2 months backhoe (lease)[4/]		
	Monitoring set-up [6/]	H	
	E-56 ($11,841)	H	Big site; popular camp; old trees
	E-134A+B ($5,213)	H	Potential loss of dock bulkhead
	E-70A5 ($33,493)	H	East Bank Trail
	R-8A, R-8B, R-8C, R-11, R-15 ($22,457)	H	Road sites
Year 3 ($72,013)	2 months backhoe (lease)[4/]		
	E-116 ($6,737)	H	N. Lightning Cr. Trail
	E-70A3 (First half) ($40,290)	H	East Bank Trail; Big Beaver Trail
	E-70A1 ($8,370)	H	East Bank Trail; Big Beaver Trail
	R-1, R-5 ($7,256)	H	Road sites
Year 4 ($73,820)	2 months backhoe (lease)[4/]		
	W-34 ($18,588)	H	
	W-36A, W-36B ($5,582)	M[7/]	
	E-70A3 (Second half) ($40,290)	H	East Bank Trail; Big Beaver Trail
Year 5 ($74,307)	2 months backhoe (lease)[4/]		
	E-9 ($9,908), E-64 ($23,460), E-68 ($6,911)	H	
	R-2, R-4, R-9, R-10, R-12, R-16 ($24,668)	H	Road sites
Year 6 ($71,516)	2 months backhoe (lease)[4/]		
	D-11 ($5,661)	H	Large site; potential loss of land
	D-8 ($34,943), D-43 ($5,558)	H	
	D-40 ($7,544)	M	
	R-14 ($8,450)	L	Road site

Table 5-1. (Continued).

Project Year (City's Obligations)[1/]	Site Name[2/]	Site Priority	Comments
Year 7	2 months backhoe (lease)[4/]		
($76,326)	E-70A4 ($33,615)	H	East Bank Trail; Big Beaver Trail
	R-3, R-7, R-13 ($9,924)	L	Road sites
	E-47 ($4,073), E-80B ($5,284), E-92 ($3,287), E-100 ($4,987)	M	
	E-70A6 ($3,293)	M	East Bank Trail; Big Beaver Trail
	E-40 ($2,503)	L	
Year 8	2 months backhoe (lease)[4/]		
($66,036)	E-95 ($18,936), E-112 ($5,275), E-118A ($3,929), E-118B ($5,661)	M	
	E-87 ($2,869), E-117 ($3,267)	L	
	Maintenance of interim & other sites ($16,739)		
Year 9	2 months backhoe (lease)[4/]		
($64,942)	W135 ($38,799)	H	Class I site
	Maintenance of previously-placed structures ($16,783)		

1/ These are the City's obligations for each of the first nine license years as set forth in Section 6.1 of this Agreement; the nine-year total is $746,000. The City's total obligation for erosion control work during pre-license years is a maximum of $99,000 pursuant to Section 6.1.1 of this Agreement.

2/ See Section 3 of the Erosion Control Plan for details about each site. Sites are numbered and prefaced with the letters "R," "D," "E," or "W": "R"=road site; "D"=Diablo Lake site; "E"=site on east shoreline of Ross Lake; "W"=site on west shoreline of Ross Lake.

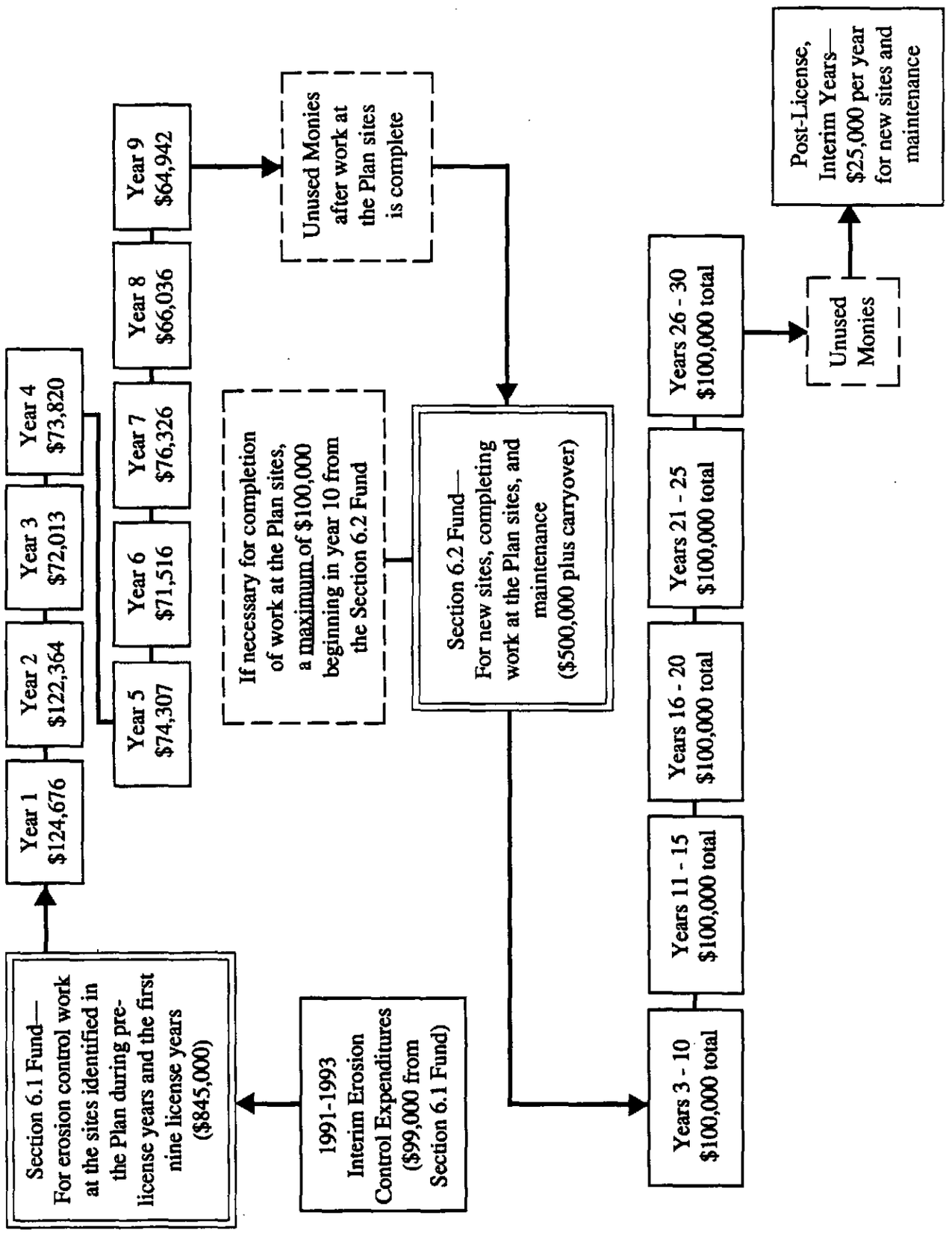
3/ First license year purchase of equipment by the National Park Service with City funds under this Agreement. Equipment to include boat, barges, barge rake, rock drill/hammer and compressor, hand tools, chain saw, electric winch, and generator at a total estimated cost of $92,000.

4/ Lease of backhoe by the National Park Service with City funds under this Agreement. Estimated lease cost is $4,680 per month.

5/ In parentheses after each site is the cost estimate for erosion control work to be done at that site. These estimates were used to derive the City's annual license year obligations. In the cases where erosion control work is planned at several road sites during a year, an estimate is given for the combined road sites.

6/ Annual monitoring program for recreation and Project facility sites where active erosion control measures have been installed, selected Class I, II, and III sites, road sites in Section 3.5 of the Plan, and new sites identified in accordance with Section 11.0 of this Agreement.

Figure 6-1. Skagit erosion control—use of funds.



6.1 SITES SPECIFIED IN THE EROSION CONTROL PLAN

The license year obligations of the City and the National Park Service specified in this Section shall not begin until the license becomes effective and in no case shall begin earlier than 1993. Within sixty (60) days of the date the license becomes effective, the National Park Service shall notify the City in writing of the year it will begin the work scheduled for license year one as specified in Table 5-1. The City's license year obligations shall begin in the following year if notification is received after the month of March in the year of the issuance of the license. The year in which the actual work begins shall be "license year one" for the purposes of this Agreement. Payment of monies due under this Section shall be pursuant to Section 2.5.2 of this Agreement. The City's funding obligations to the National Park Service for erosion control work during the pre-license years are specified in Section 6.1.1 below.

A maximum amount of $845,000 shall be provided by the City for erosion control work at the sites as identified and specified in Table 5-1 and described in the Erosion Control Plan. Additional amounts may be made available pursuant to Section 6.2. The sites in Table 5-1 are numbered and prefaced with the letters "R," "D," "E," and "W" to indicate location. From this amount the City shall provide the National Park Service with annual funding during the first nine license years as follows:

LICENSE YEAR	CITY'S OBLIGATION
1	$124,676
2	$122,364
3	$ 72,013
4	$ 73,820
5	$ 74,307
6	$ 71,516
7	$ 76,326
8	$ 66,036
9	$ 64,942
Total	$746,000

Cost estimates for the erosion control work at each of the sites in Table 5-1 and in the Erosion Control Plan have been developed and agreed to by the Parties. These estimates were used to derive the City's annual license year obligations listed above. These estimates represent the monies that shall be spent for erosion control work at each site except as mutually agreed otherwise by the Parties pursuant to Section 9.0. Total expenditures for the license year shall not exceed the total annual amounts listed above, except that these totals may be adjusted pursuant to Sections 6.2 and 6.5.1.

If, in accordance with Section 8.0 of this Agreement, the National Park Service declines to do the erosion control work at a site, and the City takes responsibility for that work, then the amount of funds remaining from the total of the $845,000 available for allocation to the National Park Service shall be reduced by the amount the City spends for work on that site.

6.1.1 Pre-license Expenditures

The City shall provide the National Park Service with up to a maximum of $33,000 in 1991, $33,000 in 1992, and $33,000 in 1993 for implementation of erosion control work at high-priority reservoir shoreline camp and trail sites as identified in the Erosion Control Plan and detailed in work plans developed by the National Park Service for these three years and as agreed between the Parties. Upon written request for a specific 1991 amount from the National Park Service, the City shall make the 1991 funds available as soon as practicable after the Parties have submitted this Agreement to the FERC pursuant to Section 2.2.3.2 of this Agreement. The National Park Service shall notify the City as early as possible in 1991 (after submittal of this Agreement to the FERC) and 1992, respectively, of the amount of funding necessary to perform erosion control work in 1992 and 1993.

The City's license year funding obligations shall not begin until 1993 at the earliest pursuant to Section 6.1 above. If license year one as defined pursuant to Section 6.1 begins in 1993, then the City shall withhold or deduct the 1993 pre-license erosion control monies (a maximum of $33,000) from the amount of its annual funding obligation for license year one. In the tenth license year, the City shall make these unexpended monies (a maximum of $33,000) available to the National Park Service for erosion control work as provided in this Agreement.

6.1.2 Monies for the City's Share of the Erosion Control Work at Project Road Sites

The monies expended by the City for erosion control work done by the City at each Project road site pursuant to Section 5.0 of this Agreement shall be deducted from the City's annual obligations to the National Park Service under Section 6.1 of this Agreement during the license year for which work at that site has been scheduled in Table 5-1 of this Agreement. The monies expended for erosion control work at Project road sites shall be allocated by mutual agreement between the National Park Service and the City pursuant to the preparation of the work plans required in Section 9.0 of this Agreement.

6.2 NEW SITES AND MAINTENANCE

The City shall provide the National Park Service the maximum amount of $500,000 for the purposes of maintaining installed erosion control measures, implementing erosion control at new sites during the license term, and completing the erosion control work at the sites specified in the Erosion Control Plan if work under Section 8.0 remains uncompleted (except for ongoing monitoring) after expenditure of all funds available in Section 6.1. The City shall make the $500,000 available to the National Park Service in license years 3 through 30 in the following scheduled amounts:

License Years 3-10:	$100,000
License Years 11-15:	$100,000
License Years 16-20:	$100,000
License Years 21-25:	$100,000
License Years 26-30:	$100,000

If both Parties agree that completion of the work at the sites specified in Section 8.0 and in the Erosion Control Plan requires more than the funds specified in Section 6.1 ($845,000), then the City shall make available, beginning in license year 10 at the earliest which shall be in addition to the $100,000 budgeted for license years 11-15, an amount up to a maximum of $100,000 for this purpose. At the end of license year 15, the remaining amount of the $500,000 shall be divided into three equal amounts which the City shall make available to the National Park Service over the three remaining 5-year license periods identified above.

6.3 PLANT PROPAGATION AND GREENHOUSE CONSTRUCTION

The City shall fund construction of a greenhouse and implementation of a plant propagation program. This work shall be performed by the City. Construction of the greenhouse facilities by the City shall be scheduled for the first three years of the new license term. The City shall budget over the 30-year term of the new license for plant propagation supplies and for a full-time staff position that the City shall assign to the plant propagation program. The City shall also make annual payments of $4,500 to the National Park Service during the term of the license (for a total of $135,000 over a 30-year period) and during any subsequent annual licenses to provide financial assistance to the National Park Service in the hiring of seasonal help and in purchasing supplies. Details of the City's obligations with regard to the plant propagation program are included in Section 6.0 of the Skagit Project Wildlife Habitat Protection and Management Plan. The site plan for the greenhouse facilities is Figure 4-2 of the Settlement Agreement on Recreation and Aesthetics.

6.4 ACCOUNTING AND FUNDING PROCEDURE

The National Park Service shall annually provide the City with an accounting report indicating what portions of the work plans prepared pursuant to Section 9.0 of this Agreement have been completed to date, how the funds the City has given to the National Park Service under this Agreement have been expended to date, and what funds have been carried over. The City shall review the accounting report and, on the basis of it, make an annual payment to the National Park Service in accordance with Section 2.5.2.

6.5 CARRY-OVER OF UNUSED MONIES

6.5.1 Sites Specified in the Erosion Control Plan

If, in accordance with Section 8.0, the National Park Service chooses to defer from one year to the next year work at one or more of the sites for which it has lead responsibility, then the portion of the $845,000 that would otherwise have been used for that work shall be carried over to the next year and shall be indexed as provided in Section 2.5.1 until the year of actual payment. This carrying-over of funds shall be done upon notice of deferral of work from the National Park Service to the City.

If, in accordance with Section 9.0, the Parties agree that work at a site in the Erosion Control Plan is unnecessary, or should not or cannot be done at all, then the portion of the $845,000 available under Section 6.1 that would otherwise have been used for that work shall be credited to the $500,000 available under Section 6.2 for work at new sites and maintenance. All such unused funds shall be indexed as provided in Section 2.5.1 until the year of actual payment. This crediting shall be done upon agreement between the Parties for modification or deletion of work at a site in accordance with Section 9.0.

If work at the sites specified in the Erosion Control Plan is completed for less than the maximum of $845,000 available under Section 6.1, then the unused portion shall be credited to the $500,000 available under Section 6.2 for work at new sites and maintenance. All such unused funds shall be indexed as provided in Section 2.5.1 until the year of actual payment. This crediting shall be done when work at the sites specified in the Erosion Control Plan has been completed (except for ongoing monitoring).

6.5.2 New Sites and Maintenance

Unused amounts of the monies that are available at the end of each of the first four time periods described in Section 6.2 shall be divided equally and credited to the funds available in the remaining time periods. All such unused funds shall be indexed as provided in Section 2.5.1 until the year of actual payment. This crediting of funds shall be done at the end of each time period.

6.5.3 Post-License Interim Years

At the end of the new license term and during subsequent annual licenses, the City shall make available to the National Park Service any unused portion of the $500,000 available in Section 6.2 for erosion control work to be done by the National Park Service during the years preceding issuance of the next license (i.e., post-license interim years), if any, as follows. During the post-license interim years, the City shall provide $25,000 annually for maintenance of installed erosion control measures and for work at new sites. The first funds to be used for this purpose shall be the unused portion of the $500,000. The City shall make up the difference, if any, between these monies and the required $25,000 annual payment.

6.5.4 No Loss of Unused Funds Until Issuance of Next License

All unused portions of the $845,000 and $500,000 available for erosion control work in Sections 6.1 and 6.2 shall be carried over to subsequent pre-license and license years as specified in Sections 6.5.1 through 6.5.3 of this Agreement. All such unused funds shall be indexed as provided in Section 2.5.1 until the year of actual payment. The National Park Service shall be authorized to draw upon the unused portions of these monies in its annual funding requests to the City for erosion control work to be done during post-license years. However, upon issuance of the next license, the City's obligations under this Agreement shall terminate, and any unused portions shall remain permanently with the City.

6.6 EXCLUSION

None of the monies specified for the implementation of this Agreement may be used for the purpose of clearing State Highway Route 20 or any other roads in the Project area of slides or other debris.

7.0 EROSION CONTROL RESPONSIBILITIES OF THE NATIONAL PARK SERVICE

The National Park Service shall have the lead role in all erosion control work under this Agreement except at Project road sites as noted in Section 5.0. As lead, the National Park Service shall be responsible for all aspects of erosion control work, including planning, design, engineering, permitting, site preparation, materials, labor, contracting, construction, vegetative planting, and operation and maintenance. All work shall be done in accordance with the general guidelines in Section 2.0 of the Erosion Control Plan.

Work for which the National Park Service has lead responsibility shall be as follows. The National Park Service shall do all of the erosion control work during the pre-license years and the term of the new license at the sites listed in Table 5-1 in accordance with the site-specific guidelines in Section 3.0 of the Erosion Control Plan except at the Project road sites as noted in Section 5.0 above and in the next paragraph of this Section. Erosion control sites are listed in Table 5-1 by location number prefaced with the letter "R," "D," "E," or "W." In addition, the National Park Service shall do all monitoring at erosion control sites as provided in Section 10.0 below. In addition, the National Park Service shall do erosion control work at new sites during the license term as identified and agreed to in accordance with the stipulations in this Agreement. In doing work at new sites, the National Park Service shall follow the general guidelines in Section 2.0 of the Erosion Control Plan. The National Park Service shall also implement additional erosion control measures as specified in Section 2.6 of the Erosion Control Plan. The National Park Service may use erosion control funding under this Agreement for operation and maintenance of equipment purchased or leased with erosion control funding under this Agreement, provided that said equipment is used exclusively for the purposes of implementing this Agreement and the Erosion Control Plan.

The National Park Service shall also be the lead for biotechnical slope protection measures (vegetation measures, including seeding) at the Project road sites identified in the Erosion Control Plan and at any new Project road sites identified in accordance with Section 11.0 of this Agreement. The National Park Service shall provide technical assistance to the City in erosion control work at Project road sites for which the City has responsibility (see Section 5.0).

The use by the National Park Service of City facilities and equipment at the Project to implement erosion control measures for which it is the lead is not included under this Agreement but may be arranged by mutual agreement between the City and the National Park Service. Installation of erosion control measures at shoreline sites must be timed around lake levels; the City is not obligated to modify lake levels to accommodate such installation. Portions of the erosion control work under this Agreement may require drawdowns of Gorge and Diablo reservoirs. The National Park Service shall coordinate with the City to schedule the least disruptive time for the work. The City retains the right to defer necessary drawdowns until they are required for other Project maintenance activities. The City shall provide assistance, through mutually agreed scheduling of the City's barges, in the implementation of erosion control work at sites D-8, D-11, D-40, and D-43 on Diablo Lake as identified in Section 3.2 of the Erosion Control Plan.

8.0 SCHEDULE FOR WORK AT THE SITES SPECIFIED IN THE EROSION CONTROL PLAN

The goal of the Parties shall be to complete the erosion control work at the sites specified in the Erosion Control Plan during the pre-license years and the first nine license years in accordance with the schedule set forth in Table 5-1. The National Park Service shall do all of the erosion control work at the numbered site locations in Table 5-1 prefaced with the letters "D," "E," or "W" (e.g., W-34) except at Project road sites, which have location numbers prefaced with the letter "R" (e.g., R-8A). Sections 5.0 and 7.0 above describe the responsibilities of the City and the National Park Service at Project road sites. The dollar amounts in Table 5-1 are the City's funding obligations to the National Park Service for each of the nine license years, as described in Section 6.1 above; the City's funding obligations to the National Park Service for erosion control work during the pre-license years are specified in Section 6.1.1. The National Park Service may use these monies to purchase or lease equipment; anticipated purchases and leases of equipment are shown in Table 5-1.

The implementation schedule shall be subject to modification through the mutual agreement of the Parties. The National Park Service shall have the option of delaying any of the work at the sites for which it has lead responsibility to the following license year and shall inform the City of such rescheduling of work. The National Park Service can reschedule the work at a site four times. The City shall become the lead on implementation of the erosion control work at a site if such work has not begun within five years after the original scheduled year for work, unless both Parties agree to waive this provision on a case-by-case basis.

9.0 EVALUATIONS AND WORK PLANS

The Parties shall have joint responsibility for preparing, on an annual basis for pre-license years and the first nine license years, and on a biennial basis for the remaining license years, an evaluation of previous erosion control work and a work plan for the following two years. Work plans shall follow the schedule set forth in Table 5-1 unless modified by agreement of the Parties. Work plans shall be consistent with the general and site-specific guidelines for erosion control measures specified in Sections 2.0 and 3.0 of the Erosion Control Plan and shall include final design drawings and specifications prepared by the National Park Service and approved by the City. Except for Project road sites, if site-specific designs significantly differ from those provided in the Erosion Control Plan, the National Park Service shall provide new design drawings and specifications for approval by the City. For Project road sites, new design drawings and specifications shall be prepared by the City, in consultation with the National Park Service. All work plans must be approved by the City.

Erosion control work at a site specified in Table 5-1 may be rescheduled at the discretion of the National Park Service as provided in Section 8.0, or the work may be modified or deleted from the Plan through the joint agreement of the Parties. Decisions to reschedule, modify, or eliminate erosion control work at a particular site shall be based upon, but not limited to, the following: seasonality, feasibility, changed erosion conditions, the completion of high-priority work, either Party's budget, or equipment and staff availability. Such decisions shall be documented in the evaluations and work plans.

10.0 EROSION MONITORING

The National Park Service shall monitor erosion at sites where both active and passive mitigation measures have been installed in accordance with this Agreement. Monitoring is the only measure proposed for erosion control at selected Class I, II, and III sites (see Table 1-1 of the Erosion Control Plan for definitions) and at critical wildlife habitat areas adjacent to eroding shorelines. The National Park Service shall begin monitoring at these sites as scheduled in Table 5-1. After consultation with and agreement from the City, the National Park Service may institute more active erosion mitigation measures at these sites as conditions change and as more is learned about the processes and rates of erosion at these sites.

The National Park Service shall undertake monitoring at sites where active erosion control measures are first installed within one year of the date of their installation in order to determine which active measures work best at the sites protected first (i.e., high-priority sites). In consultation with the City, the National Park Service shall use this information to modify erosion control measures proposed for sites assigned medium or low priority.

Monitoring shall include initial cross section surveys, placement of rebar stakes, photographic documentation, and periodic and intermittent resurveys based on first-year information. The

National Park Service shall monitor erosion at critical wildlife habitat sites yearly. Along both the transmission line corridor, especially where access roads cross steep landslide deposits, and steep slopes cut by State Highway Route 20, the National Park Service shall survey erosion annually. The National Park Service shall also monitor erosion at the Project road sites identified in Section 3.5 of the Erosion Control Plan.

The National Park Service shall monitor erosion at all new sites that are identified and for which site-specific erosion control plans are implemented in accordance with Section 11.0 below.

11.0 EROSION CONTROL WORK AT NEW SITES

New sites for erosion control work shall be identified jointly by the City and the National Park Service as follows. In conjunction with ongoing monitoring of erosion and inspection of erosion control measures at the reservoir shoreline sites identified in Section 3.0 of the Erosion Control Plan, the National Park Service shall identify any new shoreline area where erosion is such as to raise concern about the need for protection during the term of this Agreement. The National Park Service shall consult with the City to determine whether there are recreational facilities (trails, campgrounds, etc.), Project facilities (utility poles, etc.), or critical biological habitat within 300 feet of the eroding shoreline at full pool. If there are none, no further action shall be taken. If such sensitive areas (i.e., recreational facilities, Project facilities, or critical biological habitat) exist within 300 feet of the eroding shoreline, then the National Park Service shall arrange for the determination of the local shoreline erosion rate based on either known past shoreline positions, or, if these data are not available, the back-slope angle method described in Appendix A of the Erosion Control Plan.

The National Park Service shall also identify any new sensitive areas (recreational or project facilities, or critical biological habitat) where there is concern over whether the nearby shoreline area needs to be protected against erosion. If the newly identified sensitive area is within 300 feet of an eroding shoreline, then the National Park Service shall arrange for the determination of the local shoreline erosion rate based on either known past shoreline positions, or, if these data are not available, the back-slope angle method described in Appendix A of the Erosion Control Plan. If the newly identified sensitive area is more than 300 feet but less than 900 feet from the shoreline at full pool, the National Park Service shall initiate erosion monitoring. If the newly identified sensitive area is more than 900 feet from the shoreline at full pool, no further action shall be taken.

The observed bank recession rate or the erosion rate as determined by the back-slope angle method in Appendix A of the Erosion Control Plan shall be used by the National Park Service and the City jointly to determine whether sensitive areas are likely to be adversely affected by erosion over the license period plus 25 years. If both Parties agree these estimates indicate the possibility of an impact on sensitive areas from erosion, then the National Park Service shall prepare and implement a site-specific erosion control plan in consultation with the City.

The National Park Service and the City shall identify new erosion sites that occur along Project area roads. By mutual agreement and in accordance with Sections 5.0, 7.0, 9.0, and 10.0 above, the City and the National Park Service shall prepare and implement site-specific erosion control plans at these new sites.

12.0 SIGNATURES

IN WITNESS WHEREOF, the City has caused this Settlement Agreement to be executed by its Superintendent of Light pursuant to Ordinance No. 106741 and the Intervenors have executed same pursuant to applicable legal authority.

Respectfully submitted.

Dated: April 29, 1991

THE CITY OF SEATTLE

By: _____

Randall W. Hardy
Superintendent of City Light

Address for Notice:

Seattle City Light
1015 Third Avenue
Seattle, WA 98104

Dated: April 23, 1991

U.S. DEPARTMENT OF THE INTERIOR, NATIONAL PARK SERVICE

By: _____
John Earnst
Superintendent

Address for Notice:

North Cascades Park Service Complex
Pacific Northwest Region, National Park Service
U.S. Department of the Interior
North Cascades National Park Service Complex
2105 Highway 20
Sedro Woolley, WA 98284

SKAGIT RIVER
HYDROELECTRIC
PROJECT

FERC No. 553

EROSION CONTROL PLAN

City of Seattle
City Light Department

APRIL 1991

Skagit River Hydroelectric Project

FERC No. 553

Erosion Control Plan

Submitted by

City of Seattle
City Light Department

April 1991

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SUMMARY

Areas of erosion caused by the Skagit River Hydroelectric Project were identified in an earlier existing conditions report by Riedel (1990). The existing conditions report identified erosion at 1,238 sites along the three Project reservoirs and 18 sites along Project roads. (See Table 1-1, "Types of Erosion Control Sites," in this Plan).

Because it would be impractical to attempt to prevent erosion along all 16.2 miles of eroding reservoir shorelines, criteria were developed for selecting sites at which erosion control would be of most value. The primary criterion used to select sites for erosion control assessment was potential effects on recreational resources, Project facilities, and areas known to contain sensitive or rare habitat or species.

Erosion control at the selected erosion sites will include both passive and active measures. Passive measures will include monitoring erosion rates and processes at sites where erosion control would be difficult because of a high potential for large slump movements of soils (most Class I sites) or where disturbance would be undesirable (for example, osprey nesting trees). Active measures will be limited because of the wilderness setting of the Project, which precludes the use of large amounts of concrete, chemically treated lumber, or visually obtrusive structures. They will include biotechnical slope protection (vegetation), logs, rock walls, and cribbing.

On the basis of this assessment of current erosion conditions at the study sites, active erosion control measures will be implemented at 37 recreation and Project facility sites by the National Park Service pursuant to Section 7.0 of the Settlement Agreement Concerning Erosion Control between the City of Seattle, City Light Department (the City) and the U.S. Department of the Interior, National Park Service (National Park Service) (Settlement Agreement) and 18 road sites by the City and the National Park Service pursuant to Sections 5.0 and 7.0 of the Settlement Agreement. Sites that have had active erosion control measures installed and sites representing a variety of environmental settings will be monitored by the National Park Service pursuant to Section 10.0 of the Settlement Agreement. Monitoring erosion at selected sites will provide additional information on the processes and rates of erosion in the Project area at sites that could, in the future, become problem areas. Of the 74 sites selected for actions and monitoring, there are 48 on Ross Lake, 5 on Diablo Lake and 3 on Gorge Lake; the remaining 18 are along Project roads.

Sites where erosion is an immediate threat to a Project facility or to recreational, biological, or archaeological resources have been given high priority for erosion control work. Sites where erosion will eventually threaten a facility or resource have been assigned medium or low priority.

1.0 INTRODUCTION

1.1 BACKGROUND

Seattle City Light's Skagit River Hydroelectric Project (Project) on the Skagit River is located in the North Cascades Range of northwestern Washington. The area examined in this study extends from the Canadian border through the three reservoirs of the Project (Ross, Diablo, and Gorge lakes) to the confluence of the Skagit River with Bacon Creek (Figure 1-1). The Skagit River Project includes three dams constructed between 1927 and 1961, with a total generation capacity of 739 megawatts and a total storage capacity of 1.5 million acre-feet. The Project impounds 33 miles of the Skagit River basin, including 1.6 miles in British Columbia. In addition to the dams and reservoirs, the Project includes three powerhouses, transmission lines, roads, sand and gravel pits, and two towns. Seattle City Light's developments all lie within the Ross Lake National Recreation Area (NRA), which is part of the North Cascades National Park Service Complex. The lands surrounding the Project are primarily designated as part of the Stephen Mather Wilderness, where recreational uses such as fishing, camping, rafting, and hiking dominate. Downstream from the Ross Lake NRA, the Skagit River has been designated a Wild and Scenic River.

The objective of the Skagit River Hydroelectric Project Erosion Control Plan (Plan) is to describe erosion control measures that will be implemented at various sites in the Skagit River Project area in accordance with the Settlement Agreement Concerning Erosion Control between the City of Seattle, City Light Department (the City) and the U.S. Department of the Interior, National Park Service (National Park Service) (Settlement Agreement). This Plan stems from an earlier study describing existing conditions of reservoir, streambank, and road erosion in the Project area (Riedel, 1990).

The actual obligations of the City and the National Park Service for work at specific sites and funding are described in Sections 5.0 through 11.0 of the Settlement Agreement. Pursuant to Section 6.0 of the Settlement Agreement, the City will provide all funding for erosion control work. The City will do all erosion control work at Project road sites other than biotechnical slope protection measures; the City's responsibilities at these sites will include grading and site preparation for vegetation work by the National Park Service. The City will also institute a plant propagation program to supply plant material for erosion sites.

Pursuant to Section 7.0 of the Settlement Agreement, the National Park Service will do all erosion control work at Project reservoir shoreline sites and all biotechnical slope protection work at Project road sites. The National Park Service will also monitor erosion at all sites pursuant to Section 10.0 of the Settlement Agreement.

Section 1.1 of this Plan provides background, Section 1.2 describes the selection of sites for erosion control, Section 1.3 discusses constraints on the installation and construction of erosion control measures, Section 1.4 lists the criteria used to rank the need for erosion control at the individual sites, and Section 1.5 summarizes erosion processes and general techniques of erosion control. This part of the plan is to be used as guidance for reprioritizing sites and selecting new sites pursuant to Sections 9.0 and 11.0 of the Settlement Agreement.

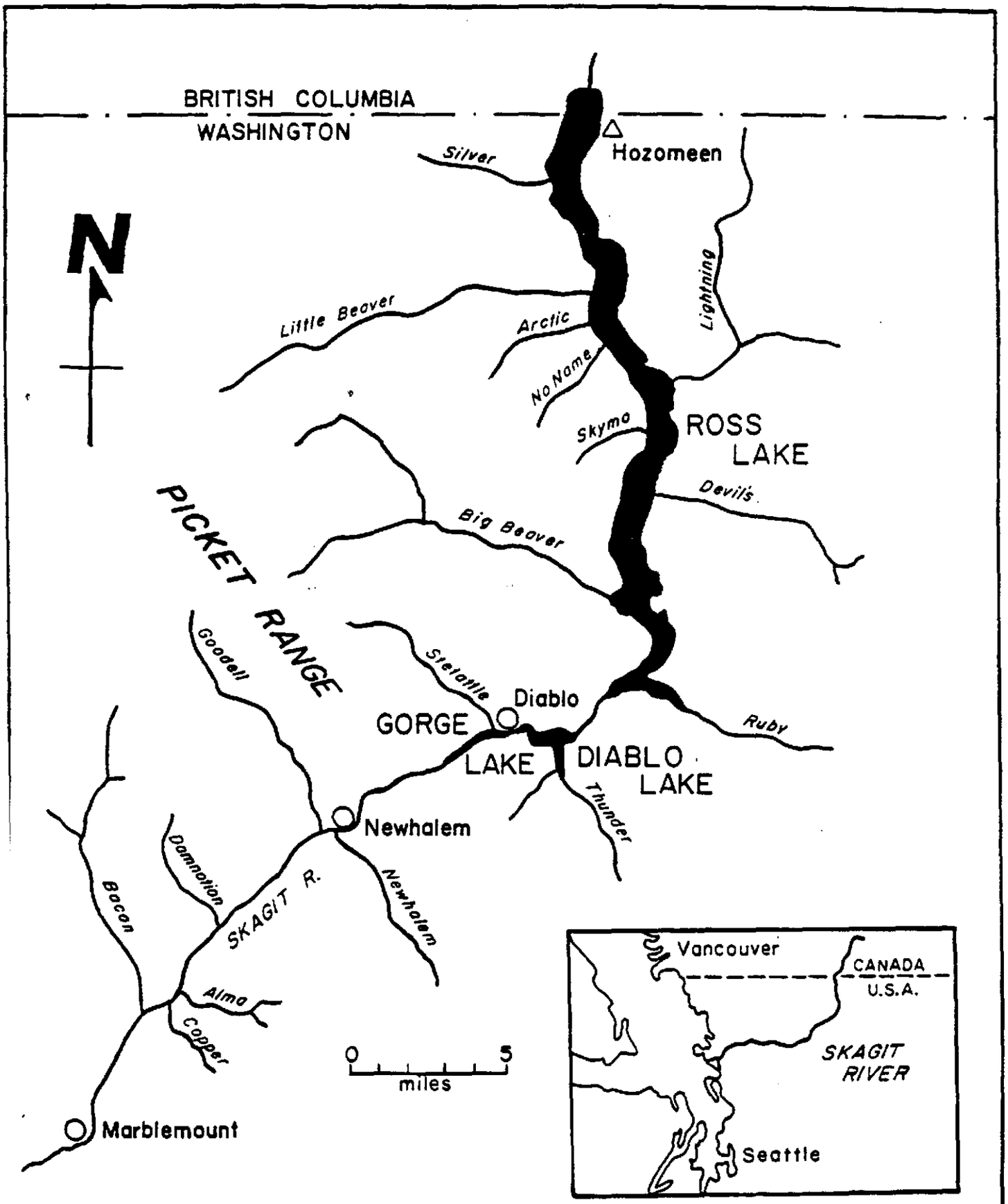


Figure 1-1 Project Study Area

Section 2.0 describes in detail the types of erosion control measures that will be used in the Project area (Sections 2.1 through 2.4); these sections will be used to choose erosion control measures at new sites and, if necessary, alternate ones at the sites in this Plan pursuant to Sections 9.0 and 11.0 of the Settlement Agreement. This section of the Plan also lists general road erosion control guidelines that the City will follow (Section 2.5) pursuant to Section 5.0 of the Settlement Agreement. It also describes additional measures that both the City and the National Park Service will take to minimize erosion in the Project area (Section 2.6) pursuant to Sections 5.0 and 7.0 of the Settlement Agreement.

Finally, Section 3.0 describes the sites and the erosion control work that will be done at each site. After an introduction (Section 3.1), site descriptions and erosion control prescriptions are given for recreation and Project facility sites (Section 3.2), Class I sites (Section 3.3), biological sites (Section 3.4), and Project road sites (Section 3.5). Erosion in the Skagit River channel is discussed in Section 3.6. The City and the National Park Service will use this part of the Plan to prepare the work plans and do the erosion control work at the Plan sites in accordance with the provisions of the Settlement Agreement. The National Park Service will do the work at shoreline sites to reduce rates of bank recession and prevent continued loss of land to shoreline erosion pursuant to Sections 7.0 and 8.0 of the Settlement Agreement. During the pre-license years the National Park Service will do the erosion control work at high-priority reservoir shoreline camp and trail sites as identified in the Plan and as agreed between the City and the National Park Service pursuant to Sections 6.1.1, 7.0, and 9.0 of the Settlement Agreement. The City and the National Park Service will do the work at the Project road sites pursuant to Sections 5.0 and 7.0 of the Settlement Agreement.

The project managers for the development of the Erosion Control Plan were Ed Pottharst of the City Light Department, Jay Brueggeman of Ebasco Environmental, and Jon Jarvis of the National Park Service. The technical leads were Bruce Stoker of Ebasco Environmental, with assistance from Jon Harbor and Tom Stewart, and Jon L. Riedel of the National Park Service.

1.2 SITE SELECTION

A variety of Project area sites have been selected for erosion control measures, including roads, areas of slope instability, important biological sites, Project facilities, and recreational facilities. (See Table 1-1, "Types of Erosion Control Sites.") Erosion control plans for archaeological sites will be prepared where appropriate as part of site-specific mitigation planning under the Archaeological Plan and its implementing Memorandum of Agreement to be developed pursuant to the Settlement Agreement Concerning Cultural Resources (Archaeological and Historic Resources). Because it would be impractical to attempt to prevent erosion along all 16.2 miles of eroding reservoir shoreline, criteria were developed for selecting sites at which erosion control would be of most value.

The primary criterion used to select sites for erosion control assessment was potential effects on recreational resources. Application of this criterion focused attention on campsites and trail sections adjacent to the reservoirs. In the rugged topography surrounding the Project, there are not many suitable locations for recreational facilities, so it is important to protect existing facilities. At these sites erosion problems are often compounded by direct human impact in terms of destruction of protective vegetation, surface soil compaction, and direct displacement (erosion) of soil.

Table 1-1. Types of Erosion Control Sites.

Class I Site—A shoreline with relatively severe erosion where large (>1,000 ft^3) mass movements were active, or where the potential for larger mass movements existed.

Class II Site—A shoreline with smaller (<1,000ft^3) active mass movements and/or where eroding bluff heights were greater than 3 to 5 feet in areas with no mass movement.

Class III Site—A shoreline with relatively minor erosion where bluff heights were less than 3-5 feet and no potential for mass movement existed.

Project Facility Site—An area with developments associated with operation and maintenance of the Project. These include transmission towers, powerhouses, and maintenance buildings.

Recreation Site—An area that the National Park Service has developed for recreation by putting in picnic tables, fire grates, sanitary facilities, and shelters. Recreation sites include campsites, picnic areas, docks, and trails.

Road Site—An area on or near a Project road where erosion caused by the road or other Project facility associated with the road is occurring. Erosion is caused by roads where the road exposes mineral soil on steep slopes and interrupts stream drainage.

Biological Site—An area known to contain sensitive or rare habitat or species.

Project facilities are threatened by shoreline erosion in only one location. This site (D-40) was examined for erosion problems.

Class I erosion sites (>1,000 ft^3 mass movements; see Table 1-1) identified in the existing conditions report (Riedel, 1990) were evaluated. These sites represent the most severe areas of slope instability and are the most visible along the reservoirs.

All shoreline sites identified by National Park Service personnel as having particular biological or cultural value were examined for potential damage by erosion. Of three osprey nesting trees on Ross Lake, only one could eventually be endangered by erosion. Known areas of sensitive or rare habitat or species do not appear to be threatened by erosion, although additional studies may identify such areas.

Sites where erosion is occurring along Project roads (Riedel, 1990) were evaluated, as were all areas where erosion threatened Project facilities such as transmission towers.

At each site where an assessment of erosion control needs was made, information was collected on site materials, vegetation, erosion rates, and erosion mechanisms. Site photographs, field notes, and field survey data were used to prepare maps or cross-sections to illustrate the nature and extent of existing erosion problems and to aid in designing erosion control methods. Initiated in August 1989, this work was largely undertaken in the first half of October 1989, when lower reservoir levels provided good exposure of the foundations of existing structures, docks, and toe-slopes of the full pool bluffs. Field work was conducted by Seattle City Light consultants (Ebasco Environmental) and the North Cascades National Park Geologist.

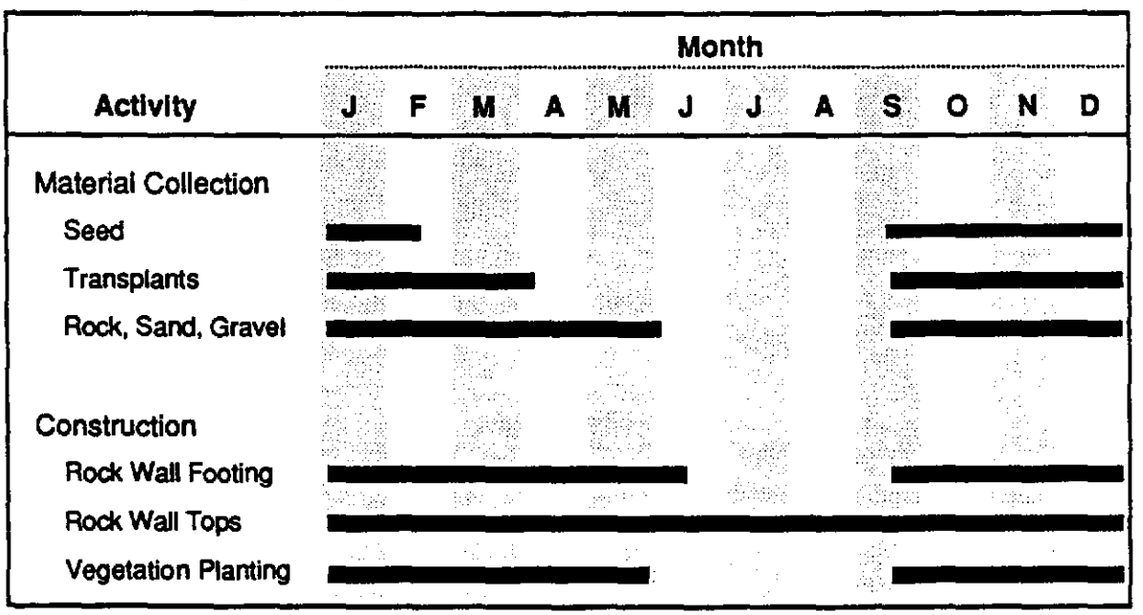
On the basis of this assessment of current erosion conditions at the study sites, 37 recreation and Project facility sites and 18 road sites (see Table 1-1 for site definitions) have been identified and given priority for installation of erosion control measures. Sites where active erosion control measures have been installed, as well as sites representing a variety of environmental settings, and one osprey nesting tree will be monitored to better evaluate future bank recession rates and processes. Monitoring of sites where erosion control measures are undertaken will also be done. If installed erosion control measures fail at a site, a repair plan will be developed and implemented.

1.3 CONSTRUCTION TIMING AND CONSTRAINTS

Fluctuating water levels on Ross Lake and vegetation collection and planting procedures require that the timing for construction of mitigation structures be seasonally coordinated. In accordance with the Settlement Agreement, the goal of the National Park Service and the City will be to implement the erosion control measures at the sites in this Plan during the pre-license years and the first ten license years. Spreading the work over this span of time will prevent logistical problems associated with having a large crew in a remote area with limited facilities. In addition, work by the National Park Service during pre-license years at several high-priority reservoir shoreline camp and trail sites will allow monitoring and analysis to determine which erosion control methods work best. Because of the steepness of slopes along the reservoirs and the intensity of the erosion processes, some structures proposed in the following plan will need to be maintained and occasionally refurbished to avoid additional damage and possibly complete failure of the structures.

The movement of material, equipment, and laborers on Ross Lake will also require coordination. The National Park Service will arrange to lease or buy a barge or other large boat to move heavy machinery and rocks. (A barge could be brought in pieces into Hozomeen and assembled on the lake.) Fluctuating lake levels will require careful scheduling for collection and movement of material and construction of erosion control measures at many of the sites (Table 1-2). Installation of erosion control measures at shoreline sites will be timed around lake levels. Portions of the erosion control work may require drawdowns of Gorge and Diablo reservoirs; the National Park Service will coordinate with the City to schedule the least disruptive time for the work. The City may defer necessary drawdowns until they are required for other Project maintenance activities. The City will provide assistance, through mutually agreed scheduling of the City's barges, in the implementation of erosion control work at the Diablo Lake sites identified in this Plan.

Table 1-2. Timing of Mitigation Activities.



Trout spawning occurs during May, June, and July, and egg incubation occurs in August and September. Work that would put sediment into tributaries of Ross Lake will be avoided in these months.

1.4 SITE PROTECTION PRIORITY

Due to variations in the rate of bank recession at individual sites, priority will be given to installation of mitigation measures at sites where damage to important resources (recreation facilities, habitat, Project facilities) is ongoing and rapid. For recreation and Project facility sites, estimates of bank recession rate and consideration of environmental factors such as slope, bank material type, and dominant erosion process were used to prioritize site protection. High priority is given to sites where erosion immediately (five years or less) threatens any of the following: recreation facilities

such as trails, campgrounds, boat docks, and toilets; valuable resources such as old-growth trees that, as a result of erosion, also pose a threat to public safety; and facilities that cannot be relocated. Areas where facilities or resources are not immediately (five to twenty years) threatened are given medium priority. Where bank recession rates are low, erosion control is given lower priority, meaning erosion protection will wait until higher priority sites are completed.

Erosion control at road sites was also prioritized. Sites where erosion posed an immediate threat to the roads or other resources were given the highest priority, while those areas where erosion rates are lower were given lower priority.

Site protection priority is listed in Table 1-3 based on an approximately ten-year program for implementation of erosion control at the sites as detailed in Section 3.0 of this Plan. In a few cases work at a medium priority site has been scheduled for the same year as work at a nearby high-priority site for efficiency. In accordance with Section 9.0 of the Settlement Agreement, during the pre-license years and the first nine license years, the City and the National Park Service will re-evaluate site priority annually in work plans for the following two years to make allowances for changes in erosion conditions.

The City and the National Park Service will identify new sites in the Project area for erosion control work and, if necessary, by mutual agreement reprioritize sites in the Plan scheduled for work or choose alternate erosion control measures for Plan sites pursuant to Sections 8.0 and 10.0 of the Settlement Agreement.

1.5 EROSION PROCESSES AND CONTROL TECHNIQUES

Most of the sites identified for erosion control measures are along reservoir shorelines. Erosion at the reservoir high water level (elevation 1602.5 feet and referred to as "max pool" in site drawings) at these sites has undercut steep slopes that have thick accumulations of Quaternary-age sediments, leading to various degrees of surface instability. Instability ranges from slump failures in thick accumulations of relatively compact materials (over-consolidated glacial deposits) to surface ravelling in the less compact glacial outwash deposits and colluvium. In either case, the removal of material at the base of the slopes destabilizes the overlying sediments, leading to bank collapse and recession. Subsequent wave action, focused on different elevations as lake levels rise and fall, removes the collapsed material and causes renewed undercutting and a continuation of the erosion cycle. Drifting logs can also adversely impact the shoreline and vegetation along it. In certain cases, collections of logs can protect sections of shoreline; in still other cases, they can have no effect. Therefore, site-specific decisions on log removal are necessary. The primary goal of erosion control is to reduce continued toe-slope erosion and stabilize the surface deposits in a visually acceptable manner.

Erosion control measures developed in this plan include both active and passive techniques. Active techniques include placement of structures and vegetation to stop erosion (Gray and Lieser, 1982; Schiechtl, 1980; Sotir and Gray, 1989; White and Francis, 1978; Water Resources Adm., 1983; Kortenhof, 1988; Lynott, 1989; and Madej et al., 1980). Passive measures include monitoring

Table 1-3. Site Protection Priority and Schedule.

Project Year	Site Name[1/]	Site Priority	Comments
Year 1	W-124	H	
	R-17	H	Road site
Year 2	Monitoring set-up[2/]	H	
	E-56	H	Big site; popular camp; old trees
	E-134A+B	H	Potential loss of dock bulkhead
	E-70A5	H	East Bank Trail
	R-8A, R-8B, R-8C, R-11, R-15	H	Road sites
Year 3	E-116	H	N. Lightning Cr. Trail
	E-70A3 (First half)	H	East Bank Trail; Big Beaver Trail
	E-70A1	H	East Bank Trail; Big Beaver Trail
	R-1, R-5	H	Road sites
Year 4	W-34	H	
	W-36A, W-36B	M[3/]	
	E-70A3 (Second half)	H	East Bank Trail; Big Beaver Trail
Year 5	E-9, E-64, E-68	H	
	R-2, R-4, R-9, R-10, R-12, R-16	H	Road sites
Year 6	D-11	H	Large site; potential loss of land
	D-8, D-43	H	
	D-40	M	
	R-14	L	Road site
Year 7	E-70A4	H	East Bank Trail; Big Beaver Trail
	R-3, R-7, R-13	L	Road sites
	E-47, E-80B, E-92, E-100	M	
	E-70A6	M	East Bank Trail; Big Beaver Trail
	E-40	L	
Year 8	E-95, E-112, E-118A+B	M	
	E-87, E-117	L	
	Maintenance of interim & other sites		
Year 9	W-135	H	Class I site
	Maintenance of previously-placed structures		

1/ See Section 3.0 for details about each site. Sites are numbered and prefaced with the letters "R," "D," "E," or "W": "R"=road site; "D"=Diablo Lake site; "E"=site on east shoreline of Ross Lake; "W"=site on west shoreline of Ross Lake.

2/ Annual monitoring program for all Class I sites in Section 3.3 (Class I Erosion Sites) of the Plan, road sites in Section 3.5 (Road Erosion Sites) of the Plan, and new sites identified in accordance with Section 11.0 of the Settlement Agreement.

3/ Work at several medium-priority sites has been scheduled for the same year as work at adjacent high-priority sites for efficiency.

schemes designed to provide more information on the process and rates of erosion, such as at Class I sites. Active erosion control and stabilization methods are limited by National Park Service management objectives to maintain the natural and wilderness conditions in the Project area.

Stabilization structures such as extensive concrete walls and chemically treated lumber are inappropriate. Preferred methods include biotechnical slope protection measures that include a combination of vegetation and structural controls (Gray and Leiser, 1982; Schiechtl, 1980; Sotir and Gray, 1989). These measures are designed to minimize the visual impacts of erosion control by using naturally occurring materials (local earth, rock, timber, and vegetation) that blend with the surrounding site features. For the types of problems encountered in the study area, a number of standard erosion control measures are appropriate, which will be tailored to individual site conditions. Depending on slope angles, wave energy levels, and shoreline soils, reduction of toe-slope retreat will involve protective measures such as anchored individual logs or networks of logs, riprap, cribbing, vegetation, and gabions. Surface stabilization will primarily be accomplished with vegetation, using local, fast-rooting plants adapted to disturbed conditions. In certain areas, successful vegetation will require planning to minimize human disturbance of sensitive slopes.

2.0 TYPICAL EROSION CONTROL MEASURES

Undercutting of toe-slopes along the reservoir shoreline is the primary cause of bank recession and slope instability. Therefore, slope protection measures are designed to stabilize the bottom of eroding shoreline slopes. Such erosion control measures vary in scale and effectiveness, and for this discussion have been subdivided into four broad groups: anchored logs, rock shore protection, cribbing, and vegetation. Vegetation, although alone generally ineffective in toe-slope protection where wave action is a major erosion process, is important in stabilizing disturbed slope surfaces in conjunction with rock armor or retaining structures. Vegetation is also important in reducing surface erosion from rain splash and rilling and in helping rock and cribbing structures blend with natural surroundings.

2.1 ANCHORED LOGS

Perhaps the simplest and cheapest means to reduce wave erosion at the base of slopes where there is relatively minor erosion is to anchor logs along the shore at the full pool level. In some areas of the Project, logs naturally collect against the shore where the dominant winds blow onshore. In these areas some wave energy is reduced when the waves break on the logs rather than directly against the bank material. However, in some cases the logs are repeatedly pushed against the shore or bottom by wave action, increasing erosion as the momentum of the logs is expended against localized points of contact with the shore. This latter effect only occurs where the logs are buoyant and free to move with the fluctuating water levels associated with individual waves. Anchoring logs to the shore restricts log movement, and thus ensures that the net effect is one of slope protection rather than erosion enhancement. A major disadvantage of logs is that water still washes behind them, potentially allowing some fine soil material to wash out.

Figure 2-1 shows a typical example of slope protection using anchored logs. If bedrock is located on one or both ends of a wedge of eroding soil, cables passed through holes drilled in the logs may be anchored with rock bolts in the bedrock. In many areas the underlying material is not bedrock, and in these cases it is important to ensure that the logs can be anchored securely. In very compact substrate (over consolidated till), logs may still be effectively anchored into the substrate, but for looser substrates anchored logs should not be used as an erosion control measure unless the logs can be tied off at both ends to large immobile objects such as existing dock anchors, stumps, and concrete or large rocks placed as anchors.

One of the advantages of using anchored logs for shore protection is that the measure replicates a natural occurrence in the reservoir setting, and thus has less negative visual impacts than other means of erosion control. However, anchored logs are generally only effective for conditions of relatively minor wave erosion. Where slopes are steep and several erosion processes are active, logs alone are ineffective.

Materials needed for log shore protection will include cable and miscellaneous hardware, rock anchors at some sites, concrete or 3- to 4-foot diameter rocks for anchors, and logs, which are abundant on the lakes.

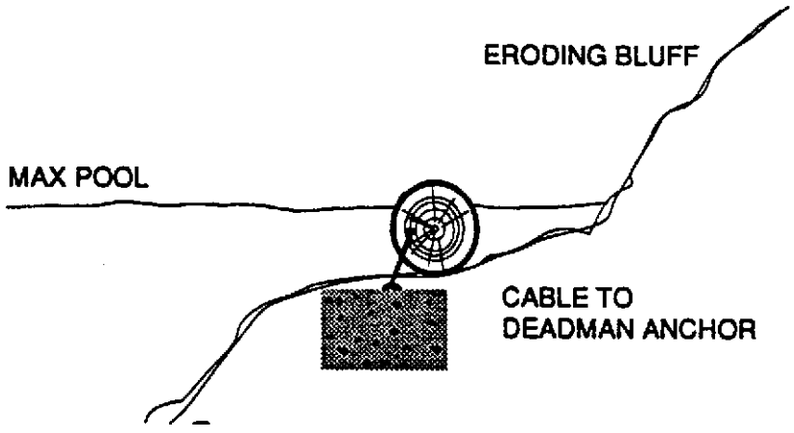


FIGURE 2-1
TYPICAL LOG
SHORE PROTECTION

Seattle City Light

2.2 ROCK SHORE PROTECTION

Where there is no substrate suitable for anchoring logs, and where erosion is severe, construction of a rock wall in combination with vegetation to protect the base of an eroding bluff will ensure a greater level of shore protection. Rock wall protection consists of placing material along the shore that is large enough to withstand movement by wave action. Wave energy is expended against the large boulders rather than more erodible bank materials. In some situations in the Project area, natural rock armor has developed (photograph of site E-95, Lightning Creek Horse Camp, on page 3-32 shows natural rock armoring). Armoring at eroding sites occurs where the shore material consists of both fine soil material and very large boulders; such boulders are common at eroding sites where the bank material is glacial till. Wave erosion removes the finer soil material, leaving behind the large boulders as a coarse lag deposit. Thus, placement of riprap as a bank protection measure replicates a situation that occurs naturally in the Project area, and is less likely to be perceived as a negative visual impact than some other means of erosion control. Shrubs and trees such as willows, alders, and vine maple can be placed among the rocks during or after installation to help prevent movement of the rocks and provide a more natural-looking shoreline.

To protect shorelines from erosion, rock walls must extend above the highest water level and below the wave scour level, and have toe protection so that erosion will not remove the foundation of the rock when the reservoir is lowered. On Ross Lake, full pool elevation is 1602.5 feet, but lake levels occasionally rise as much as 0.9 feet above this level (Riedel, 1990). Wave heights on Ross Lake can be as high as 3.5 to 4 feet (Figure 2-2) (Gray and Leiser, 1982).

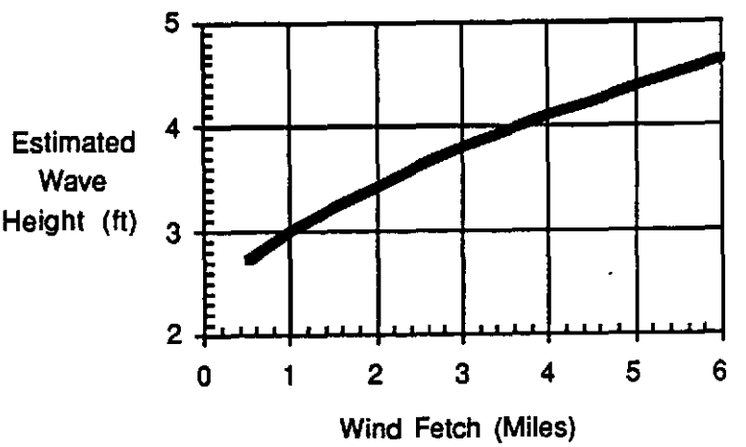


Figure 2-2. Wind fetch and estimated wave heights.

Based on wave heights and pool elevations in Ross and Diablo Lakes, rock shore protection should extend to a minimum of 1606.5 feet (4 feet above full pool) at sites open to a long fetch on Ross Lake, and 1212 feet (6 feet above full pool) on Diablo Lake where eroding bluff heights are greater than 4 feet. Where bluff heights are less than 4 feet, walls should extend to the top of the eroding bluff.

Figure 2-3 shows some typical examples of rock slope protection. The rock must be large enough to prevent rock movement by wave action, and must be trenched down into the slope to provide a stable foundation for the rock below scour levels. To prevent waves from washing loose backfill and shoreline soils from between and behind the larger rocks, a fabric or soil filter is used behind the riprap. Geotextile fabric is commonly used in this case; however, it would need to be carefully installed using a dark color fabric so that portions of the fabric are not visible. Over time portions of the riprap walls will fail, exposing the fabric. Therefore, use of a soil filter behind the riprap walls may be a better choice for the visually sensitive Project area. Soil filter material is available along the foreshore at many of the sites.

A soil filter is a porous backfill material behind the riprap with openings small enough to prevent movement of backfill soil, but sufficiently permeable to allow little resistance to seepage (Peck et al., 1974; Craig, 1983; Sowers, 1979). A typical soil filter design for the rock structures would require a gradation from the coarse 1- to 4-foot-diameter rock protection material to a cobble/gravel mixture in the first backfill layer and a gravel/sand mixture in the second backfill layer.

Rock shore protection will be used to control erosion at many of the eroding sites. When used in combination with vegetation, this method provides reliable long-term protection that can be constructed with abundant local material to fit visually with the surrounding features at many sites. Rocks are locally available near most sites in the drawdown zone, but should not be removed from beaches within 30 feet of eroding sites or beaches immediately adjacent to a site. At a few sites, rocks will need to be brought in by barge from at least a mile away.

To move and place the rock will require a backhoe for sites with low gradient beach areas and a barge-based boom for steeper areas and areas where the rock must be moved in from other locations. In all cases, a lifting device will be needed to move rocks large enough (2- to 4-foot diameter) to resist erosion by waves. The boom and backhoe could also be used to excavate foundation areas as needed, place the rock, and gather cobble and gravel from the drawdown zone for soil filter backfill material.

Movement and collection of rock will need to be seasonally coordinated with fluctuating reservoir levels. For erosion control sites too steep for a backhoe, rock would be collected during lake drawdown and stored until water levels rise enough to allow movement of the rock to near the full pool level where erosion protection is needed. Collection of rock and soil filter material will need to avoid disturbance of archaeological sites in the drawdown zone.

2.3 CRIBBING AND GABIONS

Cribbing structures will be used at sites where eroding bluffs are higher than 8 feet. They will be used to repair some existing wood cribs that were built along the East Bank Trail in the late 1960s. Some of these cribbing structures failed because of damage to the crib foundation. Most of the split cedar wood is still in good condition. Excavation of a bench to place the first level of cribbing, cable tiedowns, and 1-to-4 foot rock armor at the base of cribs will be used for many of the new and

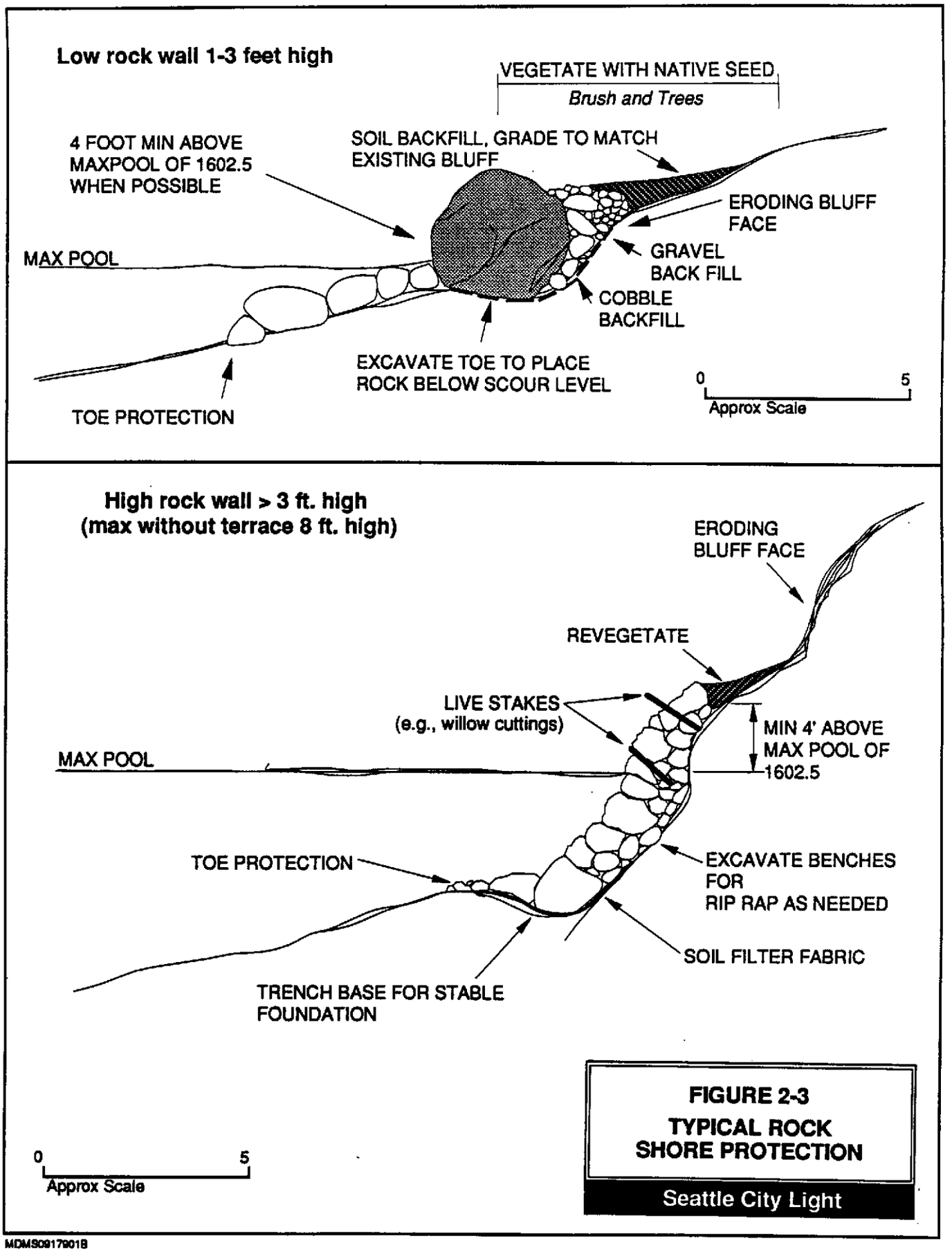


FIGURE 2-3
TYPICAL ROCK SHORE PROTECTION

Seattle City Light

restored cribs (Figure 2-4). Soil filter backfill for the portions of the cribs in the water zone is required to prevent soil from washing out of the cribs. Trees and brush will be planted among the cribbing members and on crib terraces to reduce the visual effect and help stabilize backfill soils.

Cribbing is commonly constructed from treated wood, precast concrete, or metal. Visual aspects of the Project area require the use of logs, roughcut timber or split timber. Untreated cedar wood which is naturally resistant to rotting and can be purchased locally will be used if available. The condition of the existing cedar cribbing indicates untreated cedar will last at least 25 to 30 years. Consideration will be given to custom precast cribbing members that could be made from molds of logs which simulate the appearance of wood but provide the durability of concrete: custom concrete cribbing made to look like logs would require some design effort but could be manufactured locally under contract and would have a much longer life.

Crib structures require stable, armored foundations and carefully designed tiebacks, or failure will result. A bench must be excavated to support the lowest tier for slopes over 10 degrees. Steel or wood piles can be used to hold the crib foundation if a stable shallow foundation cannot be made in the surface material. Rough-cut wood or log cribbing structures have a rustic appearance compared with gabion baskets which have a very uniform appearance when not covered with vegetation. Cribbing or gabion structures without extensive vegetation buffers stand out from their natural surroundings.

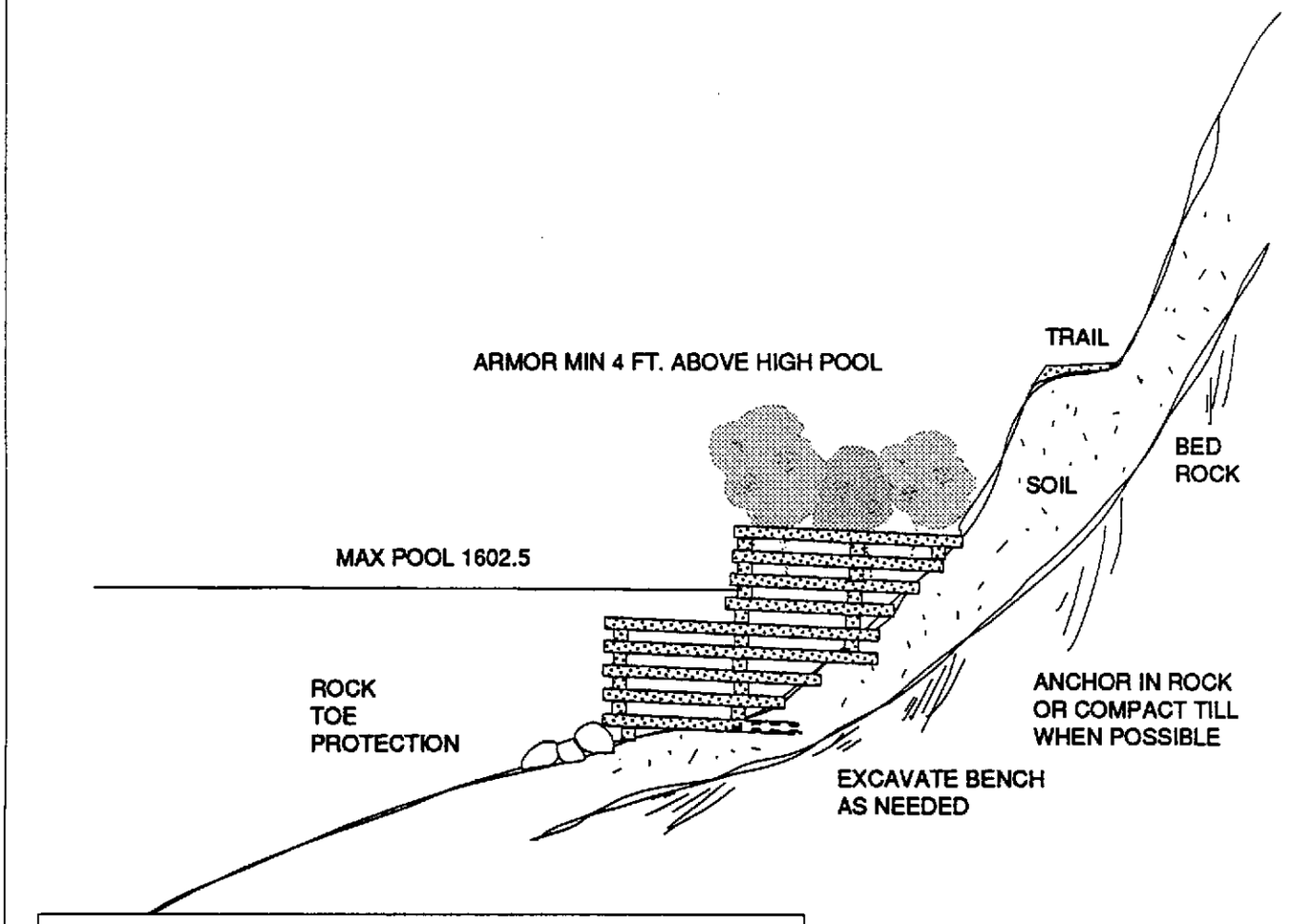
Backfill in the parts of cribs below water must be faced with 1- to 3-foot-diameter rocks for stability. Upper tiers can be backfilled with soil if soil filter design or filter fabric is used to prevent loss of fine-grained sediment. Vegetation can be planted among the cribbing members and on the crib terraces of multiple level cribs.

Gabions were once proposed but never installed by the National Park Service for repairs along the East Bank Trail (National Park Service, personal communication, 1989). Gabions are wire-mesh baskets filled with rock and linked together to provide erosion protection. Abundant fill materials are available for use in gabions, and material costs are likely to be less than cedar or concrete cribbing. Gabions require stable, armored foundations and carefully designed tiebacks, or failure will result.

Large structures made of gabions contrast sharply with the visual features of the reservoir shorelines. Gabion design will include use of vegetation to help reduce visual impact. Vegetation can be planted on tiers built up with gabions. Live stakes can be driven in the gabions if backfill in the back of the gabions is partially soil. Soil filter design is required with gabions if soil backfill is used.

2.4 VEGETATION

Vegetation assists in detention of water, slows water flow velocities, helps hold together soils and broken rocks, reduces surface erosion, and helps blend erosion control structures with the surrounding terrain. Vegetation can be used alone or in conjunction with other methods to stabilize slopes, depending on soil type and thickness, slope, wave energy, and other environmental factors.



CRIBBING MATERIAL

- UNTREATED CEDAR , OR PRE-FAB CONCRETE FROM WOOD MOLDS TO CREATE TEXTURE AND SHAPE OF ROUGH-CUT CEDAR LOGS

CRIBBING BACK FILL

- BOULDERS,COBBLES IN BASE AND FACE AREAS COBBLES,GRAVEL,SOIL FILTER IN BACK ABOVE MAX POOL, OR FILTER FABRIC IN FACE WITH FREE DRAINING BACKFILL

CRIBBING VEGETATION

- NATIVE PLANTS THAT BLEND WITH EXISTING SITE SPECIES
- PLANT BRUSH AND TREES ON CRIB TERRACES
- WILLOWS CAN BE LAYERED IN FRONT OF CRIBS ABOVE WATER LINE AS VISUAL MEASURE

FIGURE 2-4
TYPICAL CRIBBING SHORE PROTECTION

Seattle City Light

MDMS0917901C

National Park Service vegetation plans require the use of local species to protect the genetic integrity of species and the plant community as a whole. Therefore, seeds or transplants will be collected within the Skagit River Basin as close as possible to the site. Use of local varieties also provides plants that are better adapted to site conditions. Common plants at each site are listed in the third section of this Plan (Section 3.0). Plant lists for the Project area have been presented in earlier reports (Envirosphere, 1985, 1988).

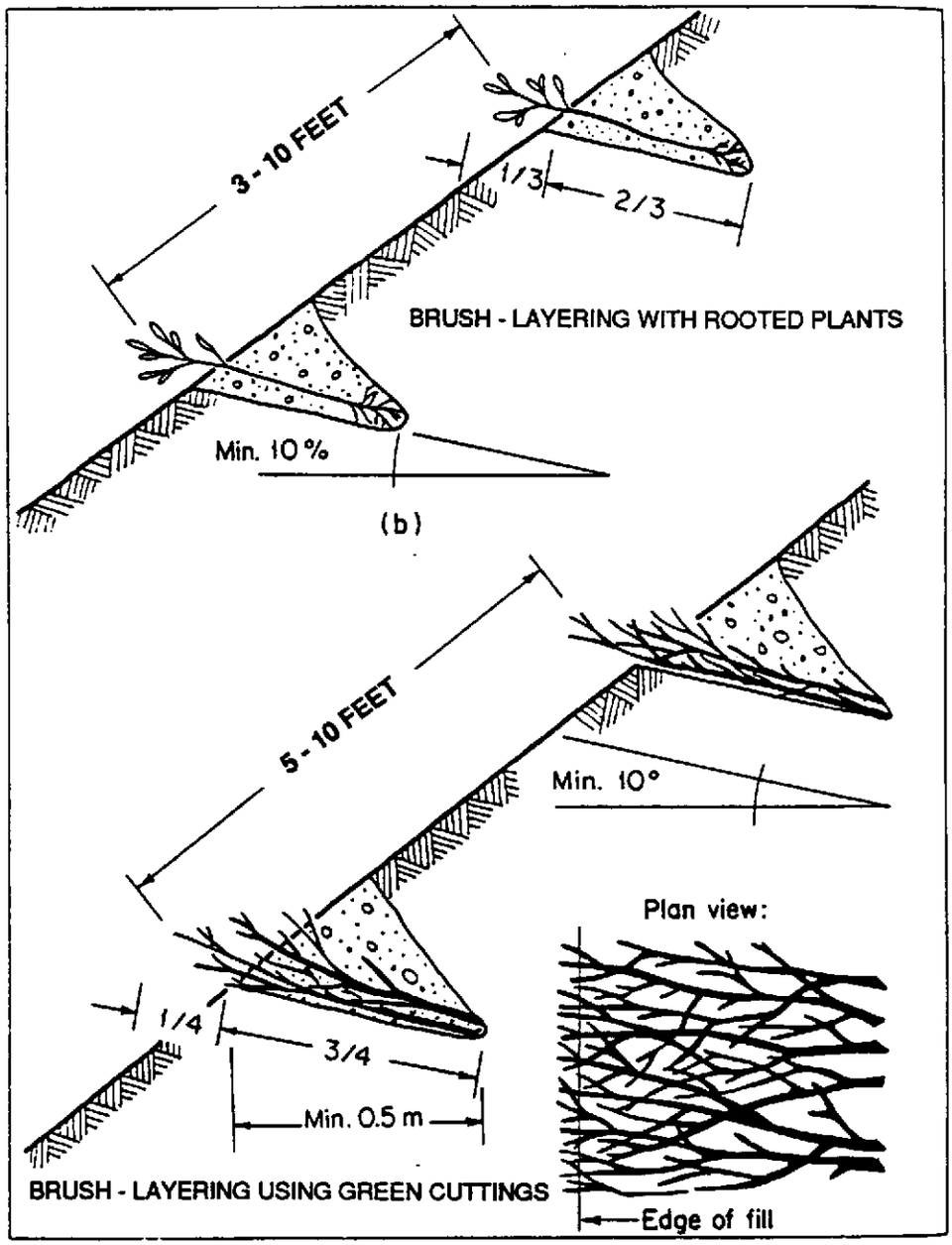
Vegetation generally involves transplanting or direct seeding of an area. At North Cascades National Park, transplanting has been the traditional method of the vegetation program. Recent experiments in the park suggest that direct seeding may be a viable alternative, although additional experimentation is needed. Transplants can come from two sources: (1) cuts from mature plants in undisturbed areas, or (2) plants grown from seeds in a nursery or greenhouse. The success of taking transplants from mature plants varies with individual species and at individual sites. The success of growing plants from seeds requires effective replication of environmental conditions in a nursery or greenhouse (e.g., soil temperature, moisture, and light).

In accordance with Sections 5.0 and 6.3 of the Settlement Agreement, the City will construct greenhouse facilities and institute a program of plant propagation. To help provide erosion control and wildlife benefits during the new license period, Seattle City Light will produce 30,000 low-elevation plants annually for vegetation efforts. This program is described in detail in Section 6.0 of the Skagit Project Wildlife Habitat Protection and Management Plan.

At most sites a combination of vegetation methods will be used. Vegetation protection alone will be tried at several sites where the intensity of erosional processes is low and shore sediments are loose- to medium-compact. Typical brush layering methods to protect slopes are shown in Figure 2-5. Areas with high rates of erosion (high wave energy) and compact bank sediments cannot be protected by vegetation alone, since vegetation may take several years to become established.

The main species used for vegetation of disturbed areas will include trees such as red alder, Douglas-fir, lodgepole pine, and western white pine; shrubs such as willow, vine maple, Oregon grape, and salal; and other local berries, grasses, and sedges. Transplants of brush, trees, and live stakes will require planning and lag time to harvest and possibly store plants until the best planting time.

Vegetation collection will be arranged seasonally (see Table 1-2). Cuttings and transplants will be taken during periods of plant dormancy (i.e., late fall to early spring), and seeds collected during the fall. Seed sources within the study area include the power line, road and trail corridors, shoreline areas, and valleys adjacent to the reservoirs such as Big Beaver, Thunder, and Lightning creeks. Live stakes and transplants within the study area will also be obtained from the same areas used to obtain seed sources with the exception of shoreline areas.



(From Gray, 1982)

FIGURE 2-5
TYPICAL BRUSH LAYERING METHODS

Seattle City Light

BRANCHES 3 -4 FEET LONG
3/4" TO 2" DIA.
SPACED AT 8 " TO 12"

2.5 GENERAL ROAD EROSION CONTROL GUIDELINES

As much as is practical, the City will use the following guidelines in the design, maintenance, and rehabilitation of Project roads. The general guidelines below and the site-specific guidelines listed in Section 3.5 (Road Erosion Sites) will help reduce the amount of sediment that commonly washes from roads during storms.

- Inspect Project area roads for problems during and after major storms.
- Provide regular maintenance of the road and water crossings.
- Use culverts in accord with the following information and guidelines. Ditch and creek culverts are likely to become plugged during storms unless greatly oversized in relation to channel sediment and woody debris. Once the culvert is partially or completely plugged the reservoir created behind the road fill can quickly fill and flow over the newly created dam. This dam has no emergency spillway or slope design to prevent it from washing out. Initial response of the road fill while the reservoir is filling is the creation of ground water seepage through the fill. Locations where the water seeps out can slump if not properly designed. Depending on the severity of the blockage, the reservoir will fill within a time frame of minutes to several hours. Once filled, water can run down slope and across the road to locations where concentrated water normally does not run. Monitoring culverts during large storms can potentially reduce maintenance and impacts from road failures. Culverts can be replaced with armored grade dips, low water crossings, and water bars on low use and closed roads. Critical crossings as defined for this report are locations where flooding would cause erosion and slope failures that would adversely impact creeks and be costly to repair if the water crossing were to fail. Upgrading of critical crossings will greatly reduce the risk of fill failure. Upgrading of critical crossings should include water bars, an armored dip, and spillway to provide for safe failure if there is a temporary blockage of the culvert (Figures 2-6 and 2-7). As a general guideline, oversized culverts should be placed at all water crossings with defined channels. Armored dips and spillways should be built at all critical crossings, and standard undersized culverts should only be used for cross culverts that drain the road and cutslope.
- Install waterbars for the duration of the wet season at culverts that do not have road dips. Leave water bars in year round where possible.
- Provide rock inlets and outlets at culverts that have moderate to high inlet or outlet water velocities.
- Do maintenance and construction near water features in the dry season.
- Use temporary straw bale or sand bag check dams during construction near creeks or ditches with flowing water (Figure 2-8).

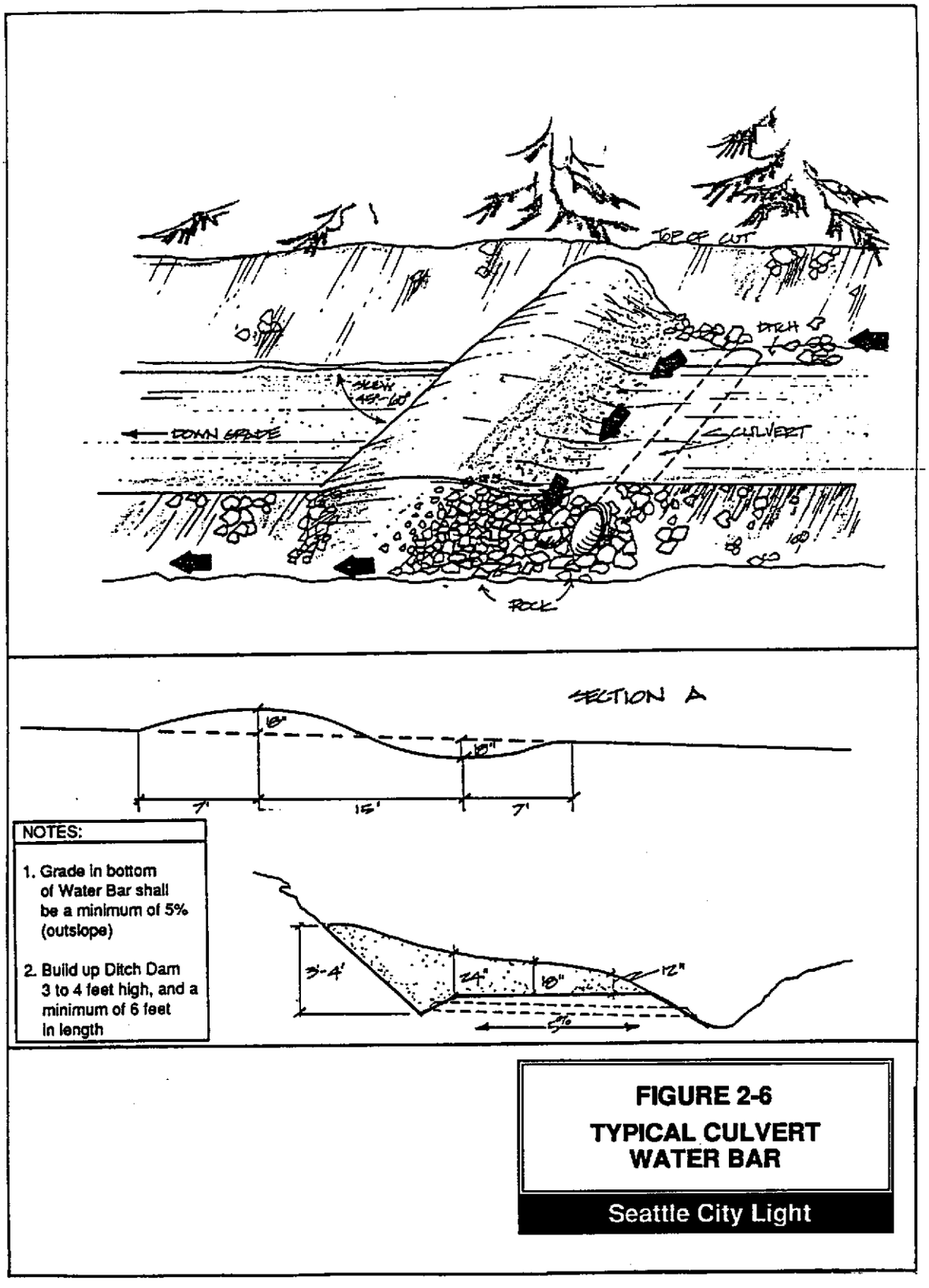


FIGURE 2-6

TYPICAL CULVERT WATER BAR

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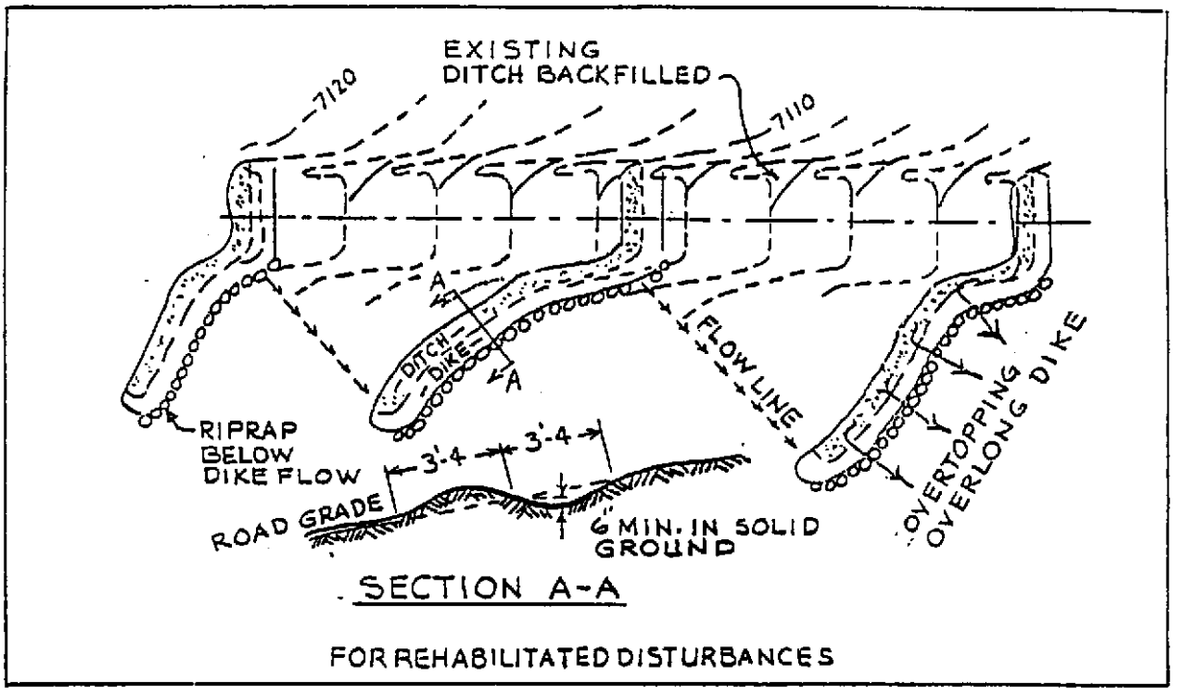
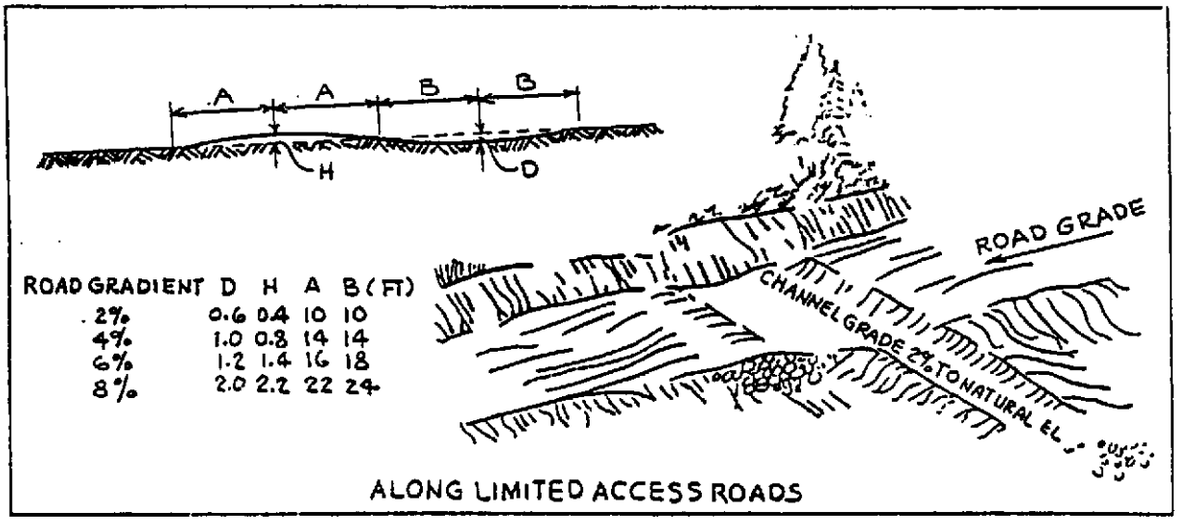


SECTION A-A

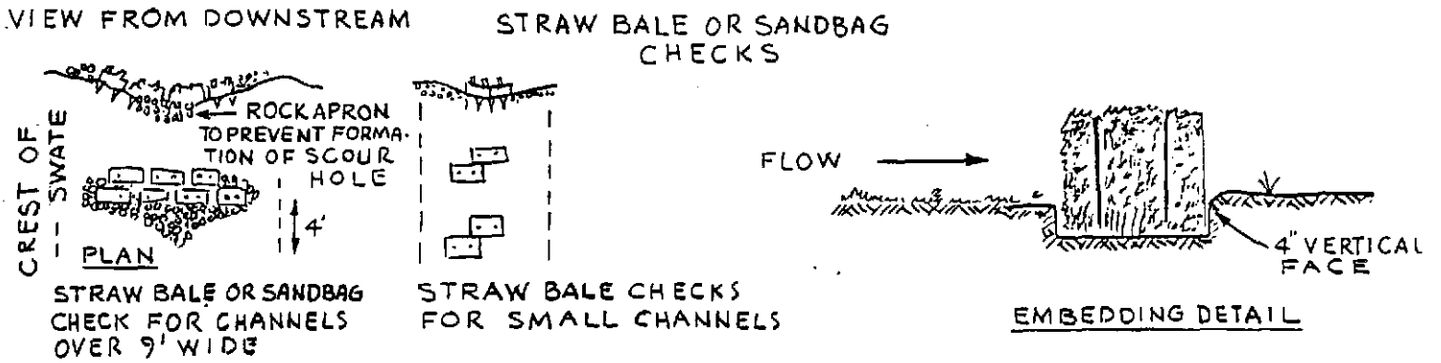
FOR REHABILITATED DISTURBANCES

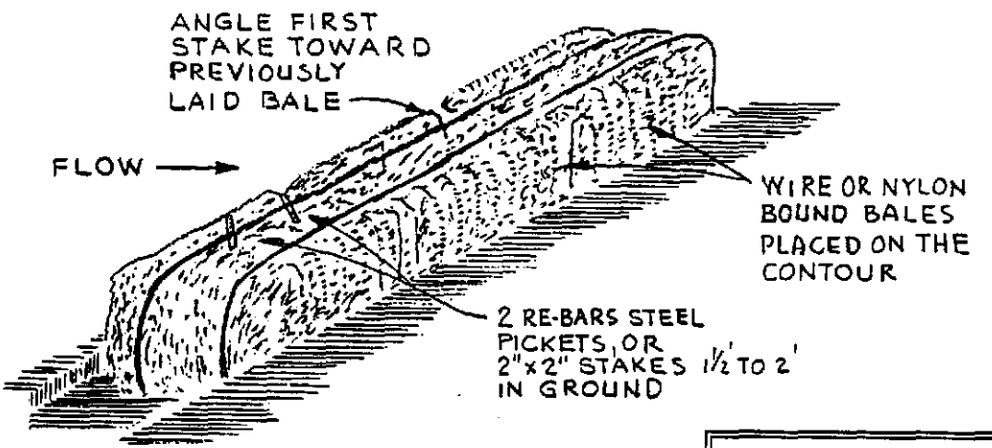


ALONG LIMITED ACCESS ROADS

FIGURE 2-7
TYPICAL ROAD SURFACE WATER BAR

Seattle City Light





ANCHORING DETAIL

FIGURE 2-8
TYPICAL CHECK DAM

Seattle City Light

- Refrain from sidecasting material; if the bed is to be expanded, build up a compacted fill. To rebuild washouts, terrace the base before starting fill lifts and use brush layering methods for living soil reinforcement if needed (Figure 2-5) (Schiechtl, 1980; Gray and Leiser, 1982). Native woody plants from a similar or greater elevation that are adapted to the site should be used to stabilize soils.

- Seed and mulch all disturbed areas with suitable native vegetation.

2.6 ADDITIONAL MEASURES TO MINIMIZE EROSION IN THE PROJECT AREA

As indicated below, the City and the National Park Service will take the following additional measures to minimize erosion in the Project area pursuant to Sections 5.0 and 7.0 of the Settlement Agreement. In siting new facilities, the City will consider erosion problems at the site and plan for erosion control measures before site construction. The City will prepare site-specific erosion control plans for all new construction and major repair and maintenance of existing facilities.

Removal of logs and woody debris is an ongoing effort on the reservoirs. Some shoreline areas are partially protected by natural and placed log booms. Log jams like the one at New Roland camp on Ross Lake will be left in place for shore protection. Debris at the mouths of streams, however, does not affect erosion and could limit fish migration up the streams to spawn. The City will remove enough debris to provide fish passage at the mouths of streams where debris blocks migration.

Trail maintenance by the National Park Service will avoid side casting of material from cutslopes over the trail edge. Side casting often causes mechanical damage to plants and the litter structure leading to reduced slope stability. The removal of vegetation for trail right-of-ways aggravates erosion problems at some sites and will be avoided if possible.

Public access points along the lakes concentrate trampling of vegetation, soil compaction, and displacement of soil. The soil compaction and continued vegetation damage precludes natural and often planted vegetation and the compacted soil leads to low infiltration of rain with resulting sheetwash and rill erosion. The National Park Service will use rock or wood trail surfaces and steps at dock sites if rill and sheetwash erosion is occurring. The National Park Service will place logs, trees, brush, and camp facilities carefully to help reduce shoreline erosion.

The City and the National Park Service will regularly maintain their shoreline structures to help prevent small erosion problems from growing into costly repairs or into stability problems that cannot be repaired.

3.0 EROSION CONTROL WORK TO BE DONE AT THE IDENTIFIED SITES

3.1 INTRODUCTION

In this section site-by-site descriptions are provided of existing conditions, projected future impacts, and proposed erosion control measures at the sites selected for erosion control and monitoring. The key to the site descriptions is presented in Table 3-1. Individual sites are identified by site numbers given to them in the existing conditions report and maps (Riedel, 1990) and are listed in Figure 3-1 of this Plan. (The maps that were submitted with that report to the Federal Energy Regulatory Commission with the City's quarterly report of January 30, 1990, collectively form a topographic map showing the specific locations of the proposed erosion control measures.) At sites with several different areas of erosion, individual erosion areas are given a letter designation (e.g., E-117A, E-117B, etc.). Unless otherwise noted, recession rates given in site descriptions are calculated from bluff height and back slope angle (Appendix A). At some sites erosion could be estimated from dated structures like dock bulkheads. At each site where erosion control structures will be installed, some combination of site description, site photographs, site sketch maps, and shoreline cross section is given. Maximum reservoir level of 1602.5 feet is labeled on cross sections as "Max Pool". As presented below, sites are listed from south to north on the east (E-#) and then from north to south on the west shore (W-#) of Ross Lake, on the shores of Diablo Lake (D-#), and on the shores of Gorge Lake (G-#). Road sites are designated with R-#, and biological sites with B-#. Recreation and Project facility sites are presented first, followed by Class I sites, biological sites, and road sites.

Table 3-1. Key to Erosion Site Descriptions.

Site Name:		Based on name of recreation facility at site or nearby geographic feature.
Location #:		Arbitrary letter and number code to track sites, see Figures 3-1 through 3-4 in this Plan and Map 3 of Riedel (1990). See previous page for the sequence in which site descriptions are given.
Photo #s:		Day . Hour . Minute, imprinted on photographs (all photos were taken in 1989).
Site Priority:	High	Erosion immediately (five years or less) threatens facilities, rare habitat, or presents threat to public safety
	Medium	Facilities, rare habitat are not immediately (five to twenty years) threatened but will probably be sometime during the relicensing period.
	Low	Bank recession rates are low, erosion protection will wait until higher priority sites are completed.
Site Conditions:		Description of existing site materials, vegetation, and erosion processes and extent. Common vegetation names are used, see Appendix B for list of scientific names.
Projected Impacts:		Estimate based on interpretation of site features, cross sections, and direct measurements of recession from dated shore features like dock bulkheads.
Erosion Control Measure:		The erosion control actions that will be taken to reduce rates of bank recession and prevent continued loss of land to shoreline erosion. For several sites options for erosion control measures are given; the City and the National Park Service will consult with each other about which option or options to choose for a site.

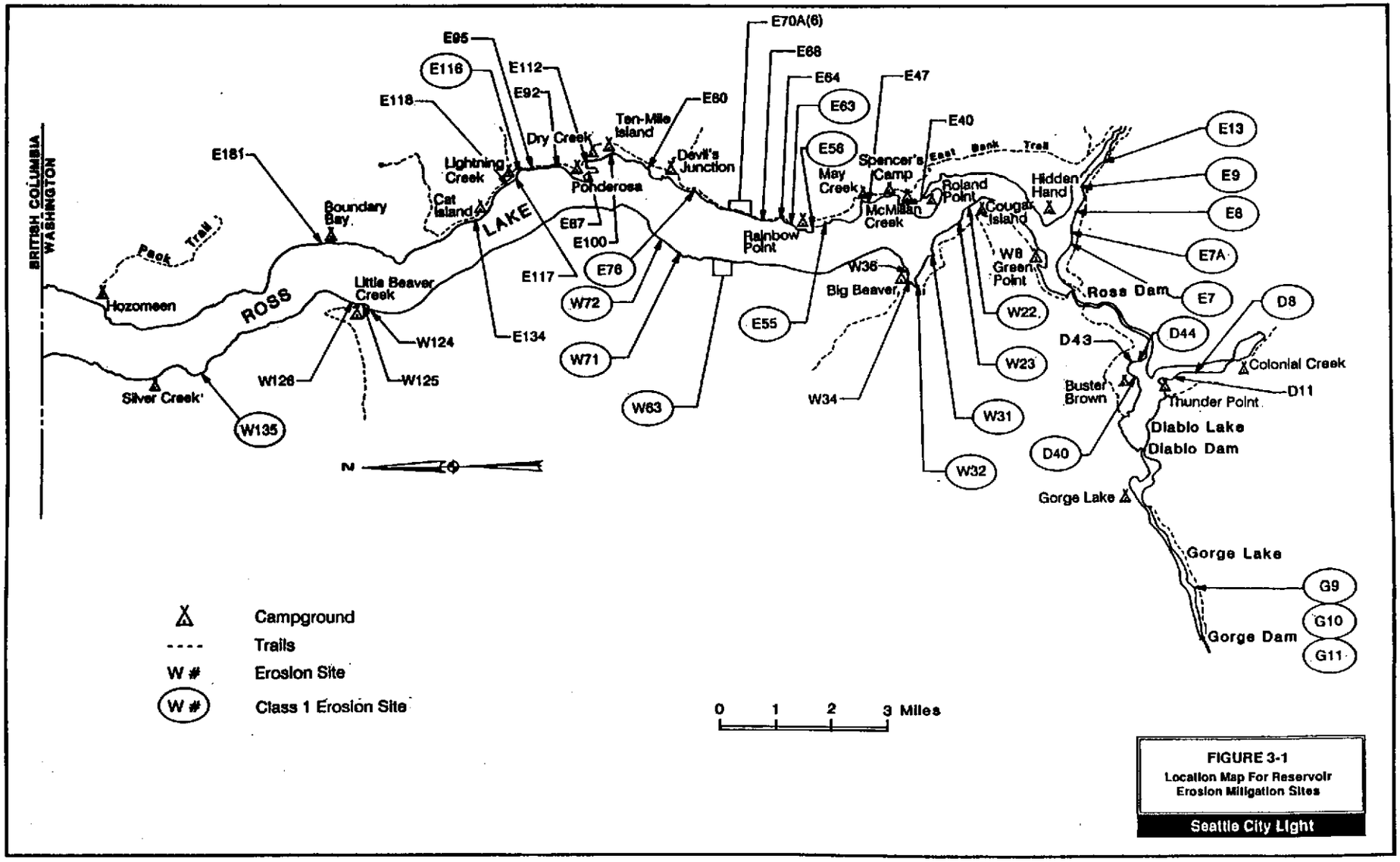


FIGURE 3-1
Location Map For Reservoir Erosion Mitigation Sites
Seattle City Light

3.2 RECREATION AND PROJECT FACILITY SITES

This section presents site-specific conditions, Project impacts, and erosion control measures for recreation sites with erosion concerns within the Project area. Sites are presented starting at the southeast shore of Ross Lake and proceeding north up the east shoreline and south down the west shore, followed by sites on Diablo Lake and Gorge Lake.

Site Name: Rowland Point Campground
Location #: none
Photo #s: 20.13.35
Site Priority: No Action

Site Conditions:
A low lying area with gentle slopes and logs that protect shallow shoreline effectively.

Projected Impacts:
If natural log protection of the shoreline is maintained, there should be no significant erosion problems at this site.

Erosion Control Measure:
The existing log protection will be left in place.

Site Name: McMillan Campground
Location #: E40
Photo #s: 20.13.18
Site Priority: Low

Site Conditions:
Dock area has been protected by 10 feet of rock wall which needs some repair. Erosion is minimal in this area.

Projected Impacts:
No significant impacts are expected.

Erosion Control Measure:
The existing rock wall at the bulkhead will be rebuilt. Brush layering techniques will be used to protect the shoreline and define public access points.

Site Name: May Creek Campground
Location #: E-47
Photo #s: 21.13.15 (1)
Site Priority: Medium

Site Conditions:

The campground sits on top of a bedrock knob above and to the south of the mouth of May Creek. Slopes are gentle (5 to 10 degrees) on top of the knob but steepen into the reservoir. Although most of the campground is on bedrock the dock area is composed of coarse, compact till that is being eroded away, and forms a 3-foot bluff at the full pool elevation. The site is generally dry because of the limited extent of soil, resulting in the dominance of lodgepole pine and Douglas-fir in the overstory, and salal, Oregon grape, huckleberry, and grasses in the understory.

Projected Impacts:

Bank recession will continue to erode the area at the head of the dock making access from the dock to shore difficult.

Erosion Control Measure:

A 30-foot-long and 5-foot-high rock wall will be built and integrated with the dock; the rock wall will consist of 2- to 3-foot-diameter boulders backfilled with soil filter and will be planted with shrubs and trees except at the access point to the dock. The public access point to the dock will be defined to prevent impacts on vegetation at the top of the wall.

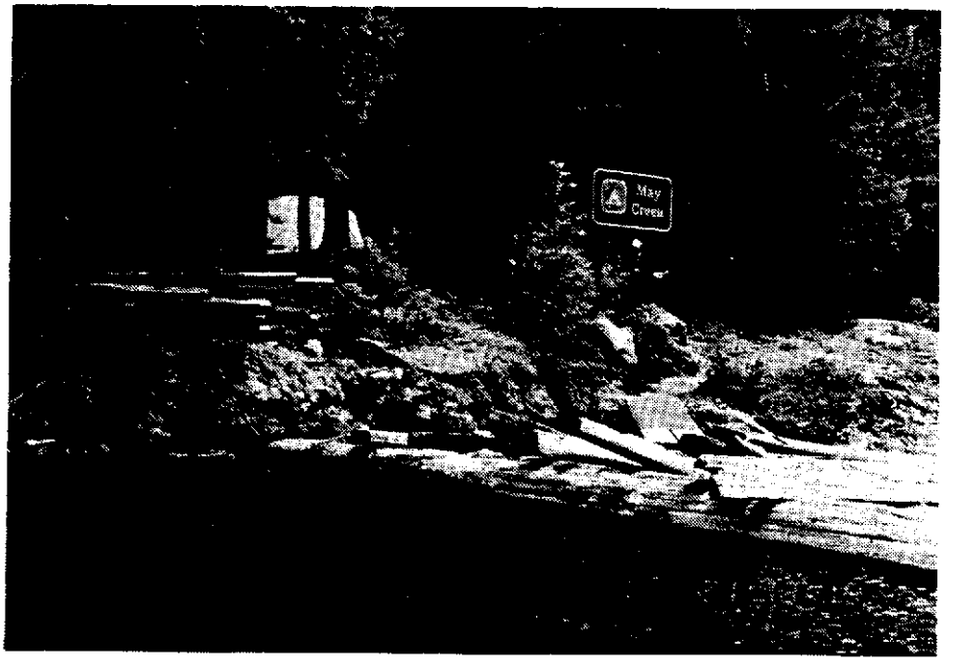


Photo 89 21 13:15 May Creek Campground

Site Name: Rainbow Point Camp (also Class I site)
Location #: E-56
Photo #s: 20.16.26 - 20.16.27 (6)
Site Priority: High

Site Conditions:

Consists of several bluffs north of Rainbow Point camp developed in 13.2 feet of streamlined compact glacial till overlying minimum 7 feet of lacustrine deposits. Length of affected shore is 867 feet. Small slumps have already occurred north and south of this site. At the north end of campsite, estimated bank recession is an average rate of 1 foot/year. Bank recession is undercutting trees and impinging on the campsite. Several hazardous trees have been cut down. In the vicinity of the campground the cut bank is about 2 feet high, but increases to 10 feet high at a northern bluff where the side slope is steeper (30 to 35 degrees). There is a long wind fetch to this area. The bluffs are characterized primarily by old-growth Douglas-fir with vine maple and grasses in the understory. Adjacent areas where the bluffs have already slumped are dominated by red alder.

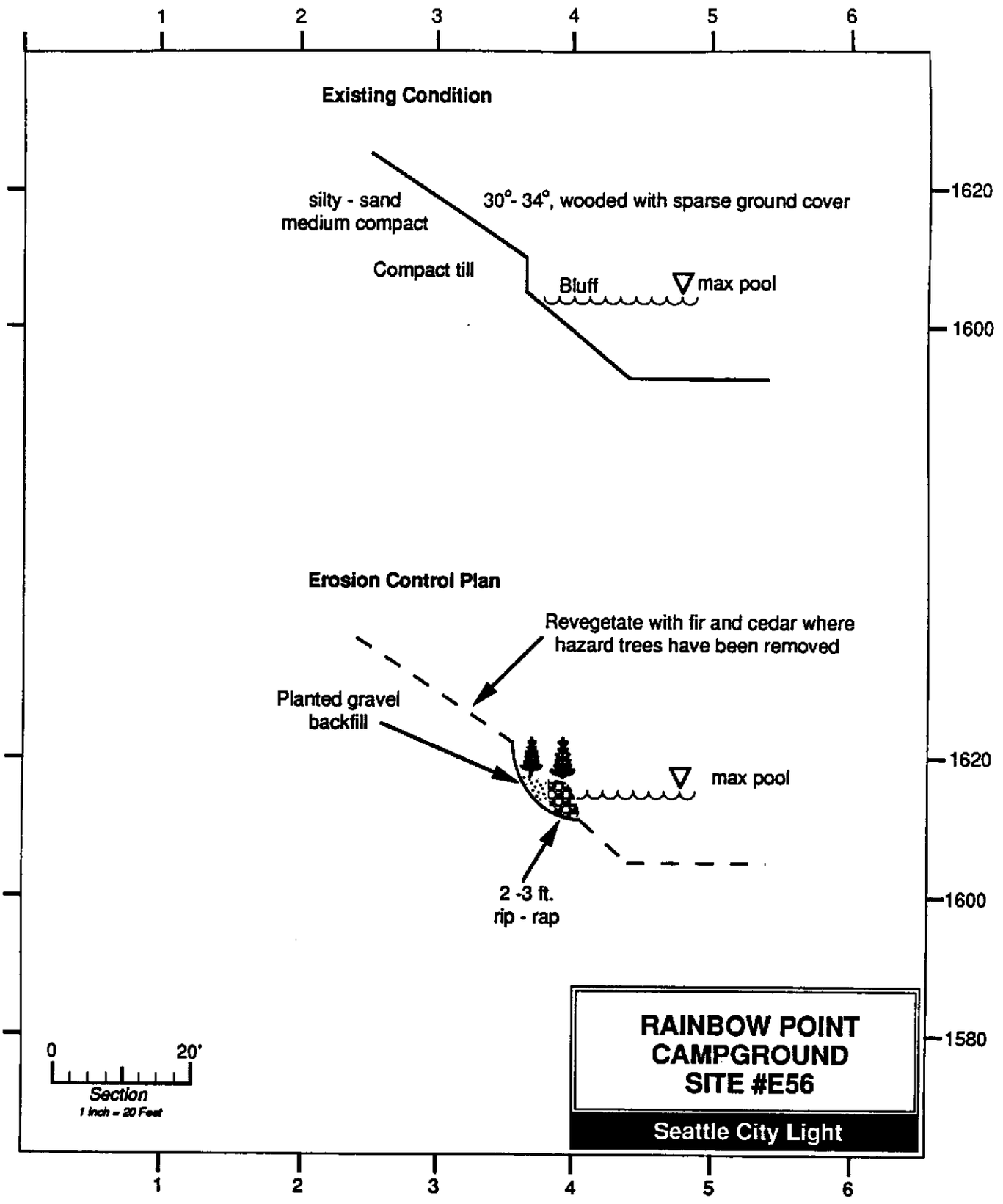
Projected Impacts:

Continued bank recession and slumping will result in the loss of large Douglas-firs on slope above the lake, which poses a potential safety hazard for the dock area.

Erosion Control Measure:

Erosion at the site will be monitored by periodically resurveying the bank, taking photographs, and installing erosion monitoring pins to more accurately calculate the bank recession rate. To protect the old growth trees, a 170-foot-long rock wall 4-foot-high will be built and backfilled with soil filter and planted with western red cedar and red alder.

Photo 89 20 16:26 Rainbow Point Camp


1
2
3
4
5
6
Existing Condition
silty - sand
medium compact
30°- 34°, wooded with sparse ground cover
Compact till
Bluff
max pool
1620
1600
Erosion Control Plan
Revegetate with fir and cedar where
hazard trees have been removed
Planted gravel
backfill
max pool
1620
2 -3 ft.
rip - rap
1600
1580
0
20'
Section
1 inch = 20 Feet
RAINBOW POINT
CAMPGROUND
SITE #E56
Seattle City Light
1
2
3
4
5
6

Site Name: East Bank Trail (cove north of Rainbow Point)
Location #: E-64
Photo #s: 21.8.21 - 21.9.40 (4); 4.15.16
Site Priority: High

Site Conditions:

A steep, wooded slope where the east bank trail runs down to the reservoir. Colluvium, till, and outwash above the bedrock is being cut back, leaving near vertical ravelling slopes of scree that are subject to minor slumping and tree fall. Bank recession is already effecting the trail in some areas. The slope above the trail is steep and rocky, making trail relocation difficult. Vegetation in this area includes Douglas-fir, red alder, vine maple, Oregon grape, bearberry, and rose. The offshore slope is too steep for riprap.

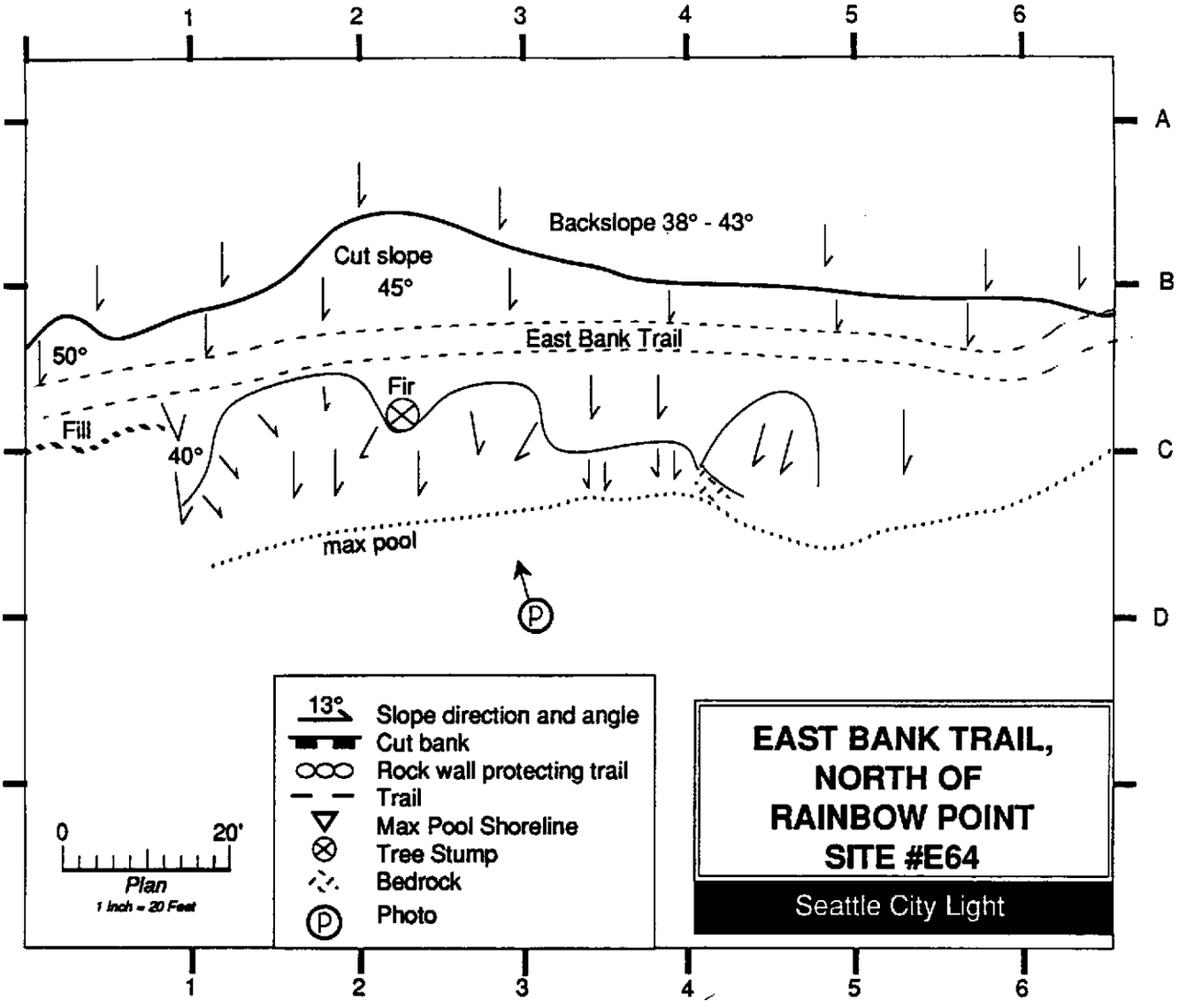
Projected Impacts:

Continued bank recession will force reconstruction or difficult relocation of the trail and threatens several large Douglas-firs in the area.

Erosion Control Measure:

Cribbing or a rock wall would be technically difficult to install because of the steep offshore gradient. With extensive excavation, cribbing could be installed, but a more manageable solution (the approach that will be used) is to cut down surface instability and undertake small-scale relocation of the trail. The trail will be moved 3 feet up the hill and a small rock wall along the present trail route will be built. The trail will be planted with local species such as vine maple and Oregon grape. Upslope from the new trail a vegetated rock wall will also be built to catch seasonal ravel until the slope has stabilized. An attempt will be made to vegetate bare areas on ravelling slopes beneath the trail, and this will be assisted by ceasing side casting of seasonal ravel during trail maintenance.

Photo 89 4 15:16 East Bank Trail (cove north of Rainbow Point)


1
2
3
4
5
6
A
B
C
D
Backslope 38° - 43°
Cut slope
45°
East Bank Trail
50°
Fir
Fill
40°
max pool
P
13°
Slope direction and angle
Cut bank
Rock wall protecting trail
Trail
Max Pool Shoreline
Tree Stump
Bedrock
Photo
0
20'
Plan
1 Inch = 20 Feet
EAST BANK TRAIL,
NORTH OF
RAINBOW POINT
SITE #E64
Seattle City Light

Site Name: East Bank Trail (north of 1st stream north of Rainbow Point)
Location #: E-68
Photo #s: 4:15:14; 4:15:21 /JR frame 14 - roll 13
Site Priority: High

Site Conditions:

A steep, wooded slope with rock outcrops where the East Bank Trail runs down to the reservoir. Till above the bedrock at reservoir level is being cut back, leaving steep ravelling slopes of scree subject to minor slumping and tree fall. Bank recession is already effecting the trail in some areas. Vegetation includes Douglas-fir, red alder, vine maple, Oregon grape, bearberry, and rose. An approximately 3-foot-wide ledge at the base of the slope at high pool could support a rock wall. Over 65 percent of the affected length of shore has rock outcrop at the base, the remaining area needs rock wall to protect the till.

Projected Impacts:

Continued bank recession will force relocation of the trail on very steep slopes.

Erosion Control Measure:

Side casting of ravel during seasonal trail maintenance will be ceased; instead, the ravel will be hauled to a stable spoils area. The disturbed areas below and adjacent to the trail will be vegetated, and a 4-foot-high rock wall at the high pool level will be constructed to protect an 80-foot length of shore composed of till in sections where there is no bedrock outcrop.

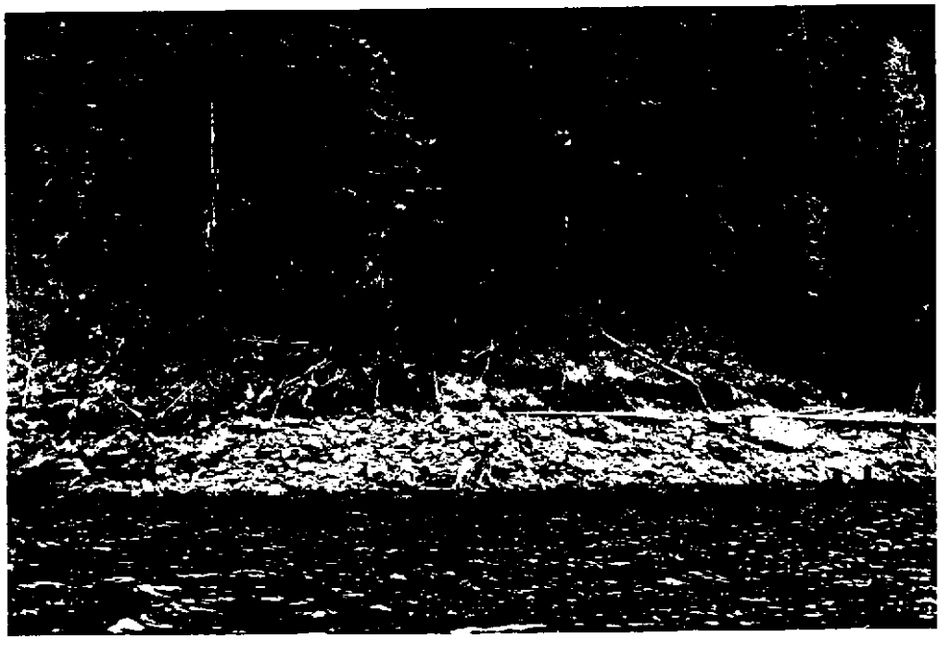


Photo 89 4 15:21 East Bank Trail (north of 1st stream north of Rainbow Point)

Site Name: East Bank Trail (1st cribbing north of Rainbow Point)
Location #: E-70A-1
Photo #s: 21.10.12; 4.15.11
Site Priority: High

Site Conditions:

Cribbing at the base of a talus chute protecting the trail is in reasonable condition. The steep cut bank would have eroded quickly without cribbing. The lower cribbing is being washed out as it is not extensive enough. To the south of the cribbed area there is an area of trail being affected by bank erosion. Vegetation in this area includes willow, red alder, goat's beard, and a variety of herbaceous species.

Projected Impacts:

There is a danger that the cribbing could fail, leading to rapid erosion which would threaten the trail. The area south of the cribbing is also threatened by bluff retreat. There is no apparent place to relocate the trail.

Erosion Control Measure:

Soil filter fill will be placed behind the lower cribbing unit and planted with local species to reduce erosion of fill and decrease visual impact. The lower cribbing will be extended 30 feet to the south, 6 feet high, and backfilled with soil filter; the backfilled area will be vegetated. A 30-foot-long, 4-foot-high rock wall with 2- to 3-foot-diameter rocks will be built south of the large stump (see photo). This rock wall will be backfilled and planted with western red cedar, vine maple, and red alder.

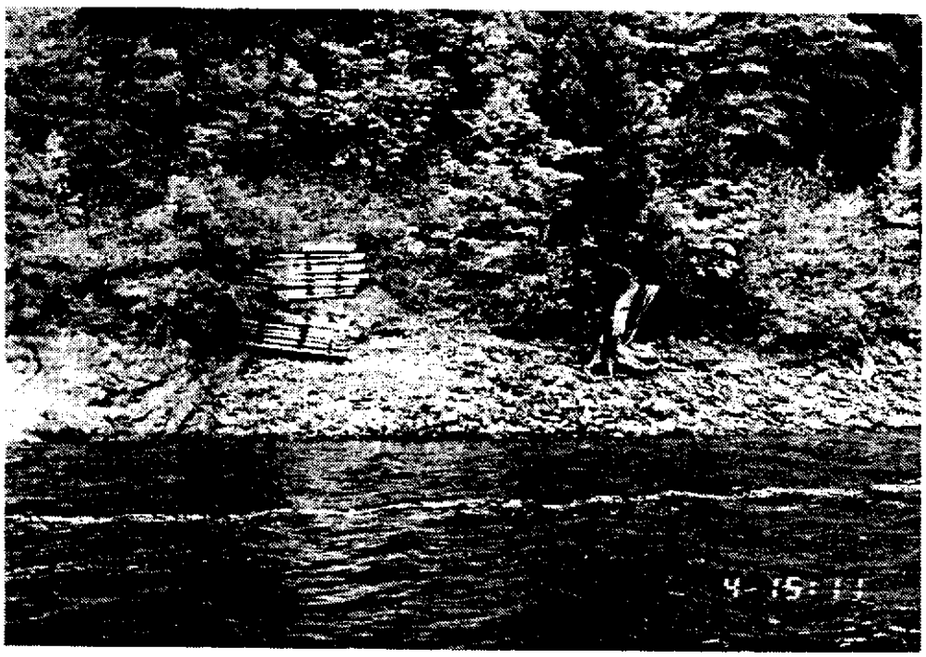


Photo 89 4 15:11 East Bank Trail (1st cribbing north of Rainbow Point)

Site Name: East Bank Trail (3rd cribbing north of Rainbow Point)
Location #: E-70A-2
Photo #s: 4.15.10, 4.16.33
Site Priority: High

Site Conditions:

A three-tiered cribbing protects a talus cone between bedrock outcrops. The lower tier in the water is breaking up as a result of undercutting; the upper two tiers are in good condition.

Projected Impacts:

Continued undercutting of the lowest tier of cribbing could lead to failure of the upper tiers and destruction of the trail.

Erosion Control Measure:

The 35-foot-long, 6-foot-high lower tier of the cribbing will be rebuilt, and the area will be backfilled and vegetated. This will require digging a small bench for the lower tier to rest on, and the placement of 3- to 4-foot rocks at the base of the crib along a 35-foot length of shore to absorb wave energy. The lower two tiers will be extended 15 feet in length with two 6-foot-high tiers to the south. For an additional 20 feet south of the new cribbing the trail right next to the rock wall will be moved, and the old 20- by 6-foot area of the old trail area will be vegetated.

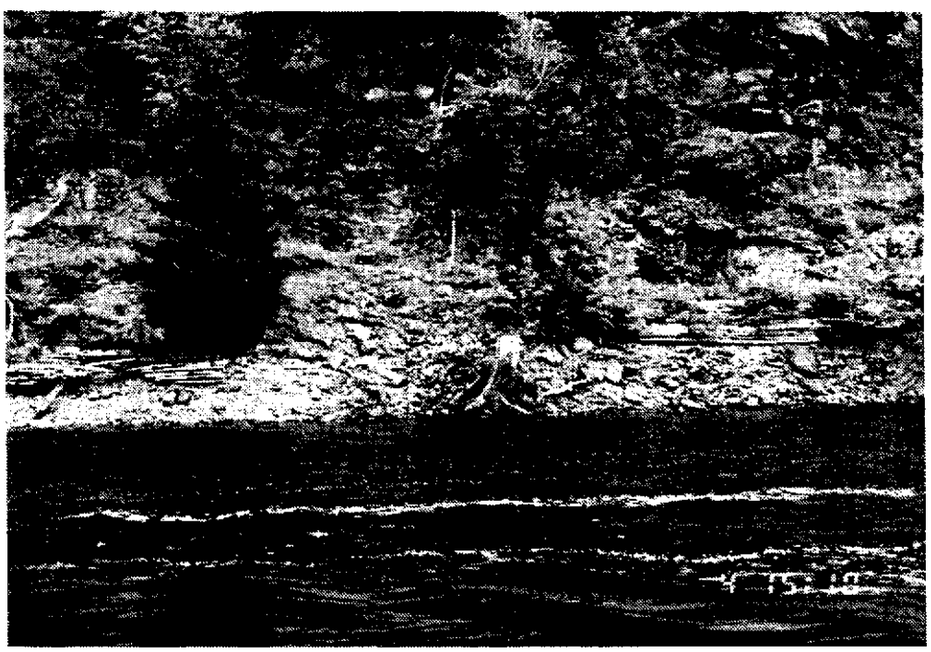
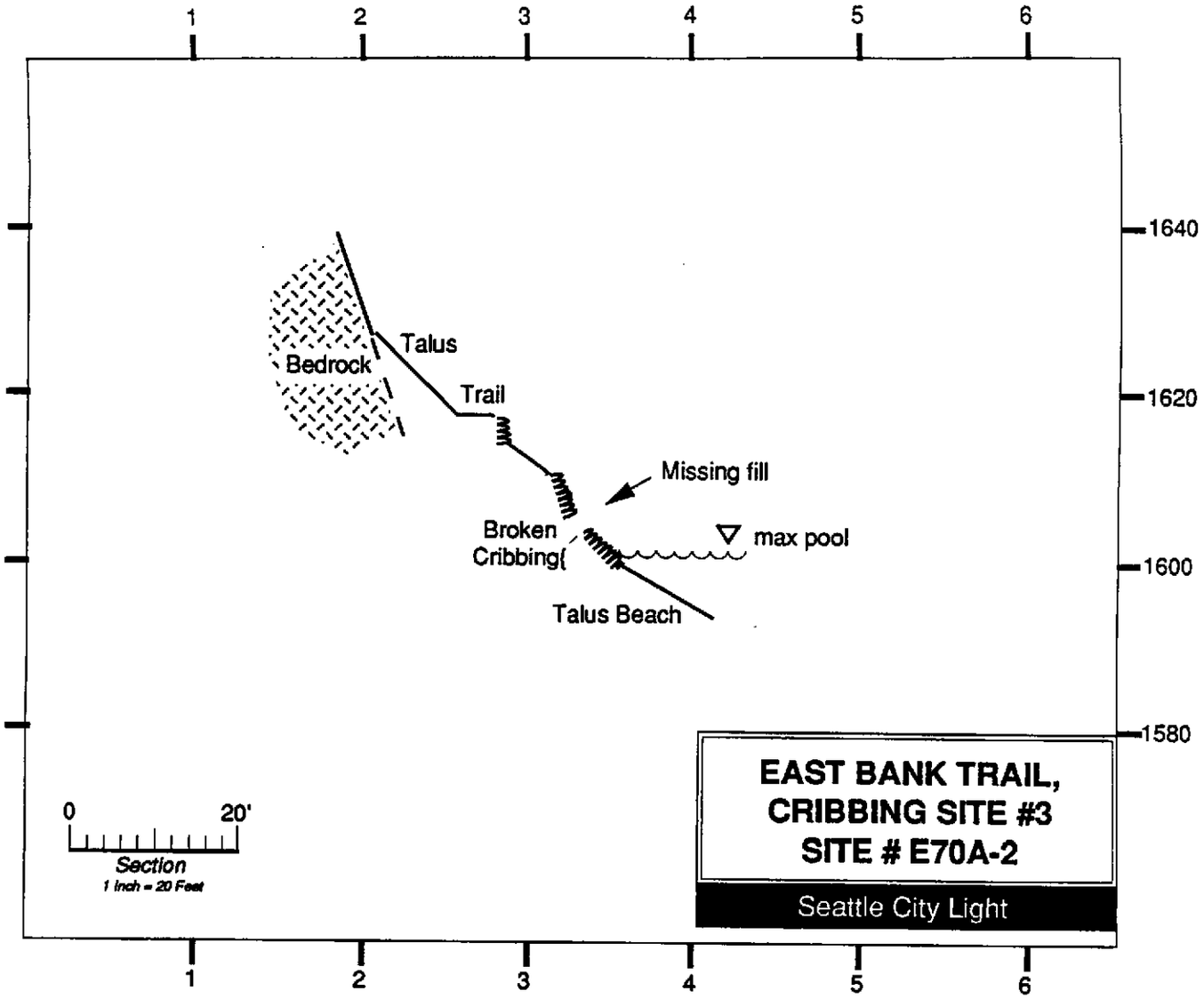


Photo 89 4 15:10 East Bank Trail (3rd cribbing north of Rainbow Point)


1
2
3
4
5
6
1640
1620
1600
1580
Bedrock
Talus
Trail
Missing fill
Broken
Cribbing
max pool
Talus Beach
0
20'
Section
1 Inch = 20 Feet
EAST BANK TRAIL,
CRIBBING SITE #3
SITE # E70A-2
Seattle City Light

Site Name: East Bank Trail (4th cribbing north of Rainbow Point)
Location #: E-70A-3
Photo #s: 21.10.41; 4.15.8; 4.16.49.
Site Priority: High

Site Conditions:

The steep talus chute running down to reservoir level may have been cribbed in the past. No cribbing is evident now, and wave erosion is undercutting the talus and threatening the trail.

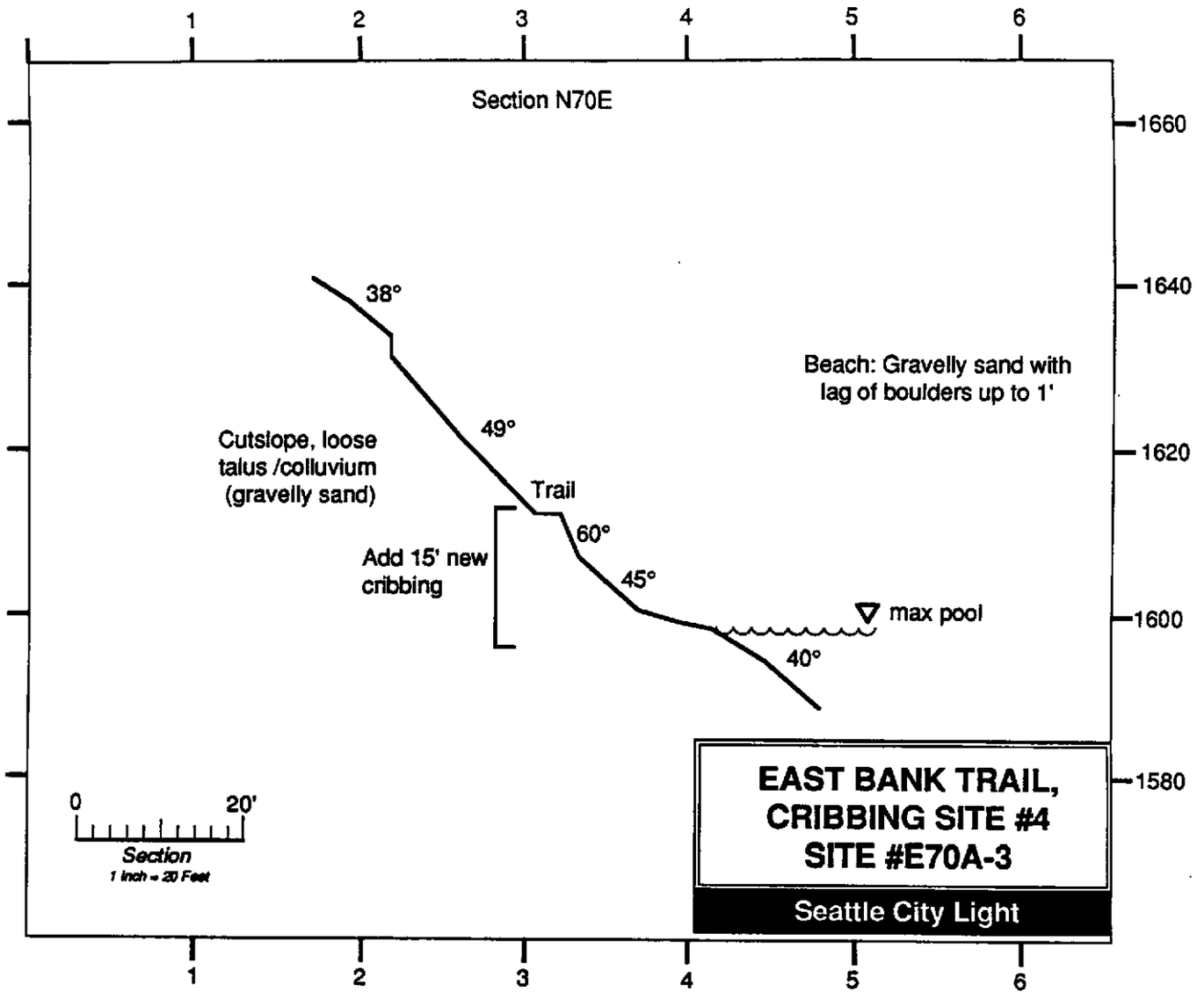
Projected Impacts:

Continued undercutting of the talus will cause continued bank recession and threaten the trail. Vegetation in this area includes vine maple and red alder.

Erosion Control Measure:

One hundred feet of new, vegetated cribbing, 15 feet high, will be constructed using 3 or 4 tiers. Each end will be tied into the bedrock, and the base of the cribbing will be armored with 3- to 4-foot boulders from a local source just to the north.

Photo 89 4 15:08 East Bank Trail (4th cribbing north of Rainbow Point)


1
2
3
4
5
6
Section N70E
1660
1640
1620
1600
1580
38°
49°
60°
45°
40°
Beach: Gravelly sand with lag of boulders up to 1'
Cutslope, loose talus /colluvium (gravelly sand)
Trail
Add 15' new cribbing
max pool
0
20'
Section
1 Inch = 20 Feet
EAST BANK TRAIL,
CRIBBING SITE #4
SITE #E70A-3
Seattle City Light

Site Name: East Bank Trail (5th cribbing north of Rainbow Point)
Location #: E-70A-4
Photo #s: 21.10.59, 4.15.7
Site Priority: High

Site Conditions:

A steep colluvial wedge between bedrock outcrops is being eroded back as a failing slope that threatens the trail. Previous cribbing at this site has been destroyed and largely removed. Vegetation at this site includes red alder, vine maple, and Douglas-fir.

Projected Impacts:

Continued recession threatens the trail both from erosion below and ravel above.

Erosion Control Measure:

To stabilize the cut slope, 6-foot-high cribbing will be constructed on the upslope side along a 45-foot length of the trail. The area upslope of the wall will be partially backfilled and vegetated. The height of the retaining wall will be designed to provide a stable cut slope; vegetation attempts on the cut slope will be continued until vegetation is well-established behind the wall. To stabilize the area below the trail, a 25-foot-high vegetated cribbing structure (3 or 4 tiers) will be constructed along a 45-foot length of the shore.

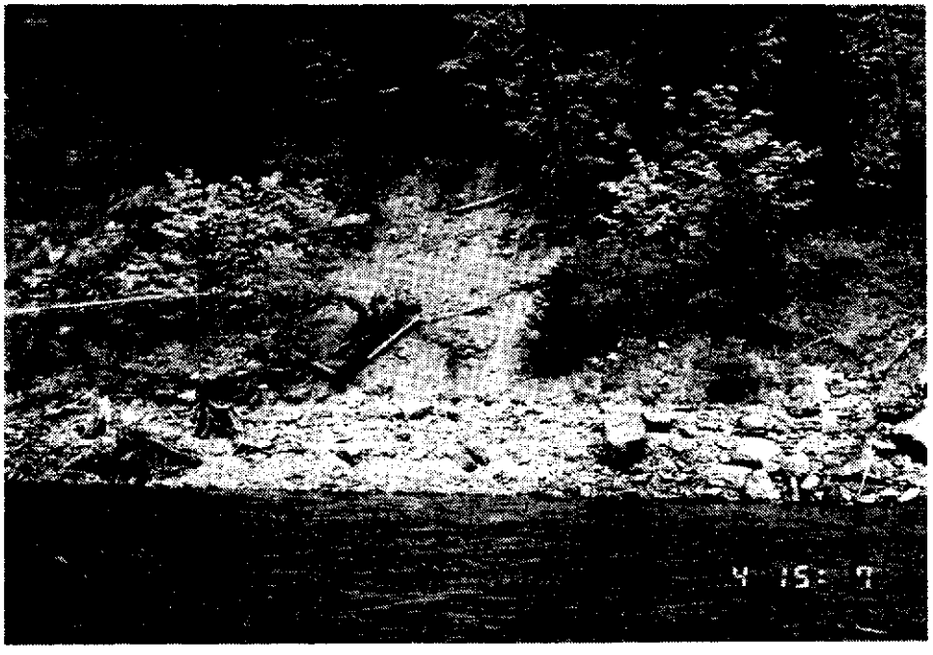
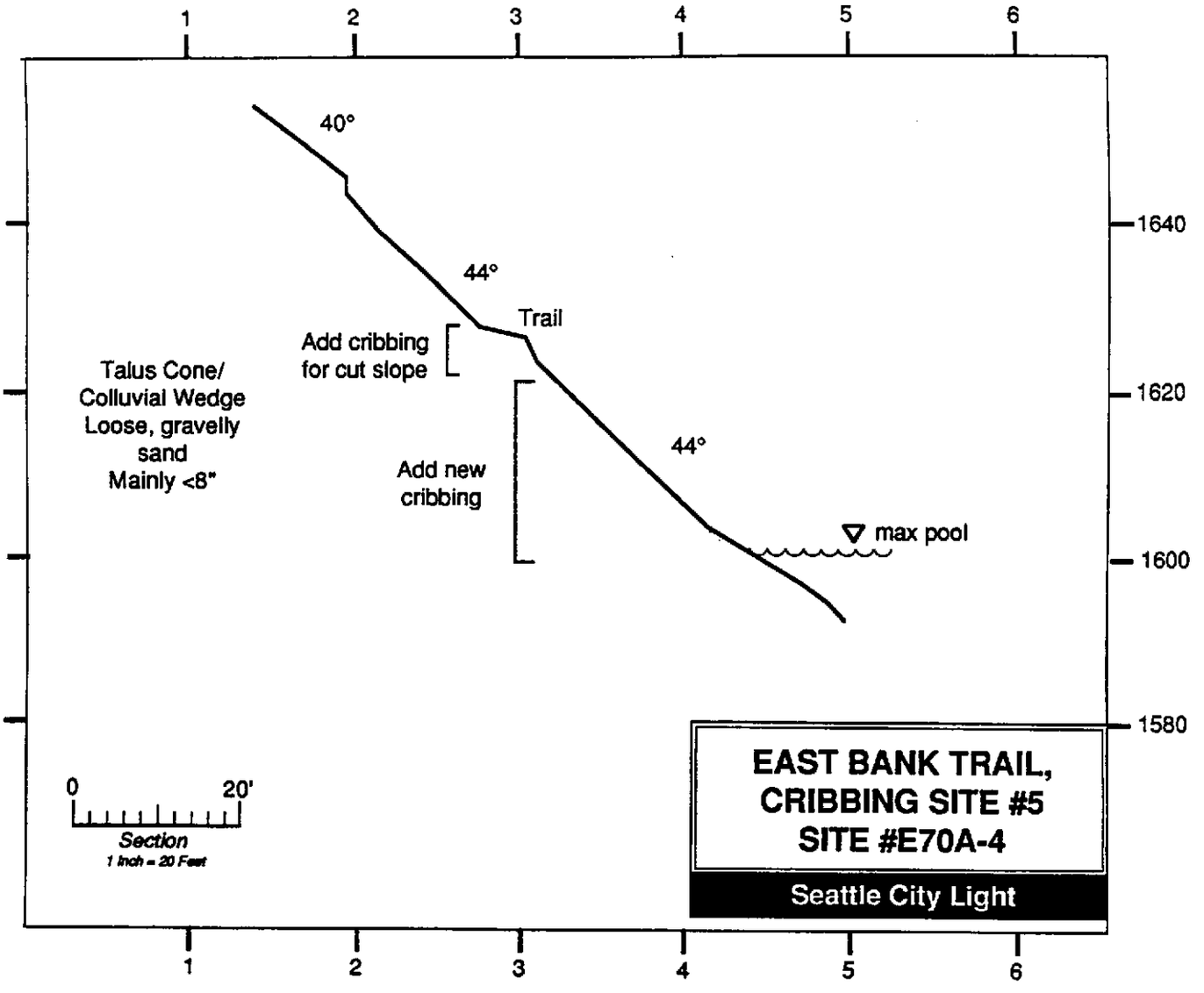


Photo 89 4 15:07 East Bank Trail (5th cribbing north of Rainbow Point)


1
2
3
4
5
6
40°
44°
Trail
Add cribbing
for cut slope
Talus Cone/
Colluvial Wedge
Loose, gravelly
sand
Mainly <8"
Add new
cribbing
44°
max pool
1640
1620
1600
1580
0
20'
Section
1 Inch = 20 Feet
EAST BANK TRAIL,
CRIBBING SITE #5
SITE #E70A-4
Seattle City Light
1
2
3
4
5
6

Site Name: East Bank Trail (6th cribbing north of Rainbow Point)
Location #: E-70A-5
Photo #s: 21.11.4, 4.15.5, 4.17.7.
Site Priority: High

Site Conditions:

A steep colluvial wedge between bedrock outcrops is eroding back as an unstable slope. The cribbing that supports the trail and protects the toe slope is in good condition except at the north end where wave action has undercut the lower cribbing, allowing slope failure above to undercut the upper tier of cribbing.

Projected Impacts:

Recession threatens the trail if the cribbing is not repaired.

Erosion Control Measure:

The 30-foot long by 3-foot high and 50-foot long by 10-foot high section of failed cribbing will be rebuilt and backfilled with soil filter; this area will be vegetated. A 5-foot high middle cribbing section will be added, starting from bedrock to the north and extending 40 feet to the south. 3- to 4-foot rocks will be used at the base of the lower cribbing unit to prevent undercutting.

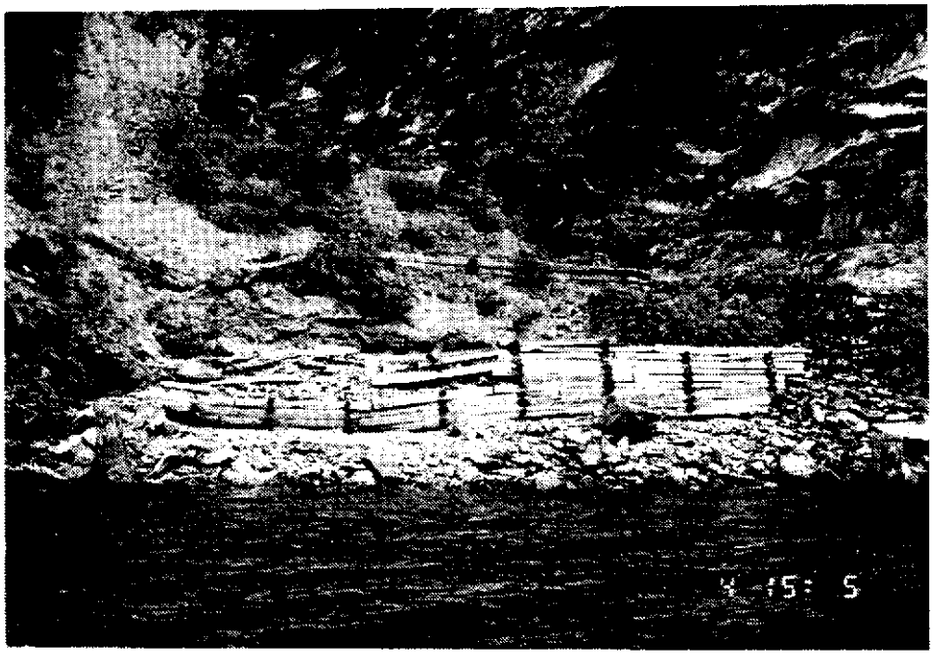
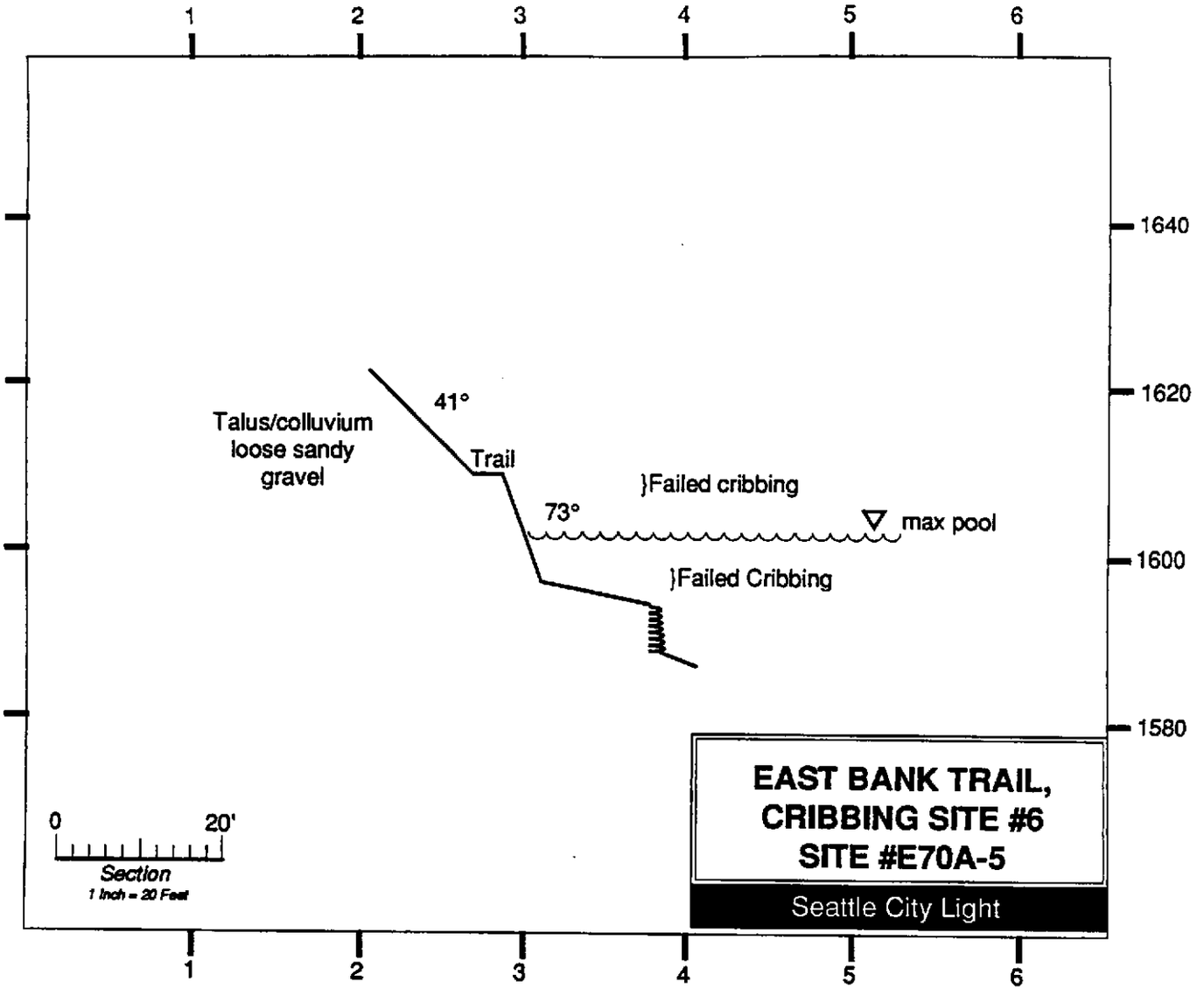


Photo 89 4 15:05 East Bank Trail (6th cribbing north of Rainbow Point)


1
2
3
4
5
6
1640
1620
1600
1580
Talus/colluvium
loose sandy
gravel
41°
Trail
}Failed cribbing
73°
max pool
}Failed Cribbing
0
20'
Section
1 Inch = 20 Feet
EAST BANK TRAIL,
CRIBBING SITE #6
SITE #E70A-5
Seattle City Light

Site Name: East Bank Trail (8th cribbing north of Rainbow Point)
Location #: E-70A-6
Photo #s: 21.11.19 - 21.11.22; 4.15.2
Site Priority: Medium

Site Conditions:

The two-tiered cribbing restraining the talus chute is in good condition. Loose material between cribbing units is unattractive and subject to ravelling.

Projected Impacts:

The cribbing is in good shape but fill material in cribbing is bare and will continue to erode by surface ravelling.

Erosion Control Measure:

The 2,000 square foot area between the two tiers of the cribbing will be vegetated to reduce ravelling and improve visual appearance.

Photo 89 15:02 East Bank Trail (8th cribbing north of Rainbow Point)

Site Name: Devil's Junction Campground
Location #: E-80 A, B, and C
Photo #s: 3.14.52 - 3.15.32 (Use 3.15.31)
Site Priority: Site A High
Site B Medium
Site C Low

Site Conditions:

A. A gently sloping, wooded campground with thin soil/colluvium over moderately compact till. The shoreline for 98 feet is comprised of a 2- to 4-foot-high overhanging, retreating bank that is receding at 1.86 feet/year. Vegetation in this area includes Douglas-fir, western red cedar, vine maple, huckleberry, and Oregon grape.

B. This site includes a 44-foot stretch of trail east of the campground. Undercutting at the high pool level is threatening the trail where it cuts into a 30 to 35 degree slope. A similar sequence of colluvium over till is present as at site A.

C. The trail is further east, and the retreating bluff is still 29 feet from the trail and the beach is well armored with angular cobbles.

Projected Impacts:

A. Bank recession will continue to reduce the campground area and threaten old growth Douglas-firs in the camp.

B. Continued undercutting and bank collapse will wipe out the trail at certain points.

C. Bluff retreat may eventually threaten the trail.

Erosion Control Measure:

A. Along part of the 98-foot eroding section, a rock wall faced with 2- to 3-foot boulders will be constructed. This rock wall will be backfilled with soil filter material and vegetated with red alder and vine maple. In the vicinity of the dock, consideration will be given to fronting the rock wall with logs hooked into either side of the dock. Vegetation will be used to protect portions of the affected shoreline and to define public access points to the lake. A path will be defined to the shore to restrict the extent of human disturbance along the eroding shore.

B. To the east of the campsite, the vegetation between the trail and the shore will be maintained by restricting brushing. Along the 44-foot threatened stretch, a rock wall faced with 2- to 3-foot boulders will be constructed; this rock wall will be backfilled with soil filter material and vegetated with red alder and vine maple.

C. Monitoring of this site will be continued, and a rock wall will be built if the trail becomes threatened.

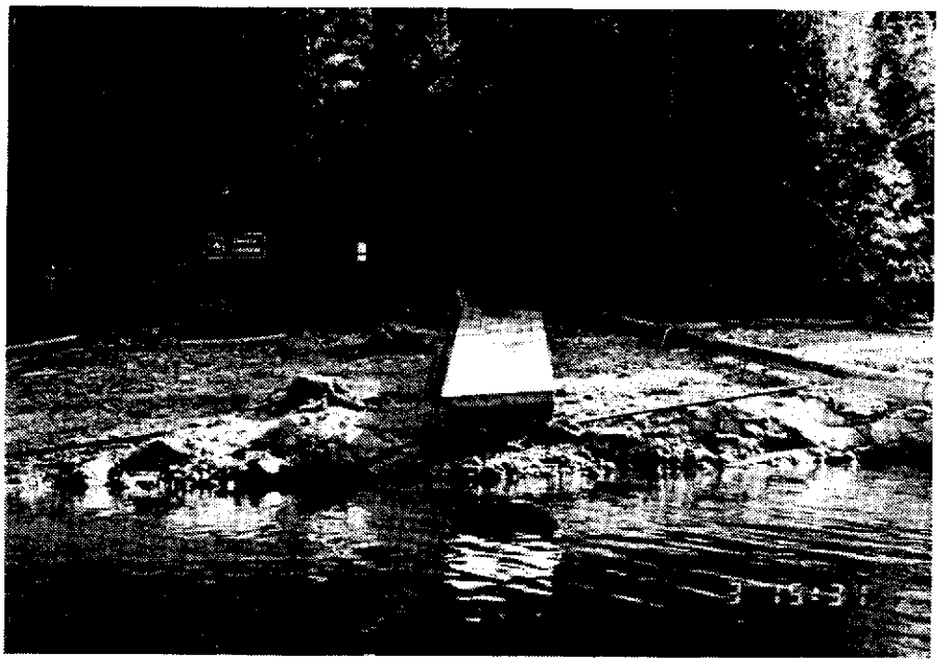
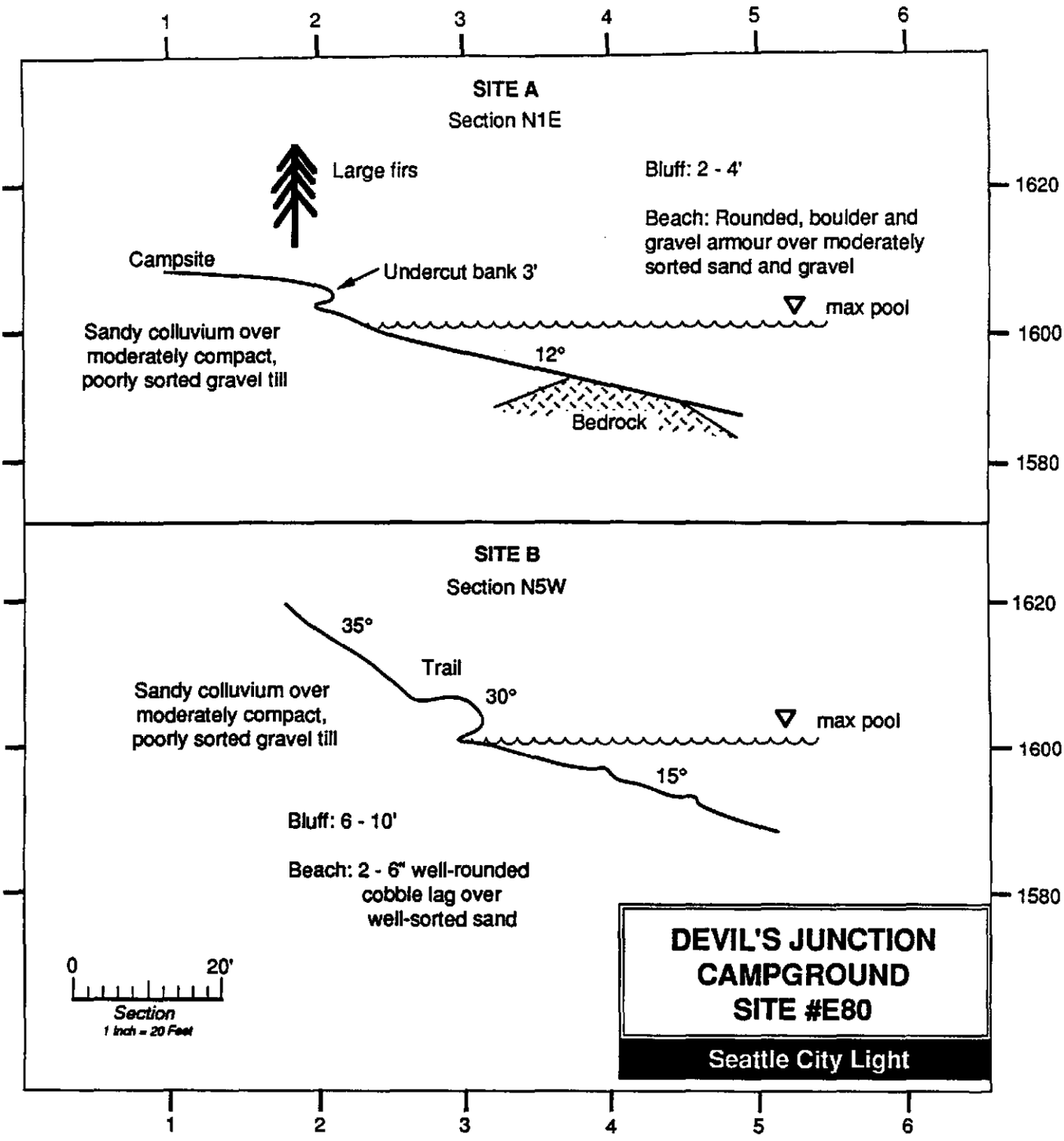


Photo 89 3 15:31 Devil's Junction Campground, Site A

Photo 89 3 14:52 Devil's Junction Campground, Site A


1
2
3
4
5
6
SITE A
Section N1E
Large firs
Bluff: 2 - 4'
Beach: Rounded, boulder and gravel armour over moderately sorted sand and gravel
Campsite
Undercut bank 3'
max pool
Sandy colluvium over moderately compact, poorly sorted gravel till
12°
Bedrock
1620
1600
1580
SITE B
Section N5W
35°
Trail
30°
Sandy colluvium over moderately compact, poorly sorted gravel till
max pool
15°
Bluff: 6 - 10'
Beach: 2 - 6" well-rounded cobble lag over well-sorted sand
1620
1600
1580
0
20'
Section
1 Inch = 20 Feet
DEVIL'S JUNCTION CAMPGROUND
SITE #E80
Seattle City Light
1
2
3
4
5
6

Site Name: Tenmile Island Campground
Location #: E-100
Photo #s: 3.15.49, 3.15.57
Site Priority: Medium

Site Conditions:

Camp sits on a glacially scoured bedrock knob with local accumulations of till and outwash. Intense wave erosion resulting from the long wind fetch to the island threatens the camp on the northeast side, where a 1-foot-high bluff is retreating. Common plants at this site include lodgepole pine, Oregon grape, and grasses.

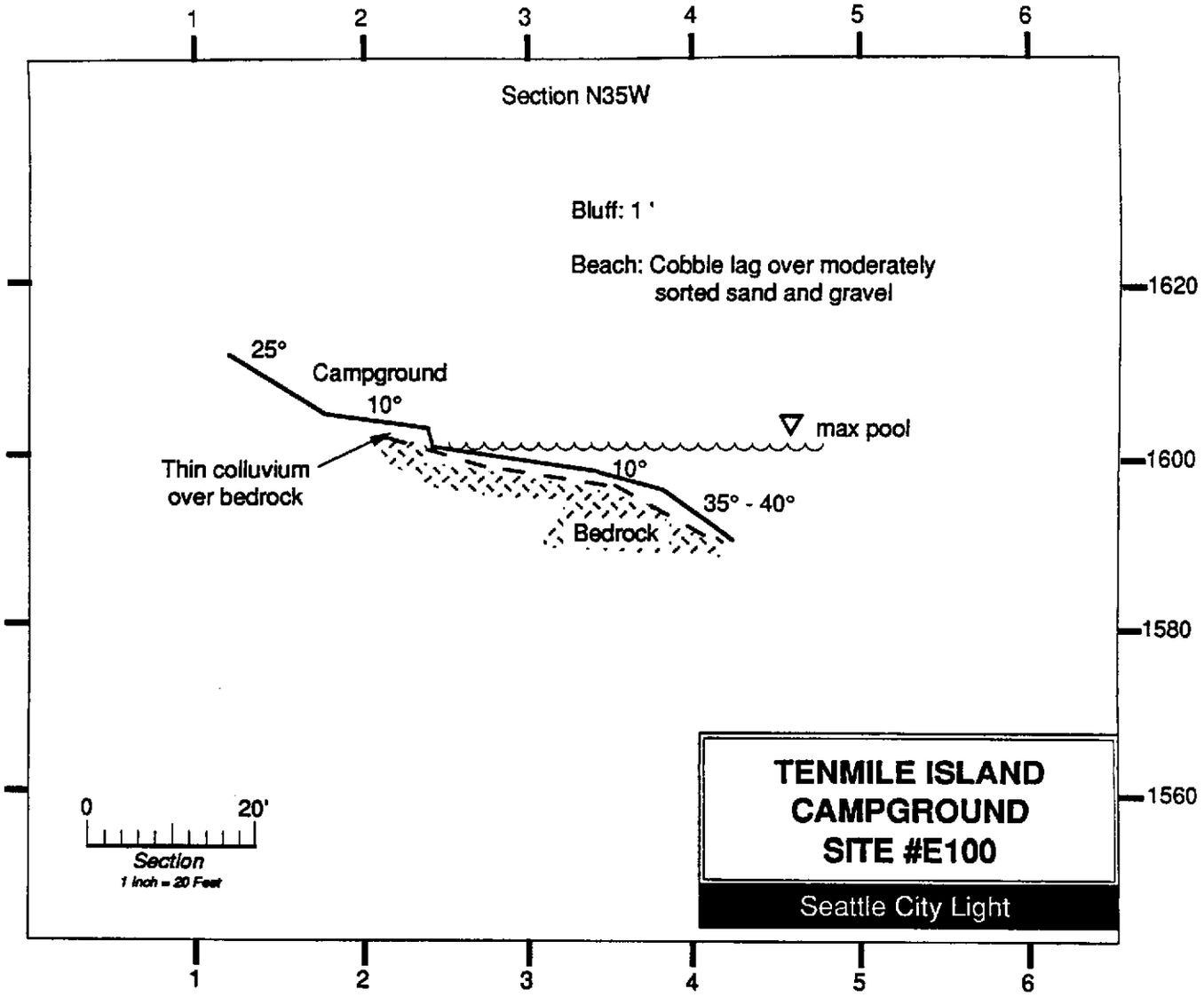
Projected Impacts:

Continued recession will reduce the camp site area directly threatening a tent pad.

Erosion Control Measure:

A rock wall 2 feet high will be constructed along the eroding bank 69 feet to the west of the camp. A combination of brush layering and rock wall will be used along the 30-foot length of eroding shore to the southeast of the camp. Rock walls will be constructed with 2-foot rocks in front and backfilled with soil filter. Local source of rocks for this work is available. Logs will be secured against the shore where they occur naturally. Drift-logs will not be removed as they are already protecting the shore.

Photo 89 3 15:49 Tenmile Island Campground


1
2
3
4
5
6
Section N35W
Bluff: 1 '
Beach: Cobble lag over moderately sorted sand and gravel
1620
25°
Campground
10°
max pool
Thin colluvium over bedrock
10°
35° - 40°
Bedrock
1600
1580
1560
0
20'
Section
1 Inch = 20 Feet
TENMILE ISLAND CAMPGROUND SITE #E100
Seattle City Light
1
2
3
4
5
6

Site Name: Dry Creek Campground
Location #: E-112
Photo #s: 3.16.10
Site Priority: Medium

Site Conditions:

In the vicinity of the campground outhouse, loose to medium compact colluvium over very compact till has been eroded to form a 2- to 4-foot-tall receding bluff. The problem is compounded by the use of this area as a shore access point. Vegetation at this site includes Douglas-fir, vine maple, red alder, and grasses.

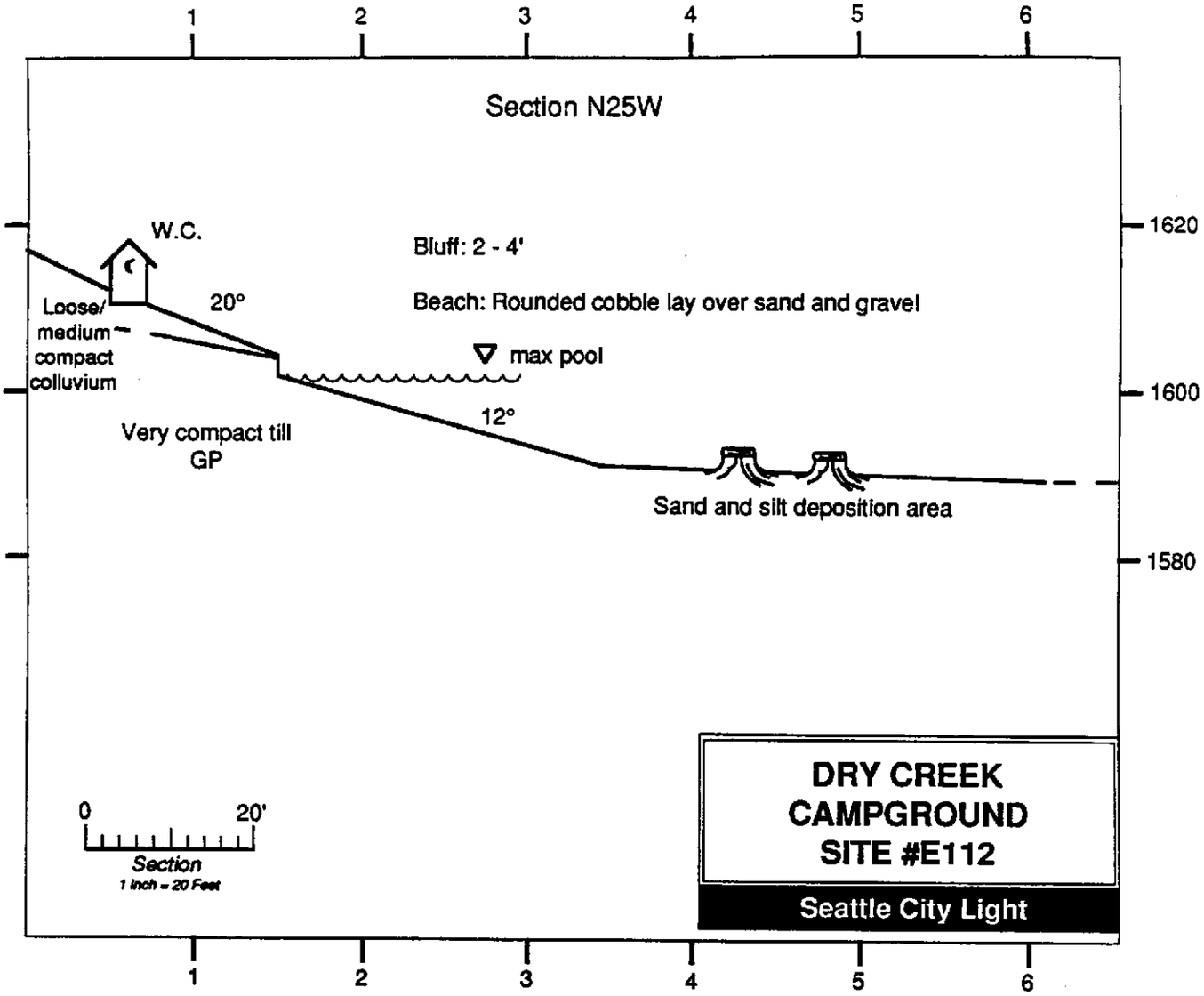
Projected Impacts:

Continued recession at an average rate of 0.4 feet/year will threaten the camp outhouse, now only 15 feet from the bluff.

Erosion Control Measure:

Along part of the 45 foot length of shore, a 2- to 4-foot-high rock wall will be constructed with 1-foot and 2-foot-diameter boulders. Logs will be anchored to the front of the wall; the large drift log (see photo) will be left in place. The area behind the wall will be vegetated; brush layering techniques will be used along parts of the wall to protect parts of the shore and to define public access points to the lake.

Photo 89 3 16:10 Dry Creek Campground


1
2
3
4
5
6
Section N25W
W.C.
Bluff: 2 - 4'
Beach: Rounded cobble lay over sand and gravel
20°
Loose/ medium compact colluvium
max pool
12°
Very compact till GP
Sand and silt deposition area
1620
1600
1580
0
20'
Section
1 inch = 20 Feet
DRY CREEK CAMPGROUND SITE #E112
Seattle City Light

Site Name: Ponderosa Campground
Location #: E-87
Photo #s: 3.16.26 - 3.16.29 (3)
Site Priority: Low

Site Conditions:

Thin soil over loose to moderately compact bouldery till is present at this site. A 12-foot section of the shore at the campground has been eroded to form a 3-foot-high bluff. In 1985, a rock wall was built using 1-foot-diameter boulders, and by 1989 this wall had been destroyed by wave action. Extremely long wind fetch and high wave energy have prevented placement of a dock at the site. This area is characterized by old growth Douglas-fir, lodgepole pine, juniper, Oregon grape, and grasses.

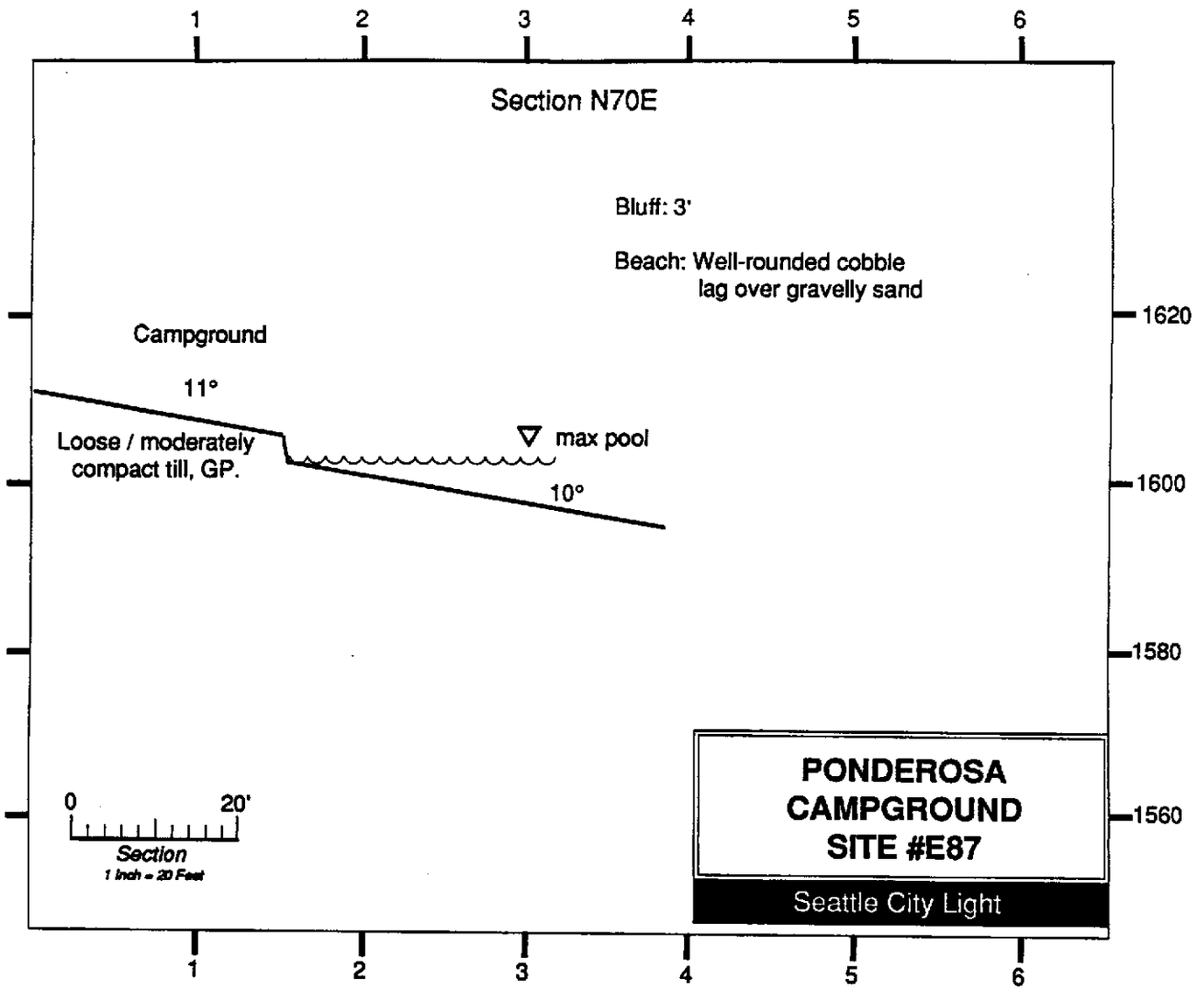
Projected Impacts:

Continued bluff recession at an average rate of 0.7 feet/year threatens the access point for the campsite, the camp sign, and in the future may threaten camp facilities.

Erosion Control Measure:

A 3-foot-high rock wall will be constructed along a 12-foot length of shoreline using 3-foot -diameter (or larger) boulders.

Photo 89 3 16:27 Ponderosa Campground


1
2
3
4
5
6
Section N70E
Bluff: 3'
Beach: Well-rounded cobble
lag over gravelly sand
Campground
11°
Loose / moderately
compact till, GP.
max pool
10°
1620
1600
1580
1560
0
20'
Section
1 Inch = 20 Feet
PONDEROSA
CAMPGROUND
SITE #E87
Seattle City Light
1
2
3
4
5
6

Site Name: Lodgepole Campground
Location #: E-92
Photo #s: 3.16.47
Site Priority: Medium

Site Conditions:

This new campground is built on a high outwash terrace. The maximum pool level is 2 feet below the top of the terrace. Outwash is composed of very coarse, clast-supported boulders and cobbles that has formed a 1.5-foot bluff in response to wave erosion. The site is predominantly an even-age stand of lodgepole pine with grasses as the dominant ground cover.

Projected Impacts:

The coarse cobble lag on the beach provides good protection and will probably limit further bluff recession to about 4 to 5 feet.

Erosion Control Measure:

To prevent bluff retreat from isolating dock and threatening outhouse, a 3- to 4-foot-high rock wall will be placed in a zone 10 feet on either side of the dock. Good local source of rock is available for this site and the area in general.

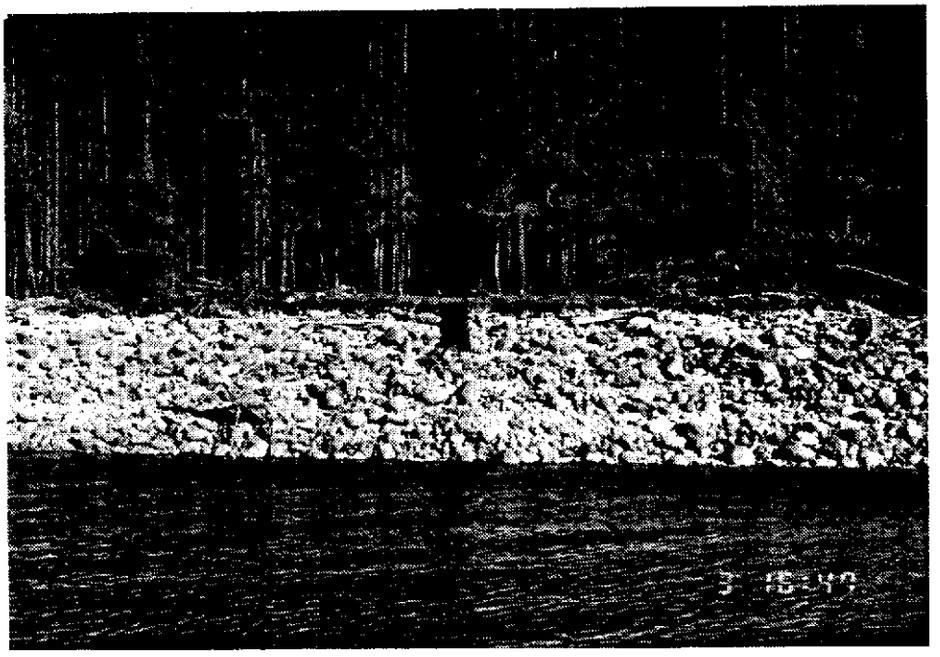
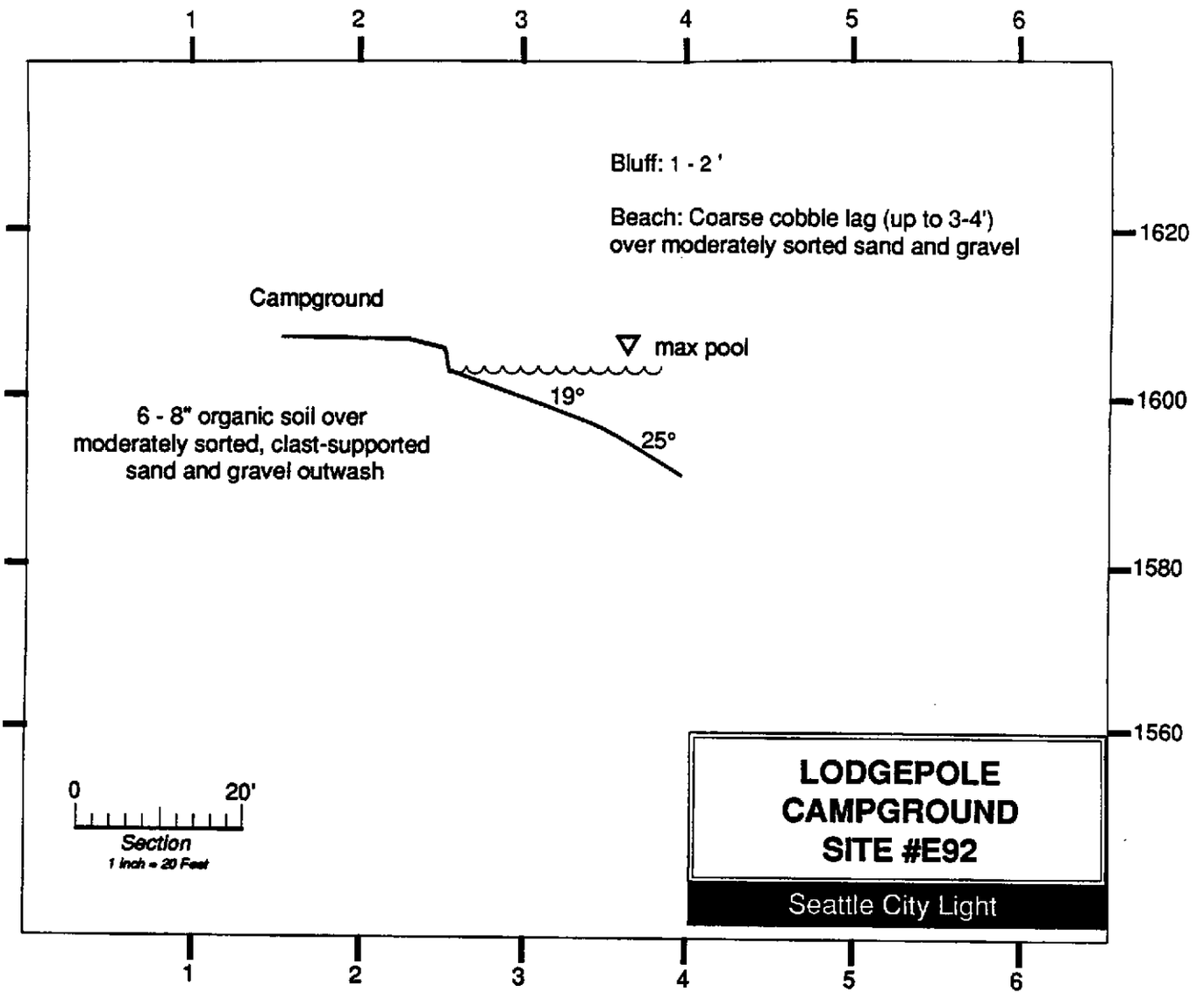


Photo 89 3 16:47 Lodgepole Campground


1
2
3
4
5
6
Bluff: 1 - 2 '
Beach: Coarse cobble lag (up to 3-4')
over moderately sorted sand and gravel
1620
Campground
max pool
19°
25°
1600
6 - 8" organic soil over
moderately sorted, clast-supported
sand and gravel outwash
1580
1560
0
20'
Section
1 inch = 20 Feet
LODGEPOLE
CAMPGROUND
SITE #E92
Seattle City Light
1
2
3
4
5
6

Site Name: Lightning Creek Horse Camp
Location #: E-95
Photo #s: 3.17.4 - 3.17.23 (4)
Site Priority: Medium

Site Conditions:

This gently sloping campground is on highly erodible sandy gravel outwash with a 4-inch organic soil. Erosion has produced a 2- to 3-foot retreating bluff, although the beach below the site is fronted by a zone of sediment deposition. Tree stump evidence suggests bluff recession of 49 feet since 1968, which equals a maximum recession rate of 2.3 feet/year. The bluff height and backslope angle method yields an estimated retreat rate of 3.4 feet/year (Appendix A). The slope here is convex so it is expected that the bluff height and backslope angle method would overestimate the retreat rate (Appendix A). This site is dominated by lodgepole pine with red alder and grasses in the understory.

Projected Impacts:

Continued recession will reduce the camp area, threaten fire grates and could expose the camp outhouse, which is only 15 feet from the shore, within the next 10 to 20 years.

Erosion Control Measure:

A rock wall 3 feet high will be constructed along 300 feet of the shore. The rock wall will be faced with 2- to 3-foot-diameter rocks to protect the toe area of the wall. A rock source to the north near Lightning Creek bridge can be used to construct this wall. The area behind the wall will be replanted with vine maple, lodgepole pine, and Douglas-fir, except at points designated for shore access. Access points from the 3 campsites to the lake will be delineated, and rock steps will be provided.

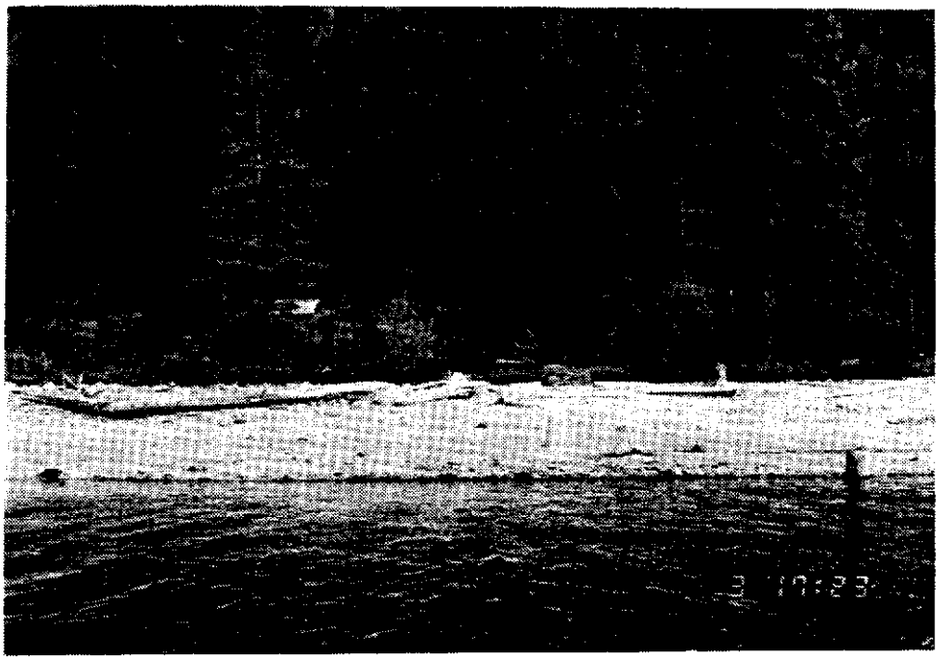
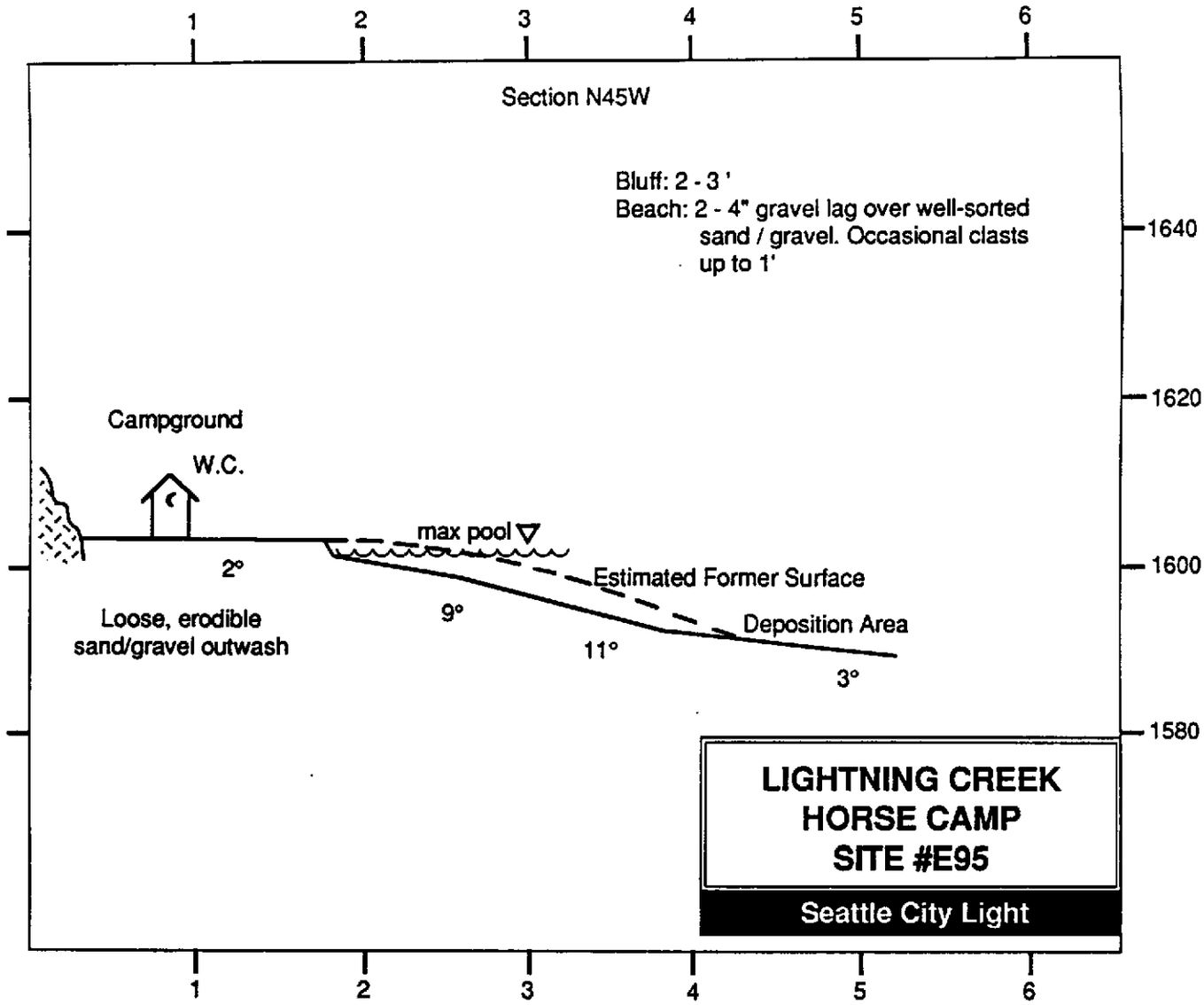


Photo 89 3 17:23 Lightning Creek Horse Camp


1
2
3
4
5
6
Section N45W
Bluff: 2 - 3 '
Beach: 2 - 4" gravel lag over well-sorted sand / gravel. Occasional clasts up to 1'
1640
1620
1600
1580
Campground
W.C.
max pool
2°
9°
11°
3°
Estimated Former Surface
Deposition Area
Loose, erodible sand/gravel outwash
LIGHTNING CREEK
HORSE CAMP
SITE #E95
Seattle City Light

Site Name: Trail North of Lightning Creek
Location #: E-116
Photo #s: 3.17.24 - 3.18.05 (3)
Site Priority: High

Site Conditions:

The trail is located on a steep (30 degree) slope, primarily composed of very loose sandy/gravel outwash deposited between two bedrock outcrops, which locally protect the toe of the slope from wave erosion. The loose outwash is easily eroded by waves at the toe of the slope and surface ravelling on the face of the bluff. Two debris slides have formed at the site and grown into 50-foot-high bluffs between the trail and the reservoir. Hikers seeking access to the lake compound erosion problems at this site. The shoreline is retreating at an average rate of 4.1 feet/year. Common plants at this site include red alder, Oregon grape, deerbrush, Douglas-fir, willow, and grasses.

Projected Impacts:

Continued bluff recession will destroy the trail.

Erosion Control Measure:

It would be difficult to stabilize this site fully without major construction of a 20-foot-high wall or large-scale slope modification that would likely be undesirable from a visual perspective. The ravelling bluff slope may be too steep for vegetation, although it would be worthwhile to attempt vegetation. Rock wall or cribbing protection of the toe slope would reduce the effects of wave erosion, and vegetation of side-cast areas above the bluff would slow bluff-head recession. However, the trail would still be threatened; therefore, the trail will be relocated upslope from the north end of Lightning Creek bridge (see sketch map).

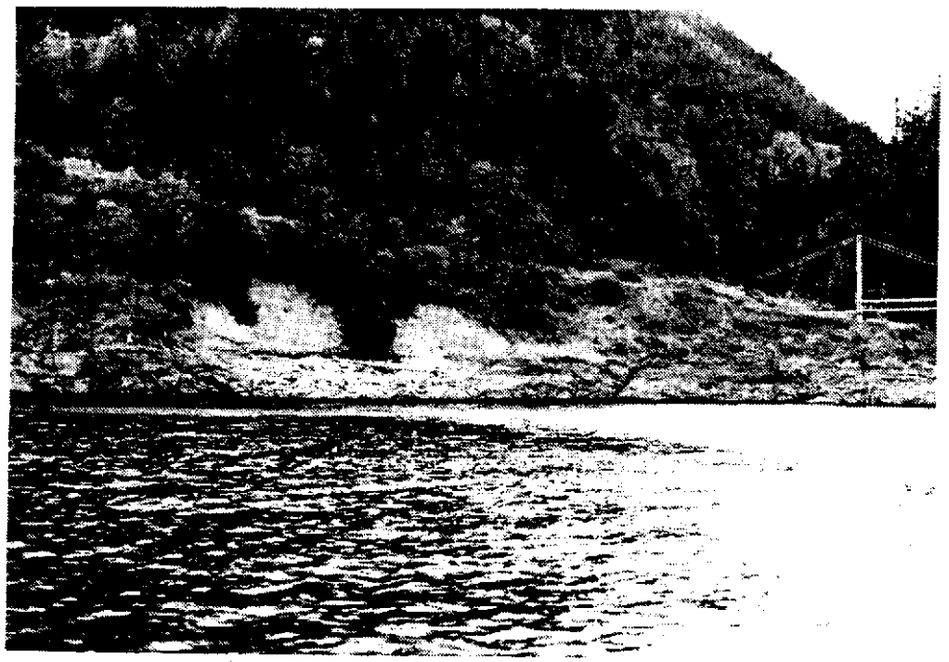


Photo 89 3 18:05 Trail North of Lightning Creek

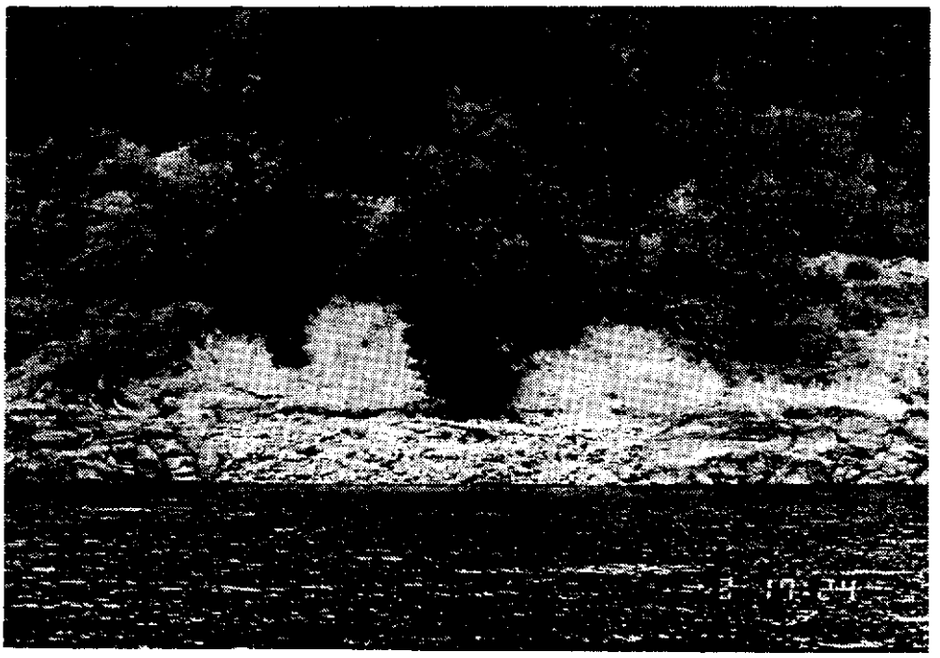
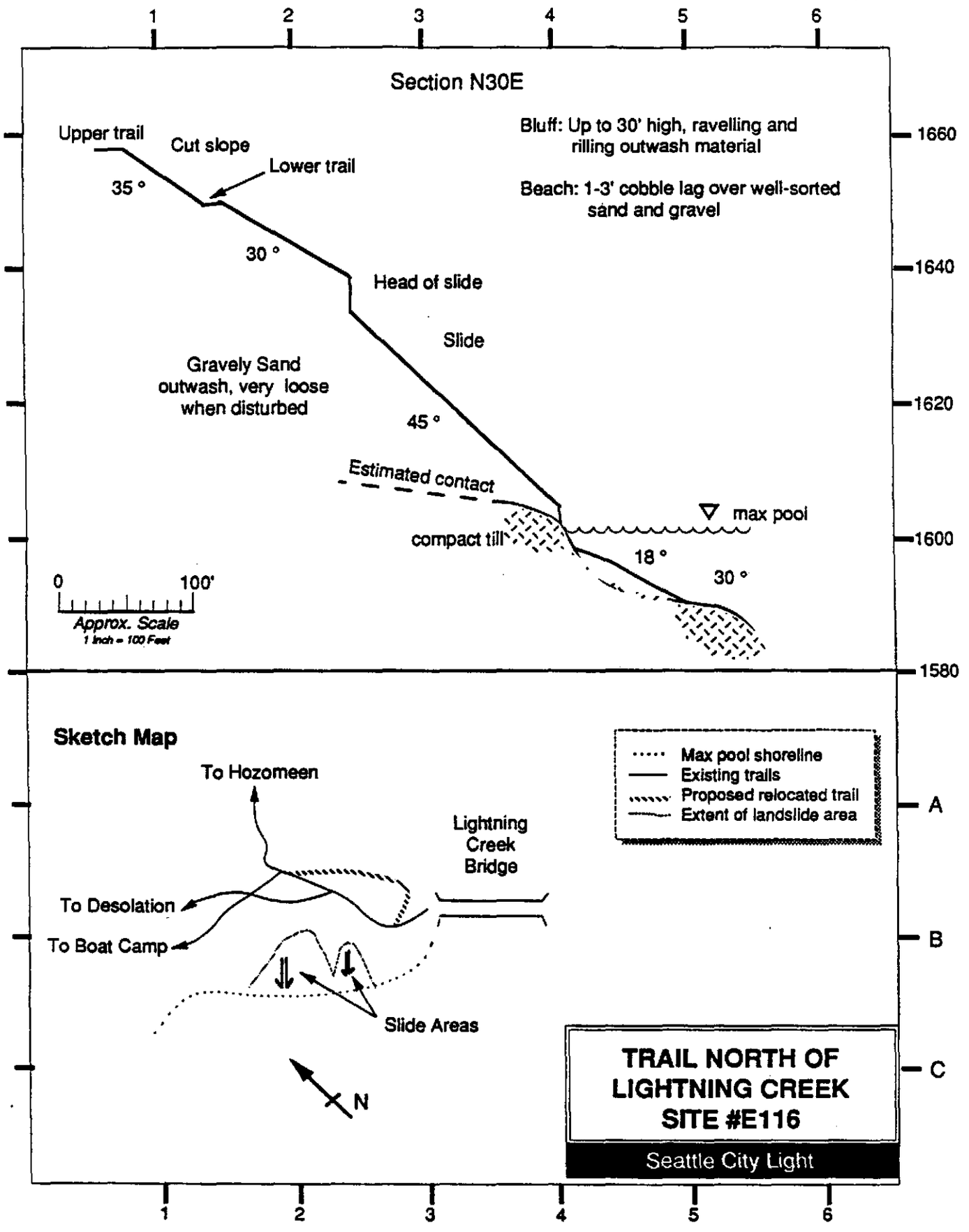


Photo 89 3 17:24 Trail North of Lightning Creek


1
2
3
4
5
6
Section N30E
Upper trail
Cut slope
Lower trail
35 °
30 °
Head of slide
Slide
Gravely Sand
outwash, very loose
when disturbed
45 °
Estimated contact
compact till
max pool
18 °
30 °
Bluff: Up to 30' high, ravelling and rilling outwash material
Beach: 1-3' cobble lag over well-sorted sand and gravel
1660
1640
1620
1600
1580
0
100'
Approx. Scale
1 Inch = 100 Feet
Sketch Map
To Hozomeen
Lightning Creek Bridge
To Desolation
To Boat Camp
Slide Areas
N
Max pool shoreline
Existing trails
Proposed relocated trail
Extent of landslide area
A
B
C
TRAIL NORTH OF LIGHTNING CREEK
SITE #E116
Seattle City Light

Site Name: Trail South of Lightning Creek Campground
Location #: E-117
Photo #s: 4.9.20 - 4.9.38 (3)
Site Priority: Low

Site Conditions:

South of the Lightning Creek Campground is a spur trail from the Desolation Peak Trail to the camp that follows the shoreline of the lake. The trail cuts across a steep talus and colluvium slope, and is protected in places by a rock wall on the shoreward side. Where the rock wall is composed of 2- to 3-foot-diameter rocks the trail is holding up, but where smaller rocks were used the trail is being eroded away. Vegetation on the slopes above the trail includes willow, Douglas-fir, vine maple, rose, red alder and thimbleberry.

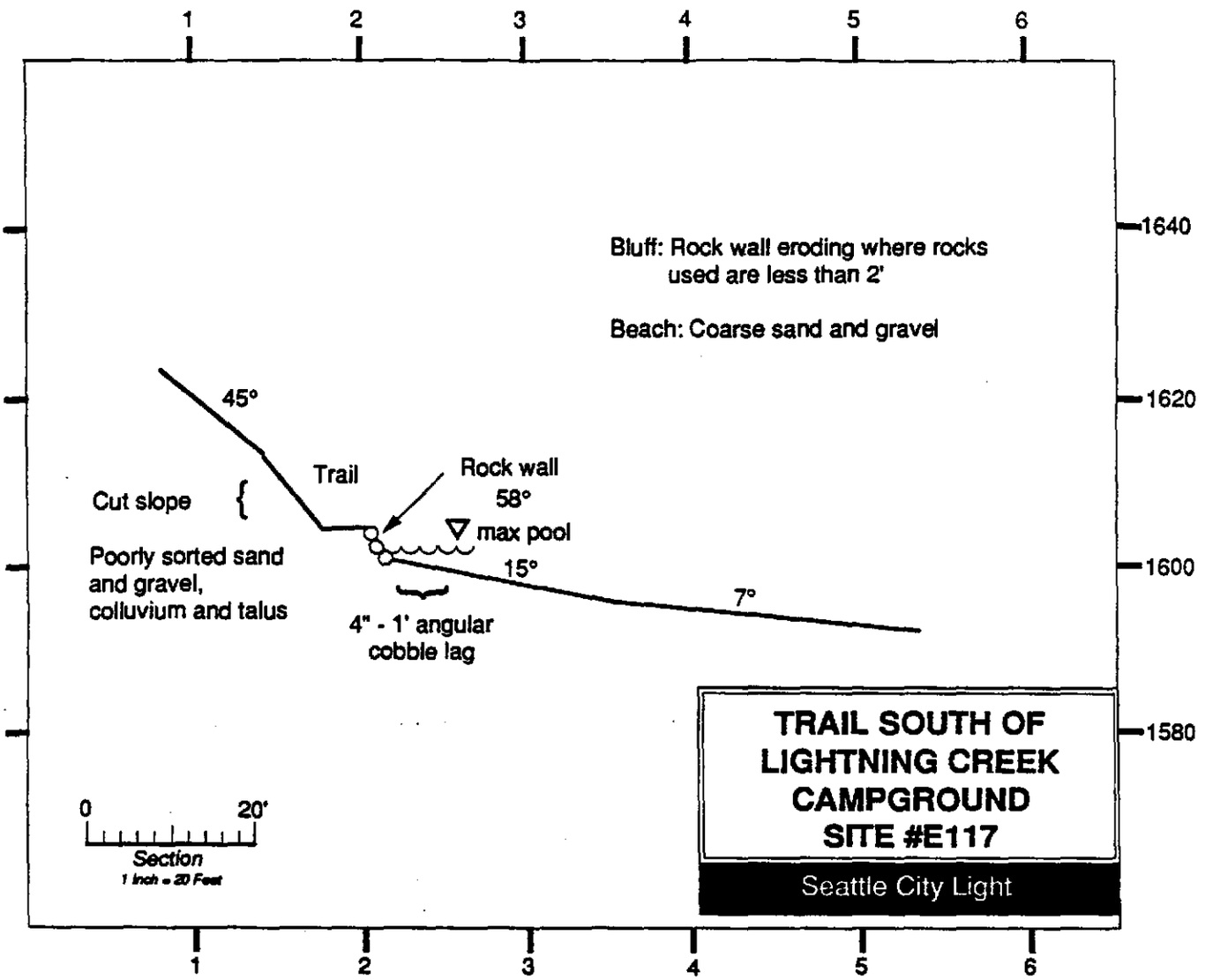
Projected Impacts:

Bank recession will continue to erode the trail.

Erosion Control Measure:

Along a 60-foot stretch of the trail, areas of eroding rock wall will be repaired through the replacement of existing material with rocks of 2 to 3 feet in diameter or greater. All shoreline rocks and logs will be left in place, and rocks for trail repair will be obtained from 150 feet along the shore, at least 30 feet away from the full pool shore. The back of the rock wall will be planted with paper birch and other local species that occur in other areas of the trail rock wall nearby.

Photo 89 4 9:38 Trail South of Lightning Creek Campground


1
2
3
4
5
6
1640
1620
1600
1580
Bluff: Rock wall eroding where rocks used are less than 2'
Beach: Coarse sand and gravel
45°
Trail
Rock wall
58°
Cut slope
max pool
Poorly sorted sand and gravel, colluvium and talus
15°
7°
4" - 1' angular cobble lag
0
20'
Section
1 Inch = 20 Feet
TRAIL SOUTH OF LIGHTNING CREEK CAMPGROUND SITE #E117
Seattle City Light

Site Name: Lightning Creek Campground
Location #: E-118
Photo #s: 4.9.5
Site Priority: Medium

Site Conditions:

A. The camp is built on a gently sloping alluvial fan. Erosion Site A is subject to intense wave erosion because of the long fetch to the south of the site. Soils are thin and overlay well-sorted alluvial sands and boulders. Shore erosion has created a small (0- to 1-foot-high) receding bank and is isolating the dock bulkhead and steps. There has been 12 feet of bank recession since the dock bulkhead was poured in 1976, a recession rate of 0.9 feet/year, compared to estimated recession using the back slope and bluff height method of 0.5 feet/year (Appendix A). Common vegetation at this site is paper birch, red alder, Douglas-fir, Oregon grape and grasses.

B. The south end of the Lightning Creek Campground is gently sloping with campground and trail areas fronted by a gentle beach into which a small alluvial channel has been cut. Because waves can reach the shore where the offshore channel cuts through the beach, this shore area is retreating and forming a 1-foot-high bank.

Projected Impacts:

A. Bank recession will continue to destroy shore vegetation, reduce the campground area, and further isolate the dock bulkhead and steps.

B. Bank recession will reduce the campground area and threaten a social trail in the campground.

Erosion Control Measure:

A. Bank recession has been reduced in some areas where boom logs are in place to protect the dock area from waves and where drift logs lie on the beach. Logs will be cable-tied to either side of the central dock bulkhead and to the existing deadman to protect these areas, or, alternatively, a 1-foot-high rock wall will be built 20 feet on either side of the dock. A more stable access ramp will be built to the dock.

B. A rock wall of 1-foot boulders will be placed along the 45 foot section of affected shore.

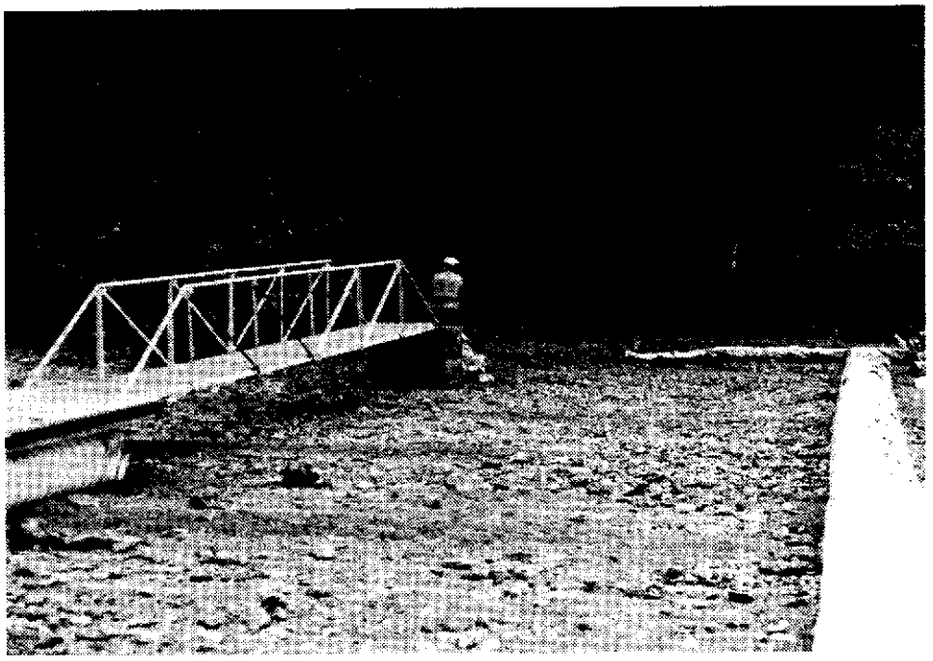
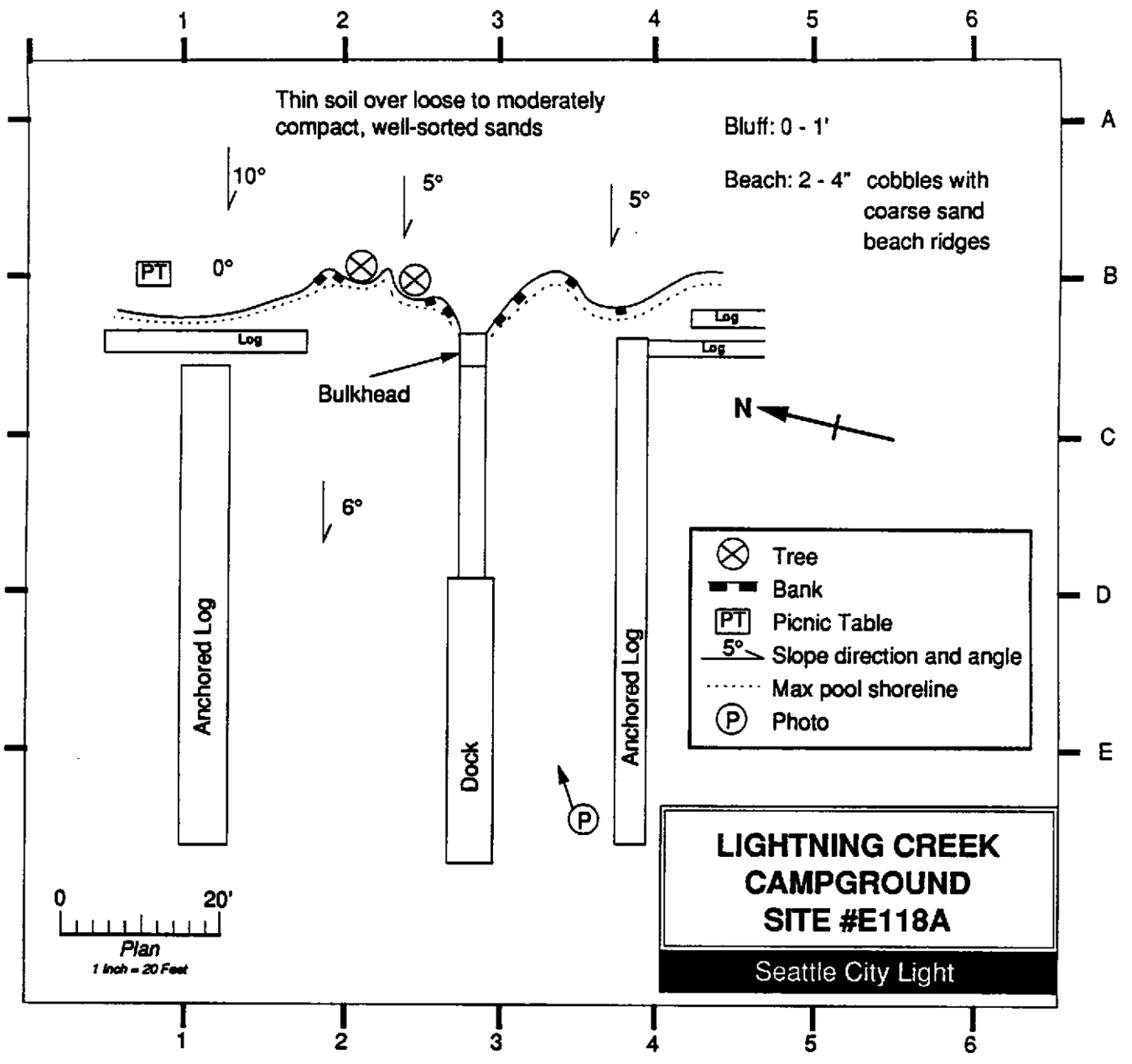


Photo 89 4 9:9 Lightning Creek Campground, Site A


1
2
3
4
5
6
A
B
C
D
E
Thin soil over loose to moderately compact, well-sorted sands
Bluff: 0 - 1'
Beach: 2 - 4" cobbles with coarse sand beach ridges
10°
5°
5°
PT
0°
Log
Log
Log
Bulkhead
N
6°
Anchored Log
Dock
Anchored Log
Tree
Bank
PT Picnic Table
5° Slope direction and angle
Max pool shoreline
P Photo
0
20'
Plan
1 Inch = 20 Feet
LIGHTNING CREEK CAMPGROUND SITE #E118A
Seattle City Light

Site Name: Cat Island Campground
Location #: E-134
Photo #s: 5.16.11 (2), 4.10.43 - 4.10.47 (4)
Site Priority: Site A High
Site B Medium

Site Conditions:

A. At the dock bulkhead, a thin wedge of colluvium between bedrock outcrops is eroding causing the isolation of the dock bulkhead and undercutting the trail leading from the dock to the camp. The eroding area is a 5-foot-high bluff that is undercutting large trees. Vegetation in this area is lodgepole pine, Douglas-fir and grasses. The minimum bank recession rate is 1.5 feet/year at the dock.

B. On the west side of the island, wedges of till in bedrock depressions at the shore are being eroded back into the camp area in two locations. Waves have undercut the shore to form a 2-foot bank.

Projected Impacts:

A. Continued bank recession will isolate the dock and wash out areas of the trail leading up to the camp. Locations to relocate the access point and dock were not apparent.

B. Continued bank recession will reduce the camp area and force closing or relocation of a camp site.

Erosion Control Measure:

A. The existing dock area and trail will be protected by extending the bulkhead 15-feet to the west over bedrock. A concrete wall faced with cobbles (see map insert) would provide a long term solution. The concrete wall option would include rebar drilled into bedrock to hold the wall in place. An alternative would be a larger backfilled rock wall that would require regular maintenance because a good foundation for loose rocks is not present. Some support could be provided for loose rocks by anchoring them to the bedrock with anchor bolts and cable.

B. At both locations a 2-foot-high rock wall faced with 1- to 2-foot-diameter rocks will be constructed, and the areas behind the walls will be vegetated. A rock source occurs 30 feet away at 5- to 10-foot drawdown. However, rocks should not be collected closer than 30-feet from the shore. The rock walls will be 30 feet and 35 feet in length, respectively. Public access point to lake will also be delineated.

Photo 89 4 10:44 Cat Island Campground, Site A

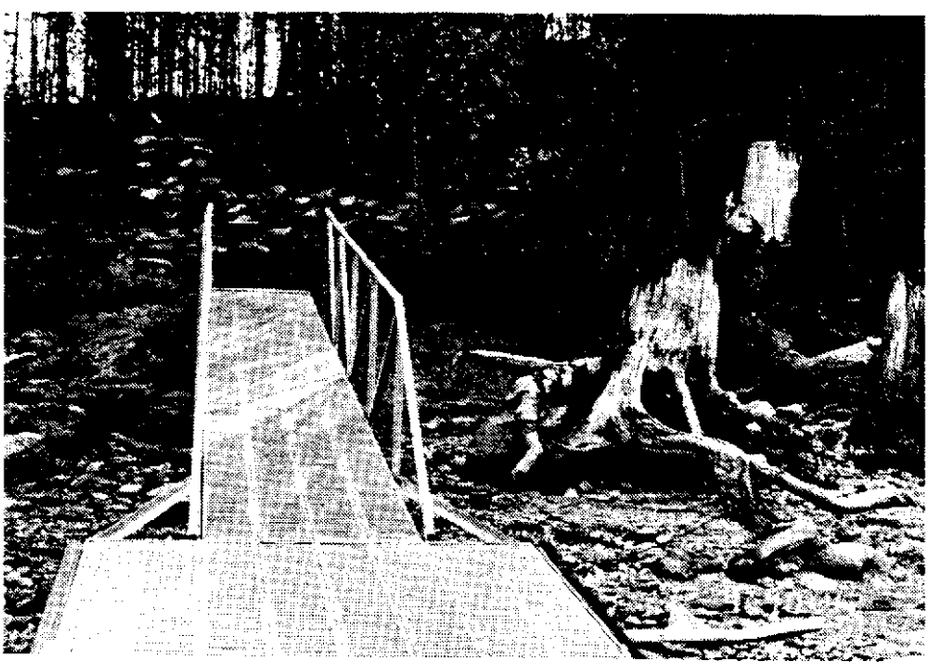


Photo 89 10:43 Cat Island Campground, Site A

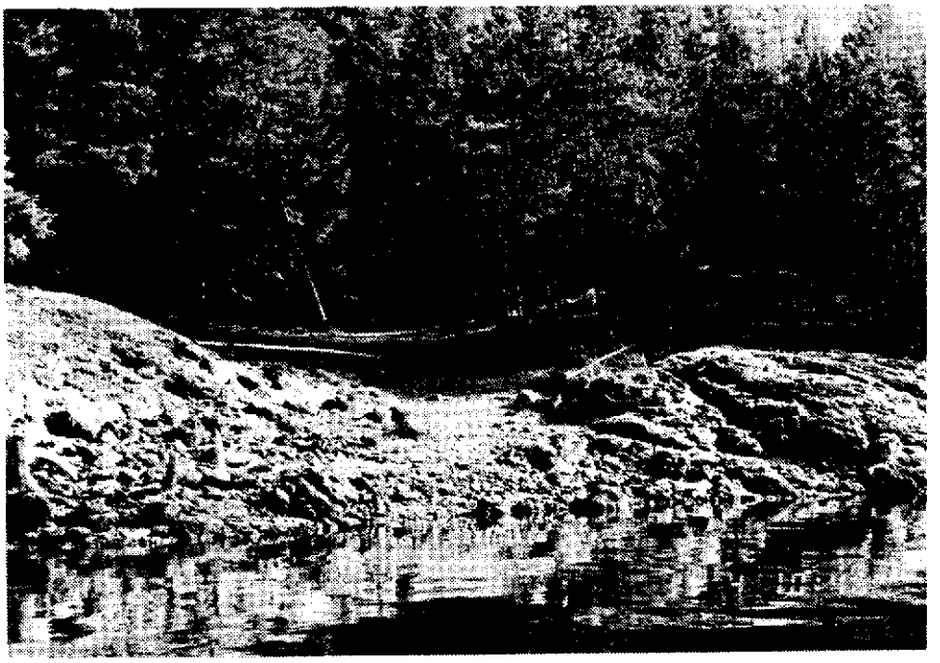


Photo 89 4 10:46 Cat Island Campground, Site B-1

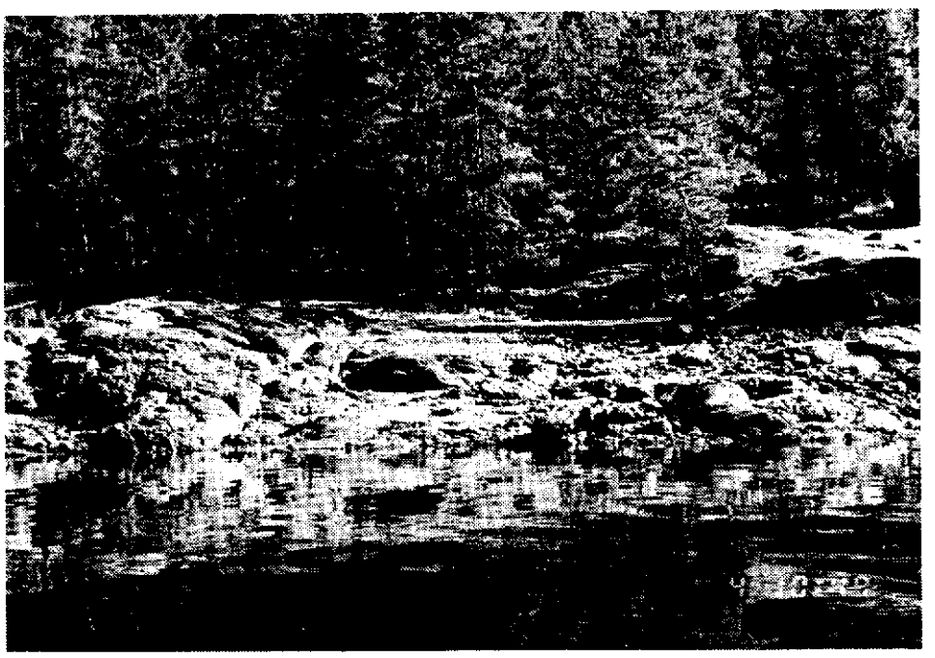
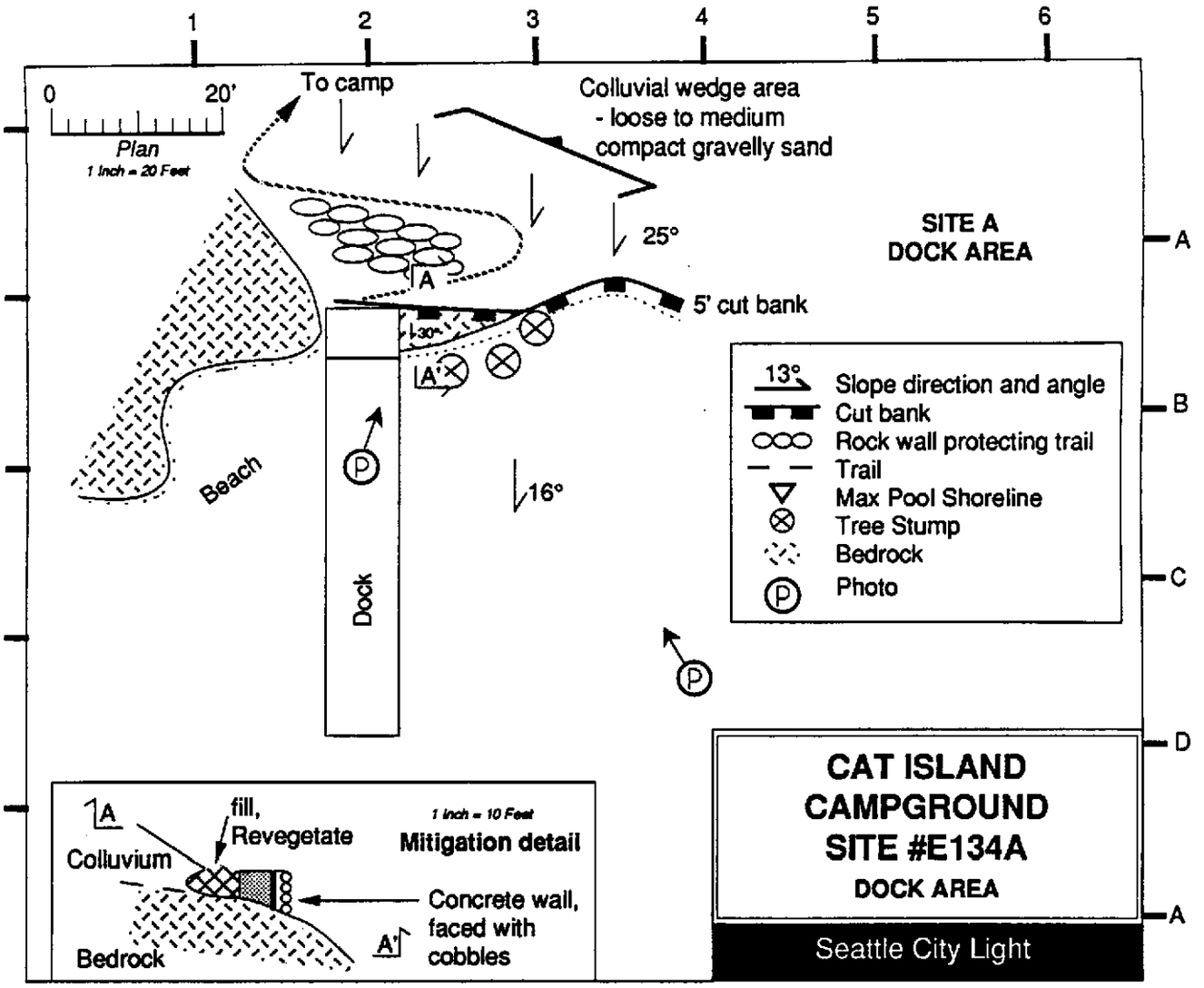
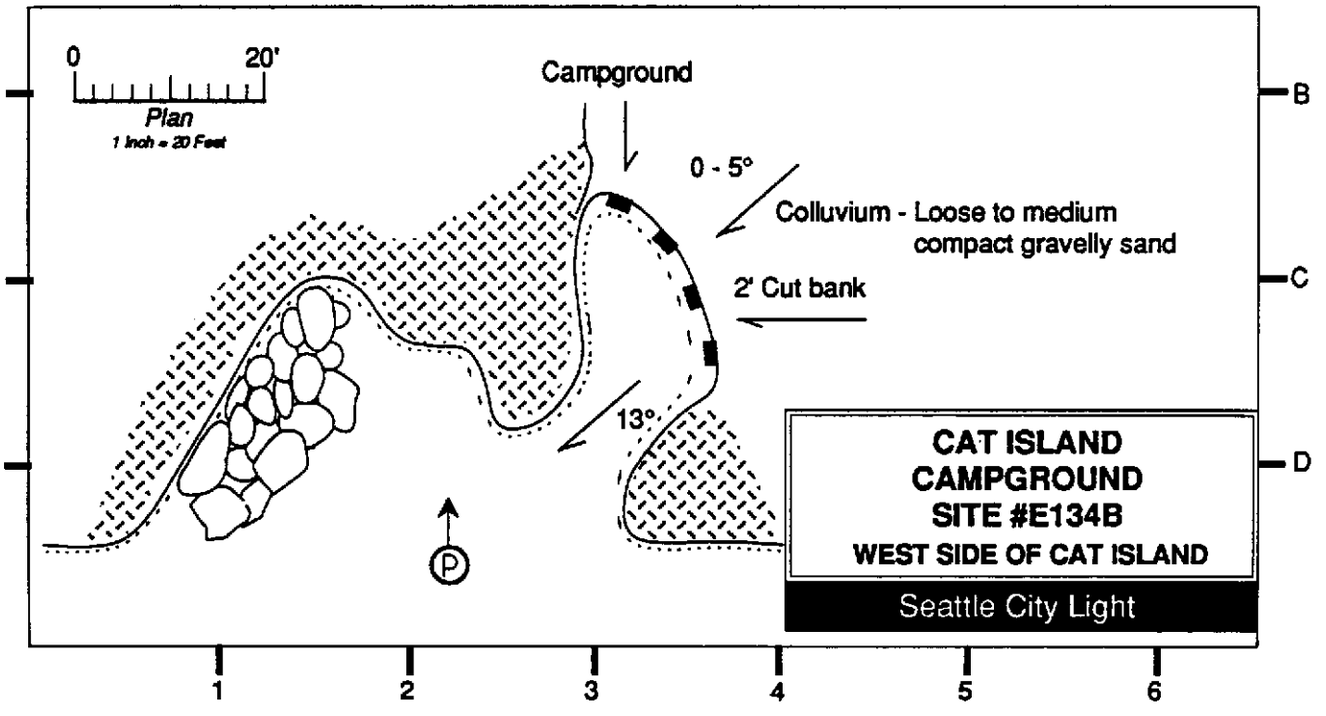


Photo 89 4 10:47 Cat Island Campground, Site B-2


1
2
3
4
5
6
0
20'
Plan
1 Inch = 20 Feet
To camp
Colluvial wedge area
- loose to medium
compact gravelly sand
25°
SITE A
DOCK AREA
A
5' cut bank
30°
A'
Beach
Dock
16°
13° Slope direction and angle
Cut bank
Rock wall protecting trail
Trail
Max Pool Shoreline
Tree Stump
Bedrock
Photo
B
C
D
A
A
fill,
Revegetate
1 Inch = 10 Feet
Mitigation detail
Colluvium
Concrete wall,
faced with
cobbles
A'
Bedrock
CAT ISLAND
CAMPGROUND
SITE #E134A
DOCK AREA
Seattle City Light


0
20'
Plan
1 Inch = 20 Feet
Campground
0 - 5°
Colluvium - Loose to medium
compact gravelly sand
2' Cut bank
13°
B
C
D
CAT ISLAND
CAMPGROUND
SITE #E134B
WEST SIDE OF CAT ISLAND
Seattle City Light
1
2
3
4
5
6

Site Name: Boundary Bay Campground
Location #: E-181
Photo #s: 5.15.59 (4); 4.14.2 - 4.14.3 (3)
Site Priority: High

Site Conditions:

This site consists of a gentle, wooded slope leading down to the boat dock and campground. Bank erosion has created a 2-foot-high bluff in sandy till and colluvium that is retreating at a rate of 1.4 feet/year. The dock bulkhead area is being isolated by a bluff retreat. This area is characterized primarily by old growth Douglas-fir and grasses.

Projected Impacts:

Continued bank recession will isolate the dock bulkhead area, reduce the campground, destroy a tent pad, and force relocation of the camp sign.

Erosion Control Measure:

Along parts of the 110-foot length of the shore, a 2- to 4-foot-high rock wall will be built, fronted with logs anchored to bedrock or till. The wall will be backfilled and planted with western red cedar, willow, vine maple, and Douglas-fir. Brush layering between sections of the rock wall will be used to define public access points to the lake.

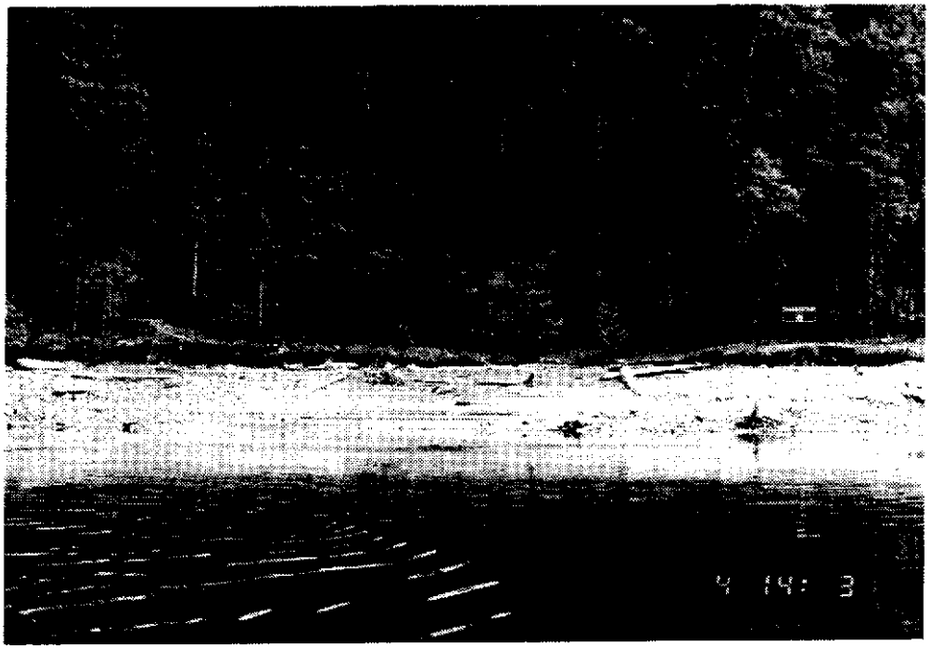
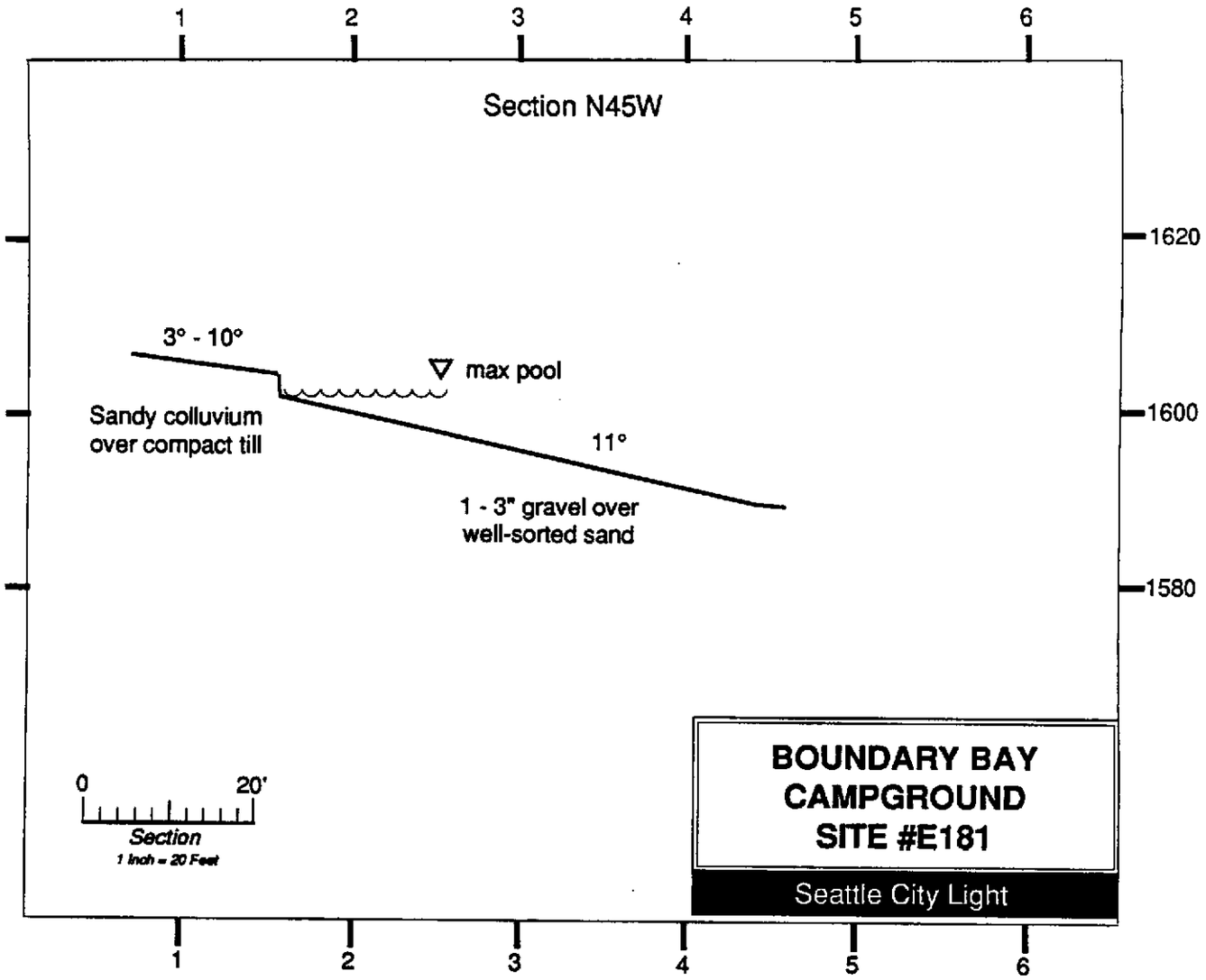


Photo 89 4 14:03 Boundary Bay Campground


1
2
3
4
5
6
Section N45W
1620
1600
1580
3° - 10°
max pool
Sandy colluvium
over compact till
11°
1 - 3" gravel over
well-sorted sand
0
20'
Section
1 Inch = 20 Feet
BOUNDARY BAY
CAMPGROUND
SITE #E181
Seattle City Light
1
2
3
4
5
6

Site Name: Green Point Campground
Location #: W7-8
Photo #s:
Site Priority: No Action

Site Conditions:

Exposed south side has till between bedrock knobs eroding, leaving a natural armor.

Projected Impacts:

Some recession is predicted, but this will not immediately affect the campsite and should slow with natural armoring.

Erosion Control Measure:

None

Site Name: Big Beaver Spur Trail
Location #: W-34
Photo #s: 20.14.10 - 20.14.48 (6)
Site Priority: High

Site Conditions:

The Big Beaver Spur Trail leads from the camp to the main Big Beaver Valley Trail along a terrace on the edge of the reservoir. It also serves as an access point to the reservoir for hikers and horse parties, compounding erosion problems. Cut bank erosion due to wave undercutting, especially in heavily tracked water access point areas, has produced an overhanging bank as much as 7 feet under the shoreline. The bank has receded at least 15 feet in the sand and gravel outwash, which is loose to moderately compact. The effected area is a 280-foot length of shore. Vegetation in this area includes willow, red alder, Douglas-fir, and lodgepole pine.

Projected Impacts:

Continued rapid bank recession will force relocation of the trail, which would remove the only access point to the reservoir along the trail.

Erosion Control Measure:

The natural log jam/boom will be extended to the west to protect the site, and a 3-foot-high rock wall will be constructed to protect the most severely eroding areas where the trail is immediately threatened. The area behind the wall will be backfilled with soil filter, and unstable areas will be vegetated with willow and red alder. Controlled access points for hikers/campers will be created with gravel footing, logs, or rock steps. Brush layering will be used to protect the shoreline.

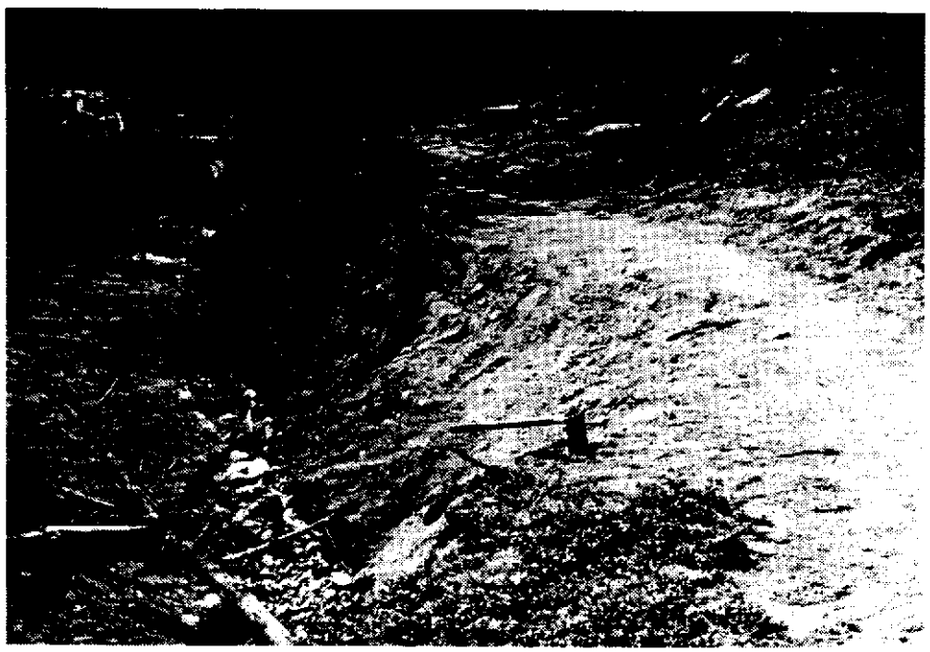
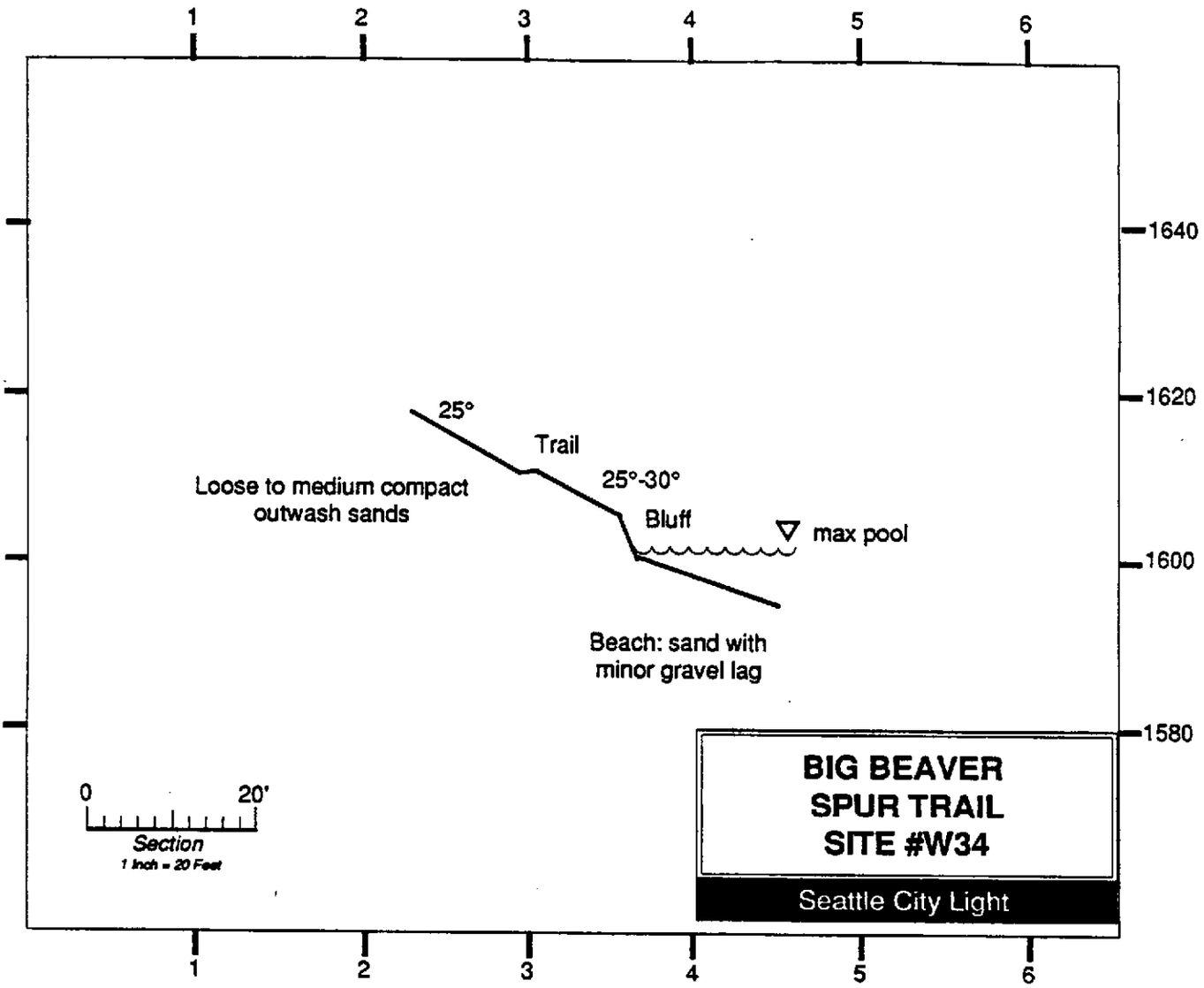


Photo 89 20 14:42 Big Beaver Spur Trail


1
2
3
4
5
6
1640
1620
1600
1580
25°
Trail
25°-30°
Bluff
max pool
Loose to medium compact
outwash sands
Beach: sand with
minor gravel lag
0
20'
Section
1 Inch = 20 Feet
BIG BEAVER
SPUR TRAIL
SITE #W34
Seattle City Light

Site Name: Big Beaver Campground
Location #: W-36
Photo #s: 20.14.50 - 20.14.58 (2)
Site Priority: Medium

Site Conditions:

A. A gentle wooded slope leads from the campground down to the reservoir. Human activity has removed all understory vegetation and has caused direct erosion of the shore to the south and east of the camp as campers seek access to the reservoir. Due to these activities and wave erosion, a 2-foot-high bluff has formed in coarse outwash. Placement of small rocks by campers has slowed erosion in some locations. Vegetation in the area is primarily Douglas-fir, lodgepole pine, and Oregon grape.

B. The dock bulkhead is tilting to the southeast and is partially isolated by the retreat of the shoreline. Substrate is sandy, gravelly outwash that is loose and very erodible when disturbed.

Projected Impacts:

A. Continued bank erosion along 40 feet of the shore in the campground will impact trees and reduce the campground area.

B. Continued bank recession at the dock will isolate the bulkhead and steps, making access to the dock difficult.

Erosion Control Measure:

A. At the campsite location 40 feet of shore will be riprapped to extend the rocks already in place and vegetated. The area will be backfilled with a soil filter and vegetated. One or two water access points will be marked for hikers and campers by vegetating parts of the shore area and building a ramp or steps.

B. A 2-foot-high, 50-foot-long rock wall will be built on the north side of the dock bulkhead with 1-to 2-foot-diameter boulders. The area will be backfilled with soil filter and vegetated.

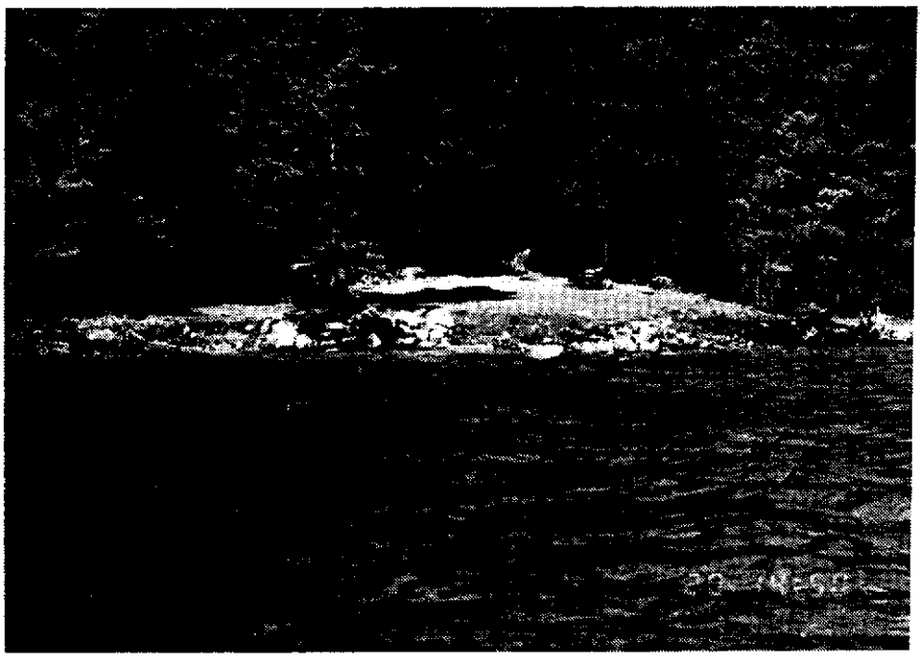


Photo 89 14:50 Big Beaver Campground, Site A

Site Name: Little Beaver Campground
Location #: W-124 (West Dock)
Photo #s: 5.14.2 - 5.14.3 (3) ; 4.13.32 - 4.13.46 (7)
Site Priority: Medium

Site Conditions:

The steep trail leading down to the dock area from the campground is eroding making access to the dock difficult. Bank erosion has produced a 1-foot-high overhanging bluff. Vegetation at this site is primarily Douglas-fir, huckleberry and red alder.

Projected Impacts:

The trail will continue to erode. There is no apparent location to move the trail without also relocating the dock area.

Erosion Control Measure:

Stairs will be built up the trail (25-foot section), and brush layering will be used to protect a 20-foot section of the shore.

Photo 89 4 13:32 Little Beaver Campground

Site Name: Little Beaver Campground
Location #: W-125 (Main campground)
Photo #s: 5.14.2 - 5.14.3 (3) ; 4.13.32 - 4.13.46 (7)
Site Priority: High

Site Conditions:

A gentle wooded slope with thin soil over till leading down to boat dock occurs at this site. Long fetch results in intense wave erosion at the site, which is isolating the dock bulkhead and has undercut the shoreline as much as 10 feet under a tent site. Shore adjacent to the boat dock is being cut back at an average rate of 0.4 feet/year, exposing the dock foundation and leaving a 4- to 6-foot bluff. Vegetation at this site includes Douglas-fir, lodgepole pine, Oregon grape, and grasses.

Projected Impacts:

Continued erosion of the cut bank will isolate the dock bulkhead making access to the dock difficult. The camp site nearest the dock will eventually collapse, reducing the camp area. The tent site is a safety hazard because it could collapse as well, most likely during a period with strong wave action.

Erosion Control Measure:

A 70-foot-long rock wall 5 to 6 feet high will be constructed. Two- to 3-foot-diameter rocks will be used at the base with 1-foot-diameter rocks on top. The wall will be backfilled with soil filter and the area behind it vegetated. Cobble and gravel fill will be poured or pushed into undercut areas.

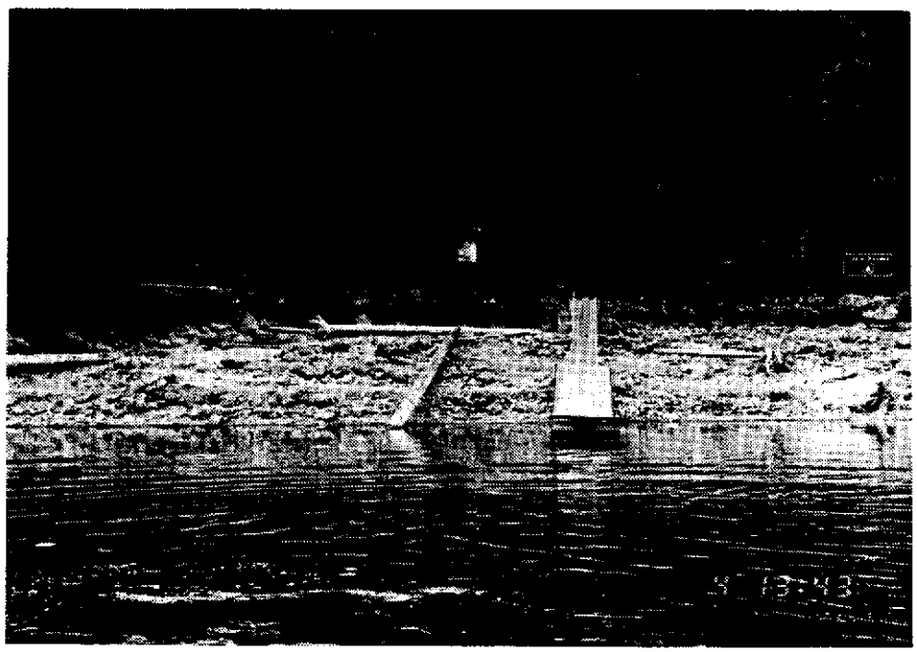
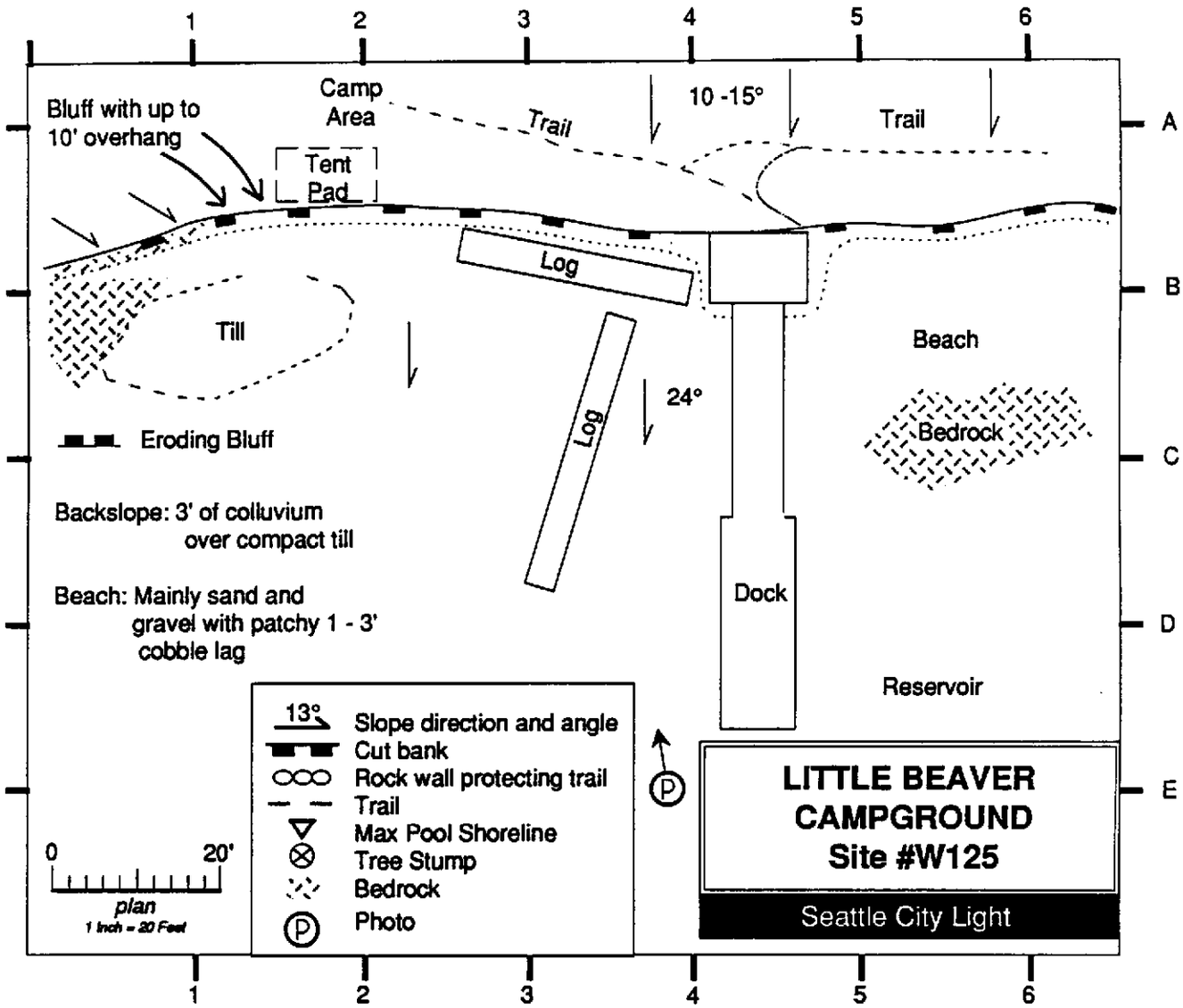


Photo 89 13:43 Little Beaver Campground


1
2
3
4
5
6
A
B
C
D
E
Bluff with up to 10' overhang
Camp Area
Tent Pad
Trail
10 -15°
Trail
Log
Till
Beach
Log
24°
Bedrock
Eroding Bluff
Backslope: 3' of colluvium over compact till
Beach: Mainly sand and gravel with patchy 1 - 3' cobble lag
Dock
Reservoir
13°
Slope direction and angle
Cut bank
Rock wall protecting trail
Trail
Max Pool Shoreline
Tree Stump
Bedrock
Photo
0
20'
plan
1 Inch = 20 Feet
LITTLE BEAVER CAMPGROUND
Site #W125
Seattle City Light

Site Name: Little Beaver Campground Trail
Location #: W-126 (trail)
Photo #s: 5.14.2 - 5.14.3 (3) ; 4.13.32 - 4.13.46 (7)
Site Priority: High

Site Conditions:

To the north of the campground, the Little Beaver Creek Trail cuts across a very steep slope (35 to 45 degrees) just above the reservoir shoreline. Cribbing placed to protect the slope beneath the trail has eroded away resulting in destruction of the trail. The slope is composed of loose, unstable colluvium. Along the trail to the north there are two areas where the trail is just above steep, failing bluffs. Vegetation at this site includes Douglas-fir, vine maple and grasses.

Projected Impacts:

Bluff recession threatens the trail in three areas.

Erosion Control Measure:

A. Sixty feet of new, planted cribbing, 12 feet high, will be constructed to protect the 2 locations. Where possible, the cribbing will be tied into the bedrock .

B. The trail will be relocated upslope of its existing location.

Photo 89 4 13:44 Little Beaver Campground Trail

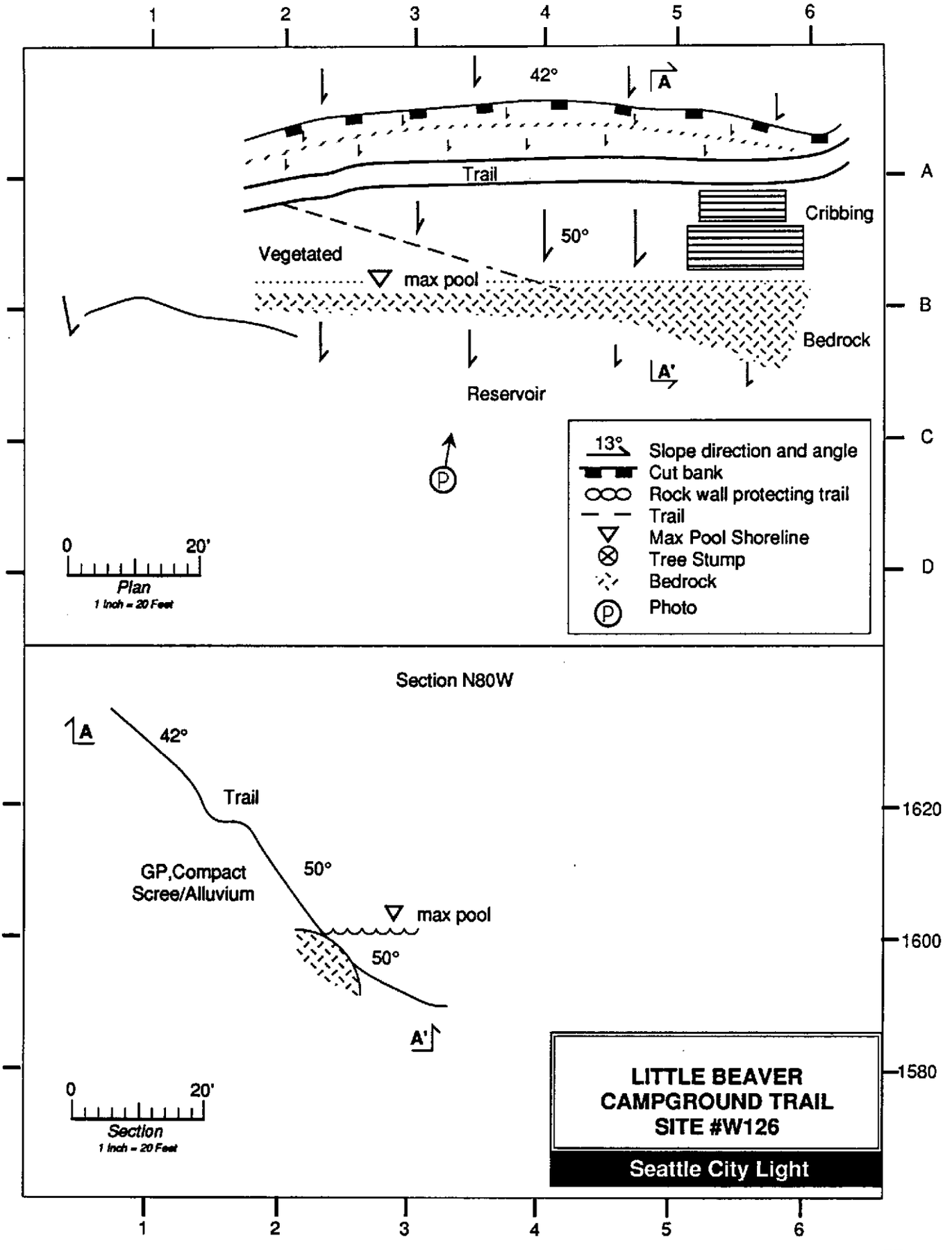

1
2
3
4
5
6
A
B
C
D
42°
A
Trail
Cribbing
50°
Vegetated
max pool
Bedrock
A'
Reservoir
P
13° Slope direction and angle
Cut bank
Rock wall protecting trail
Trail
Max Pool Shoreline
Tree Stump
Bedrock
P Photo
0
20'
Plan
1 Inch = 20 Feet
Section N80W
A
42°
Trail
GP,Compact
Scree/Alluvium
50°
max pool
50°
A'
1620
1600
1580
0
20'
Section
1 Inch = 20 Feet
LITTLE BEAVER
CAMPGROUND TRAIL
SITE #W126
Seattle City Light

Photo 13:45 Slump Area to the North of Little Beaver Camp

Photo 13:46 Slump Area to the North of Little Beaver Camp

Site Name: Thunder Point Campground
Location #: D-11
Photo #s: 20.10.56 (3)
Site Priority: High

Site Conditions:

Thick accumulation of compact glacial till overlain by 2 feet of soil forming a moderate, well vegetated slope down to the reservoir. Wave erosion has produced a cut bank in the erodible till, and is isolating the dock bulkhead and threatens the outhouse and campground. Bank recession averages 0.6 feet/year at the dock. The outhouse is 19 feet from the eroding bluff face. Vegetation at this site is Douglas-fir, lodgepole pine, Oregon grape, and salal.

Projected Impacts:

Continued bank recession will reduce the camp area, isolate the dock bulkhead and could eventually threaten the outhouse.

Erosion Control Measure:

Along parts of the shore, a 290-foot-long rock wall will be constructed, faced with 2- to 3-foot-diameter rocks; the wall will be backfilled with soil filter, and the area behind it vegetated. A source of rock could include material side cast from State Highway 20 (SR 20) across the lake or material from local pits could be barged in. Brush layering techniques will be used along portions of the eroding shoreline.

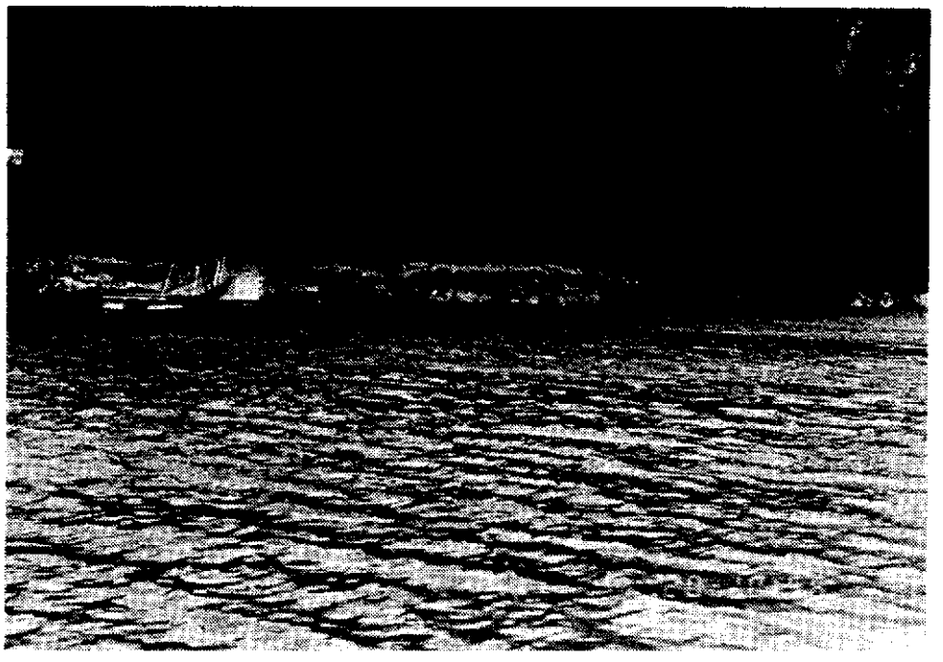
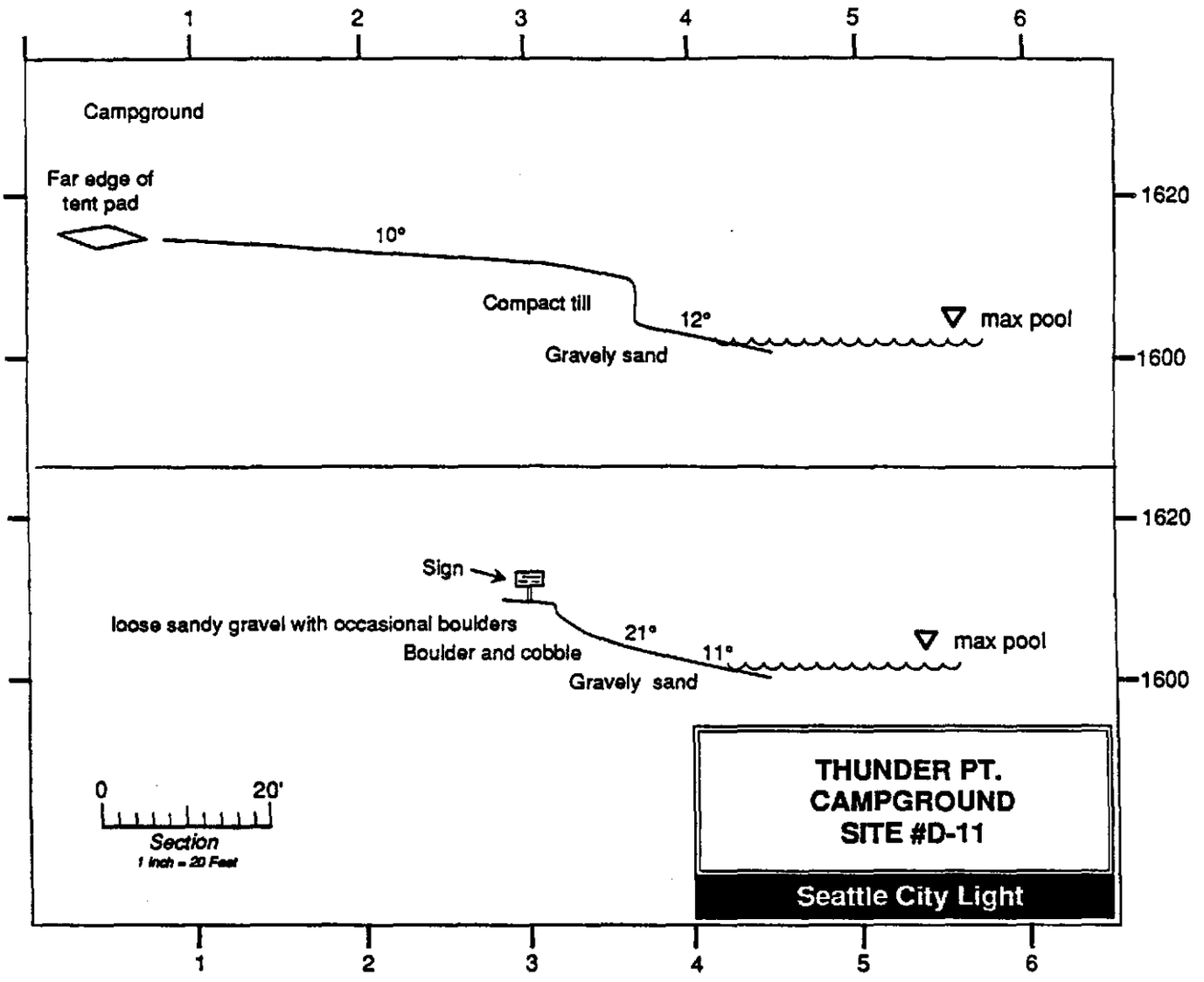


Photo 89 20 10:56 Thunder Point Campground


1
2
3
4
5
6
Campground
Far edge of tent pad
10°
Compact till
12°
max pool
Gravely sand
1620
1600
1620
Sign
loose sandy gravel with occasional boulders
Boulder and cobble
21°
11°
max pool
Gravely sand
1600
0
20'
Section
1 inch = 20 Feet
THUNDER PT.
CAMPGROUND
SITE #D-11
Seattle City Light
1
2
3
4
5
6

Site Name: Electrical Transmission Line (Class I-Diablo Lake)
Location #: D-40
Photo #s: JR rolls 24, 25 and 26.
Site Priority: Medium

Site Conditions:

The shore line exposes a thick accumulation of loose to slightly compact glacial till. Lakeshore erosion has created a 20.4-foot-high eroding bluff face along a 93-foot length of shore. Vegetation on the surface is disturbed and consists mainly of grasses.

Projected Impacts:

Continued bank recession will threaten a utility pole 23.8 feet from the eroding bluff face.

Erosion Control Measure:

Two- to 3-foot-diameter rock will be placed along the base of the 93-foot-long bluff to slow bank recession. The area behind the wall will be backfilled and the bluff face vegetated. Possible source of material is debris from construction of SR20 or material barged from a local pit. Boom logs will be secured offshore to absorb some wave energy.

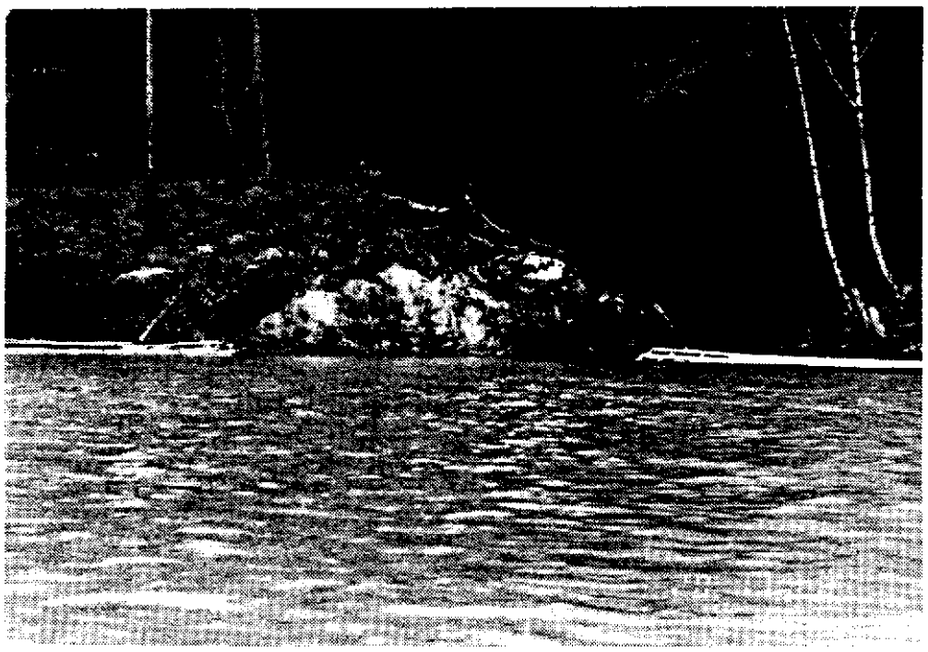
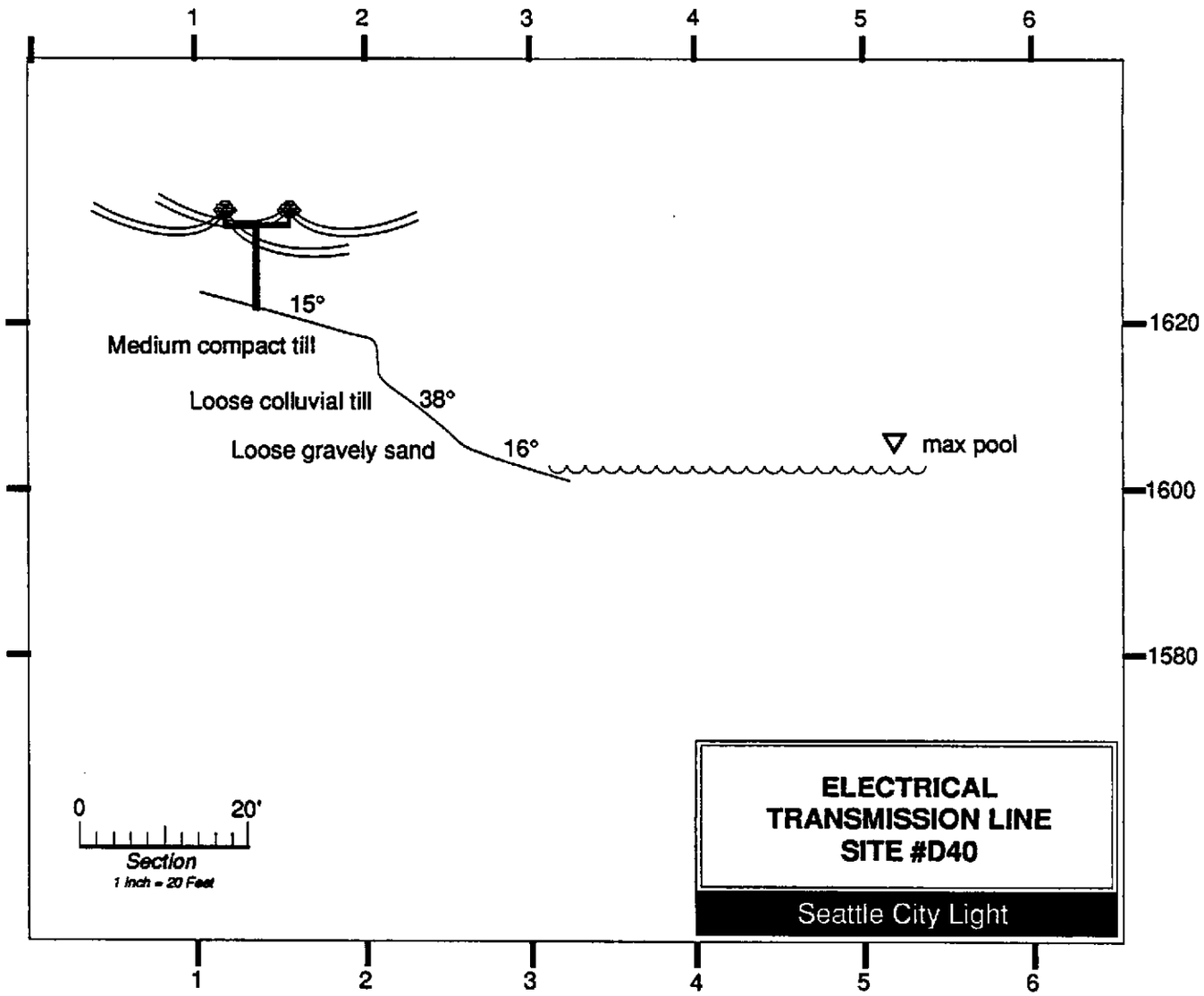


Photo 89 20 11:02 Electrical Transmission Line, Diablo Lake


1
2
3
4
5
6
15°
Medium compact till
Loose colluvial till
38°
Loose gravely sand
16°
max pool
1620
1600
1580
0
20'
Section
1 Inch = 20 Feet
ELECTRICAL
TRANSMISSION LINE
SITE #D40
Seattle City Light

Site Name: Buster Brown Campground
Location #: D-43
Photo #s: JR rolls 24, 25 and 26; 20.11.1 and 20.11.2 (3)
Site Priority: High

Site Conditions:

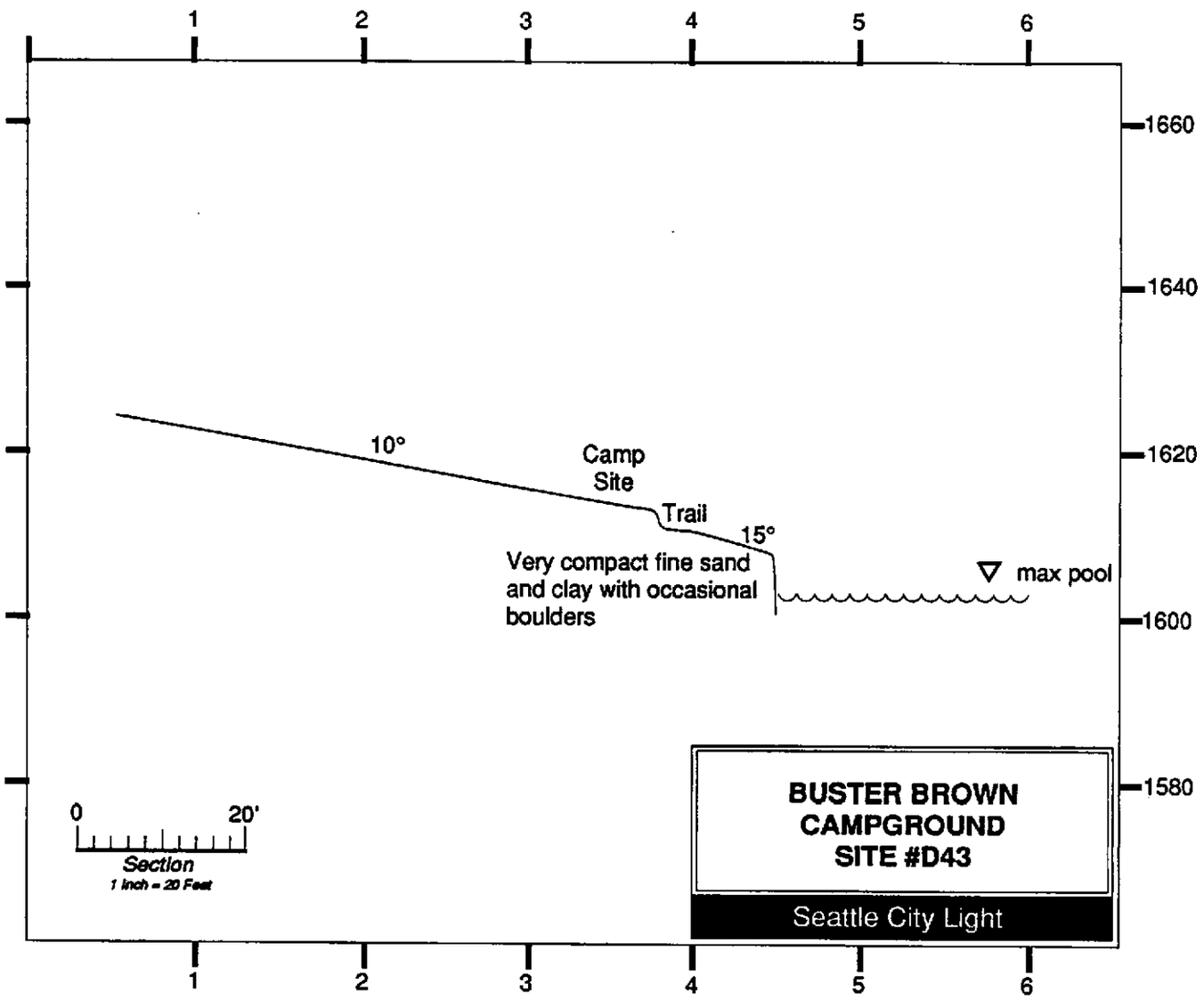
The campground is built on a small bench of very compact sand and lacustrine clay. Lakeshore erosion has created a 7.6-foot-high bluff along a 103-foot length of shore. Vegetation at this site includes Douglas-fir, red alder, vine maple, and big leaf maple.

Projected Impacts:

Continued bank recession threatens the access trail from the dock to the camping area and the camp site nearest the lake.

Erosion Control Measure:

A 100-foot-long, 3.5-foot-tall rock wall will be built at the base of the eroding bluff with 2- to 3-foot-diameter rocks (no local source of material). The area behind the wall will be backfilled with soil filter and vegetated where possible. The rock wall already in place will be reinforced to protect the dock bulkhead. The access trail will be relocated farther upslope, and the area along the eroding shoreline will be vegetated with red paper birch, big leaf maple and vine maple. An access point to the lake will be delineated. Boom logs will be anchored to the dock and bedrock at the base of the eroding bluff.


1
2
3
4
5
6
1660
1640
1620
1600
1580
10°
Camp
Site
Trail
15°
Very compact fine sand
and clay with occasional
boulders
max pool
0
20'
Section
1 inch = 20 Feet
BUSTER BROWN
CAMPGROUND
SITE #D43
Seattle City Light

3.3 CLASS I EROSION SITES

These sites represent locations where bank recession rates are highest and erosion is most severe. At many of these sites, bank recession is punctuated by mass movements of material and complicated by stratigraphic relationships. None of the sites discussed below threaten recreational or unique biological or sensitive resources. Class I sites where these resources are threatened are discussed elsewhere in the Plan.

Because protection measures for Class I sites would involve major structures that both the City and the National Park Service agree would be aesthetically unacceptable in the lake areas, mitigation of erosion at these sites will be generally passive, although active measures are discussed as options at a few sites. Information collected through monitoring at these sites will aid in the design of structures for erosion control at previously discussed sites. Further, the National Park Service, after consultation with and agreement from the City, may initiate active erosion control measures in the future as more is learned about the processes and rates of erosion at Class I sites.

Site Name: CLASS I - ROSS LAKE
Location #: E-7
Photo #s: JH photos 11,12,13 and 14 from 10/5/89
Site Priority: High

Site Conditions:

This area consists of a steep bluff face and several small vegetated slump blocks composed of layered compact sand and cobble deposits bound on either side by coarse, bouldery glacial till and bedrock. A groundwater-eroded cave 3 feet in diameter of unknown length is present 52 feet above the full pool elevation of the reservoir. The lower part of the slope is composed of loose, sandy gravel colluvium. The drawdown area is composed of a cobble lag deposit with a slope of 33 degrees. The slope above the highest slump scarp is 30 degrees for 100 feet. The length of affected shoreline is 70 feet.

Projected Impacts:

Groundwater erosion in the middle of the deposit is precursor to a large failure at the site. By slow retreat or, eventually, a massive failure, the bluff face will continue to retreat at least another 102 feet. An old trail 45 feet above the retreating bluff face is also threatened. The large scar will continue to grow both vertically and laterally as this site merges with site E-7A to the east.

Erosion Control Measure:

Groundwater piping and continued slumping of sediments will be monitored. Bank recession measuring stakes will be installed and the bank profile resurveyed. Photographs will be taken to aid the monitoring.

Site Name: CLASS I - ROSS LAKE
Location #: E-7A
Photo #s: JR rolls 24, 25 and 26
Site Priority: High

Site Conditions:

Large slumps in highly variable glacial till, lacustrine, and outwash deposits occur on the steep bedrock wall of Ruby Creek Canyon. The till is very coarse with many boulders and exhibits varying degrees of compaction. The silt and clay lacustrine sediments are interbedded with the outwash, which varies from well sorted sand to gravel. Slumps appear to be 5 to 30 years old based on the age of red alders growing on its surface. There are two slip faces, indicating that two periods of movement may have occurred. The site is bounded to the east by an eroded gully, and deposits that have a minimum thickness of 40 feet. Groundwater piping and seepage may be a problem (see description of site E-7). The slope above the highest slip face is 15 degrees for 31 feet, and the length of affected shoreline is 261 feet.

Projected Impacts:

Continued erosion at the base of the site will trigger mass movement of material into Ross Lake. The failing deposits continue for at least 31 feet upslope. The scar created by the mass movements is covered with red alder, limiting its visibility from the lake. Considering the groundwater erosion of the site just to the east, the possibility exists for a large mass movement to occur.

Erosion Control Measure:

Erosion at the site will be monitored by periodically surveying the bank and taking photographs and by installing erosion monitoring stakes to measure the bank recession rate.

Site Name: CLASS I - ROSS LAKE
Location #: E-8
Photo #s: JR rolls 24, 25 and 26.
Site Priority: High

Site Conditions:

Massive deposit of compact glacial till stands out as a ridge on the wall of Ruby Creek Canyon. Ground water is seeping out of bluff face. The site is bounded on both sides by gullies eroded into the till, and on the other side of the gullies by bedrock. Slope above the bluff is 30 degrees for 339 feet, and the length of affected shoreline is 68 feet.

Projected Impacts:

The bluff face will continue to retreat upslope at least another 40 feet, threatening vegetation. There are no facilities in the area.

Erosion Control Measure:

Erosion at the site will be monitored by periodically surveying the bank and taking photographs and by installing erosion monitoring stakes to measure the bank recession rate.

Site Name: CLASS I - ROSS LAKE
Location #: E-9
Photo #s: JR rolls 24, 25 and 26.
Site Priority: High

Site Conditions:

A large debris slide is visible from the Ross Lake Resort. The bluff face has retreated 157 feet above the full pool elevation of the reservoir. This slide has formed into a massive deposit of well-stratified, loose glacial outwash composed of sand and gravel that consists of two separate slides. These deposits persist for over 600 feet upslope as a narrowing ridge that was created by the erosion of two small, ephemeral streams. The drawdown area below the site is very steep and composed of glacial till and lacustrine deposits, which complicate groundwater movement and could act as a plane for further slope failure. The slope above the bluff face is 18 to 31 degrees, and the length of affected shore is 284 feet.

Projected Impacts:

The two slides will grow together and the bluff face will continue to move upslope, thereby enlarging the scar already visible from the Ross Lake Resort and possibly threatening an old trail 190 feet above the modern bluff face. State highway 20 is located 1,000 feet upslope and does not appear threatened by erosion at this site.

Erosion Control Measure:

Vegetation of the colluvial slope below the eroding bluff face will be attempted to reduce its visual impact and stabilize its surface. Erosion at the site will be monitored by periodically measuring and photographing bank profiles and by installing stakes to estimate the rate of bank recession.

Site Name: CLASS I - ROSS LAKE
Location #: E-13
Photo #s: JR rolls 24, 25 and 26.
Site Priority: High

Site Conditions:

A ridge of till and outwash has eroded into a bluff face west of Lillian Creek. The eroding stretch of shore is bounded on both sides by gullies that have eroded into the deposits. The slope above the bluff face is 25 degrees for at least 18 feet and the length of affected shoreline is 40 feet.

Projected Impacts:

The bluff face will continue to retreat at least another 18 feet, causing the loss of vegetation and expanding the existing scar.

Erosion Control Measure:

Erosion at the site will be monitored by periodically surveying the bank and taking photographs and by installing erosion monitoring stakes to measure the bank recession rate.

Site Name: CLASS I (ROSS LAKE)
Location #: E-55
Photo #s: JR rolls 24, 25 and 26
Site Priority: High

Site Conditions:

Two 15-foot bluffs have developed in massive lacustrine deposits capped by over 5 feet of glacial till. The deposits consist of alternating layers of very compact clay and silt and well sorted sand and gravel outwash. Groundwater seeps out of these deposits complicating bank recession.

Projected Impacts:

The two bluffs at this site will eventually grow together expanding the scar already visible as one approaches Rainbow Point Camp. Large Douglas-firs on the slope above the site will continue to fall into the lake. The slope above the bluff face is 18 degrees for at least 10 feet, and the length of the affected shore is 500 feet.

Erosion Control Measure:

Recession at the site will be monitored by periodically surveying and photographing bank profiles and by installation and measurement of bank recession stakes.

Site Name: CLASS I - ROSS LAKE
Location #: E-63
Photo #s: See JR's rolls 24, 25 and 26
Site Priority: High

Site Conditions:

Material in this area consists of a thick accumulation of very compact glacial till over very compact, well-sorted sand outwash. A small slump has recently occurred in these deposits.

Projected Impacts:

Continued bank recession of the eroding bluff face upslope to the south east is apparently threatening the nearby East Bank Trail. The site is not located near any camp area.

Erosion Control Measure:

Erosion at the site will be monitored by periodically surveying the bank and taking photographs and by installing erosion monitoring stakes to measure the bank recession rate.

Site Name: CLASS I - ROSS LAKE
Location #: E-76
Photo #s: JR rolls 24, 25 and 26.
Site Priority: High

Site Conditions:

This site occurs on a south facing, 21.5-foot bluff in a small cove north of Devil's Creek. Material in this area is 6.5 feet of very compact lacustrine deposits overlain by 15 feet of loose to compact, well sorted sand and gravel. Angular clasts are found scattered throughout the upper outwash deposit. The length of the affected shoreline is 319 feet. The north edge of this site is bedrock and at the south end slopes into a small gully.

Projected Impacts:

The shoreline will continue to retreat into the thick accumulation of sediments. Loose sand and gravel may fail because the impermeable lacustrine deposits could allow the buildup of excess groundwater pressure, leading to a larger slope failure. The East Bank Trail is located upslope but is not immediately threatened.

Erosion Control Measure:

Erosion at the site will be monitored by periodically surveying the bank and taking photographs and by installing erosion monitoring stakes to measure the bank recession rate.

Site Name: CLASS I - ROSS LAKE
Location #: W-22
Photo #s: JR rolls 24, 25 and 26
Site Priority: High

Site Conditions:

The bluff in this area has formed in a ridge of variable glacial till and outwash with gullies on either side. The outwash consists of lenses of well-sorted sand and masses of poorly sorted gravel with boulders. Till consists of slightly compact gravel and boulders. The drawdown zone below this bluff is composed of loose sand, gravel and bouldery colluvium, and the slope above the bluff face varies from 21 to 38 degrees. Total affected shore at this site is 100 feet.

Projected Impacts:

The bluff will continue to recede at least another 100 feet, resulting in the loss of large Douglas-fir and hemlock and the perpetuation of a large scar on the valley wall.

Erosion Control Measure:

Erosion at the site will be monitored by periodically surveying the bank and taking photographs and by installing erosion monitoring stakes to measure the bank recession rate.

Site Name: CLASS I - ROSS LAKE
Location #: W-23
Photo #s: JR rolls 24, 25 and 26
Site Priority: High

Site Conditions:

Two 10-foot tall bluffs have formed at this site in a highly variable outwash and till deposit that ranges from lenses of well-sorted sand to masses of poorly sorted sand, gravel and boulders. The westernmost bluff has recently failed, resulting in the loss of a large Douglas-fir. Total length of the affected shore at this site is 111 feet.

Projected Impacts:

Continued bank recession will claim more land. It is not clear how much farther back this bluff will erode, but the deposit runs at least 36 feet upslope.

Erosion Control Measure:

Erosion at the site will be monitored by periodically surveying the bank and taking photographs and by installing erosion monitoring stakes to measure the bank recession rate.

Site Name: CLASS I - ROSS LAKE
Location #: W-31
Photo #s: JR rolls 24, 25 26, and 20.14.04
Site Priority: High

Site Conditions:

This site consists of two 40-foot bluffs created by debris slides in loose, bouldery till and colluvium over bedrock. Total length of the affected shore is 83 feet.

Projected Impacts:

The bluff face at this site will continue to retreat upslope toward Big Beaver Trail, although the trail is not in immediate danger. Debris slide will continue to be active, resulting in loss of several large Douglas-firs and enlarging the large scar already present.

Erosion Control Measure:

Erosion at the site will be monitored by periodically surveying the bank and taking photographs and by installing erosion monitoring stakes to measure the bank recession rate.

Site Name: CLASS I - ROSS LAKE
Location #: W-32
Photo #s: JR rolls 24, 25, and 26
Site Priority: High

Site Conditions:

This site consists of over 6.2 feet of coarse, loose outwash composed of boulders, sand, and gravel that were deposited on a bedrock bench and are failing into Pierce Creek Canyon. Sandier outwash to the north has also eroded into a bluff. The drawdown area below the bluff is colluvium of the same material as the bluff. Total length of the affected shore is 159 feet.

Projected Impacts:

Continued bank recession will not threaten any existing facilities, but the eroding bluff face has a large scar. Bluffs will continue to erode an estimated 30 feet farther inland, where the deposit diminishes in a topographic low.

Erosion Control Measure:

Erosion at the site will be monitored by periodically surveying the bank and taking photographs and by installing erosion monitoring stakes to measure the bank recession rate.

Site Name: CLASS I - ROSS LAKE
Location #: W-63
Photo #s: JR rolls 24, 25, and 26.
Site Priority: High

Site Conditions:

This site includes 12 bluffs of very compact till from 10 to 15 feet thick over bedrock or very compact lacustrine sediments with a minimum thickness of 4 feet.

Projected Impacts:

No recreational sites are threatened in this area, but bluffs are visible from considerable distance. Continued recession will occur well upslope in the thick deposits, resulting in the loss of several large Douglas-firs. Continued bank recession will result in small slumps in the till and lacustrine sediments. There is the possibility of a larger slope failure.

Erosion Control Measure:

Erosion at the site will be monitored by periodically surveying the bank and taking photographs and by installing erosion monitoring stakes to measure the bank recession rate.

Site Name: CLASS I - ROSS LAKE
Location #: W-71
Photo #s: JR rolls 24, 25 and 26.
Site Priority: High

Site Conditions:

Four individual bluffs from 8 to 20 feet high divided by gullies occur at this site. The material is colluvium and ancient landslide consisting of angular clasts in a silty sand matrix. The area in a drawdown below the bluff is composed of gravelly colluvium.

Projected Impacts:

The area is visible from the other side of the lake but does not constitute a threat to any facility. The ancient landslide deposits appear to be stable and should not become active in the near future with current rates of shoreline erosion. Considering the thickness of the deposits, erosion in this area may continue well inland, resulting in continued loss of land.

Erosion Control Measure:

Erosion at the site will be monitored by periodically surveying the bank and taking photographs and by installing erosion monitoring stakes to measure the bank recession rate.

Site Name: CLASS I - ROSS LAKE
Location #: W-72
Photo #s: JR rolls 24, 25 and 26.
Site Priority: High

Site Conditions:

This site consists of a silt- to boulder-sized colluvium accumulation in a bedrock gully. A large, shallow, planar debris slide has occurred in this area, with a total displaced volume of 18,000 cubic yards. Some red alder has begun to colonize the slide surface. The length of the affected shoreline in this area is 56 feet, and the area below the shore bluff consists of angular boulders of local lithology.

Projected Impacts:

The slide in this area is a visual scar that will continue to grow until it reaches bedrock but is not near any campground or other area of concentrated human use. Vegetation will continue to be lost and sediment eroded into the lake.

Erosion Control Measure:

Erosion at the site will be monitored by periodically surveying the bank and taking photographs and by installing erosion monitoring stakes to measure the bank recession rate.

Site Name: CLASS I - ROSS LAKE
Location #: W-135
Photo #s: JR rolls 24, 25 and 26.
Site Priority: High

Site Conditions:

The shoreline in this area is composed of 14.4 feet of extremely compact sand, silt, and clay with a varying thickness of looser outwash and glacial till on top. Gullies that have cut into this material have created three actively retreating bluffs. In addition, groundwater seeps out of the fine deposits, although there is no evidence of groundwater piping. The beach below the site is composed of eroded masses of the silt, sand, clay, and gravel, as well as igneous and metamorphic boulders. Waves have undercut the slope 5-6 feet, and the total length of the affected shore is 396 feet.

Projected Impacts:

The shoreline will continue to retreat causing loss of vegetation, and threatening an old trail 70 feet upslope. Steep slopes, groundwater activity associated with the impermeable silt and clay sediments, and continued undercutting of the bank may result in a large (100,000+ ft^3) slope failure at this site.

Erosion Control Measure:

A rock wall will be constructed with 2- to 3-foot rock; it will be backfilled with soil filter at the base of the eroding bluffs to stop continued bank undercutting and recession. The wall will consist of three segments with a total length of 600 feet and a height of 3- to 4-feet. The area behind the wall will be vegetated; however, the bluff face is too steep and compact for vegetation.

Erosion at the site will be monitored by annually surveying the bank and taking photographs and by installing erosion monitoring stakes to measure the bank recession rate.

Site Name: CLASS I - DIABLO LAKE
Location #: D-8
Photo #s: JR rolls 24, 25 and 26.
Site Priority: High

Site Conditions:

This site consists of 10- to 20-year old slumps in glacial till, each approximately 1,150 cubic feet in volume along a 67-foot-long shore. Vegetation in this area is mainly large Douglas-fir and vine maple.

Projected Impacts:

Continued bank recession and slumps will threaten large Douglas-firs at this site.

Erosion Control Measure:

A rock wall will be constructed for 67 feet along the shore with 2 to 3 feet of rock. The wall will be backfilled with soil filter. The area behind the wall will be vegetated. Erosion at the site will be monitored by periodically surveying the bank and taking photographs and by installing erosion monitoring stakes to measure the bank recession rate.

Site Name: CLASS I (DIABLO LAKE)
Location #: D-44
Photo #s:
Site Priority: High

Site Conditions:

A large slump has occurred in loose glacial till along a steep slope, affecting 150 feet of shoreline at this site. Several older slump scars are also visible at the site.

Projected Impacts:

Continued wave undercutting of the bank will lead to more slumps and the disturbance of vegetation.

Erosion Control Measure:

Erosion at the site will be monitored by periodically surveying the bank and taking photographs and by installing erosion monitoring stakes to measure the bank recession rate.

Site Name: CLASS I - GORGE LAKE
Location #: G-8, G-9, and G-10
Site Priority: High

Site Conditions:

Three debris slides of different age have developed in loose colluvium and glacial till along 312 feet of shoreline at this site.

Projected Impacts:

The three slides will coalesce, thereby increasing the scar that is already visible from the lake and resulting in loss of vegetation from the slope above.

Erosion Control Measure:

Erosion at the site will be monitored by periodically surveying the bank and taking photographs and by installing erosion monitoring stakes to measure the bank recession rate.

3.4 BIOLOGICAL SITES

As additional information becomes available regarding sensitive species or rare habitat, new sites may be identified in accordance with Section 11.0 of the Settlement Agreement. At the present time only one of three osprey nesting trees along Ross Lake could eventually be endangered by erosion. Several other areas along the reservoirs were also examined. Mature old-growth forests are being lost to erosion at Rainbow Point (site E-56), Devil's Junction (E-80), and Boundary Bay Camp (E-181). Active mitigation measures to protect old Douglas-fir trees at these sites will be implemented as described in the earlier discussions of these sites. An old-growth stand near McMillan campground (site E-40) is not threatened by erosion since the shoreline faces north (away from prevailing winds) and has a low slope.

Site Name: Osprey Nesting Tree
Site #: B-1
Photo #s:
Site Priority: High

Site Conditions:

Nesting tree is 5 feet above the high reservoir level along a valley wall on the west shore of Ross Lake south of Big Beaver. Erosion of the shore below the tree is minor and does not directly threaten the tree.

Projected Impacts:

At the present time the site is not threatened by shoreline erosion.

Erosion Control Measure:

Erosion at the site will be monitored annually during the fall or winter but not during the nesting season in the spring and summer. If rapid erosion is noted, the National Park Service will develop an erosion control plan and implement any required emergency control measures immediately after consultation with the City.

3.5 ROAD EROSION SITES

The road system used for access to the powerline corridor and other Project facilities has several erosion problems. The roads located at the west end of the study area between Bacon and Damnation creeks are built in an area of steep unstable slopes. Groundwater seeps have been observed in several locations and State Highway Route 20 (SR 20) is cut into the toe of these slopes, complicating slope instability problems. A debris slide occurred in this area during the winter of 1989-90. Mitigation measures for this site are included in this Plan (site R-17). Some of the Project area roads are close to SR 20 which is maintained by the Washington State Department of Transportation (DOT). At Project road sites near SR 20 where erosion control work will be done, the City and the National Park Service will consult with DOT when possible before undertaking remedial efforts.

Because of the naturally unstable conditions of slopes in this area, the National Park Service will survey Project roads for potential erosion problems at least once a year. The active erosion control measures given below deal with small erosion problems associated with the roads.

Road Location: Ross Guard Station Access Road (Location A, Figure 3-2)
Site #: R-1
Photo #s: 5.10.51 - 5.10.52
Site Priority: High

Site Conditions:

Site occurs where the haul road cuts a steep bedrock slope. A 40-foot-long log buried on the downslope side of the road was placed to support the outer edge of the road and keep it from failing into the lake. The road fill material is sliding under the exposed middle of the log and falling into the lake below, which has created a 6-foot by 2-foot hole along the edge of the road.

Projected Impacts:

Continued erosion of the road fill will enlarge the hole and expose more of the log, which will eventually fall into the lake.

Erosion Control Measure:

A gabion or other type of protective wall will be built on the edge of the road. Side casting of material will be ceased, and the City will follow the general road erosion control guidelines.

Road Location: Ross Dam Access Road (Location A, Figure 3-2)
Site #: R-2
Photo #s:
Site Priority: Medium

Site Conditions:

The site is located on the Ross Lake end of the haul road, where the faces of several unvegetated roadcuts on a steep slopes of colluvium and bedrock are eroding by surface runoff and small mass failures. The base of several of the slopes are now protected by gabions to prevent sediment eroded from these slopes from getting on the road.

Projected Impacts:

Continued ravelling of the unvegetated roadcuts will continue to erode the already thin colluvial soil from the slopes, exposing bedrock and leaving large scars visible from the lake. Rocks and other debris will also continue to fall onto the roads.

Erosion Control Measure:

An attempt will be made to stabilize surficial deposits through aggressive vegetation of the slopes with brushlayers and live stakes. Trees will be planted along the base of the slope to create a visual barrier. The slope will need to be watered frequently during the first few years of vegetation to encourage plant growth since the soils here are thin.

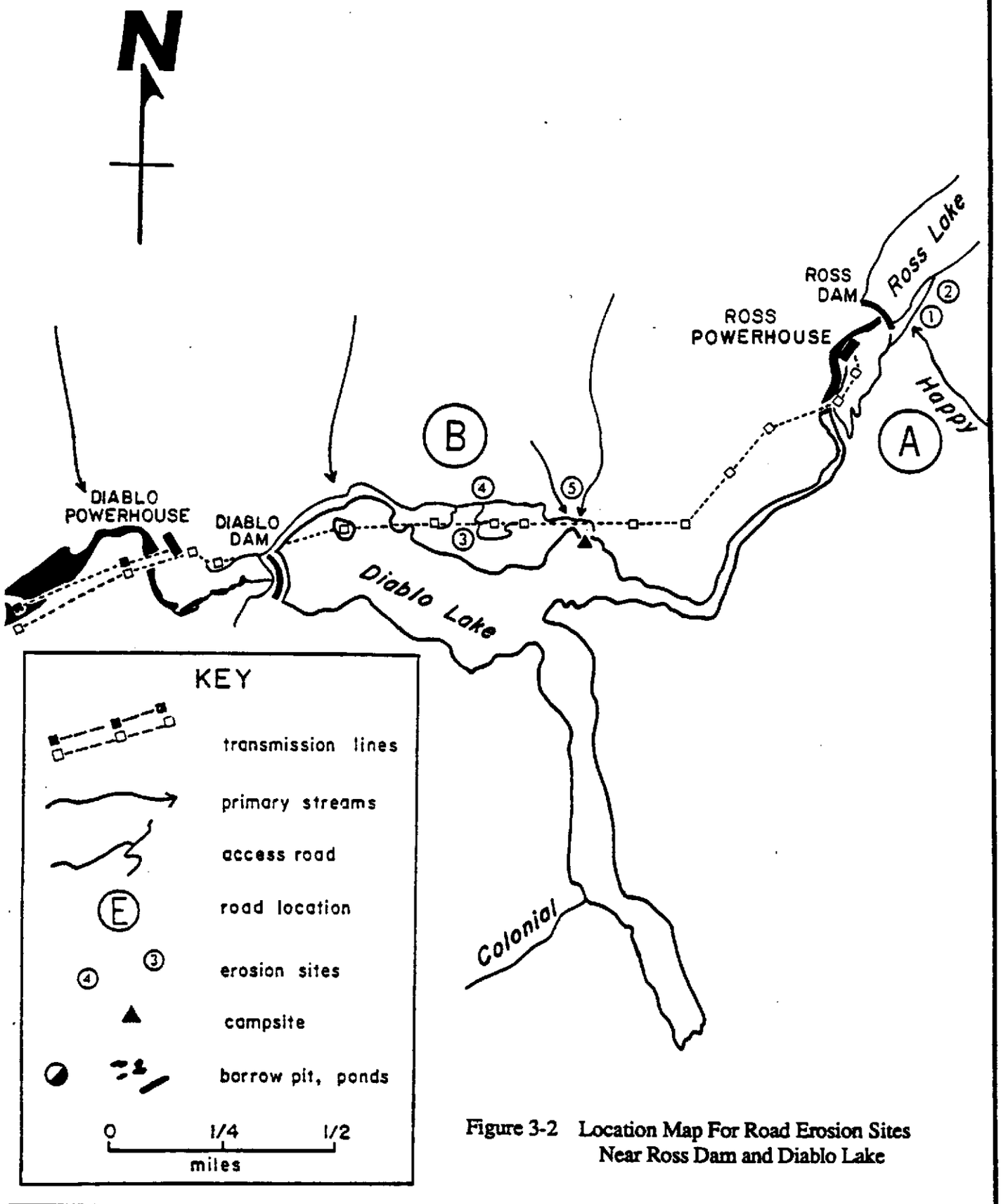


Figure 3-2 Location Map For Road Erosion Sites Near Ross Dam and Diablo Lake

Road Location: Buster Brown Roads (Location B, Figure 3-2)
Site #: R-3
Photo #s:
Site Priority: Low

Site Conditions:

Site located on steep glacially scoured bedrock hills with patches of till and colluvium. Several steep, short sections of the road near the tops of the bluffs are subject to gullying during heavy rains.

Projected Impacts:

Continued gullying of the road segments will result in the need for additional road fill material. The fill material is not carried far from the road and is not reaching any streams.

Erosion Control Measure:

Small water bars will be installed at intervals on the roads (Figure 2-7) to disperse water and prevent growth of the gullies and erosion of the road fill. Dispersing water where it could cause erosion or additional fill damage will be avoided.

Road Location: Buster Brown Roads (Location B, Figure 3-2)
Site #: R-4
Photo #s:
Site Priority: Medium

Site Conditions:

Above the junction of two roads in the Buster Brown area, the road bed and underlying till are eroding below the end of a ditch that runs along the upper end of the road.

Projected Impacts:

Continued erosion below the end of the ditch will cause the removal of road fill and bed material and deposition on the road and slope below.

Erosion Control Measure:

The ditch will be extended down to the end of the road. A culvert and water bar, or just a water bar, will be placed to direct the water under or away from the lower, intersecting road.

Road Location: Buster Brown Roads (Location B, Figure 3-2)
Site #: R-5
Photo #s:
Site Priority: High

Site Conditions:

Several drainage problems exist near the east end of the road system where the road crosses three small streams. Culverts direct two of the streams under the road, but the lowermost stream flows across the road. Ditches along the upslope side of the road between the streams are not long enough to carry water to the next stream downslope, so that water flows from the end of the ditches onto the road.

Projected Impacts:

- Continued drainage of the lowermost stream and drainage on the road below the ditches will result in erosion of the road and its substrate of clayey till. The road will continue to be seasonally flooded and some of the eroded sediment could reach Diablo Lake.

Erosion Control Measure:

Water bars will be installed at the 3 water crossings in the area.

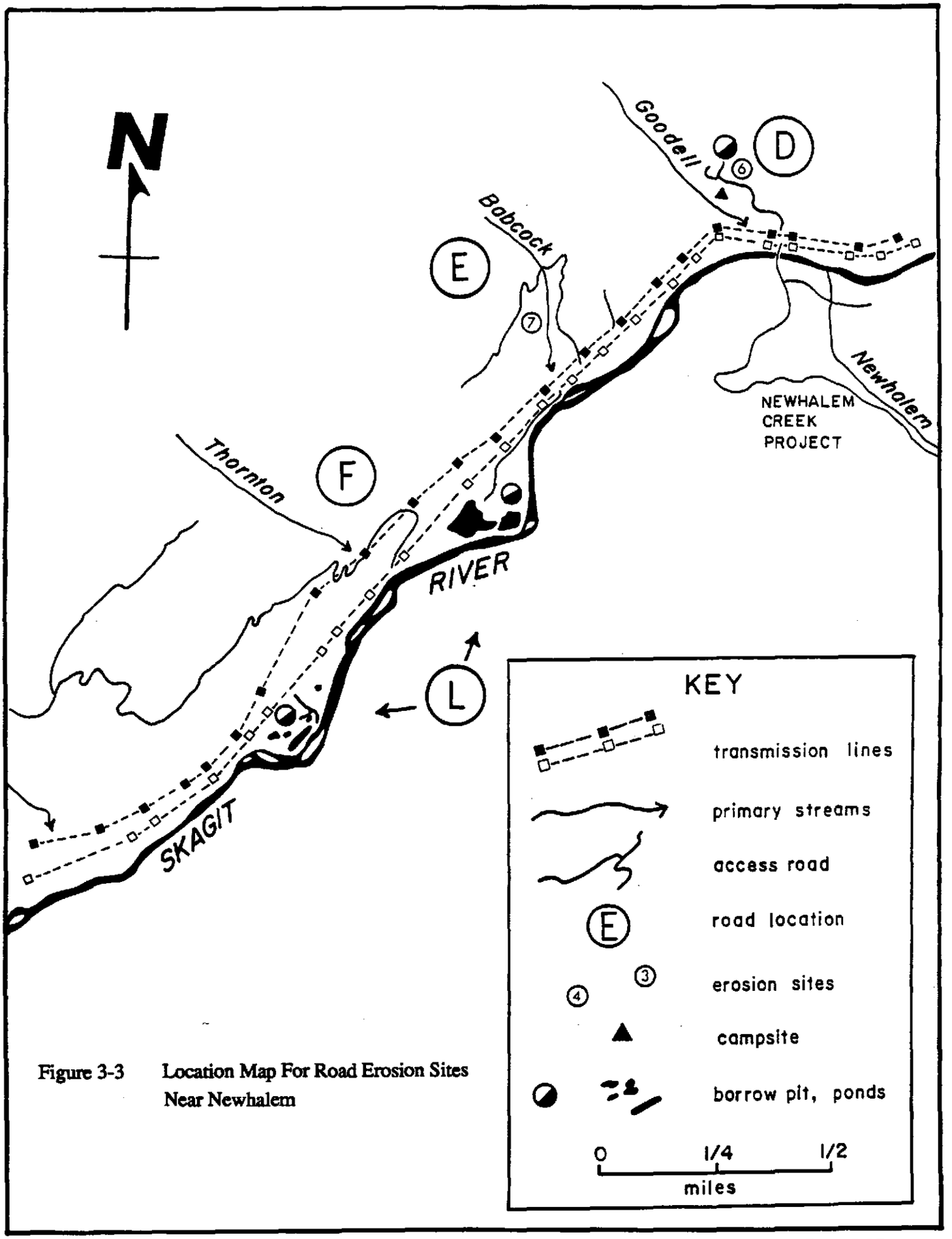


Figure 3-3 Location Map For Road Erosion Sites Near Newhalem

Road Location: Babcock Creek Road (Location E, Figure 3-3)
Site #: R-7
Photo #s:
Site Priority: Low

Site Conditions:

The Babcock Creek road runs from SR20 across a Skagit River terrace, cuts across the Babcock Creek alluvial fan and extends along the steep valley wall upslope to the west. Where the creek cuts across the alluvial fan there are occasional washouts of the road. The road is now protected by a dike.

Projected Impacts:

Continued migration of Babcock Creek will threaten different parts of the road.

Erosion Control Measure:

The area of the alluvial fan will be monitored to determine where future problems between the creek and road might develop. If monitoring reveals that the creek is encroaching on the upper road, a stabilization plan will be developed for the road.

Road Location: Shovel Spur Road (Location H, Figure 3-4).
Site #: R-8
Photo #s:
Site Priority: High

Site Conditions:

The Shovel Spur road runs from SR20 up steep slopes along a valley wall, crossing a perennial stream. Between SR20 and the first road crossing over the stream several erosion problems have developed.

R-8A. The stream has undercut part of the road at its lower end.

R-8B. The road interrupts the drainage of several small intermittent streams, which presently drain down to SR20 along a small ditch on the upslope side of the road. Once at the bottom, the water can not drain to the Skagit River and is trapped between the highway and the valley wall.

R-8C. At the crossing of the road and the creek, the creek flows under the road in a small culvert that is occasionally plugged or is too small to carry the discharge of the stream. During these events water from the creek flows down the road, depositing eroded material on SR20.

Projected Impacts:

Continued erosion of the road bed presents a recurring maintenance problem and poses a possible safety hazard for SR20 should water or sediment or both end up on the highway.

Erosion Control Measure:

R-8A. The edge of the road will be protected with a 3-foot-high by 20- to 30-foot-long wall using 2-foot-diameter rocks. The area behind the wall will be backfilled with soil filter or filter fabric and vegetated with live stakes or rooting brush. Side casting of road material from the surface of the road down to the slope below will be ceased in order to keep the slope vegetated.

R-8B. The ditch on the upslope side of the road will be deepened and extended for about 40 feet. (In the fall of 1990, the City placed a culvert under the road where it leaves SR20 to allow drainage of this water to the larger creek under SR20.)

R-8C. A larger culvert with a grade dip will be installed so water will flow over the road bed back into the channel when the culvert fails. This will damage the road fill the first time the culvert fails if an armor of cobble size rock is not utilized in the road subgrade. Road surface rock will be placed over the armor layer and a culvert water bar installed.

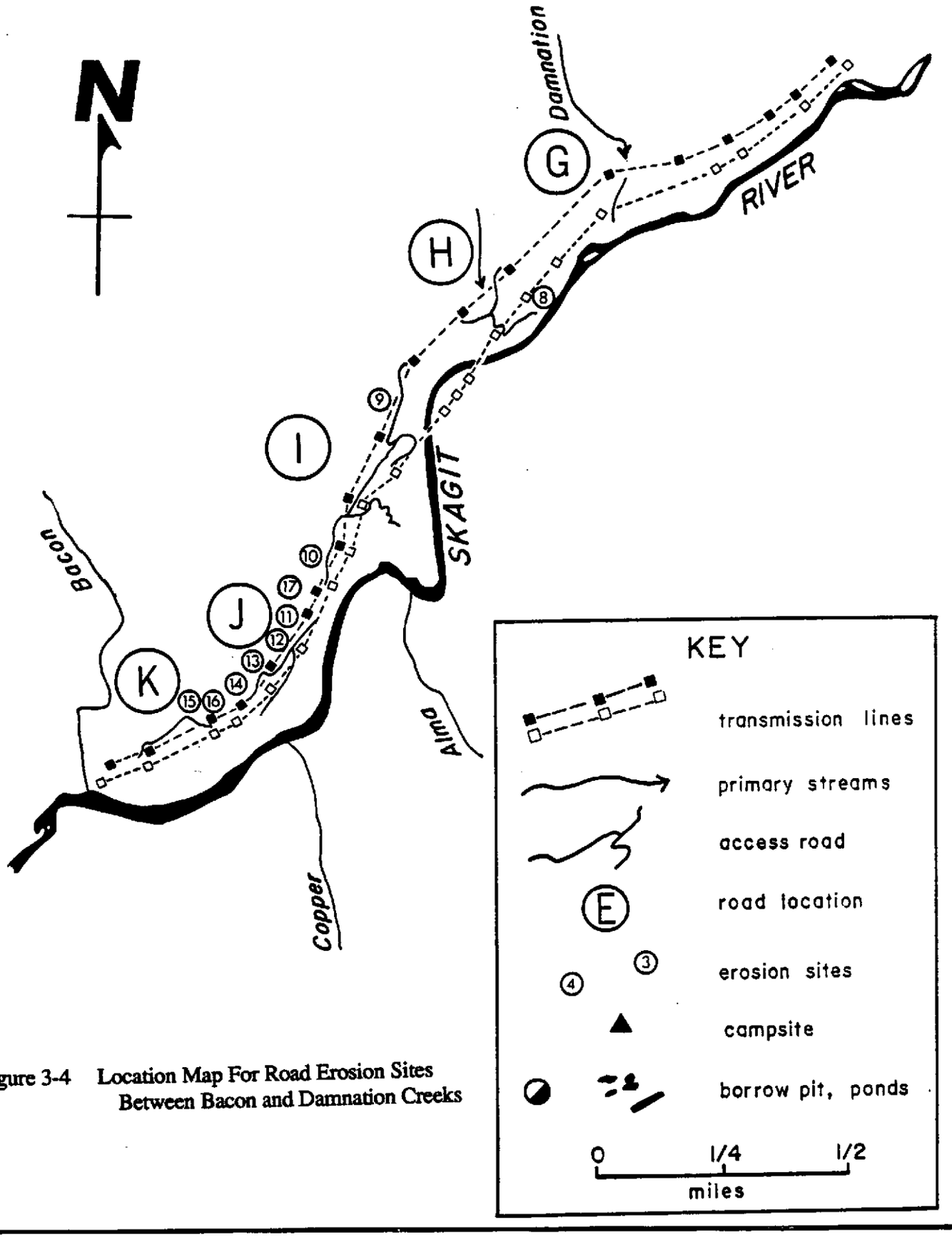


Figure 3-4 Location Map For Road Erosion Sites Between Bacon and Damnation Creeks

Road Location: Pinkies Road (Location I, Figure 3-4)
Site #: R-9
Photo #s:
Site Priority: Medium

Site Conditions:

The Pinkies road system runs across hummocky landslide deposits and very steep valley walls. At the northeast end of the road system the road cuts across a very steep slope before terminating near a transmission tower on the top of a small hill. The roadcut into the slope has created a 20-foot-high escarpment. The face of the escarpment is nearly vertical and subject to small failures of colluvium and landslide deposits off of its upper edge.

Projected Impacts:

Continued small failures of rock and soil at the top edge of the roadcut will keep vegetation from stabilizing the site and result in a minor hazard for the road below.

Erosion Control Measure:

Aggressive vegetation of the slope will be done to stabilize surficial deposits. The slope will be watered frequently during the first few years of vegetation to encourage plant growth since soils are thin. Vegetation will be done so as to be compatible with the vegetation management plan for the powerline corridor. Side casting of material will be ceased.

Road Location: Pinkies Road (Location I, Figure 3-4)
Site #: R-10
Photo #s:
Site Priority: Medium

Site Conditions:

At the southwest end of the road system the road interrupts the drainage of several small streams, which flow along the upslope side, across and below the road.

Projected Impacts:

The steepness of the slopes below the road, combined with the water problems, could lead to a slope failure.

Erosion Control Measure:

Three culverts with water bars will be installed along the road to allow drainage to the slope below. The outlets of the culverts will be rocked if erosion of the road or slope soils could occur.

Road Location: Benches Road (Location J, Figure 3-4)
Site #: R-11
Photo #s:
Site Priority: High

Site Conditions:

The northeast end of the road system terminates 200 feet to the west of a small slump in landslide sediments. The upper slip face of the slump mass appears to continue as a crack along the slope toward the road segment, which cuts across a 60 degree slope. An abandoned section of the road switchbacks above the unstable area.

Projected Impacts:

Continued failure of the slope above the road will ultimately threaten the road.

Erosion Control Measure:

The condition of the unstable slope will be monitored. Exposed soil will be vegetated.

Road Location: Benches Road (Location J, Figure 3-4)
Site #: R-12
Photo #s:
Site Priority: Medium

Site Conditions:

Site 12 is located below the southwest fork of the road near where the road leaves the terrace. The road crosses over a stream, where water discharged from the culvert onto the steep slope below is causing the growth of a slope failure below the road.

Projected Impacts:

Continued growth of the debris slide will enlarge the existing scar and may threaten the road above.

Erosion Control Measure:

Either the culvert below the road will be extended or the channel will be rocked to reduce erosion.

Road Location: Benches Road (Location J, Figure 3-4)
Site #: R-13
Photo #s:
Site Priority: Low

Site Conditions:

Up the road from site R-12 the drainage of several small streams is interrupted by the road. The streams are eroding the road fill material.

Projected Impacts:

Continued drainage of the streams along the road will result in the need for more road fill.

Erosion Control Measure:

Road water bars will be placed at all minor drainages to break up the drainage on the road and prevent erosion of the road fill.

Road Location: Benches Road (Location J, Figure 3-4)
Site #: R-14
Photo #'s:
Site Priority: Medium

Site Conditions:

At SW end of Benches Road System several groundwater seeps create surface water erosion problems on the road.

Projected Impacts:

Continued erosion of road fill and possible slope failure should ground become saturated.

Erosion Control Measure:

A ditch will be placed on the upslope side of the road to intercept stream drainage and move water off of the landing. Road fill slopes will be planted with brush, live stakes, and grass seed.

Road Location: Hardin Road (Location K, Figure 3-4)
Site #: R-15
Photo #s:
Site Priority: High

Site Conditions:

At its upper end Hardin road cuts across a steep slope before terminating at a transmission tower. About 300 feet before its terminus approximately 120 feet of the road is threatened by a slope failure. An 80-foot crack has developed in the middle of the road and the outside half of the road has begun to slump downslope.

Projected Impacts:

The affected length of road will eventually fail down the steep slope, possibly incorporating some non-road fill sediment and creating a larger instability problem.

Erosion Control Measure:

Drainage along the road will be improved, and the road segment that is failing will be rebuilt. The failing road fill will be excavated out and reconstructed with compacted fill with live brush layers.

Road Location: Hardin Road (Location K, Figure 3-4)
Site #: R-16
Photo #s:
Site Priority: Medium

Site Conditions:

At the end of the road the face of a roadcut is steep and unvegetated. Small failures of rock and colluvium are occurring off the top of the roadcut.

Projected Impacts:

The roadcut will continue to fail, resulting in a scar on the hillside.

Erosion Control Measure:

An attempt will be made to stabilize surficial deposits through aggressive vegetation of the slope. The slope will be watered frequently during the first few years of vegetation to encourage plant growth since soils are thin and the slope is steep. Vegetation will be done so as to be compatible with the vegetation management plan for the powerline corridor.

Road Location: Hardin Road (between Locations I and J, Figure 3-4)
Site #: R-17
Photo #s:
Site Priority: High

Site Conditions:

Heavy rains during the winter of 1989-90 (especially those around December 5, 1989) caused a mass of colluvium and residual soil to break loose from beneath the transmission line corridor. The debris traveled down a 40-degree slope and split before crossing SR 20 and dumping into the Skagit River. It destroyed a transmission line maintenance road connecting Pinkies to Benches Road. The slide was stable through the rest of the winter and is being reoccupied by vegetation. It was active again, however, during heavy rains in November, 1990. Other slides of similar volume and nature have occurred during the past in the immediate vicinity.

Projected Impacts:

Erosion of the unvegetated surface of the slide by rilling and ravelling will continue to carry debris onto SR 20 and into the Skagit River. A portion of the maintenance road destroyed by the slide may also fail. This slide area has been aggravated by the road cutslopes of the SCL transmission line access road and by the cutslope and ditches of State Route 20.

Erosion Control Measure:

The bare surface of the slide will be aggressively vegetated and monitored closely for continued slope failure, especially during the rainy season. The Washington State Department of Transportation will be consulted about the establishment of a spoil site where material cleaned from the SR 20 road ditch can be stockpiled, mulched, and vegetated.

Slide material that accumulates on State Route 20 should not be pushed into the Skagit River.

3.6 SKAGIT RIVER

The size and supply of sediment being moved down the river is an important feature of a river environment. In the case of the Skagit River, availability of gravel directly influences fisheries and indirectly affects other components of the ecosystem such as bald eagles. The supply of sediment and flood peaks below the Skagit River Project have been reduced. General observations along the Skagit River indicate the Project may have increased stability of the channel in the Project area, although this issue was addressed only qualitatively due to a lack of baseline data (Riedel, 1990). Reduced flood peaks may explain the apparent stability of the channel, and sediment supply from tributary creeks or channel armoring by these creeks may explain the lack of channel degradation in the Project reach. Thus, there do not appear to be any erosion problems along the Skagit River in the Project area, and erosion control measures are not currently needed along the Skagit River in the Project area.

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APPENDIX A

Bank Recession Rate Calculation Methods

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Bank Recession Rate Calculation Methods

Estimates of bank recession rates are important in attempts to assess the severity of erosion problems, and in determining the nature of erosion control techniques which are needed at any particular site. In cases where it is possible to identify past bank positions of known age, bank recession rates can be calculated precisely. For example, many of the reservoir boat camps have concrete bulkheads which were initially poured flush with the bank. Knowing the date of bulkhead emplacement, the distance between the front of the bulkhead and the current bank can be used to calculate average bank recession rates. In many cases there is no reliable control for erosion rate calculations, and less accurate methods must be used.

Making certain initial assumptions, an estimate of reservoir bank recession rates can be made from measurements of current bank topography and a knowledge of past full pool elevations:

For each site, the bluff height, beach angle and the angle of the slope leading down to the shore is known from field measurements. It is also known that the full pool elevation was about 1,602.5 feet from 1968 to present and 1,600 feet from 1952 - 1967.

APPROACH

Extrapolate the slope leading down to the shore beyond the bluff to intersect the current full pool elevation; this provides a first estimate of the amount of bank recession since 1968 (see Figure A-1). It is known that for the period 1952 - 1967 the full pool elevation was up to 1600 feet, i.e, 2 feet below the current full pool elevation. Therefore, the method outlined above and in Figure A-1 is inaccurate for situations in which the bluff height in 1967 was greater than 2 feet, and in such cases the method provides an overestimate for the amount of recession since 1968, and therefore exaggerates the recession rates. For shoreline protection design purposes it is preferable to have some slight overestimate of rates of recession rather than no estimates at all.

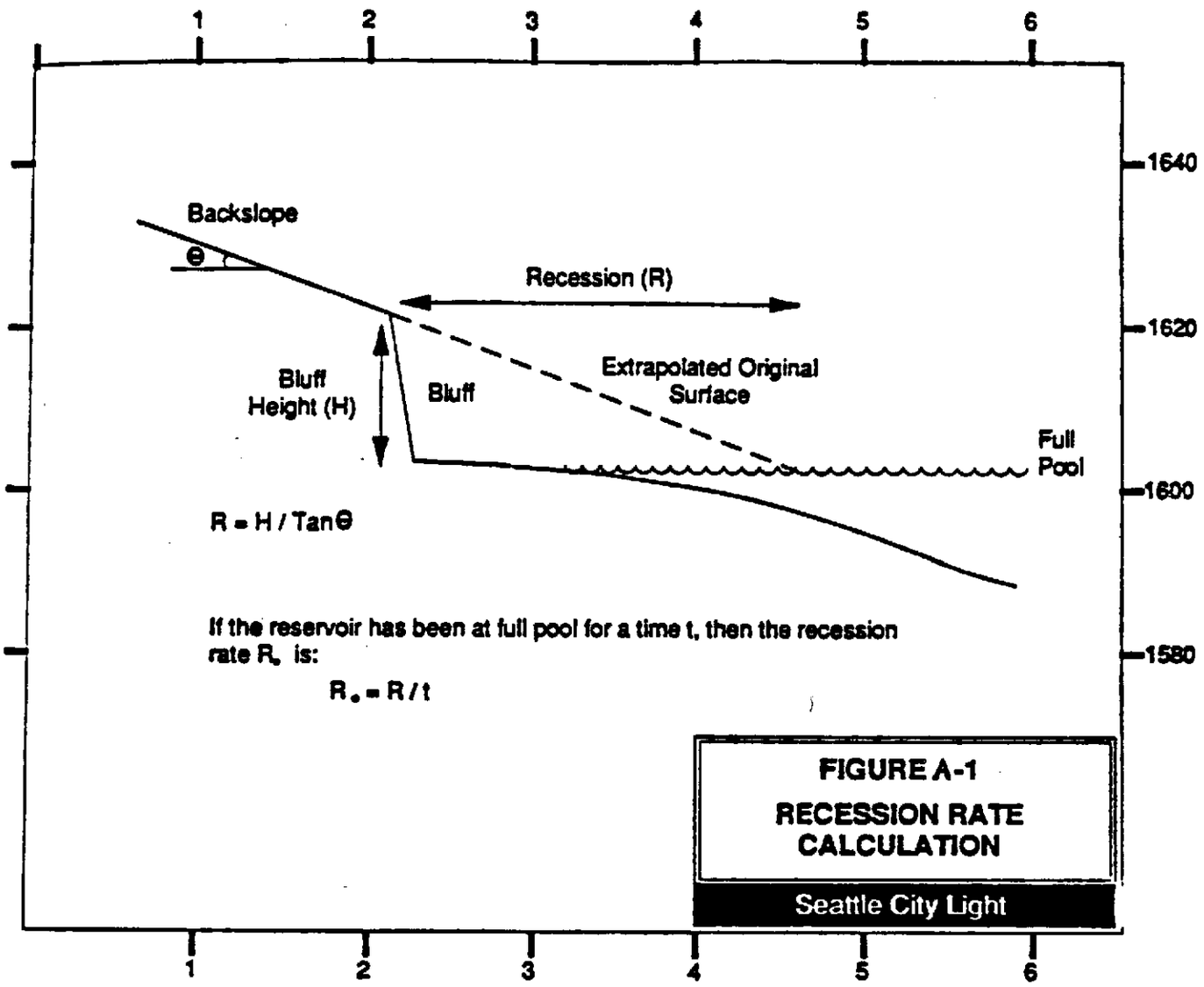
LIMITATIONS

1. Provides an overestimate of recession rates if the 1967 bluff was greater than 2 feet high.

2. Assumes linear slope elements (for extrapolation), and may thus be in error if slopes were non-linear. If the true slope eroded by bluff recession was convex, the calculated recession rate will be too high, whereas if the true slope was concave, the calculated recession rate will be too low.

3. Provides average recession rates (feet/year) whereas recession may be episodic, with highly variable actual recession rates for any given year or other time period.

Figure A-1 Recession Rate Calculation



APPENDIX B

Erosion Site Vegetation, Common and Scientific Names

APPENDIX B

Erosion Site Vegetation, Common and Scientific Plant Names

Common Name	Scientific Name
Western red cedar	*Thuja plicata*
Lodgepole pine	*Pinus contorta*
Ponderosa pine	*Pinus ponderosa*
Douglas-fir	*Pseudotsuga menziesii*
Willow	*Salix spp.*
Red alder	*Alnus rubra*
Paper birch	*Betula papyrifera*
Oregon grape	*Berberis nervosa*
Goat's beard	*Aruncus sylvester*
Rose	*Rosa spp.*
Thimbleberry	*Rubus parviflorus*
Vine maple	*Acer circinatum*
Deerbrush	*Ceanothus integerrimus*
Bearberry	*Arctostaphylos spp.*
Salal	*Gaultheria spp.*
Huckleberry	*Vaccinium spp.*