Scoping Report | Alaskan Way Seawall Feasibility Study | June 2006

US Army Corps of Engineers®

City of Seattle

Prepared for:

U.S. Army Corps of Engineers
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Scoping Report

Elliott Bay Seawall, WA General Investigation
Alaskan Way Seawall Feasibility Study
Environmental Impact Statement

U.S. Army Corps of Engineers

Prepared for:

U.S. Army Corps of Engineers
Seattle District
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Introduction

The U.S. Army Corps of Engineers, Seattle District (Corps) and the City of Seattle have begun a feasibility study on the Alaskan Way Seawall in Washington State. The City of Seattle requested Corps assistance in efforts to replace the seawall because of Corps expertise in seawall design and construction, and because the Corps may be able to obtain federal funding for the seawall rehabilitation. The feasibility study will result in a recommendation to Congress regarding whether an Alaskan Way Seawall project should be authorized under the Corps' storm damage reduction authority and, if so, how much of the cost of the seawall rehabilitation effort could be supported by the Corps. As part of this process, the Corps must prepare a National Environmental Policy Act (NEPA) environmental impact statement (EIS) and feasibility report.

This scoping report was created to describe the scoping process and scoping results, including public comments received during the scoping period. Specifically, this report includes an overview of scoping requirements under NEPA; the steps the Corps has taken to meet these requirements; a description of the alternatives to be addressed in the EIS; documents/products generated for public meetings and outreach; and comments made during the scoping process, both written and verbal.

Description of the Study Purpose and Need

The Alaskan Way Seawall is experiencing significant deterioration, leading to structural instability along the Seattle waterfront and central business district. The structural instability is putting a tremendous amount of public and private infrastructure, development, and transportation linkages at risk from earthquake, wave scour, or tidal damage. In addition, the failure of the seawall would result in a substantial risk to public safety as well as possible environmental damage.

The proposed action involves an extensive structural rehabilitation or replacement of the Alaskan Way Seawall in order to reduce damage resulting from forces mentioned above. The purpose of the proposed rehabilitation effort is to protect the public and private facilities and economic and recreational activities along the Elliott Bay and the City of Seattle shoreline.

Study Area

The study area includes approximately 8,000 feet of seawall along Seattle’s central waterfront, between S. Washington Street to the south and Broad Street to the north (Figure 1).

Figure 1. Vicinity Map Alaskan Way Seawall

Proposed Alternatives

The Alaskan Way Seawall EIS will evaluate four alternatives:

- Alternative 1 – No action;
- Alternative 2 – Vertical face wall with structural frame;
- Alternative 3 – Drilled shaft wall with soil improvements; and
- Alternative 4 – Tunnel wall.

The scoping information packet in Appendix A provides a description of each alternative.

Project Background

The southern section of the seawall consists of two types of construction: an unreinforced concrete gravity wall with supporting timber relieving platform and a pile-supported concrete sidewalk. The gravity wall and timber platform were

constructed in 1916, various types of the pile-supported concrete sidewalk were constructed in 1916 and 1964, with a significant replacement in 1987. The 1964 and 1987 construction replaced most of the original 1916 portion. All seawall sections have loose, saturated, liquefiable fill material placed behind them, consisting primarily of very loose to medium dense sand, with some amounts of gravel and silt, and small amounts of clay.

Photo of original seawall construction (Source: City of Seattle)

City maintenance records of the existing seawall reveal that there has been extensive and continual maintenance and repair of the seawall. Marine borers have extensively decayed the timber relieving platform behind the precast concrete walls. Based on subsurface geoprobe explorations, it is estimated that up to one-third of the seawall has sustained marine borer damage.

Photo showing current condition of the Alaskan Way Seawall (Source: City of Seattle)

The seawall structure is at the end of its design life of 75 years and will require continual maintenance to remain functional. If the marine borer damage is not repaired, the walls are expected to become unstable and potentially fail at key areas even during low-energy earthquakes. As constructed, the existing seawall was not designed for major earthquakes and does not meet current American Association of State Highway and Transportation Officials (AASHTO) seismic standards. A large seismic event could potentially displace liquefiable soils, exerting pressures up to three times the original pressures the structure was constructed to withstand, potentially leading to failure of the wall. Failure could be limited to isolated sections or could be very extensive.

Related Studies

Alaskan Way Viaduct and Seawall Replacement Project (AWVSRP)

The Corps' seawall feasibility study is closely related to the viaduct replacement project. The viaduct replacement project includes the replacement of a portion of the Alaskan Way Seawall in the same area as the Corps seawall study; however, the

viaduct replacement project was initiated several years ago. Much of the preliminary engineering for the seawall has been completed by the viaduct replacement project. The Corps' seawall study will utilize all applicable information and coordinate closely with the viaduct replacement project to lead synchronized seawall replacement efforts. The Corps seawall study and report to Congress will determine if federal funds should be made available for seawall rehabilitation.

Purpose and Need of Scoping

Scoping is an initial and important component of the environmental review process. The scoping process enables a project proponent, in this case the Corps, to determine the public's and agencies' major concerns. Scoping is intended to assist in identifying the issues and alternatives that will be analyzed in the draft EIS. The scoping process also helps to eliminate from detailed study those issues that are not suitable for analysis in the EIS.

NEPA Requirements for Scoping

NEPA requires a formal scoping process for the preparation of an EIS. Under NEPA, scoping is the process by which a lead agency for EIS preparation solicits input on the nature and extent of alternatives, issues, and impacts to be addressed in the EIS and the methods by which they will be evaluated. NEPA specifically requires the lead agency to consult with federal agencies having jurisdiction by law and/or special expertise on the proposed action and to solicit information from the public during preparation of the EIS.

The Council on Environmental Quality's NEPA Guidelines require the lead agency's scoping process to:

- Invite affected federal, State and local agencies, Indian tribes, project proponents, and other interested persons to participate in the EIS process;
- Determine the potential significant environmental issues to be analyzed in depth in the EIS;
- Identify and eliminate issues determined to be insignificant or addressed in other documents;
- Allocate assignments among the lead agency and any cooperating agencies regarding preparation of the EIS, including impact analysis and identification of mitigation measures;
- Identify related environmental documents being prepared; and
- Identify other environmental review and consultation requirements.

Scoping should occur as early as possible after the lead agency decides to prepare an EIS. The NEPA lead agency is required to publish a notice of intent (NOI) in the Federal Register announcing its intent to prepare an EIS. Appendix B includes the NOI for the Alaskan Way Seawall Feasibility Study and EIS.

Public Involvement Process

Notice of Intent

The first formal step in EIS preparation is publication of a NOI to prepare an EIS. The Corps published the NOI for the proposed project in the Federal Register on March 31, 2006 (Appendix B). The NOI described the proposed action and its purpose and need, and the alternatives under consideration. The NOI also announced the initiation of the formal scoping process with a 30-day public comment period.

Public Comment Period

The public scoping period for the Alaskan Way Seawall Draft Environmental Impact Statement was from March 31 through April 30, 2006.

Publicizing Scoping Efforts

The Corps announced two public scoping meetings held on April 18, 2006 at 1:30 p.m. and 4:30 p.m. in the Lopez Room of the Seattle Center. The Corps provided notice in local newspapers, in an AWVSRP email update, and mailed scoping information packages to interested parties. Notice of the public scoping meetings were published in the following newspapers:

- *Ballard News Tribune*
  April 5 and 12, 2006;
- *West Seattle Herald*
  April 5 and 12, 2006;
- *Sunday Seattle Times/Post Intelligencer*
  April 9, 2006;
- *Daily Journal of Commerce*
  April 12 and 17, 2006;
- *Seattle Times*
  April 17, 2006; and

- *Seattle Post Intelligencer*
  April 17, 2006.

Scoping information packages were mailed to 270 interested individuals, businesses, organizations/interest groups, and public agencies. The scoping information packet included a request for public comments on the scope of the EIS; the address where written comments could be sent by mail and email; an announcement for the two public scoping meetings; information on the purpose and need for the feasibility study; descriptions and drawings of the alternative construction measures under consideration; and an initial list of possible environmental impacts. A copy of the scoping information packet is provided in Appendix A.

Public Meetings

The Corps conducted two public meetings to solicit input from the public and agencies. The purpose of these meeting was to inform the public of the Alaskan Way Seawall Feasibility Study and to solicit public input on the alternatives under consideration.

According to the sign-in sheets from the two public meetings, approximately 11 members of the public or representatives of local businesses or organizations attended the meetings. A copy of the meeting agenda and sign-in sheets is provided in Appendix C.

The public scoping meetings were conducted in an open house format. The informal open house occurred during the first hour of each meeting and provided attendees with the opportunity to examine display boards with maps, photographs of existing conditions and diagrams showing the alternatives, as well as discuss the project with staff from the Corps and the City of Seattle. The open house format enabled a two-way learning process.

Project team leaders Col. Debra M. Lewis, Commander, Seattle District Corps of Engineers; Bob Chandler, Project Manager, Seattle Department of Transportation; and Tim Shaw, Project Manager, Corps of Engineers each made brief presentations at both public scoping meetings to:

- Introduce themselves and welcome public participation;
- Describe the location and function of the Alaskan Way Seawall;
- Describe the NEPA scoping process;
- Outline the purpose of the meeting;
- Provide background on the seawall and its current condition; and
- Describe the alternatives currently under consideration by the Corps and the City.

A copy of the presentation is included in Appendix C.

After the presentation, the public was invited to provide oral comments that would assist the Corps in identifying issues that should be evaluated in the EIS.

Website

On March 16, 2006, the Corps established a project website for the Alaskan Way Seawall Feasibility Study. The website contains public documents and scoping meeting information, provides answers to frequently asked questions, lists project contact information, and provides project updates.

Lead and Cooperating Agencies

The Corps as the Lead Agency in preparing the NEPA EIS invited 15 agencies and tribes to be cooperating agencies in the EIS process. Responses to these invitations, received as of June 2, 2006, are shown below.

Agencies and Tribes invited to be Cooperating Agencies

Agencies and Tribes	Cooperating agency status (as of June 2, 2006)
Federal Highway Administration	TBD
U.S. Fish and Wildlife Service	TBD
National Marine Fisheries Service	TBD
U.S. Environmental Protection Agency	TBD
Washington State Department of Transportation	Accepted
Washington State Department of Ecology	Declined
Washington State Department of Fish and Wildlife	Declined
Washington State Department of Natural Resources	Accepted
Washington State Historic Preservation Officer	Accepted
Port of Seattle	TBD
King County Department of Water and Land Resources	Accepted
Muckleshoot Tribe	TBD
Suquamish Tribe	TBD
Tulalip Tribe	TBD
Yakama Tribe	TBD

TBD = to be determined

Public Scoping Results

Oral Comments

During the course of the two public meetings, members of the public, businesses, and organizations were invited to provide oral comments. These oral comments were recorded by a court reporter at each of the two meetings. The court reporter created a record of the public meeting presentation and oral comments. These transcripts reflect the verbatim comments provided by the commenters at the two public meetings. A copy of the transcripts from the public meetings is provided in Appendix C. A total of three members of the public provided oral comments during the public scoping meetings.

In addition, attendees were provided the option of recording their comments in a more private setting on a tape recorder in a separate room. No meeting attendees chose to record their public comments on the tape recorder.

Written Comments

Meeting attendees were invited to fill out a comment card and leave it in a comment box at the meeting or to submit their comments and suggestions in writing to the following address:

Aimee Kinney
U.S. Army Corps of Engineers, Seattle District
Environmental Resources Section
P.O. Box 3755
Seattle, WA 98124-3755

-or-

aimee.t.kinney@usace.army.mil

Six comment cards were returned at the public scoping meetings, along with two letters submitted by individuals who also provided oral comments during the scoping meeting.

The Corps received a total of 11 letters and emails commenting on the EIS scope from members of the public, businesses, organizations, and public agencies.

Copies of the comments received during the scoping period can be found in Appendix C (comment cards) and Appendix D (letters and emails).

Future Steps

Scoping comments and concerns will be addressed in the draft EIS, which is expected to be completed in 2008. When completed, the draft EIS will be distributed for public and agency review. Corps responses to public comments on the draft will be included in the Final EIS, which will also be made available to the public for comment.

Appendix A

Scoping Information Packet

Request for Comments on Scope of Environmental Impact Statement

The U.S. Army Corps of Engineers, Seattle District, and the City of Seattle have begun a feasibility study on the Alaskan Way Seawall. The City of Seattle asked the Corps to assist in their efforts to replace the seawall because the Corps has expertise in seawall design and construction, and may be able to obtain federal dollars for the seawall replacement. The feasibility study will result in a recommendation to Congress regarding whether an Alaskan Way Seawall project should be authorized under the Corps' storm damage reduction authority and, if so, how much of the cost of the seawall rehabilitation effort could be funded by the Corps. As part of this process, the Corps must prepare an environmental impact statement (EIS).

This information packet provides the purpose and need for the feasibility study, descriptions and drawings of alternative construction measures under consideration, and an initial list of possible environmental impacts. Additional information on the Alaskan Way Seawall feasibility study is provided on the Seattle District website at http://www.nws.usace.army.mil.

We are seeking comment on the scope of issues to be addressed in the EIS. We encourage commenters to focus on alternatives; important natural and social resources in the study area; probable significant adverse impacts; and possible mitigation measures. **All comments must be received by April 30, 2006.**

Two public scoping meetings will be held to provide additional information and gather oral and written comments. Both meetings will be held on April 18, 2006 at Seattle Center, Northwest Rooms Building, Lopez Room (see http://www.seattlecenter.com for map). The first meeting will be held from 1:00 to 3:30 pm, and the second meeting will be held from 4:30 to 7:00 pm. Both meetings will begin with an informal open house, followed by a brief presentation, followed by public testimony.

Written comments may also be submitted to aimee.t.kinney@usace.army.mil or:

Aimee Kinney
U.S. Army Corps of Engineers, Seattle District
Environmental Resources Section
P.O. Box 3755
Seattle, WA 98124-3755

Project Purpose

The Alaskan Way seawall is experiencing significant decay and deterioration, leading to structural instability along the Seattle waterfront and central business district. Seawall structural instability is putting a tremendous amount of public and private infrastructure, development, and transportation linkages at risk of damage due to either an earthquake or wave and tidal erosion. In addition, the failure of the seawall would result in a high risk to public safety and environmental damage.

The purpose of the proposed rehabilitation effort is to protect the public facilities and economic activities along the Elliott Bay shoreline from wave and tidal damages associated with failure of the existing seawall. The study area includes approximately 7900 feet of seawall along Seattle's central waterfront, between Washington Street to the south and Bay Street to the north.

Relationship to Alaskan Way Viaduct and Seawall Replacement Project

The feasibility study is closely related to efforts to replace the seawall as part of the Alaskan Way Viaduct Replacement project (AWVSRP). The Corps is partnering with a project already in progress. However, the Corps study process is separate because we do not have the authority to fund or construct transportation projects. The seawall will be the primary focus of the Corps' analysis, rather than a secondary element of a transportation project. We are coordinating closely with the Federal Highway Administration, Washington State Department of Transportation, and City of Seattle to share information and reduce duplication of efforts. They have accomplished much of the preliminary engineering for seawall replacement, and prepared a draft EIS which evaluates replacement of the seawall. The vast amounts of data compiled and analysis completed for the March 2004 AWVSRP draft EIS will be used in the Corps EIS.

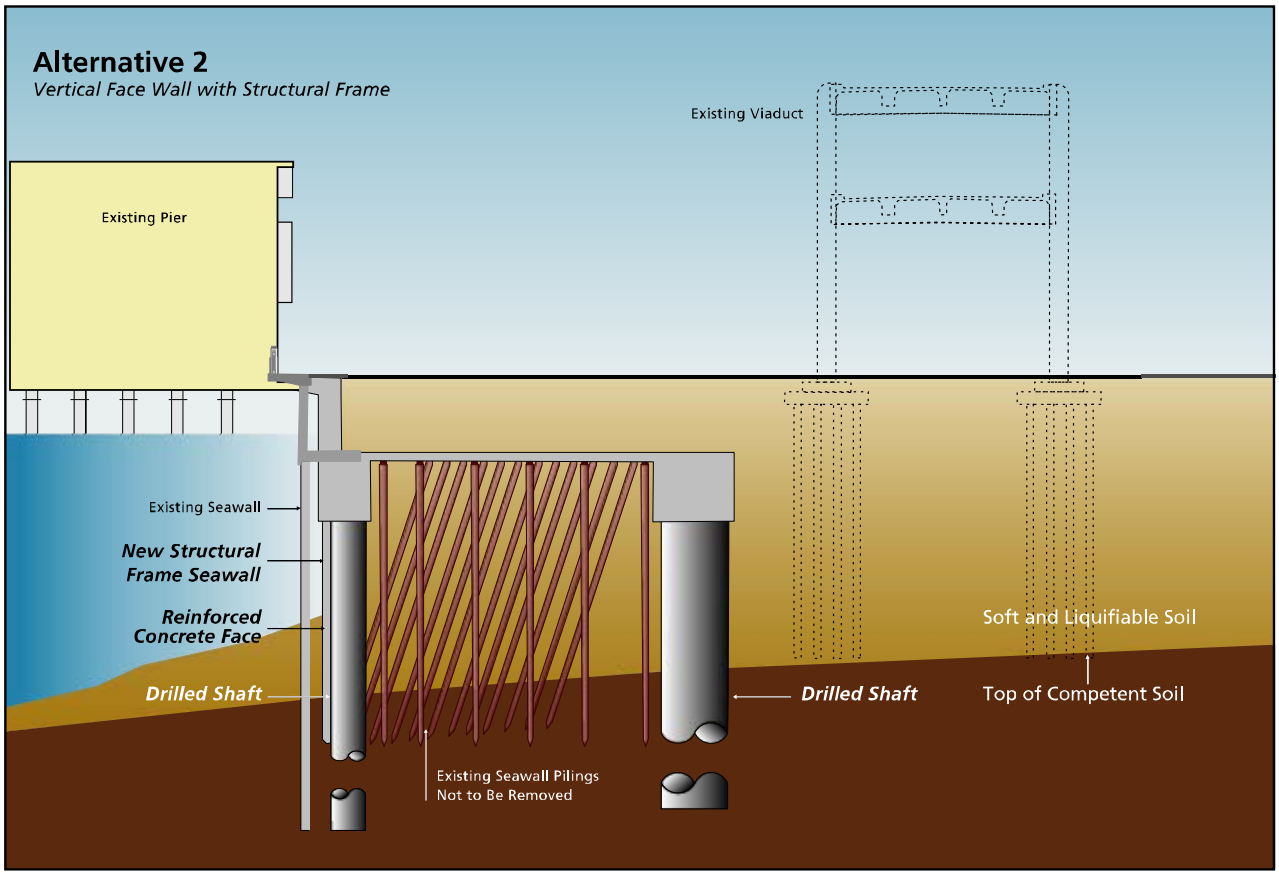
Alternatives

The Corps and the City have adopted the alternative screening process conducted for the AWVSRP. At this time, we are considering four alternative construction measures. These alternatives, described below, correspond to the seawall alternatives described in the March 2004 AWVSRP draft EIS.

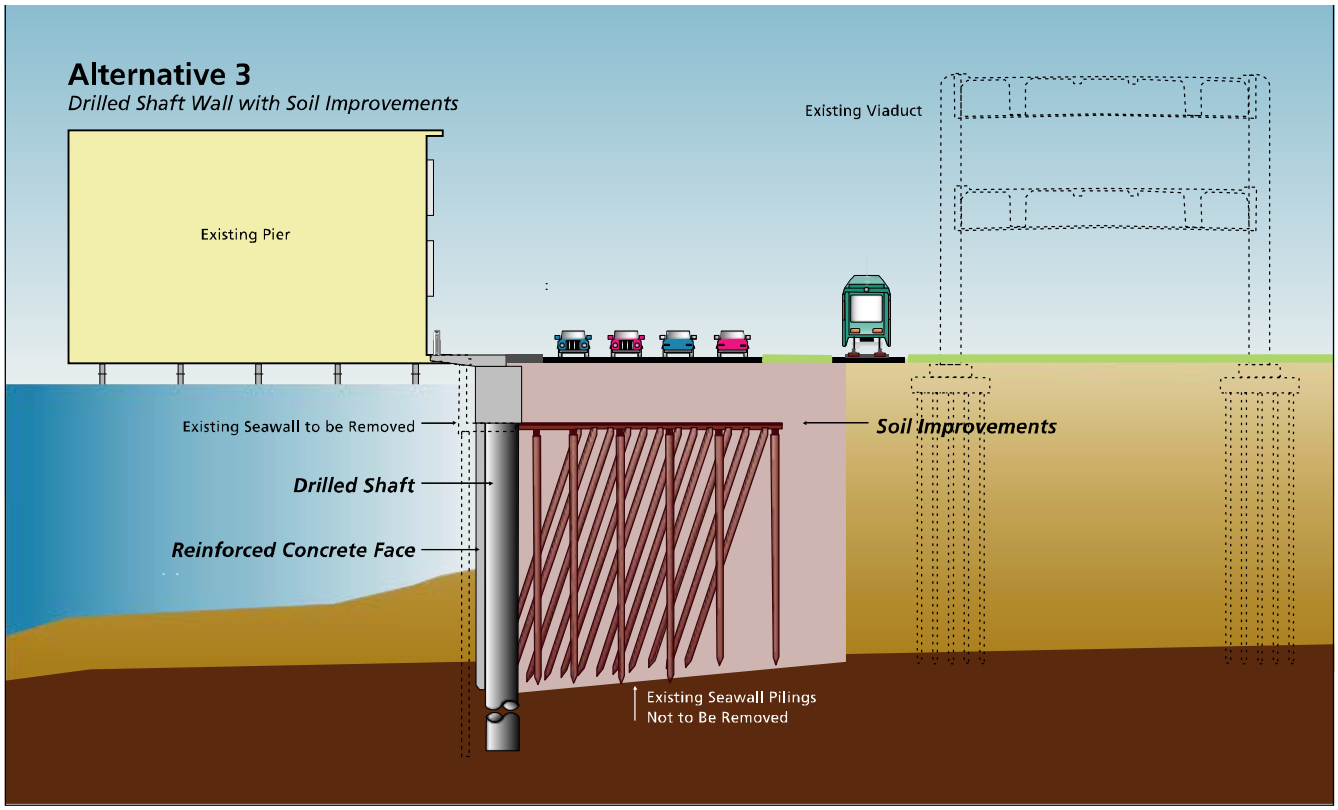
We have not yet identified a preferred alternative, but we may identify a preferred alternative in the draft EIS. We encourage you to provide recommendations for improvements to these alternatives, especially ways to create habitat for fish/wildlife, and improve public access and aesthetics along the Seattle waterfront.

Alternative 1 – No action: The no action alternative consists of continuing to repair and maintain the existing seawall. Without seismic events, the seawall could potentially remain serviceable for 25 years with continuing periodic repairs. As the structure continues to age, the cost of repairs will likely increase considerably.

Alternative 2 – Vertical face wall with structural frame: Alternative 2 consists of two concrete walls connected by a concrete T-beam. A secant pile wall would be built behind the existing seawall. A secant pile wall consists of two drilled shafts next to each other. The shafts are driven into competent soils—up to 90 feet below ground—and filled with concrete. Another shaft is drilled between the first two, overlapping both of them and eliminating voids. This forms a continuous wall of interlocking drilled shafts. The second wall would be a bulkhead constructed of drilled shafts spaced 10 to 20 feet apart and located 30 to 60 feet east of the secant pile wall. The shafts making up the bulkhead would anchor the secant pile wall. A T-beam deck, consisting of multiple bulkhead cap beams, would connect the two walls. This alternative is the same as the frame seawall alternative in the AWVSRP draft EIS.

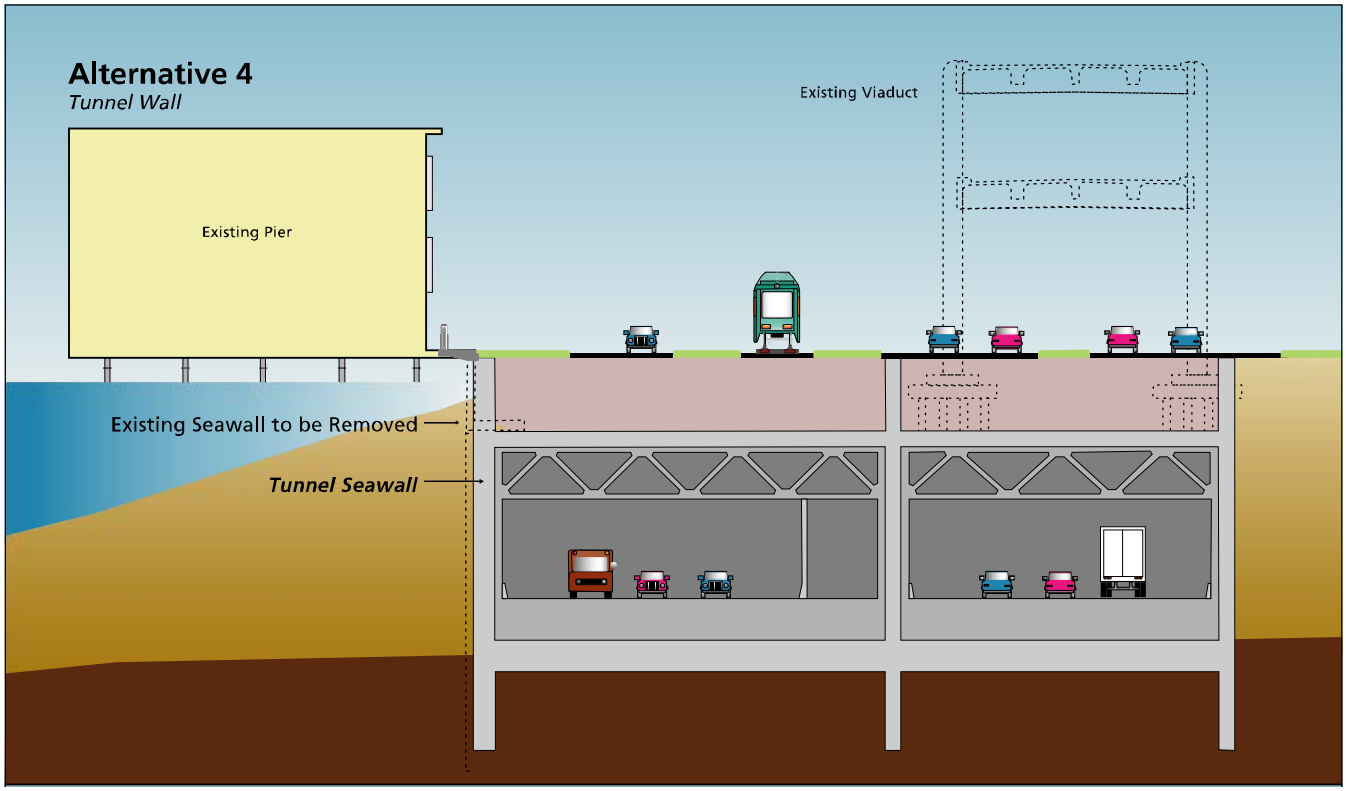


Alternative 3 – Drilled shaft wall with soil improvements: Alternative 3 involves strengthening the weak soils behind the existing seawall and constructing a continuous secant pile wall to provide needed lateral and vertical support. The soil improvements would prohibit liquefaction of the loose soils contained by the existing seawall. Soils would be strengthened through a process called jet grouting, where soils are mixed with a cement grout stabilizer. This involves drilling a hole through the existing ground surface, then inserting a rod containing a jet through which cement grout is pumped at high pressures. The high-pressure grout penetrates the existing soils, enhancing their strength. The jet is rotated while being drawn out of the hole, forming a column of improved soil. Numerous columns at close intervals are used to create a block of improved soil. The drilled shaft secant pile wall would be constructed behind the existing seawall to provide remaining required lateral resistance. This alternative is the same as the rebuild seawall alternative in the AWVSRP draft EIS.



Alternative 4 – Tunnel wall: Alternative 4 would replace the seawall with the outer wall of a tunnel between S. Washington Street and Pike Street, consistent with the proposed tunnel alternatives in the AWVSRP draft EIS. A continuous secant pile wall would be constructed to replace the existing seawall and form the outer wall of the tunnel. Most of the wall would be constructed behind the existing Alaskan Way Seawall, but a section between Pier 48 and Colman Dock may extend into Elliott Bay. This alternative would require significant excavation and dewatering.

The selection of Alternative 4 by the Corps and the City could not occur unless a tunnel alternative is adopted by the AWVSRP partners to replace the existing Alaskan Way Viaduct. Alternative 4 extends from S. Washington to Union Street and would be combined with Alternatives 1, 2, and/or 3 from Union Street north to Broad Street.



The transportation alternative shown above reflects the 2004 AWVSRP draft EIS level of tunnel design development.

Major Environmental Impacts

Several major environmental impacts could result from implementation of these alternatives. They include:

- impacts to water quality during several years of construction activities
- impacts to marine habitats – under some alternatives, portions of the seawall may be realigned waterward into Elliott Bay or landward towards Alaskan Way
- impacts to species listed under the Endangered Species Act, particularly Chinook salmon and bull trout
- impacts to historic properties
- impacts related to exposures to potentially contaminated materials landward and waterward of the seawall
- infrastructure required for post-construction storm water management
- impacts associated with the no action alternative – catastrophic failure of the seawall would lead to major impacts on the environment, as well as public facilities and infrastructure located landward of the seawall
- impacts to transportation corridors during construction activities
- impacts to businesses and residences from noise levels during construction activities
- socio-economic impacts associated with a large, multi-year construction project
- cumulative impacts – other major construction projects are located in the vicinity (including Alaskan Way Viaduct replacement, Coleman Dock upgrades, Piers 62 & 63 Central Waterfront Master Plan) and there is limited availability of suitable habitats within Elliott Bay due to historic development activities

Appendix B

Notice of Intent

''Article of Footwear with Temperature Regulation Means'' issued March 21, 2006. This patent has been assigned to the United States Government as represented by the Secretary of the Army.

FOR FURTHER INFORMATION CONTACT: Mr. Arnold Boucher at U.S. Army Soldier Systems Center, Kansas Street, Natick, MA 01760, Phone: (508) 233–5431 or E–mail: *Arnold.Boucher@natick.army.mil.*

SUPPLEMENTARY INFORMATION: Any licenses granted shall comply with 35 U.S.C. 209 and 37 CFR part 404.

Brenda S. Bowen,

Army Federal Register Liaison Officer.

[FR Doc. 06–3142 Filed 3–30–06; 8:45 am]

BILLING CODE 3710–08–M

DEPARTMENT OF DEFENSE

Department of the Army; Corps of Engineers

Availability of a Draft Environmental Impact Statement To Consider Issuance of a Department of the Army Permit Pursuant to Section 404 of the Clean Water Act for Mingo Logan Coal Company's (Mingo Logan) Proposal To Construct and Operate Spruce No. 1 Mine, Near Blair in Logan County, WV

AGENCY: Department of the Army; Corps of Engineers, DoD.

ACTION: Notice.

SUMMARY: In accordance with the requirements of the National Environmental Policy Act (NEPA), the U.S. Army Corps of Engineers (USACE) Huntington District, in cooperation with U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Service, the Office of Surface Mining and the West Virginia Department of Environmental Protection, has prepared a Draft Environmental Impact Statement (DEIS). This DEIS evaluates potential impacts to the natural, physical and human environment as a result of the proposed mining activities associated with Mingo Logan Coal Company's (Mingo Logan) Spruce No. 1 Mine. The USACE regulates this proposed project pursuant to Section 404 of the Clean Water Act. The proposed activity would involve the discharge of dredged and fill material into waters of the United States associated with the proosed construction and operation of a surface bituminous coal mine.

DATES: Submit comments by May 15, 2006. A public hearing regarding this DEIS will be held May 1, 2006 (see **SUPPLEMENTARY INFORMATION**).

ADDRESSES: Send written comments and suggestions concerning this proposal to Mrs. Teresa Spagna, Regulatory Project Manager, Regulatory Branch, CELRH–OR–FS, U.S. Army Corps of Engineers, Huntington District, 502 8th Street, Huntington, WV 25701. Telephone (304) 399–5710 or electronic mail at *Teresa.D.Spagna@Lrh01.usace.army.mil.* Requests to be placed on the mailing list should also be sent to this address.

FOR FURTHER INFORMATION CONTACT: Mrs. Teresa Spagna, Regulatory Project Manager at (304) 399–5710 or electronic mail at *Teresa.D.Spagna@Lrh01.usace.army.mil.*

SUPPLEMENTARY INFORMATION: Discharges of dredged and fill material into the waters of the United States are regulated under Section 404 of the Clean Water Act, with the permitting responsibility administered by the USACE. The proposed project must also address environmental impacts relative to the Clean Air Act, Clean Water Act, Endangered Species Act and the Fish and Wildlife Coordination Act (FWCA). In accordance with the NEPA, the DEIS evaluates reasonable alternatives for the USACE's decision making process. As required by NEPA, the USACE also analyzes the ''no action'' alternative as a baseline for gauging potential impacts.

As part of the public involvement process, notice is hereby given by the USACE-Huntington District of a Public Hearing to be held at the Earl Ray Tomlin Convention Center, in Chapmanville, Logan County, WV, from 7 to 10 p.m. on May 1, 2006. The Public Hearing will allow participants the opportunity to comment on the DEIS prepared for the proposed Spruce No. 1 Mine project.

The comments are due 45 days from the date of publication of this notice. Copies of the document may be obtained by contacting USACE Huntington District Regulatory Branch at 304–399–5210 or 304–399–5710.

Copies of the Draft EIS are also available for inspection at the locations identified below:

(1) Blair Post Office, P.O. Box 9998, Blair, WV 25022–9998.

(2) Kanawha County Public Library, 123 Capital Street, Charleston, WV 25301.

(3) Logan County Public Library, 16 Wildcat Way, Logan, WV 25601.

After the public comment period ends, USACE will consider all comments received, revise the DEIS as appropriate, and issue a Final Environmental Impact Statement.

Brenda S. Bowen,

Army Federal Register Liaison Officer.

[FR Doc. 06–3144 Filed 3–30–06; 8:45 am]

BILLING CODE 3710–GM–M

DEPARTMENT OF DEFENSE

Department of the Army; Corps of Engineers

Intent To Prepare a Draft Environmental Impact Statement for Elliott Bay Seawall, WA

AGENCY: Department of the Army, U.S. Army Corps of Engineers, DoD.

ACTION: Notice of intent.

SUMMARY: Pursuant to section 102(2)(C) of the National Environmental Policy Act (NEPA) of 1969, as amended, the U.S. Army Corps of Engineers (Corps) will prepare an environmental impact statement (EIS) for a proposed seawall rehabilitation project along the Elliott Bay shoreline in Seattle, WA. The seawall, known as the Alaskan Way Seawall, is experiencing significant decay and deterioration, leading to structural instability along the Seattle waterfront and central business district. Seawall structural instability is putting a tremendous amount of public and private infrastructure, development, and transportation linkages at risk of damage due to wave and tidal erosion, and hence potential for undermining and collapse. In addition, the failure of the seawall would result in a high risk to public safety and substantial environmental degradation. The purpose of the proposed rehabilitation effort is to protect the public facilities and economic activities along the Elliott Bay shoreline from storm damages associated with failure of the existing seawall.

DATES: Submit comments on the scope of issues to be addressed in the Draft Environmental Impact Statement (DEIS) by April 30, 2006.

ADDRESSES: Address all comments concerning this notice to Ms. Aimee Kinney, U.S. Army Corps of Engineers, Seattle District, Environmental Resources Section, PO Box 3755, Seattle, WA 98124–3755. Submit electronic comments and other date to *aimee.t.kinney@usace.army.mil.*

FOR FURTHER INFORMATION CONTACT: Questions regarding the scoping process or preparation of the DEIS may be directed to Ms. Aimee Kinney, telephone (206) 764–3634, e-mail *aimee.t.kinney@usace.army.mil.*

SUPPLEMENTARY INFORMATION:

1. *Proposed Action:* The Alaskan Way Seawall extends for a distance of approximately 7900 feet along Seattle's central waterfront, between Washington Street to the south and Bay Street to the north. The proposed action would involve an extensive structural rebuild or replacement of the seawall in order to reduce damage resulting from storms and erosion. The proposed action is closely related to the proposed replacement of the State Route (SR) 99 Alaskan Way Viaduct, which runs parallel to a portion of the seawall. The SR 99 Alaskan Way Viaduct and Seawall Replacement Project Draft Environmental Impact Statement (AWVSRP DEIS) was issued by the U.S. Department of Transportation Federal Highway Administration (FHWA), Washington State Department of Transportation (WSDOT), and City of Seattle on April 9, 2004 (69 FR 18898). The AWVSRP DEIS evaluated the rebuilding of the Alaskan Way Seawall because it is essential to the function of transportation facilities and is at risk of collapsing in a large earthquake. The geographic area covered in the AWVSRP DEIS is virtually the same as the Corps study area. However, the Corps' EIS will evaluate the seawall from a storm damage reduction perspective; the seawall will be the primary focus of the analysis rather than a secondary project element, as in the AMVSRP DEIS. The Corps is reviewing the existing body of work and coordinating closely with the city of Seattle, FHWA, and WSDOT to incorporate all relevant material from their NEPA efforts, share information, and reduce duplication of efforts.

2. *Alternatives:* There are currently four alternatives which will receive consideration in the EIS: (1) The no action alternative; (2) construction of a vertical face wall with structural frame; (3) construction of a drilled shaft wall with soil improvements; and (4) replacing the portion of the seawall adjacent to the Alaskan Way viaduct with the outer wall of the new tunnel identified as the preferred alternative for the AWVSRP. These alternatives are the same as the rebuild, frame, and tunnel wall seawall alternatives evaluated in the AWVSRP DEIS. The development of seawall study alternatives has been and will continue to be closely coordinated with the AWVSRP through the City of Seattle, WSDOT, and FHWA. The selection of the Corps tunnel wall alternative could not occur unless FHWA signed a record of decision for the AWVSRP selecting the tunnel alternative. Opportunities will be sought to incorporate measures for improvement of habitat values, as well as recreation and public access. Public input is specifically invited regarding the reasonableness of the build alternatives and whether any additional alternatives are appropriate for consideration.

3. *Scoping and Public Involvement:* This notice of intent formally commences the scoping process under NEPA. As part of the scoping process, all affected Federal, State and local agencies, Native American Tribes, private organizations, and the public are invited to comment on the scope of the EIS. To date, the following issues of concern have been identified for in depth analysis in the draft EIS: (1) Construction impacts, particularly those related to noise, water quality, transportation, and effects to businesses and residences within/adjacent to the construction zone; (2) impacts associated with potential deviation of the existing seawall alignment; and (3) potential impacts to historical properties.

4. *Scoping Meetings:* Two public Scoping meetings will be held to identify issues of major concern, identify studies that might be needed in order to analyze and evaluate impacts, and obtain public input on the range and acceptability of alternatives. Both meetings will be conducted on April 18, 2006 in the Lopez Room at Seattle Center, 305 Harrison Street, Seattle, WA 98109. The first meeting will be held from 1 to 3:30 p.m. An informal open house will be held between 1 and 2 p.m. A brief presentation will be made between 2 and 2:30 p.m. Then testimony will be taken between 2:30 and 3:30 p.m. The second meeting will be held from 4:30 to 7 p.m. Another informal open house will be held between 4:30 and 5:30 p.m. The presentation will be made again between 5:30 and 6 p.m. Then testimony will be taken between 6 and 7 p.m. Verbal or written comments will be accepted at the Scoping meetings, or written comments may be sent by regular or electronic mail to Aimee Kinney (see **ADDRESSES**). Ongoing communication with agencies, Native American tribes, public interest groups, and interested citizens will take place throughout the EIS development through the use of public meetings, mailings, and the Internet. Additional meetings will be scheduled upon completion of the DEIS.

5. *Other Environmental Review, Coordination and Permit Requirements:* The environmental review process will be comprehensive and will integrate and satisfy the requirements of NEPA, and other relevant Federal, State and local environmental laws. Other environmental review, coordination, and permit requirements may include preparation of a Clean Water Act, Section 404 evaluation by the Corps.

Dated: March 17, 2006.

Debra M. Lewis,

Colonel, Corps of Engineers, District Commander.

[FR Doc. 06–3140 Filed 3–30–06; 8:45 am]

BILLING CODE 3710–ER–M

DEPARTMENT OF DEFENSE

Department of the Army; Corps of Engineers

Intent To Prepare a Draft Supplement to the Environmental Impact Statement To Evaluate Construction of Authorized Improvements to the Federal Gulfport Harbor Navigation Project in Harrison County, MS

AGENCY: Department of the Army, U.S. Army Corps of Engineers, DOD.

ACTION: Notice of intent.

SUMMARY: The Mobile District, U.S. Army Corps of Engineers (Corps), intends to prepare a Draft Supplement to the Environmental Impact Statement (DSEIS) to address the potential impacts associated with construction of authorized improvements to the Federal Gulfport Harbor Navigation Project in Harrison County, MS. The DSEIS will be used as a basis for ensuring compliance with the National Environmental Policy Act (NEPA) and evaluating the following two alternative plans: ''No Action'' and widening to the authorized project dimensions. Gulfport Harbor is authorized to (a) A channel 38 feet deep by 400 feet wide and about 8 miles long across Ship Island Bar; (b) a channel 36 feet deep by 300 feet wide and about 12 miles long through Mississippi Sound; and (c) a stepped anchorage basin at Gulfport Harbor 32 to 36 feet deep by 1,120 feet wide and 2,640 feet long.

FOR FURTHER INFORMATION CONTACT: Questions about the proposed action and the DSEIS should be addressed to Dr. Susan Ivester Rees, Coastal Environment Team, Mobile District, U.S. Army Corps of Engineers, P.O. Box 2288, Mobile, AL 36628 by telephone (251) 694–4141 or e-mail her at *susan.i.rees@sam.usace.army.mil.*

SUPPLEMENTARY INFORMATION:

1. Gulfport Harbor is located in Harrison County, MS, on Mississippi Sound about equidistant (80 miles) from New Orleans, LA, and Mobile, AL. The existing project was adopted by the River and Harbor Act approved July 3, 1930 (House Document Number 692, 69th. Congress, 2nd. Session) and the

Appendix C.1 - Agenda

Public Scoping Meetings

April 18, 2006
Seattle Center, Lopez Room

SESSION I – 1:00 to 3:30 PM

1:00 – Open House

2:00 – Presentation

2:30 – Testimony

3:10 – Close of Public Sign-up for Comments

3:30 – End Session II

SESSION II – 4:30 to 7:00 PM

4:30 – Open House

5:30 – Presentation

6:00 – Testimony

6:40 – Close of Public Sign-up for Comments

7:00 – End Session II

Tips for Speakers:

- **Please state your name and your affiliation (if any), when you begin.** If you work for an organization, please indicate if your comments reflect the views of that organization or if they are your individual views.
- **Remember the meeting purpose.** We are here to discuss issues that should be evaluated in the Alaskan Way Seawall Environmental Impact Statement, not advocate for a specific position or alternative.
- **Focus on providing new information.** All testimony will be recorded by a court reporter, so there is no need to repeat issues that others have raised.
- **Please be as concise as possible.** If you cannot complete your comment in the time allotted, consider submitting written comments. Written and oral comments will be considered equally.

Appendix C.2 – Sign-in Sheets

Alaskan Way Seawall
Public Scoping Meeting
April 18, 2006

Name	Affiliation
Stephen Martin	J+S Inc.
EUGENE HOGLUND	SEATTLE CITIZEN
Eric Sirkin	Citizen
DAVID DEAN	citizen
Julia Hadley	Citizen
Amy Grotefendt	AWW Project
Ralph Petereit	AWP Project
ALBERT PONG	CITIZEN
Steve Smith	Kiewit
ROBERT SCULLY	DPD - CITY OF SEATTLE

Alaskan Way Seawall
Public Scoping Meeting
April 18, 2006

Name	Affiliation
H Thoisen	None
David Graves	Seattle Parks & Rec
Scott MacColl	City of Seattle
Katherine Maxwell	American Acquisition Group, LLC

Alaskan Way Seawall
Public Scoping Meeting
April 18, 2006

Name	Affiliation
Eric Forsyth	UW / Parsons Brinckerhoff
Tracie Sunday	SDOT
Craig Keller	VIADUCT PRESERVATION GROUP
GERI POOR	Port of Seattle

Alaskan Way Seawall
Public Scoping Meeting
April 18, 2006

Name	Affiliation
RALPH PEASE	ARGOSY CRUISES

Appendix C.3 – Power-Point Presentation

Alaskan Way Seawall

Environmental Impact Statement

Public Scoping Meeting, April 18
Seattle Center, Lopez Room
1:30 and 4:30 pm

US Army Corps of Engineers®
Seattle District

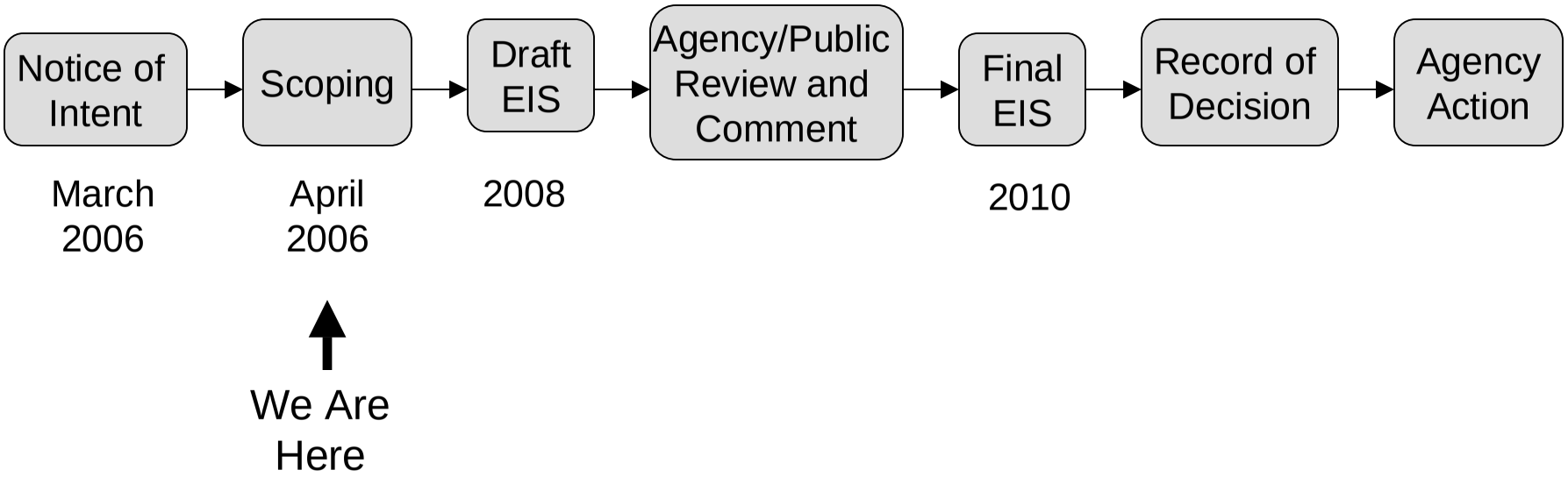
City of Seattle

Broad
Elliott
Battery
Bell Harbor
Conference
Center
Alaskan
Union
Waterfront
Park
Pier
62/63
Elliott Bay
Colman
Dock
Washington
Legend
Seawall
Type
Alts 1, 2 or 3
Alts 1, 2, 3 or 4 (Tunnel Wall)
N

US Army Corps of Engineers®
Seattle District

City of Seattle

Steps of the National Environmental Policy Act (NEPA) Environmental Review Process



US Army Corps of Engineers®
Seattle District

City of Seattle

Other Waterfront Projects

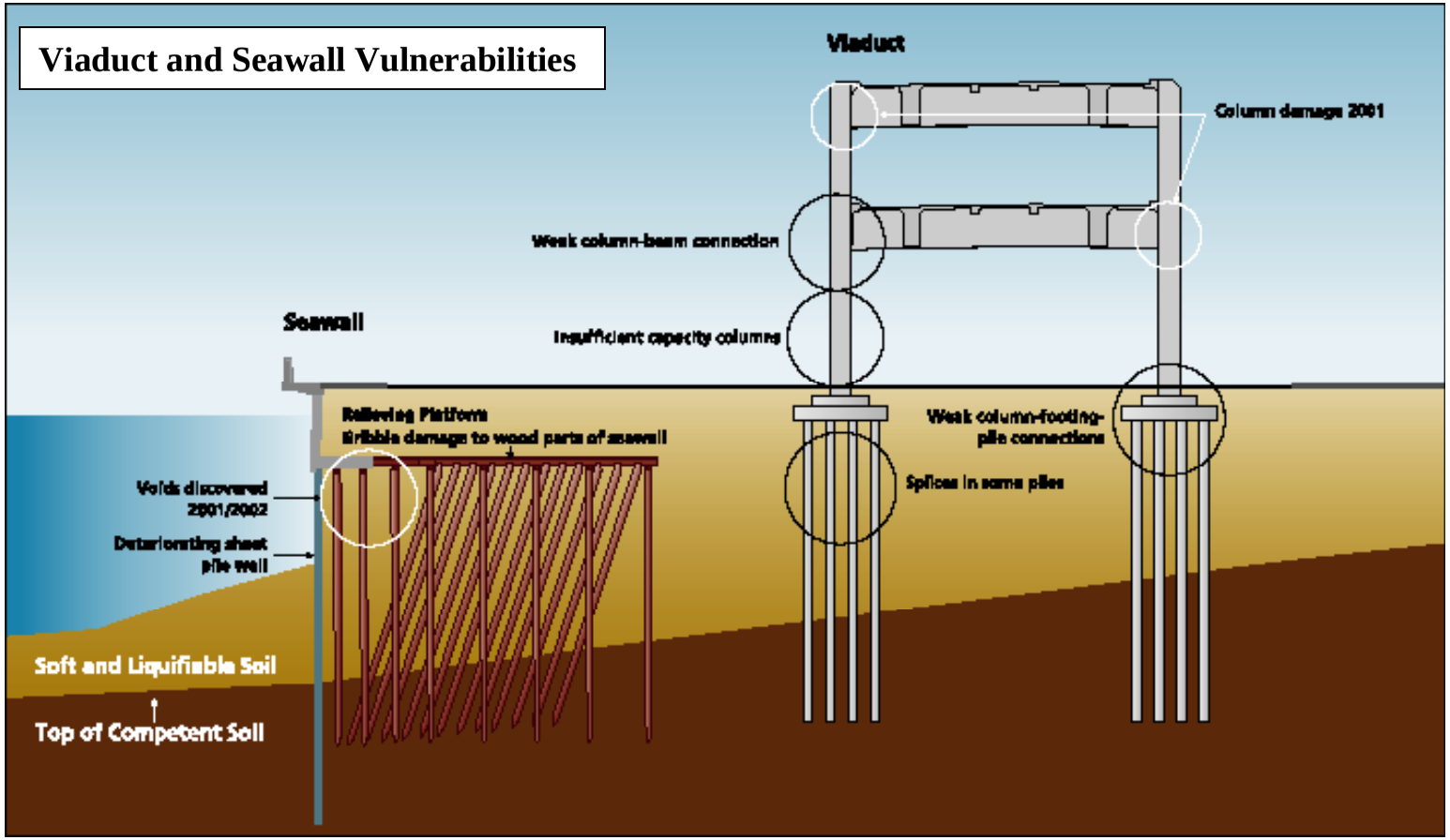
Coleman Dock
- Angela Freudenstein, WSDOT

Central Waterfront Master Park Plan (Piers 62 and 63)
- David Graves, Seattle Parks and Recreation

Waterfront Concept Plan
- Guillermo Romano, Seattle Planning and Development (DPD)

Alaskan Way Viaduct and Seawall Replacement Project
- Amy Grotefendt, WSDOT

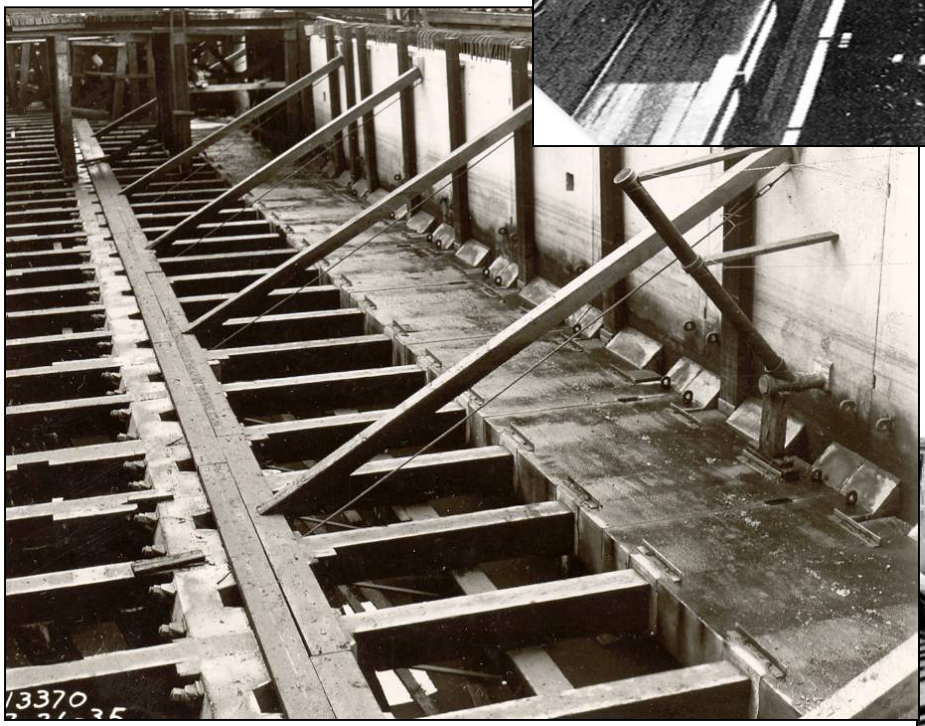
Seawall Alternatives



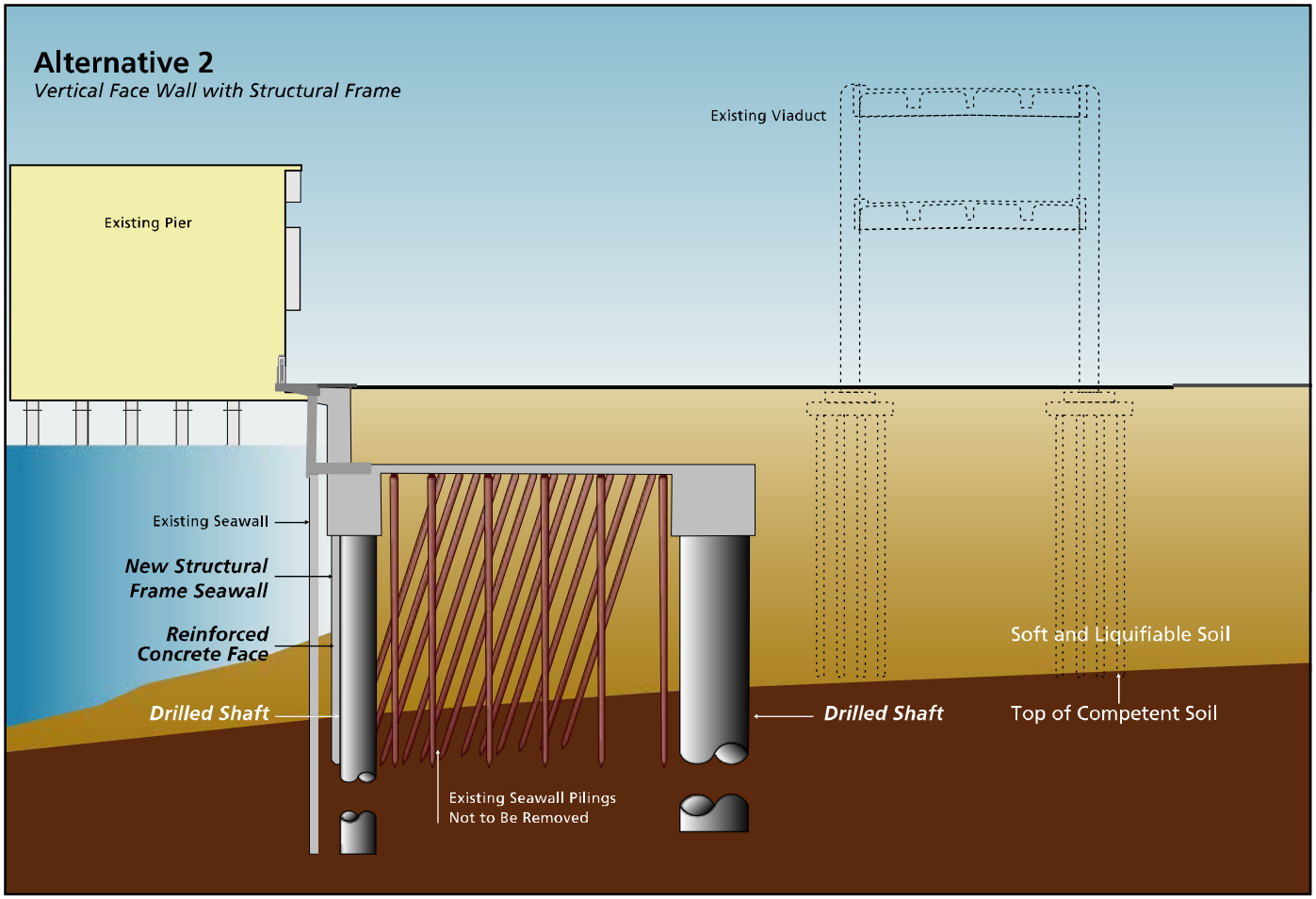
Alternative 1 – No action

Current Seawall Condition

Original Seawall Construction

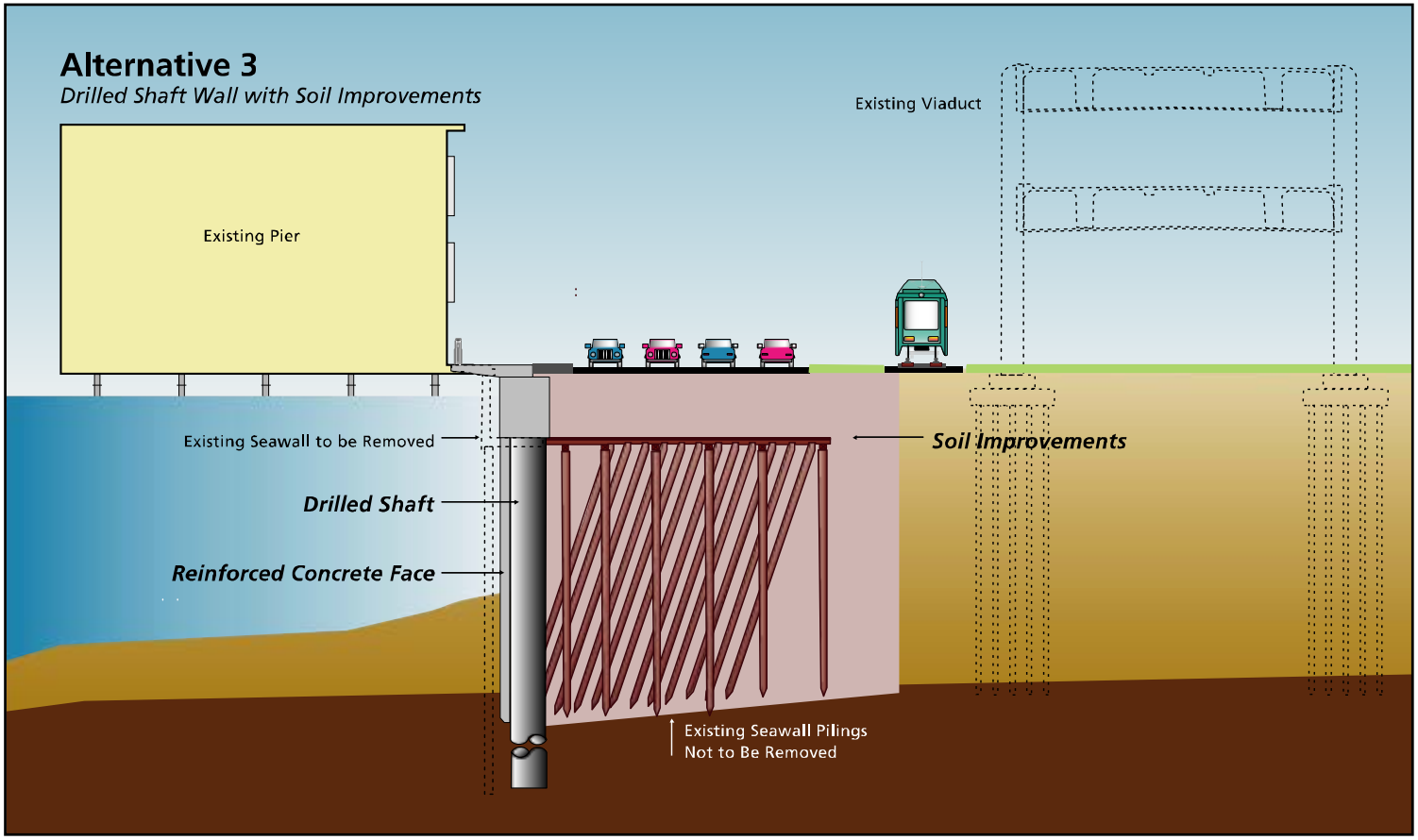


Seawall Alternatives



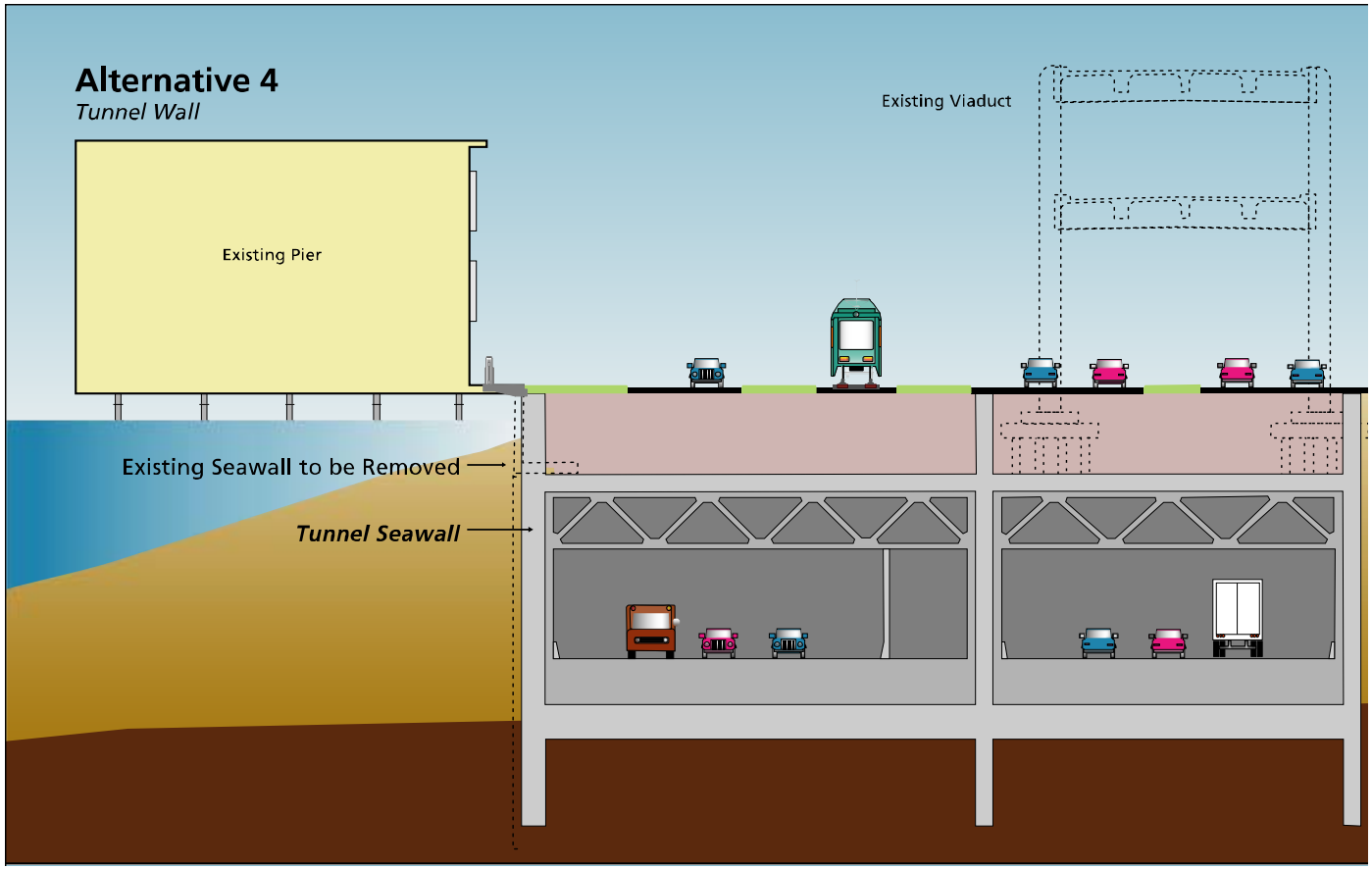
Alternative 2 – Vertical face wall with structural frame

Seawall Alternatives



Alternative 3 – Drilled shaft wall with soil improvements

Seawall Alternatives



The transportation alternative shown above reflects the 2004 AWVSRP draft EIS level of tunnel design development.

Alternative 4 – Tunnel wall

Visit our web site at: *www.nws.usace.army.mil*

Written comments may be submitted to:

Aimee Kinney
U.S. Army Corps of Engineers, Seattle District
Environmental Resources Section
P.O. Box 3755
Seattle, WA 98124-3755
-or-
aimee.t.kinney@usace.army.mil

Scoping comments must be received by **April 30**

US Army Corps of Engineers®
Seattle District

City of Seattle

Appendix C.4 – Comment Cards Submitted

1

ATTENDANCE REGISTER

Pronounced

EUGENE	D	HOGLUND	(Hōaglund)
MR ~~MRS MS MISS~~ FIRST NAME	INITIAL	LAST NAME	

3503 30th Ave WEST
ADDRESS

SEATTLE WA 98199
CITY STATE ZIP CODE

GENENSUSAN@COMCAST.NET
E-MAIL ADDRESS

FIRM, ORGANIZATION, OR AGENCY REPRESENTED

206-378-0722
PHONE NO. (OPTIONAL)

☒ I WISH TO SPEAK AT THIS MEETING

☐ PLEASE ADD ME TO THE PROJECT MAILING LIST

PRINCIPAL PURPOSE: Provides a vehicle by which people attending public meetings can indicate their views and whether they wish to present a statement or speak on the issues under discussion.
ROUTINE USES: Serves as a roster of those wishing to speak, and as an attendance record for inclusion with transcript of public meeting; treated as public record (disclosed to the public).
MANDATORY OR VOLUNTARY DISCLOSURE AND EFFECT ON INDIVIDUAL NOT PROVIDING INFORMATION: Voluntary – Not providing this information could preclude the party from speaking at a public meeting or receiving information or notices of additional meetings.

COMMENTS:

1

ATTENDANCE REGISTER

MR MRS MS MISS FIRST NAME: Eric INITIAL: M LAST NAME: Forsyth

ADDRESS: 3915 Wallingford Ave N

CITY: Seattle STATE: WA ZIP CODE: 98103

E-MAIL ADDRESS: ForsytE@wsdot.wa.gov.

FIRM, ORGANIZATION, OR AGENCY REPRESENTED: UW/Parsons Brinckerhoff PHONE NO. (OPTIONAL):

☐ I WISH TO SPEAK AT THIS MEETING

☒ PLEASE ADD ME TO THE PROJECT MAILING LIST

PRINCIPAL PURPOSE: Provides a vehicle by which people attending public meetings can indicate their views and whether they wish to present a statement or speak on the issues under discussion.
ROUTINE USES: Serves as a roster of those wishing to speak, and as an attendance record for inclusion with transcript of public meeting; treated as public record (disclosed to the public).
MANDATORY OR VOLUNTARY DISCLOSURE AND EFFECT ON INDIVIDUAL NOT PROVIDING INFORMATION: Voluntary – Not providing this information could preclude the party from speaking at a public meeting or receiving information or notices of additional meetings.

COMMENTS:

I support the tunnel option to replace the AWV. If it came to a vote, I'd vote tunnel and I'd also vote for a means to fund the project if necessary. I also believe that WSDOT and the City of Seattle needs to increase their communication level to the public. As of now mostly rumors and speculation exist throughout most of the voting populous. If people understood the situation better then they would understand the optimal solution. Thanks.

3

ATTENDANCE REGISTER

MR MRS MS MISS FIRST NAME: RALPH INITIAL: W. LAST NAME: PEASE

ADDRESS: PIER 55, SUITE 201

CITY: SEATTLE STATE: WA ZIP CODE: 98101

E-MAIL ADDRESS: RALPHP@ARGOSYCRUISES.COM

FIRM, ORGANIZATION, OR AGENCY REPRESENTED: ARGOSY CRUISES PHONE NO. (OPTIONAL): 206-623-1445

☐ I WISH TO SPEAK AT THIS MEETING

☒ PLEASE ADD ME TO THE PROJECT MAILING LIST

PRINCIPAL PURPOSE: Provides a vehicle by which people attending public meetings can indicate their views and whether they wish to present a statement or speak on the issues under discussion.
ROUTINE USES: Serves as a roster of those wishing to speak, and as an attendance record for inclusion with transcript of public meeting; treated as public record (disclosed to the public).
MANDATORY OR VOLUNTARY DISCLOSURE AND EFFECT ON INDIVIDUAL NOT PROVIDING INFORMATION: Voluntary – Not providing this information could preclude the party from speaking at a public meeting or receiving information or notices of additional meetings.

COMMENTS:

WE SINCERELY HOPE THERE WILL BE A DIALOG BETWEEN THE CORP & CITY ENGINEERS WITH AFFECTED BUSINESSES PARTICULARLY THE WATER DEPENDENT BUSINESSES. AND THE SOONER THE BETTER.

ARGOSY CRUISES CARRIES OVER 500,000 PASSENGERS A YEAR ON 10 VESSELS, WHICH OPERATE TOURS, DINNER CRUISES, CHARTERS, FOOT PASSENGER FERRIES AND SPECIAL EVENT CRUISES. I AM ANXIOUS TO DISCUSS THE NEEDS & CONCERNS OF ARGOSY AT ANY TIME IN THE FUTURE. NUMBER & EMAIL ON OPPOSITE SIDE.

ATTENDANCE REGISTER

MR MRS MS MISS	FIRST NAME	INITIAL	LAST NAME
	CRAIG		KELLER

ADDRESS: 4445 53RD AVE. S.W.

CITY	STATE	ZIP CODE
SEATTLE	WA	98116-3912

E-MAIL ADDRESS: bckeller@worldnet.att.net

FIRM, ORGANIZATION, OR AGENCY REPRESENTED	PHONE NO. (OPTIONAL)
VIADUCT PRESERVATION GROUP	(206) 935-4625

☒ I WISH TO SPEAK AT THIS MEETING

☒ PLEASE ADD ME TO THE PROJECT MAILING LIST prefer email

PRINCIPAL PURPOSE: Provides a vehicle by which people attending public meetings can indicate their views and whether they wish to present a statement or speak on the issues under discussion.
ROUTINE USES: Serves as a roster of those wishing to speak, and as an attendance record for inclusion with transcript of public meeting; treated as public record (disclosed to the public).
MANDATORY OR VOLUNTARY DISCLOSURE AND EFFECT ON INDIVIDUAL NOT PROVIDING INFORMATION: Voluntary – Not providing this information could preclude the party from speaking at a public meeting or receiving information or notices of additional meetings.

COMMENTS:

5

ATTENDANCE REGISTER

MR MRS MS MISS	FIRST NAME	INITIAL	LAST NAME
	BUD		SHASTEEN

ADDRESS: 7333 39th Av S.W

CITY	STATE	ZIP CODE
SEATTLE	WA	98136-2102

E-MAIL ADDRESS: NONE

FIRM, ORGANIZATION, OR AGENCY REPRESENTED:

PHONE NO. (OPTIONAL): 206-932-4096

☑ I WISH TO SPEAK AT THIS MEETING

☐ PLEASE ADD ME TO THE PROJECT MAILING LIST

PRINCIPAL PURPOSE: Provides a vehicle by which people attending public meetings can indicate their views and whether they wish to present a statement or speak on the issues under discussion.
ROUTINE USES: Serves as a roster of those wishing to speak, and as an attendance record for inclusion with transcript of public meeting; treated as public record (disclosed to the public).
MANDATORY OR VOLUNTARY DISCLOSURE AND EFFECT ON INDIVIDUAL NOT PROVIDING INFORMATION: Voluntary – Not providing this information could preclude the party from speaking at a public meeting or receiving information or notices of additional meetings.

COMMENTS:

6

ATTENDANCE REGISTER

MR MRS MS MISS FIRST NAME: Julia INITIAL: R LAST NAME: Hadley

ADDRESS: 3813 22nd Ave SW

CITY: Seattle STATE: WA ZIP CODE: 98106

E-MAIL ADDRESS: jhadley@uofwashington.edu

FIRM, ORGANIZATION, OR AGENCY REPRESENTED: Citizen PHONE NO. (OPTIONAL):

☐ I WISH TO SPEAK AT THIS MEETING

☒ PLEASE ADD ME TO THE PROJECT MAILING LIST

PRINCIPAL PURPOSE: Provides a vehicle by which people attending public meetings can indicate their views and whether they wish to present a statement or speak on the issues under discussion.
ROUTINE USES: Serves as a roster of those wishing to speak, and as an attendance record for inclusion with transcript of public meeting; treated as public record (disclosed to the public).
MANDATORY OR VOLUNTARY DISCLOSURE AND EFFECT ON INDIVIDUAL NOT PROVIDING INFORMATION: Voluntary – Not providing this information could preclude the party from speaking at a public meeting or receiving information or notices of additional meetings.

COMMENTS: Alternative four is the most desirable to myself. The opportunity to create a beautiful water front that people can walk to and have access to should not be passed by. The opportunity to build a seawall that also provides an infrastructure ~~that~~ where marine ecosystems can thrive and propagate (other than greebles, marine borers.) will not happen again. What we have here is an opportunity to build a legacy as significant to our area as the Olmstead designed parks. Please realize that a seawall with a Tunnel will give us the best foundation for creating something beautiful for our waterfront both above and below sealevel.

Appendix C.5 - Transcript

ALASKAN WAY SEAWALL

Feasibility Study

Public Scoping Meetings

April 18, 2006

Seattle Center, Lopez Room

1 APRIL 18, 2006

2 [2:05 P.M.]

3 COLONEL DEBRA LEWIS: Hello. Good afternoon,
4 ladies and gentlemen.

5 Welcome to the public scoping meeting for Alaskan
6 Way Seawall and environmental impact statement, or EIS,
7 sponsored by the U.S. Army Corps of Engineers and the City
8 of Seattle.

9 My name is Colonel Debra Lewis and I am the district
10 engineer for the Seattle District, U.S. Army Corps of
11 Engineers. I will be conducting today's meeting.

12 We are here today to talk about potential
13 environmental impacts of rebuilding the Alaskan Way
14 Seawall. The seawall study area extends from Washington
15 Street to Broad Street.

16 So I'm wondering if we have the -- can you see it on
17 there? Okay. Great.

18 From Washington Street to Broad Street along the
19 Elliott Bay shoreline in downtown Seattle. The seawall
20 structure is under Alaskan Way surface street and varies in
21 width between 40 and 60 feet. The seawall structure
22 supports the waterfront piers, Alaskan Way surface street,
23 utilities under Alaskan Way, and the soils supporting the
24 Alaskan Way viaduct. The purpose of the Corps' Alaskan Way
25 Seawall Project is to prevent shoreline erosion and

1 infrastructure damage.

2 Before we proceed to the public testimony portion of

3 the meeting, we want to give you some information about the

4 Corps' Alaskan Way Seawall Project.

5 After I say a few words about the purpose of this

6 meeting, Melinda Posner, facilitator from the consulting

7 firm Jones & Stokes will go over the ground rules and the

8 format of the comment session.

9 Then Bob Chandler, sitting at the table -- raise

10 your hand, Bob -- the Seattle Department of Transportation

11 project manager, will speak for a few minutes about the

12 events that led to this study.

13 Next Tim Shaw, U.S. Army Corps of Engineers project

14 manager, will tell you where we are in this project.

15 After these brief presentations, we will accept

16 comments from those individuals who have indicated a desire

17 to speak. We will adjourn at 3:30.

18 The National Environmental Policy Act, or NEPA, is a

19 law that's set up to study -- a process to study the

20 environmental effects of federal actions. It helps

21 decision makers like me take environmental consequences

22 into account when choosing between different project

23 alternatives and mitigation measures. NEPA has also set up

24 a process for disclosing information to and solicitating

25 comments from the public. For major federal projects like

1 this one, we accomplish these things by preparing an
2 environmental impact statement or EIS.
3 This slide shows the steps involved in preparing an
4 EIS. The first step is to publish a notice of intent to
5 prepare an EIS in the Federal Register.
6 The notice of intent for this project was published
7 March 31, 2006. This notice was the beginning of a 30 day
8 comment period on the scope of the seawall EIS.
9 The next step is scoping. The scoping period for
10 the Corps' Alaskan Way Seawall Project is going on right
11 now. Scoping is the time when we determine what issues and
12 alternatives will be addressed in the EIS. Scoping is one
13 of the best times for the public to provide early input on
14 a project. By identifying the issues that concern you
15 about rebuilding the Alaskan Way Seawall, we can ensure
16 they are properly considered and studied.
17 This meeting is one way you can provide input on
18 EIS. We are here to listen to your thoughts, concerns and
19 ideas about rebuilding the Alaskan Way Seawall. For
20 example, are there other alternatives we should consider?
21 Do you have ideas about how to improve one of our
22 alternatives? What do you want to know about impacts from
23 the project? What concerns do you have about how this
24 project may affect your business or residence?
25 The 30 days for public input on this phase of the

1 EIS is over at the end of this month. We will then move
2 onto the next step and begin preparing the draft EIS. The
3 EIS will be part of the Corps' feasibility report and will
4 describe alternatives and their impacts as well as possible
5 ways to mitigate for those impacts.
6 We expect the draft EIS to be released for public
7 review and comment in 2008. At that time we will open
8 another public comment period and have more public meetings
9 to provide you with the opportunity to give additional
10 input.
11 All the comments we receive on the draft EIS will be
12 addressed in the final EIS. A record of decision will then
13 be signed before any action is taken.
14 There are several other large projects being
15 developed for the Seattle waterfront right now. These
16 projects are related to the Alaskan Way Seawall but they
17 are not included in the Corps' Alaskan Way Seawall Project.
18 For example, Washington State Ferries is planning upgrades
19 for Colman Dock as part of their system plan.
20 Seattle Parks and Recreation. We have -- and
21 Seattle Planning. From the parks there is David Graves.
22 He's in the back. Raise your hand. And from Seattle
23 Planning we have Robert Scully, who is here. And working
24 on master parks plan for the central waterfront, including
25 options for improvement to the Waterfront Park in Pier 62

1 and 63.

2 Another very visible project is the effort by the
3 Washington State Department of Transportation, the Federal
4 Highway Administration, and the City of Seattle to replace
5 the Alaskan Way Viaduct. Now, Dawn Schellenberg is here.
6 Where are you, Dawn? Hold up your hand.

7 And there is information about each of these
8 projects. I brought them up here. They kind of slid down.
9 But there are projects. There are fliers and other things.
10 There is information about each of these and the other
11 projects on my the table to my left in the back of the room
12 where they're standing.

13 We're working cooperatively with the agency
14 proponents of these projects to achieve mutual goals and
15 for the future of Seattle's waterfront and ensure
16 compliance with existing laws and regulations.

17 So the Alaskan Way Seawall serves many different
18 functions on a very busy waterfront in downtown Seattle.
19 Because the seawall is showing signs of failure to perform
20 many of its functions, many agencies at federal, state and
21 local levels are involved in the replacement efforts. The
22 efforts of all of these agencies are not mutually
23 exclusive. The link among them all is the City of Seattle,
24 the owner of the seawall.

25 Bob Chandler, as I mentioned earlier, the City of

1 Seattle project manager for the Alaskan Way Seawall Project
2 will speak with you in a few minutes about the importance
3 of the seawall to the city.
4 The effort of to replace the Alaskan Way Viaduct is
5 a project most closely related to the Corps' Alaskan Way
6 Seawall Project. Rebuilding of the Alaskan Way Seawall is
7 included in the viaduct replacement project because one
8 function of the seawall is to support the waterfront
9 portion of State Route 99 transportation corridor extending
10 from Washington Street to Broad Street.
11 Because the same length of seawall is being
12 evaluated by the two projects the outcomes of the two
13 efforts are clearly closely related. The agencies involved
14 are all coordinating accordingly.
15 The decision for the transportation alternative may
16 determine the alternative selected for the central
17 waterfront portion of the Corps' Alaskan Way Seawall
18 Project from Washington to Union Street or about one-third
19 the total length of the seawall. Although the Corps is not
20 involved in the decision on the viaduct replacement, our
21 seawall alternatives are compatible with any outcome of the
22 transportation project.
23 The Corps has and will continue to incorporate
24 seawall work completed by our partner agencies on the
25 transportation project into the Corps' Alaskan Way Seawall

1 study.

2 In order to obtain approval from Congress to
3 participate in a construction project of this magnitude, we
4 must prepare an EIS that focuses on the seawall as a
5 structure that prevents shoreline erosion and
6 infrastructure damage. The body of work developed for the
7 transportation project will be utilized where possible to
8 reduce our study time and effort and minimize any
9 redundancies between the projects.

10 The varieties of functions that the seawall serves
11 and the multitude of agencies interested in replacement of
12 the seawall speaks to the importance of this structure to
13 the public interest.

14 This afternoon we are here to listen to the public's
15 thoughts, concerns and ideas about rebuilding the seawall.
16 The purpose of our scoping meeting for the Corps' Alaskan
17 Way Seawall EIS is very specific. We want to hear if you
18 have a specific suggestions on issues to be covered in the
19 seawall EIS.

20 We are here to share what we know and for me to
21 gather information to consider in our process. We are not
22 here to debate the pros and cons of specific alternatives.
23 We will not take comments on the transportation project.

24 In order to make sure that everyone who wishes to
25 speak is able to do so, we will not have a question and

1 answer session. There is a handout with answers to
2 frequently asked questions about the project at the
3 registration tables, which you signed in at earlier. And
4 there is an information session between 4:30 and 5:30 if
5 you would like to speak with members of the project team.
6 We will carefully consider your comments when
7 developing the EIS for this project. Your observations
8 will help us improve the NEPA process. Written and oral
9 presentations will be given equal weight.
10 Now I will hand over the microphone to Melinda
11 Posner, who will go over the ground rules for public
12 testimony portion of the meeting.
13 Thank you.
14 MELINDA POSNER: My comments will be brief.
15 Thank you for the introduction.
16 My role here today is to make sure we have a
17 productive meeting and that we're able to get you in here
18 and out of here on time.
19 And our format includes an open house, which we had
20 this first hour before. About a half an hour for this
21 presentation period. And then a solid hour for testimony.
22 And we're actually having two meetings today. One at this
23 time and then we're also having another meeting starting at
24 4:30 that will run until 7:00.
25 So in order to have a successful meeting, there's a

1 couple of ground rules I would like to point out. I've
2 written them on here.
3 Turn off all cell phones and pagers. That will be
4 very helpful. Thank you.
5 Stay focused on the meeting purpose. And Colonel
6 Lewis did talk about why we're here today. We've tried to
7 very clearly outline what this meeting is about through all
8 of our materials, and we want to try and focus you on
9 specifically the Alaskan Way Seawall Project. So we do ask
10 that you focus all of your comments on that.
11 And we do have, as we mentioned, representatives
12 here from other projects and folks who can talk about
13 projects that are not related to our primary focus. And so
14 we want to encourage you to do that during the open house,
15 if you have done that already, or perhaps at the beginning
16 of our second meeting at 4:30.
17 Recognize the role of the facilitator. And that's
18 really just about remembering that I'm here to facilitate.
19 My role is to keep the meeting on track, make sure we're
20 able to hear from everyone here. And that in the end I may
21 have to interrupt. I may have to redirect, as necessary,
22 to make sure that we are able to meet the objectives of the
23 meeting.
24 We also do have a court reporter here. Thank you
25 very much. And I also may need to stop and just make sure

1 our pacing is right so that he's able to catch everything.
2 I ask that you actively listen. You may hear
3 something new. And you may hear it in a different manner
4 if you've already heard before. I ask that you be
5 respectful of others and of others' opinions. I ask that
6 you refrain from having side discussions during the
7 presentation and the testimony, and that is for your
8 purposes in being able to hear it but also in us being able
9 to record it.
10 Also focus on providing new information. Everyone
11 should be able to hear the comments. And in order for us
12 to hear all the comments -- though this afternoon I believe
13 we so far have two folks who have indicated absolutely that
14 they would like to speak. So we're not going to be as
15 constrained. But we do ask that you refrain from repeating
16 comments that you -- that may have been heard already. You
17 can certainly come up to the microphone and indicate that,
18 "I support those comments just mentioned," but you don't
19 necessarily need to repeat them all. We are recording
20 them.
21 And as Colonel Lewis mentioned, we will not be
22 answering questions during the presentation or formal
23 testimony period. But, again, you do have lots of
24 opportunities and lots of staff here to answer specific
25 questions.

1 And we also have an intent to start and stop the
2 meeting on time. And we've talked about that already. And
3 I think we're right on time. It's 2:20 and we'll be ending
4 at 3:30.
5 And before we go to the presentation, I would like
6 to make a couple of comments about how to comment.
7 Presenting verbal testimony is something that can be done
8 here today, and we actually have two options for that. One
9 is right here at the microphone. And those of you who have
10 a desire to speak, have filled out one of these and
11 provided it to us. If anyone still would like to fill one
12 out, raise your hand, and we would be happy to bring you
13 one.
14 Okay. We also have in the other room another place
15 for verbal testimony to be given, if in fact we had too
16 many folks and weren't able to accommodate everyone, and
17 maybe that will be the case later this evening.
18 You may also provide written comments on this card
19 and leave them in the comment box on your way out, and/or
20 you may provide written comments. You can send a letter to
21 Aimee Kinney. Her information is on this handout that was
22 at both tables in the back of the room. You may send a
23 letter directly to her or you may send information to her
24 via email, and her email address is here as well.
25 Okay. One last word on comments. We will have a

1 transcription report available probably in a week or two,
2 and information about getting copies of the transcription
3 is available on both of the doors in the back.
4 I wanted to talk also about the procedure for
5 presenting testimony this afternoon. We do have two folks
6 who have indicated a desire to speak. What we will do is
7 call your names and have you come up to the microphone, and
8 after you speak, you may sit down or continue standing, if
9 you like.
10 We do have a time keeper to keep track of time but I
11 don't think -- I think 3 to 5 minutes is an adequate period
12 of time, if that works. And I will remind you of those
13 procedures when we're getting ready for the verbal
14 testimony, in the event we've had some additional folks
15 show up.
16 So with that, I would like to introduce Bob
17 Chandler, and I'll be back.
18 BOB CHANDLER: Hello, I'm Bob Chandler from the
19 City of Seattle.
20 What you're looking at is a cross section of the
21 seawall. And you're looking from south to north.
22 What you see on the left is Elliott Bay and then a
23 seawall and Alaskan Way behind it. And what you'll notice
24 there is it, when we tend to talk about -- when we do talk
25 about the seawall, we don't mean the wall that touches the

1 water. We mean all that structure that holds the wall up.
2 And what you see there is 30 to 50 feet, depending on where
3 you are, of untreated timber structure that's actually a
4 support for the seawall. And that structure is 13 feet
5 down from the surface. So it's something that's not easily
6 accessible or easily examined.
7 And that was built, most of the seawall was built,
8 in the mid '30s and parts of it back into the teens, 1915
9 and 1918. But most of it was built in 1934 to 1937.
10 In the drawing there you will see a circle close to
11 where the wall is and that's a representation of some of
12 the things we found after the Nisqually earthquake.
13 Subsequent to the earthquake we discovered that we
14 had settlement on Alaskan Way and particularly in front of
15 the aquarium, and it dropped 2 or 3, maybe as much as 4
16 inches. So we dug a test pit there. And what we found in
17 the test pit is some of the wood. And this is actually a
18 section of the timbers out of the test pit. And this
19 particular piece of wood was 14 inches by 18 inches by 40
20 feet long. So this is what we found. So we found
21 substantial damage from marine borers in that test pit.
22 We also had some liquefaction underneath the
23 structure as a result of the earthquake. So we had a
24 number of things going on during the earthquake and after
25 the earthquake.

1 Because we found the damage at that location, we
2 went back and looked at six more locations along the
3 seawall. What we found in our test pits were four out of
4 the six test pits had additional damage. So we were
5 finding substantial damage from marine borers, and we
6 hadn't expected that.
7 We had some damage that we found in the '50s and
8 then in the '80s that we had been working on, but we hadn't
9 expected to be that substantial across the full length.
10 We then went out and did some additional testing
11 where we drove down steel probes trying to find the timbers
12 and this relieving platform under the ground, and what we
13 were finding is about 30 to 35 percent of those test probes
14 were not finding the seawall structure where we were
15 expecting to find it.
16 This is some further examples of the timbers that we
17 found down underneath Alaskan Way. So we had substantial
18 damage.
19 In addition, in the '80s we had damage to the steel
20 sheet pile that supports part of the seawall between the
21 aquarium and the ferry terminal.
22 At that time we went in and put in a covering with
23 ekki wood, which is a material that marine borers
24 historically have not chosen to eat or bother. It's a good
25 material for saltwater environments. And it worked real

1 well until about a year and a half ago. And we're still
2 investigating why, but what we're finding now is the marine
3 borers are starting to attack that protective surface.
4 So we now have a situation with we may have to do
5 some interim work in order to protect the seawall in order
6 to get a final fix. So we're continuing to have problems
7 with the structure of the seawall as we go. So even though
8 we've done repairs over the years, we're continuing to have
9 problems with them.
10 That seawall was built, as I said, in the 1930s.
11 That's actually a pretty good life for a structure in the
12 marine environment.
13 These are pictures of some of the original seawall
14 construction. The largest picture you see is a picture of
15 what was called Railroad Avenue then, which is now called
16 Alaskan Way. And the seawall was put in along the eastern
17 edge of the pier structure. And that's where it currently
18 is.
19 So what you can see there is the area where the
20 seawall is, and where Alaskan Way Viaduct is now is what
21 used to be in the bay. So this is very difficult and
22 challenging environment to do construction in.
23 You not only have the marine materials, you have the
24 fill that we placed. There is naturally occurring fill
25 there various ice ages, and parts of Mount Rainier and

1 parts of St. Helens. So there's a lot of stuff down there,
2 none of which allows very good construction techniques to
3 be used. And then you have all those timber piles that you
4 see there. So this is a very interesting place.
5 So that's the environment that we're working in.
6 And now, Tim, you going to talk about alternatives?
7 This will be Tim Shaw.
8 TIM SHAW: I'm going to talk about the
9 alternatives that we're looking at for replacement of the
10 seawall.
11 Our seawall is utilizing the seawall specific
12 information developed in support of the viaduct replacement
13 project.
14 The alternatives I show you today were developed by
15 the Alaskan Way Viaduct and Seawall Replacement Project.
16 I'll call it the Viaduct Project for short.
17 The Viaduct Project studied a range of seawall
18 alternatives, and we reviewed their alternatives. The
19 alternatives I'm presenting best met the goals of our
20 project and also the goals of the Viaduct Project.
21 Because the alternatives changed names during the
22 development in the Viaduct Project, the names I'm using
23 don't match the names in the Viaduct Project draft EIS, and
24 there's a board over there that shows the translation.
25 We're going to start with alternative 2.

1 Alternative 1 is the no action alternative. I'll be
2 discussing only the action alternatives. Bob was already
3 discussing some of the issues with the no action
4 alternative.
5 Alternative 2 is a vertical face wall with
6 structural frame and corresponds to the frame seawall
7 alternative in the draft EIS of the Viaduct Project. This
8 alternative is a concrete wall at the waterline. During an
9 earthquake, the soil behind the wall would liquefy and the
10 pressure would topple a simple wall. To make this wall
11 system strong enough, it is tied back to large drilled
12 shafts which act as anchors. The graphic shows that the
13 current timber structure remains in place as the new
14 structure is built around and through the old. They don't
15 have to take out the old one.
16 Next slide. This is alternative 3. This is drilled
17 shaft wall with soil improvements. In this alternative
18 there is also a drilled shaft concrete wall at the
19 waterline similar to alternative 2.
20 The drilled shaft wall supports the walkway, a
21 reinforced concrete face, and the 14 feet of soil below the
22 road, which will not be improved. This graphic shows the
23 improvement goes all the way up, but I believe that top
24 part is going to remain soil. The 14 feet is the area
25 above the old timber structure.

1 The soil improvement part of the project consists of
2 injecting grout into the soil behind the drilled shaft
3 wall. The grouting would extend back about 40 feet from
4 the wall, immobilizing the soil. The block of soil behind
5 the wall would become a large block of low strength
6 concrete.
7 Where alternative 2 strengthens the wall to resist
8 soil forces, this alternative solidifies the soil to reduce
9 the forces against the wall. In an earthquake the grouted
10 soil will not liquefy and will act as a underground dam,
11 resisting pressure from the soil further inland. The
12 graphic shows again that the old timbers remain because we
13 would inject the grout right between them.
14 And next slide.
15 It's already been noticed that this graphic, the
16 transportation alternative shown in this graphic reflects
17 what was published in the 2004 draft EIS of the Viaduct
18 Project. What alternative -- the details of that
19 alternative aren't really important to this discussion.
20 If the transportation project selects a tunnel, that
21 tunnel would run along the waterfront for about one-third
22 of the length of the seawall. In that location, the wall
23 of the tunnel itself will be the seawall. Right there.
24 Even if the tunnel is selected, the remainder of the
25 seawall from Union north to Myrtle Edwards Park would still

1 be replaced by one of the other alternatives we already
2 looked at. So alternative 4 actually would have to include
3 some of either alternative 2 or 3.
4 The Corps is not involved no the decision on the
5 viaduct replacement. Our alternatives are compatible with
6 any outcome of that decision.
7 And next slide.
8 There is more information on the alternatives in the
9 scoping packets available at the registration desk just
10 inside the door.
11 The Corps brings engineering technical expertise to
12 the team and may also be an additional funding source for
13 seawall reconstruction.
14 Our first step is to be sure that we're aware of
15 significant issues that need to be addressed in our seawall
16 EIS, and that's what we're here to talk about tonight.
17 At this point I'll turn it over to Melinda to begin
18 the testimony.
19 MELINDA POSNER: Thank you, Tim. Okay. All
20 right. Thanks.
21 Okay. So I still have two cards. Is there anybody
22 else who would like to speak who has provided a card?
23 No? Okay.
24 Well, then I will call out both of your names, and
25 if you could come up to the microphone right there, that

1 would be great. And I apologize if I pronounce any names
2 incorrectly, though there have been some instructions given
3 to me.
4 Gene Hoglund and Bud Shasteen.
5 GENE HOGLUND: Correct. Very good.
6 MELINDA POSNER: All right. Okay.
7 Mr. Hoglund.
8 GENE HOGLUND: Good afternoon, U.S. Army Corps
9 of Engineers and Aimee.
10 My name is Gene Hoglund. I'm a resident of Seattle
11 and a 49 year member of the International Association of
12 Machinists and Aerospace Workers. I'm retired.
13 MELINDA POSNER: Can I interrupt you for one
14 moment? Because I forgot to ask you to spell your last
15 name and note your address. I'm sorry.
16 GENE HOGLUND: Okay. My spelling of my last
17 name is H-O-G-L-U-N-D. My address is 3503 30th Avenue
18 West, Seattle 98199.
19 MELINDA POSNER: Thank you.
20 GENE HOGLUND: I am opposed to alternate 4, the
21 Alaskan Way tunnel that will be built over the Seattle
22 fault. I support alternate 3, the seawall. I believe it
23 would be the less expensive and I think it would probably
24 stand up better in an earthquake.
25 And dear Ms. Kinney:

1 In considering the issues of the major environmental
2 impacts, by this letter, enclosures and references, I
3 oppose the digging of a tunnel over the Seattle fault. The
4 City of Seattle has ignored and withheld works of many
5 geological experts in the EIS, who have in numerous studies
6 examined the Seattle fault, the attendant catastrophic
7 tsunami damage and lahar flows in the area of the proposed
8 Alaskan Way tunnel.
9 The Army Corps of Engineers should not become an
10 accomplice with the mayor's office in suppressing all
11 discussions and examinations of the hazards and risks
12 related to earthquakes on the Seattle fault and the
13 resulting tsunamis. If you do so, the history of disaster
14 preparedness in Seattle will judge you as severely as it
15 will those responsible for the inadequate levees of New
16 Orleans.
17 I have listed below a few of the many major risks to
18 the people of Seattle that were left out of the 2004 EIS:
19 The 2003 tsunami hazard map of Elliott Bay and the
20 Mount Rainier lahar flows;
21 The 2001 USGS map showing the Seattle fault zone
22 northern edge of the Colman Dock;
23 The 7 percent nearly half mile long tunnel grades;
24 The impact to water quality and marine habitats; and
25 The cumulative impacts of gridlock on this freight

1 corridor will have a devastating effect on maritime and
2 other industries.
3 This withholding of vital information in the EIS of
4 federal hazard maps is a wrongful act by the City of
5 Seattle to cover up the risks to the citizens who will be
6 forced to drive in this most expensive and dangerous one
7 mile tunnel in the USA.
8 And I list the tsunami hazard maps, which can be
9 downloaded and which I will email.
10 The two Seattle fault rupture zone US maps, showing
11 the location of structures of the Seattle fault zone.
12 The map showing the fault north of the Colman Dock,
13 which is enclosed, which would be directly under the city's
14 proposed tunnel, can also be found.
15 And I wanted to note that -- suggest that the
16 surface rupture of this fault zone occurred as recently as
17 a thousand years ago, with as much as 22 feet of vertical
18 displacement. The northern portion of the zone appears to
19 be the most recently active and capable of rupturing the
20 ground surface. And this is a quote from the Alaskan Way
21 Viaduct Geology and Soils Technical Memorandum.
22 And I'll just kind of skip by the other volcano
23 hazards.
24 But I'm going to address the Washington state Growth
25 Management Act, which is an RCW for the state of

1 Washington, and it requires all cities to identify
2 geological hazard areas within their jurisdictions and
3 formulate development regulations for their protection.
4 Geological hazard areas are defined as areas, because of
5 their susceptibility to earthquakes, faulting or other
6 geological events, are not suited for development
7 consistent with the public health and safety concerns.
8 On August 16 a letter informed the mayor of Seattle
9 that the critical area update required the city to include
10 the Seattle fault and tsunami as geological hazards. The
11 mayor and staff ignored this section of state law in this
12 update. I believe this is an attempt to cover up the
13 dangers and risks at this location of this tunnel to allow
14 the city to ignore federal guidelines for tsunami hazards.
15 And I'm going to include it. It's about a 62 page on what
16 to build in a tsunami inundation area.
17 The Alaskan Way Viaduct and Seawall Replacement
18 Project, engineering manager, in a letter to me dated
19 February 4, indicated it would be prudent to analyze the
20 risk of flooding of the tunnel due to an earthquake on the
21 Seattle fault, and the possible resulting tsunami.
22 Their preliminary examination of the risk indicate
23 that should such an event take place, the tunnel would only
24 be partially flooded. While this view may be too
25 optimistic, the map shows 6 to 16 feet of inundation at the

1 north end of the tunnel.

2 Scientists take seriously the potential risks which
3 the are posed by the Seattle fault and by the inundation
4 from tsunamis.

5 The Army Corps of Engineers, who are contemplating
6 financial aid and permitting new construction on the
7 Seattle fault that crosses east to west, and is something
8 which simply cannot be ignored, should also consider these
9 risks.

10 The impacts to businesses. The maritime industrial
11 groups in Ballard and state truckers association are
12 rallying to fight the waterfront tunnel because of the cost
13 and loss of this transportation corridor. And I have
14 included that article.

15 Additionally, state representative Mary Lou
16 Dickerson has raised the issue of mega transportation
17 projects averaging 40 percent cost overruns. This letter
18 also states that the citizens of Seattle will have to bear
19 the extra cost of burden.

20 There is no financial risk to the mayor of Seattle,
21 supporter of the tunnel. He has taken huge campaign
22 contributions from a group that supports building the
23 proposed tunnel.

24 And I'm going to quote from another document which I
25 have included.

1 Cost underestimations and overruns cannot be
2 explained by error and seem to be best explained by a
3 strategic misrepresentation; namely, lying with a view to
4 getting the project started.
5 And that is included.
6 While it appears that no one has a crystal ball to
7 know when the Seattle fault earthquake will occur, the fact
8 is it's not if, but when.
9 The USGS maps and the tsunami hazard map of Elliott
10 Bay shows very clearly that an earthquake on the Seattle
11 fault can generate tsunamis and would result in severe
12 vertical disruption of the tunnel. There is every reason
13 to believe that these effects could jeopardize public
14 safety.
15 Because of the RCW 47 requires the improvement the
16 traveler safety and because of the proposed Alaskan Way
17 tunnel would be built over an active fault, with many
18 attendant risks to life and safety, we request that the
19 tunnel no longer be considered as a replacement of the
20 elevated roadway on the Seattle waterfront.
21 The safety of the citizens from the earthquake
22 fault, tsunami flooding of this tunnel, and other dangers
23 has yet to be addressed in the EIS.
24 And the history of misrepresentation of the Seattle
25 fault and its location by city officials and the Washington

1 State Department of Transportation should raise a red flag.
2 I believe the Army Corps of Engineers should contact the
3 Justice Department for an investigation of
4 misrepresentation, fraud and corruption, before any permit
5 is issued for a waterfront tunnel.
6 And my name is Gene Hoglund, and thank you very
7 much.
8 MELINDA POSNER: Thank you. Thank you.
9 BUD SHASTEEN: Good afternoon. My name is Bud
10 Shasteen from West Seattle. Address is 7333 39the Avenue
11 Southwest, Seattle 98136-2102. Good citizen, I use that
12 dash number.
13 I'm very glad to find out the U.S. Army Corps of
14 Engineers is involved in this. I'm not going to discuss
15 New Orleans here, but I think we'll get it right in
16 Seattle.
17 I do have a couple of questions. My main point
18 being here today is I want to get the alternative that will
19 be least disruptive of traffic. And of course money is a
20 question here.
21 I was talking to Mr. Tim Shaw, and he relieved me a
22 little bit in saying we're talking 600 to 800 million
23 dollars. And that was kind of a relief, because we've been
24 faced with people talking about billions of dollars here.
25 I have a comment. I can't quite believe that when

1 they first built the seawall, they didn't use treated
2 lumber. I think they had creosote in those days. But
3 maybe that's all they used. That's a little question I
4 would like to ask.
5 Looking at their alternatives, it looks like
6 alternative 2 or alternative 3 would do the job. And I
7 would also like to have someone discuss the relative
8 expenses involved in the two alternatives.
9 I do believe that this is a good session. I'm glad
10 to be here. And if we could answer those couple of
11 questions I had about it, it looks like either alternative
12 would do what we need to do. And I just wanted to know
13 what would happen if we do alternative 1. Would our docks
14 collapse? It looks like they would, with the shape of the
15 wood that you've brought out of there.
16 So I would favor alternative 2 or 3. Probably 3
17 looks like it would be a little less expensive.
18 So I would like to have answers to that, if I could
19 get them.
20 Thank you.
21 MELINDA POSNER: Thank you.
22 Is there any other public testimony at this point?
23 Okay.
24 Well, with that I think we can close the public
25 testimony. If we do have anyone show up between now and

1 3:30, we can take that. And we probably have time for
2 questions and comments with the individual stations and
3 representatives who are here.
4 Thank you very much.
5 [Applause.]
6 [2:42 p.m.]
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1 APRIL 18, 2006

2 [5:46 p.m.]

3 COLONEL LEWIS: Thank you for delaying so we

4 could have a few more folks join us.

5 Good evening, ladies and gentlemen. Welcome to the

6 public scoping meeting for the Alaskan Way Seawall

7 Environmental Impact Statement, or EIS, sponsored by the

8 Army Corps of Engineers and the City of Seattle. My name

9 is Colonel Debra Lewis. I am the district engineer for the

10 Seattle District, U.S. Army Corps of Engineers. I will be

11 conducting tonight's meeting.

12 We are here this evening to talk about potential

13 environmental impacts of rebuilding the Alaskan Way

14 Seawall.

15 The seawall study area extends from Washington

16 Street to Broad Street along the Elliott Bay shoreline in

17 downtown Seattle. The seawall structure is under Alaskan

18 Way surface street and varies in width between 40 and 60

19 feet.

20 The seawall structure supports the waterfront piers,

21 Alaskan Way surface street, utilities under the Alaskan

22 Way, and the soils supporting the Alaskan Way Viaduct. The

23 purpose of the Corps' Alaskan Way Seawall Project is to

24 prevent shoreline erosion and infrastructure damage.

25 Before we proceed to the public testimony portion of

1 the meeting, we want to give you some information about the
2 Corps' Alaskan Way Seawall Project. After I say a few
3 words about the purpose of this meeting, Melinda Posner --
4 Melinda, raise your hand -- a facilitator from the
5 consulting firm Jones & Stokes, will go over the ground
6 rules and format of the comment session.
7 Then Bob Chandler, sitting right next to me, the
8 Seattle Department of Transportation project manager, will
9 speak a few minutes about the events that led to this
10 study.
11 Next Tim Shaw, who is from the U.S. Army Corps of
12 Engineers, project manager, will tell you where we are in
13 the project.
14 After these brief presentations, we will accept
15 comments from those individuals who have indicated a desire
16 to speak. So we don't have that many people who have said
17 that they're going to speak. So if you still want to
18 speak, please put your name in.
19 We will adjourn at 7 p.m. or earlier if there is
20 lack of interest, and we quickly efficiently get over this
21 process.
22 The National Environmental Policy Act, or NEPA, is a
23 law that's set up a process to study the environmental
24 effects of federal actions. It helps decision makers like
25 me to take environmental consequences into account when

1 choosing between different project alternatives and
2 mitigation measures.
3 NEPA also set up a process for disclosing
4 information to and solicitating comments from the public.
5 For major federal projects like this one, we accomplish
6 these things by preparing an environmental impact
7 statement, or EIS.
8 This slide shows the steps involved in preparing an
9 EIS.
10 The first step is to publish a notice of intent to
11 prepare an EIS in the Federal Register. The notice of
12 intent for this project was published on March 31, 2006.
13 This notice was the beginning of a 30 day comment period on
14 the scope of the seawall EIS.
15 The next step is scoping. The scoping period for
16 the Corps' Alaskan Way Seawall Project is going on right
17 now. Scoping is the time when we determine what issues and
18 alternatives will be addressed in the EIS. Scoping is one
19 of the best times for the public to provide early input on
20 a project.
21 By identifying the issues that concern you about
22 rebuilding the Alaskan Way Seawall, we can ensure they are
23 properly considered and studied. This meeting is one way
24 you can provide input on the EIS. We are here to listen to
25 your thoughts, concerns, and ideas about rebuilding the

1 Alaskan Way Seawall.
2 For example, are there other alternatives we should
3 consider? Do you have ideas about how to improve one of
4 our alternatives? What do you want to know about the
5 impacts from the project? What concerns do you have about
6 how this project may affect your business or residence?
7 The 30 days for public input on this phase of the
8 EIS is over at the end of this month. We will then move
9 onto the next step and begin preparing the draft EIS.
10 The EIS will be part of the Corps' feasibility
11 report and will describe alternatives and their impacts as
12 well as possible ways to mitigate for these impacts. We
13 expect the draft EIS to be released for public review and
14 comment in 2008. At that time we'll open another public
15 comment period and have more public meetings to provide you
16 with the opportunity to give additional input.
17 All the comments we receive on the draft EIS will be
18 addressed in the final EIS. A record of decision will then
19 be signed before any action is taken.
20 There are several other large projects being
21 developed for the Seattle waterfront right now. These
22 projects are related to the Alaskan Way Seawall but are not
23 included in the Corps' Alaskan Way Seawall Project.
24 For example, Washington State Ferries is planning
25 upgrades for Colman Dock as part of their system plan.

1 Seattle Parks and Recreation -- and right now and
2 Seattle Planning. We have Robert Scully. Please raise
3 your hand. Who is working here from Seattle Department of
4 Planning and Development. And so they're working on master
5 parks plans for the central waterfront, including options
6 for improvements to the Waterfront Park and Pier 62 and 63.
7 Another very visible project is the effort by the
8 Washington State Department of Transportation, the Federal
9 Highway Administration, and the City of Seattle to replace
10 the Alaskan Way Viaduct.
11 Now, tonight we have Amy Grotenfendt -- if she'll
12 raise her hand. She's here on the Alaskan Way Viaduct.
13 So there is information about each of these projects
14 on a table to my left near the back of the room.
15 We are working cooperatively with the agency
16 proponents of these projects to achieve mutual goals for
17 the future of Seattle's waterfront and ensure compliance
18 with existing laws and regulations.
19 The Alaskan Way Seawall serves many different
20 functions on a very busy waterfront in downtown Seattle.
21 Because the seawall is showing signs of failure to perform
22 many of its functions, many agencies at federal, state and
23 local levels are involved in replacement efforts.
24 The efforts of all these agencies are not mutually
25 exclusive. The link among them all is the City of Seattle,

1 the owner of the seawall.

2 Bob Chandler, who I introduced earlier, the City of
3 Seattle project manager for the Alaskan Way Seawall
4 Project, will speak with you in a few moments about the
5 importance of the seawall to the city.

6 The effort to replace the Alaskan Way Viaduct is the
7 project that is most closely related to the Corps' Alaskan
8 Way Seawall Project. Rebuilding of the Alaskan Way Seawall
9 is included in the viaduct replacement project because one
10 function of the seawall is to support the waterfront
11 portion of the State Route 99 transportation corridor
12 extending from Washington Street to Broad Street.

13 Because the same length of seawall is being
14 evaluated by the two projects, the outcomes of the two
15 efforts are clearly closely related. The agencies involved
16 are all coordinating accordingly.

17 The decision for the transportation alternative may
18 determine the alternative selected for the central
19 waterfront portion of the Corps' Alaskan Way Seawall
20 Project from Washington to Union or about one-third the
21 total length of the seawall.

22 Although the Corps is not involved in the decision
23 on the viaduct replacement, our seawall alternatives are
24 compatible with any outcome of the transportation project.

25 The Corps has and will continue to incorporate

1 seawall work completed by our partner agencies on the
2 transportation project into the Corps' Alaskan Way Seawall
3 study.
4 In order to obtain approval from Congress to
5 participate in a construction project of this magnitude, we
6 must prepare an EIS that focuses on the seawall as a
7 structure that prevents shoreline erosion and
8 infrastructure damage. The body of work developed for the
9 transportation project will be utilized where possible to
10 reduce our study time and effort and minimize any
11 redundancies within the projects.
12 The variety of functions that the seawall serves and
13 the multitude of agencies interested in replacement of the
14 seawall speaks to the importance of this structure to the
15 public interest. This evening we are here to listen to the
16 public's thoughts, concerns and ideas about rebuilding of
17 the seawall.
18 The purpose of our scoping meeting for the Corps'
19 Alaskan Way Seawall EIS is very specific. We want to hear
20 if you have a specific suggestions on issues to be covered
21 in the seawall EIS.
22 We are here to share what we know and for me to
23 gather information to consider in our process. We are not
24 here to debate the pros and cons of specific alternatives.
25 We will not take comments on the transportation project.

1 In order to make sure that everyone who wishes to
2 speak is able to do so, we will not have a question and
3 answer session.
4 We will carefully consider your comments when
5 developing the EIS for this project. Your observations
6 will help us improve the NEPA process. Written and oral
7 presentations will be given equal weight.
8 And I did want to mention we do have the ability to
9 do oral -- if you want to do it separately and not in front
10 of the group, we have a separate room set up.
11 Now I will hand the microphone over to Melinda
12 Posner, who will go over ground rules for the public
13 testimony portion of the meeting.
14 MELINDA POSNER: Thank you.
15 Good evening. Melinda Posner, facilitator for the
16 meeting tonight.
17 My role is really to make sure that we are able to
18 meet the meeting objectives as outlined by Colonel Lewis,
19 to make sure we stay on track, and conclude the meeting on
20 time, and make sure we have the opportunity for all the
21 comments to be heard or provided in either written form or
22 talk one-on-one with our team members.
23 So to do that, we have designed a meeting format
24 that includes an open house, where you had the opportunity
25 to look at some of the materials and talk with team

1 members, and then the presentation, which is what's going
2 to be occurring next, and then time for public testimony.
3 And we've shortened this just a little bit, in looking at
4 the crowd and how many comments we've received from those
5 who want to speak. And that way we'll have additional time
6 perhaps for meeting one or one with staff members.
7 This is the second meeting that we've had. We had
8 an earlier one this afternoon. And we were glad to see
9 some folks there as well.
10 In order to have a successful meeting, I'm just
11 going to touch on some ground rules, very basic, kind of
12 common rules of behavior. But I think we will be even more
13 productive by following them.
14 Turning off all cell phones and pagers. Thank you
15 very much.
16 Stay focused on the meeting purpose. And Colonel
17 Lewis talked about what this meeting is and what this
18 meeting is not. We know there are some very clear links to
19 some other projects. But we're here to hear about the
20 seawall and we're going to try to have you focus your
21 comments on that.
22 And as she also mentioned, we do have additional
23 staff members representing these other projects. So you do
24 have the opportunity to share comments, ask questions, and
25 obtain additional information on those kind of separately

1 from the public testimony.
2 Recognize the role of the facilitator. That just
3 means recognizing that I am here and that I am managing
4 this part of the meeting and the public testimony, and
5 wanting to make sure that everyone has an opportunity to
6 speak, and that we do it in a manner that provides equal
7 opportunity.
8 In some cases I may have to interrupt or redirect.
9 I'm not expecting to have to do that too much this evening.
10 Actively listen. We ask that you do actively
11 listen, that you are respectful of others and others'
12 opinions. And that you refrain from side discussions
13 during the presentation and the public testimony, so that
14 you're all able to hear all the comments, and also we're
15 able to record them. We do have a court reporter who is
16 recording all comments.
17 Focus on providing new information. And, again,
18 this is a little more directed, and we have a lot of
19 people, a lot of folks commenting, and we are hearing the
20 same set of comments over and over. We are giving equal
21 weight to both oral and written comments. And once those
22 comments have been made, they are recorded. So it's not
23 necessary for you to repeat all of the previous comments
24 you've heard. You certainly can get up and share that you
25 would echo and agree with all the comments that have been

1 put forth so far.
2 And, again, as Colonel Lewis mentioned, we'll just
3 be accepting comments during the testimony and not
4 answering question.
5 So I wanted to talk a little bit about the
6 commenting opportunities. At the very beginning of the
7 room, at both tables actually, the blue cards. These allow
8 you to write a comment and leave it with us in the comment
9 box. And/or check off the box that says: I would like to
10 speak.
11 And I have received one comment card so far. I
12 wanted to make sure that, if there is anyone else who would
13 like to speak during the public testimony period, if you
14 want to raise your hand, we can get a card to you. And if
15 not, we'll have this one scheduled.
16 Okay.
17 In terms of providing other comments, Colonel Lewis
18 also mentioned we do have a room set aside to provide
19 verbal testimony. Not in a public forum. And you're
20 welcome to do that during this time.
21 I mentioned providing the written comments and
22 leaving those with us. But also if you would like to take
23 more time and share comments with us, there is an
24 information packet in the back that looks like this, and at
25 the bottom there is an email address for Aimee Kinney, who

1 is right here, and also a physical address for her, if you
2 want to mail a letter.
3 So those are the ways that you can comment.
4 There will also be a transcription available
5 probably a week or two, but that is also available to you.
6 There is instructions on the back door, back there, that
7 tell you who to contact to get a copy of the transcription.
8 Okay.
9 And then I was just going to talk a little bit about
10 the procedure for presenting testimony. Since we only have
11 one person, it makes it a little bit easier. But we were
12 expecting about three to five minutes per comment. And
13 I'll be asking you to come up and state your name and
14 address, and we'll have your comments.
15 And then we'll have some wrap up, wrap up comments
16 from the colonel.
17 All right.
18 And with that, I would like to introduce -- all of a
19 sudden I'm looking at you thinking: Who is that? Bob
20 Chandler, Seattle Department of Transportation. You're
21 going to sit at the table too.
22 [Handing microphone over.]
23 BOB CHANDLER: Okay.
24 Again, I'm Bob Chandler from the City of Seattle,
25 and thank you for coming this evening.

1 Up on the slide or up on the wall you'll see a slide
2 of the seawall, and on your left you will see Elliott Bay,
3 and then the actual wall that touches the sea, and you'll
4 see a lot of timber back underneath the Alaskan Way.
5 So when we talk about the Alaskan Way Seawall, we
6 really don't talk about or mean just the wall that touches
7 the water. We're talking about that structure underneath
8 Alaskan Way. And that structure is 40 to 60 feet wide and
9 it's made out of timber. And most of it was constructed in
10 the 1930s. Some of it goes back as far as 1915 but most of
11 it was built in the 1930s.
12 That timber that's back in there is 13 feet down.
13 It's untreated timber. And it's actually done fairly well,
14 for a marine environment. It's been there for 70 years.
15 But after the Nisqually earthquake we noticed
16 settlement right in front of the aquarium. And the street,
17 Alaskan Way, dropped about three inches. So we dug a test
18 pit there, and what we found was a lot of the timbers that
19 supported by the seawall had been attacked by marine
20 borers. And this is one of the timbers actually out of
21 that particular pit. And this piece of wood or timber was
22 14 inches by 18 inches by 40 feet long. And this is the
23 section right near the seawall or under that part of
24 Alaskan Way, and that's what the marine borers have caused
25 or damage they have caused.

1 What we then did is we looked and we dug six other
2 test pits along Alaskan Way, up and down the length of it,
3 and four of those six areas we found additional damage
4 similar to what we are seeing here. Some of it worse, some
5 of it a little better.
6 So we went out and did some additional probing with
7 steel probes, and we sunk those every 100 feet along
8 Alaskan Way. And what we found was about 30 to 35 percent
9 of the seawall structure has had some form of damage. And
10 because it's 13 feet down, we can't truly assess all the
11 details of it or how bad it is but we know that we have
12 some substantial problems.
13 We also had during the earthquake -- and on that
14 picture that's on the screen there's a little circle near
15 the seawall. And in that area there was liquefaction. And
16 this soil is all fill, and when you have earthquakes, that
17 tends to liquefy. So we had voids form underneath the
18 seawall. So we had another issue that causes seawall to be
19 vulnerable, which is seismic activity.
20 Now we can go onto the other slide.
21 And this is just another example, from some of the
22 test pits that we dug out there, of the damage that we were
23 seeing from marine borers.
24 The other issue we've had that's come up since the
25 earthquake is in the areas between the aquarium and the

1 ferry terminal we have a sheet pile wall, and that wall
2 over time has corroded. So in the mid '80s we put in a
3 covering, and this covering was made out of what's called
4 ekki wood, and this is a piece of the wood out of that
5 covering. And it's a material that was supposedly
6 impervious to marine borers. In fact, for 15 to 20 years
7 it did quite well.
8 Over the last two years what we've seen is an
9 increasingly progressive and very rapid attack by a
10 different type of marine bore called ship worms that's now
11 attacking the facing on the seawall. And it's become very
12 rapid now to where we're up to probably 15 percent of it
13 has been damaged. So we may have to end up having to some
14 interim work to protect the seawall until we come up with
15 an ultimate fix. So the seawall itself over the last
16 several years has continued to see increasing damage from
17 marine borers.
18 Go ahead.
19 Just a little bit on the history. And you can see
20 some slides here. And if you look at the picture on the
21 upper right, that was taken in 1931. And on the left of
22 that picture are the existing piers that are out there now.
23 And that's where the seawall is.
24 So what Seattle did, in order to create a deep water
25 Harbor, is really took the land to the sea. So everywhere

1 out there where the seawall is, where Alaskan Way is, where
2 Alaskan Way Viaduct is, was formerly part of Elliott Bay.
3 This presents some real challenges for us from a
4 construction standpoint, because this area is either fill
5 that was placed when the seawall went in. Or if you look
6 there, there is a lot of timber, a lot of piling and a lot
7 of materials. And most of that material is not very
8 competent material. So from a structural standpoint, it
9 does not support structures of any kind.
10 So in order to work in this area presents a real
11 challenge. So that's one of the issues here, is we're
12 working in a very wet, an environment that the soils are
13 poor, and we have a lot of debris and timber that's left
14 there from the 1880s on. So it's a very challenging
15 environment.
16 With that, Tim's going to talk about some of the
17 alternatives that we're going to look at.
18 TIM SHAW: I'm Tim Shaw, the project manager
19 for the Corps of Engineers, and I will talk about the
20 alternatives.
21 Our seawall study is utilizing the seawall specific
22 information developed in support of the viaduct replacement
23 project. The alternatives I'll show you today were
24 developed by the Alaskan Way Viaduct and Seawall
25 Replacement Project, which I'll call the Viaduct Project

1 for short.
2 The Viaduct Project studied a range of seawall
3 alternatives, and we reviewed their alternatives. The
4 alternatives I'm presenting best met the goals of our
5 project and also the goals of the Viaduct Project.
6 Because the alternatives changed names during
7 development of the Viaduct Project, the names I'm using
8 don't match the names you'll see in the Viaduct Project
9 draft EIS. But we have a crosswalk over here if you wanted
10 to look them up.
11 Alternative 1 -- we should see alternative 2 up
12 there. Alternative 1 is the no action alternative, which
13 I'm not going to discuss. I'll be talking about the action
14 alternatives.
15 Alternative 2 is a vertical face wall with
16 structural frame and corresponds to the frame seawall
17 alternative in the Viaduct Project draft EIS. This
18 alternative is a concrete wall at the waterline. During
19 the earthquake the soil behind the wall would liquefy and
20 the pressure would topple a simple wall. To make this wall
21 system strong enough, it is tied back to large drilled
22 shafts which act as anchors.
23 The graphic shows the current timber structure
24 remains in place as the new structure is built around or
25 through it.

1 Alternative 3 is the drilled shaft wall with soil
2 improvements. In this alternative there is also a drilled
3 shaft concrete wall at the waterline similar to alternative
4 2. The drilled shaft wall supports the walkway, a
5 reinforced concrete face, and the 13 feet of soil below the
6 road that not be improved. The 13 feet is the area above
7 the old timber structure.
8 The soil improvement part of the project consists of
9 injecting grout into the soil behind the drilled shaft
10 wall. The grouting would extend back about 40 feet from
11 the wall, immobilizing the soil. The block of soil behind
12 the wall would then become a large block of low strength
13 concrete.
14 Where alternative 2 strengthens the wall to resist
15 soil forces, this alternative solidifies the soil to reduce
16 the forces against the wall. In an earthquake, the grouted
17 soil will not liquefy and will act as an underground dam
18 resisting pressure from soil further inland. The graphic
19 shows again that the old timbers would remain because we
20 would inject the grout between them.
21 And that graphic, the pink area is the improved
22 area, and it kind of exaggerates it a bit. That upper area
23 wouldn't actually be improved and it ends about the back
24 end of the timbers.
25 And next slide.

1 The transportation alternative shown in the graphic
2 reflects what was shown in the 2004 draft EIS from the
3 Viaduct Project. So we recognize that that's not
4 necessarily current.
5 If the transportation project selects a tunnel, that
6 tunnel would run along the waterfront for about one-third
7 of the length of the seawall. In that location the wall of
8 the tunnel itself would be the seawall. Even if the tunnel
9 is selected, the remainder of the seawall would be replaced
10 by one of the other alternatives. So alternative 4
11 actually would have to include some of either alternative 2
12 or 3.
13 The Corps is not involved in the decision on the
14 viaduct replacement. Our alternatives are compatible with
15 any outcome of that decision.
16 And next slide.
17 There is more information on the alternatives in the
18 scoping packets available at the registration desk. The
19 Corps brings engineering technical expertise to the team
20 and also may be an additional funding source for seawall
21 construction.
22 Our first step is to ensure that we are aware of the
23 significant issues that need to be addressed in the seawall
24 EIS. That's what we're here to talk about tonight.
25 At this point I'll turn the meeting back over to

1 Melinda for the testimony.
2 MELINDA POSNER: Thank you, Tim.
3 Okay. Craig Keller is our speaker. If you want to
4 come up to the microphone, that would be great, and share
5 your comments.
6 CRAIG KELLER: Okay.
7 MELINDA POSNER: If you could also spell your
8 name and state your address.
9 CRAIG KELLER: Thank you.
10 My name is Craig Keller, a resident of West Seattle,
11 4445 53rd Avenue Southwest. Traveled on the viaduct to
12 come here tonight.
13 I am speaking for a group of engineers and
14 interested citizens who would have more of a problem with
15 the EIS process on the transportation level. And I totally
16 understand that's not totally apropos to what we're doing
17 here tonight.
18 But as has been discussed, these issues are in a
19 common publication, the draft EIS, and so many of -- there
20 are some common issues, especially in a tunnel project
21 where the seawall is proposed to have this -- a common wall
22 with the tunnel.
23 So because of that I am coming and asking that the
24 Army Corps' EIS inform itself of some of these interlocking
25 issues.

1 The greatest problem that we see with the other EIS
2 process is the fact that decisions have been made, and a
3 retrofit option, which is the lowest impact for traffic
4 disruption, has been eliminated from official consideration
5 without due consideration to the transportation impacts.
6 They will be severe.
7 It's also -- that process has happened without due
8 consideration to utility interruptions. Those are both
9 construction impacts that a seawall project will have as
10 well, and they'll be sharing -- you know, there will be
11 some common responsibility to all those.
12 Just for a little brief information on those
13 transportation impacts, we know that the projection from
14 the Washington Department of Transportation is that with
15 either a tunnel or a rebuild project, the total closure of
16 the viaduct will be between one and a half and three and a
17 half years, with partial closure up to 11 or 12 years.
18 Washington Department of Transportation has also
19 gone on record stating that, with that closure, that the
20 congestion to I-5 traffic through downtown Seattle will
21 move from five hours a day to 14 hours a day. So these
22 impacts will indeed be severe.
23 Beyond the negative impacts to regional economy and
24 access to federal facilities due to transportation
25 restrictions, the city's tunnel seawall project also

1 presents the most deleterious effects upon electricity,
2 water, sewer, telecommunications and natural gas service to
3 all facilities, including federal facilities, Coast Guard
4 among them.
5 Quote, "Multiple relocations of utilities could
6 affect the local economy by increasing the risk of frequent
7 and/or accidental loss of service to retail and commercial
8 businesses. The utility construction sequencing of the
9 Alaskan Way Viaduct and Seawall Replacement Project will be
10 a major undertaking in and of itself."
11 And that was a quotation from the draft EIS -- well,
12 it's the utility relocation. What would that be? The
13 Appendix O, I believe.
14 So, in conclusion, we think the seawall project is
15 sort of -- there's an attempt to inextricably link it with
16 the transportation project. And I do hope that the Army
17 Corps' EIS process informs itself of those effects.
18 For example, we see three different options on
19 seawall. And just to inform the public how the pressures
20 from the transportation side, which may have faulty EIS
21 process, how that has influenced or attempted to influence
22 the progress or the development of the seawall project
23 itself independently, and then how that affects the attempt
24 to obtain federal dollars for a non-seawall type project.
25 So I thank you very much.

1 MELINDA POSNER: Thank you very much.
2 Okay. That concludes our public testimony period.
3 We are here until 7 o'clock. And what I thought I
4 might suggest is we could have our concluding comments from
5 the colonel, and that way you are free to stay until 7 and
6 talk with team members, and/or you can leave, but clearly
7 show where we are at the end of, you know, this
8 presentation period.
9 Okay.
10 With that, I'll bring the microphone back.
11 COLONEL LEWIS: Okay.
12 As I mentioned earlier, the official scoping period
13 will be open through April 30. Written comments may be
14 sent to the U.S. Army Corps of Engineers until that date.
15 Our mailing address is on the screen and on the scoping
16 information packet at the registration table at the back of
17 the room.
18 Following the close of the scoping period, we will
19 prepare the draft environmental impact statement, taking
20 into consideration the comments received. We will have
21 additional public meetings once the draft EIS is complete.
22 That's likely in 2008.
23 On behalf of the U.S. Army Corps of Engineers and
24 City of Seattle, I wish to thank you all for coming and
25 participating in tonight's meeting.

1 Thank you.

2 [Applause.]

3 [6:19 p.m.]

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CERTIFICATE

THE STATE OF WASHINGTON)
)
COUNTY OF KING)

I, the undersigned officer of the Court under my commission as a Notary Public in and for the State of Washington, hereby certify that the foregoing deposition upon oral examination of the witness named herein was taken stenographically before me and thereafter processed under my direction;

That the witness before examination was first duly sworn by me to testify truthfully; that the transcript of the deposition is a full, true and correct transcript of the testimony; That I am neither attorney for nor a relative or employee of any of the parties to this action; further, that I am not a relative or employee of any attorney or counsel employed by the parties hereto, nor financially interested in its outcome.

IN WITNESS WHEREOF, I have hereunto set my hand and seal this 1st **day of** June **2006.**

Paul Frederickson

NOTARY PUBLIC in and for the State of Washington residing at

FOX ISLAND

Appendix D

Written Comments-Email or Letter

RECEIVED
APR 18 2006

Eugene Hoglund
3503 30th Ave. W
Seattle, WA 98199
206-378-0722

April 18, 2006

Ms. Aimee Kinney
U.S. Army Corps of Engineers, Seattle District
Environmental Resources Section
P.O. Box 3755
Seattle, WA 98124-3755

Re: **Opposition to Alternative 4 - Alaskan Way Tunnel, built over the Seattle fault.**
I SUPPORT ALTERNATIVE-3 SEAWALL. EPH

Dear Ms. Kinney:

In considering the issues of major environmental impacts, by this letter, enclosures and references, I opposed the digging of a tunnel over the Seattle Fault. The City of Seattle has ignored and withheld the works of many geological experts in the EIS who have, in numerous studies, examined the Seattle Fault, the attendant catastrophic tsunami damages and lahar flows to the City of Seattle in the area of the proposed Alaskan way Tunnel.

The Army Corps of Engineers should not become an accomplice with the Mayor's office in suppressing all discussions and examination of the hazards and risks related to Earthquakes on the Seattle Fault and resulting tsunamis. If you do so, the history of disaster preparedness in Seattle will judge you as severely as it will those responsible for the inadequate levee of New Orleans.

I have listed below a few of the many major risks to the people of Seattle that were left out of the 2004 EIS. (1) The 2003 Tsunami Hazard map of Elliott Bay & Mount Rainier Lahar Flows. (2) The 2001 USGS map, Seattle Fault zone shows the northern edge north of the Colman dock. (3) The 7% nearly ½ mile long tunnel grades. (4) Impacts to water quality and marine habitats (5) the cumulative impacts of gridlock on this freight corridor will have a devastating effect on the maritime and other industries. This withholding of vidal information in the EIS of federal hazard maps is a wrongful act by the City of Seattle to cover-up the risk to the citizens who will be forced to drive in the most expensive and dangerous 1-mile tunnel in USA.

1. **Tsunami Hazard Map of the Elliott Bay Area, Seattle, Washington: Modeled Tsunami Inundation from a Seattle Fault Earthquake"** was funded by congress and developed with the help of the city of Seattle and the 2002 Puget Sound Tsunami Sources workshop report Site: http://www.dnr.wa.gov/geology/pubs/pubs_ol.htm#hazards ofr-2003-14 (Map has been filed with the Seattle Department of Planning and Development on March 8, 2005

2. Seattle Fault Rupture Zone USGS Map shows location of structures in the Seattle Fault Zone. The maps showing the fault north of Coleman Dock is enclosed, which would be directly under the Cities proposed tunnel and can also be found.
http://earthquake.usgs.gov/regional/pacnw/activefaults/sfz/sfzfig2a.html
http://wrgis.wr.usgs.gov/docs/wgmt/pacnw/lifeline/map66kb.html

Note "...**suggest that surface rupture of this fault zone occurred as recently as 1,100 years ago with as much as 22 feet of vertical displacement"..."the northerner portion of the zone appears to be the most recently active and capable of rupturing the ground surface"** Quote taken from AWV&SRP Geology and Soils Technical Memorandum Page 27, March 2004.

3. Volcanic Hazard Areas are describe in the King County Executive Report of the Best Available Science, Volume 1, dated February 2004, and USGS Plate 11 OFR 98-428 is a map on a lahars flow from an eruption on Mount Rainier that covers parts of the Seattle waterfront. The Volcanic Hazard is described in detail in the BAS report of King county.

4. The Washington State Growth Management Act (RCW 36.70A) requires all cities to identify geologically hazardous areas within their jurisdictions and formulate development regulations for their protection"... Geologically hazardous areas are defined as areas that because of their susceptibility to earthquakes (faulting, liquefaction) or other geologic events--are not suited for development consistent with public health and safety concerns

On August 16, 2005 a letter informed the Mayor of Seattle that the Critical Area update required the city to include the Seattle fault and Tsunami as geological hazards. The Mayor and *staff ignored this section of State law in the Seattle's update. I believe this is attempt to cover-*up the dangers and risk at this location of this tunnel to allow the city to ignore the federal guidelines for tsunami hazards, (Designing for Tsunami enclosed)

The Alaskan Way Viaduct and Seawall Replacement Project Engineering Manager, in a letter to me dated February 4, 2005, indicated, "it would be prudent to analyze the risk of the flooding of the tunnel due to an earthquake on the Seattle Fault, and a possible resulting tsunami". There "preliminary examination of the risk indicates that should such an event take place the tunnel would only be partially flooded" While this view may be too optimistic the map shows 6'-16' of inundation at the north end of the tunnel.

Scientists take seriously the potential risks, which are posed by the Seattle Fault and by inundation from tsunamis; the Army Corps of Engineers who are contemplating financial aid and permitting new construction on the Seattle Fault that crosses the city East/West and is something, which simply cannot be ignored, should also consider these risks.

Impacts To businesses. The Maritime industrial groups in Ballard and state truckers association are rallying to fight the waterfront tunnel because of tunnel costs and loss of this transportation corridors (**Industries and truckers to fight waterfront tunnel** March 20, 2006 Business Journal)

Additionally, State Rep. Mary Lou Dickerson has raised the issue of Mega Transportation projects averaging 40% cost overruns. This letter states also that the citizens of Seattle will have to bare the extra cost overruns. (Letter enclosed)

There is no financial risk to the Mayor of Seattle, supporter of the tunnel. He has taken huge campaign contributions from the group that supports building the proposed tunnel... Quote "Cost underestimation and overrun cannot be explained by error and seem to be best explained by strategic misrepresentation, namely, lying with a view to getting projects started. (Review Mega projects and Risks: An Anatomy of Ambition. Enclosed)

It appears that while no one has a crystal ball to know when the Seattle Fault Earthquake will occur, the fact is, its not if, but when. The USGS map and the "Tsunami Hazard Map of Elliott Bay" shows very clearly that an earthquake on the Seattle fault can generate tsunamis and would result in a severe vertical disruption of the tunnel. There is every reason to believe that these effects could jeopardize public safety. Because RCW 47 requires the improvement of traveler safety, and because the proposed AW tunnel would be built over an active fault with many attendant risks to life and safety, we request that the tunnel no longer be considered as the replacement of an elevated roadway on the Seattle waterfront.

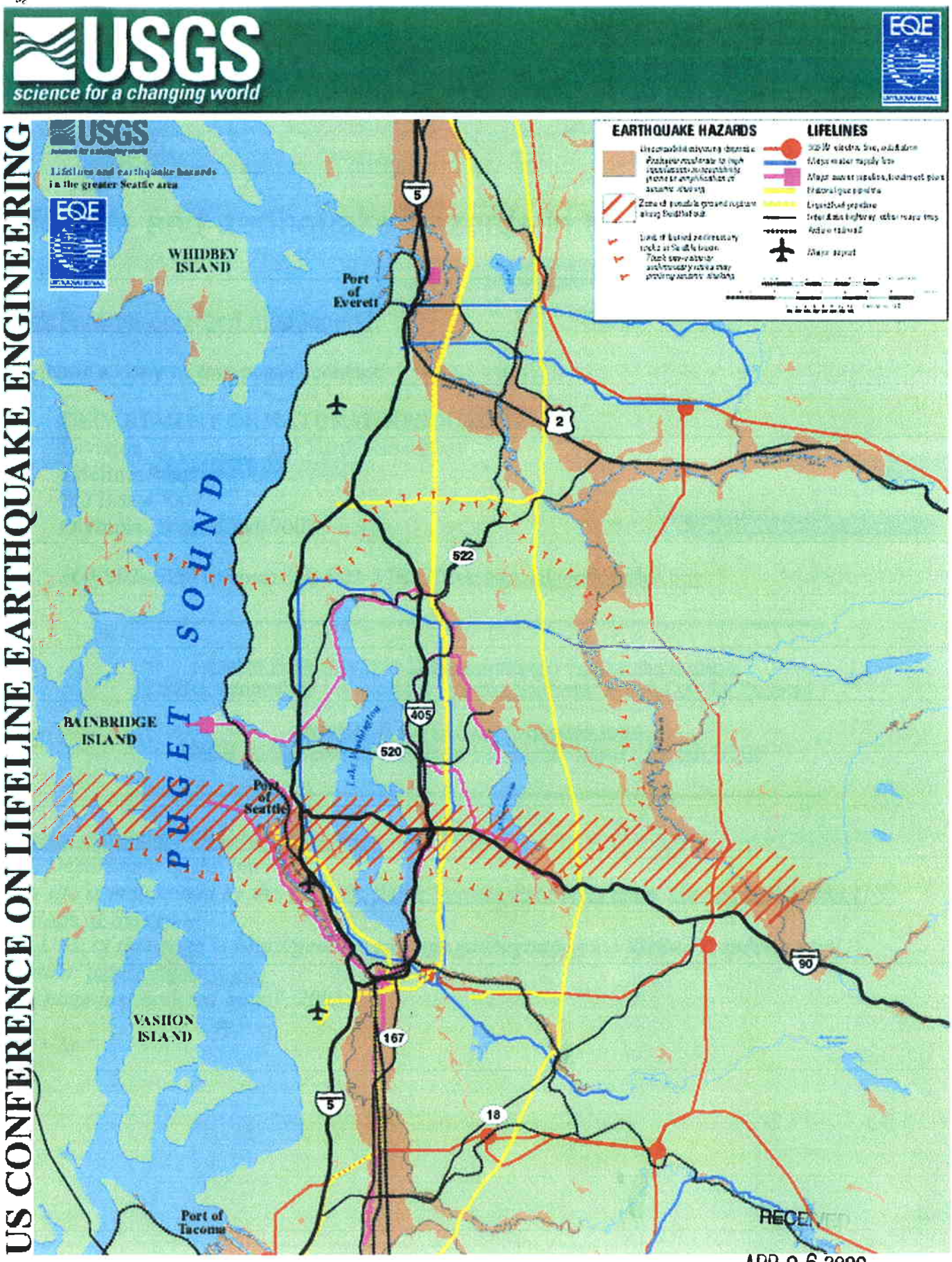
The safety of the citizens from earthquake fault, tsunamis flooding of this tunnel, and other dangers has yet to be addressed in the EIS. The history of misrepresentation of the Seattle Fault and its location by city officials and WSDOT should raise a red flag. I believe the Army Corps of Engineers should contact the Justice Department for an investigation of misrepresentation, fraud and corruption before any permit is issued for a waterfront tunnel.

Sincerely,

Eugene D Hoglund

Eugene Hoglund

Enclosure:
Maps Seattle Fault Rupture Zone USGS
Letter of February 4, 2005 (tunnel would only be partially flooded)
Letter of April 4, 2006 (40% cost overruns)
Letter to Mayor Greg Nickels August 16,2005
Puget Sound Business Journal March 20,2006



US CONFERENCE ON LIFELINE EARTHQUAKE ENGINEERING

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APR 0 6 2006
AWVSRP

Lifelines and earthquake hazards in the greater Seattle area

Click here for enlarged map legend.

To obtain a copy of this poster, contact:

DEPARTMENT OF NATURAL RESOURCES
Division of Geology and Earth Resources
Lifelines Map
PO Box 47007
Olympia, WA 98504-7007

360-902-1450 (phone) 360-902-1785 (fax); tara.salzer@wadnr.gov

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| Lifeline vulnerability | About map | Pacific Northwest Urban Corridor Project |

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Contact: ***pstoffer@usgs.gov***
This page last updated May 7, 2003

ACTIVE TECTONICS OF THE SEATTLE FAULT AND CENTRAL PUGET SOUND, WASHINGTON -- IMPLICATIONS FOR EARTHQUAKE HAZARDS

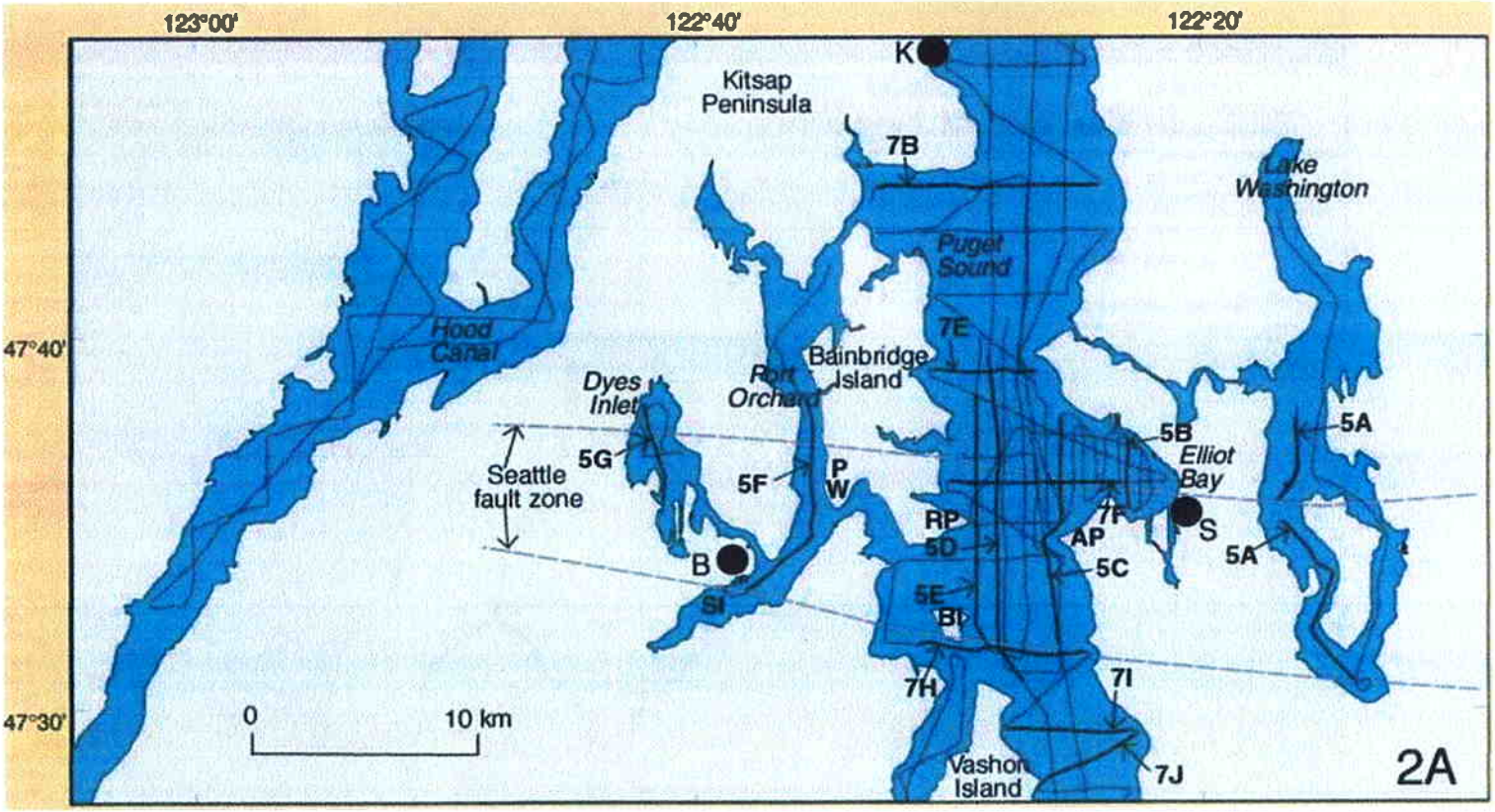

Figure 2. A. Map showing tracklines of USGS high-resolution, multichannel, seismic-reflection profiles near the Seattle fault zone. Locations of profiles and parts of profiles shown in Figures 5 (A, B, C, D, E, F, G) and 7 (B, E, F, H, I, J) are highlighted and labeled. AP = Alki Point; B = Bremerton; BI = Blake Island; K = Kingston; PW = Point White; RP = Restoration Point; S = Seattle; SI = Sinclair Inlet.

Figure 2. B. Map showing tracklines of conventional industry seismic-reflection profiles examined for this study. Parts of profiles shown in Figure 7 (A, C, D, G,) are highlighted and labeled. AP = Alki Point; BI = Blake Island; K = Kingston; PW = Point White; RP = Restoration Point; S = Seattle.

Last modified Thursday, March 29, 2001

Washington State
Department of Transportation
Douglas B. MacDonald
Secretary of Transportation

Urban Corridors Office
Alaskan Way Viaduct & Seawall Project
999 Third Avenue, Suite 2424
Seattle, WA 98104
206-382-5287 / Fax 206-382-5291
TTY: 1-800-833-6388
www.wsdot.wa.gov

February 4, 2005

Mr. Eugene Hoglund, Coordinator
Citizens for and Elevated Solution
3503 30th Ave. West
Seattle, WA 98199

RE: Alaskan Way Viaduct and Seawall Replacement Project

Dear Mr. Hoglund:

Thank you for the letter you sent on January 18, 2005 regarding the Alaskan Way Viaduct and Seawall Replacement (AWV) Project. The AWV team appreciates receiving public feedback on our project, and we hope that you will continue to stay informed as progress continues. Please note that Maureen Sullivan is no longer the AWV Project Director, and so, I am responding on her behalf.

We would like to respond to each of the questions you asked regarding the Tunnel alternative:

> *Question 1) Why was this additional cost left off the September 13, 2004 project cost flyer? This could make the tunnel alternative nearly 2 billion dollars more than the rebuilt.*

The costs for the lid and lowered Aurora were not included, because they had not been fully developed, nor had they gone through the CEVP™ cost verification process. Several of the elements of the preferred alternative were not agreed upon by the lead agencies until December 2004, and hence, they were not included in the earlier flyer. In order to compare the alternatives on an equal basis, Lowered Aurora would need to be included in both the Rebuild and the Tunnel alternatives. The cost differences above what was reported in the September flyer would be related only to the lid near Steinbrueck Park. Current estimates show the lid costs at $80 to $100 million. This would change the range between Rebuild and Tunnel alternatives to $800 million and $1.0 billion, including lowered Aurora in both cases.

> *Question 2) Does not answer the statement that an earthquake could rupture the lining and flood the tunnel; The fact is, in the event of an earthquake on the Seattle fault, the tunnel could be flooded by a tsunami, trapping everyone that could not escape. The tunnel is being built over the Seattle fault*

As previously stated, both the Rebuild and Tunnel alternatives are being designed to withstand the design year earthquake (2500 year recurrence) without catastrophic failure. The tunnel liner is no more likely to fail in an earthquake, than the rebuild structure is

likely to fall down. As part of our design, and given the recent events in Malaysia, it would be prudent to analyze the risk of flooding of the tunnel due to an earthquake on the Seattle Fault, and a possible resulting tsunami. Although the risk of a tsunami in Elliott Bay is very low, a preliminary examination of the risk indicates that should such an event take place the tunnel would only be partially flooded. The only open entrance for water is the south portal, and this would severely limit the amount of water that could enter the tunnel as the wave passed by. The tunnel pumping system will be able to eventually dry the tunnel again. The foundations, retaining walls, and other supporting structure of the Rebuild alternative will also be examined for potential failure due to a tsunami. It is worth noting that the referenced DNR/NOAA study states that the model run does not include the influences of changes in tides, and is referenced to mean high water. It also states, "While the modeling can be a useful tool to guide evacuation planning, it is not of sufficient resolution to be useful for land-use planning."

Question 3) Why is this grade not a chokepoint?

The 7% grade and its effect of reducing the speed of fully loaded trucks will not create a chokepoint because: (a) the majority of the truck traffic will exit to Western Ave, meaning they will be in the right exit lane and have little effect on the two through lanes, and (b) the through traffic, including trucks, traveling beyond the exit to Western will need to slow down to 30 mph to negotiate the Battery Street Tunnel, regardless of the roadway grade in advance of the tunnel.

In summary, nearly all projects have to find a balance between the needs of the traveling public and the impacts on the local community. Any new project must be designed with the utmost safety in mind, in concert with the associated costs, risks, benefits to the community, and with respect to context sensitive design.

Please feel free to keep appraised of all the latest information on our project. The project website at http://www.wsdot.wa.gov/projects/viaduct/ is updated regularly, and is an excellent place to find the latest information. Thank you again for taking the time to share your concerns related to the AWV project.

Sincerely,

Thomas Roy Madden P.E.
Engineering Manager, AWV

cc: Allison Ray, WSDOT
Linda Mullen, WSDOT
Doug MacDonald, WSDOT
Megan Hall, FHWA
Mark Bandy, WSDOT

STATE REPRESENTATIVE,
36th DISTRICT
MARY LOU DICKERSON

State of
Washington
House of
Representatives

JUVENILE JUSTICE & FAMILY LAW
CHAIR
CHILDREN & FAMILY SERVICES
NATURAL RESOURCES,
ECOLOGY & PARKS
TRANSPORTATION

April 4, 2006

Gene Hoglund
3503 30th Avenue West
Seattle, Washington 98199

Dear Gene,

Thank you for taking the time to contact me and for sharing your comments regarding my amendment to the Transportation Budget bill setting a deadline for funding to be in hand for the Alaskan Way Viaduct Tunnel. I'd like to share with you my reasoning for offering the amendment.

We all know the Viaduct needs to be replaced with a newer, safer facility. Five years ago when the Nisqually Earthquake struck, it was said to have a 1 in 20 chance in failing in the next earthquake. Now it's 5 years later, and we've accomplished much in the way of planning and design, as well as having approved substantial funding, but the question remains which viaduct replacement will be built -- a tunnel or an aerial structure?

We have in hand enough money to replace the viaduct as it stands today. We have about $2.4 billion in hand now, and that's enough to finance the above-ground structure. It's not enough to finance a tunnel. Current cost estimates for the "core tunnel" are $3.2 - $3.6 billion. But that's not the whole tunnel project. The whole tunnel project as the Mayor has said he wants to build costs $4.4 billion. That's the Mayor's own cost estimate. $4.4 billion is $2 billion more than is available today. Who's going to pay that $2 billion?

I've seen preliminary finance plans that say the money for the core tunnel -- the project that will cost up to $3.6 billion -- will potentially come from the following sources:

- $400 million from Seattle utilities, to pay the cost of moving utilities
- $250 million from City of Seattle transportation funds
- $200 million from the Port of Seattle

It is important to note that the above funding has not been secured or appropriated.

These three funding sources, together with the $2.4 billion in hand, are probably enough to build the core tunnel (if it comes in at its currently estimated costs). Where do these funds come from? Taxpayers and ratepayers. Seattle residents. Now, some of this will have to be financed whether we build the tunnel or the aerial structure -- like the costs to move the utilities. So Seattle ratepayers will in all likelihood see higher utility bills for several years to come in order to finance the viaduct replacement.

LEGISLATIVE OFFICE: PO BOX 40600, OLYMPIA, WA 98504-0600 • 360-786-7860 **E-MAIL:** dickerson.marylou@leg.wa.gov
TOLL-FREE LEGISLATIVE HOTLINE: 1-800-562-6000 • TDD: 1-800-635-9993
DISTRICT OFFICE: 2208 N.W. MARKET, SUITE 310A, SEATTLE, WA 98107 • 206-545-6513
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But this just gets the core tunnel. How about the entire tunnel project the mayor wants -- which will take another $1 billion or so. That's another $1 billion in taxes levied on the citizens of Seattle. I think it's just too much money. Too much money that's being spent on a single project, when there are other projects that need funding -- the replacement for the SR 520 floating bridge, for example -- as well as non-transportation priorities like elementary and secondary education.

There are many benefits of the tunnel -- opening up our waterfront, moving the traffic noise underground, taking a once-in-a-lifetime opportunity to redesign our cityscape -- those are all wonderful benefits of a very ambitious project. But can we afford it? Can we afford it if the costs come in as projected -- $4.4 billion. What happens if we run into unforeseen problems that cause costs to skyrocket -- where does that money come from? **Keep in mind that nationally these mega transportation projects average a 40% cost overrun.**

I think we have too many competing needs -- both within transportation and outside of transportation -- to invest so much of the citizens' tax dollars in this one project. Just like families may want to buy a big fancy house on the waterfront, but look at the household finances and realize they can't afford it if they're also going to pay the weekly grocery bill, pay for health insurance, and send the kids to college, our city must look at the bottom line and whittle down the spending appetite for this one project so there's enough left over for the rest of the city's needs.

My amendment didn't close the door on the tunnel. My amendment just said the money had to be in hand. In the legislation that finally passed the legislature, which I supported, we required the citizens of Seattle to vote by November of this year -- either directly or through a city council vote -- on whether they prefer the tunnel or the rebuild option. This vote will take place after an independent panel of experts reviews the financial feasibility of both options, and reports back to the Legislature by September 1st. The Governor will then decide if the financing plan for the viaduct is "feasible and sufficient" to complete the project. It is the Governor, who by December, will choose the final option.

In closing, let me say that we've got to stop arguing about the project and begin building it. We can't wait til the next earthquake hits.

Thank you again for contacting me. I appreciate hearing from you.

Sincerely,

Mary Lou

Mary Lou Dickerson
WA State Representative
36th District

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Dept. of
Planning & Development
AUG 16 2005
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Eugene Hoglund
3503 30th Ave. W
Seattle, WA 98199
206-378-0722

August 16, 2005

Gregory J. Nickels, Mayor of the City of Seattle
Diane Sugimura, Director, Seattle DPD

Re: RCW 36.70A requires all cities and Counties to identify geologically hazards areas within their jurisdiction and formulate developments regulation for their protection.

Dear Mayor Nickels, Ms. Sugimura and DPD Staff:

We write out of concern that the issues raised in our March 08, 2005 (letter enclosed) are not being included in the Critical Areas Update, **the Seattle Fault Zone** and the **Tsunamis Hazard Map of Elliott Bay.** Additional documents and the Final EIS from North Bay (which is in Seattle's jurisdiction) are made part of this letter. State law requires you to address the **Seattle fault earthquake** and the **tsunami inundation** in the **Critical Areas Update**.

The following excerpts from Seattle Fault Documents are enclosed for your perusal:

1. RCW 36.70A.030 (5) "Critical areas" include. ...(e) geologically hazardous areas.
2. RCW 36.70A.030 (9) "Geologically hazardous areas" means areas that because of their susceptibility to erosion, sliding, earthquake, or other geological events, are not suited to the siting of commercial, residential, or industrial development consistent with public health or safety concerns.
3. RCW 36.70A.170 (1)...each city, shall designate where appropriate: (d) Critical areas.

4. North Bay Master Plan EIS, April 2005 Volume 11 **Technical Appendices. Geologic Hazards** pages 8-10 **Ground Rupture. "The Puget Sound region contains numerous fault zones, and the Seattle Fault Zone,** located about 4 kilometers south of the North Bay site is the closest reported fault zone. **The Seattle Fault Zone is about 4 to 6 kilometers wide....rupture of the ground surface occurred about 1100 years ago with about 20 feet of permanent vertical displacement at that location.**

5. Letter from City of Seattle, Diane M. Sugimura, Director, DPD dated May 26, 2005 to Port of Seattle North Bay DEIS comments: Page 2, Earth: Page 3.1-6 The National Oceanic and Atmospheric Administration has published estimates of how an earthquake from the Seattle Fault could cause a tsunami that would have severe effects on low-lying land in the city the terminal 91 area appears to be particularly at risk for such an event. The EIS should describe the relative risks and potential impacts to human occupants and on-site structures under each alternative.

6. RESPONSE TO LETTER 1, CITY OF SEATTLE Comment Noted, the cited revision to include discussion of tsunamis in the Earth section of the Draft EIS is noted.

7. page 3.1-7 North Bay Master Plan Final EIS CHAPTER 3 ERRATA "Tsunamis." Tsunamis are earthquake-generated waves that occur in open water bodies. ...A tsunami could be generated by a rupture along the Seattle Fault Zone...The results of the study published in 2003 entitled **"Tsunami Hazard Map of the Elliott Bay Area, Seattle, Washington: Modeled Tsunami Inundation from a Seattle Fault Earthquake"** are available online at http://www.dnr.wa.gov/geology/pubs/pubs_ol.htm#hazards ofr-2003-14.pdf. The results of this modeling study indicates that a magnitude 7.3 to 7.6 earthquake caused by a major rupture on the Seattle Fault may result in a tsunami wave that could inundate much of the Elliott Bay waterfront to a varying degrees. Calculated wave heights in Elliott Bay from this event are estimated at approximately 6 meters (about 20 feet)...
page 3.-16 The potential impacts of a large tsunami in Elliott Bay include the adverse effects of a temporary inundation of much of the North Bay site by the tsunami wave, and damage/injury caused by debris carried by the wave. **These potential impacts are expected to be similar to tsunami-related impacts along much of the lower portions of the Elliott Bay waterfront and would apply to the existing on any future development at the site.**

8. **Quote:** Seattle Times February 20, 2005 "**Seattle Fault old, active and just 8 miles down.** The Seattle Fault has been one of the most active on the West Coast for millions of years...**scientists fear the fault could be the most dangerous in the Northwest"...**
Quote: Seattle Times February 20, 2005 "**Pinpointing devastation if Seattle Fault ruptures.** In the past 3,000 years, it has violently rearranged the local landscape as many as **four times—or every 750 years, on average...there's at least a 5 percent chance the fault will let loose again within the next 50 years...Without that kind of leadership here...I don't think we're going to be addressing these problems"**

Summary: Based on the information the city now has from USGS studies, maps and North Bay EIS of the Seattle fault, City Hall should comply with the Laws of the State of Washington (RCW 36. 70A.) I believe that by ignoring the Seattle Fault, City Hall can continue to aid development unimpeded in known hazard areas. It would be a wrongful act to knowingly attempt to withhold these GEOLOGICALLY HAZARDOUS AREAS from the Critical Areas Update.

Thank you for your consideration, Sincerely,

Eugene Hoglund

Eugene Hoglund

Enclosures: Letter Critical Areas Update Dated March 8, 2005
RCW 36.70A.030
North Bay DEIS pages 8-10, Seattle Fault Earthquake
Letter from City of Seattle DPD North Bay DEIS, Dated May 26, 2005
North Bay Final EIS ERRATA "Tsunamis"

BOOK REVIEW: **Megaprojects and Risk: An Anatomy of Ambition**

Bent Flyvbjerg, Nils Bruzelius and Werner Rothengatter, Cambridge University Press, Cambridge, UK, 2003, 207 pages

BY **JOSEPH COATES**

This book documents beyond question that those who promote large-scale infrastructure and civil works projects running to billions of dollars, leave "Public and private investors, parliaments, media and the general public.. .routinely inadequately informed and misled regarding the risks involved in megaprojects" [1]. Having confirmed what we all know who follow the field, they go into overwhelming and convincing detail about experience in many countries and integrate earlier studies on the subject with their own.

Flyvbjerg, Bruzelius and Rothengatter are, respectively, Professor in the Department of Development and Planning at Aalborg University, Denmark; Associate Professor at Stockholm University and a consultant in transport and planning; and Head of the Institute of Economic Policy Research, University of Karlsruhe, Germany.

The situation is, at core, unchanged in the past 70 years. Their research shows that the situation is similar throughout the industrialized and industrializing nations, from Asia to the Americas. They examined the new Hong Kong airport, the Akashi Kaikyo bridge in Japan, the Sydney harbor tunnel, Thailand's Second Stage Expressway, the Boston "Big Dig," freeways and railways in California, the new Denver international airport, etc. The book is particularly relevant to the futurist community because all megaprojects when completed are around for a long time and are becoming more the fashion in infrastructure construction, and often, if not usually, involve mixes of national and international governments, private and public capital as well as development banks.

Cost overruns are not the only aspect of the problem that they highlight. The failure of economic and social performance after the projects have been built is common. "The Channel tunnel, opened in 1994 at a construction cost of £4.7 billion, is a case in point, with several near bankruptcies caused by construction cost overruns of 80%, financing costs that are 140% higher than those forecast and revenues less than half of those projected..." [2]. Denver's *US$5* billion new international airport"... was close to 200% in cost overrun and passenger traffic in the opening year was only half of that projected" [3].

The Major Projects Association, an organization of contractors, consultants, banks and others interested in megaproject development, has concluded that "too many projects proceed that should not have [been] done" [4]. Regional development claims for megaprojects are often merely a sop to promote political acceptance, and many of them depend upon "nonmeasurable or insignificant claims."

The authors cite as a core factor, underlying all of these dreadful situations with **megaprojects, the lack of transparency in decision making and the weak involvement of the civil society, or what they call a "democracy deficit."** They make a big point of the failure to pay attention to risks and the **lack of accountability in the project** decision-making processes as a main source of difficulties. The authors' concept of risk is almost entirely limited to financial risk.

Most megaprojects involve three features that are systematically ignored or **underplayed: uncertainty about facts, high-decision stakes, and values in dispute.** Risk assessment, essential to dealing with these factors, is usually absent or inadequate.

In their own work, the authors emphasize three projects: the Channel tunnel, opened in 1994; the Great Belt link, opened in 1997 and 1998, connecting East Denmark with Continental Europe; and the Oresund link between Sweden and Denmark, which opened in the year 2000.

They cite a study out of Aalborg University that looked at 258 projects costing approximately US$90 billion, 1995 prices. Some of their conclusions are the following:

- *In 9 out of 10 transport* infrastructure projects, costs are underestimated, resulting in cost overrun;
- For rail, actual costs are, on the average, 45% higher than estimated costs (standard deviation, S.D. = 38);
- For fixed links (tunnels and bridges), actual costs are, on the average, 34% higher than estimated costs (S.D. = 62);
- For roads, actual costs are, on the average, 20% higher than estimated costs (S.D. = 30);
- For all project types, actual costs are, on the average, 28% higher than estimated costs (S.D. = 39);
- Cost underestimation and overrun exist across 20 nations and five continents; it appears to be a global phenomenon;
- Cost underestimation and overrun appear to be more pronounced in developing nations than in North America and Europe (data for rail only);
- Cost underestimation and overrun have not decreased over the past 70 years. No learning seems to take place;
- Cost underestimation and overrun cannot be explained by error and seem to be best explained by strategic misrepresentation, namely, lying, with a view to getting projects started [5].

A snapshot of construction overruns from transportation projects is given in Table 1. One would think that with the worldwide experience in transportation projects, more realistic estimates would be the rule, not the exception.

For the widespread failure in demand, i.e., use of forecasts, they cite seven reasons: inadequate methodology, often involving applying the wrong forecasting tool; poor database; discontinuous behavior and the influence of complementary factors;

Puget Sound Business Journal (Seattle) - March 20, 2006
http://seattle.bizjournals.com/seattle/stories/2006/03/20/story5.html

Puget Sound Business Journal

BUSINESS PULSE SURVEY: What will be the ultimate legacy of Bill Gates?

Industries and truckers to fight waterfront tunnel

Puget Sound Business Journal (Seattle) - March 17, 2006 by Steve Wilhelm Staff Writer

Maritime industrial groups in Ballard and a state truckers association are rallying behind the notion of replacing the Alaskan Way Viaduct on the downtown Seattle waterfront with another above-ground roadway.

The Ballard groups are planning to organize a campaign to fight the city's preferred option, which is to demolish the viaduct and replace it with a waterfront tunnel. Companies in the industrial neighborhoods of Ballard and Interbay in Seattle, as well as representatives of the Washington Trucking Association, say a new viaduct would save money and better suit their transportation needs.

"We'll be actively campaigning for the rebuild, and against the tunnel. ... This is going to be a real battle," said Eugene Wasserman, president of the North Seattle Industrial Association. "We think it (the tunnel) will put some of our businesses out of business, especially those that serve the Pacific maritime fleet."

Their stance puts them at odds with Mayor Greg Nickels and others who see the double-deck viaduct as a barrier between downtown Seattle and Elliott Bay, and prefer to replace the viaduct with a more costly tunnel.

The debate also represents a clash of values between the industrial neighborhoods and upscale residents in Seattle's increasingly tony downtown. Blue-collar critics of the proposed tunnel are more interested in rebuilding a roadway that will allow all truck traffic, and will cost less, than they are in opening up views of Elliott Bay from downtown.

The early maneuverings could signal a lively debate if, as expected, the question of how to replace the viaduct is put before voters in an advisory ballot this fall.

Many Ballard business people, who run shipyards and fuel docks along Salmon Bay, say a central issue is that trucks with fuel oil for the fishing fleet, and solvents and toxic wastes from shipyards, won't be allowed through the tunnel and will have to travel on surface streets instead.

While the Washington State Department of Transportation estimates the surface route will add only five to 10 minutes to a truck trip, industry interests contend that the reality, with a fully loaded fuel truck, will be far longer.

Warren Aakervik, president of the Ballard Oil Co. and an opponent of the tunnel who sits on the board of the North Seattle Industrial Association, said he believes the current 45-minute round trip to get fuel from Harbor Island in West Seattle will take twice as long, if not longer, if the tunnel is built.

But the mayor sticks with the state's five-minute estimate, contending that only 40 trucks make the trip each day, adding that a short delay is a "relatively minor impact."

The Washington Trucking Association, which represents freight haulers and other trucking companies throughout the state, opposes the tunnel primarily because of its higher cost.

"From an industry perspective, we prefer the cheaper option, based on the fact that there are only so many dollars available for the Puget Sound area infrastructure," said association Vice President

Jim Tutton. "It's certainly very likely that hazardous materials won't be allowed to be trucked through the tunnel, and there will be a lot of container traffic coming out of the ports going north that would be prohibited from going through the tunnel."

The state transportation department estimates that building a tunnel would cost $3.7 billion to $4.5 billion, compared with a new viaduct for $2.5 billion to $2.9 billion.

The existing two-level viaduct was damaged in the 2001 Nisqually earthquake and is considered vulnerable to further earthquake damage. It roughly parallels the north-south Interstate 5 corridor several blocks to the west.

The Ballard opposition to a tunnel is partly based on geography, because the core of Ballard's traditional industrial community is within a mile of the Ballard Bridge. That bridge is the starting point for steady truck traffic that uses the viaduct to shuttle fuel, supplies and toxic wastes between Ballard's industrial zone and warehouses, and supply depots on Harbor Island and farther south. Ballard business people view any slowing of that traffic as a threat.

Nickels responds that he does care about the Ballard and Duwamish industrial zones, and is pushing hard to replace the current viaduct with a tunnel able to carry similar traffic volume, partly to support those districts. But he adds that he disagrees with choosing the viaduct option mainly in order to keep trucks with hazardous materials on the highway as opposed to surface streets.

"That will not bring the maritime industry to its knees," he said about the tunnel option.

But to Wasserman, head of the North Seattle Industrial Association, there's a larger problem of the values and needs of the traditional maritime community not being valued by City Hall.

"The mayor and the state are slowly strangling our freight routes," Wasserman said. "There's a cultural war going on here between the knowledge workers and the blue-collar workers, and the knowledge workers don't want the blue-collar workers around."

Another organization opposing the tunnel is the Ballard Interbay North End Manufacturing Industrial Center, or BINMIC. John Kane, chairman of the BINMIC committee, said the consensus of his membership also is that a new viaduct is preferable, primarily because of lower cost and less obstruction to hazardous cargoes.

"We think we have to make sure there's enough funds for every other project around King County and our region," Kane said. " We don't want the tunnel to turn into a Seattle-centric project when there's plenty of other projects."

Contact: swilhelm@bizjournals.com • 206-447-8505x113

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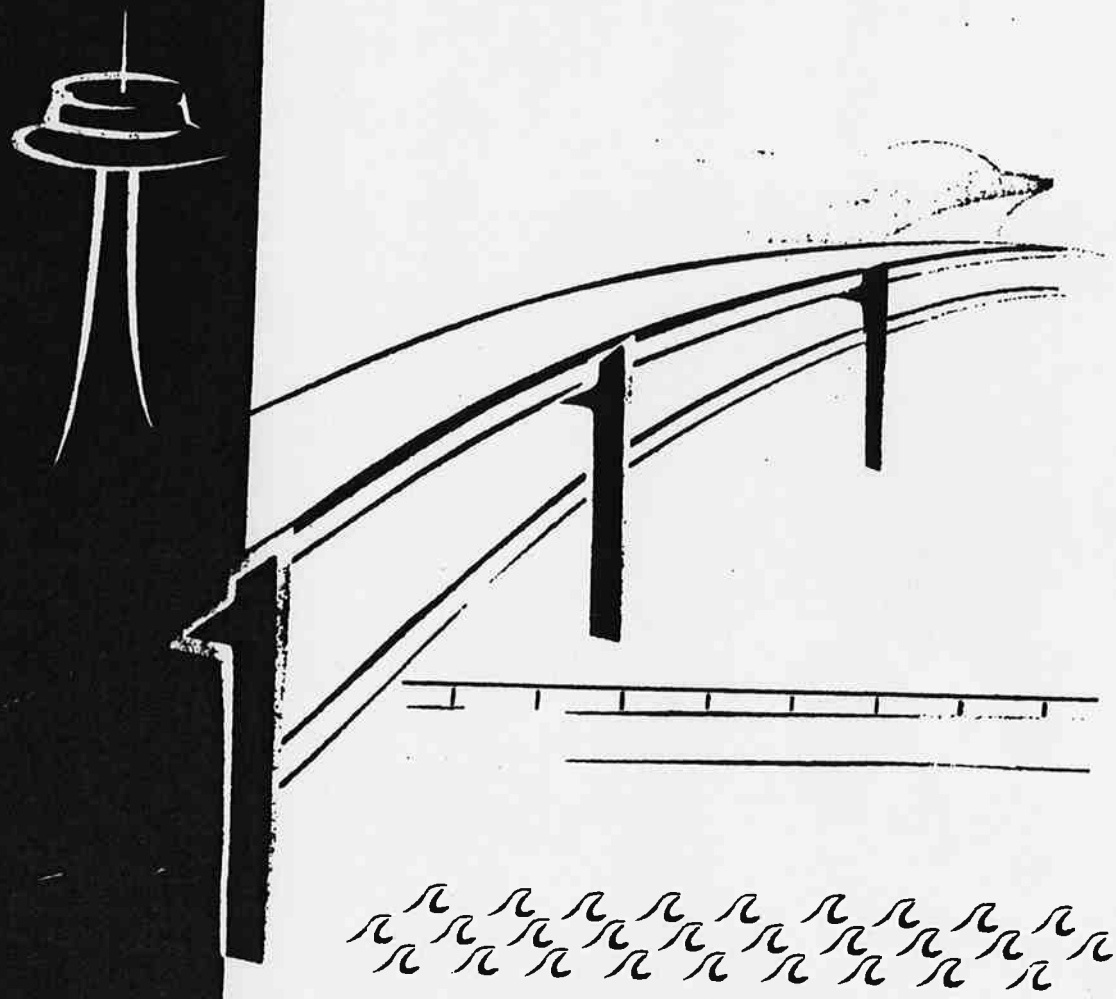
SR 99 ALASKAN WAY VIADUCT &
SEAWALL REPLACEMENT PROJECT

Draft Environmental Impact Statement
Appendix T
Geology and Soils
Technical Memorandum



Submitted by:
PARSONS BRINCKERHOFF QUADE & DOUGLAS, INC.

Prepared by:
SHANNON & WILSON, INC.

U.S. Department of Transportation
Federal Highway Administration

Washington State Department of Transportation

City of Seattle

Beach deposits began to accumulate about 5,000 years ago when the sea level reached its approximate present elevation. These sediments were reworked and then overlain by alluvial deposits from the Duwamish River and landslide debris from higher ground to the east of the shoreline. In some areas, these deposits were also interbedded with each other (alternating thicknesses of beach, alluvial, and landslide deposits).

During the last century, fill material was placed prior to and after construction of the Alaskan Way Seawall to depths of 5 to 50 feet along E. Marginal Way and the Port of Seattle facilities to the south and to depths of 10 to 40 feet along the waterfront. Fill also exists west of the Seawall. A large volume of unconsolidated material exists in the vicinity of Pier 66 between Broad and Lenora Streets. This material was reportedly placed in this area during the historic Belltown/Denny Regrade project in the early 20th century. Much of the shallow soil along the southern portion of the project corridor was soil that was dredged from the Duwamish Waterway and hydraulically placed (placed by using water).

On the hillsides east of the project area and south of the Seattle Center, a complex series of glacially overridden soil (soils that were compacted by the weight of overriding glacial ice) layers are present. These soils were deposited during glacial events and during interglacial periods (periods where no glaciers were present) that were similar to the present-day environment. These glacially overridden soils also underlie the younger, relatively loose and soft, post-glacial soils that were deposited along the waterfront and Duwamish River delta. Portions of the alignment are located within the Denny Regrade, where much of the post-glacial soil was removed during the early 20th century. On the eastern side of the Regrade, relatively soft post-glacial soils are present in the swale that occupied the ground between Denny and Queen Anne Hills. On the western side, some of the soils have been disturbed by landsliding along the steep slopes that defined the shoreline before fill was placed in the low-lying areas.

4.4 Geologic Hazards

Geologically hazardous areas are defined as areas that—because of their susceptibility to erosion, landslides, earthquakes (faulting, liquefaction, ground shaking, etc.), or other geologic events—are not suited for development consistent with public health and safety concerns. Washington State's Growth Management Act (Chapter 36.70A RCW) requires all cities and counties to identify geologically hazardous areas within their jurisdictions and formulate development regulations for their protection.

The City of Seattle has developed Regulations for Environmental Critical Areas and accompanying maps (City of Seattle 2002). These regulations require that detailed geotechnical studies be prepared to address specific standards relating to site geology and soils, seismic hazards, and facility design. The following sections summarize the geologic hazard types that may be anticipated within the project corridor. It should be noted that many of these hazards are interrelated.

4.4.1 Landsliding

The City of Seattle has identified landslide-prone areas that include steep slopes, known landslide areas, and areas with landslide potential because of geologic conditions. Steep slopes are defined by the City of Seattle as slopes steeper than an average of 40 percent and with at least 10 feet of vertical change. The only steep slopes along the project alignment are on the eastern side of the Burlington Northern Santa Fe (BNSF) railroad tracks, between Virginia Street and Bell Street. The steeper parts of the slopes in this area range from about 50 to 100 percent. In the past few years, several small shallow landslides have occurred on this slope. They are typically 1 to 3 feet deep and are generally 10 to 30 feet wide. No recent deep-seated landslides have been observed in this area. During a seismic event, increased shallow landsliding may occur. In addition, the fill materials placed west of the Seawall in the vicinity of Pier 66 may also experience landsliding during a seismic event.

4.4.2 Erosion

The project area is primarily classified as urban development and is therefore not an erosion hazard area. However, the steep slopes located along the east side of the BNSF railroad tracks between Virginia Street and Bell Street have experienced surface erosion and gully development under conditions of significant runoff.

4.4.3 Fault Rupture

The southern end of the project area is located within the Seattle Fault Zone. The Seattle Fault is believed to be a thrust or reverse fault, with the bedrock south of the fault being shoved up and over the bedrock and soil to the north of the fault. Within a few miles of the ground surface, the fault breaks up, creating a number of rupture surfaces or splays at the ground surface. The width of the rupture zone at the ground surface is approximately 2 to 4 miles wide, north to south (Johnson et al. 1999). The fault zone extends from the Kitsap Peninsula near Bremerton on the west to the Sammamish Plateau on

the east. Exhibit 4-1 shows the location of the two most northern splays within the project area.

Geologic evidence gathered over the last 10 years suggests that surface rupture of this fault zone occurred as recently as 1,100 years ago with as much as 22 feet of vertical displacement (Bucknam et al. 1992). Recent trenches excavated along the fault locations indicate that there have been about three events where the surface was ruptured in the past 10,000 years (Nelson et al. 2000). Consequently, the recurrence of surface fault rupture within the zone appears to be on the order of thousands of years. Also, fault splays in the northern portion of the zone appear to be the most recently active and capable of rupturing the ground surface, resulting in several feet of vertical offset.

4.4.4 Liquefaction

Soil liquefaction occurs in loose, saturated, sandy soil when the water pressure in the pore spaces increases to a level that is sufficient to separate the soil grains from each other. This phenomenon occurs during ground shaking and results in a reduction of the shear strength of the soil (a quicksand-like condition). The reduction in strength depends on the degree and extent of the liquefaction. Liquefaction can result in ground settlement, lateral spreading (lateral ground movement on gentle slopes), landsliding, localized ground disruptions from sand boils (ejection of sand and water at the ground surface), and reduced vertical and lateral capacity for structure foundations. Buildings, bridges, and other structures founded on or in the liquefied soils may settle, tilt, move laterally, or collapse. The degree of liquefaction depends on the consistency and density of the soil, the grain-size distribution of the soil, and the magnitude of the seismic event. Settlement could also result from partial liquefaction and/or densification of unsaturated sand.

Geologic units in the project area that typically have a high susceptibility to liquefaction include the recent alluvial and beach deposits and nonengineered fills. These deposits are primarily located in the southern portion of the project corridor and along the waterfront. Liquefaction studies in the Puget Sound region have found that glacially overridden deposits have a low susceptibility to liquefaction. Liquefaction hazard areas have been mapped by the City of Seattle and are shown on Exhibit 4-1. Liquefaction studies have also been accomplished for this project using the results of available explorations and the borings completed for this project (see *Geotechnical and Environmental Memoranda* [Shannon & Wilson 2002b]). The results of these studies generally confirm the liquefaction areas shown on Exhibit 4-1.

4.4.5 Ground Motion Amplification

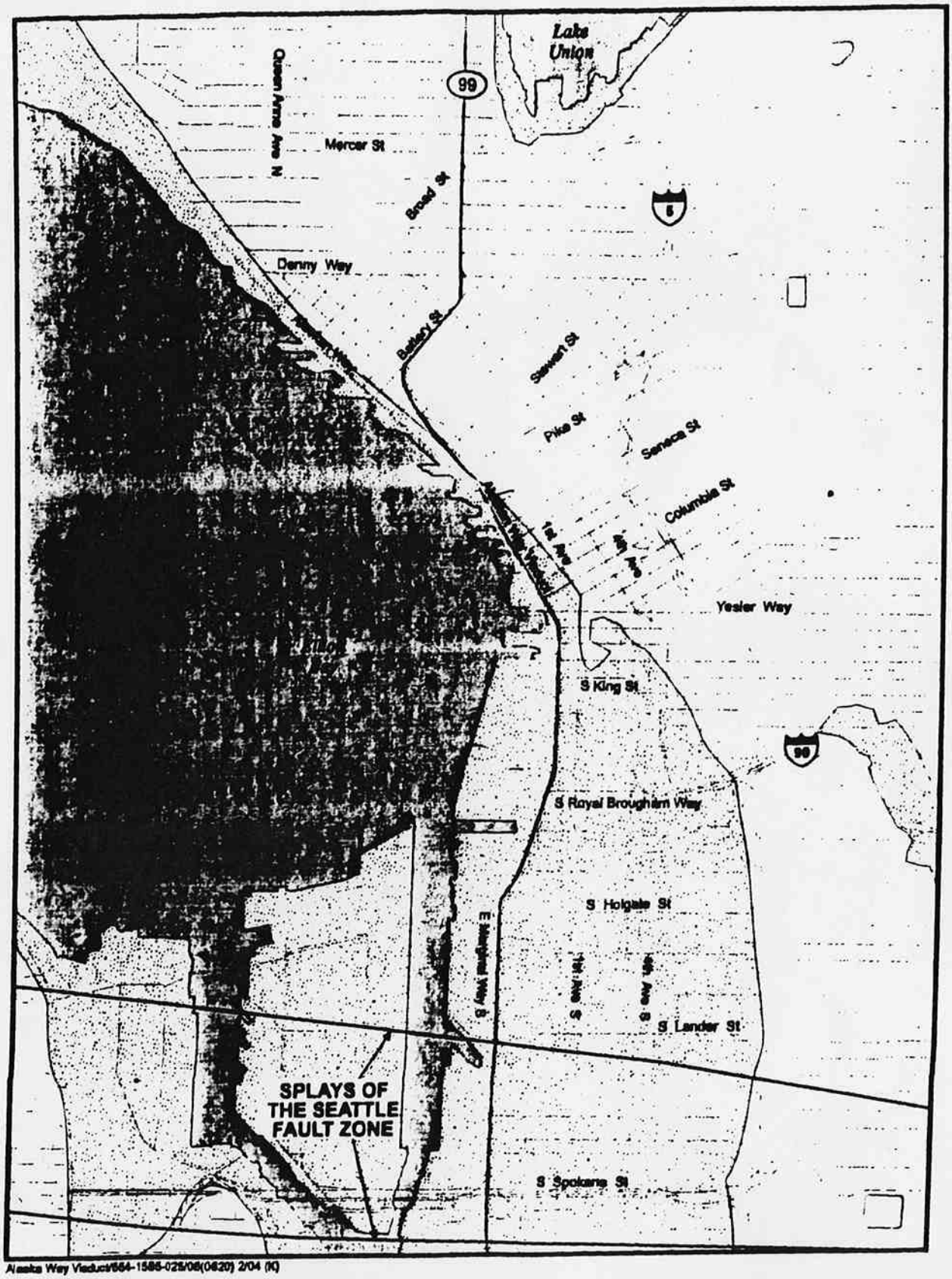
The presence of soil above bedrock can change the intensity of ground shaking felt at the ground surface from what would have been felt if only bedrock were at the ground surface. Very soft or loose soils may cause the ground shaking to be amplified (greater than that felt on rock) or attenuated (less than that felt on rock). Ground motion amplification may result in higher ground motions felt by long bridges and similar long-period structures.

The soil conditions in the project area range from deep, loose, liquefiable deposits at the south end to deep, glacially overridden, sandy, silty, and gravelly soils at the north end. At the south end of the project area, the potential for ground motion amplification varies. For small or distant earthquakes that cause low levels of shaking, the potentially liquefiable soils are likely to amplify the ground shaking. For large, nearby earthquakes that cause higher levels of shaking, little amplification or even attenuation of higher-frequency ground motions is possible before liquefaction will occur. However, for the same nearby earthquake, low-frequency ground motions at liquefiable sites are likely to be amplified. The soils at the north end of the project area are not expected to amplify earthquake ground motions.

4.4.6 Seiches and Tsunamis

Seiches and tsunamis are short-duration, earthquake-generated water waves. Seiches are waves that occur in enclosed bodies of water, and tsunamis are waves that occur in the open ocean. The extent and severity of these waves is dependent upon ground motions, fault offset, and location. Studies on these types of waves in the Puget Sound were presented by the Center for Tsunami Inundation Mapping Efforts (Gonzalez 2002). These findings indicated that a magnitude 7.3 to 7.6 earthquake caused from rupture of the Seattle Fault may result in a wave that would inundate much of the waterfront in excess of 6 feet. Most of the central and southern portions of the viaduct would likely be inundated with at least 1 foot of water.

Tsunamis generated from large earthquakes in the Pacific Ocean basin would also likely result in inundation of the waterfront and viaduct. These studies are currently ongoing, but several feet of inundation along the waterfront and viaduct corridor from a tsunami run-up is likely. Historic data from the 1964 Alaska earthquake in Prince William Sound show a tsunami run-up of 0.8 feet (Wilson and Torum 1972).



Alaska Way Viaduct/664-1585-025/06(0620) 2/04 (K)

References: Seattle Fault Splays, Johnson (1999).
Liquefaction areas, City of Seattle (2002).

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SCALE IN FEET

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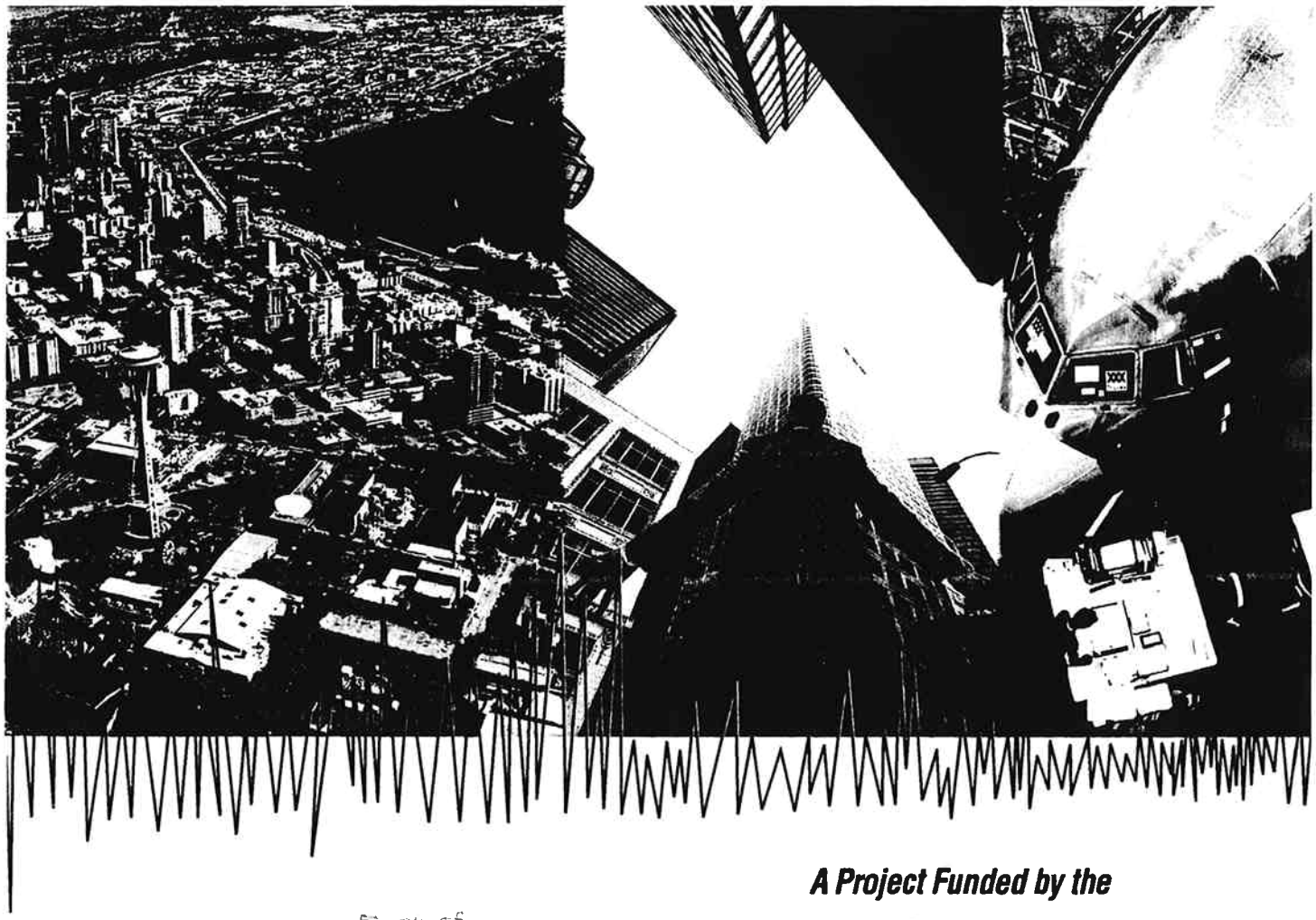
Liquefaction Areas

Exhibit 4-1
Mapped Liquefaction Areas and Seattle Fault Zone

Scenario for a Magnitude 6.7 Earthquake on the Seattle Fault

Excerpts from a publication of the same title to be released March 2005



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A Project Funded by the

Earthquake Engineering Research Institute

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Washington Emergency Management Division

February 2005

Designing for Tsunamis

Seven Principles for Planning and Designing for Tsunami Hazards

March 2001

A multi-state mitigation project of the National Tsunami Hazard Mitigation Program (NTHMP)

National Oceanic and Atmospheric Administration (NOAA)
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INTRO

Introduction

Burning petroleum storage tanks along the Seward, Alaska, waterfront after the 1964 tsunami and earthquake. Credit: Anchorage Museum of History and Art

"Seward was…attacked by the main tsunami waves…as the wave traveled along the shore, it spread burning oil…the resulting fires engulfed the downtown…surge forces destroyed homes, docks, canneries, and the small boat harbor…virtually the entire downtown…was destroyed by fire."

Account of the effects of the 1964 Alaska earthquake and resultant tsunami in Seward, Alaska, in *Planning for Risk: Comprehensive Planning in Tsunami Hazard Areas.*

The Threat of Tsunamis to Coastal Communities

Tsunami waves generated by earthquakes, volcanic eruptions, or underwater landslides can reach 50 feet or more in height and devastate coastal communities. In recorded history, tsunamis worldwide have killed hundreds of thousands of people. Since 1946 six tsunamis have killed nearly 500 people and damaged hundreds of millions of dollars of property in Alaska, Hawaii, and along the West Coast of the United States.

Tsunamis are infrequent events but can be extremely destructive. While Hilo, Hawaii, suffered seven significant tsunamis in the last century, and Crescent City, California, experienced two damaging tsunamis in four years (1960 and 1964), many communities at risk in the Pacific region have no recent experience with tsunami damage and, hence, may have a false sense of security regarding the hazard.

An estimated 489 cities within the Pacific states of Alaska, California, Hawaii, Oregon, and Washington are susceptible to tsunamis; as many as 900,000 residents of these cities would be inundated by a 50-foot tsunami.

Beyond preparing for evacuation and emergency response, communities can reduce their tsunami risk by modifying their land use planning and development approval practices. Although planning for tsunamis will not be a top priority for most coastal communities, relatively small efforts to plan for this hazard can significantly increase community safety.

900,000 people in Alaska, California, Hawaii, Oregon, and Washington live in areas in danger of being inundated by a 50-foot tsunami.

Introduction

Purpose and Organization of the Guidelines

The purpose of these guidelines is to help coastal communities in the five Pacific states—Alaska, California, Hawaii, Oregon, and Washington—understand their tsunami hazards, exposure, and vulnerability, and to mitigate the resulting risk through land use planning, site planning, and building design. Emergency response and evacuation are addressed extensively in other publications and are only discussed in these guidelines as they relate to land use, siting, and building design and construction issues (see the references at the end of the guidelines concerning emergency response and evacuation planning for tsunamis).

These guidelines are intended for use by local elected, appointed, and administrative officials involved in planning, zoning, building regulation, community redevelopment, and related land use and development functions in coastal communities. The guidelines should also be helpful to state officials having similar responsibilities.

These guidelines are organized according to seven basic principles:

Principle 1: Know your community's tsunami risk: hazard, vulnerability, and exposure

Principle 2: Avoid new development in tsunami run-up areas to minimize future tsunami losses

Principle 3: Locate and configure new development that occurs in tsunami run-up areas to minimize future tsunami losses

Principle 4: Design and construct new buildings to minimize tsunami damage

Principle 5: Protect existing development from tsunami losses through redevelopment, retrofit, and land reuse plans and projects

Principle 6: Take special precautions in locating and designing infrastructure and critical facilities to minimize tsunami damage

Principle 7: Plan for evacuation

For each principle, the discussion includes background information on the topic, recommended process steps for implementing the principle, and specific how-to strategies. Several case studies in the guidelines illustrate how communities in the Pacific

Damage from the 1964 tsunami in Kodiak, Alaska. Credit: NOAA

region are addressing tsunami hazards. The guidelines also contain references and contacts for obtaining further information about planning for tsunami hazards. More detailed information on each of the topics discussed in the guidelines is contained in a companion set of background papers that were compiled during the preparation of these guidelines.

The Regulatory Context

All development in coastal areas is subject to federal, state, and local policies and regulations. Understanding the regulatory context is critical to the successful implementation of a tsunami mitigation program.

State and Local Development Regulations

Every coastal community in the five Pacific states has a land use planning and regulation process that responds to state mandates or guidelines, which vary among the states:

- All five Pacific states require local land use planning, and all except Alaska have statewide planning guidelines. Alaska has statewide planning guidelines for coastal resource districts.
- Oregon and Washington require local plans to be consistent with statewide planning goals. California and Hawaii have statewide planning guidelines that are advisory only. Alaska requires a consistency review of coastal resource district plans with statewide standards and with other districts' plans.
- California, Oregon, and Washington require hazard mitigation as part of their general land use planning process. Alaska requires it for coastal resource district plans only. Hawaii only suggests that this topic be addressed.
- California, Oregon, and Washington require conformance with a state model building code based on the Uniform Building Code (UBC). Alaska only mandates adoption of a fire code, and Hawaii does not have a state-mandated building code. All of the counties in Hawaii and the larger cities in Alaska have adopted a version of the UBC.

A community's comprehensive plan is at the top of the local land use planning/regulatory process hierarchy. The comprehensive plan is implemented day-to-day through project review and permitting.

Local governments typically require formal approvals for land divisions, the establishment of certain new uses ("conditional uses"), and the physical layout of new development.

Federal Regulations and Programs

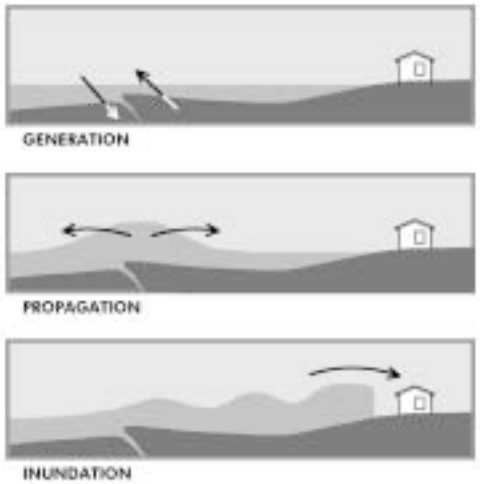
While the federal government has supported state and local planning through numerous programs over the years, there are no federal requirements for statewide or local land use planning. There are, however, two federal programs that are particularly important for land use planning in coastal areas.

The 1972 Coastal Zone Management Act (CZMA) established a voluntary partnership among the federal government, coastal states, and local governments to develop individual state programs for managing coastal resources. The state component consists of federally-approved Coastal Management Programs (CMPs) in 32 coastal states and territories, including the five Pacific states. The purpose of the CZMA is to promote the orderly development and protection of the country's coastal resources.

The National Flood Insurance Program (NFIP), established in 1968, is part of a comprehensive approach to reduce flood damage and to cope with the disastrous effect of floods. The NFIP is administered by the Federal Insurance Administration (FIA), a component of the Federal Emergency Management Agency (FEMA). The NFIP makes federally-backed flood insurance available in communities that adopt and enforce floodplain management ordinances to reduce future flood losses. NFIP requires projects to be located above the 100-year flood or inundation areas.

P•1

Principle 1: Know your community's tsunami risk: hazard, vulnerability, and exposure



A tsunami is a series of long waves generated by a sudden displacement of a large volume of water.

Understanding your community's tsunami hazard, vulnerability, and exposure to damage is the foundation for land use and building strategies that can mitigate tsunami risk. While much remains to be learned about tsunamis, sufficient knowledge, technical information, and expertise already exist to assess the tsunami hazard and risk in all coastal communities.

The Nature of Tsunamis

A tsunami is a series of long waves generated by a sudden displacement of a large volume of water. Tsunamis are triggered by submarine earthquakes, submarine volcanic eruptions, underwater landslides or slumps of large volumes of earth, meteor impacts, and even onshore slope failures that fall into the ocean or a bay.

Most tsunamis originate in the Pacific "Ring of Fire," which is the most active seismic feature on earth. Tsunamis are typically classified as either local or distant. Locally-generated tsunamis have minimal warning times and may be accompanied by damage resulting from the triggering earthquake such as groundshaking, surface faulting, liquefaction, or landslides. Distant tsunamis may travel for hours before striking a coastline.

In the open ocean, a tsunami may be only a few feet high but can travel up to 500 miles per hour. As a tsunami enters the shoaling waters near a coastline, its speed diminishes, its wavelength decreases, and its height increases greatly. However, the first wave usually is not the largest. Several larger and more destructive waves often follow the first one. While tsunami waves slow upon reaching the coastline, they still travel faster than Olympic long-distance runners can run—faster than 15 miles per hour.

The configuration of the coastline, the shape of the ocean floor, and the characteristics of advancing waves play important roles in the destructiveness of the waves. A wave may be small at one point on a coast and much larger at other points. Bays, sounds, inlets, rivers, streams, offshore canyons, islands, and flood control channels may cause various effects that result in greater damage than many people

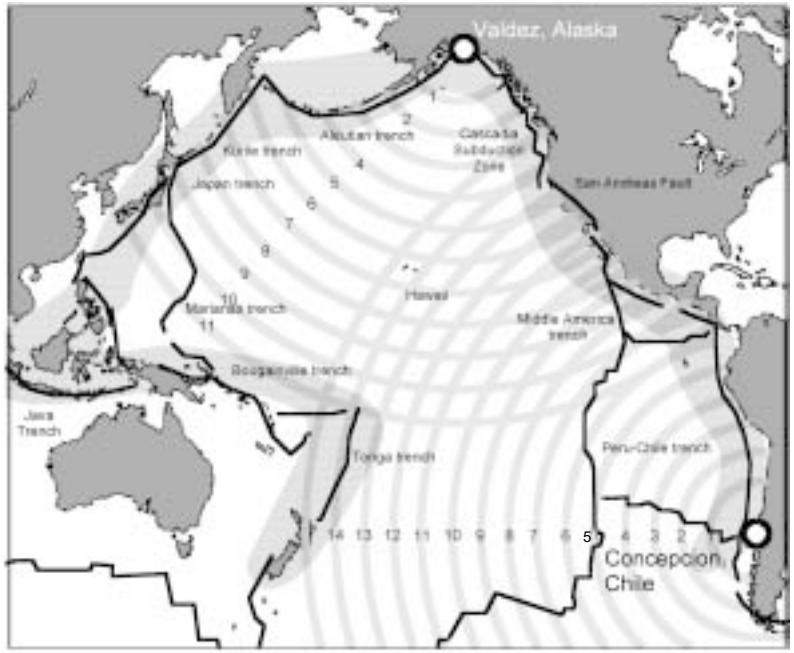
Principle 1: Know your community's tsunami risk: hazard, vulnerability, and exposure

would expect. It has been estimated, for example, that a tsunami wave entering a southern California flood control channel could reach a mile or more inland, especially if it enters at high tide. Offshore canyons can focus tsunami wave energy and islands can filter the energy. The orientation of the coastline determines whether the waves strike head-on or are refracted from other parts of the coastline.

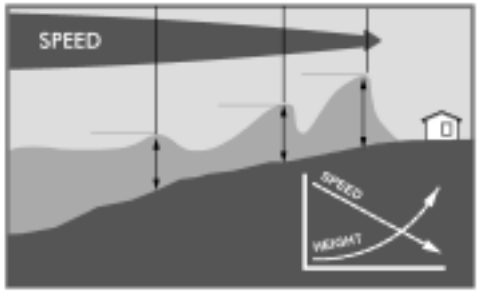
Unlike earthquake shaking that can be damaging over large areas—hundreds of square miles is not unusual—tsunamis impact long, low-lying stretches of linear coastlines, usually extending inland for relatively short distances. Upon striking a coast, the wave reflects back to sea, and then can return to the coastline as a series of waves.

The first visible indication of an approaching tsunami may be recession of water (drawdown) caused by the trough preceding the advancing, large inbound wave crest. Rapid drawdown can create strong currents in harbor inlets and channels that can severely damage coastal structures due to erosive scour around piers and pilings. As the water's surface drops, piers can be damaged by boats or ships straining at or breaking their mooring lines. The vessels can overturn or sink due to strong currents, collisions with other objects, or impact with the harbor bottom.

Conversely, a rise in water level may be the first indication of a tsunami. The advancing tsunami may initially resemble a strong surge increasing the sea level like the rising tide, but the tsunami surge rises faster and does not stop at the shoreline. Even if the wave height appears to be small, three to six feet for example, the strength of the accompanying surge can be deadly. Waist-high surges can cause strong currents that float cars, small structures, and other debris. Boats and debris are often carried inland by the surge and left stranded when the water recedes.



The Pacific "Ring of Fire" is the most active seismic feature on earth. Tsunami waves triggered by seismic activity can travel across the Pacific Ocean at up to 500 miles per hour, striking distant coastal areas in a matter of hours. The figure shows the estimated number of hours for tsunami-generated waves to travel across the Pacific Ocean from Alaska and Chile, respectively.



As a tsunami approaches shore, it slows down and dramatically increases in height.

Outflow following inundation also creates strong currents, which rip at structures and pound them with debris, and erode beaches and coastal structures.

As tsunamis reach the shoreline, they may take the form of a fast-rising tide, a cresting wave, or a bore. The bore phenomenon resembles a step-like change in the water level that advances rapidly (from 10 to 60 miles per hour). Normal tidal bores at the Bay of Fundy, Canada, or the Yellow River, China, provide examples of this phenomenon.

The force and destructive effects of tsunamis should not be underestimated. At some locations, the advancing turbulent wave front will be the most destructive part of the wave. In other situations, the greatest damage will be caused by the outflow of water back to the sea between crests, sweeping all before it and undermining roads, buildings, bulkheads, and other structures. This outflow action can carry enormous amounts of highly damaging debris with it, resulting in further destruction. Ships and boats, unless moved away from shore, may be dashed against breakwaters, wharves, and other craft, or be washed ashore and left grounded after the withdrawal of the seawater.

The Destructiveness of Tsunamis

Though rare, tsunamis are devastating events for humankind. In recorded history, hundreds of thousands of people all over the world have died as a result of tsunamis. Some scholars believe that a tsunami resulting from the eruption of the volcano Thera destroyed the Minoan culture in the Mediterranean in 1628 B.C.

Since 1946, six destructive tsunamis have caused nearly 500 deaths and damaged hundreds of millions of dollars of property in Alaska, Hawaii, and along the U.S. West Coast.

The destructive potential of tsunamis was most dramatically illustrated by the 1960 Chile earthquake and the 1964 Alaska earthquake, two of the largest earthquakes ever measured.

The 1960 earthquake off coastal Chile devastated parts of Chile and almost instantly raised a California-sized piece of land on the ocean floor about 30 feet. Its companion series of tsunami waves resulted in further losses in many other Pacific Rim and island locations, including Hilo, Hawaii, and Japan.

Principle 1: Know your community's tsunami risk: hazard, vulnerability, and exposure

Over 2,000 lives were lost, including 61 in Hawaii and 122 in Japan. The earthquake-generated tsunami waves registered on tide gauges for more than a week around the Pacific Rim.

The tsunamis generated by the 1964 Alaska earthquake also spread destruction around the Pacific Rim. In Alaska alone, waves and the effects of groundshaking and submarine landslides destroyed portions of numerous coastal communities. Whittier suffered losses to docks, oil facilities, and rail facilities with wave run-up noted at an elevation of 104 feet in a narrow passage. Kodiak suffered subsidence due to the groundshaking, followed by multiple tsunami waves that inundated the low-lying areas of town, destroying virtually all docking facilities and driving boats and other debris ashore. Valdez experienced submarine landslides triggering waves as high as 23 feet, destroying much of the town. Seward experienced 30- to 40-foot tsunamis and local submarine landslides, causing extensive damage to the docking areas and fires in petroleum storage facilities.

Exposure to Tsunamis

Coastlines have always been a favored location for human settlements. Because of the attractiveness of coastal locations and the long gaps between devastating tsunami events, coastal communities have continued to develop in recent times with new housing, maritime facilities, and resort developments. As a result, more people and facilities are threatened by the destructive force of tsunamis. According to one recent estimate, 489 cities in Alaska, California, Hawaii, Oregon, and Washington are susceptible to tsunami inundation, with an estimated 900,000 people living or working within areas that could be inundated by a 50-foot tsunami.

Understanding the Risk to Your Community

Understanding the tsunami threat is the first step in reducing potential losses. These guidelines repeatedly stress the importance of compiling and applying good local tsunami hazard information.

Potential destructiveness of tsunamis in the five Pacific states

State	Cities susceptible to tsunamis	Population endangered by a 50-foot tsunami
Alaska	52	47,000
California	152	589,500
Hawaii	123	131,000
Oregon	60	31,500
Washington	102	96,000
Total	489	895,000

Source: Tsuinfo Alert, v.2, no. 2, March-April, 2000. Terry Wallace, University of Arizona, Department of Geosciences.

Principle 1: Know your community's tsunami risk: hazard, vulnerability, and exposure

Damage to Crescent City, California, from the 1964 tsunami. Nearly 900,000 people in the five Pacific states live in the inundation zone for a 50-foot tsunami. Credit: Del Norte Historical Society

Tsunami risk is a function of three factors: 1) the nature and extent of the tsunami hazard; 2) the vulnerability of facilities and people to damage; and 3) the amount of development or number of people exposed to the hazard.

There is no substitute for having a local evaluation of a community's hazard, vulnerability, and exposure. The information will help communities understand the causes and consequences of a tsunami in order to design specific loss-prevention measures and programs.

Process for Obtaining Local Tsunami Hazard Information

1) Prepare Tsunami Inundation Studies

The first step in understanding your risk is to estimate the extent and pattern of your community's potential tsunami inundation, tsunami frequency (recurrence interval), and the reliability of the estimate. In all five Pacific states, state agencies are conducting ongoing tsunami mapping programs. The methodologies used and the geographic coverage of efforts vary from state to state. Generally, the mapping programs involve some combination of computer modeling, historical research, and field confirmation. The current round of tsunami inundation mapping is designed primarily to support evacuation planning, but provides a good starting point for land use planning as well.

Because of the often simplistic assumptions that are made in a statewide study, local land use managers should conduct their own more refined assessments of tsunami inundation potential. Each level in the land use planning, site planning, and building design hierarchy requires a different level of refinement in the information concerning potential inundation and destructive effects. In many cases, it will only be possible to gather adequate information about the potential effects of local tsunamis because distant tsunamis are more difficult to model.

Principle 1: Know your community's tsunami risk: hazard, vulnerability, and exposure

Tsunami studies should include:

- reviewing historic records and describing potential local and distant tsunami sources
- evaluating potential for ground failures and other geologic effects
- estimating number of waves, their heights, arrival times, and inundation depths
- calculating water velocities and debris loads
- estimating probabilities of occurrence and levels of certainty

Preparing these studies will ordinarily require the assistance of consulting specialists. Local governments may also want to create an advisory committee composed of members from nearby colleges and universities, government agencies, consulting organizations, and civic and professional organizations.

2) Prepare Tsunami Loss Scenario Studies

Knowing the extent and pattern of inundation allows communities to assess the potential damage such inundation would do to existing development and infrastructure. Scenario studies based on assumed conditions provide a graphic illustration of what can happen to a community, both during and after a destructive tsunami. These studies should also address other hazards, such as local earthquakes, that may cause concurrent damage. Local tsunamis pose unique problems for emergency planners since the facilities and infrastructure needed for evacuation may be damaged by the earthquake that triggers the tsunami.

Such scenarios typically assess potential losses to important buildings and structures, transportation systems, and utility systems. The resulting tsunami loss scenario study will provide the foundation for reducing potential losses. The most important principle is that the study be accepted as the best that could have been done within the constraints of funding, time, and knowledge. Because of the inherent limitations associated with loss studies, it will be important for all involved to reach consensus on the results. This will help ensure community and political acceptance–a key ingredient for establishing effective loss-reduction measures. However, consensus may be hard to reach in these

Wave generated by the 1946 tsunami in the Keaukaha area of Hilo, Hawaii. Credit: Pacific Tsunami Museum

studies, and differing interpretations or conclusions need to be identified and discussed.

The case study on page 14 describes an earthquake and tsunami scenario for the north coast of California, including damage probability and assessments for a variety of facilities, infrastructures, and services. The Federal Emergency Management Agency (FEMA) has developed a geographic information system (GIS)-based natural hazard loss estimation methodology, called HAZUS, that can be adapted to address tsunami hazards in scenario studies.

Release of any loss scenario study should be accompanied by briefings of key community groups and leaders, the media, elected and appointed officials, and others important to adopting and applying loss reduction measures.

Strategies for Applying Hazard Information to Reducing Future Losses

Strategy 1: Incorporate Hazard Information into Short- and Long-Term Planning Processes

One of the best ways to prevent future losses from natural hazards is to ensure the subject is addressed along with all other issues in short- and long-term comprehensive planning programs and project reviews. Some jurisdictions require that public safety considerations or specific hazards be addressed. The resulting information becomes part of the evaluation and decision-making processes. The scope of the hazard information will vary with the breadth or narrowness of the project, such as amending a growth management plan, reviewing a specific development proposal, or modifying a zoning ordinance.

The information should be used to evaluate major development proposals so that risk mitigation is factored into decisions, approvals, and permits.

Moreover, knowing that such information will be needed, owners and developers should be required to supply detailed hazards data and mitigation measures as part of their proposals. Communities should have specific administrative and review procedures to ensure the effectiveness of this process.

Strategy 2: Use Hazard Information to Build Public and Political Support for Mitigation Measures

Hazard information, loss estimates, and planning scenarios are powerful tools to create understanding and commitment to mitigation. They should be used to acquaint the populace with their exposure and vulnerability, empower them to take precautionary measures, build political consensus about acceptable risk-reducing policies and programs, and strengthen emergency preparedness and warning programs.

Moreover, hazard information, or procedures for consulting such information, should be included in other programs and processes affecting current and future development. This will ensure that risk management becomes a regular part of the decision-making processes leading to sustainable and more disaster-resistant communities.

Strategy 3: Estimate Reduced Future Losses by Evaluating the Effectiveness of Loss-Prevention Measures

One of the biggest challenges in preventing losses from natural hazards, especially for rare events such as tsunamis, is to show that mitigation measures would be effective. At the community level, the value of mitigation investments can be estimated by using scenarios and maps to evaluate actions taken to reduce vulnerability and exposure to tsunami hazards. Informed judgments can be made by quantifying the losses that likely would have occurred if such precautions had not been taken.

Strategy 4: Periodically Re-evaluate Community Vulnerability and Exposure

The tsunami hazard is unlikely to change over time, but communities are changing constantly. This dynamic process leads to changes in vulnerability and exposure. Effective long-term tsunami

Damage from the 1960 tsunami in the Waiakea area of Hilo, Hawaii. Parking meters were bent by the force of the debris-filled waves. Credit: U.S. Navy

mitigation means that loss studies should be reviewed and revised periodically—at least every five years—to reflect changes in development patterns and demographics. Regular review and revision will ensure that the most current information is applied, and it could help to demonstrate the effectiveness of loss prevention.

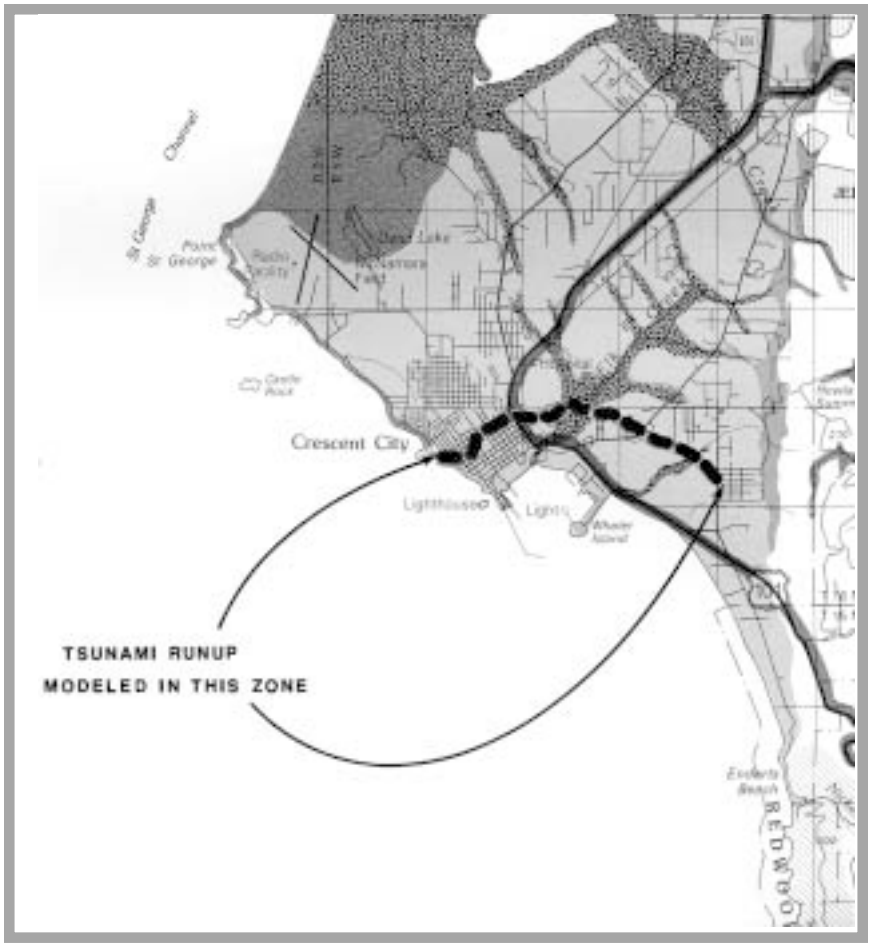
Community vulnerability certainly should be re-evaluated following a disaster or other severe event, perhaps including comparable events in other locations around the world.

Case Study: Planning Scenario for Humboldt and Del Norte Counties

In 1995, the California Division of Mines and Geology published Special Publication 115, entitled *Planning Scenario in Humboldt and Del Norte Counties, California for a Great Earthquake on the Cascadia Subduction Zone.* This report includes a description with supporting maps of the potential effects of a tsunami on the cities of Eureka (Humboldt County) and Crescent City (Del Norte County). This report is an example of local hazard and risk information that can be used to support mitigation efforts.

The scenario earthquake is assumed to generate a local tsunami that would arrive minutes after the earthquake. The maps depict potential structure and infrastructure damage and show locations likely to be flooded by a tsunami caused by a potential great earthquake (magnitude 8.4) occurring offshore on the Gorda segment of the Cascadia Subduction Zone.

The planning scenario includes damage probability and assessments for a variety of facilities, infrastructure, and services including: schools and colleges, hospitals, highways, airports, marine facilities, railroads, and facilities for electric power, natural gas, petroleum products, water supply, and wastewater. These assessments are intended to assist localities in planning for emergency response efforts and pre-disaster retrofitting and other risk mitigation efforts.



Excerpt from Scenario Map for Humboldt and Del Norte Counties

P•2

Principle 2: Avoid new development in tsunami run-up areas to minimize future tsunami losses

Aerial view of tsunami and earthquake damage to Valdez, Alaska, showing the extent of inundation along the coastline from the 1964 Great Alaska Earthquake. Coastal-dependent development can conflict with safety goals. Credit: U.S. Department of the Interior

Tsunami risk can be mitigated most effectively by avoiding or minimizing the exposure of people and property through land use planning. Development should be prevented in high-hazard areas wherever possible. Where development cannot be prevented, land use intensity, building value, and occupancy should be kept to a minimum. Where these strategies are not available and development will occur in possible tsunami inundation areas, planners and designers must look to mitigation through site planning techniques as discussed under Principle 3 or building construction techniques as discussed under Principle 4.

The Role of Land Use Planning in Reducing Tsunami Risks

Land use planning in communities guides the location, type, and intensity of development and can, therefore, be used to reduce the community's exposure to tsunami hazards. Principle 2 focuses on large-scale land use planning issues, such as those that are dealt with in comprehensive plans, zoning ordinances, and subdivision regulations. It focuses on the types, patterns, and densities of uses that could and should be allowed within potential tsunami inundation areas based on consideration of the risk. It is important to remember that the more locational mitigation (Principle 2) is used, the less design mitigation (Principles 3 and 4) is required.

Process for Implementing Land Use Planning Strategies

The following outlines the steps that can be taken when formulating a community land use strategy for tsunami risk mitigation.

1) Understand Locational Context

Opportunities for reducing tsunami risk differ depending on local circumstances, so a one-size-fits-all approach cannot be used. The presence or absence of development within tsunami hazard areas will determine the type of planning approach that is feasible. For example, vacant land conversion, such as expansion of an existing

community or development of a new community, will require different mitigation strategies than will other forms of development such as infill, redevelopment, reuse, or changes in occupancy (see Principle 5).

2) Understand Trade-Offs

Mitigation often means making trade-offs between or among competing goals when dealing with land use planning issues and tsunami hazards. For example, the public access emphasis in Coastal Zone Management (CZM) programs argues for locating visitor-serving development along the coastline; yet this access can be at direct odds with public safety goals for minimizing new development in tsunami inundation areas.

Coastal-dependent development such as ports and harbors that, by their nature, have to be situated on the coast can also conflict with safety goals. Other planning goals such as compact/dense downtowns can also result in increased risk.

These trade-offs need to be recognized in the planning process. The revision process for a comprehensive plan is a good time to weigh alternatives and to balance competing goals.

3) Review and Update Existing Safety Element

The existing safety or natural hazards element of the comprehensive plan should be reviewed to determine if it adequately recognizes tsunami hazards and how the risk is managed when decisions are made. The following information should be inventoried and updated, as necessary (see Principle 1):

- technical information such as inundation zones
- loss scenario information
- goals and policies

In addition, it should be recognized that tsunami hazards often overlap other hazards and that mitigation for other hazardous conditions can assist in mitigating tsunami risk. Such hazards might include riverine flooding, hurricanes/typhoons, landslides, coastal erosion, and earthquakes.

4) Review and Update Existing Land Use Element and Other Plans

The existing land use element, other comprehensive plan elements, and special plans should be reviewed to determine what changes are needed to address

Erosion along the Oregon coast. Mitigation for other hazardous conditions such as erosion, flooding, hurricanes, and seismic hazards can assist in mitigating tsunami risk. Credit: Oregon Department of Land Conservation and Development

the tsunami hazard, and be updated as necessary. Land use policies and programs should address tsunami hazards as part of a comprehensive tsunami mitigation program.

Such an update should focus on the location and vulnerability to damage of existing and planned land uses in the community, including the following:

- residential
- commercial/visitor-serving
- industrial (general)
- industrial (hazardous materials)
- public facilities (transportation and water systems)
- critical facilities and systems (communication, emergency response, electrical power, water supply, and natural gas systems)

5) Review and Update Existing Zoning, Subdivision, and Other Regulations

Existing zoning, subdivision, and other regulations should be reviewed and updated with an eye toward mitigating future tsunami losses. Requirements for consistency between the comprehensive plan and zoning and subdivision regulations vary among the states. In California, for example, the zoning code is considered part of the local coastal program (LCP) for coastal communities and is required to be consistent with the general plan.

6) Planning for Post-Tsunami Reconstruction

Disasters create the opportunity to eliminate nonconforming uses and reshape existing patterns of development to minimize future losses. On the other hand, they can also create enormous pressure to rebuild the community quickly and exactly as it was before the disaster. These rebuilding issues should be addressed through the land use planning process before a disaster strikes so that a community is prepared to deal with rebuilding issues in the event of a disaster.

Principle 2: Avoid new development in tsunami run-up areas to minimize future tsunami losses

Specific Land Use Planning Strategies to Reduce Tsunami Risk

The following are specific recommended land use planning strategies that a community can use to reduce tsunami risk.

Strategy 1: Designate Tsunami Hazard Areas for Open-Space Uses

The designation and zoning of tsunami hazard areas for such open-space uses as agriculture, parks and recreation, or natural hazard areas is recommended as the first land use planning strategy to consider. This strategy is designed to keep development at a minimum in hazard areas. It is particularly effective in areas that have not yet experienced development pressure. It is obviously more difficult in areas that are already partially developed or that have strong development pressures.

Strategy 2: Acquire Tsunami Hazard Areas for Open-Space Uses

A second strategy is to acquire tsunami hazard areas for open-space uses. Open-space acquisition has several advantages over strictly regulatory approaches such as zoning. Acquisition ensures that the land will be controlled by a public agency or nonprofit entity, and it removes any question about a regulatory taking. The primary disadvantage to acquisition is cost.

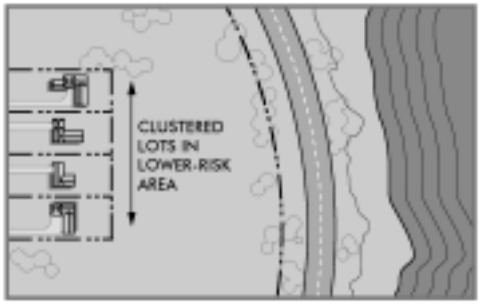
There are multiple approaches to acquisition. Since land ownership is in effect a bundle of rights, including the rights to sell, lease, and develop the property, some of these rights, such as the right to develop, can be sold separately from the rest of the property.

For example, a purchase of development rights (PDR) program is based on purchasing the right to develop land from the bundle of rights associated with the land. A PDR program involves the purchase of the development rights to a property, generally through the granting of a conservation, open-space, or scenic easement that restricts the uses to which the property owner may put the land. A PDR program can also be constructed to purchase a fee-simple interest in a property and then to resell the property with an easement restricting future

Park on the Hilo, Hawaii, waterfront. Open space uses such as parks can keep development at a minimum in hazard areas. Credit: County of Hawaii

Principle 2: Avoid new development in tsunami run-up areas to minimize future tsunami losses

Large-lot zoning can ensure that only very low density residential uses are allowed in hazard areas.



Development can be clustered on site areas where risks are the lowest.

development. A similar result can be obtained through purchasing a fee-simple interest and then leasing the property with restrictions on use. PDR programs are more effective in preserving land from development where development pressure has not yet driven up land prices.

Strategy 3: Restrict Development through Land Use Regulations

In areas where it is not feasible to restrict land to open-space uses, other land use planning measures can be used. These include strategically controlling the type of development and uses allowed in hazard areas, and avoiding high-value and high-occupancy uses to the greatest degree possible.

For example, plan designations and zoning districts can use density restrictions or large-lot zoning (e.g., 10-acre minimum) to ensure that only very low-density residential uses are allowed in hazard areas. Another technique is to require clustering of development on site areas where risks are the lowest.

Strategy 4: Support Land Use Planning through Capital Improvement Planning and Budgeting

The capital improvement planning and budgeting process can be used to reinforce land use planning policies. A major factor in determining future development patterns is where a local jurisdiction chooses to extend sewer and water lines, roads, and other public facilities and services. Decisions can either discourage or encourage development in tsunami and other hazard areas.

Natural hazard risk mitigation should be integrated into infrastructure policy. Infrastructure policies by themselves will not preclude development in certain areas, but they can reinforce land use plans, and they can shape market forces to encourage development in less hazardous areas by not subsidizing infrastructure that serves a higher-risk hazardous area.

Strategy 5: Adapt Other Programs and Requirements

The safety element of a comprehensive plan and the zoning, subdivision, and other programs designed to implement the comprehensive plan may contain regulations that are applicable to tsunami risk mitigation even if tsunami hazards are not mentioned explicitly. Many of these programs and regulations can be adapted relatively easily to address tsunami hazards. For example, existing floodplain restrictions, hillside and landslide controls, and environmental, scenic, recreational, and wildlife-protection requirements can help address tsunami hazards and should be modified for that purpose.

P•3

Principle 3: Locate and configure new development that occurs in tsunami run-up areas to minimize future tsunami losses

The waterfront area of Crescent City, California, flooded by the 1960 tsunami. Credit: USGS

When development is to be sited within a tsunami hazard area, the physical configuration of structures and uses on a site can reduce potential loss of life and property damage. This includes the strategic location of structures and open space areas, interaction of uses and landforms, design of landscaping, and the erection of barriers.

The Role of Site Planning in Reducing Tsunami Risk

Within the broader framework of a comprehensive plan, site planning determines the location, configuration, and density of development on particular sites and is, therefore, an important tool in reducing tsunami risk.

At the site planning level in the planning/regulatory hierarchy, the focus typically is on a single parcel or collection of parcels of land 2 to 200 acres in size, under the control of a single owner. This scale of planning provides limited opportunities for avoiding the tsunami hazard entirely, but can provide a broad range of opportunities to design a project to minimize tsunami damage.

Process for Implementing Site Planning Strategies

The following outlines the steps that can be taken when formulating a site planning strategy for tsunami hazard mitigation.

1) Create a Project Review Process that is Cooperative, Comprehensive, and Integrated

The most effective site planning in coastal areas includes a project review process that reflects the area's vulnerability and exposure to tsunami hazards, considers the broader policy and regulatory context, and is part of a larger mitigation strategy. An interactive and informed site planning and review process can save time for project sponsors and provide better mitigation solutions.

Communities interact with project proponents at various levels in the preparation and review of site plans. The level of review relates to the scale and context of a project. Some projects require site and concept review, while others require a review of fully developed designs. Community-level project

review can occur parallel to the design process in an interactive fashion. Alternatively, project site review can be more reactive based on predetermined criteria or plans.

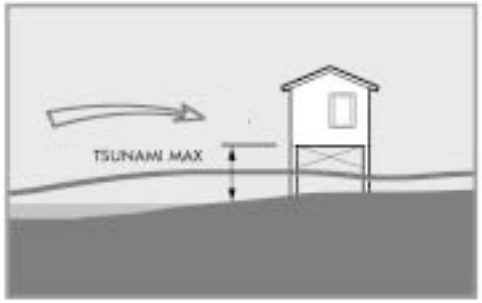
Some communities have adopted comprehensive development policies for waterfront areas to ensure that site planning is part of a review process that implements a larger mitigation plan, economic objectives, and community design concepts. Without this broader framework, community-wide mitigation objectives can be overlooked in a site plan review process that involves different disciplines and multiple departments and decision-making bodies.

2) Understand Local Site Conditions

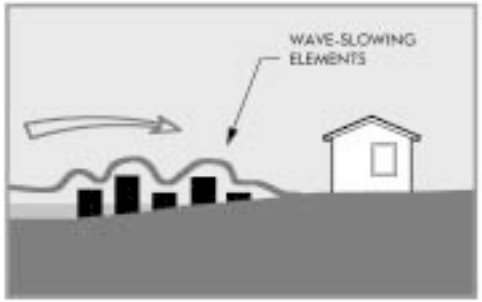
Local planning officials and project sponsors must develop mitigation strategies that reflect the character of the site and immediate context. This includes understanding how tsunamis impact different types of site geography, land uses and building types, and development patterns. The depth of tsunami inundation, speed of currents, presence of breaking wave or bore conditions, debris load, and warning time can vary greatly from site to site.

The site analysis phase can be used to establish site plan parameters for tsunami mitigation. Many communities have mapped hazard areas. Within these areas, communities may also have more detailed plans that include site analysis. The analysis typically includes geographic conditions, critical infrastructure (see Principle 6), area access and egress (see Principle 7), and existing and future development patterns. The analysis may also include economic feasibility and community design objectives.

Regional hazard maps can identify many of these at-risk areas, but typically they do not reflect the catastrophic potential of a tsunami that is accompanied by other disasters. Besides inundation, near-source earthquakes can cause damage and possibly lower the elevation of the entire region, causing flooding. Fires, broken infrastructure, liquefaction, mudslides, erosion, and other hazardous conditions can create scenarios that make communities even more vulnerable to tsunami waves. Therefore, each site assessment should identify other hazardous conditions besides elevation and shoreline configuration.



Avoiding



Slowing

3) Choose a Mitigation Strategy for the Site

Many communities work with project sponsors to select a mitigation approach during the site planning process. Generally, this includes siting solutions that avoid, slow, steer, or block inundation. These can be blended with building design and engineering that provides hardened or passive ways of handling the force of a tsunami (see Principle 4).

Specific Site Planning Strategies to Reduce Tsunami Risk

There are four basic site planning techniques that can be applied to projects to reduce tsunami risk:

1) Avoid inundation areas

2) Slow water currents

3) Steer water forces

4) Block water forces

These basic strategies can be used separately or be combined into a broader strategy. The methods can be used in passive ways to allow tsunamis to pass through an area without causing major damage, or they can be used to harden structures and sites to withstand the force of a tsunami. The efficacy of these techniques depends on the intensity of the tsunami event. If the tsunami hazard is underestimated, development in the area may still be vulnerable to a larger event.

Strategy 1: Avoiding

Avoiding a tsunami hazard area is, of course, the most effective mitigation method. At the site planning level, this can include siting buildings and infrastructure on the high side of a lot or raising structures above tsunami inundation levels on piers or hardened podiums.

Strategy 2: Slowing

Slowing techniques involve creating friction that reduces the destructive power of waves. Specially designed forests, ditches, slopes, and berms can slow and strain debris from waves. To work effectively, these techniques are dependent on correctly estimating the inundation that could occur.

Principle 3: Locate and configure new development that occurs in tsunami run-up areas to minimize future tsunami losses

Strategy 3: Steering

Steering techniques guide the force of tsunamis away from vulnerable structures and people by strategically spacing structures, using angled walls and ditches, and using paved surfaces that create a low-friction path for water to follow.

Strategy 4: Blocking

Hardened structures such as walls, compacted terraces and berms, parking structures, and other rigid construction can block the force of waves. Blocking, however, may result in amplifying wave height in reflection or in redirecting wave energy to other areas.

Mitigation Strategies by Type of Development

The following describes various types of new development that may be exposed to tsunami damage and identifies possible mitigation strategies for these different types of development.

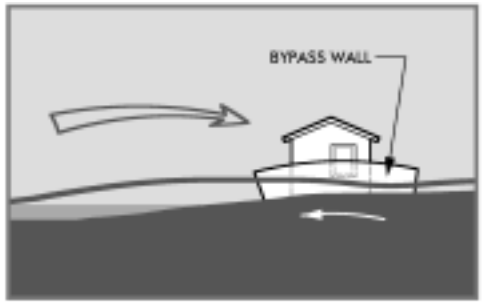
1) Infill Housing

In small communities, individual homes and infill housing are the most common forms of development. Often, there is great political pressure to allow development of smaller sites that do not permit locating development out of the hazard area. Communities can require that these smaller projects be raised above inundation levels and that engineering features be added to their design. However, they can still be vulnerable to damage from debris and other structures that may break free and collide with them. In some cases, new infill buildings can be sited on the high side of a lot to avoid being hit by another structure.

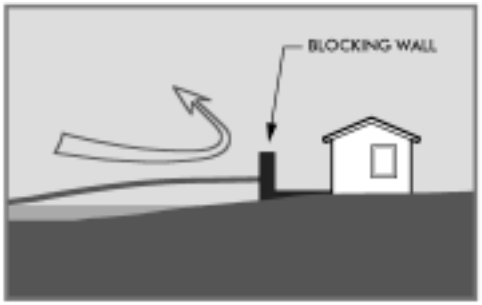
2) New Neighborhoods and Subdivisions

To reduce tsunami damage, the layout of new subdivisions in shoreline areas can include:

- providing maximum spacing between buildings
- elevating buildings above inundation levels
- placing houses behind a tsunami control forest or larger hardened buildings



Steering



Blocking

Principle 3: Locate and configure new development that occurs in tsunami run-up areas to minimize future tsunami losses

Elevated restaurant in Hilo, Hawaii. Lower level is designed to allow waves to pass through. Credit: Mintier & Associates

- siting primary access roads outside inundation areas and secondary access roads perpendicular to the shore

3) High-Rise Hotels

New hotels in coastal areas are typically multi-level concrete frame structures. The lower levels of these buildings can be designed for public areas such as lobbies and support uses (such as parking) for upper level rooms. In Hawaii, for example, lower levels of hotels have been designed to allow waves to pass through the ground floor parking, lobby, and service spaces, leaving upper level rooms and meeting spaces undamaged. These buildings must be designed to withstand both tsunami and earthquake forces.

4) Resorts

Resorts can include a broad range of facilities and services, such as small-scale cottages, large hotels, tennis facilities, swimming pools, golf, and beach-related recreation. Resort planning can draw on a variety of mitigation methods, including open space and tsunami forests, elevating or locating structures above estimated inundation levels, and buffering smaller buildings with larger hotels and waterfront structures.

5) Community Commercial

The downtowns of most coastal communities are located adjacent to piers and beach areas. The primary access roads typically follow the coastline and are lined with commercial enterprises. Both of these development patterns are susceptible to damage by tsunamis. Strengthening and expanding harbor structures can help protect adjacent commercial areas. Depending on the tsunami, however, breakwaters can be swamped by the rising tide and be ineffective. New buildings can be elevated above inundation levels or hardened and designed to withstand tsunami forces.

6) Industrial

Dry docks, refineries, power plants, and other shoreline industrial facilities are of special concern. Destruction or flooding of industrial facilities can add another environmental dimension to a tsunami disaster with burning oil, toxic chemicals, and other hazardous materials. Floating buildings, debris, and

boats can crush pipes and tanks. Protecting industrial facilities with walls and stronger anchoring can help; however, locating these types of uses outside of inundation zones is the most effective mitigation technique.

7) Essential and Critical Facilities

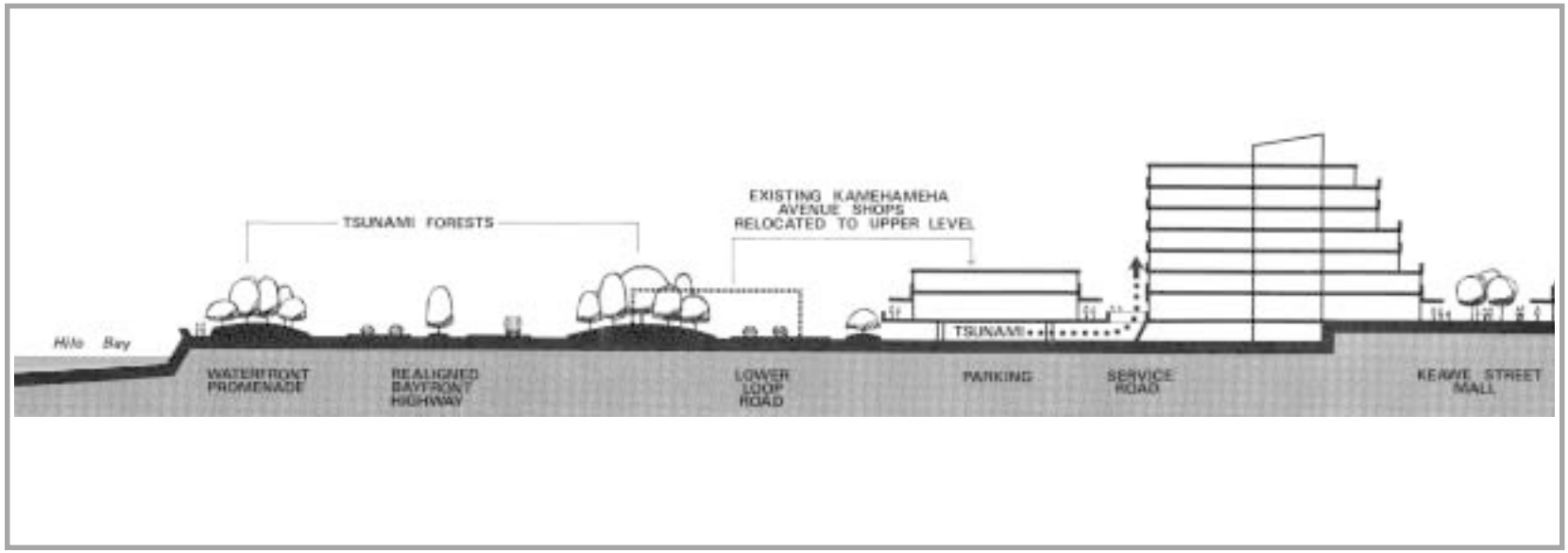
Fire stations, power substations, hospitals, sewage treatment facilities, and other critical infrastructure generally should not be located in inundation zones. Relocation of these types of facilities out of inundation areas should be an integral part of any tsunami mitigation plan. Where essential service facilities such as fire stations or permanent lifeguard stations must be located in tsunami hazard areas, they should be designed or retrofitted to survive tsunami damage. This topic is discussed in more detail under Principle 6.

Damage to port facilities in Seward, Alaska, from the 1964 tsunami. Locating industrial facilities outside of inundation zones is the most effective mitigation technique. Credit: U.S. Army Corps of Engineers

Case Study: Hilo Downtown Development Plan

The Hilo Downtown Development Plan was adopted in 1974 to guide efforts to revitalize the downtown core of Hilo, Hawaii. The Plan established a Safety District based on the 1946 and 1960 tsunami inundation lines. All redevelopment in the Safety District was subject to urban design and building design standards. Any structure below the 20-foot elevation contour line was required to be designed to withstand the force of a major tsunami. A Parking District was also designated in the Plan to provide parking for downtown businesses and to use parking structures as a protective barrier from a tsunami for inland structures. Parking facilities have been constructed in accordance with the Plan.

In 1985, the Hilo Downtown Development Plan was superceded by the Downtown Hilo Redevelopment Plan under the authority of Chapter 27, Flood Control, of the Hawaii County Code.



A section through the lower downtown area from the *Hilo Downtown Development Plan*. Credit: County of Hawaii

P•4

Principle 4: Design and construct new buildings to minimize tsunami damage

Damage to building in Hilo, Hawaii, from the 1960 tsunami. Although there are engineering techniques and materials that can be used to resist tsunami forces and inundation, in cases of intense tsunamis, they will reduce losses but not prevent severe damage. Credit: Pacific Tsunami Museum

Where buildings are to be constructed in a tsunami hazard area, the design and construction of the buildings–including construction materials, building configuration, and tsunami-specific design features–can reduce loss of life and property damage.

The Role of Construction Design in Reducing Tsunami Risk

As discussed under Principles 2 and 3, in areas subject to tsunamis and damaging run-up, the most effective mitigation technique is to locate new buildings away from potential inundation areas. Where this is not possible, building design and construction will play a critical role in the performance of structures in the event of a tsunami.

Performance Objectives

A performance objective for a building depends upon several considerations:

- **location of the building and its configuration (size, shape, elevations, and orientation)**
- **intensity and frequency of the tsunami hazard selected for design**
- **structural and non-structural design standards**
- **choice of structural and finish materials**
- **reliability of utilities**
- **professional abilities of designers**
- **quality of construction**
- **level of confidence in these factors**

Hospitals, fire stations, and schools would be assigned higher performance objectives than those assigned to tourist accommodations.

Potential tsunami damage to buildings can be minimized during the early project design stage where performance objectives are decided, governing standards are reviewed, and the configuration of the building is chosen. These decisions govern the building's final design and its actual construction. However, while special engineering techniques and materials can be used to resist tsunami forces and inundation, in the case of an intense tsunami, they will reduce losses but not prevent severe damage.

Principle 4: Design and construct new buildings to minimize tsunami damage

Building Codes

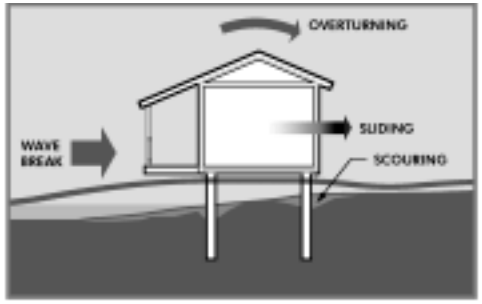
Building construction in the United States is governed at the local level by building codes. Building codes establish minimum acceptable requirements for protecting life, addressing property damage, and preserving the public health, safety, and welfare in the built environment. Building codes are applied to new construction as well as to existing buildings undergoing reconstruction, repair, rehabilitation, or alteration, or when the nature of the use is changed to a new occupancy that increases the risk or exceeds the structural capability of the building.

Process for Implementing Construction Design Strategies

1) Adopt and Enforce Appropriate Building Codes and Design Standards

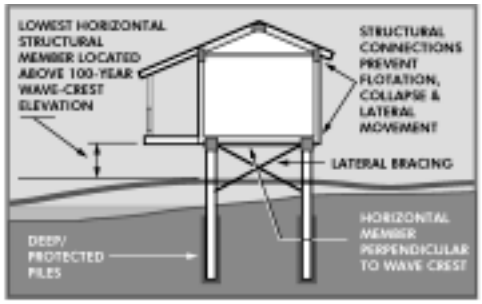
Most local building codes used in the Pacific states are based on the Uniform Building Code (UBC) prepared by the International Conference of Building Officials (ICBO). In California, Oregon, and Washington, the state governments mandate code adoption and enforcement at the local level. Alaska only mandates adoption of a fire code, and Hawaii does not mandate the use of a model code, leaving the option to county governments. All the counties in Hawaii and the larger cities in Alaska have adopted a version of the UBC. The states mandating the use of the UBC allow local government amendments that are more stringent than the mandated code provisions.

The UBC includes design requirements and standards for fire, wind, floods, and earthquakes, but it does not contain requirements for tsunami-resistant design. While a few communities have adopted tsunami-resistant building design standards, the vast majority of coastal communities have not. The City and County of Honolulu has adopted special requirements for floods and tsunamis as part of its Revised Ordinances. With appropriate modifications to reflect local conditions, these could serve as a general model for other states and municipalities. Guidance for architects and engineers in the design for tsunami forces is included in FEMA's *Coastal Construction Manual,* also known as FEMA 55. The manual deals with tsunamis in a manner similar to the Honolulu ordinance but uses more current information.



Forces on structures created by tsunamis

Principle 4: Design and construct new buildings to minimize tsunami damage



Design solutions to tsunami effects

2) Ensure That Codes and Standards Address the Full Range of Potential Hazards

While these guidelines emphasize tsunami loss prevention, other hazards such as earthquake groundshaking should, of course, also be addressed in the design of new buildings. Landslides, liquefaction, and other ground failures are potential problems in many coastal areas, as are seasonal floods where rivers and streams enter the ocean. Loss-prevention measures have already been adopted for most of these hazards, and it is important to recognize them in the effort to minimize direct tsunami losses.

3) Apply Locally Valid Tsunami Hazard Information

Where a tsunami hazard study has been prepared to inform local design decisions, the information can be used to decide whether to permit construction at a given site. If construction is to be permitted, the building design must address tsunami-related forces, including water pressure, buoyancy, currents and waves, debris impact, scour, and fire. The analyses will vary depending on location, building size, and type of construction, such as reinforced concrete, wood, light metal, and others.

4) Select the Intensity of Design Events

It is essential in the local hazard study to estimate tsunami intensity for various return intervals. Small tsunamis are less damaging, but they may be more frequent than occasional greater events. Smaller tsunamis might serve as the basis for designing most buildings. However, the rarer large events with higher water levels and stronger forces should be the basis for designing critical facilities, such as hospitals, fire stations, and refineries.

5) Define the Building's Performance Level

Performance levels describe expectations of owners, occupants, and regulators relative to the amount of damage a building could sustain from a tsunami and the building's ability following a tsunami event to support the uses for which it was intended. The design of a building to achieve a particular performance level involves a set of decisions that begins with determining the importance of the building and understanding the consequences of damage to the building.

Principle 4: Design and construct new buildings to minimize tsunami damage

There are four performance levels that can be considered for buildings: minimum, safety, reoccupancy, and operational levels.

Buildings located, designed, and constructed to the *minimum level* should withstand water forces without being moved off their foundations or sites, but they could still be damaged by debris, flooding, ground failures, or other effects.

Buildings constructed to perform at a *safety level* should withstand water forces, debris and wave-break impacts, earthquake shaking, ground failure, and fire without significant structural damage. People in taller buildings would be able to evacuate vertically above the level of wave action resulting from a locally-generated tsunami.

Buildings constructed to a *reoccupancy level* should meet the safety level of performance, but additional precautions should be taken so they can be reoccupied within a few days to weeks after cleanup, minor repairs, and the restoration of utilities. This level requires the careful choice of the building location and the use of flood-resistant materials.

Finally, the most demanding requirements are used to design buildings to meet the *operational level* of performance. These buildings should be capable of resisting all expected forces and hazards. They must also have backup emergency systems and utilities so they can be used immediately following a tsunami.

Damage to buildings in Hilo, Hawaii, from the 1946 tsunami. Credit: Pacific Tsunami Museum

Specific Design and Construction Strategies to Reduce Tsunami Risk

Strategy 1: Choose Appropriate Design Solutions Based on Expected Tsunami Effects

Design and construction of new buildings should address forces associated with water pressure, buoyancy, currents and waves, debris impact, scour, and fire.

Substantially constructed buildings of concrete, masonry, and heavy steel frames are likely to perform fairly well in a tsunami unless compromised by earthquake shaking. Wood-frame buildings,

manufactured housing, and light steel-frame structures at lower elevations close to the shoreline are likely to fare poorly in a tsunami. Not every area affected by tsunami run-up, however, will experience damaging forces. Buildings in less hazardous areas affected by shallow run-up water depths should survive with repairable damage if they are designed and constructed well. The force of currents and breaking waves, fast-moving waterborne debris, and scouring currents may exceed the resisting capabilities of most buildings unless the buildings are constructed with specific design elements and materials.

The table on page 35 lists the possible effects of tsunamis on structures (such as flooding, water pressures and forces, buoyancy, debris impacts, foundation scouring) and suggests possible design solutions for each of the potential effects (such as elevating and anchoring buildings; designing for water forces, pressures, and impact loads; and using deep piles or piers). As noted above, it is important that the design measures be based on the local hazard study so that expected forces determine the design solutions.

Strategy 2: Require Qualified Architects and Engineers to Design Large Buildings

Building design is governed by engineering principles and practices and by building codes that establish minimum standards relating to public health and safety; however, codes are no substitute for competent engineering, design, construction, and quality assurance.

Specialized expertise is often needed when designing and constructing large, complex, or unusually shaped buildings. Communities should identify proposed projects that require specially qualified and licensed professionals, see that the owning/developing organizations secure such assistance early in the project planning phase, and help locate sources of qualified assistance. Professional associations can help local officials find needed experts such as architects and geotechnical, coastal, and structural engineers who are familiar with coastal design and construction issues.

Some jurisdictions require that such professionals be involved in building design and be identified on the

building's plans and specifications. The use of such experts is especially important when codes and standards are absent or inadequate, or when the proposed building is intended to exceed the minimum life safety standards contained in commonly used codes and standards.

Strategy 3: Inspect Construction to Assure Requirements are Met

Construction inspection is important to ensure that buildings are constructed according to the appropriate standards. Independent inspections can be provided in several ways: 1) use of qualified permitting agency staff; 2) use of independent technical experts retained by the governing jurisdiction; or 3) requiring the owner to use such experts whose reports would be provided to the governing jurisdiction for review and acceptance. In some areas, licensed construction inspectors and consulting engineers provide these services.

Principle 4: Design and construct new buildings to minimize tsunami damage

Tsunami effects and design solutions

Phenomenon	Effect	Design Solution
Inundation	• Flooded basements • Flooding of lower floors • Fouling of mechanical, electrical, and communication systems and equipment • Damage to building materials, furnishings, and contents (supplies, inventories, personal property) • Contamination of affected area with waterborne pollutants	• Choose sites at higher elevations • Raise the building above the flood elevation • Do not store or install vital material and equipment on floors or basements lying below tsunami inundation levels • Protect hazardous material storage facilities that must remain in tsunami hazard areas • Locate mechanical systems and equipment at higher locations in the building • Use concrete and steel for portions of the building subject to inundation • Evaluate bearing capacity of soil in a saturated condition
	• Hydrostatic forces (pressure on walls caused by variations in water depth on opposite sides)	• Elevate buildings above flood level • Anchor buildings to foundations • Provide adequate openings to allow water to reach equal heights inside and outside of buildings • Design for static water pressure on walls
	• Buoyancy (flotation or uplift forces caused by buoyancy)	• Elevate buildings • Anchor buildings to foundations
	• Saturation of soil causing slope instability and/or loss of bearing capacity	• Evaluate bearing capacity and shear strength of soils that support building foundations and embankment slopes under conditions of saturation • Avoid slopes or provide setback from slopes that may be destabilized when inundated
Currents	• Hydrodynamic forces (pushing forces caused by the leading edge of the wave on the building and the drag caused by flow around the building and overturning forces that result)	• Elevate buildings • Design for dynamic water forces on walls and building elements • Anchor building to foundations
	• Debris impact	• Elevate buildings • Design for impact loads
	• Scour	• Use deep piles or piers • Protect against scour around foundations
Wave break and bore	• Hydrodynamic forces	• Design for breaking wave forces
	• Debris impact	• Elevate buildings • Design for impact loads
	• Scour	• Design for scour and erosion of the soil around foundations and piles
Drawdown	• Embankment instability	• Design waterfront walls and bulkheads to resist saturated soils without water in front • Provide adequate drainage
	• Scour	• Design for scour and erosion of the soil around foundations and piles
Fire	• Waterborne flammable materials and ignition sources in buildings	• Use fire-resistant materials • Locate flammable material storage outside of high-hazard areas

P•5

Principle 5: Protect existing development from tsunami losses through redevelopment, retrofit, and land reuse plans and projects

Astoria, Oregon, at the mouth of the Columbia River. Many of the tsunami risk mitigation techniques used for new development can be applied to existing development, but their application will be limited by site constraints and building conditions. Credit: Army Corps of Engineers

The challenges in protecting existing development from tsunami losses are many and complex. For coastal communities that are nearly built out, protecting existing development may be the only real mitigation option available. However, land uses, buildings, and infrastructure change over time, creating opportunities to incorporate tsunami (and other hazard) loss-prevention measures to help make communities less vulnerable in the future.

The Role of Renewal in Reducing Tsunami Risk

Efforts to renew communities can take many forms, including redefining permitted land uses, changing zoning standards, changing building uses and occupancies, retrofitting and rehabilitating buildings, and redeveloping districts to improve their economic vitality. There may also be special considerations in tsunami-vulnerable areas such as protecting landmarks and historic structures, creating scenic vistas, providing improved access to coastal amenities, improving services, and accommodating needed housing and commercial activities.

While many tsunami mitigation techniques used in new development can be applied to existing development, their application will be limited by site constraints and building conditions.

The reconstruction process following a disaster provides an opportunity to create or modify land uses, implement redevelopment plans, rehabilitate buildings, and vacate high-hazard lands subject to repetitive losses–all with the intent of reducing future losses.

Process for Reducing Vulnerability Through Renewal Efforts

1) Inventory At-Risk Areas and Properties

If not already available, an inventory should be completed of buildings, critical facilities, and infrastructure elements in the potential tsunami inundation area (see Principle 1 for a more detailed discussion of this topic). More than a simple tally, this inventory should take into account the type of structure, its age, size and configuration, construction material, and use.

Principle 5: Protect existing development from tsunami losses through redevelopment, retrofit, and land reuse plans and projects

For risk-mitigation purposes, it is important to assess the condition of buildings and their construction characteristics. Significant deterioration may demand replacement, but retrofit and rehabilitation may be appropriate in other cases.

Some buildings are complex, having been modified or expanded over time. It is rare that adequate drawings of older buildings are available. This usually means that an engineering study is needed to determine the actual characteristics of the building before project-specific rehabilitation or retrofit plans can be made.

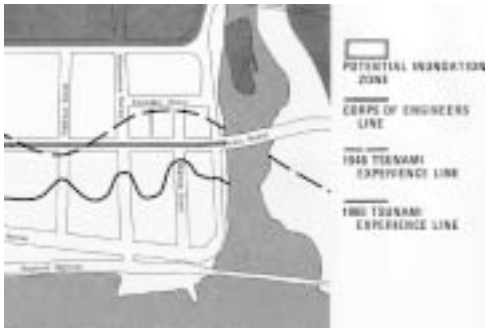
2) Evaluate and Revise Plans and Regulations to Address Redevelopment, Retrofit, and Reuse Issues

Periodically, communities perform an in-depth review and revision of their land use, comprehensive, and growth management plans. The periodic plan updates provide a broad context within which redevelopment and renewal policies and plans can be developed.

Building codes primarily address new construction; generally, they do not address renovations and retrofitting comprehensively or in detail. Local building codes should be amended to fully address risk mitigation in the context of building renovation. As a starting point, there are several examples of code amendments concerning retrofitting buildings for earthquake hazards that can be adapted for tsunami hazards. The Federal Emergency Management Agency (FEMA) sponsored the preparation of a multiple-volume guide on rehabilitating buildings to resist earthquake forces. Several states and communities have also adopted laws and ordinances governing the retrofitting and rehabilitation of existing buildings to reduce future losses from earthquakes.

Anchor bolts. Measures to resist earthquake shaking, such as anchoring and bracing buildings, can also help to reduce tsunami damages. Credit: Northridge Collection, Earthquake Engineering Research Center, University of California, Berkeley

Principle 5: Protect existing development from tsunami losses through redevelopment, retrofit, and land reuse plans and projects



An excerpt from the tsunami inundation map in the *Hilo Downtown Development Plan*. Credit: County of Hawaii

Specific Renewal Strategies to Reduce Tsunami Risk

Strategy 1: Adopt Special Programs and Development Regulations

There is a variety of specific development regulations and programs that local communities can implement to minimize tsunami risk, including:

- redesignating and rezoning land in tsunami hazard areas for uses more consistent with the risk as non-conforming uses are phased out
- limiting additions to existing buildings in tsunami hazard areas
- buying specific properties in tsunami hazard areas and removing or relocating buildings

Strategy 2: Use Redevelopment Strategies to Reduce Tsunami Risk

Redevelopment land acquisition and financing powers can be used on a district-wide scale to reconfigure uses or infrastructure, retrofit specific buildings, or remove buildings altogether in tsunami hazard areas.

Strategy 3: Use Incentives and Other Financial Measures to Support Loss Prevention

One key to the success of redevelopment and other renewal measures is helping building owners bear the cost of the proposed changes. There are many commonly used incentives that help spur renewal, such as reduced property taxes, waiving of permit and inspection fees, and low interest loans. Local officials should ensure that whatever incentives are used include risk mitigation as an eligible purpose.

Strategy 4: Adopt and Enforce Special Provisions for the Retrofit of Existing Buildings

Retrofit of existing buildings should be encouraged when the effort will improve tsunami resistance to a level capable of meeting identified performance objectives, or to minimize floating debris that can damage nearby buildings. Retrofitting may be required for all buildings within a hazard zone, or may be mandated only when substantial modifications are made to existing structures or when there are changes in building occupancy.

Principle 5: Protect existing development from tsunami losses through redevelopment, retrofit, and land reuse plans and projects

The complexities associated with strengthening existing structures may require the development, adoption, and implementation of special codes, standards, and procedures. Moreover, special purpose requirements may exist, such as codes governing the rehabilitation of historic buildings, that may or may not contain provisions for protecting against hazards. Flexibility may be needed to ensure that effective mitigation techniques can be applied to such properties without seriously disrupting their original characteristics.

The standards for upgrading buildings involve the same factors as constructing new buildings; however, upgrading to achieve a selected performance objective is more expensive to implement after initial construction is completed. Dealing with the vulnerability of existing buildings is difficult because of the limited number of alternatives and cost of remedial measures that will withstand hydrodynamic and impact loads.

Measures that improve resistance to tsunamis in combination with other more frequently occurring hazards are more likely to be feasible. These include elevating buildings above the base flood elevation, improving foundations to resist scour and erosion, and anchoring and bracing the buildings to resist earthquake shaking. Although these measures can reduce tsunami damage, especially in the statistically more-frequent small tsunamis, they will not ensure that a building is able to withstand the intense forces associated with larger events.

Strategy 5: Require Qualified Architects and Engineers to Design Effective Measures to Protect Existing Development

As discussed under Principle 4, specialized expertise should be used to help design measures to reduce future losses. Such expertise is important when considering measures to strengthen existing development because of the complexities associated with such projects and the greater reliance placed on experience and judgment. Design professionals and engineers who specialize in rehabilitation and retrofit practices can be located through professional associations and contacts with local practitioners.

P•6

Principle 6: Take special precautions in locating and designing infrastructure and critical facilities to minimize tsunami damage

Bore advancing through the railroad bridge at the Wailuku River in Hilo, Hawaii, during the 1946 tsunami. Credit: Pacific Tsunami Museum

Certain facilities in a community deserve special attention in the planning and design process to minimize damage to them. Infrastructure such as transportation systems for people and goods, and utility systems such as communications, natural gas, water supply, power generation, and transmission/distribution systems are essential to the continued operation of a community and need to be functional—or easily and rapidly repairable—following a disaster.

Other facilities in the community are considered critical because of their occupants or the functions they contain. These include: 1) essential service facilities such as fire stations; 2) hazardous facilities such as chemical plants or fuel storage tanks; and 3) special occupancy structures with uses such as government functions important to sustaining a community, buildings with large numbers of occupants, or buildings such as convalescent homes with occupants who cannot evacuate the premises readily.

The Role of Infrastructure and Critical Facility Location and Design in Reducing Tsunami Risk

Infrastructure and critical facilities are often located on the coast within tsunami hazard areas. In some cases, such as fire stations, the facilities may need to be located in tsunami hazard areas; in other cases, they could just as easily be located outside the tsunami hazard area.

Because of the services these facilities provide—or the harm they could cause—to the community, their performance during natural hazard events is a community-wide concern that needs to be considered as part of a tsunami risk management effort.

Process for Implementing Infrastructure and Critical Facility Location and Design Strategies

1) Understand Tsunami Mitigation Responsibilities

Managing the tsunami risk is a responsibility shared by the government and private sectors. Depending

Principle 6: Take special precautions in locating and designing infrastructure and critical facilities to minimize tsunami damage

on the community, infrastructure systems and critical facilities may be owned and managed by local or state agencies, special districts, private companies, nonprofit organizations, federal departments and agencies, joint powers authorities, or others. Mitigation programs need to involve all participants in the planning process.

2) Understand and Describe the Nature and Extent of the Tsunami Hazards for Infrastructure and Critical Facilities

Principle 1 provides background information on local tsunami risk studies and hazard scenarios. In such studies, it is important to include information about infrastructure and critical facilities and to identify who is responsible for their location, design, construction, operation, and maintenance. This work includes the following:

- Define the tsunami hazard (see Principle 1) and describe it by intensity (expected effects) and probability of occurrence.
- Inventory and gather data about infrastructure elements and critical facilities in the potential damage area and describe why their functions make tsunami resistance an important issue for the community and what makes each facility vulnerable to damage from tsunami forces.
- Identify the responsible organizations and include their representatives in the mitigation process.

3) Adopt Comprehensive Risk Management Policies

Communities should adopt policies to manage the tsunami risk and integrate them into coastal management programs, land use plans, floodplain zoning, capital outlay plans, building regulation programs, and other procedures used to control the use and safety of facilities near the shoreline.

Essential service facilities should be operational following a hazard event. This concept already is contained in the Uniform Building Code (UBC) and could be adapted for tsunami hazards. The UBC requires the use of enhanced seismic and wind forces for design, and enhanced structural inspection during construction of essential service facilities. To ensure stronger structures, the UBC uses

A boat washed up over 400 feet onshore from the wharf by the 1946 tsunami in Hilo, Hawaii. Credit: Pacific Tsunami Museum

Examples of infrastructure and critical facilities

INFRASTRUCTURE

Transportation Systems

- Roads, highways, bridges, parking lots and structures, and traffic control systems
- Railroads track beds, bridges, and rail and switching yards for freight and passengers
- Transit systems (rail, trolley, tram, and motor coach), storage and maintenance facilities, power systems and substations, control systems, bridges, tunnels, and tubes
- Airports and control towers
- Maritime ports, and maritime traffic control systems, marine terminals, loading/unloading facilities, storage facilities (including tank farms), docks, and ship moorings, piers, seawalls, and bulkheads

Utility Systems

- Electrical generation, transmission, substations, and distribution systems
- Natural gas production, processing, storage, transmission, pump, and distribution systems
- Land line communication systems: switching stations, trunk lines, and data lines

(cont.)

an "importance factor" to increase the force levels by 15 to 50 percent over those calculated for other occupancy categories.

4) Adopt a Comprehensive Infrastructure and Critical Facility Plan

Communities should revise or adopt measures that deal with existing and new infrastructure, critical facilities, and waterfront-dependent uses in relation to tsunami hazards. These comprehensive infrastructure and critical facility plans should define performance objectives for the various types of existing and planned facilities in the community. Strategies should include relocating or, if possible, strengthening existing infrastructure and critical facilities against tsunami forces. They should also include providing redundant facilities and emergency response measures to lessen the impact of losing infrastructure and critical facilities that remain at risk.

Proposals for new critical facilities and infrastructure located in tsunami hazard areas should be considered carefully to determine whether the performance expected is acceptable once feasible design measures are implemented. Proposals for new infrastructure should be evaluated in terms of the increased risk because of induced growth. For example, construction of new buildings and facilities may be facilitated by the provision of new water or wastewater collection services in the hazard area.

Existing infrastructure and critical facilities are particularly problematic. It is difficult and expensive to improve the tsunami performance of existing facilities and infrastructure, and relocation is usually impractical, especially in the short term. However, understanding the risk to these existing facilities and anticipating the consequences of tsunami events can lead to long-term risk-reducing strategies (see Principle 5 for a more detailed discussion of issues related to existing buildings).

Because of the varied nature and differing importance of infrastructure systems and critical facilities, an effort must be made to rank their relative importance to the community and to establish

Principle 6: Take special precautions in locating and designing infrastructure and critical facilities to minimize tsunami damage

performance objectives to help guide mitigation actions. This work includes the following:

- Determine appropriate performance levels (i.e., acceptable damage condition for a given tsunami intensity and probability). See Principle 4 for a discussion of performance levels.
- Determine how each existing system and facility has addressed tsunami and earthquake mitigation plus any important site hazards, such as potential landslides or soil failures.
- Establish a scale of relative importance to help focus mitigation efforts (e.g., preventing losses of the potable water systems may be more important than preventing losses of the wastewater system).
- Set acceptable outage intervals for each element (e.g., the community hospital must be minimally functional within one hour of the event, but a major street could be bypassed for two weeks).
- For new infrastructure and critical facilities, determine appropriate performance levels and whether their use is dependent on a waterfront location.
- For existing infrastructure and critical facilities, determine which mitigation options or combination of options can reduce the risk and whether the remaining risk would be acceptable.

Specific Infrastructure and Critical Facility Location and Design Strategies to Reduce Tsunami Risk

Strategy 1: Locate New Infrastructure and Critical Facilities Outside the Tsunami Hazard Area or Design to Resist Tsunami Forces

- Examine plans for infrastructure and critical facilities to see if other, equally efficient alternative locations, alignments, and routes can be used. Most critical facilities need not be located in a tsunami hazard area to serve their intended purpose. Some essential facilities may need to be located in a tsunami hazard area because alternative locations will not serve the day-to-day needs of the community.
- Reserve sites for infrastructure and critical facilities either outside the tsunami hazard area or in areas where the risk can be reduced through feasible measures.
- Prohibit new critical facilities in tsunami hazard areas unless: 1) they are waterfront dependent and the design can mitigate the vulnerability to such an extent that the resulting facility will perform as needed; 2) risk is reduced through

Examples of infrastructure and critical facilities (cont.)

- Cellular systems, switching stations, antenna, and towers
- Cable systems for television, radio, and data
- Satellite systems for television and data
- Potable water systems: wells, water supply sources, storage, pumps, and treatment and distribution systems
- Sewerage collection, mains, pumps, treatment facilities, and outfalls
- Pipelines that transport oil, fuels, and other petroleum products
- Storm water runoff facilities, drainage, and pipelines

CRITICAL FACILITIES

Essential Services

- Police stations
- Firehouses
- Hospitals with surgery, acute care, or emergency rooms
- Emergency operations and communications facilities and equipment
- Garages and shelters for emergency vehicles and aircraft

(cont.)

Examples of infrastructure and critical facilities (cont.)

- Standby power-generating equipment for essential services
- Tanks or other structures containing water or other fire-suppression material or equipment required to protect essential, hazardous, or special occupancy facilities
- Permanent lifeguard stations

Special Occupancy Structures

- Schools
- Universities and colleges
- Residential treatment centers and nursing and convalescent homes
- Retirement communities
- Large-occupancy structures
- Power-generating stations and other utility facilities needed for continuous operations

Hazardous Facilities

- Fuel docks and storage
- Spent nuclear fuel storage
- Chemical storage facilities
- Rail tank cars and trucks with chemicals
- Munitions storage, loading docks, and harbors

mitigation and emergency planning measures; or 3) the need for the facility outweighs the consequences of its loss during a tsunami (e.g., a small hospital in a remote, tsunami-prone area may be justified because it needs to be close to the population for routine emergencies).

- Prohibit infrastructure improvements that will encourage construction of other facilities that cannot withstand the tsunami hazard.
- Consider the impact of new infrastructure on hazard intensity and distribution. For example, does it change drainage patterns, increase exposure to inundation, or channel currents in a way that will increase the hazard?
- Provide redundant facilities and infrastructure outside tsunami hazard areas where elements and facilities must serve high-hazard areas.
- Employ design professionals qualified in coastal, structural, and geotechnical engineering on infrastructure and critical facility projects in high-hazard areas. Communities should identify proposed projects that should involve specially qualified and licensed professionals, see that the owning organizations secure the specialized assistance as early as possible in the project planning, and locate both local and distant sources of qualified assistance that can be contacted when needed.
- Where it is impractical to locate infrastructure and critical facilities outside tsunami hazard areas, ensure that adequate mechanisms exist to isolate the damaged area, such as shutoff valves, detours, and others.

Strategy 2: Protect or Relocate Existing Infrastructure and Critical Facilities

- Do not allow expansion or renovation of existing facilities in tsunami hazard areas without requiring measures to reduce the risk.
- Construct barriers (reinforced walls and columns) to protect against impact forces and scour.
- Elevate existing facilities above the inundation elevation.
- Relocate portions of at-risk facilities.
- Take advantage of the eventual obsolescence of existing infrastructure and critical facilities as an opportunity to phase out the facility, relocate the facility, or incorporate design standards that will allow for acceptable performance following a tsunami.

Principle 6: Take special precautions in locating and designing infrastructure and critical facilities to minimize tsunami damage

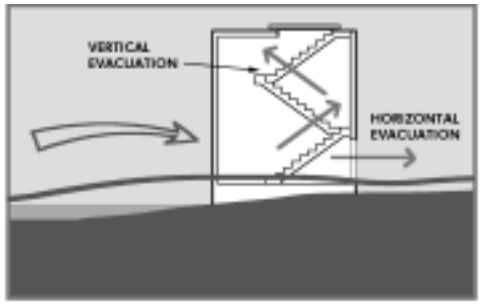
Strategy 3: Plan for Emergencies and Recovery

- **Prepare emergency plans to cope with the emergency situation and expedite recovery.**
- **When waterfront-dependent infrastructure and critical facilities cannot be newly designed or retrofitted to withstand tsunami forces, they should be considered expendable and planning should be undertaken for evacuation, emergency response, recovery, and replacement facilities. It is important to remember that in a tsunami an expendable building may turn into debris that can batter people and non-expendable structures.**

Petroleum tank on fire due to damage from the 1964 tsunami on Highway 101 near Crescent City, California. Credit: Del Norte Historical Society

P•7

Principle 7: Plan for evacuation



Vertical and horizontal evacuation

The primary strategy for saving lives immediately before tsunami waves arrive is to evacuate people from the hazard zone. Two methods are generally available:

- horizontal evacuation—moving people to more distant locations or higher ground
- vertical evacuation—moving people to higher floors in buildings

Horizontal evacuation and other emergency response measures are outside the scope of these guidelines and have been addressed in other publications (see Resources and Bibliography at the end of the guidelines). Vertical evacuation, however, is addressed in these guidelines since it is linked to issues of land use, siting, and building design and construction.

The Role of Vertical Evacuation in Reducing Tsunami Losses

Evacuating people can save lives and reduce injuries, but it will have little, if any, effect on reducing property and economic losses. In coastal areas where building and population densities are high, where roads, bridges, and other horizontal evacuation methods are limited, or where warning time may be insufficient, vertical evacuation may be needed as an alternative or supplement to horizontal evacuation. Land use planning, site planning, and building design discussed in the previous principles play an important role in a community's ability to rely, at least partially, on vertical evacuation to protect people.

Process for Implementing a Vertical Evacuation Strategy

1) Inventory Existing Buildings

The building stock for vertical evacuation varies greatly across communities. Thus, it is critical that a community inventory and assess buildings that could serve as vertical evacuation shelters. This may be difficult because important information about existing buildings, such as drawings and calculations, may not be available. Professional engineers play a key role in evaluating the capacity of structures to

resist expected forces, and their reports often lead to rehabilitation and retrofit work designed to strengthen the buildings. This topic is discussed in more detail under Principle 5.

2) Ensure Adequate Standards Apply to New Buildings

New buildings to be designated as vertical evacuation shelters must have sufficient structural integrity to resist expected tsunami forces and earthquake groundshaking for tsunamis originating locally. Building codes and other applicable standards should ensure the tsunami and earthquake resistance of new buildings. These standards should go beyond the minimum life safety requirement of most locally-adopted codes.

Communities and building owners should also secure the assistance of qualified professionals in the fields of geotechnical, coastal, and structural engineering. Further information about building siting and design can be found under Principles 3, 4, 5, and 6.

3) Designate Emergency Services Personnel to Lead the Program

Vertical evacuation, while dependent on structures for its success, is primarily an emergency preparedness and response measure. It is important, therefore, that those community officials responsible for planning and managing emergency programs and operations take lead responsibility for vertical evacuation planning. In addition, it is extremely important to involve building owners and tenants in the process of establishing a vertical evacuation program.

4) Resolve Related Issues

There are several other issues that are important to vertical evacuation. These vary among communities and states, but include emergency preparedness requirements, standards of care for evacuees, access to designated shelters, and liability of public agencies and building owners.

Tsunami evacuation route sign in Crescent City, California. Credit: FEMA

Specific Vertical Evacuation Plan Strategies to Reduce Tsunami Exposure for People

Strategy 1: Identify Specific Buildings to Serve as Vertical Shelters

Some existing buildings can serve as vertical shelters and newer ones can be located, designed, and constructed with that use in mind. Local building officials and consulting engineers can help inventory the community's stock of candidate buildings, evaluate the buildings' tsunami- and earthquake-resistant capabilities, and establish criteria and standards for rehabilitation or new construction that meet the expected hazard forces so the buildings will be able to serve as shelters.

Factors to be considered in determining a building's suitability include size, number of stories, access, contents, and available services. Only those buildings judged able to withstand the potential tsunami and earthquake forces and that meet other occupancy criteria should be designated as shelters. For example, if expected tsunami wave heights will not exceed one story (about 10 feet), then open-floor designs can be used to allow the waves to pass through with minimal impact on the building. Further information about evaluating the tsunami resistance of existing buildings is discussed under Principle 5.

Strategy 2: Work Out Agreements and Procedures with Building Owners

To a large extent, vertical evacuation shelters will be designated in privately owned buildings. For a program to be effective, therefore, appropriate agreements should be negotiated with the owners, and the owners or their representatives should be involved in the creation and maintenance of the program. While they will vary among communities and states, issues related to notification, standards of care, compensation, duration of occupancy, security, and liability will be important to the owners.

Strategy 3: Ensure Procedures Exist to Receive and Disseminate Warnings

It is very important that tsunami-vulnerable communities have adequate procedures and systems for notification by official warnings so appropriate actions can be taken, sometimes many hours in

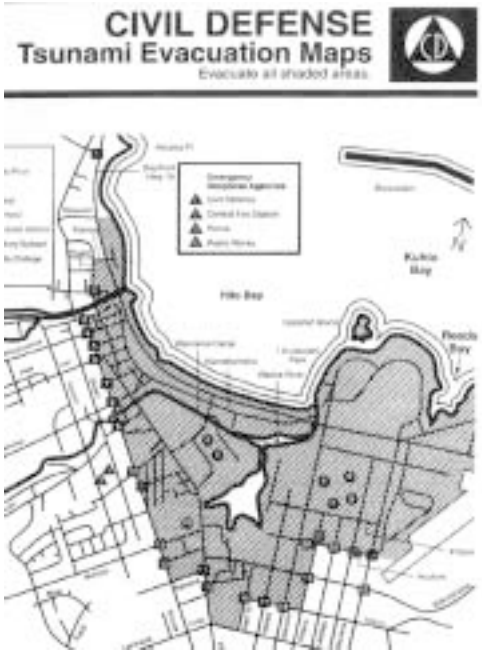
advance for distant tsunamis. Local tsunamis pose special problems because insufficient time might preclude official warnings. Some communities are advising and training their residents and visitors to evacuate immediately whenever earthquake shaking is felt. If no tsunami warning is issued, people can return after a short time.

Strategy 4: Implement Effective Information and Education Programs

Communities can use brochures, single-page instructions, periodic warning system tests, electronic and print media information, signs, and emergency response exercises to maintain awareness and instill effective response behavior. Some of this information will be directed towards specialized institutions, such as schools, hospitals, and convalescent-care facilities, and non-English speaking community members. Because of seasonal tourism in many coastal communities, some information is designed especially for tourists. Depending on the community's needs, it is important that information and education efforts be routine, comprehensive, and tailored for special facilities and populations.

Strategy 5: Maintain the Program Over the Long Term

Tsunamis are rare events, but their impacts on coastal communities can be devastating. It is a challenge to maintain emergency preparedness programs and procedures when the threat is perceived as remote. It is, therefore, important that vertical evacuation measures be integrated into community response plans and that they be reviewed and revised regularly. Since cooperation is essential, these reviews should include building owners and others involved in the program. Periodic simulations are a valuable learning exercise, and regular informational and instructional materials should be provided to those occupying potential tsunami damage areas.



Tsunami evacuation map from the civil defense section of the Hilo, Hawaii, telephone book

Case Study: Tsunami Warning Programs

The following is a description of tsunami warning programs. This topic is not directly related to vertical evacuation, but provides helpful background information.

As part of an international cooperative effort to save lives and protect property, the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service operates two tsunami warning centers. The West Coast and Alaska Tsunami Warning Center (WCATWC) in Palmer, Alaska, serves as the regional tsunami warning center for Alaska, British Columbia, Washington, Oregon, and California.

The Pacific Tsunami Warning Center (PTWC) in Ewa Beach, Hawaii, serves as the regional tsunami warning center for Hawaii and as a national/international warning center for tsunamis that pose a Pacific-wide threat. This international warning effort became a formal arrangement in 1965 when PTWC assumed the international warning responsibilities of the Pacific Tsunami Warning System (PTWS). The PTWS is composed of 26 international member states that are organized as the International Coordination Group for the Tsunami Warning System in the Pacific.

The two tsunami warning centers coordinate the information being disseminated. The objective of the tsunami warning centers is to detect, locate, and determine the magnitude of potentially tsunamigenic earthquakes. Earthquake information is provided by seismic stations. If the location and magnitude of an earthquake meet the known criteria for generation of a tsunami, a tsunami warning is issued to warn of an imminent tsunami hazard. The warning includes predicted tsunami arrival times at selected coastal communities within the geographic area defined by the maximum distance the tsunami could travel in a few hours. A tsunami watch with additional predicted tsunami arrival times is issued for a geographic area defined by the distance the tsunami could travel in a subsequent time period.

continued on next page

Tsunami hazard zone logo

Case Study: Tsunami Warning Programs, cont.

If a significant tsunami is detected by sea-level monitoring instrumentation, the tsunami warning is extended to the entire Pacific Basin. Sea-level (or tidal) information is provided by NOAA's National Ocean Service, PTWC, WCATWC, university monitoring networks, and other participating nations of the PTWS.

Tsunami watch, warning, and information bulletins are disseminated to appropriate emergency officials and the general public by a variety of communication methods:

- Tsunami watch, warning, and information bulletins issued by PTWC and WCATWC are disseminated to local, state, national, and international users as well as the media. These users, in turn, disseminate the tsunami information to the public, generally over commercial radio and television channels.
- The NOAA Weather Radio System, based on a large number of VHF transmitter sites, provides direct broadcast of tsunami information to the public.
- The U.S. Coast Guard also broadcasts urgent marine warnings and related tsunami information to coastal users equipped with medium frequency (MF) and very-high-frequency (VHF) marine radios.
- Local authorities and emergency managers are responsible for formulating and executing evacuation plans for areas under a tsunami warning. The public should stay tuned to the local media for evacuation orders should a tsunami warning be issued. And, the public should not return to low-lying areas until the tsunami threat has passed and the local authorities announce the "all clear."

GLOSSARY

Amplitude:
The tsunami's rise above or drop below the ambient water level as read on a tide gauge.

Bore:
Traveling wave with an abrupt vertical front or wall of water. Under certain conditions, the leading edge of a tsunami wave may form a bore as it approaches and runs onshore. A bore may also be formed when a tsunami wave enters a river channel, and may travel upstream penetrating to a greater distance inland than the general inundation.

Harbor Resonance:
The continued reflection and interference of waves from the edge of a harbor or narrow bay. This interference can cause amplification of the wave heights and extend the duration of wave activity from a tsunami.

Horizontal Inundation Distance:
The distance that a tsunami wave penetrates onto the shore. Measured horizontally from the mean sea level position of the water's edge, it is usually measured as the maximum distance for a particular segment of the coast.

Inundation:
The depth, relative to a stated reference level, to which a particular location is covered by water.

Inundation Area:
An area that is flooded with water.

Inundation Line (limit):
The inland limit of wetting, measured horizontally from the edge of the coast, defined by mean sea level.

Local/Regional Tsunami:
Source of the tsunami is within 1000 km of the area of interest. Local or near-field tsunami has a very short travel time (30 minutes or less), mid-field or regional tsunami waves have times on the order of 30 minutes to 2 hours. Note: "local" tsunami is sometimes used to refer to a tsunami of landslide origin.

Period:
The length of time between two successive peaks or troughs. May vary due to complex interference of waves. Tsunami periods generally range from 5 to 60 minutes.

Run-up:
Maximum height of the water onshore observed above a reference sea level. Usually measured at the horizontal inundation limit.

Seiche:
An oscillating wave in a partially or fully enclosed body of water. May be initiated by long period seismic waves, wind and water waves, or a tsunami.

Tidal Wave:
Common term for tsunami used in older literature, historical descriptions, and popular accounts. Tides, caused by the gravitational attractions of the sun and moon, may increase or decrease the impact of a tsunami, but have nothing to do with their generation or propagation. However, most tsunamis (initially) give the appearance of a fast-rising or fast-ebbing tide as they approach shore, and only rarely appear as a near-vertical wall of water.

Travel Time:
Time (usually measured in hours and tenths of hours) that it took the tsunami to travel from the source to a particular location.

Tsunami:
A Japanese term derived from the characters "tsu" meaning harbor and "nami" meaning wave. Now generally accepted by the international scientific community to describe a series of traveling waves in water produced by the displacement of the sea floor associated with submarine earthquakes, volcanic eruptions, or landslides.

RESOURCES

RESOURCES FOR LOCAL GOVERNMENT OFFICIALS AND THE PUBLIC

Compiled by Lee Walkling, Library Information Specialist, Washington Department of Natural Resources, Division of Geology and Earth Resources

BOOKS

American Institute of Professional Geologists, 1993. *The Citizens' Guide to Geologic Hazards—A Guide to Understanding Geologic Hazards, Including Asbestos, Radon, Swelling Soils, Earthquakes, Volcanoes, Landslides, Subsidence, Floods, and Coastal Hazards.* Arvada, CO: American Institute of Professional Geologists. (Good overview and easy-to-understand explanations)

Myles, Douglas, 1985. *The Great Waves.* New York: McGraw-Hill Book Company. (For the general public)

Mileti, Dennis S., 1999. *Disasters by Design—A Reassessment of Natural Hazards in the United States.* Washington, D.C.: John Henry Press. (Preparedness and mitigation)

Atwater, Brian F.; Marco V. Cisternas; Joanne Bourgeois; Walter C. Dudley; James W. Hendley, II; Peter H. Stauffer, compilers, 1999. *Surviving a Tsunami—Lessons from Chile, Hawaii, and Japan.* U.S. Geological Survey Circular 1187.

U.S. Federal Emergency Management Agency, 1998. *The Project Impact Hazard Mitigation Guidebook for Northwest Communities—Alaska, Idaho, Oregon, Washington.* Washington, D.C.: U.S. Federal Emergency Management Agency. (Good list of additional resources and websites and books in the appendix)

U.S. Federal Emergency Management Agency, 1993. *Are You Ready? Your Guide to Disaster Preparedness.* Washington, D.C.: U.S. Federal Emergency Management Agency.

U.S. Federal Emergency Management Agency, 1998. *Property Acquisition Handbook for Local Communities.* 3 vol. poster (FEMA 317). Washington, D.C.: U.S. Federal Emergency Management Agency. (For more information: http://www.fema.gov/mit/handbook/)

U.S. Federal Emergency Management Agency, 2000. *Coastal Construction Manual—Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas.* 3rd. ed., 3 vol. (FEMA 55) Washington, D.C.: U.S. Federal Emergency Management Agency. (For more information: http://www.fema.gov/MIT/bpat/bpn0600e.htm)

PERIODICALS

Natural Hazards Observer (print and online versions) (http://www.colorado.edu/IBS/hazards/o/o.html)

The bi-monthly newsletter of the Natural Hazards Center. It covers current disaster issues; new international, national, and local disaster management, mitigation, and education programs; hazards research; political and policy developments; new information sources; upcoming conferences; and recent publications.

TsuInfo Alert Newsletter

The bi-monthly newsletter of the National Tsunami Hazards Mitigation Program is distributed to approximately 250 emergency managers of the five Pacific coastal states. Back issues are online: http://www.wa.gov/dnr/htdocs/ger/tsuinfo/index.html

RESOURCES

WEBSITES

http://www.geophys.washington.edu/tsunami/intro.html
University of Washington Geophysics Program - many links to other tsunami sites.

http://www.fema.gov/library/tsunamif.htm
FEMA tsunami fact sheet and links.

http://www.pmel.noaa.gov/tsunami/
NOAA/PMEL Web site, with links to inundation mapping, modeling, events, forecasting and the National Tsunami Hazards Mitigation Program sites.

http://www.pmel.noaa.gov/tsunami-hazard/links.html
Important links to major tsunami sites.

http://www.redcross.org/disaster/safety/guide/tsunami.html
Red Cross tsunami site, with overview, discussion of warning systems, and good preparedness information.

http://www.geocities.com/CapeCanaveral/Lab/1029/
The Tsunami Page of Dr. George P.C. (Pararas-Carayannis)
Just about everything you'd need to know about tsunamis!

http://www.fema.gov/mit/handbook
Property Acquisition Handbook for Local Communities (FEMA 317).

VIDEOS

Forum: Earthquakes and Tsunamis (2 hrs.)
CVTV-23, Vancouver, WA (January 24, 2000)
Two lectures: Brian Atwater describes the detective work and sources of information about the January 1700 Cascadia earthquake and tsunami; Walter C. Dudley talks about Hawaiian tsunamis and the development of warning systems.

Tsunami: Killer Wave, Born of Fire (10 min.)
NOAA/PMEL.
Features tsunami destruction and fires on Okushiri Island, Japan; good graphics, explanations, and safety information. Narrated by Dr. Eddie Bernard (with Japanese subtitles).

Waves of Destruction (60 min.)
WNET Video Distribution
An episode of the "Savage Earth" series. Tsunamis around the Pacific Rim.

Disasters Are Preventable (22 min.)
USAID
Ways to reduce losses from various kinds of disasters through preparedness and prevention.

Tsunami: Surviving the Killer Waves (13 min.)
DOGAMI
Two versions, one with breaks inserted for discussion time.

Raging Planet; Tidal Wave (50 min.)
Produced for the Discovery Channel in 1997, this video shows a Japanese city that builds walls against tsunamis, talks with scientists about tsunami prediction, and has incredible survival stories.

BIBLIOGRAPHY

American Farmland Trust. *Saving the Farm: A Handbook for Conserving Agricultural Land.* San Francisco: American Farmland Trust, January 1990.

American Society of Civil Engineers, Task Committee on Seismic Evaluation and Design of Petrochemical Facilities of the Petrochemical Committee of the Energy Division of ASCE. *Guidelines for Seismic Evaluation and Design of Petrochemical Facilities*. New York: ASCE, 1997.

Berke, Philip R. "Hurricane Vertical Shelter Policy: The Experience of Two States." *Coastal Management* 17, (3) (1989): 193-217.

Bernard, E.N., R.R. Behn, et al., "On Mitigating Rapid Onset Natural Disasters: Project THRUST," *EOS Transactions, American Geophysical Union* (June 14, 1998): 649-659.

Bernard, E.N., "Program Aims to Reduce Impact of Tsunamis on Pacific States," *EOS Transactions, American Geophysical Union* Vol. 79 (June 2, 1998): 258-263.

Boyce, Jon A. "Tsunami Hazard Mitigation: The Alaskan Experience Since 1964," Master of Arts thesis, Department of Geography, University of Washington, 1985.

Camfield, Frederick E. "Tsunami Engineering," United States Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS, Special Report No. SR-6 (February 1980).

California Department of Real Estate. *A Real Estate Guide*. Sacramento, 1997.

Center of Excellence for Sustainable Development (http://www.sustainable.doe.gov)

Community Planning Program, Municipal and Regional Assistance Division, Department of Community and Economic Development, State of Alaska (http://www.dced.state.ak.us/mra/Mradplan.htm)

Department of Community, Trade, and Economic Development, State of Washington (http://www.cted.wa.gov)

Department of Land Conservation and Development (DLCD), State of Oregon (http://www.lcd.state.or.us)

Dudley, Walt. *Tsunamis in Hawaii*. Hilo, HI: Pacific Tsunami Museum, 1999.

Dudley, Walter C. and Min Lee. *Tsunami!* Honolulu: University of Hawai'i Press, 1998.

Earthquake Engineering Research Institute, "Reconnaissance Report on the Papua New Guinea Tsunami of July 17, 1998," *EERI Special Earthquake Report* (January 1998).

Federal Emergency Management Agency (FEMA) (http://www.fema.gov/)

Federal Emergency Management Agency. *Coastal Construction Manual—Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas.* 3rd ed., 3 vol. (FEMA 55) Washington, D.C.: FEMA, 2000.

Federal Emergency Management Agency. *Multi-Hazard Identification and Risk Assessment: A Cornerstone of the National Mitigation Strategy.* Washington, DC: FEMA, 1997.

Foster, Harold D. *Disaster Planning: The Preservation of Life and Property*. New York: Springer-Verlag New York, Inc., 1980.

Governor's Office of Planning and Research, State of California. *General Plan Guidelines*, 1998 ed. Sacramento, 1998.

Hawaii Coastal Zone Management Program, Office of Planning, Department of Business, Economic Development and Tourism, State of Hawaii (http://www.state.hi.us/dbedt/czm/index.html)

Bibliography

Honolulu, City and County of: Revised Ordinances of the City and County of Honolulu, Article 11. Regulations Within Flood Hazard Districts and Developments Adjacent to Drainage Facilities. (http://www.co.honolulu.hi.us/refs/roh/16a11.htm)

Institute for Business and Home Safety. *Summary of State Land Use Planning Laws*. Tampa, April 1998.

International Conference of Building Officials, *1998 California Building Code (1997 Uniform Building Code)*. Whittier, 1997.

Kodiak Island Borough (http://www.kib.co.kodiak.ak.us/)

Lindell, Michael K. and Ronald W. Perry. *Behavioral Foundations of Community Emergency Planning*. Washington, DC: Hemisphere Publishing Corporation, 1992.

McCarthy, Richard J., E.N. Bernard, and M.R. Legg, "The Cape Mendocino Earthquake: A Local Tsunami Wakeup Call?" *Coastal Zone '93, Proceedings*, 8th Symposium on Coastal and Ocean Management, New Orleans, July 19-23, 1993.

Mileti, Dennis S. *Disasters by Design: A Reassessment of Natural Hazards in the United States*. Washington, DC: Joseph Henry Press, 1999.

National Academy of Sciences. *Earthquake Engineering Research—1982*. Washington, DC: National Academy Press, 1982.

National Coastal Zone Management Program, Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration (http://wave.nos.noaa.gov/programs/ocrm.html)

National Research Council. Ocean Studies Board, *Science for Decision-Making: Coastal and Marine Geology at the U.S. Geological Survey*. Washington, DC: National Academy Press, 1999.

1960 Chilean Tsunami (http://www.geophys.washington.edu/tsunami/general/historic/chilean60.html)

Oregon Department of Land Conservation and Development. *A Citizen's Guide to the Oregon Coastal Management Program*. Salem, March 1997.

Pacific Marine Environmental Laboratory, Tsunami Hazard Mitigation: A Report to the Senate Appropriations Committee (http://www.pmel.noaa.gov/~bernard/senatec.html)

Pacific Marine Environmental Laboratory (PMEL) Tsunami Research Program (http://www.pmel.noaa.gov/tsunami/)

People for Open Space. *Tools for the Greenbelt: A Citizen's Guide to Protecting Open Space*. People for Open Space, San Francisco, September 1985.

Petak, William J. and Arthur A. Atkisson. *Natural Hazard Risk Assessment and Public Policy: Anticipating the Unexpected*. New York: Springer-Verlag New York Inc., 1982.

Ruch, Carlton E., H. Crane Miller, Mark Haflich, Nelson M. Farber, Philip R. Berke, and Norris Stubbs. *The Feasibility of Vertical Evacuation*. Monograph No. 52. Boulder: University of Colorado, Natural Hazards Research and Applications Information Center, 1991.

San Francisco Bay Conservation and Development Commission (http://ceres.ca.gov/bcdc/)

Schwab, Jim et al., "Planning for Post-Disaster Recovery and Reconstruction," *Planning Advisory Service* Report Number 483/484. Chicago: American Planning Association for the Federal Emergency Management Agency, December 1998.

Spangle, William and Associates, Inc., et al., *Land Use Planning After Earthquakes*. Portola Valley, CA: William Spangle and Associates, Inc., 1980.

Spangler, Byron D. and Christopher P. Jones, "Evaluation of Existing and Potential Hurricane Shelters," *Report No. SGR-68*. Gainesville: University of Florida, Florida Sea Grant College Program, 1984.

Bibliography

Sprawl Watch Clearinghouse (http://www.sprawlwatch.org)

State of California, Department of Conservation, Division of Mines and Geology. *Planning Scenario in Humboldt and Del Norte Counties, California, for a Great Earthquake on the Cascadia Subduction Zone*. Special Publication 115. Sacramento, 1995.

State of California, Governor's Office of Emergency Services. *Findings and Recommendations for Mitigating the Risks of Tsunamis in California*. Sacramento, September 1997.

_____. *Local Planning Guidance on Tsunami Response*. Sacramento, May 2000.

State of Oregon, Oregon Emergency Management and Oregon Department of Geology and Mineral Industries. *Draft Tsunami Warning Systems and Procedures: Guidance for Local Officials*. Salem, undated.

Steinbrugge, Karl V. *Earthquakes, Volcanoes, and Tsunamis: An Anatomy of Hazards.* New York: Skandia America Group, 1982.

University of Tokyo, "A Quick Look Report on the Hokkaido-Nansei-Oki Earthquake, July 12, 1993," Special Issue July 1993 INCEDE newsletter, International Center for Disaster Mitigation Engineering, Institute of Industrial Science, Tokyo.

Urban Regional Research for the National Science Foundation, *Land Management in Tsunami Hazard Areas*. 1982.

Urban Regional Research for the National Science Foundation, *Planning for Risk: Comprehensive Planning for Tsunami Hazard Areas.* 1988.

United States Army Corps of Engineers, *Coastal Engineering Manual*, (in publication). (http://chl.wes.army.mil/library/publications)

United States Army Corps of Engineers: *Coastal Engineering Technical Notes* (http://chl.wes.army.mil/library/publications/cetn)

United States Army Corps of Engineers. *Shore Protection Manual*. 4th ed. 2 vols. Washington, DC: US Army Engineer Waterways Experiment Station, Coastal Engineering Research Center, US Government Printing Office, 1984.

Wallace, Terry C., "The Hazards from Tsunamis," *TsuInfo Alert,* V. 2, No. 2. (March - April 2000).

Western States Seismic Policy Council, Tsunami Hazard Mitigation Symposium Proceedings, Ocean Point Resort, Victoria, BC, November 4, 1997. San Francisco, 1998.

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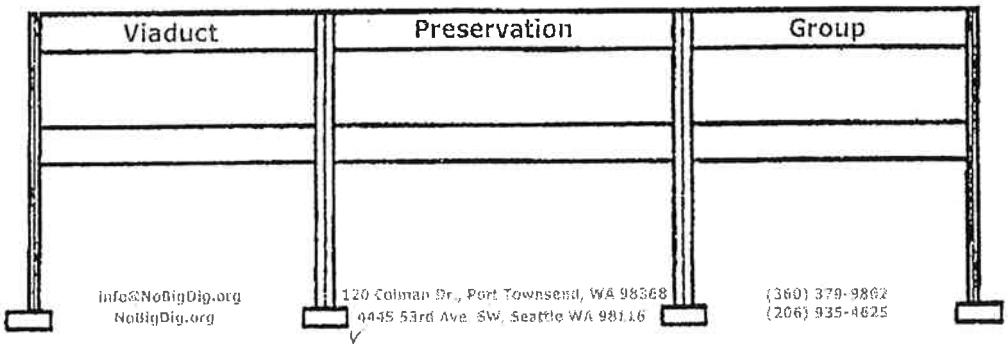

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April 18, 2006

Ms. Aimee Kinney
U.S. Army Corps of Engineers, Seattle District
Environmental Resources Section
P.O. Box 3755
Seattle, WA 98124-3755

Re: Alaskan Way Seawall EIS

Dear USACE:

Seattle residents and property owners, including the Federal government, are presently unaware of the chaos the will be loosed upon them by construction of a proposed SR99 Waterfront Tunnel. As the USACE is well aware, the City of Seattle has designed its particular Tunnel scheme so that it is dependent upon Seawall reconstruction. The Federal government must not allow this ruse to extract Federal dollars for non-Federal purposes and for private benefit. Because even Seattle elected officials lack the truth about the impacts of tunnel/seawall construction, the USACE's EIS investigation can bring much light to the process.

Today, even with the City of Seattle proclaiming a Tunnel the "preferred alternative," City officials have not revealed the construction impacts as they relate to access to federal facilities after complete elimination of SR99 roadway capacity for at least 1.5 years and constricted capacity for as long as 11 years.

Draft EIS: Appendix C Transportation Discipline Report, SR99: Alaskan Way Viaduct & Seawall Replacement Project (2004) reports that the many transportation impacts of Tunnel construction range from "Severe" to "Very Severe" to "Extremely Severe." The USACE must investigate the impact of citywide traffic gridlock upon all federal facilities inside Seattle, including the National Guard Armory at Interbay, the Jackson Federal Office Building, the Coast Guard Station at Pier 36, Federal Courthouses, Federal Reserve Bank, United States Post Offices, etc. We have attached pages 279-283, 297 of this Draft EIS report.

Transportation impacts of Tunnel construction will, indeed, be severe. The Washington Department of Transportation has revealed that complete closure of SR99 for either Tunnel or Rebuild would last from between "1.5 to 3.5 years." WSDoT has also gone on record stating that any closure of SR99 would

trigger Interstate-5 congestion through Downtown Seattle to grow from 5 hours to 14 hours daily. SDoT estimates that surface streets would fill with five times the usual number of vehicles. How will this certainty affect federal facilities in Seattle and the Puget Sound region?

Perhaps the Nisqually Earthquake-year study commissioned by the Washington Department of Transportation said it best:

> A very important consideration in replacement of the existing structure is how traffic can be maintained during the six to eight years required for demolition and new construction. The cost to the 100,000 users of the Viaduct, and the cost to Seattle in general, will probably make total closure to traffic an unacceptable option.
>
> -- Alaskan Way Viaduct Report of the Structural Sufficiency Review Committee, 6/28/01

Beyond the Tunnel's negative impact on regional economy and access to federal facilities due to transportation restrictions, the City's Tunnel/Seawall scheme also presents the most deleterious effect upon electricity, water, sewer, telecommunications and natural gas service to federal facilities in Seattle. Draft EIS: Appendix O Transportation Discipline Report, SR99: Alaskan Way Viaduct & Seawall Replacement Project (2004) states:

> Multiple relocations of utilities could affect the local economy by increasing the risk of frequent and/or accidental loss of service to retail and commercial businesses. The utility construction sequencing for the Alaskan Way Viaduct and Seawall Replacement Project will be a major undertaking in and of itself." (P. 141)

Though the above Draft EIS reports have essentially scoped the impacts, the true economic and job-loss costs of these impacts are today unknown to Seattle residents, including those responsible for Federal facilities.

Viaduct Preservation Group's view is that the Viaduct Retrofit option has been imprudently eliminated from "official" consideration in large part due to technical staff making policy decisions while ignoring construction impacts and elected officials making technical decisions while ignoring Tunnel construction impacts. In reality, Retrofit is among reasonable alternatives that any EIS must consider. The City's EIS has failed in that charge. The USACE's EIS's must not follow them blindly. The City of Seattle has artificially married Seawall reconstruction with Tunnel construction and thereby burdened the Federal government with this EIS investigation and federal taxpayers with a potential funding responsibility. Due to the Retrofit's relatively low construction impacts on Federal facilities' access to transportation and utility service, the USACE should investigate how Retrofit would benefit Seawall reconstruction. The USACE must consider how incremental Seawall reconstruction demands and expense will, in fact, be precipitated by Tunnel construction. Retrofit requires no direct Seawall impacts. The USACE may very well discover that Tunnel construction compromises the Seawall's structural system beyond a state from which it can be retrofitted using conventional methods. Even Viaduct retrofits formerly recommended by Washington Department of Transportation included mitigation of liquefiable soils behind the Seawall by cement injection grouting. It is this soil improvement method that The Viaduct Preservation Group includes in our Retrofit recommendation. It is this method that would relieve lateral soil pressure on the Seawall, allowing the Seawall to be strengthened by more cost-effective and less disruptive methods than presently pitched by the City of Seattle. Conventional strengthening methods can be pursued once the Seawall is unchained from the

City's Tunnel/Waterfront Redevelopment scheme. Even today, due to lack of project funding, the City has removed the major Seawall length from its construction proposal. Alternate methods of seawall retrofit and reconstruction that are NOT subservient to a Tunnel project must be evaluated.

- May the USACE investigate and quantify the severe construction impacts of a Tunnel construction effort that has been made integral to Seawall reconstruction.

- May the USACE investigate and quantify how the unnecessary combination of Tunnel and Seawall construction may inflate Seawall reconstruction costs.

- May the USACE investigate and quantify how SR99 Retrofit, as proposed by the Viaduct Preservation Group or WSDoT, offers a reasonable, least-cost and low construction impact option for SR99 as it relates to the Alaskan Way Seawall.

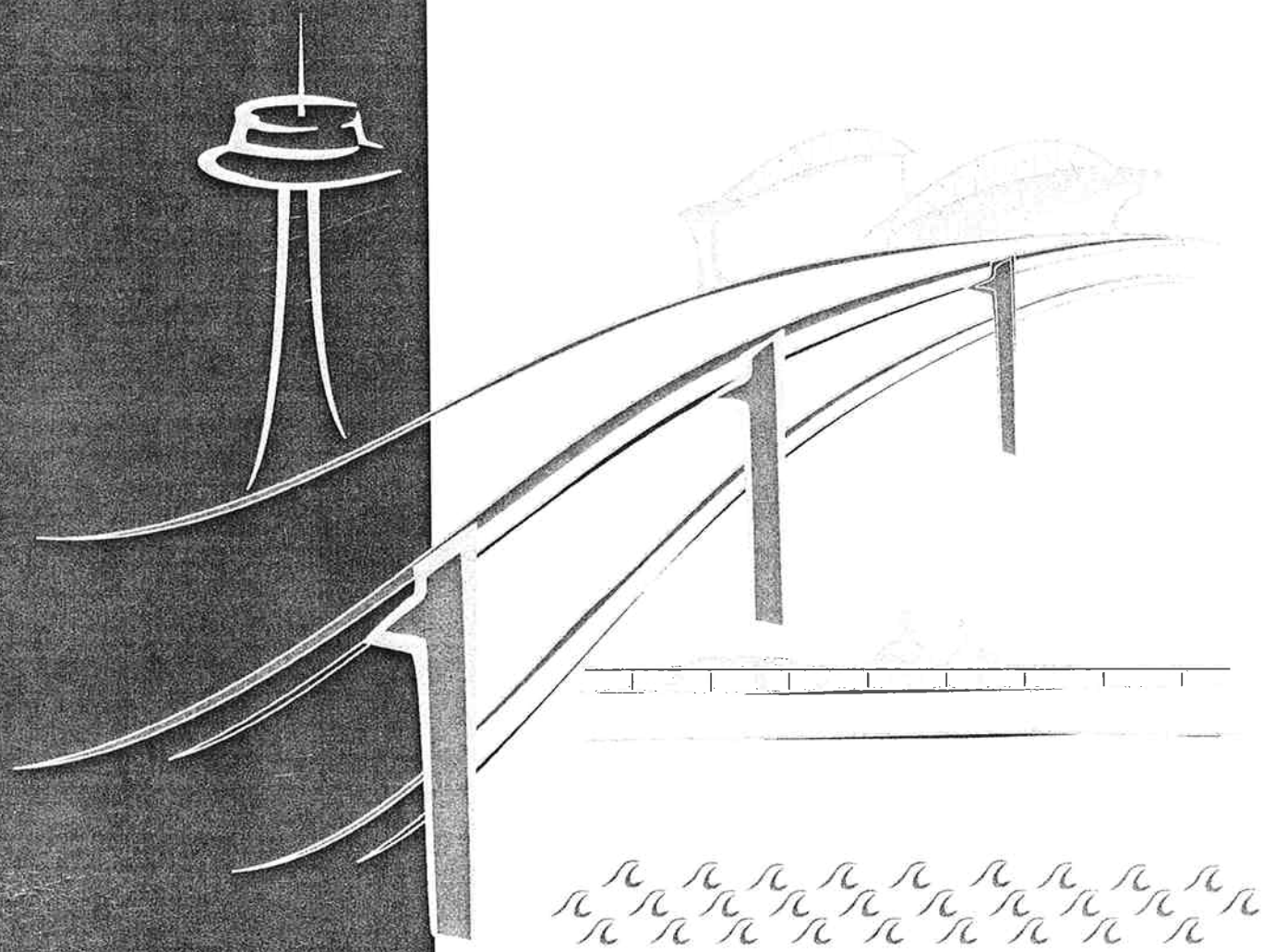
Yours truly,

Craig Keller

Craig Keller, on behalf of,
The Viaduct Preservation Group --- Founders, Victor O. Gray, P.E. & Neil Twelker, Ph.D., P.E.

SR 99: ALASKAN WAY VIADUCT & SEAWALL REPLACEMENT PROJECT

Draft Environmental Impact Statement
Appendix C
Transportation Discipline Report



MARCH 2004

Submitted by:
PARSONS BRINCKERHOFF QUADE & DOUGLAS, INC.

Prepared by:
PARSONS BRINCKERHOFF QUADE & DOUGLAS, INC.

U.S. Department of Transportation Federal Highway Administration

Washington State Department of Transportation

City of Seattle

street traffic will be diverted to the temporary roadway above the seawall with two lanes of traffic in each direction available for detour traffic.

Traffic Locations (Traffic Stage 4):

- SR 99 northbound – on southbound aerial (Pike Street to BST), southbound BST, and northbound temporary at-grade roadway (S. Holgate Street to Pike Street)
- SR 99 southbound – on Broad Street Detour
- Alaskan Way (south of Pike Street) – temporary roadway above seawall
- Alaskan Way (north of Pike Street) – streetcar rail bed

Traffic Stage 5 – Surface Restoration and Project Closeout

During Stage 5's 8 months of construction activities, all SR 99 and Alaskan Way surface street traffic will be moved to their permanent configurations.

6.3 Findings

The objectives of this analysis are to (1) identify probable construction impacts to transportation services and potential problem areas; and (2) identify probable approaches for mitigation where impacts are severe for further analysis before the issuance of the Final EIS.

Generally, in-depth analysis for construction impacts and mitigation measures is most appropriately initiated after the Preferred Alternative is selected and the project is better defined. Detailed technical analysis is required and beyond the scope of this effort at this early stage in the process. Recognizing this, the assessments below are largely qualitative and assessed to the level allowable at the present stage of project definition. The assessment covers all affected transportation modes operating in the corridor. The transportation modes include:

- General highway traffic
- Transit services
- Ferry services
- Parking
- Bicycle and pedestrian facilities
- Freight (trucks and rail)

6.3.1 General Highway Traffic

General Findings

The construction impacts caused by various alternatives on general highway traffic are summarized below.

- All Build Alternatives will cause severe traffic impacts during construction in the corridor. The Rebuild and Surface Alternatives will cause the most severe impacts among all the Build Alternatives, followed by the Aerial, Tunnel, and Bypass Tunnel Alternatives.
- The impacts to traffic on SR 99 are quantified by capacity loss at three major screenlines in the corridor: Midtown, First Avenue S., and Elliott/Western ramps. In this analysis, only the major construction stages are included, i.e., the first stage of site preparation and the last stage of restoration are excluded. This is necessary for two reasons: (1) to avoid diluting the construction impacts in the most disruptive stages; and (2) to screen out the impacts caused by the final configurations, as in the case of the Surface Alternative.
- The Bypass Tunnel and Tunnel Alternatives will cause similar levels of traffic impacts. Mainline traffic will be diverted to the new tunnel after removal of the existing viaduct structure. Through traffic will be reasonably maintained on the new facilities. The Bypass Tunnel Alternative appears to operate slightly better in that (1) the cumulative capacity loss is consistently less than that of the Tunnel Alternative, and (2) it will be easier to complete the construction of the northbound on-ramp at SR 519, which is an important replacement for the existing First Avenue S. on-ramp.
- The Aerial Alternative provides reasonable accommodation for through traffic by the provision of a temporary viaduct structure. The provision of a temporary facility, however, prolongs the construction period. The Aerial Alternative is the alternative with the longest construction period. Thus, the construction impacts will be more severe than those caused by the two tunnel alternatives.
- With the retrofit work carried out on the viaduct while maintaining mainline traffic along construction sites, the Rebuild Alternative cannot provide a reasonable accommodation for through traffic. Considerable traffic diversion to I-5 may occur. Traffic conditions during off-peak hours may be even worse than in peak hours, as further lane reduction and ramp closure may be necessary during construction. The "closure as needed" nature of the construction approach will make it difficult to implement an effective traffic management plan without causing confusion to motorists.
- As in the case of the Rebuild Alternative, the Surface Alternative does not provide a reasonable facility for through traffic during construction. The Surface Alternative is different from the other Build Alternatives in that the traffic conditions will not improve to pre-construction conditions after the completion of construction due to

overall reduction in capacity within the SR 99 corridor. Effective demand management measures are extremely important both during construction and after the completion of the project.

Exhibit 6-6 summarizes the length of construction stages, while Exhibit 6-7 compares the total loss of capacity during major construction stages other than the Site Preparation (Stage 1) and Restoration (last construction stage) stages for all alternatives. The capacity losses are measured at the screenline locations at midtown, First Avenue S., and Western/Elliott Avenues, respectively.

Exhibit 6-6. Duration of Construction Stages

	Rebuild	Aerial	Tunnel	Bypass Tunnel	Surface
Duration of Construction (Months)	86	129	109	102	98
Duration of Major Construction States (Excludes Site Preparation and Restoration Stages)	78	114	96	84	84
Duration of Most Disruptive Construction Stage	78	48	36	30	30

Exhibit 6-7. Capacity Loss During Construction

	Rebuild	Aerial	Tunnel	Bypass Tunnel	Surface
First Avenue S.					
Average Capacity Loss – Duration of Major Construction Stages	53%	29%	25%	22%	48%
Capacity Loss During Most Disruptive Stage	56%	47%	42%	38%	50%
Midtown					
Average Capacity Loss – Duration of Major Construction Stages	49%	29%	28%	25%	48%
Capacity Loss During Most Disruptive Stage	56%	51%	51%	47%	82%
Elliott/Western Avenue					
Average Capacity Loss – Duration of Major Construction Stages	39%	33%	35%	34%	36%
Capacity Loss During Most Disruptive Stage	43%	41%	41%	41%	48%

Rebuild Alternative

Approach of Construction and Traffic Detour

The Rebuild Alternative will require substantially more full closures than the other Build Alternatives (refer to assumptions – Section 6.1 for weekend, 2-week full closures, and summer closures). For periods that do not have full

closures, two traffic lanes on the existing facility will be made available during peak hours as rebuilding and retrofitting activities take place along the facility. Mainline lanes and ramps may be closed as required by construction work. Since the lane closure is on an as-needed basis, it will be more difficult to develop and implement an effective traffic management plan.

- With retrofit construction work carried out on the viaduct along with mainline traffic being maintained in two narrowed lanes, the viaduct will undergo considerable traffic congestion throughout the construction period. Motorists will encounter frequent lane shifting, ramp closures, and lane closures when traveling on the mainline.
- Traffic conditions during off-peak hours may be considerably worse than during peak periods, since the number of traffic lanes may be further reduced as required by the construction activities. Complete ramp or viaduct closure may be required.
- During the two major construction stages (Stages 2 and 3), considerable through traffic will tend to divert to I-5 because of the generally poor traffic operating conditions on the viaduct mainline. The two construction stages will require about 78 months to complete.
- One lane in each direction on the surface street can only provide minimum access functions for the properties along the project site.
- There are no construction activities north of the Battery Street Tunnel, and hence no impacts will be caused to the South Lake Union area.

Capacity Loss

The capacity losses for the Rebuild Alternative are summarized below and in Exhibit 6-7.

- The Rebuild Alternative will be completed in 86 months (7.2 years), which is 43 months shorter than the Aerial Alternative. The two disruptive construction stages, Stages 2 and 3, will take 78 months (6.5 years) to complete.
- At the First Avenue S. screenline, the overall average capacity loss is about 53 percent over a period of 78 months. At the most disruptive stage when retrofit work is carried out a the midtown ramp, which will last for about 24 months, ramp closure will be required from time to time. It is estimated that 56 percent of the capacity will be lost.
- At the Midtown screenline, the overall average capacity loss is about 49 percent over a period of 78 months, while capacity loss during the most disruptive stage is estimated at approximately 56 percent.
- At the Elliott/Western Avenue screenline, the overall average capacity loss is about 39 percent, which is comparable to those of the other

alternatives and much milder than at the midtown screenline. During the most disruptive stage, construction activities would cause a capacity loss of 43 percent at this screenline.

Aerial Alternative

Approach of Construction and Traffic Detour – Mainline

Generally, the Aerial, Tunnel, and Bypass Tunnel Alternatives follow the same concept in maintaining through traffic in the SR 99 corridor. A facility of at least two lanes in each direction will have been completed first, before the existing viaduct may be removed. In the case of the Aerial Alternative, the facility is a temporary viaduct, accompanied by temporary ramps and shoofly to provide a facility for through traffic in the corridor.

Pike Street to Battery Street Tunnel

Widening of the Mercer Street Underpass will be performed prior to diverting southbound SR 99 traffic to the Broad Street Detour. Southbound traffic will be diverted to Broad Street, Alaskan Way, and connections to the mainline sections in the midtown area (Broad Street Detour). A two-lane grade-separated structure will be provided near the intersection of Broad Street and Alaskan Way to carry detoured traffic over the BNSF mainline. As the single-level viaduct between Pike Street and Battery Street Tunnel is being replaced, the construction work to upgrade the Battery Street Tunnel will also be performed.

Northbound SR 99 traffic will generally follow the current alignment and Battery Street Tunnel in this segment, and the southbound traffic will be diverted to the Broad Street Detour. The southbound leg of the aerial structure south of the Battery Street Tunnel will be constructed first, together with the upgrading of the southbound Battery Street Tunnel. After completion of the southbound aerial structure, the northbound traffic will make use of the new southbound aerial structure and the upgraded southbound Battery Street Tunnel, which will allow construction of the northbound viaduct (Pike Street to Battery Street Tunnel) and the upgrades to the Battery Street Tunnel. The existing ramps to service the Elliott/Western corridor will be removed.

S. King Street to Pike Street

A temporary viaduct facility with two lanes in each direction will be provided to the west of the current viaduct prior to removal of the existing viaduct and construction of the new aerial structure.

This Flexible Transportation Package is proposed to provide the system and demand management tools needed to respond to changing conditions, with the focus of investments targeted for the construction period.

Exhibit 6-8. Summary of Construction Impacts

	Design Plans				
Transportation Mode	**Rebuild**	**Aerial**	**Tunnel**	**BypassTunnel**	**Surface**
General Highway Traffic	●	◕	◑	◑	●
Transit Services	◑	◑	◑	◑	◑
Ferry	◕	◕	◕	◕	◕
Parking	●	●	●	●	●
Bike/Pedestrians	◕	◕	◕	◕	◕
Trucks	●	◕	◑	◑	●
Rail	◑	◔	◑	◑	◑

Severity of Impacts

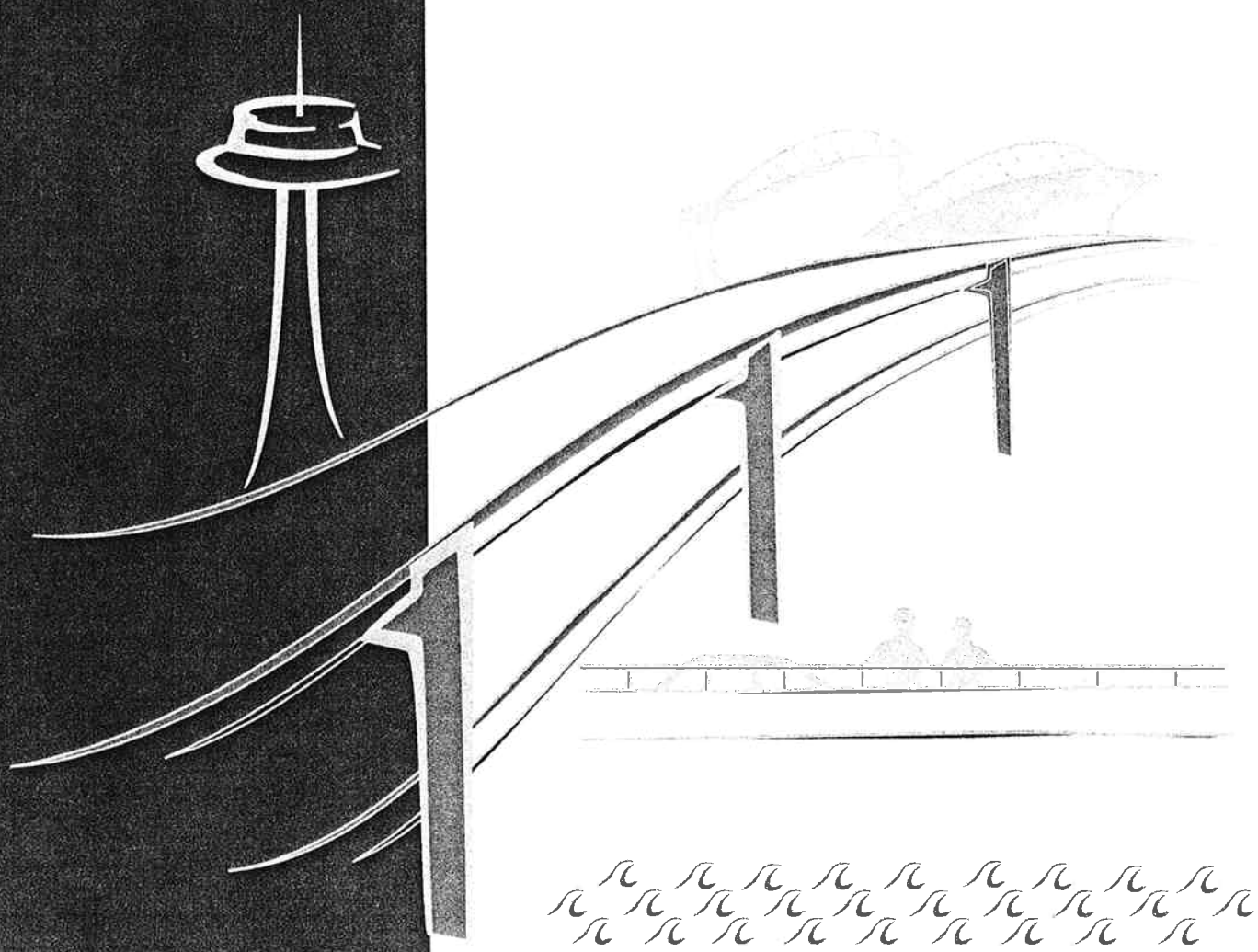
●	Extremely severe
◕	Very Severe
◑	Severe
◔	Moderate
○	Light

Strategies

The following section provides a summary of the flexible transportation strategies selected to be implemented for all five Build Alternatives. The emphasis of these strategies will be to help mitigate traffic congestion during construction. Exhibit 6-9 provides potential performance benefits of the strategies if implemented in the corridor. Further work during the development of the Preferred Alternative will be required to better define the role and function of these strategies. This analysis will also yield more precise information on performance benefits and impact mitigation effectiveness as appropriate.

SR 99: ALASKAN WAY VIADUCT & SEAWALL REPLACEMENT PROJECT

Draft Environmental Impact Statement
Appendix O
Public Services and Utilities Technical Memorandum



MARCH 2004

Submitted by:
PARSONS BRINCKERHOFF QUADE & DOUGLAS, INC.

Prepared by:
PARAMETRIX

U.S. Department of Transportation Federal Highway Administration

Washington State Department of Transportation

City of Seattle

somewhat minimized as the expansion of these facilities is currently anticipated to be completed just prior to Stage 1 construction activities for the Alaskan Way Viaduct and Seawall Replacement Project.

In combination, the effects of the development projects occurring concurrent with the Alaskan Way Viaduct and Seawall Replacement Project could include traffic disruptions and lane closures, which could result in additional response time difficulties and travel time delays to emergency and other public service vehicles at select locations in the AWV study area. If not properly mitigated, lane closures as a result of multiple projects under construction concurrently could result in substantial impacts to response times and travel time delays for police, fire, and emergency medical services. However, it is expected that SDOT will oversee the development of such projects and approvals for lane closures in such a way as to reduce construction impacts.

If construction of the Alaskan Way Viaduct and Seawall Replacement Project overlaps with construction of other planned actions, such as the Monorail and Link Light Rail, construction and demolition activities would generate solid waste that could contribute to cumulative effects for solid waste management facilities. Mitigation measures would be implemented, such as up-front coordination during planning and design with the solid waste management facilities, to reduce these effects. In addition, as other major planned actions (e.g., Monorail and Link Light Rail) are subject to separate environmental review, it is anticipated that mitigation measures applied to these planned actions would reduce the overall combined effects.

7.1.2 Utilities

In general, cumulative impacts to utilities would result from overlapping construction schedules among the planned actions by increasing the risk and frequency of service disruption. Potential utility outages would affect business and residential customers as well as public services. Services to customers could be temporarily disconnected each time a utility line is relocated. Multiple relocations of utilities could affect the local economy by increasing the risk of frequent and/or accidental loss of service to retail and commercial businesses.

The utility construction sequencing for the Alaskan Way Viaduct and Seawall Replacement Project will be a major undertaking in and of itself. If construction of the Alaskan Way Viaduct and Seawall Replacement Project overlaps with construction of other proposed actions, such as the Link Light Rail and Monorail, the multiple utility relocations will require utility purveyors to secure permitting, skilled personnel, and specialized equipment

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NOVAR CORPORATION
a real estate services company

Tuesday, April 25, 2006

Aimee Kinney
U.S. Army Corps of Engineers, Seattle District
Environmental Resources Section
P.O. Box 3755
Seattle, WA 98124-3755

Re: Request for Comments on Scope of Environmental Impact Statement for the Alaskan Way Seawall

Dear Ms. Kinney:

Hillclimb Court is a community of 38 business and residential units located between Western Avenue and Alaskan Way just south of the Pike Street Hillclimb. We are writing to support your Alaskan Way Seawall feasibility study. Because we are a property that is located in close proximity to the waterfront, we are concerned about the potential risks as we understand them if the seawall is not replaced as suggested by the "No Action" alternative. We would like to see a project to replace the seawall move forward. Your study should examine the economic impacts of the "No Action" alternative and your preferred alternative should weight highly public access and aesthetics along the waterfront.

We thank the US Army Corps of Engineers, Seattle District for partnering with the City of Seattle to consider this project and to assist in obtaining funding for it. We wish you the best of luck with your study.

Sincerely,

Darrin Knight

Darrin Knight
Property Manager
On behalf of the Hillclimb Court H.A.

P.O. Box 77040 Seattle, Washington 98177-0040 Telephone: (206) 527-4405 Fax: (206) 527-4408

GRAHAM & DUNN PC

ELAINE L. SPENCER
(206) 340-9638
espencer@grahamdunn.com

April 26, 2006

RECEIVED
APR 27 2006

Aimee Kinney
U.S. Army Corps of Engineers, Seattle District
Environmental Resources Section
P.O. Box 3755
Seattle, WA 98124-3755

Re: Alaskan Way Seawall EIS

Dear Ms. Kinney:

Last Thursday I received the scoping notice for the EIS on the Alaskan Way Seawall replacement. For at least three years I have been actively involved in the Alaskan Way viaduct and seawall replacement project, both as a citizen of Seattle and as a representative of a number of property owners whose property abuts Alaskan Way. Thus it seems surprising at best that only now I would receive notice of the scoping for this EIS. Nonetheless, these are some preliminary comments on the scope of the EIS.

Each of the four alternatives you propose to study will be 1) extraordinarily expensive, 2) extraordinarily disruptive to the businesses, residents and property owners who depend upon not just access to Alaskan Way but on the quiet enjoyment of it as a major pedestrian amenity, and 3) will essentially permanently foreclose alternative ways of accomplishing the primary task of a seawall, to protect upland development from the adverse impacts of surf and tides, with less adverse impact on aquatic resources and in a more human-friendly way for a great city to meet its waterfront. On this later point, we would direct you to a recent publication by People for Puget Sound, which illustrates a number of more people- and fish-friendly ways that at least parts of the waterfront might be able to meet Puget Sound. Each of the illustrations of People for Puget Sound would be rendered difficult or impossible by your chosen alternatives. The Seattle Art Museum has recently demonstrated that it is possible to replace the seawall along its part of the waterfront at vastly less cost and with virtually no disruption. Although we recognize that its part of the seawall may not be typical of the depth of the entire wall, there is no explanation of why something more like the approach of the Art Museum, or some other intermediate approach, would not be adequate for at least some other portions of the seawall. There is no explanation of why the approach cannot vary over the length of the seawall, reserving the more brutal alternatives you propose for only those areas where there are truly no less environmentally and economically costly choices.

Pier 70
2801 Alaskan Way ~ Suite 300
Seattle WA 98121-1128
Tel 206.624.8300
Fax 206.340.9599
www.grahamdunn.com

From the draft EIS on the seawall and viaduct replacement, we understand that a substantial part of the reason for the extraordinarily disruptive alternatives that were chosen for the seawall replacement was not so much the need to maintain the function of the seawall itself, but rather a concern about liquefaction of the fill under Alaskan Way that occurred during the Nisqually quake. We understand that liquefaction opened voids under Alaskan Way, necessitating emergency repairs, including filling those voids with concrete. (We must emphasize, however, that those repairs were accomplished with far less cost or disruption than the proposed replacement of the seawall under your chosen alternatives would entail.) In essence, we understand that the justification for these alternatives is that absent providing support for the street itself, in a major liquefaction quake Alaskan Way could experience significant settlement that would necessitate repairs and could close it for an extended period.

If that is in fact the justification for the alternatives that were chosen, it is particularly important to disclose other less costly and less intrusive alternatives that could address the function of the seawall, albeit without necessarily protecting Alaskan Way from the risks faced by <u>all</u> the streets that have been built on fill in Seattle. Most of the streets between Pioneer Square and Spokane Street in Seattle are built on fill, most of which is equally subject to liquefaction. The question that the EIS should assist decision-makers in making is, in a world with finite resources and many public facilities at risk of serious damage in a worst-case earthquake, how do we choose which facilities to replace before such an event?

I would suggest that four criteria are relevant to that question.

1. We should replace or repair facilities where significant loss of life is likely in a quake. Although that is a very real risk with respect to the Alaskan Way viaduct, it is far less clear that it is a risk with respect to liquefaction causing subsidence of a surface street.

2. We should replace or repair facilities, the failure of which would impair the ability of the region as a whole to recover from a serious quake. Again, the Alaskan Way viaduct, which currently carries 110,000 vehicle trips a day and is one of only two major north-south routes through Seattle, meets that criteria. Alaskan Way surface street does not.

3. We should replace or repair facilities where the cost and disruption to do so is minor compared to the potential risk when an earthquake happens. That is why we strap our water heaters to the wall, bolt our houses to their foundations, and have easily accessible ways to turn off the gas. The cost and hassle of doing those things pales by comparison to the cost and risk of not doing them.

4. We should <u>not</u> replace or repair facilities where the present cost and disruption of doing so is likely to be essentially equivalent to the cost and disruption that would be

experienced after an earthquake. Without more information as to the rationale for the four alternatives being considered, it would appear that is the case here.

Each of these alternatives will leave Alaskan Way closed or barely functional for months, if not years, at a time. The probable impact of each of these alternatives on the residents and businesses that depend on Alaskan Way, and particularly its amenity value as a pedestrian destination as well as simply a transportation facility, will be very similar to the impact of a worst case liquefaction event causing significant subsidence on the street. Each of these alternatives will close Alaskan Way for months now and totally disrupt the property owners along it, potentially driving them out of business now. Major subsidence of Alaskan Way after a quake may have a similar impact, and its repair may have a similar cost to what is being proposed. On the other hand, the Nisqually quake demonstrated that even a major quake may not damage Alaskan Way to an extent that repair is nearly as disruptive or costly as the proposed fix.

In that context, it is incumbent upon the EIS to fully disclose the need that is dictating the choice of these alternatives, and to disclose the other alternatives which might adequately allow the seawall to continue to perform its core function, with less cost and disruption and less adverse impact on fisheries, and to disclose the risks associated with the choice of a less impactful alterative. This is not to suggest that the "no action" alternative be chosen. Rather it is to say that the EIS must consider solutions to the seawall that fix the seawall without attempting to resolve all the issues associated with the fill under Alaskan Way in a manner that disrupts Alaskan Way as much as a worst-case earthquake would disrupt it.

Thank you for considering these comments. Please put me on the notice list for all further public input.

Sincerely,

GRAHAM & DUNN PC

Elaine L. Spencer

ELS/els
M31512-710898

The New Urban Waterfront

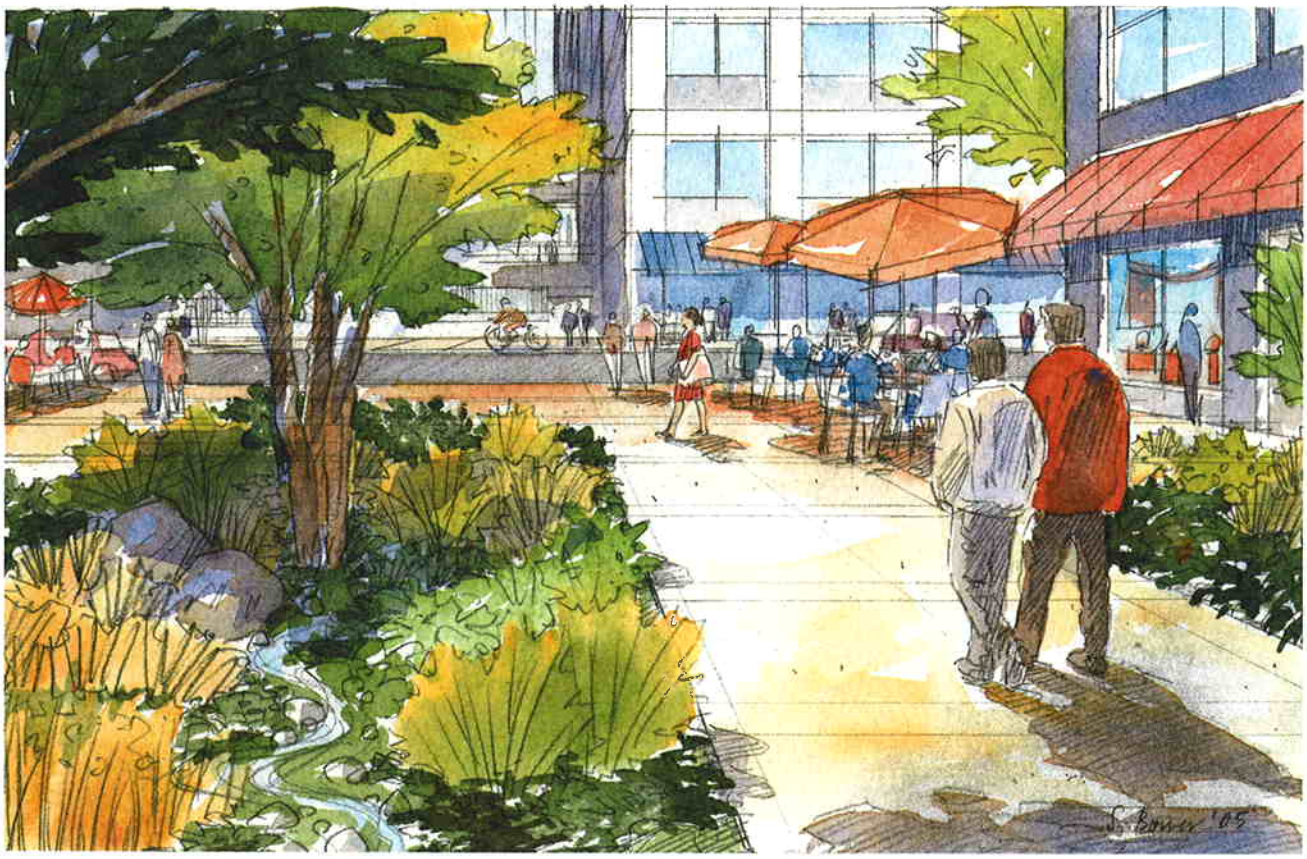
People partnering with wildlife

PEOPLE FOR PUGET SOUND

pugetsound.org

WHAT PEOPLE NEED

COVER:
Created pocket beach in an urban area includes a continuous pedestrian walkway along the water's edge



RIGHT:
Stormwater garden in an urban area…

…flows into Puget Sound as a fresh water cascade

Created beach provides kayak, canoe, tribal and public access

What people need:

- Continuous, uninterrupted public access along the waterfront
- Ability to experience and learn about the marine environment at its shoreline
- Clean water for swimming and fishing
- Economic development and environmental improvements working together

Pocket beaches with native vegetation in park areas

Created cove provides shelter for juvenile fish and brings people to the water

WHAT SALMON NEED

Created tidepools in park areas using rip rap

What salmon and other wildlife need:

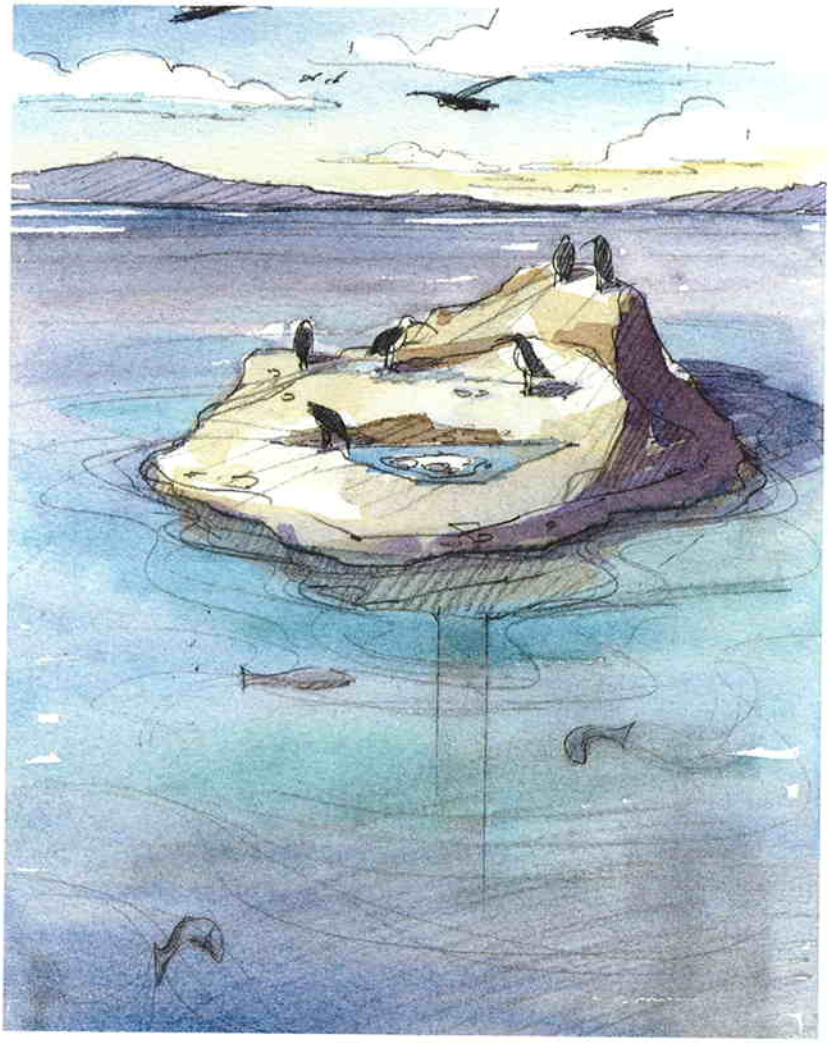
- A continuous fish migration corridor along the shoreline
- Diverse native nearshore habitat for feeding, nesting, and resting
- Protection from predators
- Appropriate flows of clean stormwater
- Clean sediments

Created tidepools in urban areas, with piers pushed out to allow fish migration

Two potential ways to add habitat to vertical seawalls: planter boxes…

…and tiered shelves

THE VISION



Bird island anchored by cables

About the illustrator

Stephanie Bower produced the paintings in this brochure.

Stephanie received her B.Arch. from the University of Texas at Austin, followed by an M.S. in Interior Design from Pratt Institute in New York. She is a licensed Architect in New York where she was heavily involved in Brooklyn Waterfront Planning issues.

In Seattle, Stephanie teaches drawing and maintains a freelance architectural illustration practice.

Many cities bordering Puget Sound are in the process of redeveloping and revitalizing their urban waterfronts into significant community assets, places that can be made inviting to residents, visitors, and wildlife.

People For Puget Sound is actively involved in many of these waterfront redevelopment plans because they pose excellent opportunities to provide clean water and healthy wildlife habitat in the urban setting.

These illustrations show many ways to create habitat and help clean stormwater while supporting a vital, thriving economy.

For more information about our work on urban waterfronts contact People For Puget Sound at (206) 382-7007.

PEOPLE FOR PUGET SOUND
pugetsound.org

People For Puget Sound is a regional citizens' organization founded in 1991 to educate and involve people in protecting and restoring the land and waters of Puget Sound.

www.pugetsound.org

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APR 27 2006

waterfront landings

April 27, 2006

Aimee Kinney
U.S. Army Corps of Engineers, Seattle District
Environmental Resources Section
P.O. Box 3755
Seattle, WA 98124-3755

RE: Alaskan Way Seawall EIS

Dear Ms. Kinney:

I submit to you these comments on the scoping notice for the EIS on the Alaskan Seawall on behalf of the Owner's Association of Waterfront Landings (WFL) and as president of the Association's Board of Directors.

We have reviewed the letter of Elaine L. Spencer, Graham & Dunn PC dated April 26, 2006. We strongly support her comments on behalf of the waterfront properties she represents (including WFL). In addition, we wish to address some points of particular concern to the residential community of Waterfront Landings Condominium.

Waterfront Landings is a 232 unit residential condominium community with an aggregated property valuation of over $125 million. It is located directly on the waterfront on Alaskan Way.

The Waterfront Landings community of 386 residents includes 96 (25%) senior citizens, 79 (21%) of whom are retirees, and 20 children. The waterfront is our home. We chose to live here specifically because of the beauty and relatively peaceful lifestyle the waterfront environment affords us despite the urban setting. We have a very substantial financial and emotional investment in what happens to the waterfront. It is critical to our residents that adequate plans be put in place to mitigate the impact of the Seawall repair or replacement project on our homes. Inadequate or ineffective mitigation procedures will adversely, seriously impact our property and the habitability of our homes. We are deeply concerned about the viability of the waterfront, including our homes, businesses and access to the public at large during any repair or construction process.

We understand the safety and liability issues that drive the need to repair or replace the Alaskan Way Seawall. However, we firmly believe that the chosen alternative must be worth the pain and disruption it will take to do the project. Specifically, the end result must substantially enhance the safety of those living on the waterfront with the least cost and disruption and the least adverse impact to marine habitats and fisheries.

Although the 386 WFL residents may not agree on a particular alternative for this project, we are certainly united in our deep concerns about our quality of life during any repair or replacement alternatives. It is critical to us as homeowners that the repair or construction periods are minimized and that focused efforts be made to assist those of us living and working on the waterfront so that we can maintain our way of life during that period.

Waterfront Landings is a unique community of Seattle citizens. We are the only residential complex on the Seattle waterfront. We provide economic support for nearby waterfront, Pike Place Market and downtown restaurants and retail commerce. Many of us also work in Seattle, some walking to work at downtown and waterfront businesses. Our community is literally a part of the fabric of the waterfront and Seattle's downtown. Our residents, therefore, share unique and deep concerns for proper and effective impact mitigation plans. Our specific impact minimization concerns include:

1) Access to our homes
2) Noise levels and air quality
3) Traffic congestion and parking

We also believe monetary mitigation for loss of habitability of our homes, loss of value to our properties, and emotional strife during a prolonged replacement period will become serious issues.

1. Vehicle access to and from our homes.
We require 24-hour, 7-days per week vehicle access to our building at both the north and south ends. Because this is our home, we need free ingress and egress each day to get to work, get home, and live our lives in some form of normalcy. It is essential that emergency vehicles such as fire and ambulance have access to our building. Closure of Alaskan Way is not an option for us, nor is busing from nearby parking lots. Many of us come and go at all hours of the day and night, especially to attend to our work and livelihoods. Disruption of access to our building during replacement construction alternatives is unacceptable.

2. Noise levels and air quality.
We anticipate increased noise due to repair or replacement activities. The daytime noise will be bad enough, but without reprieve at night (10 pm to 6 am), it would be impossible to live reasonable lives. Construction noise on a 24/7 basis is not conducive to residential living. Air quality will also be a factor due to the dirt and dust associated with a project of this magnitude. To endure increased noise and poor air quality for years without appropriate mitigation is not acceptable for a residential community. Further, over half of the homes in WFL do not have air conditioning and these residents depend on open windows for ventilation and cooling, especially during the summer months. Construction over a several year period may require that windows be shut for the duration. Monetary mitigation commensurate with suffering or implementing alternative options (i.e., installation of air conditioning) would be necessary.

3. Traffic congestion and parking.
We are concerned that Alaskan Way as a surface road continues to support general-purpose traffic, tourist traffic, ferries, and cruise ship access. Mitigation for increased traffic congestion will be necessary. Limited parking is always an issue on Alaskan Way, therefore off-sight parking for construction workers and a plan for displacement of existing parking spaces on and off street is crucial.

In conclusion, although we support the need to address the problems we face with the Alaskan Way Seawall repair or replacement, we have genuine and serious concerns that must be addressed during the planning process. We are concerned with how traffic will be handled during repairs or replacement construction. We are concerned about vehicle access to and from our homes. We are concerned about our quality of life due to construction noise and air pollution.

Without proper planning and careful mitigation measures, whatever safety and economic benefits derive from the Alaskan Way Seawall repair or replacement project will be far outweighed by the adverse impacts of financial and emotional losses to residents living on Alaskan Way during the construction period.

We strongly urge the U.S. Army Corps of Engineers, Seattle District to consider the issues that the Alaskan Way Seawall repair or replacement project portends to homeowners and citizens living on the waterfront. We implore that you provide justification for any alternatives put forth and fully disclose the risks and impacts of this project.

Thank you for your consideration of these concerns. Please send notices of any further opportunities for public comment to Waterfront Landings.

Sincerely,

Elizabeth M. Kanny
Board President
Waterfront Landings Condominium
1950 Alaskan Way
Seattle, WA 98101

Port of Seattle

April 28, 2006

RECEIVED
MAY - 1 2006

Ms. Aimee Kinney
US Army Corps of Engineers, Seattle District
Environmental Resources Section
PO Box 3755
Seattle, WA 98124

RE: Alaskan Way Seawall EIS Scoping Comments

Dear Ms. Kinney:

Thank you for the opportunity to review and comment on the scope of the Alaskan Way Seawall EIS. We recognize the importance of this project to Port business and operations. We take this opportunity to summarize our Port ownership and operations near the seawall, to discuss related infrastructure that those facilities rely on, and to respond directly to items in your request for comments.

- Potentially impacted Port facilities include container and cruise terminals in the Elliott Bay and our property and bulkhead ownership along the seawall. These properties represent a variety of land uses and vary in their access needs. The uses include public access points, Port headquarters and operations, and our tenants' operations.
- These facilities rely on surrounding infrastructure which, in turn, depend on the seawall's structural support, including: the transportation functionality of Alaskan Way, the mainline rail trackage, and infrastructure in the street right-of-way.
- Finally, we comment on the project alternatives and elements of the environment presented in your request for comments.

Port facilities, ownership/operations and tenant operations

Container, Cruise and other terminals: While our container terminals lie to the south and west of the seawall, the seawall plays a vital role in keeping the transportation arteries flowing to minimize transportation congestion in the North Duwamish area. Elliott Bay, and the Port of Seattle, is an international trade gateway, contributing to our local, regional and national economy. Container trade through the Port was 2.1 million 20-foot equivalent units (TEUs) last year, a 17% increase from 2004. Maintaining the capacity of traffic operations in the Alaskan Way Corridor is essential to the smooth and efficient flow of imports and exports from ship to land. Additionally, the Seattle cruise ship business has experienced huge growth since homeporting began in the last decade. This year, we expects about 200 cruise visits with about 735,000 passengers. The cruise ship terminal at Pier 66 sits between two sections of the seawall understudy. The second terminal is currently located at Terminal 30, and under consideration for relocation to Terminal 91. Similarly, our Central Waterfront complex at Pier 66, which has been growing since the mid-1990s, and the Port Headquarters at Pier 69, depend on the seawall for access and infrastructure.

POS properties and bulkheads along the seawall: Our properties adjacent to the seawall are also varied in their use and have distinct access issues:

P.O. Box 1209
Seattle, WA 98111-1209 USA
(206) 728-3000
FAX (206) 728-3252
www.portseattle.org

LOCATION	LAND USE/ACCESS
Pier 69 (2711 Alaskan Wy): 1. Port Headquarters 2. Victoria Clipper passenger terminal 3. Seafloor Surveys, Inc offices 4. Public access along pier apron	1. Port employees/visitors generally park in the World Trade Center Parking Garage, 2 blocks south. 2. Many Victoria Clipper passengers also park remotely; significant numbers of commercial & private vehicles queue on Alaskan Way in front of P-69 for pick-up/drop-off. 3. Water-dependent tenant 4. Waterside access is available to the public at P-69
Pier 66, Bell Street Pier Complex 1. Cruise ship terminal 2. Conference center, museum, restaurant complex & viewpoint, marina, grocery/deli 3. Public plazas: rooftop & fountain 4. World Trade Center & parking facility on eastside of Alaskan Way 5. Bulkhead	1. We will provide detailed information on cruise terminal operations at your request. Access needs include busses, commercial & private autos, & provisioning trucks during the half-day Port call. 2. Most visitors park in the WTC garage & cross over Alaskan Way on the Bell St. pedestrian overpass. 3. Public recreation opportunities (also museum & boating) 4. World Trade Center includes offices & restaurant. 5. The City Seawall breaks at Pier 66, which sits atop a bulkhead built around 1915, and strengthened in the 1990s w/ construction of Bell St. Pier.
Pier 48 Uplands & Pier	Under study for redevelopment; uplands operating in interim as a surface parking facility. Access from Alaskan Way. This is just beyond the southern terminus of the seawall.

Related Infrastructure:

The Seawall is integral to the functioning of Alaskan Way, as a corridor for transportation and utilities, and supporting the BNSF Railway's mainline.

Alaskan Way surface: The existing surface Alaskan Way plays an integral role for access to waterfront properties, transit, freight delivery and over-legal trucks, tourist activities, bicycle route, ferries (both state and private), and cruise ship access. Specifically,our properties above rely on Alaskan Way surface street for their access be it passenger vehicle, freight deliveries, or pedestrian/bicycle. In addition, Alaskan Way is designated as the "over-legal" route through downtown. In the recent past, the Waterfront Streetcar has run along this roadway, and we expect it will be re-established after Viaduct/Seawall construction.

Utilities: We are concerned that a failure of the seawall could cause loss of power, steam, water and sewer operations to our facilities.

Rail: The mainline BNSF railroad tracks for the West Coast run parallel to the seawall from the Seattle tunnel's North Portal at about Lenora St to Bay Street. The container business relies on intermodal transfers to rail lines for about 65-70% of the imports and 50% of the exports and the BNSF Railway carries more than half of these containers to the north on this mainline. In addition, the Pier 86 grain terminal (located to the North near Galer Street) depends on these tracks for access from the mainline. Passenger trains also operate daily on this track.

Comments on Project Alternatives and Elements of the environment

Project Alternatives: It appears that the alternatives proposed in this EIS are derived significantly from the preceding work in the Viaduct/Seawall study. We note that those were developed primarily in the context of a transportation corridor study. Further, there has been some proposed phasing of the viaduct project such that the seawall north of Union Street may not be constructed concurrently with the main viaduct replacement. If there were an option that provided less construction impact, with relatively high level of protection from the risk of seawall failure, that should be considered for the northern part of the corridor.

Elements of the environment: Given the Port land uses and operations described above, we ask that you address the following impacts in your analysis. Impacts shown in bold are in addition to those impacts anticipated in your request for comment itemization.

- Impacts to **recreational properties**: Please address public access at Pier 69 and the Bell St. Pier
- Impacts to marine habitat: In developing Pier 66 in the 1990s, the Port carried out substantial clean-up work along the waterfront. There is a four-acre sediment cap and a very healthy habitat mitigation site within the marina (lying west of the city's seawall). Please address the potential for disruptions to this habitat.
- Impacts associated with the No Action alternative: please address impacts to Port and tenant assets and operations in case of catastrophic seawall failure impacting the corridor and adjacent infrastructure.
- Impacts to transportation corridors during construction activities: this is a significant concern for the multiple modes using Alaskan Way for access or through trips. Please identify proposed construction process, discuss resultant impacts, and propose mitigation measures.
- **Geotechnical impacts**: Please address the potential that soil strengthening improvements along Alaskan Way may have a destabilizing impact on our bulkhead at Pier 66.
- Impacts to businesses and residences from noise **and air quality**: please address air quality and noise impacts to Port operations and tenants as described above.
- Socio-economic impacts associated with large, multi-year construction project: please address impacts on Port operations and tenants.

Efficient access and infrastructure for Port properties is vital to our economy. We look forward to working with the Corps and the City on this study to provide necessary data or contacts within the Port and develop a workable solution for the risk of seawall failure. Thank you for your efforts.

Sincerely,

Geraldine Poor

Geraldine Poor
Regional Transportation Manager
206-728-3778

cc: City – John Arnesen
POS – Okamoto, S. Jones, A. Kenny

Kinney, Aimee T NWS

From: gene hoglund [genensusan@comcast.net]
Sent: Saturday, April 29, 2006 7:15 AM
To: Kinney, Aimee T NWS
Subject: FW: Alaskan way seawall additional information to letter of April 18, 2006

Eugene Hoglund
3503 30th Ave. W
Seattle, WA 98199
206-378-0722

April 19, 2006

Ms. Aimee Kinney
U.S. Army Corps of Engineers, Seattle District
Environmental Resources Section
P.O. Box 3755
Seattle, WA 98124-3755

Re: **Opposition to Alternative 4 - Alaskan Way Tunnel, built over the Seattle fault.**
I support Alternative-3 Seawall

Dear Ms. Kinney:

In considering the issues of major environmental impacts, by this letter, enclosures and references, I opposed the digging of a tunnel over the Seattle Fault. Additional information to my April 18, 2006 letter, on the City of Seattle response to the North Bay EIS by requesting inclusion of the Tsunami Hazard Map of Elliott Bay.

1. The City of Seattle Department of Planning and Development, by letter of May 26, 2005 to the Port of Seattle regarding the North Bay development singled out that "NOAA has published estimates of how an earthquake on the Seattle Fault could cause a tsunami that would have severe effects on low lying land in the city. The Terminal 91 area appears to be particularly at risk for such an event. The EIS should describe the related risks and potential impacts to human occupants and on-site structures under each alternative."

(This City of Seattle, Department of Planning and Development letter can be found in Chapter 4 page page 4-2 of the NORTH BAY MASTER PLAN, FINAL ENVIRONMENTAL IMPACT STATEMENT. dated July 2005)

2. The Finial EIS Statement of the NORTH BAY MASTER PLAN included a full page and a half in CHAPTER 3 'ERRATA' to Tsunamis. "Tsunamis are earthquake-generated waves that occur in open water bodies.....A tsunami could be generated by a rupture along the Seattle Fault Zone or by large earthquakes in the pacific Ocean Basin.... in 2003 entitled" Tsunami Hazard Map of the Elliott Bay Area, Seattle, Washington: Modeled Tsunami Inundation from a Seattle Fault Earthquake" are available on line at http://www.dnr.wa.gov/geology/pdf/ofr03-14.pdf. The results of this modeling study indicate that a magnitude 7.3 to 7.6 earthquake caused by a major rupture on the Seattle Fault may result in a tsunami wave that could inundate much of the Elliott Bay waterfront to varying degrees. Calculated wave heights in Elliott Bay from this event are estimated a approximately 6 meters (about 20 feet)".....

(the entire document can be found on page 3-1 of the North Bay Master Plan FEIS. Dated July 2005

Sincerely,

Eugene Hoglund
3503 30th Ave West
Seattle WA 98199

WASHINGTON DIVISION OF GEOLOGY AND EARTH RESOURCES
OPEN FILE REPORT 2003-14

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Doug Sutherland - Commissioner of Public Lands
Division of Geology and Earth Resources
Ron Teissere - State Geologist

NOAA TIME Center
Pacific Marine Environmental Laboratory
Seattle, Washington

Tsunami Hazard Map of the Elliott Bay Area, Seattle, Washington: Modeled Tsunami Inundation from a Seattle Fault Earthquake

by

Timothy J. Walsh[1], Vasily V. Titov[2], Angie J. Venturato[2], Harold O. Mofjeld[2], and Frank I. Gonzalez[2]

2003

[1] Washington Division of Geology and Earth Resources, PO Box 47007, Olympia, WA 98504-7007, tim.walsh@wadnr.gov
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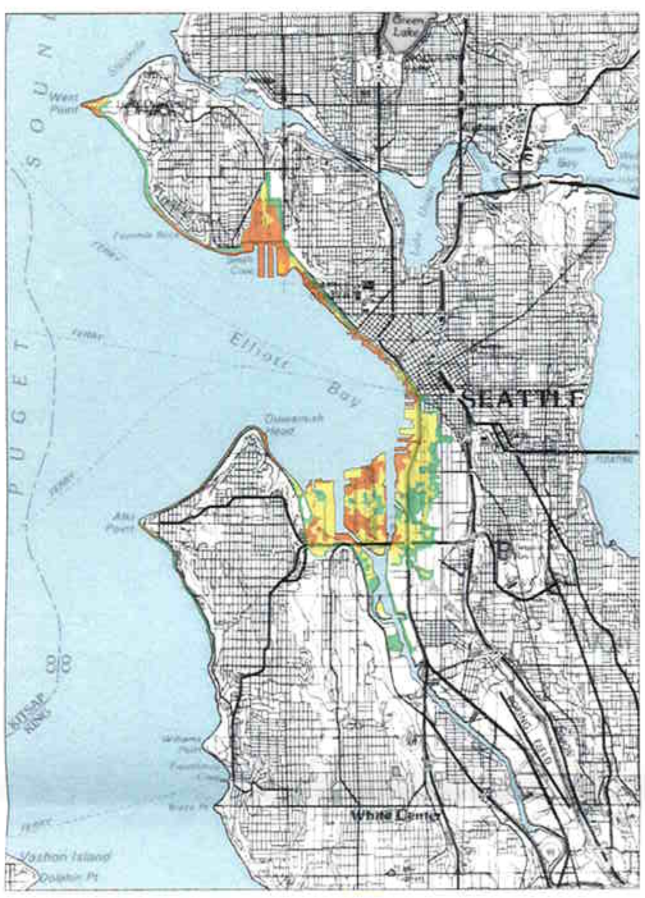
Vasily.Titov@noaa.gov, Angie.J.Venturato@noaa.gov, Harold.Mofjeld@noaa.gov, Frank.I.Gonzalez@noaa.gov



Depth of inundation: 0–.5 meters .5–2 meters 2–5 meters

SCALE 1:60,000

MAP LOCATION

INTRODUCTION

In 1995, Congress directed the National Oceanic and Atmospheric Administration (NOAA) to develop a plan to protect the West Coast from tsunamis generated locally. A panel of representatives from NOAA, the Federal Emergency Management Agency (FEMA), the U.S. Geological Survey (USGS) and the five Pacific coast states wrote the plan and submitted it to Congress, which created the National Tsunami Hazard Mitigation Program (NTHMP) in October of 1996. The National Tsunami Hazard Mitigation Program is designed to reduce the impact of tsunamis through warning guidance, hazard assessment, and mitigation. A key component of the hazard assessment for tsunamis is delineation of areas subject to tsunami inundation. This map is part of a series of tsunami inundation maps produced by the Washington Department of Natural Resources, Division of Geology and Earth Resources, in cooperation with the Washington Emergency Management Division, as a contribution of the National Tsunami Hazard Mitigation Program (Walsh and others, 2003a,b; 2002a,b; 2000). These maps are produced using computer models of earthquake-generated tsunamis from nearby seismic sources. The modeling for this map was done by the Center for the Tsunami Inundation Mapping Efforts (TIME) at NOAA's Pacific Marine Environmental Laboratory in Seattle for a scenario earthquake on the Seattle fault.

THE SEATTLE FAULT

Geographic features now known to be associated with the Seattle fault have been noted for many years. Vancouver (1798) noted that the fault-uplifted bedrock wavecut platform at Restoration Point (Fig. 1, Location 1) on Bainbridge Island "did not possess that beautiful variety of landscape, being an almost impenetrable wilderness of lofty trees" that characterized the rest of his explorations in Puget Sound. Kimball (1897) described the Newcastle Hills (Fig. 1, Location 2), part of the hanging wall of the fault, as a "postglacial eruption". Daneš and others (1965) interpreted the large gravity and magnetic anomalies through central Puget Sound and the associated abrupt change in the sedimentary section thickness as an active fault with about 11 km of displacement. Rogers (1970) collected additional gravity and magnetic data across the structure and named it the Seattle–Bremerton fault. Gower (1978) demonstrated that the uplift at Restoration Point (Fig. 1, Location 1) was Holocene in age and Bucknam and others (1992) showed that there was an uplift of 7 meters produced on the fault about 1,000 years ago.

In 1996, the first of a series of lidar (Light Detection And Ranging) surveys was flown over Bainbridge Island. This and subsequent lidar missions have enabled scientists to locate splays of the fault in a number of places accurately enough to dig trenches (Bucknam and others, 1999; Nelson and others, 2002). Lidar mapping and trenching have enabled scientists to accurately map the amount of uplift on the fault in some places. Also in 1996, the U.S. Geological Survey began several large-scale geophysical studies. An aeromagnetic study of the Puget Sound (Blakely and others, 1999, 2002) enabled more accurate location of the fault along its entire length. Seismic reflection and tomographic studies, such as SHIPS (Seismic Hazards Investigations in Puget Sound) and other geophysical studies in Puget Sound have greatly increased the understanding of the fault characteristics at depth (Pratt and others, 1997; Johnson and others, 1999; Brocher and others, 2001; ten Brink and others, 2002; Van Wagoner and others, 2002), although considerable uncertainties and controversy remain.

There also is substantial evidence that earthquakes on the Seattle fault can generate tsunamis. Atwater and Moore (1992) showed that tsunamis inundated part of Whidbey Island (Fig. 1, Location 5) and West Point (Fig. 1, Location 4) about 1000 years ago, and Jacoby and others (1992) showed that a tree in the tsunami deposit at West Point died in the same season of the same year as a drowned forest carried into Lake Washington by a huge landslide from Mercer Island, strongly implicating the A.D. 900–930 event. A discontinuous sand layer along Snohomish delta distributaries—Ebey Slough, Steamboat Slough, Union Slough, and Snohomish River (Fig. 1, Location 6)—also probably was deposited by the tsunami from the large A.D. 900–930 earthquake on the Seattle fault (Bourgeois and Johnson, 2001).

MODELING

Tsunami inundation shown on the map is based on a computer model of waves generated by the Seattle fault (Titov and others, in press). The model used is the finite difference model of Titov and Synolakis (1998), also known as the Method of Splitting Tsunami (MOST) model (Titov and González, 1997). It uses a grid of topographic and bathymetric elevations and calculates a wave elevation and velocity at each gridpoint at specified time intervals to simulate the generation, propagation and inundation of tsunamis in the Elliot Bay area.

In this MOST model study, the tsunami is generated by a Seattle fault deformation model that simulates the A.D. 900–930 event as a credible worst-case scenario of magnitude 7.3. The magnitude was chosen to be consistent with the 2002 USGS update of the National Seismic Hazard Maps (Frankel and others, 2002). Parameter values are based on Brocher and others (2001), Calvert and Fisher (2001), and ten Brink and others (2002).

Table 1. Segment (west to east) parameters for magnitude 7.3 Seattle fault earthquake models. The vertical deformation pattern is shown in Figure 1.

Segment	Depth (km)	Length (km)	Width (km)	Strike (°)	Dip (°)	Slip (m)
1	0.5	15.2	20	87.9	60	1
2	0.5	6.3	20	86.6	60	1
3	0.5	8.9	20	96.0	60	12
4	0.5	3.2	20	128.8	60	11
5	0.5	11.5	20	99.3	60	4
6	0.5	14.9	20	81.0	60	1

The slip distribution was constrained, through trial-and-error, to match available field estimates of vertical displacement at three sites—Alki Point (Fig. 1, Location 3; +4 m), Restoration Point (Fig. 1, Location 1; +7 m) and West Point (Fig. 1, Location 4; +1±0.5 m).

Titov and others (in press) also modeled a M7.6 event, and the tsunami inundation values and patterns were essentially the same as for the M7.3 event. No doubt this is due to the fact that the deformation patterns and values were very similar for both events, since they were each constrained by field estimates at the three sites. Also, the smaller ground displacement zone of the M7.3 event forms a more concentrated tsunami source that compensates for its smaller overall displacement.

The computed tsunami inundation is shown on the map in three color-coded depth ranges—0–0.5 m, 0.5–2 m, and greater than 2 m. These depth ranges were chosen because they are approximately knee-high or less, knee-high to head-high, and more than head-high. The limit of tsunami inundation is the landward edge of the green zone. In previous maps, we have shown only the edge of inundation, but for this map, much higher resolution bathymetric and topographic data were available. Figure 2 also shows current velocities in two zones—less than or greater than 1.5 meters/second (~3 miles/hour), which is the current speed at which it would be difficult to stand. Within this zone, computed velocities locally exceed 20 meters/second (~40 miles/hour). Computed wave heights in Elliott Bay were approximately 6 meters. Figure 3 shows a time progression of the wave across Elliott Bay at 30-second intervals. Note that because Harbor Island is uplifted by the earthquake, the Duwamish Waterway initially drains rapidly before the wave reflects off the north side of the bay and then inundates the Harbor Island area.

LIMITATIONS OF THE MAP

Because the nature of the tsunami depends on the initial deformation of the earthquake, which is poorly understood, the largest source of uncertainty is the input earthquake. The earthquake scenario used in this modeling was selected to honor the paleoseismic constraints, but the next Seattle fault earthquake may be substantially different from these. Sherrod and others (2000) show that an uplift event at Restoration Point predating the A.D. 900–930 event was smaller. Trenching of subsidiary structures to the Seattle fault that are thought to be coseismic with the main fault trace (Nelson and others, 2002) indicate that there were at least two earthquakes in the 1500 years before the A.D. 900–930 event. These, however, did not produce prominent uplifted wavecut platforms similar to the one made by the A.D. 900–930 event, suggesting that significant earthquakes have occurred on the fault that had different and smaller uplifts in central Puget Sound.

Another significant limitation is that the resolution of the modeling is no greater or more accurate than the bathymetric and topographic data used. This can be up to 50 meters horizontally, although high-resolution multibeam data (Gardner and others, 2001) is available for Elliott Bay and 2-foot contour topography is available for the city of Seattle.

The model run does not include the influences of changes in tides and is referred to mean high water. The tide stage and tidal currents can amplify or reduce the impact of a tsunami on a specific community. In Elliott Bay, the mean spring tide range is about 11 feet and can be as much as about 16 feet (NOAA, accessed at http://co-ops.nos.noaa.gov/co-ops.html, June 25, 2003). This means that, while the modeling can be a useful tool to guide evacuation planning, it is not of sufficient resolution to be useful for land-use planning.

ACKNOWLEDGMENTS

This project was supported by the National Tsunami Hazards Mitigation Program (NTHMP) in cooperation with the city of Seattle and the Washington Emergency Management Division. Information about NTHMP is available at http://www.pmel.noaa.gov/tsunami-hazard/. Discussions with Tom Pratt, Brian Sherrod, and Craig Weaver (all USGS, Seattle) were invaluable for calibrating the fault source model. Karl Wegmann and Steve Palmer, both Washington Division of Geology and Earth Resources, provided helpful reviews.

REFERENCES CITED

Atwater, B. F.; Moore, A. L., 1992, A tsunami about 1000 years ago in Puget Sound, Washington: Science, v. 258, no. 5088, p. 1614-1617.

Blakely, R. J.; Wells, R. E.; Weaver, C. S., 1999, Puget Sound aeromagnetic maps and data: U.S. Geological Survey Open-File Report 99-514, version 1.0. [Accessed Oct. 3, 2000, at http://geopubs.wr.usgs.gov/open-file/of99-514/]

Blakely, R. J.; Wells, R. E.; Weaver, C. S.; Johnson, S. Y., 2002, Location, structure, and seismicity of the Seattle fault zone, Washington—Evidence from aeromagnetic anomalies, geologic mapping, and seismic-reflection data: Geological Society of America Bulletin, v. 114, no. 2, p. 169-177.

Brocher, T. M.; Parsons, T. E.; Blakely, R. J.; Christensen, N. I.; Fisher, M. A.; Wells, R. E.; SHIPS Working Group, 2001, Upper crustal structure in Puget Lowland, Washington—Results from the 1998 Seismic Hazards Investigation in Puget Sound: Journal of Geophysical Research, v. 106, no. B7, p. 13,541-13,564.

Bourgeois, Joanne; Johnson, S. Y., 2001, Geologic evidence of earthquakes at the Snohomish delta, Washington, in the past 1200 yr: Geological Society of America Bulletin, v. 113, no. 4, p. 482-494.

Bucknam, R. C.; Hemphill-Haley, Eileen; Leopold, E. B., 1992, Abrupt uplift within the past 1700 years at southern Puget Sound, Washington: Science, v. 258, no. 5088, p. 1611-1614.

Bucknam, R. C.; Sherrod, B. L.; Elfendahl, G. W., 1999, A fault scarp of probable Holocene age in the Seattle fault zone, Bainbridge Island, Washington [abstract]: Seismological Research Letters, v. 70, no. 2, p. 233.

Calvert, A. J.; Fisher, M. A.; SHIPS Working Group, 2001, Imaging the Seattle fault zone with high-resolution seismic tomography: Geophysical Research Letters, v. 28, no. 12, p. 2337-2340.

Daneš, Z. F.; Bonno, M.; Brau, J. E.; Gilham, W. D.; Hoffman, T. F.; Johansen, D.; Jones, M. H.; Malfait, Bruce; Masten, J.; Teague, G. O., 1965, Geophysical investigation of the southern Puget Sound area, Washington: Journal of Geophysical Research, v. 70, no. 22, p. 5573-5580.

Frankel, A. D.; Petersen, M. D.; Mueller, C. S.; Haller, K. M.; Wheeler, R. L.; Leyendecker, E. V.; Wesson, R. L.; Harmsen, S. C.; Cramer, C. H.; Perkins, D. M.; Rukstales, K. S., 2002, Documentation for the 2002 Update of the National Seismic Hazard Maps: U.S. Geological Survey Open-File Report 02-420. [Accessed June 25, 2003, at http://pubs.usgs.gov/of/2002/ofr-02-420/]

Gardner, J. V.; van den Ameele, E. J.; Dartnell, Peter, 2001, Multibeam mapping of the major deltas of southern Puget Sound, Washington: U.S. Geological Survey Open-File Report 01-266, 1 v.

Gower, H. D., 1978, Tectonic map of the Puget Sound region, Washington, showing locations of faults, principal folds, and large-scale Quaternary deformation: U.S. Geological Survey Open-File Report 78-426, 22 p., 1 plate, scale 1:250,000.

Jacoby, G. C.; Williams, P. L.; Buckley, B. M., 1992, Tree ring correlation between prehistoric landslides and abrupt tectonic events in Seattle, Washington: Science, v. 258, no. 5088, p. 1621-1623.

Johnson, S. Y.; Dadisman, S. V.; Childs, J. R.; Stanley, W. D., 1999, Active tectonics of the Seattle fault and central Puget Sound, Washington—Implications for earthquake hazards: Geological Society of America Bulletin, v. 111, no. 7, p. 1042-1053, 1 plate.

Kimball, J. P., 1897, Physiographic geology of the Puget Sound basin [in 2 parts]: American Geologist, v. 19, no. 4, p. 225-237 [part 1]; v. 19, no. 5, p. 304-322 [part 2].

Nelson, A. R.; Johnson, S. Y.; Wells, R. E.; Pezzopane, S. K.; Kelsey, H. M.; Sherrod, B. L.; Bradley, L.-A.; Koehler, R. D., III; Bucknam, R. C.; Haugerud, R. A.; Laprade, W. T., 2002, Field and laboratory data from an earthquake history study of the Toe Jam Hill fault, Bainbridge Island, Washington: U.S. Geological Survey Open-File Report 02-60, 1 v., 2 plates.

Pratt, T. L.; Johnson, S. Y.; Potter, C. J.; Stephenson, W. J.; Finn, C. A., 1997, Seismic reflection images beneath Puget Sound, western Washington State—The Puget Lowland thrust sheet hypothesis: Journal of Geophysical Research, v. 102, no. B12, p. 27,469-27,489.

Rogers, W. P., 1970, A geological and geophysical study of the central Puget Sound lowland: University of Washington Doctor of Philosophy thesis, 123 p., 9 plates.

Sherrod, B. L.; Bucknam, R. C.; Leopold, E. B., 2000, Holocene relative sea level changes along the Seattle fault at Restoration Point, Washington: Quaternary Research, v. 54, no. 3, p. 384-393.

ten Brink, U. S.; Molzer, P. C.; Fisher, M. A.; Blakely, R. J.; Bucknam, R. C.; Parsons, T. E.; Crosson, R. S.; Creager, K. C., 2002, Subsurface geometry and evolution of the Seattle fault zone and the Seattle basin, Washington: Seismological Society of America Bulletin, v. 92, no. 5, p. 1737-1753.

Titov, V. V.; González, F. I., 1997, Implementation and testing of the Method of Splitting Tsunami (MOST) model: NOAA Technical Memorandum ERL PMEL-112 (PB98-122773), 11 p.

Titov, V. V.; González, F. I.; Mofjeld, H. O.; Venturato, A. J., (in press), NOAA TIME Seattle tsunami mapping project—Procedures, data sources, and products: NOAA Technical Memorandum OAR PMEL-124, 15 p.

Titov, V. V.; Synolakis, C. E., 1998, Numerical modeling of tidal wave runup: Journal of Waterway, Port, Coastal and Ocean Engineering, v. 124, no. 4, p. 157-171.

Vancouver, George, 1798, repr. 1992, A voyage of discovery to the north Pacific Ocean, and round the world, in which the coast of north-west America has been carefully examined and accurately surveyed—Undertaken by His Majesty's command, principally with a view to ascertain the existence of any navigable communication between the north Pacific and north Atlantic Oceans, and performed in the years 1790, 1791, 1792, 1793, 1794, and 1795: G. G. and J. Robinson [London], 3 v.

Van Wagoner, T. M.; Crosson, R. S.; Creager, K. C.; Medema, G. F.; Preston, L. A.; Symons, N. P.; Brocher, T. M., 2002, Crustal structure and relocated earthquakes in the Puget Lowland, Washington, from high-resolution seismic tomography: Journal of Geophysical Research, v. 107, no. B12, 2381, DOI 10.1029/2001JB000710, p. ESE 22-1 - 22-23.

Walsh, T. J.; Caruthers, C. G.; Heinitz, A. C.; Myers, E. P., III; Baptista, A. M.; Erdakos, G. B.; Kamphaus, R. A., 2000, Tsunami hazard map of the southern Washington coast—Modeled tsunami inundation from a Cascadia subduction zone earthquake: Washington Division of Geology and Earth Resources Geologic Map GM-49, 1 sheet, scale 1:100,000, with 12 p. text.

Walsh, T. J.; Myers, E. P., III; Baptista, A. M., 2002a, Tsunami inundation map of the Port Angeles, Washington area: Washington Division of Geology and Earth Resources Open File Report 2002-1, 1 sheet, scale 1:24,000.

Walsh, T. J.; Myers, E. P., III; Baptista, A. M., 2002b, Tsunami inundation map of the Port Townsend, Washington area: Washington Division of Geology and Earth Resources Open File Report 2002-2, 1 sheet, scale 1:24,000.

Walsh, T. J.; Myers, E. P., III; Baptista, A. M., 2003a, Tsunami inundation map of the Neah Bay, Washington, area: Washington Division of Geology and Earth Resources Open File Report 2003-2, 1 sheet, scale 1:24,000.

Walsh, T. J.; Myers, E. P., III; Baptista, A. M., 2003b, Tsunami inundation map of the Quileute, Washington, area: Washington Division of Geology and Earth Resources Open File Report 2003-1, 1 sheet, scale 1:24,000.

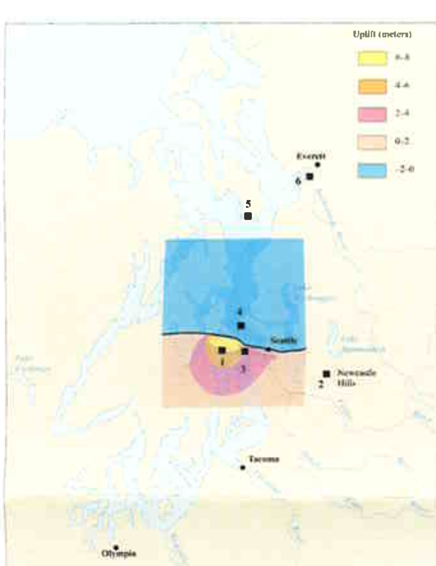
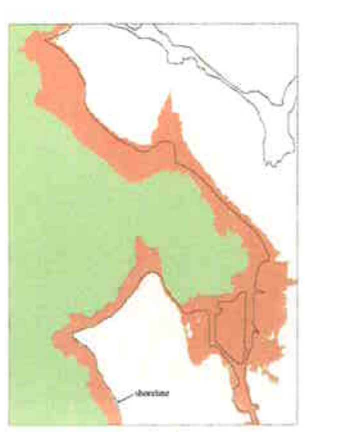


Figure 1. (left) Map showing Seattle fault and associated ground deformation model used in this study. Numbered locations are localities mentioned in text. 1, Restoration Point; 2, Newcastle Hills; 3, Alki Point; 4, West Point; 5, Cultus Bay; 6, Snohomish Delta.



Current velocity: none; medium <1.5 m/s; high >1.5 m/s

Figure 2. Computed current velocity zones. Note that velocities are highest along the shoreline and in narrow channels. One meter/second is ~2.2 mph.

Figure 3. Frozen frames of animation of modeled tsunami at 30-second intervals (from left to right). The wave crest is colored pale blue. Note that because Harbor Island is uplifted by the earthquake, the Duwamish Waterway initially drains rapidly before the wave reflects off the north side of the bay and then inundates the Harbor Island area.

The phenomenon we call "tsunami" (soo-NAH-mee) is a series of traveling ocean waves of extremely long length generated by disturbances associated primarily with earthquakes occurring below or near the ocean floor. Underwater volcanic eruptions and landslides can also generate tsunamis. In the deep ocean, their length from wave crest to wave crest may be a hundred miles or more but with a wave height of only a few feet or less. They cannot be felt aboard ships nor can they be seen from the air in the open ocean. In deep water, the waves may reach speeds exceeding 500 miles per hour.

Tsunamis are a threat to life and property to anyone living near the ocean. For example, in 1992 and 1993 over 2,000 people were killed by tsunamis occurring in Nicaragua, Indonesia and Japan. Property damage was nearly one billion dollars. The 1960 Chile Earthquake generated a Pacific-wide tsunami that caused widespread death and destruction in Chile, Hawaii, Japan and other areas in the Pacific. Large tsunamis have been known to rise over 100 feet, while tsunamis 10 to 20 feet high can be very destructive and cause many deaths and injuries.

From *Tsunamis—The Great Waves*
by the U.S. Department of Commerce,
National Oceanic and Atmospheric Administration,
National Weather Service, Intergovernmental Oceanographic Commission,
and International Tsunami Information Center
Accessed at http://www.nws.noaa.gov/om/brochures/tsunami.htm on 8/27/02

Kinney, Aimee T NWS

From: albert pong [amenehune2@yahoo.com]
Sent: Sunday, April 30, 2006 11:54 PM
To: Kinney, Aimee T NWS
Subject: Comment Seawall Scope Statement

06 April 30
Seattle Seawall: Comments

About 1100 AD, 900 years ago, a fault, a few miles south of Harbor Island ruptured. The fault crossed what is now the Duwamish River/Water--Way. The northern segment rose 12 feet relative to the south portion. That rupture ended a marine trough. A mudslide 600 years ago, and following sedimentation, filled the southern end of Lake Washington, creating what is now Kent Valley, with a marsh that extended from what is now South Center north to Jackson Street in Seattle.

The marsh was drained by dredging the Duwamish River, filling (lowering Mt Jackson and digging out Dearborn St.) and lowering Lake Washington 9 feet over a 50 year period.

Seismically active Seattle is over-due for an earthquake that will destroy the "Elliot Bay Seawall".

A rupture of the Seattle fault(s), which is directly under where the tunnel would be place would destroy the tunnel and the seawall built as part of the joint project.

Alternative 4 - Tunnel wall has the tunnel more than fifty feet below sea-level resting on saturated incompressible glacial till. A rupture with vertical displacement would lift, rupture and dislocate the tunnel and seawall, exacerbating a catastrophic failure. The depth, width and breath of the debris field will make recovery very difficult.

Even if the the tunnel isn't destroyed by a rupture, the tunnel would have high operating and maintenance. The pumping of exhaust air and water that will seep through the walls and gush through any crack, will be an enormous cost.

As shown by the current backlog of $500 million of delayed maintenance for streets, retaining walls, bridges and sidewalks; the deterioration and falling of acoustic panels at the KingDome; and the failure of the State of Washington to maintain the drains on the viaduct, the tunnel will be neglected to the point of catastrophe.

Even in designed operating condition, the tunnel would force onto crowded surface streets thousands of cumbersome trucks laden with flammable cargoes. The tunnel will be noisier that the KingDome after the acoustic panels were removed.

It is much preferred---for cost, minimizing of construction delays and obstructions, efficacy, efficiency and risk management --- that a new layer of plate steel pilings be added seaward of the existing pilings.

The old pilings should be left in place and used as a guide for the installation of new plate steel pilings.

Boxed trusses of steel pipes, and braced to lean against the existing wall will serve as a guide in installing the new siding.

New, thicker, wider and durable-type plate steel piling should reduce the cost of

installation, and improve durability.

The heavier piling should cleave through the uplift of a vertical displacement rupture, avoiding a catastrophic failure.

Loose fill and rotten and worm-eaten firs would be removed and replaced with large concrete blocks. The blocks would be of the type used as retaining walls and barriers, and would be stacked cross-hatch or basket weave fashion in staggered layers following the progress of the new siding.

The stack of blocks would buttress the steel pilings against a tsunami or crash of a ferry or other large craft and deflect liquefaction behind the seawall.

Following a displacement rupture earthquake, whatever jumbled blocks can be re-arranged with a minimum of effort, if needed..

The trusses, with gratings, would serve as inspection and work platforms above the water. With eyes, shackles, and pulleys; inspection and work boxes could be suspended and maneuvered under the trusses.

After the soil behind the seawall has been stabilized to the point that it will not threaten the seawall, the viaduct could be retrofitted.

The cost of a retrofitted seawall and retrofitted viaduct could be less than $1 billion. Not only is the tunnel much more expensive, the tunnel will have a cost over-runs much more than $1 billion.

The construction time for a seawall/viaduct retrofit is a fraction of the time of the other projects.

The nine year gridlock associated with construction of the tunnel will result in an irreversible decline as in St. Louis (from 885,000, 1950, to less than 300,000, 2005) and Newark New Jersey.

albert pong
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Kinney, Aimee T NWS

From: gene hoglund [genensusan@comcast.net]
Sent: Tuesday, May 02, 2006 12:16 AM
To: Kinney, Aimee T NWS
Subject: Please consider adding this to Alaskan way seawall 2nd additional information to letter of April 18, 2006

April 18, 2006
Additional information on the Elliott Bay Tsunami from a Seattle fault earthquake.

Ms. Aimee Kinney
U.S. Army Corps of Engineers, Seattle District
Environmental Resources Section
P.O. Box 3755
Seattle, WA 98124-3755

Re: **Opposition to Alternative 4 - Alaskan Way Tunnel, built over the Seattle fault.**

Dear Ms. Kinney:

In considering the issues of major environmental impacts, by this letter, enclosures and references, I opposed the digging of a tunnel over the Seattle Fault and in a tsunami hazard zone. Please consider the additional information to my April 18, 2006 letter:

The 2002 Workshop Report on Puget Sound Tsunami Sources. "INTRODUCTION. Future Puget Sound tsunamis are guaranteed by a combination of setting and history".... introduces its finding by specific reference to the Growth Management Act (and to the 1995 Amendment to that act) which requires cities to include the "best available Science" when developing critical areas ordnances, and encourages consultation with teams of qualified scientific experts to do so. The 2002 Report, among others was undertaken" In the spirit of complying with these requirements."

This study, which I have listed below, constitute some of the "Best Available Science" on the Elliott Bay Tsunami

Puget Sound Tsunami Sources 2002 Workshop Report (35 page) by 23 highly respected Scientists and Geologists from around the United States were participants in this workshop to Develop quantitative descriptions of potential sources for inundation modeling to assess Puget Sound tsunami hazards. A joint Special Report by NOAA, USGS, WSDNR, AND WSMDEMD. Report enclosed or can be found at:

http://www.pmel.noaa.gov/pubs/PDF/gonz2526/gonz2526.pdf

Sincerely,

Eugene Hoglund
3503 30th Ave West
Seattle WA 98199

Puget Sound Tsunami Sources

2002 Workshop Report

A Joint Special Report

National Oceanic and Atmospheric Administration
United States Geological Survey
Washington State Department of Natural Resources
Washington State Military Department Emergency Management Division

On the cover: Puget Sound has a history of tsunamis that includes water waves generated by this landslide at the Tacoma Narrows. The slide occurred three days after the magnitude-7.1 Olympia earthquake of April 13, 1949. It generated a tsunami that reflected off the opposite shore and propagated back to the coast on which the landslide occurred.

NOAA OAR Special Report

Puget Sound Tsunami Sources—2002 Workshop Report

A contribution to the Inundation Mapping Project of the
U.S. National Tsunami Hazard Mitigation Program

Workshop Report Committee:

Frank I. González, compiler, with contributions from Brian L. Sherrod, Brian F. Atwater, Arthur P. Frankel, Stephen P. Palmer, Mark L. Holmes, Robert E. Karlin, Bruce E. Jaffe, Vasily V. Titov, Harold O. Mofjeld, and Angie J. Venturato

Sponsored by:

National Oceanic and Atmospheric Administration
U.S. Geological Survey
Washington State Department of Natural Resources
Washington State Military Department Emergency Management Division

Workshop Organizing Committee:

G. Crawford, F. González (Chair), M. Holmes, H. Mofjeld, B. Sherrod, V. Titov, A. Venturato, T. Walsh, C. Weaver

June 2003

Contribution 2526 from NOAA/Pacific Marine Environmental Laboratory

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Puget Sound Tsunami Sources Workshop History

This workshop was jointly sponsored by NOAA's Center for Tsunami Inundation Mapping Efforts (TIME), the U.S. Geological Survey, the Washington State Military Department Emergency Management Division (WAEMD), and the Washington State Department of Natural Resources (WADNR). The Workshop Organizing Committee consisted of:

George Crawford	WA State Emergency Management Division
Frank González (Chair)	NOAA TIME Center
Mark Holmes	U. Washington
Hal Mofjeld	NOAA TIME Center
Brian Sherrod	U.S. Geological Survey
Vasily Titov	NOAA TIME Center
Angie Venturato	NOAA TIME Center
Tim Walsh	WA State Dept. Natural Resources
Craig Weaver	U.S. Geological Survey

This committee held a planning meeting on 24 April 2002. On 9 May, an informational e-mail was distributed to 35 individuals, inviting their participation and soliciting pre-workshop scientific contributions for the workshop web site. The web site served to stimulate and facilitate pre-workshop e-mail discussion and to provide resource material for the subsequent workshop activities. Twenty-three attendees participated in the workshop, held on 10 June 2002 at NOAA's Pacific Marine Environmental Laboratory in Seattle, Washington. The full list of invitees and the pre-workshop contributions are posted on the workshop web site at *http://www.pmel.noaa.gov/tsunami/time/PS_source_wkshp/*. The full list of workshop participants is provided in Appendix A.

At the workshop, the following sub-groups were formed to concentrate on specific source issues:

Earthquake Sources: A. Frankel, C. Garrison-Laney, T. Jovanelly, B. Sherrod, C. Weaver, J. Whisler

Delta Failure and Landslide Sources: J. Gardener, M. Holmes, R. Karlin, R. Kayen, S. Palmer, H. Shipman, T. Walsh, H. Yeh

Paleotsunami Field Evidence: B. Atwater, B. Jaffe, H. Mofjeld, V. Titov

The remaining participants were specialists in tsunami modeling and emergency management, and they participated in each sub-group as needed.

Subsequently, the following individuals served as lead contributors to individual sections of the report: González (Sections 0 and 1), Sherrod, Atwater, and Frankel (Section 2), Palmer, Holmes, and Karlin (Section 3), Jaffe and Atwater (Section 4), Titov, Mofjeld, González, and Venturato (Section 5). In June 2002, a first rough draft was distributed via e-mail list *PugetSources@pmel.noaa.gov* to all workshop invitees and participants for their review. The manuscript went through several rounds of revision and review before completion in June 2003.

Puget Sound Tsunami Sources—2002 Workshop Report

Workshop Report Committee:

Frank I. González, compiler, with contributions from Brian L. Sherrod, Brian F. Atwater, Arthur P. Frankel, Stephen P. Palmer, Mark L. Holmes, Robert E. Karlin, Bruce E. Jaffe, Vasily V. Titov, Harold O. Mofjeld, and Angie J. Venturato

Executive Summary

Potential tsunami sources in Puget Sound were reviewed by a 23-person panel of geoscientists, oceanographers, and emergency managers who participated in a 1-day workshop. Their goal was to lay scientific groundwork for hazard assessment in coastal areas threatened by tsunamis and, in so doing, assist emergency managers that seek to comply with the spirit of the Washington State Growth Management Act, which instructs officials to seek out and consider the "best available science." The panelists recommended that tsunami modelers focus on several kinds of sources, and they also recommended improvements in source identification and modeling.

Tsunami Modeling Recommendations

- *Earthquakes* on the Seattle fault zone, the Tacoma and South Whidbey Island faults, and other structures that generate tsunamis by tectonically raising or lowering the floor of Puget Sound, consistent with best estimates that may include fault parameters used in the USGS National Seismic Hazard Map (Table 2.1 or updates) and paleoseismic estimates of land-level change.

- *Delta slope failures* of the Puyallup, Duwamish, and Snohomish River deltas, with parameters based on the 1894 Commencement Bay event (Table 3.1) and a scaled-down 1964 Valdez event (Table 3.3).

- *Submarine landslides* associated with Quaternary faults (not deltas), with parameters based on currently unpublished seismic profiling data and maps (Table 3.4).

- *Subaerial landslides*, with parameters based on the 1949 Tacoma Narrows landslide (Table 3.2).

- Tsunami modelers should develop these source scenarios in close collaboration with geoscience experts on earthquakes, slope stability, and paleotsunami evidence in Puget Sound.

Science Improvement Recommendations

- Use LIDAR data to update deformation estimates for A.D. 900 Seattle Fault earthquake and for other fault ruptures.

- Do additional fieldwork to document coastal deformation and constrain the eastern end of the Tacoma Fault.
- Expand the existing program of slope instability mapping to increase the geographical coverage and improve the quality of submarine and subaerial landslide assessments, including the acquisition of multibeam bathymetry and sediment cores.
- Improve estimates of wave height and water velocity of prehistoric and recent tsunamis through combined use of sedimentology and inundation modeling.
- Do additional fieldwork to check for tsunami deposits at Lynch Cove, Lake Washington, Lake Sammamish, and other Puget Sound area sites.
- Make and update summary maps that incorporate all available field evidence for tsunami deposits, coseismic deformation, and submarine and subaerial landslides.
- Develop methods to assess the sensitivity of coastal areas to tsunami inundation, based on multiple simulations that reflect the possible range of variations in the source parameters.
- Hold yearly workshops to review the best available scientific information and develop updated recommendations for tsunami inundation mapping in Washington State.

1. Introduction

Future Puget Sound tsunamis are guaranteed by a combination of setting and history. The inland waters and lakes of the Puget Sound lowland cross active faults and contain records of earthquakes and landslides. From geologic and historical evidence, it is known that some of these events have generated tsunamis. A workshop on 23 January 2001 concluded that "Tsunamis and landslides in the greater Puget Sound region pose significant hazards that must be included in local and regional emergency response and development plans" (Crawford *et al.*, 2001). That workshop was organized by the Washington State Military Department Emergency Management Division (WAEMD), the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Geological Survey (USGS), all partners of the U.S. National Tsunami Hazard Mitigation Program (Bernard, 2001).

A major goal of the national tsunami program is to develop tsunami inundation maps for all U.S. coastal communities at risk (González *et al.*, 2001). In 2002, NOAA's Center for Tsunami Inundation Mapping Efforts (TIME) made initial simulations of Seattle-Duwamish waterfront inundation by a tsunami generated by an M 7.3 Seattle Fault earthquake scenario. In 2003, the TIME Center plans to begin numerical simulations and mapping of tsunami inundation in the Puget Sound lowland. Such simulations are intended to help state, county, and municipal officials develop emergency management tools, including evacuation maps, response plans, educational material, and outreach and mitigation programs. The inundation maps are expected to evolve as emergency managers apply them and as researchers revise their scientific basis.

In Washington, this effort provides the basis for community development of a mitigation plan that is in compliance with the Washington State Growth Management Act, under which coastal areas threatened by tsunamis are designated as critical areas (Washington State Office of Community Development, 2002). In 1995, a section was added to the Growth Management Act that requires counties and cities to include the "...best available science when developing policies and development regulations to protect the functions and values of critical areas..." and encourages state officials to "...consult with a qualified scientific expert or team of qualified scientific experts to identify scientific information, determine the best available science, and assess its applicability to the relevant critical areas" (Washington State Legislature, 1995).

In the spirit of complying with these requirements, a Puget Sound Tsunami Sources Workshop was organized by NOAA's TIME Center, the USGS, WAEMD, and Washington Department of Natural Resources (WADNR). This workshop had two specific objectives:

1. Develop quantitative descriptions of potential sources for inundation modeling to assess Puget Sound tsunami hazards.

2. Develop recommendations for improving the scientific basis for source specification and tsunami source modeling.

The 1-day workshop was held on 10 June 2002 at NOAA's Pacific Marine Environmental Laboratory in Seattle, Washington. The 23 participants included scientists with specialties in earthquakes, landslides, delta failures, paleotsunami field evidence, tsunami modeling, and emergency management (Appendix A). Strawman source scenarios, reports, and other relevant reference materials were contributed by invitees prior to the workshop. These were made available on the workshop web site, at *http://www.pmel.noaa.gov/tsunami/time/PS_source_wkshp/* .

The workshop consisted of whole-group discussions and sub-group sessions. First, an open discussion of earthquake, delta failure, and landslide scenarios was held; participants then divided into three sub-groups. Two sub-groups concentrated on developing quantitative descriptions of potential tsunami sources—the first dealt with earthquake uplift and subsidence, the second with slope failures. The third sub-group dealt with geologic records of past tsunamis and their triggers. Finally, an example was presented of a recent tsunami inundation modeling study for the Seattle-Duwamish waterfront area.

2. Earthquake Sources

2.1 Background

Earthquakes at Puget Sound occur along faults in three tectonic settings: within the subducted oceanic plate (Juan de Fuca plate) at depth beneath Puget Sound, within the overriding continental plate (North America plate), and at the boundary fault between those plates.

For each of these sources, the largest earthquakes recur at poorly known, probably irregular, intervals. On average, the intervals are on the order of decades for the Juan de Fuca plate, millennia for the best-known of the upper-plate faults (the Seattle Fault), and centuries for the plate boundary (*http://www.ess.washington.edu/SEIS/PNSN/INFO_GENERAL/eqhazards.html*).

Although few earthquakes result in tsunamis at Puget Sound, each of the three earthquake sources has demonstrated its capability of generating such waves. A landslide that set off a tsunami in Tacoma Narrows occurred a few days after the 1949 earthquake in the Juan de Fuca plate (Noson *et al.*, 1988). The earthquake of ca. A.D. 900 on the Seattle fault caused uplift that triggered a tsunami in central Puget Sound and also caused landslide-generated waves in Lake Washington (Atwater and Moore, 1992). Tsunamis from plate-boundary earthquakes probably account for several sand sheets on northwestern Whidbey Island (Williams and Hutchinson, 2000) and at Discovery Bay (Williams *et al.*, 2002).

2.2 Priority Areas

The workshop focused on coseismic uplift and subsidence along three fault zones as sources for tsunamis in the Puget Sound region—the Seattle Fault,

Tacoma Fault, and South Whidbey Island Fault. Also discussed was coseismic subsidence 1100 years ago near Olympia (Sherrod, 2001), and the Cascadia Subduction Zone (CSZ) as a likely source for tsunamis at northwestern Whidbey Island (Williams and Hutchinson, 2000) and Discovery Bay (Williams *et al.*, 2002). Puget Sound probably has additional tectonic sources of tsunamis, particularly vertical displacement along faults beneath the Sound near the latitude of the Strait of Juan de Fuca (Johnson, 2001). These structures, along with rapidly changing views of the Seattle and Tacoma faults, will need reassessment in future workshops.

Maps in Fig. 1 summarize several aspects of the region's earthquake hazards. Figure 1a schematically summarizes the general location of some known fault zones at Puget Sound. This map includes deformation contours for a worst-case event—the modeled crustal deformation pattern for an M 7.3 Seattle Fault earthquake discussed in section 5.0, below. Figure 1b presents the modeled deformation pattern for an M 9.1 earthquake on the CSZ. Figure 1c provides estimates of peak ground acceleration that might be experienced in the Puget Lowlands area with a 2% probability of exceedance in 50 years (Frankel *et al.*, 1996).

Seattle Fault

Tsunami generation models for the Seattle Fault Zone depend on a complicated geometry that was being reassessed as this report was written and revised. This reassessment may produce large changes in fault parameter estimates, in which case the tsunami source models presented in Table 5.1 may require modification.

Previously, the Seattle Fault Zone was inferred to have roots in a widespread, nearly horizontal detachment fault tens of kilometers beneath much of Puget Sound (Pratt *et al.*, 1997). It was also mapped as containing multiple near-surface strands that are rooted in a master reverse fault (Johnson *et al.*, 1999; Blakely *et al.*, 2002). More recently, this master fault has been considered largely disconnected from near-surface strands. Instead, much like a well-studied reverse fault in Japan (Ishiyama *et al.*, 2002), the master fault may terminate kilometers below the surface, and the master fault may deform rocks above it much like the blade of a snowplow. These various interpretations provide many ways of suddenly raising or lowering the floor of Puget Sound—the deformation that would generate a tsunami.

The main mapped strands of the Seattle Fault Zone, from north to south, have been called the Frontal fault, the Blakely Harbor fault, and the Orchard Point fault (Johnson *et al.*, 1999; Blakely *et al.*, 2002). The Frontal fault projects to the surface about 3.5 km north of Restoration Point and may dip steeply to the south (Brocher *et al.*, 2001; Calvert and Fisher, 2001; ten Brink *et al.*, 2002).

A late Holocene earthquake, with a magnitude (M) of 7 or more occurred on the Seattle Fault Zone about 1100 years ago (Bucknam *et al.*, 1992). This earthquake, probably between A.D. 900 and 930 (Atwater, 1999), generated a tsunami known from deposits at West Point (in Seattle), Cultus Bay (at the south end of Whidbey Island), and the Snohomish River delta near

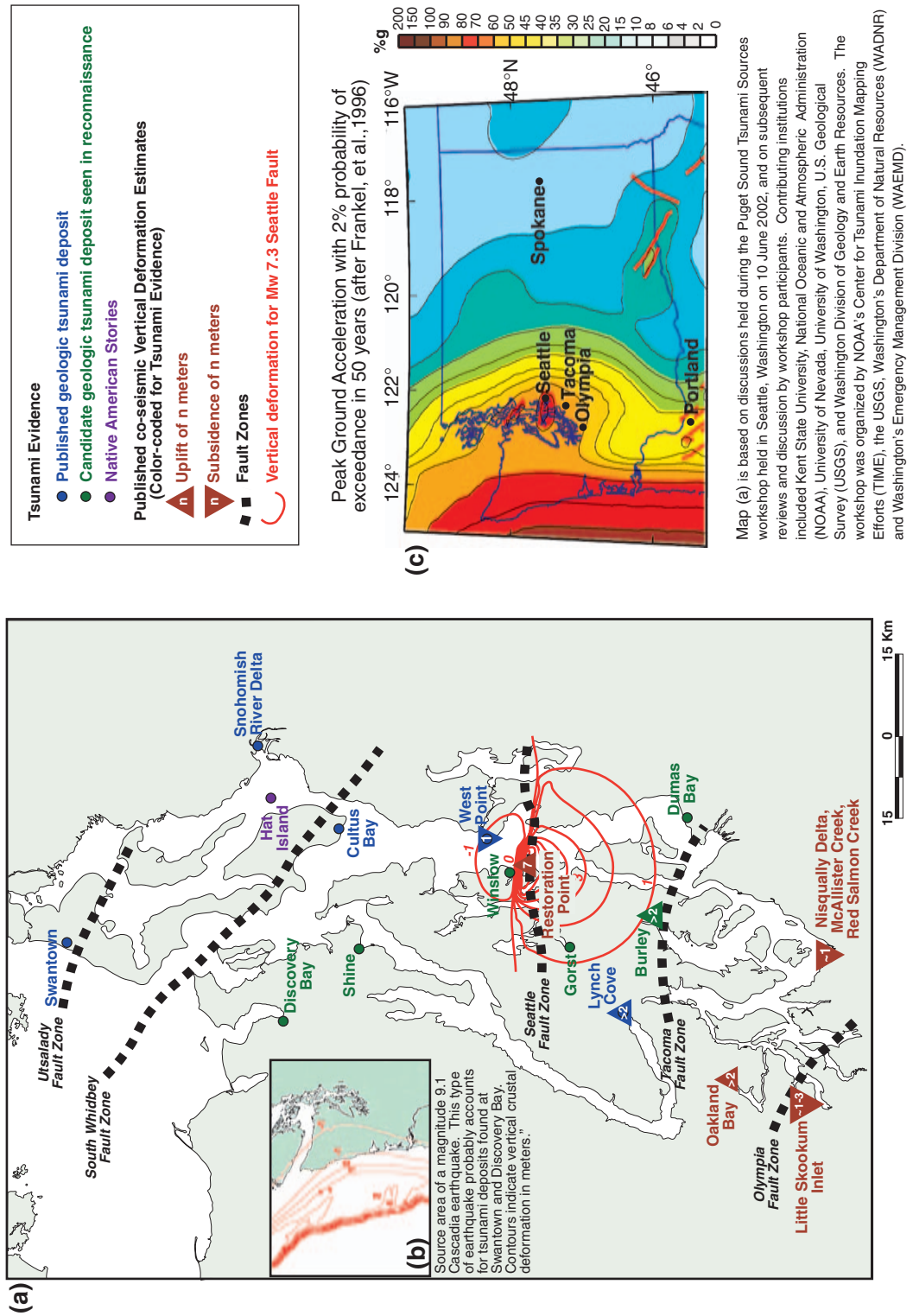


Figure 1: (a) Schematic of fault zone locations in the Puget Sound region, with vertical deformation contours for an Mw 7.3 Seattle Fault. Inset (b) Vertical deformation for an M 9.1 Cascadia earthquake. (c) Pacific Northwest peak ground acceleration with 2% probability of exceedance in 50 years (from Frankel *et al.*, 1996).

Everett (Atwater and Moore, 1992; Bourgeois and Johnson, 2001). The tsunami probably resulted from 5–7 m of uplift in a band 6 km wide south of the fault, and secondarily from as much as 1 m of subsidence to the north. This uplift and subsidence displaced large volumes of water in Puget Sound, whether or not fault rupture extended upward to the floor of the sound.

A south-facing scarp within the Seattle Fault Zone, identified by airborne laser mapping, crosses Bainbridge Island about 2 km north-northwest of Restoration Point (Bucknam *et al.*, 1999). Stratigraphy and structure exposed in trenches excavated across the scarp show a postglacial history of folding and faulting from multiple earthquakes, with the most recent event occurring about 1100 years ago (Nelson *et al.*, 1999; 2002). A full-length report on the trench results was nearing completion as this workshop report was being written.

A north-facing scarp within the Seattle Fault Zone, near the west shore of Lake Sammamish, was recently trenched by Sherrod (2002). He found evidence for one postglacial surface rupture and dated it to the past 13,000 calendar years.

Tacoma Fault

Like the Seattle Fault Zone, the Tacoma Fault separates an area of coseismic uplift from an area of coseismic subsidence (Brocher *et al.*, 2001). The documented examples of these land-level changes date to about 1100 years ago (Bucknam *et al.*, 1992). Though much remains to be learned about its extent and shape, the Tacoma Fault is evident from gravity and aeromagnetic anomalies, seismic tomography, and seismic-reflection lines. The fault likely runs westward and northwestward from Tacoma across much of the Puget Lowland (Fig. 1a). Seismic tomography implies at least 6 km of post-Eocene uplift to the north relative to basinal sedimentary rocks to the south.

Uplift to the north of the fault and subsidence to the south occurred most recently in A.D. 800–1200, not necessarily in a single year (Sherrod *et al.*, 2002). To the northwest at Lynch Cove, tide flats rose as much as 3 m between A.D. 870–990. Uplift 16 km to the east at Burley, accompanied there by liquefaction and a tsunami, allowed woody shrubs to invade former tideflats in A.D. 770–1000. Shells in tideflat mud at North Bay record uplift loosely dated to the past 3000 years. Fossil foraminifera from Dumas Bay limit the eastward extent of uplift north of the fault, for they show that a brackish marsh remained in the intertidal zone throughout the last 2000 years. However, trees at Wollochet Bay, on the south side of the fault, subsided into the intertidal zone. A single radiocarbon age implies that this subsidence occurred A.D. 980–1190, in which case the subsidence postdates uplift at Lynch Cove and Burley by 30–270 years.

The age range of this uplift on the north side of the Tacoma Fault includes times of coseismic uplift and subsidence at many sites around Puget Sound. As noted above, an earthquake raised shorelines along the Seattle Fault Zone in A.D. 900–930; moreover, several shores of southern Puget Sound subsided A.D. 860–940. Therefore, the uplift north of the Tacoma Fault either coincided with a single large event in A.D. 900–930, or it represents a

separate earthquake of about that age. However, the subsidence at Wollochet Bay implies either coseismic or aseismic deformation after A.D. 900–930.

South Whidbey Island Fault

The South Whidbey Island Fault is one of several that splay eastward from the Strait of Juan de Fuca and appear to displace postglacial deposits (Wagner and Tomson, 1987). It has been mapped as a transpressional deformation zone that crosses Admiralty Inlet and southern Whidbey Island (Johnson, 1996; 2001). This zone separates pre-Tertiary rocks to the northeast from Eocene volcanic and sedimentary rocks to the southwest. The highest Tertiary rocks have as much as 420 m of relief across the fault, either from vertical tectonic movement (Johnson, 1996) or from subglacial erosion. An earthquake on the South Whidbey Island Fault might produce both vertical and horizontal displacement of the floor of Puget Sound.

Compared with the Seattle and Tacoma structures, the South Whidbey Island Fault may have produced little vertical displacement in the Holocene. The evidence reported thus far comes from northern Whidbey Island, where two sites (Crockett and Hancock Lakes) appear to differ by about 2 m in relative sea-level change about 3000 years ago. The inferred difference is tentative because it has been reported only in abstract and because it has been inferred from differences in the radiocarbon age of intertidal deposits at similar elevation (Kelsey and Sherrod, 2001).

2.3 Event Descriptions

Table 2.1 provides fault parameter estimates for the Seattle and South Whidbey Island Fault Zones as used by the USGS National Seismic Hazard Mapping Project (Frankel *et al.*, 2002). Because of lively research and debate about the structure and Holocene history of these faults, the tabulated parameters represent a recent consensus that is already out of date. The lack of estimates for the Tacoma Fault reflects an early stage of research into the Holocene history of this structure.

2.4 Recommendations

Tsunami Source Modeling

- Seattle Fault: Incorporate the most current fault and earthquake parameters provided by active researchers and the USGS National Seismic Hazard Mapping Project.

- South Whidbey Island Fault: Incorporate the most current fault and earthquake parameters provided by active researchers and the USGS National Seismic Hazard Mapping Project.

Table 2.1: Fault parameters used in making the 2002 version of the USGS National Seismic Hazard Map (Frankel *et al.*, 2002, `http://geohazards.cr.usgs.gov/eq/faults/fsrpage21.html#washington`). End points listed in the table should not be interpreted as a straight line fault trace; they correspond to the two ends of a more complex fault trace that is not detailed here (Art Frankel, personal communication). T, the recurrence time for earthquakes of magnitude M, is especially uncertain. In the characteristic earthquake model, a fault produces earthquakes of one size only (of M 7 in the case of the Seattle and south Whidbey Island faults) at the indicated recurrence interval. In the truncated Gutenberg-Richter model, the fault produces earthquakes in a certain size range (greater than M 6.5, in this case) at the indicated recurrence interval. The 2002 hazard map gives the two models equal weight (Frankel *et al.*, 2002, p. 11).

						Characteristic-earthquake model		**Truncated Gutenberg-Richter model**	
Fault Zone	**Slip Rate (m/1000 yr)**	**End Points (deg., lat., long.)**	**Length (km)**	**Width (km)**	**Dip (deg)**	**T (yr)**	**M**	**T (yr)**	**M**
Seattle	0.5	47.6, −121.9 47.6, −122.9	71	21	45	5000	7	1000	≥6.5
Tacoma	TBD	TBD	50	TBD	TBD	TBD	TBD	TBD	TBD
S. Whidbey Island	0.6	47.9, −122.3 48.2, −123.0	63	17	60	3000	7	1000	≥6.5

Science Improvement

- Seattle Fault: Use high-resolution topography from LIDAR, verified by field work, to update estimates of crustal deformation for A.D. 900 event.
- Tacoma Fault: Study surface ruptures and shoreline changes that can be associated with the fault.

3. Delta Failure and Landslide Sources

3.1 Background

The working group identified three distinct landslide situations that could result in a significant tsunami affecting local communities bordering Puget Sound: submarine landslides on delta fronts, submarine slides elsewhere in the Sound, and slides from adjacent uplands.

Submarine landslides can originate on the delta slopes of major rivers flowing into the Sound, in particular the Nisqually, Puyallup, Duwamish, and Snohomish rivers. In 1894 a large submarine landslide occurred on the Puyallup River delta in Commencement Bay, resulting in two deaths and the destruction of the Northern Pacific freight docks and other port facilities (Stephen Palmer, unpublished data; Gardner *et al.*, 2001). A smaller submarine landslide in 1943 destroyed jetties along the mouth of the Puyallup River (University of Washington, Department of Oceanography, 1953). In addition to these Puget Sound examples, larger submarine landslides have

occurred on river deltas in British Columbia and Alaska. Some of these slides were triggered by large earthquakes, and others resulted simply from river delta evolution, including oversteepening of the delta front. The submarine landslides resulting from the 1964 Alaska earthquake resulted in more than 50 deaths and the near-total destruction of three port communities: Valdez, Seward, and Whittier (Wilson and Torum, 1972; Spaeth and Berkman, 1972; Lander, 1988). At Valdez, large tsunamis were generated by a number of submarine slides, including a massive slide off the Lowe River delta that included the Valdez waterfront and the shore north of town; docks, canneries, the boat harbor, and many boats were totally destroyed, oil tanks were set on fire, and 31 died. At Seward, the earthquake triggered slides on the Resurrection River fan delta, causing a large stretch of waterfront to slide into Resurrection Bay; the slide and the resultant tsunami destroyed almost the entire economic foundation of the community and caused 11 deaths. Whittier suffered 13 fatalities, destruction of docks, oil tank farms, and railroad facilities, due to the earthquake and tsunami waves evidently generated by delta failures. Known historical Puget Sound delta failures, all far smaller than these Alaskan examples, are shown in Fig. 2, as are the locations of major river deltas.

Additional landslides originate on steep submarine slopes that are not part of a delta. Unpublished seismic profiling data and mapping presented by members of the working group (Robert Karlin and Mark Holmes) indicate that large submarine landslides have occurred on submarine slopes in Puget Sound, Lake Washington, and Lake Sammamish that are not associated with large river deltas, but that appear proximal to a number of Quaternary faults that cross the Sound (Karlin *et al.*, 2002). Large prehistoric landslides have been identified on continental shelves and slopes off Europe, Africa, and North and South America (Moore, 1978). Most have been identified through seismic profiling and sediment coring on the continental margins. In addition, some submarine slope failures, such as the Grand Banks landslide of 1929, have occurred during historical times. This landslide caused a tsunami that resulted in the loss of 27 lives in southern Newfoundland (Heezen and Ewing, 1952; Heezen and Drake, 1964; Hasagawa and Kanamori, 1987). The 1929 slide apparently consisted of multiple slumps of many sizes (Piper *et al.*, 1999). In 1998, a large submarine landslide is suspected of contributing to a Papua New Guinea tsunami that caused more than 2200 fatalities (Titov and González, 2001).

Subaerial landslides that fall into Puget Sound with sufficient volume and velocity, and at the appropriate tidal conditions, can generate large water waves. Such a tsunami was generated by a landslide at the Tacoma Narrows that occurred three days after the 1949 Ms 7.1 Olympia earthquake. The landslide occurred on the steep bluff bordering The Narrows, and the fall of the slide debris into the water caused the tsunami (Chleborad, 1994). Native American oral tradition suggests that a large subaerial landslide at Camano Head created a water wave that drowned many people on Hat (Gedney) Island (Shipman, 2001). Because the story does not include ground shaking, this landslide was not necessarily associated with an earthquake. Figures 3

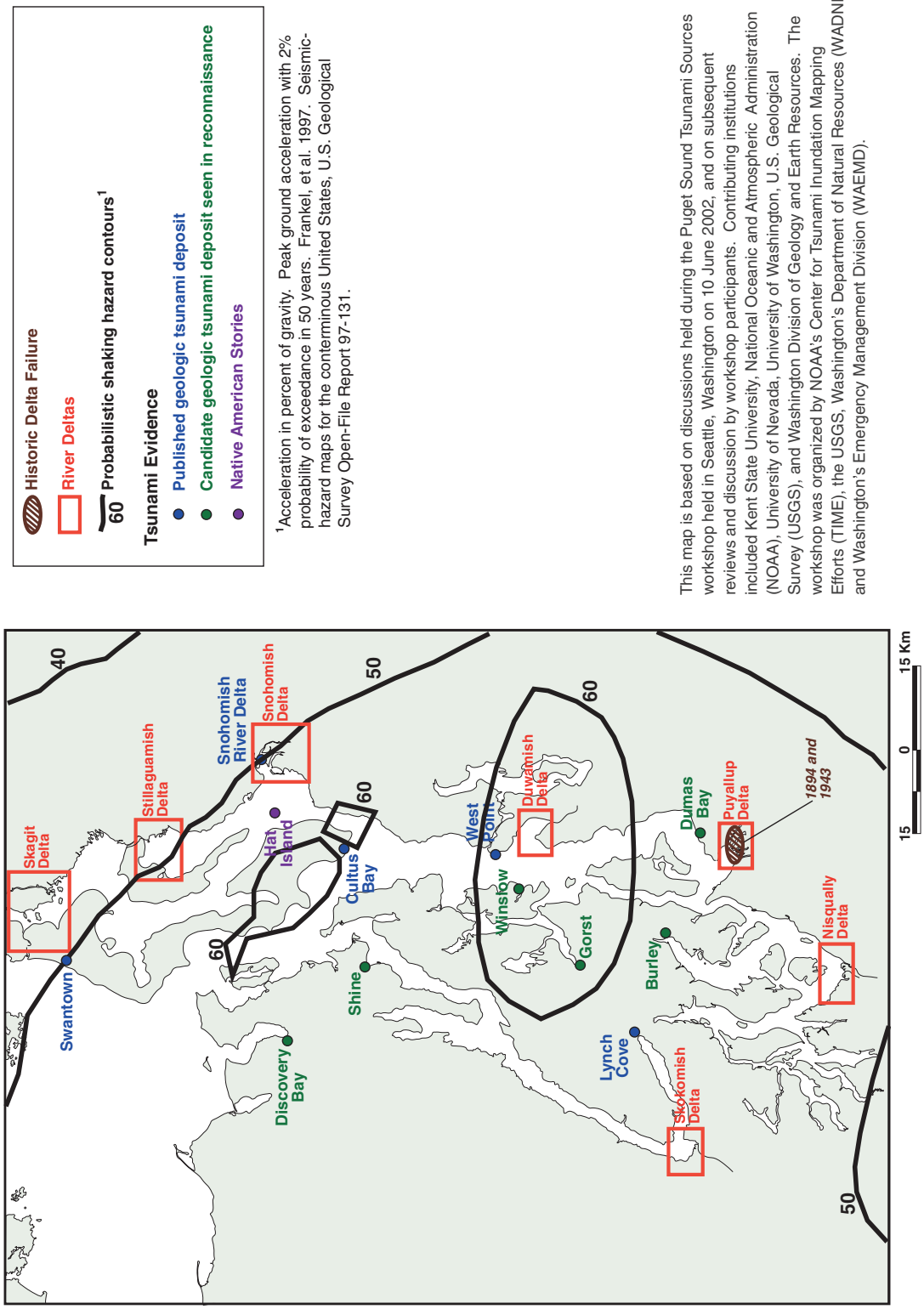


Figure 2: Locations of major river deltas in Puget Sound, including two historic failures of the Puyallup River delta that occurred in 1894 and 1943, and locations for which evidence of past tsunamis exists. Also presented are contours of peak ground acceleration with 2% probability of exceedance in 50 years (Frankel *et al.*, 1997).

and 4 summarize information on both submarine and subaerial landslides discussed at the workshop.

3.2 Priority Areas

Several hypotheses may aid in setting priorities for modeling tsunamis from landslide sources.

River delta failures

Deltas of the Puyallup, Duwamish, and Snohomish Rivers probably pose more of a landslide hazard than do other Puget Sound deltas, as shown by historical submarine landslides on the Puyallup River delta, the proximity of these three deltas to major port facilities, and stability analysis of the Duwamish River delta slope (Kayen *et al.*, 1999).

Non-deltaic submarine landslides

Away from deltas, submarine areas most susceptible to landsliding may be in the vicinity of faults having Quaternary displacement. This inference is based on preliminary mapping of Puget Sound (Fig. 3), Lake Washington, and Lake Sammamish submarine landslides (Fig. 4) by Karlin and Holmes.

Subaerial landslides

Landslides as large as the 1949 Tacoma Narrows failure are the subaerial slides most likely to cause tsunamis in Puget Sound. The two major geological parameters that control the generation of a water wave from subaerial landslides are the volume of the slide mass, and the motion of the mass as it reaches the water body. Some very large prehistoric landslides have been mapped along Puget Sound bluffs; when reactivated, these deep-seated landslides tend to be very slow moving (inches per day), and would not appear to be capable of generating a tsunami.

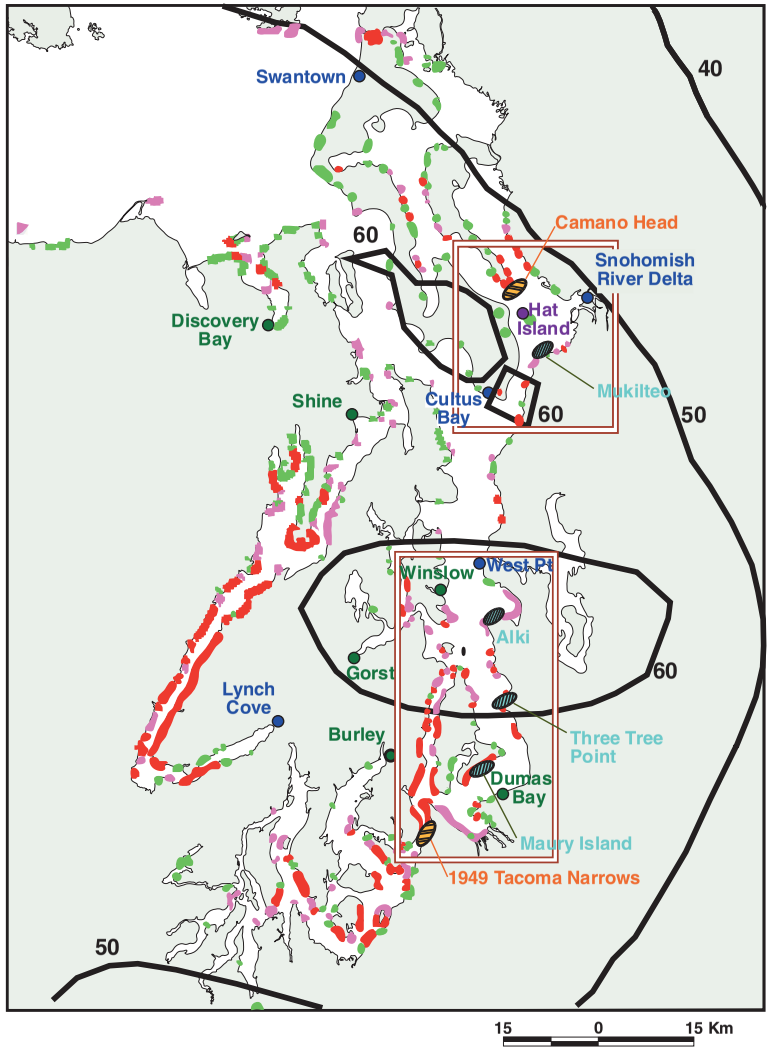
3.3 Scenarios

As further guidance for tsunami modeling, landslides at Puget Sound can be envisioned in several scenarios: landslides with historical precedent in Puget Sound, credible "worst case" landslides based on analogies with other places, and submarine slides not associated with river deltas.

Historical precedent scenarios

The first kind of scenario is based on tsunamigenic Puget Sound landslides such as the 1894 Commencement Bay delta failure and the 1949 Tacoma Narrows subaerial landslide. The geometry of each is well defined from field observations, and summaries of the estimated parameters are provided in Tables 3.1 and 3.2.

Scenario landslides based on local historical precedent offer the great advantage of having dimensions and effects like those known to have occurred



Landslides

- Potential landslide zones of concern identified at workshop
- Large submarine landslides[1]
- Subaerial landslides
- 60 Probabilistic shaking hazard contours[1]
- Steep coastal topography
- Deep coastal water
- Steep topography near deep water

Tsunami Evidence

- Published geologic tsunami deposit
- Candidate geologic tsunami deposit seen in reconnaissance
- Native American Stories

[1] Unpublished data. See text.

[1] Acceleration in percent of gravity. Peak ground acceleration with 2% probability of exceedance in 50 years. Frankel, et al. 1997. Seismic-hazard maps for the conterminous United States, U.S. Geological Survey Open-File Report 97-131.

This map is based on discussions held during the Puget Sound Tsunami Sources workshop held in Seattle, Washington on 10 June 2002, and on subsequent reviews and discussion by workshop participants. Contributing institutions included Kent State University, National Oceanic and Atmospheric Administration (NOAA), University of Nevada, University of Washington, U.S. Geological Survey (USGS), and Washington Division of Geology and Earth Resources. The workshop was organized by NOAA's Center for Tsunami Inundation Mapping Efforts (TIME), the USGS, Washington's Department of Natural Resources (WADNR) and Washington's Emergency Management Division (WAEMD).

Figure 3: Potential landslide zones, including the location of the 1949 Tacoma Narrows slide and unpublished field data (Karlin and Holmes) for large submarine slides. Also presented are contours of peak ground acceleration with 2% probability of exceedance in 50 years (Frankel *et al.*, 1997), locations for which evidence of past tsunamis exists, and a TIME Center analysis of gridded bathymetric and topographic data to identify sites with steep coastal topography adjacent to deep coastal water.

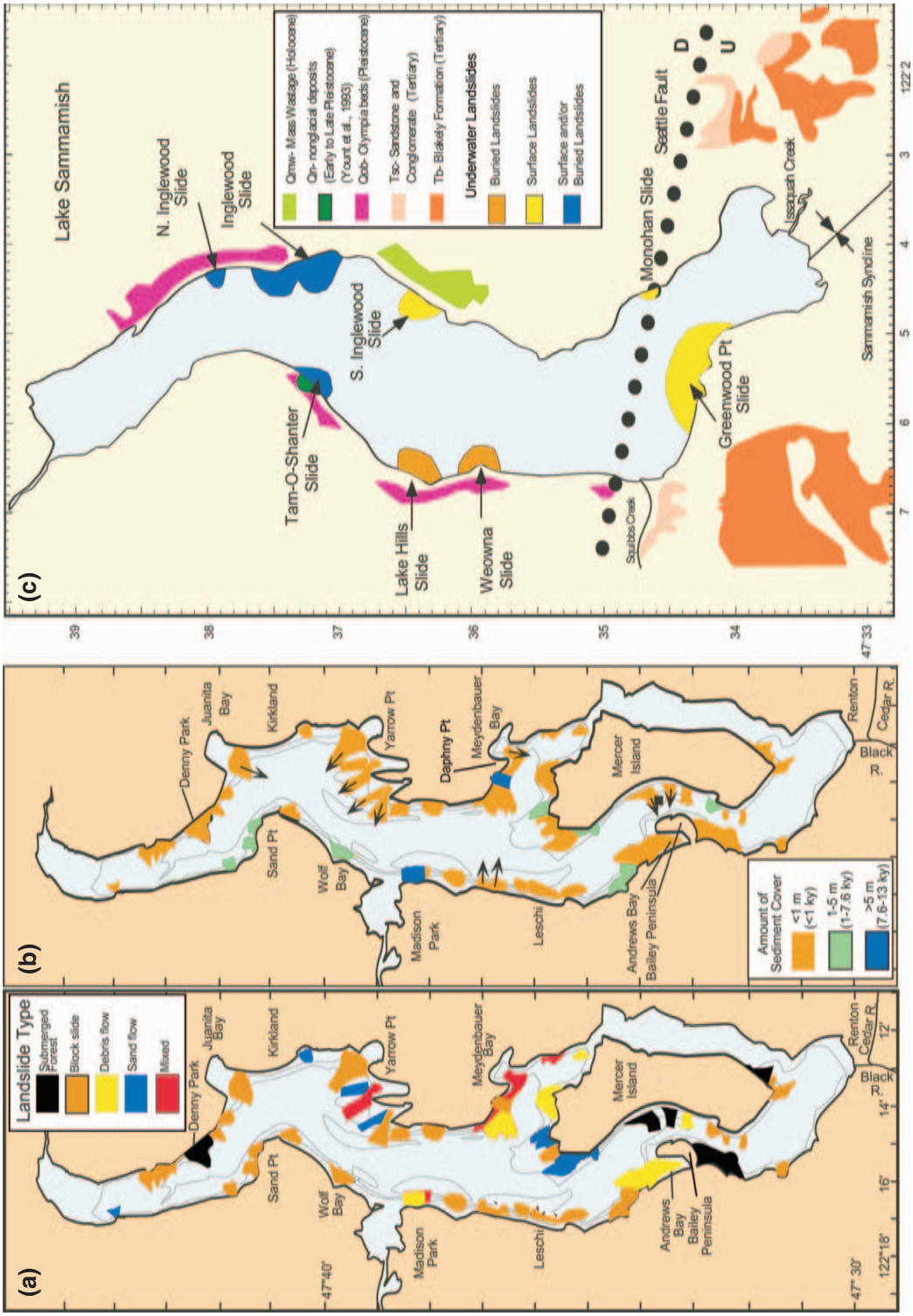


Figure 4: (a) Lake Washington subaqueous landslides mapped from high-resolution single channel seismic reflection profiles and swath sidescan imagery, and classified into submerged forests, coherent block slides, debris flows, sand flows, and mixed slumps. (b) Lake Washington subaqueous landslides classified by age. (c) Lake Sammamish geologic map, showing underwater landslides, onland exposures of pre-Frasier geology, and Holocene mass wasting.

at Puget Sound. Well-defined historic landslides that produced observed water waves provide a means for evaluating tsunami models and for estimating such factors as the velocity of the landslide mass.

Worst-case scenarios

"Worst-case" scenarios for landslides at Puget Sound can be explored by means of analogy with landslides in similar settings elsewhere. For example, as a starting hypothesis, tsunami modelers could assume a landslide about one-third the volume of the 1964 Valdez slide—a giant delta-front failure triggered by the 1964 Alaska earthquake. This particular worst case could be modeled as a delta slope, submarine, or subaerial occurrence. In all cases, however, it probably needs a large earthquake as a trigger. And because the recurrence of large shallow earthquakes on faults at Puget Sound is poorly known at best, defining the likelihood for outsize failures will ultimately depend on better definition of prehistoric earthquake recurrence.

Coulter and Migliaccio (1966) provide the best documentation of the 1964 Valdez submarine landslide. Their Figure 2 shows that Valdez Arm is a long east-west oriented fjord that terminates at the (former) town of Valdez, where it is approximately 3 miles (5 km) in width. A large delta formed by the Lowe and Robe rivers and a large stream flowing from the Valdez Glacier occupies the east end of the fjord, which was the former site of the town of Valdez. They report a total landslide volume estimated at 96 million cubic yards (74 million cubic meters). The delta slopes to a depth of 600 ft at the bottom of the fjord approximately 2 miles west of the tide flat. Based on their Plate 2, the total perimeter of the landslide is approximately 2500 m, and the top to toe distance is about 1200 m; these dimensions require an average thickness of about 25 m. Consequently, one possible geometry of a landslide that is only one third the volume of the Valdez failure would have a width of 1700 m, a thickness of 20 m, and a top to toe length of 800 m.

Could such a landslide fit into the Puyallup or Duwamish River deltas? Both Elliott and Commencement Bays are at the head of fjords that have been significantly filled with sediment during the mid to late Holocene (Dragovich *et al.*, 1994). Large deltas deposited by the Puyallup and Duwamish rivers occupy the head of these flooded fjords, similar in setting to the delta at the head of Valdez Arm. The floor of the fjords in Elliott and Commencement bays are at a depth of approximately 450 ft, somewhat shallower than at Valdez.

Because of the shallower depth of the floors of Elliott and Commencement bays, the top to toe distance of the proposed "worst-case" submarine landslide scenario must be decreased to a distance of 500 m. To accommodate this decrease, the perimeter and thickness of the scenario landslide can be set to 2000 m and 25 m, respectively. These small changes yield a landslide volume of 25 million cubic meters, roughly one third of the volume of the 1964 Valdez failure (Table 3.3).

Commencement Bay is approximately 2.5 miles wide, and similar in width to Valdez Arm. This is more than sufficiently wide to accommo-

date the "worst-case" delta failure scenario. The Puyallup River is largely free flowing with its water and sediment source originating from Mt. Rainier glaciers. Because of anthropogenic changes to the White/Stuck River channels, sediment supply to the Puyallup delta has significantly increased in the last 100 years. The history of delta landslides (1894 and 1943) clearly indicate the potential instability of this location.

Elliott Bay is just a little over 2 km in width, and the "worst-case" scenario delta failure would just fit within the embayment. Because of anthropogenic changes to the White/Stuck River channels and dams on the Green River, sediment supply to the Duwamish delta has significantly decreased in the last 100 years. However, the Duwamish delta is situated directly above the Seattle Fault, and the predicted ground motions from a major earthquake on this fault could easily exceed the ground motion that caused the 1964 delta failure in Valdez. Because of this factor, failure of the entirety of the Duwamish delta front does not seem far-fetched.

The Snohomish delta appears similar to the Puyallup in width, bathymetric configuration, and sediment supply. From that perspective, it would easily accommodate the "worst-case" scenario.

What is the likelihood of occurrence of this worst-case scenario? Because the most likely trigger for the "worst-case" failure of the Duwamish delta is an M 7 earthquake directly beneath it, on the Seattle Fault, this Duwamish scenario is subject to large uncertainties in estimating the recurrence intervals for such earthquakes (Section 2.2). In the event of a large earthquake on the Seattle Fault, the tsunami from tectonic displacement of the floor of the sound may further destabilize the Duwamish delta when troughs in the tsunami reduce the water load on the delta front.

The Puyallup delta has a rich history of small and moderate-sized failures, and this represents only a 110-year historic record. If delta failures behave like other natural phenomena (e.g., floods or earthquakes), then this short history suggests that the recurrence of an 1894 failure on this delta is relatively frequent on a geologic timescale. Prediction of the recurrence of this failure using statistical methods would no doubt yield a recurrence in the hundreds or few thousands of years, with large uncertainty. This situation is similar to attempts to assign a recurrence to the Seattle Fault. Although the historic Puyallup delta failures were non-seismogenic, the "worst-case" event on the Puyallup delta would likely have a seismic trigger; in this case, the appropriate question would be: "What is the recurrence of major earthquakes on nearby fault structures, especially the Tacoma Fault?"

The Nisqually delta has a significantly shallower slope, is inherently more stable than either the Puyallup, Duwamish, or Snohomish deltas, and was not considered a likely candidate for the modeling study without a more detailed evaluation. The M 6.8 Nisqually earthquake on 28 February 2001 did not trigger a Nisqually delta failure. It is not surprising that this slope remained stable in this earthquake as it did in the somewhat larger 1949 Olympia earthquake. Ground shaking in the port area of Tacoma during the Nisqually earthquake was less than 0.1 g peak ground acceleration and of short duration; this seismic loading was at or below the threshold necessary to generate liquefaction in the worst soil conditions. One hallmark of this

earthquake was the paucity of subaerial landslides, likely the result of the severe drought conditions that preceded the event. However, the slopes adjacent to the Salmon Beach landslide triggered by the 1949 Olympia event did fail. If soil moisture conditions were nearer normal, this landslide might have been large enough to reach the Sound and generate a splash wave as was generated in 1949.

The Duwamish delta was shaken more strongly than the Puyallup delta during the Nisqually earthquake, and comparison of pre- and post-earthquake surveying indicated movement of Harbor Island by a number of inches. Whether this was the initiation of a delta failure that might have accelerated if the shaking was significantly stronger and/or longer is speculative. The Snohomish delta was too far distant from the Nisqually earthquake epicenter to experience even moderate shaking.

Non-deltaic submarine slide scenarios

Tables 3.4 and 3.5 provide estimates of the dimensions of selected large landslides in Puget Sound, compiled by Robert Karlin, Mark Holmes, and Shane Smith from high-resolution seismic reflection profiles, sidescan imagery, and bathymetric data. They tend to be located near Quarternary faults that cross Puget Sound, Lake Washington, and Lake Sammamish (Figs. 3 and 4). There are no historical records of these slides, and it is unknown whether they generated tsunamis.

Lake Washington subaqueous slides are presented in Fig. 4a, classified into submerged forests, coherent block slides, debris flows, sand flows, and mixed slumps. Coherent block slides are recognizable in sidescan imagery as displaced blocks with widths more than about 20 m. Block slides show coherent, but often deformed bedding in seismic reflection profiles. Submerged forests are large block slides that have upright or fallen trees on them, with the trees visible on sidescan sonar images. Debris flows show a strong reflective contrast with normal lake sediment, and may contain small boulders interspersed with incoherent sediment flows. Such flows are often found at the toe of block slides, but can occur separately. Sand flows have a bright signature on sidescan records compared with normal sediment. They show little structure, except occasional sand waves. Mixed flows are undifferentiated areas with both debris and incoherent sediment flows. Fig. 4b classifies these slides by age. The seismic reflection profiles show a distinctive sequence of reflectors within the Holocene lake sediments that can be correlated with stratigraphy known from piston coring (Karlin and Abella, 1992; 1996). The Holocene section consists of ∼1 m of transparent soft sediments over a clayey silty seismite deposited throughout the lake about 1100 years ago. The 5–15 cm thick Mazama ash deposited ∼7600 years ago forms a prominent reflector at 3–5 m sub-bottom depth. A strong acoustic contrast of the Holocene lake sediments with a hard blue-gray glacial clay at 7–20 m sub-bottom depths gives a strong, recognizable glacial/ interglacial reflector. Given the sedimentation rates in the lake and the subbottom depths of the 1100-year silt layer at 1 3 m and the 7600-year Mazama ash at 3–5 m, landslides with sediment cover of 1–3 m probably are from 1100 to 7600 years

old. Landslides with >5 m sediment covers probably are of early Holocene age.

Lake Sammamish geology, underwater landslides, onland exposures of pre-Frasier geology, and Holocene mass wasting are presented in Fig. 4b. The underwater landslide distribution was determined from high-resolution seismic reflection profiling and sidescan swath mapping by R. Karlin, M. Holmes, and T. Pratt. The geology is modified from Minard and Booth (1988), Booth and Minard (1992) and Yount *et al.* (1993). Also see Prunier (1998).

3.4 Recommendations

Tsunami modelers should work closely with geoscientists who have past experience evaluating slope stability in the Puget Sound region, because it is particularly important for the credibility of the modeling that the source parameters and location of the tsunamigenic landslide are defensible. Two of the slide parameters listed in Tables 3.1 to 3.4—duration and acceleration—are essential to the modeling, but values will be difficult or impossible to obtain through field observations. Landslide source locations are not spatially random, but rather depend on factors that typically make slopes unstable (steepness of slope, geologic conditions, etc.).

Tsunami source modeling

- Tsunami scenarios should include:
  - Delta slope failures of the Puyallup, Duwamish, and Snohomish Rivers, using scenarios similar to the historical 1894 Commencement Bay event summarized in Table 3.1 and a worst-case scenario of unsure but likely very rare occurrence, based on a scaled-down version of the 1964 Valdez submarine landslide as in Table 3.3.
  - Submarine landslides due to non-delta slope failures proximal to known Quaternary faults, including those identified at Alki Point and Maury Island, using scenarios similar to that summarized in Table 3.4.
  - Subaerial landslides of the size and magnitude of the 1949 Tacoma Narrows event, summarized in Table 3.2.

Science improvement

- Expand the existing program of slope instability mapping to increase the geographical coverage and improve the quality of assessments:
  - Acquire multi-beam bathymetric data and denser high-resolution seismic reflection data, first in the areas of potential concern as shown in Fig. 3, and then for the rest of Puget Sound.
  - Collect bottom sediment cores for geological and geotechnical characterization directed toward submarine slope stability assessment.

- Characterize the geometry, nature, and timing of major submarine and subaerial landslides to determine their frequency of occurrence, method(s) of failure, and tsunami generating potential.

Table 3.1: Historic delta landslide.

Justification: Historic precedent based on the 1894 Commencement Bay landslide
Probability of occurrence: Less than 50% in 50 years (recurrence interval of at least 100 years)
Locations: Puyallup, Duwamish, and Snohomish River deltas

Parameter	Probable Range of Values (MKS Units)	Comments
Geometry	Length: 400 m Width: 300 m Thickness: 20 m Volume: 2.4×10^6 m^3 Slope angle: 15 degrees Aspect: Parallel to delta slope fall line	Geometry of this landslide well defined
Time History	Duration: TBD Distance of slide: TBD Initial acceleration: TBD **or**	Parameters can be estimated by back calculation using the 1894 Commencement Bay slide geometry and reported wave height.
	Density: TBD Sediment type: TBD	Volume, slope, density and sediment type can provide a rough estimate of initial acceleration.

Table 3.2: Subaerial landslide.

Justification: Historical precedent based on the 1949 Tacoma Narrows landslide
Probability of occurrence: Recurrence interval of 50 years or more
Locations: Slope north of Tacoma Narrows Bridge—possibly analogous to other steep bluffs along Puget Sound

Parameter	Probable Range of Values (MKS Units)	Comments
Geometry	Length: 150 m Width: 120 m Thickness: 8 m Volume: 1.5×10^5 m^3 Slope angle: 35 degrees Aspect: Parallel to delta slope fall line	Geometry of 1949 landslide well defined
Time History	Duration: 5–10 seconds Distance of slide: 75 m Impact acceleration: TBD **or**	Slope, volume, density, and sediment type can provide a rough estimate of impact acceleration.
	Density: TBD Sediment type: TBD	

Table 3.3: Worst-case delta failure.

Justification: Based on 1964 Valdez submarine landslide volume, scaled by 1/3.
Probability of occurrence: Unknown if this large a landslide can occur at all throughout the study areas. If so, the probability is dependent on that of large earthquakes on nearby faults.
Locations: Major river deltas, especially those of the Puyallup, Duwamish, and Snohomish Rivers.

Parameter	Probable Range of Values (MKS Units)	Comments
Geometry	Length: 500 m Width: 2000 m Thickness: 25 m Volume: 25×10^6 m^3 Slope angle: Site dependent Aspect: Parallel to delta slope fall line?	Geometry of 1964 landslide well defined, but may not be applicable to Puget Sound
Time History	Duration: TBD Distance of slide: TBD Initial acceleration: TBD **or** Density: TBD Sediment type: TBD	Volume, slope, density, and sediment type can provide a rough estimate of initial acceleration.

Table 3.4: Submarine landslide.

Justification: Slides indicated by unpublished seismic profiling data and mapping (R. Karlin, M. Holmes). Tsunami generation potential undetermined. No historic precedent exists.
Probability of occurrence: Unknown
Locations: Proximal to known Quaternary faults that cross Puget Sound, Lake Washington, and Lake Sammamish (see Figs. 3 and 4 for potential landslide zones).

Parameter	Probable Range of Values (MKS Units)	Comments
Geometry	Length: 0.5 to 3 km Width: 0.5 to 5 km Thickness: 50 to 100 m Volume: 2.4×10^6 m^3 (Maximum value that constrains specification of length, width, and thickness) Slope: Variable Aspect: Parallel to slope fall line?	
Time History	Duration: TBD Distance of slide: TBD Initial acceleration: TBD **or** Density: TBD Sediment type: TBD	Estimate parameters by back calculation, using 1894 Commencement Bay slide geometry and reported wave height. Volume, slope, density, and sediment type can provide a rough estimate of initial acceleration.

Table 3.5: Dimensions of selected large landslides in Puget Sound. Table compiled by Robert Karlin and Shane Smith from high-resolution seismic reflection profiles, sidescan imagery, and bathymetric data. Volumes were approximated by a wedge of volume (Width × Length × Thickness)/2.

Name	**Width (m)**	**Length (m)**	**Thickness (m)**	**Volume (10^6 m^3)**	**Type**
Maury Island South	590	1830	60	33	Block slide
Maury Island Mid	300	1330	50	10	Block slide
Maury Island North	1000	2780	50	70	Block slide
Three Tree Point	1750	3390	TBD	TBD	Three complex slides each with multiple events
Restoration Point	1000	1050	TBD	TBD	Block slide, bathymetric expression
Alki Point	1000	2700	5 to 20 for most recent debris flow	7 to 27	Deformation zone covered by debris flow(s), bathymetric expression
Edmonds	1850	2850	120	316	Large block slide, bathymetric expression
Mukilteo	1400	2750	10–15	20 to 29	Sand flow
Edgewater	1280	2940	5 to >40 for most recent slide	10 to >76	Multiple block slides of varying thickness
Possession Point South	630	1250	60 for most recent slide	23	Multiple block slides and events
Possession Point Middle	500	1230	75	23	Two or more block slides and events
Possession Point North	920	1530	75	53	Multiple block slides and events

4. Paleotsunami Field Evidence

4.1 Background

At Puget Sound, tsunami hazards are being identified and quantified by combining geologic field observations with inundation modeling. Although earthquakes, landslides, and delta failures have the potential to generate tsunamis in Puget Sound and nearby lakes, little is known about the frequency and size of tsunamis from these sources. Geologic field evidence useful in tsunami inundation modeling includes: (1) amount and distribution of coseismic uplift and subsidence, (2) size and location of delta failure and landslide scarps and deposits, (3) distribution, grain size, and internal structure of tsunami deposits, (4) microfossils, which are useful in quantifying subsidence and uplift and in identification of tsunami deposits, and (5) dateable material within deposits that help establish tsunami frequency.

Tsunami deposits are especially valuable because they demonstrate that Puget Sound tsunamis have occurred in the past, as illustrated by deposits of the A.D. 900–930 tsunami identified in Seattle, Cultus Bay, and the Snohomish delta (Atwater and Moore, 1992; Bourgeois and Johnson, 2001; Koshimura *et al.*, 2002). Deposits can be used for education of the general public and by emergency managers as solid evidence of a tsunami hazard. For example, locations of identified tsunami deposits appear on a tsunami inundation map for the southwest coast of Washington (Walsh *et al.*, 2000).

4.2 Priority Areas

To identify a tsunami deposit is to identify a tsunami hazard, but tsunami deposits in the Puget Sound area have not been comprehensively identified. Therefore, the entire Puget Sound area is a priority area for tsunami deposit research, except for the very few spots where deposits have already been identified. High potential areas should be explored in a reconnaissance mode, with high priority given to those areas where modeling reasonable source scenarios suggests large tsunamis. This type of collaboration by modelers and field geologists will improve definition of areas with tsunami risk. The area studied should include the shores of Lake Washington because large, potentially tsunamigenic landslides occurred there 1100 years ago, and because currents from a moderate tsunami in Lake Washington could pose a hazard to floating bridges.

4.3 Inferences About Past Tsunamis

What happened at Puget Sound during past tsunamis can be learned, to some extent, from clues in tsunami deposits. Sedimentation models can be used in conjunction with inundation models to interpret tsunami deposits found in the Puget Sound area and help estimate tsunami parameters, including inundation distance, runup height, flow depth, and flow velocity; bottom friction estimates, extremely important in inundation modeling, can also be improved by using velocity estimates from both inundation and tsunami

sedimentation models (Titov *et al.*, 2001). If deposits can be dated, then estimates can also be made of tsunami frequency.

4.4 Recommendations

Tsunami source modeling

- Incorporate any available paleotsunami parameter estimates into site-specific tsunami model development, as a test of accuracy and as a possible constraint on model input parameters.

Science improvement

- Map tsunami deposits where present at Puget Sound and Lakes Washington and Sammamish.
- Conduct detailed sedimentology, micropaleontology, and age dating studies at selected tsunami deposit sites.
- Continue the combined use of sedimentation and inundation models to help improve estimates of paleotsunami parameters.
- Compile geologic evidence for coseismic uplift and subsidence, landslides, delta failures, and tsunami deposits and develop maps of this evidence to help constrain and test tsunami models.
- Improve quantification of coseismic uplift and subsidence.

5. Seattle-Duwamish Waterfront Inundation

The NOAA Center for Tsunami Inundation Mapping Efforts (TIME) recently modeled tsunami inundation along the Seattle-Duwamish waterfront (Titov *et al.*, 2003). This modeling provides preliminary estimates of the flooding that might result from a rare event—a large earthquake on the Seattle fault. The computed tsunami results entirely from tectonic uplift and subsidence during the earthquake; not included in the model is delta-front failure, such as discussed in Section 3.

5.1 Background

NOAA's TIME Center has been conducting numerical model simulations of Puget Sound tsunamis for the Washington State Emergency Management Division (WAEMD). The first modeling effort was a relatively coarse-grid simulation covering most of Puget Sound for a tsunamigenic earthquake on the Seattle fault (Koshimura *et al.*, 2002). The results of that simulation were one factor considered by the WAEMD in identifying Puget Sound communities at risk and prioritizing these communities for development of fine-resolution inundation maps.

5.2 Priority Areas

The coarse-grid Puget Sound simulation suggested that, based on the extreme scenario modeled, a significant tsunami could strike the Seattle-Elliott Bay area, which is characterized by high population and critical infrastructure, within a few minutes of an earthquake on the nearby Seattle Fault. Subsequently, the WAEMD funded the NOAA TIME Center to develop inundation map products for the somewhat larger Seattle-Duwamish area.

5.3 Event Description

Source specification

TIME modelers used an M 7.3 earthquake on the Seattle Fault Zone as a nearly worst-case tsunami generating mechanism. Because the recurrence intervals for such an earthquake probably span thousands of years, it is believed that a similar event has a very low probability of occurring in our lifetimes. The justification for modeling this low, but finite, probability event as a credible near-worst-case Puget Sound threat is the significant and growing population and infrastructure that is now at risk.

The model uses assumptions about the dip of the fault plane and the width and length of fault rupture that are within the broad range of possibilities consistent with reports cited in Section 2.2. For instance, the Brocher *et al.* (2001) interpretation suggests dips of ∼60° to 80° and fault widths of ∼30 km (values not specifically provided in the text, but shown on a figure), while Calvert and Fisher (2001) suggested dip angles of 40° to 80° (60° ± 20°). The slip distribution was constrained, through trial and error, to match available field estimates of vertical displacement at three sites—Alki Point, Restoration Point, and West Point—which presumably occurred as a result of the earthquake in A.D. 900–930. The fault parameters specified for the simulation are provided in Table 5.1. The comparison of computed displacement with field estimates is provided in Table 5.2, and the resulting vertical deformation is illustrated in Fig. 1a, along with the location and values of the vertical deformation field estimates.

It should be noted that different sets of model parameters can produce similar fits to the observations. Thus, each of these two models, though somewhat different, provide a reasonable fit to the observed deformation. In this case, it made little difference in the inundation model results. It is generally true, however, that professional judgment must be applied to assess the geophysical credibility of each model. Because of this, and because the geometry and earthquake history of the Seattle fault remain controversial among Earth scientists, these model parameters need to be reviewed in a separate, formal workshop, in which experts come together to reach a consensus and provide official recommendations. Such a workshop, dedicated to tsunami source specification, is essential to developing site-specific tsunami generation scenarios and the resulting inundation maps. A workshop dedicated to the systematic assessment of current scientific information by a group of experts is a traditional way of establishing the best available science for a particular topic and judging the adequacy of that science to contribute

Table 5.1: Sub-fault parameters for magnitude 7.3 and 7.6 Seattle Fault earthquake models. The M 7.3 vertical deformation pattern is shown in Fig. 1a.

Sub-fault (west to east)	Depth (km)	Length (km)	Width (km)	Strike (deg)	Dip (deg)	M 7.3 Slip (m)	M 7.6 Slip (m)
1	0.5	15.2	20	87.9	60	1	3
2	0.5	6.3	20	86.6	60	1	3
3	0.5	8.9	20	96.0	60	12	14
4	0.5	3.2	20	128.8	60	11	10
5	0.5	11.5	20	99.3	60	4	4
6	0.5	14.9	20	81.0	60	1	3

Table 5.2: Vertical deformation values for field estimates and the M 7.3 and M 7.6 Seattle Fault models. See Fig. 1a for the geographical location of the sites.

Site	Field (m)	M 7.3 Model (m)	M 7.6 Model (m)
Alki Point	4–6.5	3.9	4.0
Restoration Point	7	7.1	7.0
West Point	-1 ± 0.5	-1.2	-1.0

meaningfully to issues of concern—public safety and hazard mitigation, for example.

Accordingly, recommendations below include yearly workshops, because updating tsunami source specification is an important part of developing and improving inundation maps. As an example of source refinement, the Koshimura *et al.* (2002) model is characterized by a magnitude Mw 7.6 with uniform slip of 2.8 m on each of six sub-faults composed of a shallow fault plane dipping 60° situated directly above a deeper fault plane with dip of 25°. A different seismic source model emerges if an earthquake in the range Mw 7.3–7.6 has sources composed of six sub-faults, each with independently assigned slip along a single plane that dips 60° (Table 5.1). The TIME model may need revision as patterns of coseismic vertical deformation become clearer from studies of fault geometry (ten Brink *et al.*, 2002) and high-resolution topographic maps (`http://duff.geology.washington.edu/data/raster/lidar/surfmap/`).

Model results

The model of Titov and Synolakis (1998), also known as the Method of Splitting Tsunami (MOST) model (Titov and González, 1997) was used by TIME modelers to simulate the generation, propagation, and inundation of tsunamis in the Seattle-Duwamish area. Close communication was maintained during the study with WAEMD and the Washington Department of

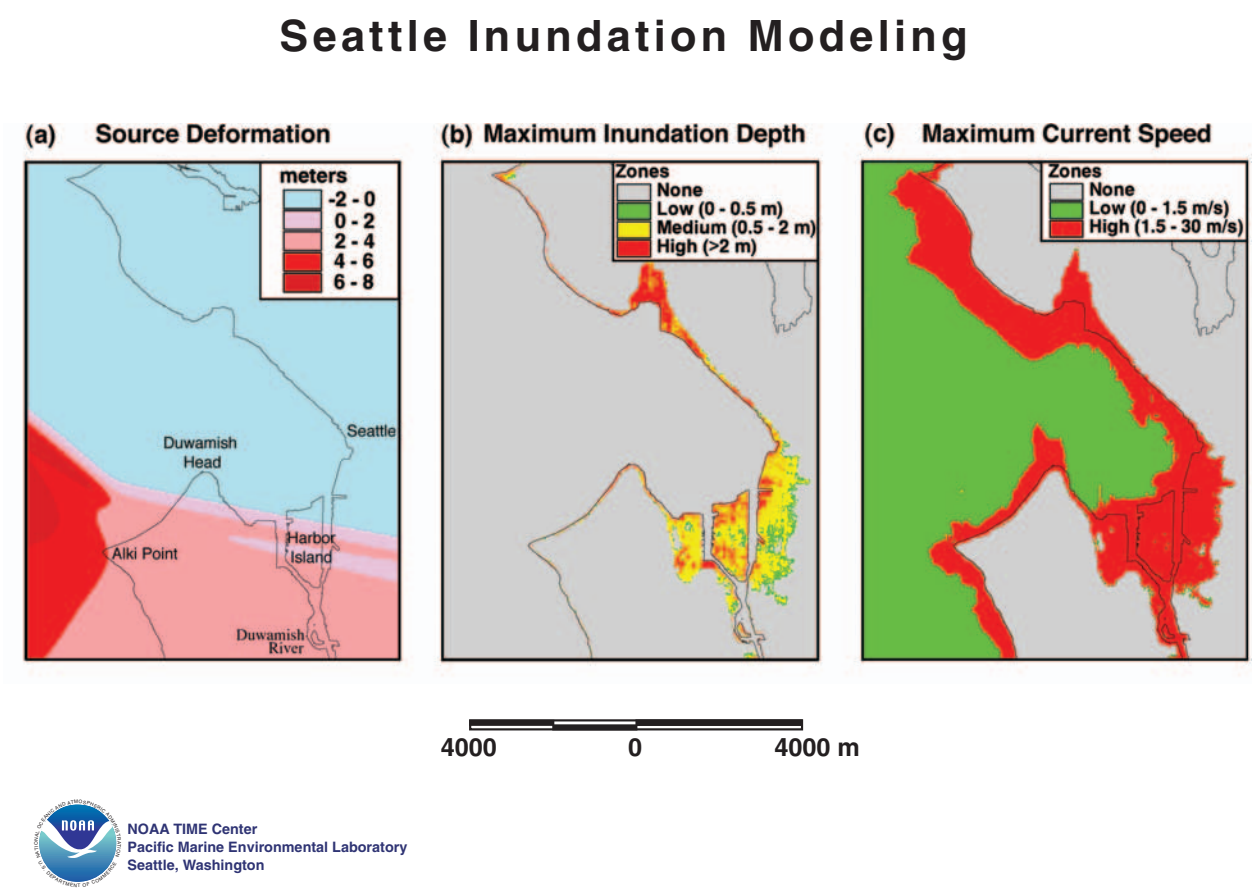


Figure 5: Seattle-Duwamish waterfront inundation modeling products: (a) crustal deformation in the Seattle-Duwamish area; (b) zoned maximum inundation depth; (c) zoned maximum current speed. See text for discussion of selection of ranges for individual zones.

Natural Resources (WADNR) and, upon completion of the study, a suite of model-derived mapping products were delivered to both agencies in the form of electronic files and, where appropriate, hard copy representations. The product suite included an animation of the entire simulation, which is also available for viewing on the Workshop website (*http://www.pmel.noaa.gov/tsunami/time/PS_source_wkshp/*). Three graphical summary products derived from that simulation are presented in Figs. 5a–c.

Figure 5a presents the computed vertical deformation for the Seattle-Duwamish area. The general pattern is one of subsidence as great as 2 m at Duwamish Head, the north end of Harbor Island, and the entire region north of these sites, including the Seattle waterfront, and uplift as great as 4 m south of these sites. The decrease in the modeled uplift eastward from Alki Point may prove inconsistent with uplifted tidal-flat deposits along the Duwamish River (B.F. Atwater, unpublished data).

Figures 5b and 5c present two fundamental modeling products of primary importance to emergency managers—maximum inundation depth (the height of water above land) and maximum current speed, respectively. These products are obtained by monitoring each variable at individual grid points

and saving the maximum value attained over the course of the entire simulation. Zonation is then performed to produce the maps shown—i.e., the fine scale details are deliberately suppressed by binning values into zones with ranges that have physical significance to emergency managers. Thus, for an average adult, the depth range zones correspond roughly to "up to knee-high" (Low), "up to head-high" (Medium) and "over the head" (High), and current speed zones are roughly "up to the speed of a brisk walk" (Low) and "faster than a brisk walk" (High). For the Seattle-Duwamish waterfront areas, the computed water depths are greater than 2 m and the current speeds in excess of 2 m/s.

Model limitations

The model has limited ability to simulate tsunami generation and tsunami effects. The model results express few uncertainties about the fault geometry, the spatial distribution of slip, and the amount of surface rupture that generate the tsunami. Although the tectonic deformation illustrated in Fig. 5a is accounted for in the tsunami inundation computations, additional tsunami sources such as delta failure, submarine and subaerial landslides, and liquefaction, were not. Nor does the simulation account for hydrodynamic effects on the tsunami wave and currents of smaller scale features and objects—buildings, automobiles, maritime vessels, large rocks, trees, and the thousands of shipping containers stored on Harbor Island, for example—that would, in some cases, become entrained debris that would act as projectiles. Also ignored are the effects on structures and humans of the tsunami waves and currents, as well as hazards such as the spreading of flammable liquids.

Source uncertainty and sensitivity studies

There is a fundamental difference in the nature of the seismic hazard maps and the inundation map presented here. The seismic hazard maps are developed as a weighted probabilistic distribution of earthquake events. In contrast, the inundation map is deterministic: it is intended to represent a maximum credible event based on an extreme scenario earthquake that occurs rarely.

In a deterministic approach, multiple simulations can be conducted to develop site-specific sensitivity studies. Such studies constrain the possible range of source parameters—e.g., variations in the magnitude, location, dip, slip, etc., of earthquake sources—and then perform tsunami inundation simulations that correspond to the source variations. The result is a mapping of potential source variation into potential tsunami inundation variation that provides additional insight into the vulnerability of a site. This approach is routinely used in many other scientific and engineering disciplines and is frequently referred to as a response study, in which the input to a system is varied systematically and the output is analyzed and interpreted to characterize the system.

As a very simple example of this approach, an M 7.6 Seattle fault event was also modeled, subject to the constraint that the resulting deformation

pattern must match the three field observations at least as well as the M 7.3 model. Again, trial and error was used to adjust the fault plane parameters. The M 7.6 slip values and the resulting deformation values at the three field sites are listed in Tables 5.1 and 5.2. The M 7.6 model produced a vertical deformation pattern that was somewhat different, but very similar, to the pattern produced by the M 7.3 model. As a consequence, the M 7.6 model produced tsunami inundation values and patterns that were essentially the same as the M 7.3 event.

5.4 Recommendations

In addition to recommendations in previous sections about tsunami sources, the following may improve tsunami inundation models and mitigation products derived from them.

Science improvement

- Complete Puget Sound LIDAR coastal bathymetric/topographic surveys.
- Complete Puget Sound swath-beam bathymetric surveys.
- Use Puget Sound LIDAR and swath-beam surveys to develop a system of improved bathymetric/topographic computational grids.
- Review and assess existing models for sub-aerial and sub-aqueous slides, and determine the sensitivity of tsunami generation to variations in the model parameters.
- Review and assess existing methodologies for simulating tsunami effects on and interactions with structures and humans.
- Develop hardware and software technologies for fast, efficient multiple simulations.
- Develop methods for site-specific, multiple simulation sensitivity studies.
- Develop improved hazard mitigation products based on site-specific sensitivity studies, in close collaboration with WAEMD and WADNR.
- Conduct yearly workshops to review the best available scientific information and develop recommendations for Washington State inundation mapping.

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References

Atwater, B.F. (1999): Radiocarbon dating of a Seattle earthquake to A.D. 900–930 [abstract]. *Seismol. Res. Lett.*, *70*, 232.

Atwater, B.F., and A.L. Moore (1992): A tsunami about 1000 years ago in Puget Sound, Washington. *Science*, *258*, 1614–1617.

Bernard, E.N. (2001): The U.S. National Tsunami Hazard Mitigation Program. In *Proceedings of the International Tsunami Symposium 2001 (ITS 2001)* (on CD-ROM), NTHMP Review Session, R-1, Seattle, WA, 7–10 August 2001, 21–27, URL `http://www.pmel.noaa.gov/its2001/`.

Blakely, R.J., R.E. Wells, C.S. Weaver, and S.Y. Johnson (2002): Location, structure, and seismicity of the Seattle fault zone, Washington: Evidence from aeromagnetic anomalies, geologic mapping, and seismic-reflection data. *Geol. Soc. Am. Bull.*, *114*(1), 169–177.

Booth, D.B., and J.P. Minard (1992): Geologic map of the Issaquah quadrangle, King County, Washington. U.S. Geological Survey Miscellaneous Field Studies Map MF-2206, scale 1:24,000.

Bourgeois, J., and S.Y. Johnson (2001): Geologic evidence of earthquakes at the Snohomish delta, Washington, in the past 1200 yr. *Geol. Soc. Am. Bull.*, *113*, 482–494.

Brocher, T.M., T. Parsons, R.J. Blakely, N.I. Christensen, M.A. Fisher, R.E. Wells, and the SHIPS Working Group (2001): Upper crustal structure in the Puget Lowland, Washington: Results from the 1998 Seismic Hazard Investigation in Puget Sound. *J. Geophys. Res.*, *106*(B7), 13,541–13,564.

Bucknam, R.C., E. Hemphill-Haley, and E.B. Leopold (1992): Abrupt uplift within the past 1700 years at southern Puget Sound, Washington. *Science*, *258*, 1611–1614.

Bucknam, R.C., B.L. Sherrod, and G. Elfendahl (1999): A fault scarp of probable Holocene age in the Seattle Fault Zone, Bainbridge Island, Washington. *Seismol. Res. Lett.*, *70*(2), 233.

Calvert, A.J., and M.A. Fisher (2001): Imaging of the Seattle Fault Zone with high resolution seismic tomography. *Geophys. Res. Lett.*, *28*(12), 2337–2340.

Chleborad, A.F. (1994): Modeling and analysis of the 1949 Narrows landslide, Tacoma, Washington. *Bull. Assoc. Eng. Geol.*, *31*, 305–327.

Coulter, H.W., and R.R. Migliaccio (1966): Effects of the earthquake of March 27, 1964 at Valdez, Alaska. U.S. Geological Survey Professional Paper 542-C, 36 pp., 3 plates.

Crawford, G., H. Mofjeld, and C. Weaver (eds.) (2001): Summary of Puget Sound Tsunami/Landslide Workshop, January 23 and 24, 2001. URL `http://www.pmel.noaa.gov/tsunami/Ws20010123/`.

Dragovich, J.D., P.T. Pringle, and T.J. Walsh (1994): Extent and geometry of the mid-Holocene Osceola Mudflow in the Puget Lowland—Implications for Holocene sedimentation and paleogeography. *Wash. Geol.*, *22*(3), 3–26.

Frankel, A., C. Mueller, T. Barnhard, D. Perkins, E.V. Leyendecker, N. Dickman, S. Hanson, and M. Hopper (1996): National Seismic Hazard Maps: Documentation June 1996. U.S. Geological Survey Open-File Report 96-532.

Frankel, A., C. Mueller, T. Barnhard, D. Perkins, E.V. Leyendecker, N. Dickman, S. Hanson, and M. Hopper (1997): Seismic-hazard maps for the conterminous United States. U.S. Geological Survey Open-File Report 97-131.

Frankel, A.D., M.D. Petersen, C.S. Mueller, K.M. Haller, R.L. Wheeler, E.V. Leyendecker, R.L. Wesson, S.C. Harmsen, C.H. Cramer, D.M. Perkins, and K.S. Rukstales (2002): Documentation for the 2002 update of the national seismic hazard maps. U.S. Geological Survey Open-File Report 02-420, 33 pp., URL `http://geohazards.cr.usgs.gov/eq/of02-420/OFR02-420.pdf`.

Gardner, J.V., E.J. van den Ameele, G. Gelfenbaum, W. Barnhardt, H. Lee, and S. Palmer (2001): Mapping southern Puget Sound delta fronts after the 2001 Nisqually earthquake. URL `http://geopubs.wr.usgs.gov/open-file/of01-266/html/article.htm`.

González, F.I., V.V. Titov, H.O. Mofjeld, A.J. Venturato, and J.C. Newman (2001): The NTHMP Inundation Mapping Program. In *Proceedings of the International Tsunami Symposium 2001 (ITS 2001)* (on CD-ROM), NTHMP Review Session, R-2, 29–54, URL `http://www.pmel.noaa.gov/its2001/`.

Hasagawa, H.S., and H. Kanamori (1987): Source mechanism of the magnitude 7.2 Grand Banks earthquake of November 1929: Double couple or submarine landslide. *Bull. Seismol. Soc. Am.*, *77*(6), 1984–2004.

Heezen, B.C., and C.L. Drake (1964): Grand Banks slump. *Bull. Am. Assoc. Petrol. Geol.*, *48*(2), 221–233.

Heezen, B.C., and M. Ewing (1952): Turbidity currents and submarine slumps, and the 1929 Grand Banks earthquake. *Am. J. Sci.*, *250*, 849–873.

Ishiyama, T., K.J. Mueller, M. Togo, K. Takemura, and A. Okada (2002): Geomorphology and kinematics of the Nobi-Ise active fault zone, central Japan: Implications for the kinematic growth of tectonic landforms within an active thrust belt [abstract]. American Geophysical Union 2002 Fall Meeting, abstract S11B-1140, URL `http://www.agu.org/meetings/fm02/waisfm02.html`.

Johnson, S.Y. (1996): The southern Whidbey Island fault: An active structure in the Puget Lowland, Washington. *Geol. Soc. Am. Bull.*, *108*(3), 334–354.

Johnson, S.Y. (2001): Active tectonics of the Devils Mountain fault and related structures, northern Puget Lowland and eastern strait of Juan de Fuca region, Pacific Northwest. U.S. Geological Survey Professional Paper 1643, 45 pp.

Johnson, S.Y., S.V. Dadisman, J.R. Childs, and W.D. Stanley (1999): Active tectonics of the Seattle fault and central Puget Sound, Washington: Implications for earthquake hazards. *Geol. Soc. Am. Bull.*, *111*(7), 1042–1053.

Karlin, R.E., and S.E.B. Abella (1992): Paleoearthquakes in the Puget Sound region recorded in sediments from Lake Washington, U.S.A. *Science*, *258*(5088), 1617–1620.

Karlin, R.E., and S.E.B. Abella (1996): A history of Pacific Northwest earthquakes recorded in Holocene sediments from Lake Washington. *J. Geophys. Res.*, *101*(B3), 6137–6150.

Karlin, R.E., M. Holmes, S.E.B. Abella, and R. Sylwester (2002): Holocene landslides and a 3500 year sediment record of Pacific Northwest earthquakes from Lake Washington, Pacific Northwest. *Geol. Soc. Am. Bull.*, in press.

Kayen, R.L., W.A. Barnhardt, and S.P. Palmer (1999): Geomorphological and geotechnical issues affecting the seismic slope stability of the Duwamish River delta, Port of Seattle, Washington. In *Optimizing Post-Earthquake Lifeline System Reliability, Proceedings of the 5th U.S. Conference on Lifeline Earthquake Engineering*, W.M. Elliott, and P. McDonough (eds.), American Society of Civil Engineers, Technical Council on Lifeline Earthquake Engineering Monograph No. 16, 482–492.

Kelsey, H.M., and B.L. Sherrod (2001): Test for Late Holocene displacement on the Southern Whidbey Island Fault Zone, northern Puget Lowland, Washington. *Seismol. Res. Lett.*, *72*(2), 253.

Koshimura, S., H.O. Mofjeld, F.I. González, and A.L. Moore (2002): Modeling the 1100 bp paleotsunami in Puget Sound, Washington. *Geophys. Res. Lett.*, *29*(20), 1948, doi: 10.1029/2002GL015170.

Lander, J.F. (1988): An analysis of tsunami fatalities in the United States. In *Proceeding of the Natural and Man-Made Hazards in Coastal Areas Conference*, Ensenada, Mexico.

Minard, J.P., and D.B. Booth (1988): Geologic map of the Redmond quadrangle,

King and Snohomish Counties, Washington. U.S. Geological Survey Miscellaneous Field Investigations Map MF-2016, scale 1:24,000.

Moore, D.G. (1978): Submarine slides. In *Developments in Geotechnical Engineering,* 14A, Rockslides and Avalanches, 1, B. Voight (ed.), Elsevier Scientific Publishing Company, 564–604.

Nelson, A.R., S.Y. Johnson, R.E. Wells, S.K. Pezzopane, H.M. Kelsey, B.L. Sherrod, L.-A. Bradley, R.D. Koehler, III, R.C. Bucknam, R. Haugerud, and W.T. Laprade (2002): Field and laboratory data from an earthquake history study of the Toe Jam Hill fault, Bainbridge Island, Washington. U.S. Geological Survey Open-File Report 02-0060, URL `http://greenwood.cr.usgs.gov/pub/open-file-reports/ofr-02-0060/`.

Nelson, A.R., S.K. Pezzopane, R.C. Bucknam, R.D. Koehler, C.F. Narwold, H.M. Kelsey, W.T. Laprade, R.E. Wells, and S.Y. Johnson (1999): Holocene surface faulting in the Seattle Fault Zone, Bainbridge Island, Washington [abstract]. *Seismol. Res. Lett.*, *70*(2), 233.

Noson, L.L., A. Qamar, and G.W. Thorsen (1988): Washington State earthquake hazards. Washington Division of Geology and Earth Resources Information Circular 85, 77 pp.

Piper, D.J.W., P. Cochonat, and M.L. Morrison (1999): The sequence of events around the epicentre of the 1929 Grand Banks earthquake: Initiation of debris flows and turbidity current inferred from sidescan sonar. *Sedimentology*, *46*(1), 79–97.

Pratt, T.L., S. Johnson, C. Potter, W. Stephenson, and C. Finn (1997): Seismic reflection images beneath Puget Sound, western Washington State: The Puget lowland thrust sheet hypothesis. *J. Geophys. Res.*, *102*, 27,469–27,489.

Prunier, C.F. (1998): Holocene faulting and landsliding in Lake Sammamish related to the Seattle fault. M.S. thesis, University of Nevada, Reno, NV.

Sherrod, B.L. (2001): Evidence for earthquake-induced subsidence about 1100 yr ago in coastal marshes of southern Puget Sound, Washington. *Geol. Soc. Am. Bull.*, *113*(10), 1299–1311.

Sherrod, B.L. (2002): Late Quaternary surface rupture along the Seattle fault zone near Bellevue, Washington [abstract]. American Geophysical Union 2002 Fall Meeting, abstract S21C-12.

Sherrod, B.L., T. Brocher, and R.C. Bucknam (2002): Asynchronous land-level change along the Tacoma Fault in A.D. 800–1200 [abstract]. *Seismol. Res. Lett.*, *73*(2), 240.

Shipman, H. (2001): The fall of Camano Head: A Snohomish account of a large landslide and tsunami in Possession Sound during the early 1800s. *TsuInfo Alert*, *3*(6), 13–14, URL `http://www.wa.gov/dnr/htdocs/ger/tsuinfo/2001-06.pdf`.

Spaeth, M.G., and S.C. Berkman (1972): The tsunamis as recorded at tide stations and the seismic sea wave warning system. In *The Great Alaska Earthquake of 1964: Oceanography and Coastal Engineering*, Committee on the Alaska Earthquake, National Academy of Sciences, 38–110.

ten Brink, U.S., P.C. Molzer, M.A. Fisher, R.J. Blakely, R.C. Bucknam, T. Parsons, R.S. Crosson, and K.C. Creager (2002): Subsurface geometry and evolution of the Seattle Fault Zone and the Seattle Basin, Washington. *Bull. Seismol. Soc. Am.*, *92*, 1737–1753.

Titov, V.V., and F.I. González (1997): Implementation and testing of the Method of Splitting Tsunami (MOST) model. NOAA Tech. Memo. ERL PMEL-112 (PB98-122773), NOAA, Pacific Marine Environmental Laboratory, 11 pp.

Titov, V.V., and F.I. González (2001): Numerical study of the source of the July 17, 1998 PNG tsunami. In *Tsunami Research at the End of a Critical Decade*, G.T. Hebenstreit (ed.), Kluwer Acad. Pub., Netherlands, 197–207.

Titov, V.V., F.I. González, H.O. Mofjeld, and A.J. Venturato (2003): NOAA TIME Seattle Tsunami Mapping Project: Procedures, data sources, and products. NOAA Tech. Memo. OAR PMEL-124, NOAA, Pacific Marine Environmental Laboratory, 20 pp., in press.

Titov, V.V., B. Jaffe, F.I. González, and G. Gelfenbaum (2001): Re-evaluating source mechanisms for the 1998 Papua New Guinea tsunami using revised slump estimates and sedimentation modeling. In *Proceedings of the International Tsunami Symposium 2001 (ITS 2001)* (on CD-ROM), NOAA/PMEL, Seattle, WA, 7–10 August 2001, 2–5.

Titov, V.V., and C.E. Synolakis (1998): Numerical modeling of tidal wave runup. *J. Waterw. Port Coast. Ocean Eng.*, *124*(4), 157–171.

University of Washington, Department of Oceanography (1953): Puget Sound and Approaches, A Literature Survey. Work performed under Contract No. Nonr-447(00), Task Order 477(06) of the Office of Naval Research, Volume II.

Wagner, H.C., and J.H. Tomson (1987): Offshore geology of the Strait of Juan de Fuca, State of Washington and British Columbia, Canada. Washington Division of Geology and Earth Resources Open File Report 87-1, 16 pp., 7 plates.

Walsh, T.J., C.G. Caruthers, A.C. Heinitz, E.P. Myers, III, A.M. Baptista, G.B. Erdakos, and R.A. Kamphaus (2000): Tsunami hazard map of the southern Washington coast—Modeled tsunami inundation from a Cascadia Subduction Zone earthquake. Washington Division of Geology and Earth Resources Report GM-49, 12 pp., 1 pl. scale 1:100,000.

Washington State Legislature (1995): Growth Management Act—Procedural Criteria for Adopting Comprehensive Plans and Development Regulations. Washington Administrative Code WAC 365-195-900 through 925, URL `http://www.leg.wa.gov/wac/`.

Washington State Office of Community Development (2002): Citations of Recommended Sources of Best Available Science for Designating and Protecting Critical Areas. URL `http://www.ocd.wa.gov/info/lgd/growth/`.

Williams, H., and I. Hutchinson (2000): Stratigraphic and microfossil evidence for late Holocene tsunamis at Swantown Marsh, Whidbey Island, Washington. *Quatern. Res.*, *54*, 218–237.

Williams, H., I. Hutchinson, and A. Nelson (2002): Multiple sources for late Holocene tsunamis at Discovery Bay, Washington State. American Geophysical Union, 2002 fall meeting, abstract S22B-1032.

Wilson, B.W., and A. Torum (1972): Effects of the tsunamis: An engineering study. In *The Great Alaska Earthquake of 1964: Oceanography and Coastal Engineering*, Committee on the Alaska Earthquake, National Academy of Sciences, 361–523.

Yount, J.C., J. Minard, and G. Dembroff (1993): Geologic map of surficial deposits in the Seattle $30' \times 60'$ quadrangle. U.S. Geological Survey Open File Report 93-233, 2 sheets.

Addendum: Seismic Surface Wave Forcing of Water Waves and Seiches (by H. O. Mofjeld)

Well after the workshop, the Mw 7.9 Alaska earthquake on 3 November 2002 generated strong seismic surface waves southward that created damaging water waves in Lake Union (Barberopoulou *et al.*, 2002) and Puget Sound marinas (A. Qamar and W. Steele, private communication). There is also evidence that the Seattle sedimentary basin acted to amplify the seismic surface waves in its vicinity (Barberopoulou *et al.*, 2002). Vertical seismic wave amplitudes as large as 0.3 m were recorded in the Seattle area.

Strong seismic waves will occur in the Puget Sound region as the result of earthquakes on local, Cascadia, and even distant fault zones. Therefore, it is appropriate to include seismic surface waves as potential geophysical sources of dangerous water waves in Puget Sound.

To fully characterize the seismic surface waves as sources, a database is needed that contains the probabilities of their amplitudes, frequencies, and orientations as functions of geographical location. Of particular importance are the horizontal velocities of the ground, since these are the primary mechanism generating the water waves at the shore (Mofjeld, in preparation). These are needed for the fault zones in the Puget Sound region, the Cascadia Subduction Zone, and more distant regions such as Alaska. The orientation is important because the amplitudes of the water waves can be very sensitive to this parameter.

Also needed are observed and synthetic time series of the seismic surface waves to drive water response models. The wave periods of greatest interest are between one to 60 seconds, in terms of generating dangerous waves and seiches within small bodies of water.

The USGS shake map for the Puget Lowland is an essential step forward in developing this database. At present, it provides peak accelerations due primarily to earthquakes on the Seattle Fault, South Whidbey Island Fault, and the Cascadia Subduction Zone. These accelerations need to be integrated in time in order to give peak horizontal velocities. Deep focus earthquakes under the Puget Lowland occur on irregular decadal to multidecadal timescales, as observed in the 20th century. While they are less prone to generate strong seismic surface waves than shallow earthquakes, they cannot be discounted as potential sources.

References

Barberopoulou, A., K. Creager, A. Qamar, G. Thomas, and W. Steele (2002): Local amplification of seismic waves from the Mw 7.9 Alaska earthquake and a damaging seiche in Lake Union, Seattle, Washington. Fall AGU Meeting, Abstracts.

Mofjeld, H.O., F.I. González, V.V. Titov, and J.C. Newman: The generation of seismic seiches and their dependence on seismic wave dispersion and imperfect boundary reflection. In preparation.

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May 2, 2006

Reply to
Attn Of: ETPA-083

Ref: 06-016-COE

Ms. Aimee Kinney
Dept of Army Corps of Engineers
Seattle District, Environmental Resources Section
P.O. Box 3755, Seattle WA 98124-3755

Dear Ms. Kinney:

The U.S. Environmental Protection Agency (EPA) has reviewed the Notice of Intent for the proposed seawall rehabilitation project along the Elliott Bay shoreline in Seattle, Washington (Alaskan Way Seawall) in accordance with our responsibilities under the National Environmental Policy Act (NEPA) and Section 309 of the Clean Air Act. Thank you for the opportunity to provide comments at this stage of the environmental impact statement (EIS) development process.

Section 309, independent of NEPA, specifically directs the U.S. Environmental Protection Agency (EPA) to review and comment in writing on the environmental impacts associated with all major federal actions. Under our policies and procedures, we evaluate the document's adequacy in meeting NEPA requirements. We have enclosed a copy of *EPA's Section 309 Review: The Clean Air Act and NEPA*, which provides further elaboration of our EIS review responsibilities.

The scoping comments that follow are provided to inform the Corps of Engineers (Corps) of issues that EPA believes to be significant and warrant explicit treatment during the NEPA process. In providing these comments, it is our goal to have these issues addressed in the draft EIS.

We appreciate the opportunity to participate early in the planning process for this project and are available to discuss issues or answer questions that arise while you develop the draft EIS. Should you have any questions regarding our comments please contact Patricia Betts at (360) 407-6925 or by electronic mail at betts.patty@epa.gov.

Sincerely,

Christine B. Reichgott

Christine B. Reichgott, Manager
NEPA Review Unit

Attachment

U.S. Environmental Protection Agency
Scoping Comments for
Alaskan Way Seawall

Areas of Focus for the Alaskan Way Seawall EIS

The NOI states that the Corps will seek opportunities to "incorporate measures for improvement of habitat values, as well as recreation and public access". These functions and values are important resources for the City's shoreline. EPA strongly supports a hard look at opportunities to improve these three areas.

The NOI states that the Corps will conduct an in-depth analysis in the draft EIS of "construction impacts, particularly those related to noise, water quality, transportation, and effects to businesses and residences within/adjacent to the construction zone." EPA agrees these are issues of concern for this project. We suggest the following also be given priority:

- If applicable for any of the alternatives, examine potential impacts to aquatic species (including shore birds) from loss of habitat due to fill in marine waters or vibration generating construction activities such as pile driving.
- Conduct impact analysis for any construction that could be staged from the water side of the seawall or materials delivered by boat/barge to the construction area.
- Consider the potential impacts to the built and natural environment from the yearly construction schedule (for activities scheduled for seasons within a year) and the overall schedule (number of years) as part of the construction impacts.
- Analyze and implement effective mitigation for construction related air quality impacts

Coordination with the Alaska Way Viaduct Seawall Replacement Project (AWVSRP) NEPA Efforts

The Corps has committed to coordinate and incorporate all relevant material from the AWVSRP NEPA efforts, share information, and reduce duplication of efforts. EPA recognizes the importance of this coordination, particularly in this situation, and supports the Corps' commitment to coordinate.

Purpose and Need

The NOI does not specifically identify the Purpose and Need for this project although it does state the focus of this DEIS analysis will be on evaluating the storm damage reduction perspective for the seawall. We hope that, at a minimum, the Purpose and Need of this proposal is consistent with the overall AWVSRP Purpose and Need, and especially the Seawall portion of the AWVSRP Purpose and Need. If it is not consistent, or if alternatives examined in one EIS would be precluded by the other, it will be important to disclose this and work to resolve the conflict with AWVSRP before a final EIS is released for either project.

The EIS should include a clear and concise statement of the underlying purpose and need for the proposed project, consistent with the implementing regulations for NEPA (see 40 CFR 1502.13). In presenting the purpose and need for the project, the EIS should reflect not only the Corp's purpose, but also the broader public interest and need. Given the size of this project, a concise statement is of critical importance to setting up the analysis of alternatives, which could range from too tightly focused to too broad, depending on how the statement is written. The purpose and need statement and the alternatives analysis should discuss how project activities may adversely affect ecosystem recovery.

Public Participation and Environmental Justice

The EIS should disclose what efforts were taken to ensure effective public participation. In addition, if low income or people of color communities will be impacted by the proposed project, the EIS should disclosed what efforts were taken to meet environmental justice requirements consistent with Executive Order (EO) 12898 (*Federal Actions to Address Environmental Justice in Minority and Low-Income Populations)*. This should include the following.

> A description of the methodology and criteria utilized for identifying low income and people of color communities, the sources of data utilized for these analyses, and the references utilized for establishing the criteria.
>
> A comprehensive accounting of all impacts on low income and people of color, including (but not limited to) cumulative and indirect impacts, exposure pathways unique to the impacted communities, historic exposures, and impacts to cultural, historic and protected resources. In addition, the EIS needs to determine if the impacts to low income and people of color communities will be disproportionately higher than those on non-low income and non-people of color communities. For such a determination, the EIS must identify a reference community, provide a justification for utilizing this reference community, and include a discussion of the methodology for selecting the reference community.

The EIS must demonstrate that communities bearing disproportionately high and adverse effects have had meaningful input into the decisions being made about the project. The EIS needs to describe what was done to inform the communities about the project and the potential impacts in will have on their communities (notices, mailings, fact sheets, briefings, presentations, exhibits, tours, news releases, translations, newsletters, reports, community interviews, surveys, canvassing, telephone hotlines, question and answer sessions, stakeholder meetings, and on scene information), what input was received from the communities, and how that input was utilized in the decisions that were made regarding the project.

Consultation with Native American Tribes

The proposed project may affect historical or traditional cultural places of importance to the area's Native American communities. The EIS needs to identify historic resources, and assure that treaty rights and privileges are addressed appropriately. If the proposed project will have impacts on Native Americans, the development of the EIS should be conducted in consultation with all affected tribal governments, consistent with Executive Order (EO) 13175 (*Consultation and Coordination with Indian Tribal Governments)*. EO 13175 states that the U.S. government will continue to work with Indian tribes on a government-to-government basis to address issues concerning Indian tribal self-government, trust resources, and Indian tribal treaty and other rights. Documentation of these consultations should be included in the EIS. Consistent with the July 28, 1999 memorandum from the Council on Environmental Quality (CEQ) to Heads of Federal Agencies, we strongly urge the Corps to consider inviting affected Tribal governments to participate in the EIS development process as cooperating agencies. This would provide for the establishment of a mechanism for addressing intergovernmental issues throughout the EIS development process.

General Scoping Comments

Given the nature of the project, it is likely that the Corps' Alaskan Way Seawall EIS will incorporate a substantial amount of information and analysis from the AWVSRP NEPA effort. In that light, the following comments should be considered as appropriate when reviewing information from the AWVSRP NEPA effort and when developing new information for the Alaskan Way Seawall EIS.

Range of Effects/Impacts

NEPA calls for analysis of effects and impacts in a broad sense, addressing important issues that arise during scoping. Impacts from a project may be both beneficial and adverse. A significant effect may exist even if the Federal agency believes that on balance the effect will be beneficial. There can be situations when adverse impacts occur even though regulations are met. For example, several air toxics are not regulated but are known to create a health risk. Therefore, it is important to consider impacts that may not be managed through existing regulations. The environmental analysis needs to evaluate and disclose the impacts from all emissions regardless of whether there is a regulation that manages those emissions. "Potential violation of Federal, State, or local law or requirements imposed for the protection of the environment" is but one of ten factors that should be considered in evaluating severity of impact (40 CFR 1508.27(b)).

Water Quality

The Alaskan Way Seawall may include activities that have potential to degrade water quality. Section 303(d) of the Clean Water Act (CWA) requires the State of Washington to identify those waterbodies which are not meeting or not likely to meet State water quality standards. The EIS must disclose which waterbodies may be impacted by the project, the nature of the potential impacts, and the specific pollutants likely to impact those waters. It should also report those water bodies potentially affected by the project that are listed on the State's current 303(d) list and whether Washington Department of Ecology has developed a water quality restoration plan (Total Maximum Daily Load) for the waterbodies and the pollutants of concern. If a Total Maximum Daily Load (TMDL) has not been established for those water bodies on the 303(d) list, then in the interim until one is established, the EIS must demonstrate that there will be no net degradation of water quality to these listed waters.

Antidegradation provisions of the CWA apply to water bodies where water quality standards are currently being met. This provision prohibits degrading water quality unless an analysis shows that important economic and social development necessitates degrading water quality. The EIS should explain how the antidegradation provisions would be met for the proposed project.

Aquatic Resources

Project construction and maintenance will likely affect aquatic resources: water quality (discussed above), open water habitats, nearshore subtidal and intertidal habitats, and shorelines. These resources will experience varying degrees of impacts and alteration of their hydrologic functions, and project encroachment may degrade habitat for fish and other aquatic biota. For any impacts that cannot be avoided through siting and design, the EIS document should describe the types, location, and estimated effectiveness of best management practices applied to minimize and mitigate impacts to aquatic resources.

The EIS document should describe aquatic habitats in the affected environment (e.g., habitat type, plant and animal species, functional values, and integrity) and the environmental consequences of the proposed alternatives on these resources. Impacts to aquatic resources should be evaluated in terms of the acreage to be impacted and by the functions they perform.

It is possible the proposed activities will require a Clean Water Act Section 404 permit from the Army Corps of Engineers. EPA recognizes the Corps is the lead authority regarding the 404 (b) 1) alternatives analysis. With that in mind, EPA would like to reiterate our interests for the alternatives analysis. EPA would like the EIS to discuss in detail how planning efforts (and alternative selection) conform with Section 404(b) (1) guidelines sequencing and criteria and have avoided impacts to wetlands and other special aquatic sites to the maximum extent practicable. The EIS should discuss alternatives that would avoid wetlands and aquatic resource impacts from fill placement, water impoundment, construction, and other activities before proceeding to minimization/mitigation measures.

Air Quality

There is heightened concern for human health from projects that result in air toxics emissions and particulate matter from mobile sources, particularly diesel exhaust. The National Air Toxics Assessment, http://www.epa.gov/ttn/atw/nata, asserts that a large number of human epidemiology studies show increased lung cancer associated with diesel exhaust and significant potential for non-cancer health effects. Also the Control of Emissions of Hazardous Air Pollutants from Mobile Sources Final Rule (66 FR 17230, March 29, 2001) lists 21 compounds emitted from motor vehicles that are known or suspect to cause cancer or other serious health effects.

EPA strongly recommends that the EIS disclose whether vehicular air toxics emissions would result from project construction, discuss the cancer and non-cancer health effects associated with air toxics and diesel particulate matter, and identify sensitive receptor populations and individuals that are likely to be exposed to these emissions. The EIS should then identify and commit to appropriate mitigation for the identified impacts.

Endangered Species Act

Activities at the proposed location for the Alaskan Way Seawall Project may impact endangered, threatened or candidate species listed under the Endangered Species Act (ESA) and their habitats, as well as state sensitive species. The EIS needs to discuss the direct, indirect and cumulative impacts on all threatened and endangered species and their habitat. Of particular concern are water quality standard requirements for ESA listed salmonids that may be impacted by the proposed project such as temperature, dissolved oxygen, and sediments. In addition, the EIS should describe the critical habitat for all ESA listed species, identify any impacts the proposed project will have on these species' critical habitat, and how it will meet all requirements under ESA.

Habitat

The proposed project may have impacts on marine life. The EIS should describe the current quality and potential capacity of habitat, its use by fish and wildlife on and near the proposed project area, and identify known fish corridors, migration routes, and areas of seasonal fish and wildlife (bird, marine mammal) congregation. The EIS should evaluate effects on fish and wildlife from habitat removal and alteration, aquatic habitat fragmentation caused by infrastructure, land use, and management activities, and human activity. The EIS should also evaluate the impacts the project may have on aquatic plant species and their habitats.

The level of detail should adequately describe the:

- existing condition of the marine habitat
- degree of adverse impact from the project, and
- desired and possible marine/nearshore habitat functions and values in the project area

Focusing on habitat improvement will be very important for this already heavily impacted area.

Cumulative Impacts

EPA has issued guidance on how we are to provide comments on the assessment of cumulative impacts, *Consideration of Cumulative Impacts in EPA Review of NEPA Documents*, which can be found on EPA's Office of Federal Activities home page at: http://www.epa.gov/compliance/resources/nepa.html. The guidance states that in order to assess the adequacy of the cumulative impacts assessment, five key areas should be considered. EPA will be using the five key areas as a basis for review of the cumulative effects analysis:

1. Identifies resources if any, that are being cumulatively impacted;
2. Determines the appropriate geographic (within natural ecological boundaries) area and the time period over which the effects have occurred and will occur;
3. Looks at all past, present, and reasonably foreseeable future actions that have affected, are affecting, or would affect resources of concern;
4. Describes a benchmark or baseline; and
5. Includes scientifically defensible threshold levels.

Monitoring

As discussed above, the proposed project has the potential to impact air and water quality, marine life (e.g. seabirds, marine mammals, and plants), and habitat. Predicting the severity of these impacts and the effectiveness of mitigation measures is an imprecise science. We recommend that the project include a monitoring program designed to assess both impacts from the project and the effectiveness of measures utilized to mitigate such impacts. The EIS should describe such a monitoring program and how it will be used as an effective feedback mechanism for the proposed project.

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Washington State Department of Transportation

Douglas B. MacDonald
Secretary of Transportation

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Michael Anderson
Director and CEO

May 10, 2006

Aimee Kinney
US Army Corps of Engineers
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Alaskan Way Seawall Feasibility Study
Scoping comments

Dear Ms. Kinney,

I apologize for lateness of this letter but do hope that you will consider our comments as you move forward with your project. I would like to thank you for the opportunity to review and comments on the scope of environmental impact statement of the Alaskan Way Seawall Feasibility Study.

Our most important concern is to ensure that our Seattle Ferry Terminal remains operational during the full length of construction of the Alaskan Way Seawall. Colman Dock is Washington's busiest terminal and is used by over nine millions riders per year, or about 31,000 trips per day. Service to this traveling public must be maintained. As a result, the Corps will need to work closely with Washington State Ferries (WSF) to ensure that construction activities do not interfere with the operation of the terminal.

We note the emphasis placed on cumulative effects in your scoping notice. It is likely that construction of the seawall and reconstruction of the terminal will occur during the same time period. It is important to coordinate these major construction activities. By doing so, potential cumulative effects such as traffic, noise and air pollution, and impacts to the aquatic and built environments will be minimized.

WSF is considering a number of design and configuration options for the terminal. To ensure that our opportunities are not precluded by the planning and design for the seawall at or near the terminal, it is incumbent upon the Corps to coordinate its activities closely with WSF.

Washington State Ferries

We look forward to cooperating with you as your project moves forward. Thank you for the opportunity to comment. If you have any further questions regarding the Seattle Ferry Terminal project you can reach Angela Freudenstein, Project Environmental Manger-Colman Dock at 206-382-5230; FreudA@wsdot.wa.gov or Tim King, Project Manager at 206-515-3703; TKing@wsdot.wa.gov.

Sincerely,

Kojo Fordjour
Environmental Manager-WSF

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cc: Project File
Angela Freudenstein/WSDOT
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