APPENDIX B

STATE OF WASHINGTON
DEPARTMENT OF COMMUNITY, TRADE AND ECONOMIC DEVELOPMENT
OFFICE OF ARCHAEOLOGY AND HISTORIC PRESERVATION
111 21st Avenue S.W. • P.O. Box 48343 • Olympia, Washington 98504-8343 • (360) 753-4011

August 17, 1995

Mr. Cyrus M. McNeely, Acting Chief
Environmental Resources Section
U.S. Army Corps of Engineers
Seattle District
Post Office Box 3755
Seattle, Washington 98124-2255

Log: 080495-02-COE-S
Re: Commencement Bay Restoration Plan and Programmatic Environmental Impact Statement

Dear Mr. McNeely:

Thank you for contacting the Washington State Office of Archaeology and Historic Preservation (OAHP) regarding the above referenced project. From your letter, I understand the Corps of Engineers is joining with several federal and state agencies and tribal governments to restore natural resources injured through release of hazardous substances and discharge of oil into the Commencement Bay.

In response, I concur with your recommendation that research and field investigations be conducted after individual restoration plans are identified. Also, I support including a general cultural resource management plan in the Restoration Plan (RP) and Environmental Impact Statement (EIS) which will assure that all cultural resources (including archaeological, historic, and traditional cultural properties) are appropriately identified, evaluated and protected.

Again, thank you for the opportunity to comment. On behalf of OAHP, I look forward to working with you toward protection of cultural resources within the Commencement Bay watershed. Should you have any questions, please feel free to contact me at (360) 753-9116.

Sincerely,

Greg Griffith

Gregory A. Griffith
Comprehensive Planning Specialist

GAG:tjt

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
ENVIRONMENTAL & TECHNICAL SERVICES DIVISION
525 NE Oregon Street
PORTLAND, OREGON 97232-2737
503/230-5400 FAX 503/230-5435

AUG 0 8 1995

F/NWO3

Mr. Robert C. Clark
Restoration Center Northwest
NMFS Northwest Regional Office F/NWO
7600 Sand Point Way, NE
Seattle, Washington 98115-0070

Re: Species List Request for Development of a Restoration Plan for Commencement Bay, Puget Sound, Washington

Dear Mr. Clark:

The National Marine Fisheries Service (NMFS) has reviewed your July 13, 1995, letter to Jacqueline Wyland requesting a list of threatened and endangered species for development of a restoration plan for Commencement Bay, Puget Sound, Washington.

We have enclosed lists of those anadromous fish species that are listed as threatened or endangered under the Endangered Species Act (ESA), those that are proposed for listing, and those that are candidates for listing. This inventory includes only anadromous species under NMFS' jurisdiction that occur in the Pacific Northwest. The U.S. Fish and Wildlife Service should be contacted regarding the presence of species falling under its jurisdiction.

Available information indicates that no listed Snake River salmon are in the project area or immediately downstream from it. The final critical habitat designated for the listed salmon (December 28, 1993, 58 FR 68453) does not include the proposed project area.

All of the anadromous fish species that are presently candidates for listing under the ESA are known to be present in the proposed action area; these species are chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), chum salmon (*O. keta*), sea-run cutthroat trout (*O. clarki clarki*), steelhead (*O. mykiss*), sockeye salmon (*O. nerka*), and pink salmon (*O. gorbuscha*). It is important to note that candidates for listing have no status under the ESA. Once a candidate is proposed for listing, or is listed, a conference or consultation may be required. Please refer to the ESA section 7 implementing regulations, 50 CFR Part 402, for information on the conference and consultation process.

Other threatened and endangered species under NMFS' jurisdiction that could be present in the project vicinity are the steller sea lion (*Eumetopias jubatus*), the humpback whale (*Megaptera novaeangliae*), and leatherback sea turtle (*Dermochelys coriacea*). A list of threatened and endangered marine mammals and sea turtles that occur in Puget Sound is also enclosed.

This letter constitutes the required notification of the presence of any Federally listed threatened or endangered species or critical habitat under NMFS' jurisdiction in the permit area that may be affected by the proposed project (Appendix A to Part 330, Section C.13(5)(i)).

If you have any further questions, please contact Ben Meyer of my staff at (503) 230-5425.

Sincerely,

Elizabeth Holmes Gaar
Habitat Branch Chief

Enclosure

cc: F/NWO Brent Norberg

ENDANGERED AND THREATENED MARINE MAMMALS AND SEA TURTLES UNDER THE JURISDICTION OF NATIONAL MARINE FISHERIES SERVICE THAT MAY OCCUR OFF WASHINGTON AND OREGON

MARINE MAMMALS

Humpback Whale	*Megaptera novaeangliae*
Blue Whale	*Balaenoptera musculus*
Fin Whale	*Balaenoptera physalus*
Sei Whale	*Balaenoptera borealis*
Sperm Whale	*Physeter macrocephalus*
Steller Sea Lion	*Eumetopias jubatus*

MARINE TURTLES

Leatherback Sea Turtle	*Dermochelys coriacea*
Loggerhead Sea Turtle	*Caretta caretta*

****

ENDANGERED AND THREATENED MARINE MAMMALS AND SEA TURTLES UNDER THE JURISDICTION OF NATIONAL MARINE FISHERIES SERVICE THAT MAY OCCUR IN THE PUGET SOUND

MARINE MAMMALS

Humpback Whale	*Megaptera novaeangliae*
Steller Sea Lion	*Eumetopias jubatus*

MARINE TURTLES

Leatherback Sea Turtle	*Dermochelys coriacea*

ENDANGERED, THREATENED, PROPOSED, AND CANDIDATE SPECIES UNDER NATIONAL MARINE FISHERIES SERVICE JURISDICTION THAT OCCUR IN THE PACIFIC NORTHWEST

Listed Species

Snake River Sockeye Salmon	*Oncorhynchus nerka*
Snake River Fall Chinook Salmon	*Oncorhynchus tshawytscha*
Snake River Spring/Summer Chinook Salmon	*Oncorhynchus tshawytscha*

Proposed for Listing

Umpqua River Sea-run Cutthroat Trout	*Oncorhynchus clarki clarki*

Candidates for Listing (all Northwest stocks of the following)

Chinook Salmon	*Oncorhynchus tshawytscha*
Coho Salmon	*Oncorhynchus kisutch*
Pink Salmon	*Oncorhynchus gorbuscha*
Chum Salmon	*Oncorhynchus keta*
Sockeye Salmon	*Oncorhynchus nerka*
Sea-run Cutthroat Trout	*Oncorhynchus clarki clarki*
Steelhead	*Oncorhynchus mykiss*

United States Department of the Interior

FISH AND WILDLIFE SERVICE
North Pacific Coast Ecoregion
3704 Griffin Lane SE, Suite 102
Olympia, Washington 98501-2192
(360) 753-9440 FAX: (360) 753-9008

August 30, 1995

Mr. Patrick Cagney, EIS Coordinator
U.S. Army Corps of Engineers, Seattle District
P.O. Box 3755
Seattle, Washington 98124-2255

FWS Reference: 1-3-95-SP-844

Dear Mr. Cagney:

As you are aware, the U.S. Fish and Wildlife Service (Service)is joint lead agency with the National Oceanic and Atmospheric Administration for development of the Programmatic Environmental Impact Statement and Restoration Plan (RP/EIS) for restoration activities resulting from the Commencement Bay Natural Resource Damage Assessment. The RP/EIS must evaluate the impacts of the proposed restoration program on endangered species. As project manager for the RP/EIS we are sending you the enclosed list of proposed and listed threatened and endangered species, and candidate species (Attachment A) that may be present within the area of the proposed restoration planning boundaries in King and Pierce Counties, Washington. The Service is responsible for providing such a list for federal projects.

Both listed and proposed species may occur in the vicinity of the project. Therefore, pursuant to the regulations implementing the Endangered Species Act (Act), impacts to both listed and proposed species must be considered by the joint lead agencies in a biological assessment. Since the EIS is programmatic, the biological evaluation may be of a general nature with site specific biological assessments conducted during the environmental assessment phase for individual projects. The results of the project specific biological assessment will then determine if a consultation and/or conference is required.

Candidate species are included simply as advance notice to federal agencies of species which may be proposed and listed in the future. However, protection provided to candidate species now may preclude possible listing in the future.

Your interest in endangered species is appreciated. If you have additional questions regarding your responsibilities under the Act, please contact Jim Michaels or Judy Lantor of this office at the letterhead phone/address.

Sincerely,

Nancy J. Gloman
for
David C. Frederick
Supervisor

jkl/tb
Enclosures
SE/COE/SP-844/King, Pierce
c: WDW, Region
WNHP, Olympia

ATTACHMENT A

LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES AND CANDIDATE SPECIES WHICH MAY OCCUR WITHIN THE VICINITY OF THE PROPOSED NRDA RESTORATION PLAN PROGRAMMATIC EIS PROJECT BOUNDARY, INCLUDING COMMENCEMENT BAY, THE WATERSHED OF COMMENCEMENT BAY AND ITS MAIN TRIBUTARIES, AND PUGET SOUND COASTAL AREAS ADJACENT TO THE BAY IN PIERCE & KING COUNTIES, WASHINGTON

1-3-95-SP-844

LISTED

Bald eagle (*Haliaeetus leucocephalus*) - wintering bald eagles may occur in the vicinity of the project from about October 31 through March 31.

There is one bald eagle communal winter night roost located within the project boundary at:

There are nine bald eagle nesting territories located within the project boundary at:

. Nesting activities occur from about January 1 through August 15.

Gray wolf (*Canis lupus*) - may occur in the vicinity of the project.

Grizzly bear (*Ursus arctos = U.a. horribilis*) - may occur in the vicinity of the project.

Marbled murrelet (*Brachyramphus marmoratus marmoratus*) - may occur in the vicinity of the project (marine environment). Nesting murrelets may occur in the vicinity of the project from about March 1 through mid-September.

Peregrine falcon (*Falco peregrinus*) - spring and fall migrant falcons may occur in the vicinity of the project.

Northern spotted owl (*Strix occidentalis caurina*) - may occur in the vicinity of the project.

Major concerns that should be addressed in your biological assessment of the project impacts to listed species are:

1. Level of use of the project area by listed species.

ATTACHMENT A (1-3-95-SP-844) Continued

2. Effect of the project on listed species' primary food stocks, prey species, and foraging areas in all areas influenced by the project.

3. Impacts from project construction/implementation (i.e., habitat loss, increased noise levels, increased human activity) which may result in disturbance to listed species and/or their avoidance of the project area.

DESIGNATED

Critical habitat for the northern spotted owl occurs within the project boundary in: portions of . portions of , and , portions of all sections of and portions of and portions of and .

PROPOSED

Critical habitat for the marbled murrelet occurs within the project boundary in: portions of portions of , and , portions of all sections of , portions of , and portions of and .

CANDIDATE

The following candidate species may occur in the vicinity of the project:

<u>Animals</u>:
~~Black tern~~ *(Chlidonias niger)* possible migrant
Bull trout *(Salvelinus confluentus)*
California wolverine *(Gulo gulo luteus)*
Cascades frog *(Rana cascadae)*
Fender's soliperlan stonefly *(Soliperla fenderi)*
Fringed myotis (bat) *(Myotis thysanodes)*
~~Harlequin duck~~ *(Histrionicus histrionicus)*
~~Little willow flycatcher~~ *(Empidonax traillii brewsteri)*
Long-eared myotis (bat) *(Myotis evotis)*
Long-legged myotis (bat) *(Myotis volans)*
Northern goshawk *(Accipiter gentilis)*
~~Northern red-legged frog~~ *(Rana aurora aurora)*
Northwestern pond turtle *(Clemmys marmorata marmorata)*
Olive-sided flycatcher *(Contopus borealis)*
~~Olympic mudminnow~~ *(Novumbra hubbsi)*

ATTACHMENT A (1-3-95-SP-844) Continued

Pacific fisher *(Martes pennanti pacifica)*
Pacific Townsend's (= western) big-eared bat *(Plecotus townsendii townsendii)*
c Spotted frog *(Rana pretiosa)*
Tailed frog *(Ascaphus truei)*
~~Yuma myotis (bat)~~ *(Myotis yumanensis)*

Plants:

Castilleja cryptantha (obscure Indian paintbrush)
Cypripedium fasciculatum (clustered lady's-slipper)

ATTACHMENT B

FEDERAL AGENCIES' RESPONSIBILITIES UNDER SECTIONS 7(a) AND 7(C) OF THE ENDANGERED SPECIES ACT OF 1973, AS AMENDED

SECTION 7(a) - Consultation/Conference

Requires:

1. Federal agencies to utilize their authorities to carry out programs to conserve endangered and threatened species;
2. Consultation with FWS when a federal action may affect a listed endangered or threatened species to ensure that any action authorized, funded, or carried out by a federal agency is not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat. The process is initiated by the federal agency after it has determined if its action may affect (adversely or beneficially) a listed species; and
3. Conference with FWS when a federal action is likely to jeopardize the continued existence of a proposed species or result in destruction or an adverse modification of proposed critical habitat.

SECTION 7(c) - Biological Assessment for Construction Projects *

Requires federal agencies or their designees to prepare a Biological Assessment (BA) for construction projects only. The purpose of the BA is to identify any proposed and/or listed species which is/are likely to be affected by a construction project. The process is initiated by a federal agency in requesting a list of proposed and listed threatened and endangered species (list attached). The BA should be completed within 180 days after its initiation (or within such a time period as is mutually agreeable). If the BA is not initiated within 90 days of receipt of the species list, please verify the accuracy of the list with our Service. No irreversible commitment of resources is to be made during the BA process which would result in violation of the requirements under Section 7(a) of the Act. Planning, design, and administrative actions may be taken; however, no construction may begin.

To complete the BA, your agency or its designee should: (1) conduct an onsite inspection of the area to be affected by the proposal, which may include a detailed survey of the area to determine if the species is present and whether suitable habitat exists for either expanding the existing population or potential reintroduction of the species; (2) review literature and scientific data to determine species distribution, habitat needs, and other biological requirements; (3) interview experts including those within the FWS, National Marine Fisheries Service, state conservation department, universities, and others who may have data not yet published in scientific literature; (4) review and analyze the effects of the proposal on the species in terms of individuals and populations, including consideration of cumulative effects of the proposal on the species and its habitat; (5) analyze alternative actions that may provide conservation measures; and (6) prepare a report documenting the results, including a discussion of study methods used, any problems encountered, and other relevant information. Upon completion, the report should be forwarded to our Endangered Species Division, 3704 Griffin Lane SE, Suite 102, Olympia, WA 98501-2192.

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* "Construction project" means any major federal action which significantly affects the quality of the human environment (requiring an EIS), designed primarily to result in the building or erection of human-made structures such as dams, buildings, roads, pipelines, channels, and the like. This includes federal action such as permits, grants, licenses, or other forms of federal authorization or approval which may result in construction.

STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

P.O. Box 47600 • Olympia, Washington 98504-7600

(206) 407-6000 • TDD Only (Hearing Impaired) (206) 407-6006

September 5, 1995

Mr. Pat Cagney
U.S. Army Corps of Engineers
P.O. Box 3755 ATTN: CENPS-EN-PL-ER
Seattle, WA 98124

Dear Pat:

I have contacted the Natural Heritage program at DNR for a list of state threatened or endangered species. They will be responding with a map and narrative on plant species, but they do not have jurisdiction over other species. I then contacted the Department of Fish and Wildlife for their species. They provided several publications referred me to a WDOE computer database which can print out maps. In searching the publications there are very few species which stand out in the Commencement Bay area or watershed. However, the following is provided and is based on information from their Region 4.

WDFW has both what they call priority habitats and species. The species are broken out into several categories. There are listed and candidate species. Listed species are species of fish and wildlife officially designated as Endangered, Threatened or Sensitive. Candidate species are species which are under review for possible listing as Threatened, Endangered or Sensitive. Another criterion is Valuable Aggregations. These are species which because of their tendency to aggregate are susceptible to decline like heron rookeries, sea bird concentrations or marine mammal haul out areas. The third criteria is Important Recreational and/or Commercial species which are vulnerable to habitat loss.

Those species found in the WDFW publication and located in Region 4, which is Whatcom, Skagit, Snohomish, King and Pierce county are:

Western pond turtle	Endangered
Marbled murrelet	Threatened
Bald eagle	Threatened
Peregrine falcon	Endangered
Sandhill crane	Endangered
Northern spotted owl	Endangered
Western gray squirrel	Threatened
Gray wolf	Endangered
Gray whale	Endangered
Sea lion, Stellar	Threatened

Not all of these species will be found in the Puyallup drainage area and Commencement Bay, however. In addition to species, various habitats are classified as priority areas. Those listed for Region 4 are:

> Caves, cliffs, Eelgrass meadows, Estuary, Estuary-like, Kelp beds, Oak woodlands, Old growth/mature forests, Prairies and Steppe, Riparian, Rocky shores, Snag habitats, Talus, Urban natural open space, Freshwater wetlands and deepwater habitats.

I am enclosing the plant designations from Natural Heritage which I just received Thursday.

I will be asking our GIS personnel to print out the digitized information soon and will provide these to you as soon as possible.

Sincerely,

Fred Gardner

Fred Gardner
Toxics Cleanup Program

FG:fg

I:\USERS\FGAR461\WP\SPECIES

WASHINGTON STATE DEPARTMENT OF
Natural Resources

JENNIFER M. BELCHER
Commissioner of Public Lands
KALEEN COTTINGHAM
Supervisor

August 31, 1995

Fred Gardner
Department of Ecology
PO Box 47600
Olympia WA 98504-7600

SUBJECT: Commencement Bay Programmatic EIS - Natural Resource Assessment for Hazardous Waste Releases Liability Evaluation

We've searched the Natural Heritage Information System for information on rare plants, high quality native wetlands and high quality native plant communities in the vicinity of your project. A summary of this information is enclosed. I have also enclosed rare plant species lists for Pierce and King Counties.

The Washington Natural Heritage Program is responsible for information on the state's endangered, threatened, and sensitive plants as well as high quality native plant communities and wetlands. The Department of Fish and Wildlife manages and interprets data on wildlife species of concern in the state. For information on animals of concern in the state, please contact the Priority Habitats and Species Program, Washington Department of Fish and Wildlife, 600 Capitol Way North, Olympia, WA 98501-1091, or by phone (360) 902-2543.

The Natural Heritage Information System is not a complete inventory of Washington's natural features. Many areas of the state have never been thoroughly surveyed. There may be significant natural features in your study area that we don't yet know about. This response should not be regarded as a final statement on the natural features of the areas being considered and doesn't eliminate the need or responsibility for detailed on-site surveys.

I hope you'll find this information helpful.

Sincerely,

Sandy Norwood

Sandy Norwood, Environmental Review Coordinator
Washington Natural Heritage Program
Division of Forest Resources
PO Box 47016
Olympia WA 98504-7016
(360) 902-1667, FAX (360) 902-1787

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SEP 1 1995
ECOLOGY

Enclosures

WASHINGTON NATURAL HERITAGE INFORMATION SYSTEM
ENDANGERED, THREATENED AND SENSITIVE PLANTS
HIGH QUALITY NATIVE WETLANDS AND HIGH QUALITY NATIVE PLANT COMMUNITIES
IN THE VICINITY OF COMMENCEMENT BAY PEIS
REQUESTED BY DEPARTMENT OF ECOLOGY

Data current as of August 1995

TOWNSHIP, RANGE AND SECTION	ELEMENT NAME	STATE STATUS	FEDERAL STATUS
T21N R02E S10 S2 S15 N2	Douglas fir-western hemlock/evergreen huckleberry plant community		
T21N R04E S20 S2 S29 N2	red alder/salmonberry plant community		
T21N R04E S20 S2 S29 N2	low elevation freshwater wetland		
T21N R04E S20 S2 S29 N2	low elevation sphagnum bog		

WASHINGTON NATURAL HERITAGE INFORMATION SYSTEM
Endangered, Threatened, and Sensitive Vascular Plants

Federal Status definitions:

LE = Listed Endangered: Any taxon which is in danger of extinction throughout all or a significant portion of its range and which has been formally listed as such in the Federal Register pursuant to the Federal Endangered Species Act.

LT = Listed Threatened: Any taxon which is likely to become endangered within the foreseeable future throughout all or a significant portion of its range and which has been formally listed as such in the Federal Register pursuant to the Federal Endangered Species Act.

PE = Proposed Endangered: Any taxon which is in danger of extinction throughout all or a significant portion of its range and which has been proposed for listing as such in the Federal Register pursuant to the Federal Endangered Species Act.

PT = Proposed Threatened: Any taxon which is likely to become endangered within the foreseeable future throughout all or a significant portion of its range and which has been proposed for listing as such on the Federal Register pursuant to the Federal Endangered Species Act.

C = Candidate species: Taxa for which current information indicates the probable appropriateness of listing as Endangered or Threatened.

State Status definitions:

E = Endangered: Any vascular plant taxon in danger of becoming extinct or extirpated from Washington within the foreseeable future if factors contributing to its decline continue. Populations of these taxa are at critically low levels or their habitats have been degraded or depleted to a significant degree.

T = Threatened: Any vascular plant taxon likely to become Endangered in Washington within the foreseeable future if factors contributing to its population decline or habitat degradation or loss continue.

S = Sensitive: Any vascular plant taxon that is vulnerable or declining and could become Endangered or Threatened in the state without active management or removal of threats.

X = Possibly Extinct or Extirpated from Washington: Based on recent field searches a number of plant taxa are considered to be possibly extinct or extirpated from Washington. Taxa in this group are all high priorities for field investigations. If found, they will be assigned one of the above status categories.

M = Monitor: Taxa of potential concern, but for which no status has yet been assigned.

Washington Natural Heritage Information System
Endangered, Threatened, and Sensitive Vascular Plants of Washington
August 1995

Pierce County

Scientific Name	Common Name	State Status	Federal Status*	Historic Record**
AGOSERIS ELATA	TALL AGOSERIS	Sensitive		H
ASTER CURTUS	WHITE-TOP ASTER	Sensitive	C	
ASTER JUNCIFORMIS	RUSH ASTER	Sensitive		
BOTRYCHIUM LANCEOLATUM	LANCE-LEAVED GRAPE-FERN	Sensitive		
BOTRYCHIUM LUNARIA	MOONWORT	Sensitive		
BOTRYCHIUM MONTANUM	MOUNTAIN MOONWORT	Sensitive		
BOTRYCHIUM PINNATUM	ST. JOHN'S MOONWORT	Sensitive		
CAREX COMOSA	BRISTLY SEDGE	Sensitive		
CASTILLEJA CRYPTANTHA	OBSCURE INDIAN-PAINTBRUSH	Sensitive	C	
CASTILLEJA LEVISECTA	GOLDEN INDIAN-PAINTBRUSH	Endangered	PT	H
CHAENACTIS THOMPSONII	THOMPSON'S CHAENACTIS	Sensitive		H
CIMICIFUGA ELATA	TALL BUGBANE	Threatened	C	H
CYPRIPEDIUM FASCICULATUM	CLUSTERED LADY'S-SLIPPER	Threatened	C	
ERYTHRONIUM REVOLUTUM	PINK FAWN-LILY	Sensitive		H
GITHOPSIS SPECULARIOIDES	COMMON BLUE-CUP	Sensitive		H
HOWELLIA AQUATILIS	HOWELLIA	Endangered	LT	
LATHYRUS TORREYI	TORREY'S PEAVINE	Pos Extirpated		
LUZULA ARCUATA	CURVED WOODRUSH	Sensitive		H
LYCOPODIELLA INUNDATA	BOG CLUBMOSS	Sensitive		
MICROSERIS BOREALIS	NORTHERN MICROSERIS	Sensitive		H
MONTIA DIFFUSA	BRANCHING MONTIA	Sensitive		H
PEDICULARIS RAINIERENSIS	MT. RAINIER LOUSEWORT	Sensitive		
POLYSTICHUM CALIFORNICUM	CALIFORNIA SWORD-FERN	Sensitive		
RANUNCULUS POPULAGO	MOUNTAIN BUTTERCUP	Sensitive		
SAXIFRAGA DEBILIS	PYGMY SAXIFRAGE	Sensitive		H
TRILLIUM PARVIFLORUM	SMALL-FLOWERED TRILLIUM	Sensitive		
WOODWARDIA FIMBRIATA	CHAIN-FERN	Sensitive		H

* C = Candidate for listing, LE = Listed Endangered, LT = Listed Threatened, PT = Proposed Threatened
** H = Known only from historic record (i.e. before 1980)

Washington Natural Heritage Information System
Endangered, Threatened, and Sensitive Vascular Plants of Washington
August 1995

King County

Scientific Name	Common Name	State Status	Federal Status*	Historic Record**
ARENARIA PALUDICOLA	SWAMP SANDWORT	Pos Extirpated	LE	H
ASTER CURTUS	WHITE-TOP ASTER	Sensitive	C	
BOTRYCHIUM LANCEOLATUM	LANCE-LEAVED GRAPE-FERN	Sensitive		
BOTRYCHIUM PINNATUM	ST. JOHN'S MOONWORT	Sensitive		
CAMPANULA LASIOCARPA	ALASKA HAREBELL	Sensitive		
CAREX COMOSA	BRISTLY SEDGE	Sensitive		
CAREX PAUCIFLORA	FEW-FLOWERED SEDGE	Sensitive		
CAREX SAXATILIS VAR MAJOR	RUSSET SEDGE	Sensitive		
CAREX STYLOSA	LONG-STYLED SEDGE	Sensitive		
CASSIOPE LYCOPODIOIDES	CLUBMOSS CASSIOPE	Sensitive		
CASTILLEJA LEVISECTA	GOLDEN INDIAN-PAINTBRUSH	Endangered	PT	H
CIMICIFUGA ELATA	TALL BUGBANE	Threatened	C	H
GALIUM KAMTSCHATICUM	BOREAL BEDSTRAW	Sensitive		
LOBELIA DORTMANNA	WATER LOBELIA	Threatened		
LYCOPODIELLA INUNDATA	BOG CLUBMOSS	Sensitive		H
LYCOPODIUM DENDROIDEUM	TREELIKE CLUBMOSS	Sensitive		
OROBANCHE PINORUM	PINE BROOMRAPE	Sensitive		
PLATANTHERA CHORISIANA	CHORIS' BOG-ORCHID	Threatened		
PLATANTHERA OBTUSATA	SMALL NORTHERN BOG-ORCHID	Sensitive		
PLEURICOSPORA FIMBRIOLATA	FRINGED PINESAP	Sensitive		
UTRICULARIA INTERMEDIA	FLAT-LEAVED BLADDERWORT	Sensitive		

* C = Candidate for listing, LE = Listed Endangered, LT = Listed Threatened, PT = Proposed Threatened
** H = Known only from historic record (i.e. before 1980)

MINUTES OF THE
COMMENCEMENT BAY RP/EIS PUBLIC MEETING
6 DECEMBER 1995
HELD AT THE
TACOMA WASTEWATER TREATMENT CENTER

Introduction to the Minutes Format. Three columns are presented. The first column indicates which Trustee representative or Cooperating agency representative spoke. The second column indicates which member of the audience spoke. If the person was known to me, I entered there name, if the person was unknown I entered an x. The third column is the commentary expressed by either the applicable trustee/cooperating staff or member of the public. Comments enclosed by parenthesis may more accurately reflect the intent of what was said. When the meeting commenced at 1800, 22 people were in attendance. Between 1800 and 1810, 8 more arrived. More people arrived after 1810. Overall, approximately 40 people attended the meeting.

Dr. Clark introduced the Trustee and Cooperating Agency representatives:

Trustee Representative	Representing
Dr. Robert Clark	National Oceanic and Atmospheric Administration
Fred Gardner	Washington State Department of Ecology
Roderick Malcom	Muckleshoot Indian Tribe
Jeff Krausmann	US Fish and Wildlife Service
Gail Siani	National Oceanic and Atmospheric Administration
Lt (jg) Jennifer Young	National Oceanic and Atmospheric Administration
Judy Lantor	US Fish and Wildlife Service
Denise Baker	US Fish and Wildlife Service
Glen St. Amant	Muckleshoot Indian Tribe
Pat Cagney	Corps of Engineers (Project Manager)
Bill Sullivan	Puyallup Tribe of Indians

Trustee or Cooperating Agency Representative	Public	Comments
Dr. Robert Clark		Began an opening presentation and described the Trustees and the two cooperating agencies (EPA and Corps). The purpose of workshop is to share information with the public in response to the public's request for early input into EIS. The EIS as mailed out is the raw pre-draft EIS. No formal decisions have been made in regard to the DEIS. The formal DEIS for public comment and review will be issued next year (1996). The FEIS is anticipated to be issued in the summer of 1996. The purpose of the tonight's public meeting is to respond to the public desire for more input. At this meeting, the Trustees and Cooperating Agencies will note the sense of verbal comments. However, the audience is encouraged to provide written comments, even to providing proposed text for inclusion into the EIS. At this time the EIS preparers have no direct authorship of the document. However, next week the EIS work group will start to prepare EIS comments.
		We (the EIS workgroup) have some concerns about the DEIS: A. better incorporation of scoping comments into the EIS (the EIS workgroup will go back and review the scoping document to address this situation); B. the alternatives section was difficult to put together as the EIS is programmatic rather than for a a project (The EIS workgroup wants to spend more time on this section); C. can the screening process be improved (many public documents not currently in the DEIS could be included); D. does the DEIS reflective NRDA needs (is it more of an implementation plan rather than plans on the ground); and E. can some material be removed from the EIS
		The above areas are some of those in which in the EIS workgroup is seeking suggestions, but the night is wide open. If the audience has suggestions beyond the EIS workgroup comments, they were encouraged to put them forward.

Fred Gardner		The state will probably adopt the NEPA EIS as a SEPA document when becomes a final document. The DEIS is the first time the EIS workgroup has seen the document as a whole, but the EIS workgroup has had input into portions of it earlier. He again emphasizes the Workgroup is willing to listen and change document as required.
Dr. Robert Clark		The floor was then opened to the audience.
	Jim Gouche	How do we get on the mailing list? We have received no documentation for this EIS or meeting.
Pat Cagney		CBCAC is on mailing list, but since they have changed their chairman, the mailing list may need to be changed.
Fred Gardner		In the future the EIS workgroup will spend more time checking mailing list to ensure all people or organizations that request to be on the mailing list, are on it. Obviously CBCAC is an important player.
Judy Lantor		CBCAC not receiving the EIS or notice was probably just an oversight, if not for federal furlough checking would have been more effective.
	Jim Gouche	Part of our problem is knowing whom (of the Trustees) to talk to. They thought Rob Wolteria (NOAA) was the informal PR person for the Trustees.
Gail Siani		The Trustees will update and correct mailing list.
	David McEntee (Simpson Tacoma Kraft)	Was happy to see the attention paid to the landscape approach. However, he did not see that the landscape approach had considered the landscape that the EIS or plan would be applied to such as the current landscape dominated by the River, Port and City. Furthermore he wanted references to successful and unsuccessful restoration projects within Commencement Bay. Greater emphasis on existing restoration projects in the Bay would add credibility to the document.

Fred Gardner		It is hoped that the EIS workgroup does not have to rewrite whole document, nor does the EIS workgroup want to.
	Cheryl Miller	Appreciated the opportunity for comment and wished more agencies would do this (pre-formal DEIS meetings) before proposals are set in concrete.
Dr. Robert Clark		Encouraged the audience not to hold back, but to give input to the EIS workgroup for use.
Judy Lantor		In the first week of January 1996, the Trustees will sit down begin the revisions. However, the Trustees are already beyond the time frame set for this process.
Dr. Robert Clark		Any good comments that come in will be worked to best of the EIS workgroup abilities, but if specific comments are not incorporated, the public still has the opportunity for comment upon the formal DEIS.
Glen St. Amant		The Trustees are aware of some of the deficiencies and will be working on them. The comments tonight have not been out of line with Trustee comments
Dr. Robert Clark		In fairness to contractor, they had a difficult job to do as much material needed to be reviewed and this was not in their area of expertise. Now is opportunity to bring up to what everyone wants
	Dave McEntee	In the preferred alternative examples of specific restoration examples should be used, such as site proposals on a map of Foss Waterway or Rushton shoreline.
	Dave McEntee	Cleanup activity under Superfund will restore much of the Bay, none of that is discussed, and the Trustee must build off of that to move ahead.
Dr. Robert Clark		The Trustees are working closely with the EPA, but great uncertainty exists to how much actual restoration versus remediation were arise from cleanup activities. However, the Trustees are trying to ensure conflicts do not arise
Pat Cagney		Stated the Trustees had reviewed the drafts of all the reports.

	Ken Wiener	The criteria of the Restoration Panel was good, a low ranked site could be valuable in a high quality area
	David McEntee	Agreed that edges are problematic. Geographical features are important. Could be habitat edges in a particular area are very important.
	Ken Wiener	The Puget Sound Management Plan is an EIS and a Plan together.
	Ken Wiener	It is good that the Restoration Plan and EIS are in the same document. That is positive, but a lot of stuff that does not have to be in the EIS. Page after page of analysis of impacts can be consolidated. But what troubled him the most was what was not there: *a real substantive analysis of land use and shoreline consistency*. Such an analysis is both practical and is required by SEPA. The CBCAC Restoration Plan is an adopted part of the City Shoreline Program. Consistency analysis in the EIS is very light, given the large size of the port and surrounding land uses. There is no discussion that connects land use with restoration opportunities. CBCAC articulated land use goals and polices that dovetailed with restoration. CBCAC commented on this during scoping. GMA, and Tribal standards need to be met and discussed. How the Restoration Plan works with other plans and options needs to be discussed.
Fred Gardner		Asked how people found the pull out charts and graphics?
	Leslie Ryan	Not very readable
	David McEntee	Not very readable
x		The Trustees then explained that the Trustees had coloured ones and the mailed out ones were black and white.

Dr. Robert Clark		Much of the geographic area is in the appendices. Much of what is required in the document and plan is in the appendices, but needs to be pulled together. Are there any suggestions on how to solve this.
Fred Gardner		Is there utility to place into the EIS how NEPA or the EIS process works?
Pat Cagney		Flow charts work well
	Jim Gouche	There was a request to work backwards from the specific to the general to illustrate a project on the ground to outline the time and actions required to implement the project. This would also help the public believe that things would happen on the ground.
	Leslie Ryan	The EIS needs to be clear as to where people can again come in for public comment. The formal DEIS needs some sort of fact sheet and a short summary. Suggested that the fact sheet or a summary sheet be sent to the mailing list.
Dr. Robert Clark		A fact sheet is required and will be part of the EIS.
	Ken Wiener	CBCAC looked at many values and sites and come up with a goals that had landscape concept with an ability to select site specific projects. Several scoping letters suggested that the criteria developed by the restoration panel are applicable to the RP/EIS. The Trustees could apply criteria to create landscape plan but would have the freedom to select specific projects.
	David McEntee	Identified the bay edges and the river corridor as key areas. Even though a project on a (habitat) edge may be low priority it might have greater benefit compared to working within a larger area to create a patch.
	Ken Wiener	Found that high priority sites did match functional systems in the Bay. Both can be accomplished
Fred Gardner		Depending upon PRP settlements some of the high ranked sites may not be restored.

	Cheryl Miller	Are the Trustees looking at other things beside salmon?
Judy Lantor		Yes, salmon are just the easy to talk about. For example Goglihite wetland restoration site has numerous species using it.
Dr. Robert Clark		We do not know the amount of money involved. It will probably decrease in time because of increased acquisition costs, etc. It will be a dynamic process for the next 10 to 15 years. It is a challenge to put into a concise document.
	Ken Wiener	One thing to help make happen over the next 10 to 20 years if a variety of folks to part to make it happen, if depends upon normal NRDA may take many years. The EIS comes off as conventional NRDA: *as the Trustee this* and *the Trustees that*. Rather than a discussion of the environment and what needs to be done, rather than encouraging other parties to participate in the plan.
Fred Gardner		We have tried the carrot instead of the stick.
	Ken Wiener	That is not evident in this document
Fred Gardner		We have tried hard to get people to the table.
	Jim Gouche	The Trustees should put target dates into this document with a flowchart. The target dates can be revised in the future. People are scared of a process that will just be procedural rather than substantive with actual restoration. The public wants a time frame for hands on project. It should not be open ended.
Bill Sullivan		Perhaps by explaining pending and proposed actions?
Roderick Malcom		The Trustees need to be more careful about the use of the term "*open-ended*" when referring to the NRDA process. That open ended refers to the collection of the last damages and creation of the last restoration project, not beginning of the first restoration project.
Dr. Robert Clark		The Trustees are sitting on property we can not restore until the EIS is finished.

Gail Siani		Asked if people found charts and maps useful?
	David McEntee	A picture is worth a 1,000 words.
	Cheryl Miller	Unable to read black and white and grey map.
	David McEntee	Maps are useful if show habitat types, restoration areas and natural features. The more information has about resources, the more ownership may be taken by the community. Habitat maps also have educational value.
	Cheryl Miller	Found some of the maps confusing as was the map of the whole study area.
Judy Lantor		Some salmonid maps have new information. This is very valuable for Basin planning.
	David McEntee	Would like to have reference tools
	Cheryl Miller	Perhaps the study area over the maps
Judy Lantor		The primary and secondary study areas are marked in the EIS.

	x	EPA has come out in the Federal Register with a proposal to create the formal process of delisting some sites from the Superfund list. Does delisting effect our management plans?
Bill Sullivan		Such delisting helps the Trustees as it let us know about cleaner areas and also tags some areas with the red flag.
Dr. Robert Clark		Delisting could push a proposed project from a low to a high rating due to changes in perceived levels of contamination.
	David McEntee	Has looked at his scoping letter and other scoping letters. A number of scoping comments were not addressed. He will provide a list of substantive comments not addressed, that are important enough to be addressed and looked at in the RP/EIS. This RP/EIS has the potential to be the national standard for bay wide restoration. He acknowledged that the Trustees are very cost conscious and he is supportive of that, but if the Trustees look at importance of the restoration to the community and how could be used elsewhere the RP/EIS would be enhanced by geographically basing it.
	Ken Wiener	It would help the RP/EIS if it was more clear how the tiering process would work, the tiering process is important information. For example, what are the Trustees doing now, what will the Trustees do later, and what the Trustees not do later as it was done earlier.
	Leslie Ryan	Questioned how cost-benefit analyses weighs into the Restoration Plan given that urban restoration sites are more expensive to do.
Judy Lantor		Cost benefit is one of the criteria as well as the ecological benefit versus the environmental costs. It will come out in the ranking.
Bill Sullivan		It is hoped the mitigation in industrial sites would provide much of the quilt work of habitat and Trustee our dollars could be best spent on getting the best bang for the buck.

	Cheryl Miller	The discussion of the expanded study area, does not state whether the preferred alternative is within the primary or expanded study areas. However, the expanded study area goes so far up the watershed and includes many jurisdictions. Do the Trustees address expansion and urbanization based upon Pierce County comprehensive plan? Though much of the watershed is not currently urbanized, much of it is currently slated for urbanization. This will affect restoration. The EIS does not realistically address urban issues.
Judy Lantor		All the alternatives look at the primary and expanded area. All alternatives would look at anthropogenic influences upon restoration. The ecological needs of migratory species (what spawning and rearing habitats might be needed) might indicate which study area is needed
Bill Sullivan		The Trustees need to come up with scenarios for the integrated approach.
	Leslie Ryan	Does the EIS identify what injuries are being restored by specific restoration projects?
	Ken Wiener	Does not think document should look at issues such as this release caused this injury, won't be able to make specific linkages. If working on a watershed basis, a particular site may not be the place of injury but the restoration should relate to the injury. If a site is in an area that is not contaminated, it can still be viewed as ecologically important.
	Leslie Ryan	What triggers looking at the expanded study area?
Judy Lantor		Some of the species are migratory. We can't analyze separate projects in isolation.
	Leslie Ryan	What if of two species, one is in primary and one is in expanded study area, how do the Trustees choose?
Bill Sullivan		The Trustees will do both. The Trustees will do what projects and combinations make the most sense.
	Cheryl Miller	Judy Lantor's explanation is not in the text.
Pat Cagney		Page 1 through 7 has a good rationale

Jeff Krausmann		Much of the Bay is not cleaned up yet. Can't do anything until source control and cleanup is finished.
	Ken Wiener	The source control program can lead into a discussion of priorities.
Pat Cagney		It is in the Management Plan.
	Ken Wiener	Volume two of the RP/EIS has inventory of potential restoration sites but not an evaluation of the potential sites. Environmental consequences should be an evaluation of the impacts rather than an inventory. Try to avoid some of the boilerplate inventory of impacts, though at times some boilerplate is helpful with the explanation. However, there are ways to put in and ways to put in such discussion. Must evaluate the importance of the impact.
	Leslie Ryan	What does acquisition of equivalent natural resources and services mean?
Roderick Malcom		Acquisition of alternative natural resources and services is the creation of equivalent natural resources or services if due to other factors, the restoration of the original natural resource or service is not feasible. Such acquisition could occur off site.
	Ken Wiener	The document mixes them up - that is part of the problem. Tools used in the integrated approach should benefit the environment
Roderick Malcom		Habitat creation takes a long time to reach maturity. The public wants to see visible results from the restoration. Acquisition could be used over the short term to provide services to the public while the longer term habitat restoration projects are developing.
	Leslie Ryan	Is buying land acquisition? Do the Trustees intend to buy land and then do nothing with the land?
	Ken Wiener	Not really purchasing for preservation but for the purpose of the larger ecosystem.
Fred Gardner		We could do some enhancement

	x	Prefers the term "*phasing*" over "*tiering*" as the term "*tiering*" suggests hierarchy.
	x	In reference to the sign up sheet passed round does the phrase "*on mailing list*" mean currently on mailing list or desires to be placed on mailing lists?
Gail Siani		The Trustees will clear this issue up for future public meetings.
	x	There is much discussion about restoration but not much about prevention. Money is better spent on prevention rather than restoration
Dr. Robert Clark		Explained the regulatory system and the restriction applicable to NRDA funds. The Trustee framework is for damages from chemical toxicants.
Fred Gardner		DOE and EPA play a role in prevention.
Glen St. Amant		The dollar damages are for pollution damages that have stopped or with known stop dates.
Jeff Krausmann		The EIS and restoration process will lead to greater public emphasis upon source control, awareness of the issue, and stewardship.
	Leslie Ryan Jim Gouche	Requested that another public meeting be held prior to the formal DEIS goes out for public comment.
Dr. Robert Clark		Stated that this workshop took required (set back the process) 6 weeks of RP/EIS time due to 2 weeks to prepare the meeting including public notification, 1 week trustee review, 2 to 3 weeks reviewing and incorporating comments and reaching concurrence among 7 entities. The Trustees are willing to meet with the public, but the Trustees are also hearing that the public wants to this process to move ahead fast. The process is roughly a year behind schedule.
	Leslie Ryan	More public meetings now may speed up the process later.

	Cheryl Miller	How will the Trustees prevent musical restoration sites? If NRDA money is used in concert with some other entities mitigation projects, how will the Trustees prevent future owners from doing something else with the site? How are the sites to be retained for the future?
Dr. Robert Clark		NRDA sites will be in perpetuity, that component is integral to NRDA. If a NRDA restoration project is in concert with someone else it part of the conditions would be a that the site is for perpetuity and if in concert with someone else would have caveat. Land use be would restricted through vehicles such as deed restrictions.
	Cheryl Miller	Would be very hesitant to rely upon piecemeal mitigation to provide the bulk of the restoration for habitat patches.
Dr. Robert Clark		We can only rely on our own. The NRDA Trustees have only a part of the program and are restricted in what actions they can undertake. The Trustees are hoping as resource agency staff to encourage resource agencies to write mitigation permits for perpetuity, though there are problems of defining perpetuity.
Fred Gardner		We are trying to focus on the landscape and connectivity potential, so that mitigation could pick up others.
	Ken Wiener	There are tremendous opportunities for restoration on public land, but DNR has a concern about restoration use on public lands. Consistency with DNR is not addressed in the RP/EIS such as aquatic and navigation needs (e.g. sites at the tips of waterways).
Fred Gardner		DNR working on the tidelands issue, but the issue is complicated.
	Ken Wiener	Wants *analysis* not inventory regarding the DNR aquatic lands issue
Pat Cagney		All suggestions presented tonight are good, but the EIS work group is limited to what can be addressed in a single document
	Ken Wiener	One of the purposes of tiering is to discuss why some things are not being discussed now.

	Ken Wiener	The Trustees might make issues more focused and just set the Restoration plan out rather than pages explaining how the plan evolved. People would then be given a couple of weeks to review.
Dr. Robert Clark		There is still a problem as most people in the public need two weeks to schedule ahead to attend meeting. Do we give less notice of public meetings and have fewer people attend (in order not to slow the process down too much). The mailing and notification can not be for a single interest group but for everyone.
	Leslie Ryan	It is a good idea to have a second meeting for redefining the Integrated Approach and should happen as soon as possible in January, perhaps at the next quarterly meeting for the Trustees, 9 January 1996 at 1330.
	Dave McEntee	Put an advertisement into the paper and keep the discussion focused.
Judy Lantor		That would be a difficult date to do as comments will be received till 29 Dec 95.
	Ken Wiener	We also know some of the people that are the most interested and can call them to see if absolutely impossible to hold at a certain date. We could send a postcard to the mailing list.
	Jim Gouche	Ten days is need for mailing. Papers have a "*for free*" column
The meeting adjourned.		
	x	As the meeting was breaking up someone suggested EMail as a way for the Trustees to keep the public informed of the RP/EIS process and progress.

APPENDIX C

Supplemental Habitat Description and Analysis

1.0 INTRODUCTION

The information contained in this appendix provides greater detail on several of the topics contained in the RP/EIS. The results of information contained in this appendix have been distilled and included in section 2.0, the Affected Environment, and section 4.0, Environmental Consequences, of Volume I of the EIS. The complete text included in this appendix is intended to provide an historical basis which could serve as a template for future restoration.

Several of the alternatives in the RP/EIS rely on the linkage between the restoration of specific habitat types and the potential benefits provided to injured natural resources. Recognizing the connection between habitats, their associated functions and the assemblages of species that utilize them together with how these habitats were integrated in the historic landscape increases the possibility of successful habitat based restoration.

To aid in quantifying the effects of habitat restoration under all alternatives with a habitat restoration goal, a state-of-the-art computer program, FRAGSTATS, was utilized to provide a hypothetical quantification of potential changes in landscape structure. This appendix summarizes the results of the analysis and demonstrates how various restoration actions might affect the ecological conditions in these areas.

2.0 HISTORIC HABITAT TYPES AND CONDITIONS

The following review of historic habitat types and conditions is based on the Commencement Bay Cumulative Impact Study (Corps et al., 1993): *Historical Review of Special Aquatic Sites* (David Evans and Associates, 1991) and *Assessment of Habitat Loss* (Shapiro and Associates, 1992). A major objective of the CB/CIS was to document and map historical changes in mudflats, vegetated shallows, and wetlands occurring in Commencement Bay.

Literature, maps, and photographs were collected for the period from 1850 to 1991, with emphasis on the period from 1877 to 1941. Habitat changes during this period chronicle the development of railroads, shipping, logging, agriculture, and other industries in the region. The year 1877 was chosen as the starting point for the historical analysis, because no record of significant filling of mudflats or marshes was found prior to this date.

2.1 Mudflats

Mudflats were defined as broad flat areas along the sea coast and coastal rivers to the head of tidal influence. In 1877, the area bound by mean lower low water (MLLW) and mean higher high water (MHHW) was totally intertidal mudflat, encompassing an area of approximately 1,829 to 2085 acres. Based on the USFWS habitat classification system (Cowardin et al., 1979), this type of habitat was estuarine, intertidal, unconsolidated shore, mud, regularly flooded (E2US3N). Several historical documents referred to these areas as "barren mudflats". It is presumed that this habitat was devoid of emergent or vascular plants, but probably maintained high abundances of green algae.

2.2 Vegetated Shallows

Vegetated shallows were defined as permanently inundated areas that under normal circumstances support communities of rooted aquatic vegetation, such as eelgrass beds and turtle grass in estuarine or marine systems. Eelgrass beds were apparently scarce to absent in most of the Bay in 1877 and thereafter. However, 1990 surveys by the Washington Department of Natural Resources confirmed that several eelgrass beds now exist with the primary study area. Using the Cowardin et al. (1979) system, these eelgrass beds would be classified as estuarine, intertidal, aquatic bed, rooted vascular (E2AB3).

2.3 Wetlands

Wetlands were defined as areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. The emphasis in the CB/CIS (Corps et al., 1993) was on estuarine systems. Estuarine emergent marsh (E2EM2) covered 2,471 to 3,890 acres of the Puyallup delta in 1877. Salt/brackish marsh probably extended from MHHW southeastward to the approximate location of present-day Interstate 5.

2.4 Habitat Losses

2.4.1 Estuarine

Relatively little habitat loss is thought to have occurred from approximately 1877 to 1894. An estimated 11 acres of mudflat and 20 acres of saltmarsh were lost in 1874 when the Northern Pacific Railroad was constructed to connect the cities of Puyallup and Tacoma. The most significant habitat loss (1,020 acres total) during the period 1894 to 1907 resulted from attempts to dredge and relocate the Puyallup River. Lumber production, coal storage and shipping, copper smelting, fish canning, and flour milling were some of the prevalent industrial operations established in the primary study area prior to 1900.

Irreversible changes to the Puyallup River delta were initiated during the period 1907 to 1917, when 542 acres of mudflat and 64 acres of marsh were lost. By 1917, City Waterway, Puyallup Waterway, Middle Waterway, Hylebos Waterway, Milwaukee Slip, and a basin between Middle and Puyallup Waterways were created by dredging in the mudflats of Commencement Bay. The lower Puyallup River, South 11th Street, and Lincoln Avenue were also diked during this period to convert tidal marshes for agricultural use. The resulting decrease in tidal influence and increase in siltation changed the former salt marsh to brackish marsh. As much as 28% of the mudflat and marsh habitat needed for salmon production was lost from 1907 to 1917 (USFWS, 1991).

Most of the habitat loss (162 acres of mudflat, 72 acres of marsh) from 1917 to 1927 occurred in the waterways and port areas, and resulted from dredging, as well as filling for construction of piers, wharves, and warehouses. Blair Waterway was constructed during this period. Shipbuilding was an important industry, especially during World Wars I and II.

Habitat changes in the upper delta appeared to be minor, although farming and residential growth began to expand northward from the upper reaches of the delta.

From 1927 to 1941, existing waterways were dredged to extend, widen, or deepen their channels; in addition, St. Paul and Sitcum Waterways were constructed. By the late 1920s, the focus of industrial activities in the area began shifting from lumber to electrochemical industries. Much of the chemical contamination presently found in the nearshore area of Commencement Bay is directly attributable to the electrochemical industries (Shapiro and Associates, 1992). As population dramatically increased during this period, increasingly more marsh was filled for residences, barns, and roads, and the remaining marsh habitat gradually became fragmented and isolated. Total habitat losses during this period amounted to 133 acres of mudflat and 1,676 acres of marsh.

Most of the habitat losses and associated functions up to 1941 occurred in the intertidal area; large industrial development had not yet taken place in the marsh areas. However, by the end of the 1980s, the majority of brackish marsh and intertidal mudflat had been altered, filled, and developed. Between 1941 and 1991, most habitat losses (412 acres of mudflat, 1,587 acres of marsh) in the primary study area resulted from deepening of existing channels, maintenance dredging, and filling. Based on the proportional loss of the combined mudflat and marsh habitat, the salmon production potential of the estuary in 1988 was 4% of the historic potential, and the demersal fish production potential was 9% of predevelopment conditions (USFWS, 1991).

2.4.2 Riverine

It is reasonable to assume that, prior to European settlement, riverine habitats in the expanded study area, such as oxbows, forested uplands, floodplain habitats, riparian corridors, and wetlands, were structurally and functionally linked to the estuarine habitats in the primary study area, and provided feeding, rearing, and refuge areas for numerous fish, invertebrates, birds, and mammals. However, the losses of these riverine habitats were not quantified as part of the CB/CIS (Corps et al., 1993) and have not been documented elsewhere. The wetland/upland boundary in 1877 is thought to have been near present-day Interstate 5. Upland vegetation along the Puyallup River was probably dominated by Douglas fir, western red cedar, hemlock, and sitka spruce. Little of the former native riparian corridor is thought to remain along the lower Puyallup River, Hylebos Creek, or Wapato Creek. A major portion of the upper Puyallup-White River Basin, approximately 563,000 acres, is still forested. Over 133,000 acres is within Mt. Rainier National Park and is in a "reserved" classification (Kunz, 1993). Most of the upper White River watershed is managed for timber production and has been logged for the past 100 years. Logging and logging-related activities throughout the upper watershed have created slope stability problems and increased sediment loads in many non-glacial tributaries. In addition, much of the natural habitat diversity in the watershed has been destroyed by flood control practices, such as removal of vegetation, removal of large woody debris from the river channel, levee construction, gravel removal, and channelization (South Puget Sound Spring Chinook Technical Committee, 1995).

In general, stresses to the biotic components of river and stream ecosystems arise from: (1) changes in the quality, quantity, and seasonal availability of food for organisms; (2) deterioration of water quality, including temperature changes and excessive turbidity and sedimentation; (3) modifications of the habitat, including the substrate; (4) water quantity or flow mistiming; and (5) biotic interactions (Karr et al., 1986). In the expanded study area, the primary stresses have probably been deterioration of water and sediment quality, channelizing, diking and other physical modifications to the channel and riparian zones of Wapato Creek, Hylebos Creek, and the Puyallup River, and water diversions for out-of-river uses. We suspect that oxbows and floodplain habitats have been lost or degraded primarily because of river straightening and flood control projects. Vegetation management practices, industrial, agricultural, and residential development, and logging, as well as other stressors, probably resulted in losses of riparian corridors and forested uplands in the expanded study area.

2.5 Effects of Habitat Losses on Biological Resources

2.5.1 Fish and Macroinvertebrates

Based on the historical assessment of changes in fish and shellfish populations in Chapters 3 and 4 of the CB/CIS (Corps et al., 1993), the probable effects of estuarine habitat loss in the primary study area can be summarized as follows:

- Inadequate data are available from the period prior to urbanization to quantify adverse impacts on fish and macroinvertebrates resulting from estuarine habitat loss. Nevertheless, the incremental loss of intertidal mudflat and tidal marsh habitats in the primary study area probably resulted in diminished populations and reduced geographical distributions of many species of anadromous salmonids, demersal fish, clams, crabs, and shrimp.

- The loss in primary productivity as a result of shrinking tidal marsh acreage reduced the available estuarine detritus supply.

- Dredging, diking, and channelizing of the Puyallup River probably altered the suitability of habitats for wetland and aquatic plants, benthic invertebrates, demersal fish, and the animals that prey on these organisms. Beechie et al. (1994) found that diking, ditching, and dredging associated with agricultural and urban lands in the Skagit River basin accounted for 73% of summer habitat losses and 91% of winter habitat losses for coho salmon smolt production. Similar losses could be expected in the Puyallup-White River Basin. Blocking culverts and poor forestry practices also accounted for significant losses of summer and winter rearing habitat in the Skagit River basin.

- The reduction of intertidal mudflat habitat to 4% of its historic level severely impacted clams and oysters. Some species, such as the bentnose clam, butter clam, and other once abundant species, are now rarely found in the Bay.

- In conjunction with the loss of habitat, contaminated sediments from industrial activities have led to histopathological disorders in flatfish and elevated contaminant levels in shellfish. McCain et al. (1990) and Varanasi et al. (1993) clearly demonstrated that, during their residency in urban estuaries, juvenile chinook salmon bioaccumulate substantial levels of toxic chemicals and that diet represents an important route of exposure.

The probable effects of loss of riverine-riparian habitat in the expanded study area on fish and macroinvertebrates include:

- Loss of shade and increased water temperatures
- Reduction in prey resources available for fish
- Reduction in terrestrial carbon inputs to the system
- Reduced primary productivity and nutrient cycling
- Loss of woody debris
- Increased erosion, bank failures, sedimentation, and flooding
- Decreased structural diversity
- Decreased access to historic ranges due to blockages, such as dams and culverts.

2.5.2 Benthic and Epibenthic Invertebrates

Insufficient data are available from the primary study area prior to its urbanization to quantify the effects of historic habitat losses and degradation of benthic habitats on benthic and epibenthic invertebrates. However, Simenstad et al. (1993) suggested that qualitative and semiqualitative data on benthic habitats in the dredged waterways provide irrefutable evidence that development of Commencement Bay has modified the historic structure of benthic communities.

Becker et al. (1990) conducted laboratory sediment bioassays and evaluated alterations of benthic macroinvertebrate assemblages at 43 stations in the Bay, and at 4 reference stations in Carr Inlet. The authors found that three indicators of environmental contamination--sediment chemical concentrations, sediment bioassays, and benthic macroinvertebrate assemblages showed that localized areas of the Bay were "grossly polluted". The grossly polluted areas were located near four major sources of contamination: the copper smelter at Ruston Shoreline, the storm drain at the head of Thea Foss Waterway, the pulp mill at the mouth of St. Paul Waterway, and the chemical plant near the head of Hylebos Waterway. The gross reductions of total abundance, total number of taxa, and major taxa abundance, as well as the increased bioassay responses, at the stations closest to these four sources confirmed that these stations were highly contaminated. The observed alterations of benthic macroinvertebrate assemblages were attributed to both acute and chronic exposures to toxic chemicals that induce a variety of lethal (i.e., mortality) and sublethal (e.g., reduced fecundity) responses.

In addition to the prolonged accumulation of pollutants in the benthic communities, hardening and steepening of the shoreline and shallow water habitats have likely resulted in reduced benthic production and altered taxa composition. Yet, it is unclear what effects reduced benthic production and shifts in benthic community taxa may have had on higher level consumers such as fish and wildlife.

Restoration, creation, or enhancement strategies that integrate complexes of natural habitats over broader landscapes of the delta will be required to promote more natural and ecologically important communities that once typified the estuary (Simenstad et al., 1993). The most prominent benthic and epibenthic habitats for restoration and enhancement include low gradient mudflats, deltaic tidal channels, emergent brackish marshes, and eelgrass beds.

2.5.3 Avifauna

Year-to-year variation in numbers and species in the primary and expanded study areas precludes reliable quantification of population trends for individual species or bird groups. However, based on Appendix A, Avian Assessment, the probable effects of habitat loss and chemical contamination on avifauna in the primary and expanded study areas can be summarized as follows:

- The diversity of avian species does not appear to have decreased in the Bay because of habitat loss. However, a significant loss of abundance has occurred for many species in comparison to substantially greater populations of waterfowl in less disturbed estuarine systems such as the Nisqually, Skagit, Nooksack, Snohomish, and Stillaguamish river deltas.

- The loss of riverine-riparian and estuarine habitat, in combination with contaminated water, sediments and prey organisms, likely resulted in changes in food habits and available prey for many species of birds, as well as shifts in species composition.

- Urbanization of the Bay, combined with the loss of estuarine and riverine wetland habitat, shifted the species composition from predominantly waterfowl to less wetland-dependent passerines and song birds, which inhabit the urban and suburban areas.

- Some bird species, such as western grebes, great blue herons, pigeon guillemots, and glaucous-winged gulls, have bioaccumulated contaminants through the food web by feeding on contaminated assemblages of aquatic plants and animals.

2.5.4 Mammals

Because no specific information is available on use of the primary or expanded study areas either prior to development or in recent times, the effects of habitat loss and releases of contaminants on upland and marine mammals are unknown (Shapiro and Associates, 1992). It is reasonable to assume, however, that reduction in available estuarine and riverine habitat has resulted in reduced abundances and distribution of some mammal populations, as well as reductions in available food resources and breeding areas.

3.0 LANDSCAPE ANALYSIS

3.1 Landscape Perspective on Historical Habitat Losses

The picture of Commencement Bay in the late 1800s that emerges from the CB/CIS historical analysis is one of broad mudflats, extensive tidal marshes, and numerous, dendritic tidal creeks formed by the Puyallup River and Wapato and Hylebos Creeks. The meandering Puyallup River and numerous tidal creeks connected the entire system, providing pathways for estuarine water to move across the mudflats and into and out of the tidal marshes, access routes for estuarine organisms such as juvenile salmonids that used the marshes as nursery and feeding habitats, and export of marsh detritus into the estuary. Forested uplands formed fringing riparian habitats along the Bay and its tributaries. Thus, in its pre-settlement condition, the Bay was a heterogenous matrix of many different, but structurally and functionally connected, habitats. The arrangement, size, and productivity of these habitats was basically unaffected by human uses of the landscape. Hence, natural processes controlled the flow of energy, animals, and materials through the landscape.

The extensive mudflats, tidal creeks, and tidal marshes once supported rich assemblages of flora and fauna, remnant populations of which still persist in the Bay. Based on comparisons of hypothesized historical conditions in the Commencement Bay estuary and existing conditions in the less disturbed and degraded Nisqually River estuary, the CB/CIS provides a compelling argument that Commencement Bay was formerly a major, non-coastal stopover area for migrating waterfowl and shorebirds. The mudflats and marsh habitats probably provided a rich food source, as well as high quality nesting and roosting areas, and refuge from predation. These same habitats also supported diverse assemblages of invertebrates, anadromous and resident fish (many of which were of importance commercially, recreationally, or for Tribal harvest, especially salmon), and small mammals.

As noted by Simenstad and Thom (1992), when estuarine habitats are lost or degraded, so are the array of critical functions and services they provide--for example, sediment retention and other mechanisms of shoreline erosion control, water quality improvement, trophic energy (food web) support, fish and wildlife habitat, recreation, resource harvest, energy sources, education and science, aesthetic appreciation, promotion of biodiversity, and the maintenance of microclimate characteristics. The authors give three examples where dramatic resource declines have resulted, at least in part, from major changes in the estuarine habitats of Puget Sound: 1) the survival of Pacific salmon has been severely depressed in developed estuaries relative to less disturbed estuaries; 2) Pacific herring spawning has decreased with the loss of vegetated shallows, especially eelgrass; and 3) shorebird fitness has decreased due to continuing fragmentation of estuarine littoral mudflat habitats.

> The key point is that for injured species and services restoration to succeed, comprehensive restoration planning must take place at the landscape scale. The landscape perspective is critical to planning the distribution, composition, and character of habitat restoration opportunities to ensure that injured species and resources derive maximum benefit from the limited funds available for restoration (Simenstad and Thom, 1992). The restoration effort should ensure, as much as is practical, that the spatial distribution of the restored resources and services will approximate the historic condition. To achieve this objective, we must strive to understand how individual habitats function within the larger landscape (e.g., watershed) to which they are intimately linked. This requires research into both the historical structure and processes once present in the pre-development estuary, and the attributes of habitats that promote specific functions, which are critical to injured species.

3.2 Analysis of Changes in Landscape Metrics Associated with Habitat Losses

A glossary is provided in section 5.0, page C-31, which includes landscape ecology and metric terms, as well as, the ecological implication of changes in the various metrics described below. The field of landscape ecology focuses on three characteristics of the landscape: structure, function, and change. In particular, landscape ecology involves an analysis of how various components (e.g., habitats) within a landscape interact in terms of the exchange of energy, materials, and animals. The shape of a habitat, for example, may affect the degree to which a certain population of animals utilize the habitat. There are a large number of examples from terrestrial systems that show that edges of habitats are utilized by a selected group of species, and interiors of habitats are used by another group of species. Edges generally have higher productivities, as well as greater exchange rates for materials and energy with adjacent habitats, in comparison to habitat interiors (Forman and Godron, 1986).

Landscape metrics can be used to document how fragmentation of a landscape affects terrestrial and aquatic populations. Robinson et al. (1995) recently showed how nest predation and parasitism by cowbirds on forest birds increased with forest fragmentation in nine midwestern (United States) landscapes. Minello et al. (1994) found that increasing marsh edges, by constructing new channels in marshes, enhanced the use of marshes by decapods and small bait fishes in the Galveston Bay system, Texas.

The effects of habitat changes in Commencement Bay on several landscape ecology metrics were calculated using the program FRAGSTATS (McGarigal and Marks, 1994). FRAGSTATS calculates habitat metrics from a geographic data base contained on a geographic information system (GIS) at the Corps, Seattle District. The data base for this analysis consisted of habitat maps drawn from 1877 navigation charts for Commencement

Bay and habitat maps compiled from field studies conducted by Seattle District and others through 1995. The area analyzed extends from the Interstate Highway 5 corridor to Puget Sound. This area, which encompasses approximately 4,876 ha (12,049 acres), contained the vast majority of historical marshes, and was well mapped in 1877. This area also coincides with the primary study area for the Commencement Bay Programmatic EIS. FRAGSTATS analysis for the expanded study area could not be done, because the 1877 maps did not cover the area upstream of the Highway 5 corridor.

The changes in habitats are summarized in Table C-1 and illustrated in Figure C-1. Open water habitat increased along with commercial and industrial area. Decreases were most pronounced in mudflat and tidal marsh areas. Table C-1 shows that the percent of total area occupied by the largest patch (=largest patch index) of marsh, mudflat, and forest has decreased substantially. For mudflats and marshes, this indicates that very large patches once occupied the historical landscape, and by 1995 even the largest patches comprised a very small proportion of the landscape.

The next two metrics in Table C-1, number of patches and mean patch size, highlight the fragmentation of the habitats that has accompanied the loss of habitats. The remaining marsh, mudflat, and forest areas have been divided into 5, 43 and 6 patches, respectively. Only one open water habitat remains in the landscape, where originally seven were present. Mean patch size has declined dramatically for all habitats except open water.

Mean shape index is based upon the edge length to interior area ratio for the patches of each habitat in the landscape (Forman and Godron, 1986; McGarigal and Marks, 1994). An index value of 1 indicates a round patch (i.e., minimal edge to interior), and larger values indicate increasing relative edge length and shape irregularity. Figure C-1 shows that marsh patches have become somewhat more rounded, and are now very nearly round on average. Mudflat patches have gone from very irregular and elongate to nearly round. Open water patches are far more irregular than in the past. Finally, forest patches, which were somewhat irregular, have become somewhat more irregular in shape.

Decreasing patch sizes, as well as increasing mean shape index indicate that the patches will function primarily as edges as opposed to interiors. This means, in general, that "edge" species will be favored over "interior" species. However, dramatic declines in the total area of habitat and patch size make the general landscape much less valuable to both edge and interior species. For example, although marshes have only become somewhat more rounded since 1877, they have declined from being the second most dominant habitat of the landscape to an almost insignificant component. Although the percentage loss is somewhat less than marshes, mudflats have become very highly fragmented into 43 small and, on-average, round patches. With decreasing size, is a concordant decline in the probability of encounter and use of these habitats by mudflat-dependent species such as shorebirds, chum salmon, English sole, and Dungeness crab (Shreffler and Thom, 1993; Simenstad et al., 1991).

Table C-1. Habitat Areas and Metrics from FRAGSTATS Analysis of Commencement Bay in 1877 and 1995. The Region Covered is from the Interstate 5 Corridor to Puget Sound.

Metrics	Tidal Marsh	Mudflat	Open Water	Forested
Area (ha)				
1877	1569	843	2452	12
1995	2	77	2716	5
Largest Patch Index (%)				
1877	28.0	17.3	50.2	0.2
1995	0.01	0.2	55.7	0.1
No. Patches				
1877	12	1	7	3
1995	5	43	1	6
Mean Patch Size (ha)				
1877	131	843	350	4.1
1995	0.3	1.8	2716	0.8
Mean Shape Index				
1877	1.8	7.0	1.6	2.2
1995	1.1	1.8	4.3	3.3

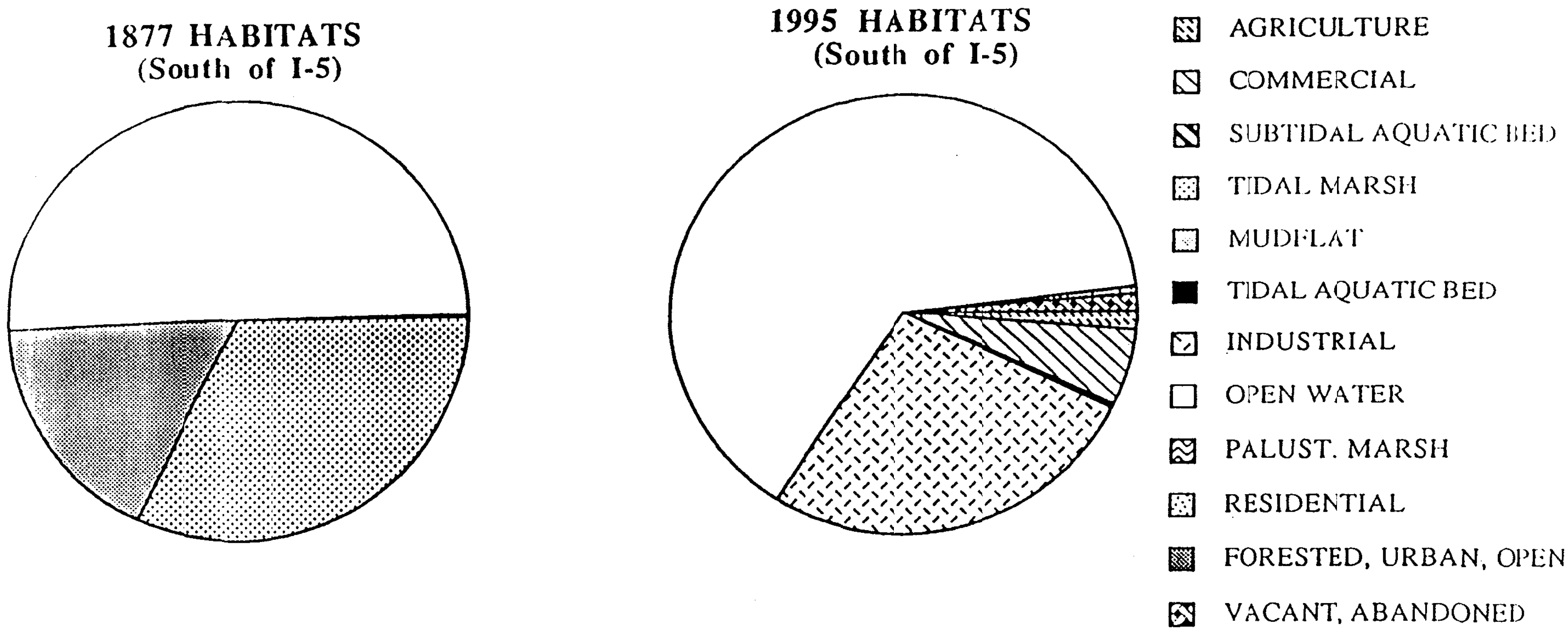


Figure C-1. **Habitat areas and metrics from FRAGSTAT analysis of Commencement Bay in 1877 and 1995.**

The effect of declining marsh area and fragmentation of marsh patches on marsh primary productivity, a key habitat process, can be roughly estimated for Commencement Bay. Hutchinson (1986) summarized data on mean peak standing crop of sedge marsh (*Carex lyngbyei*) from the region, and presented available values for edges and interiors of marshes. The mean edge standing crop and interior standing crop were 600 and 401 g dry wt m^{-2}, respectively. These peak standing crop values are used here as an estimate of annual net primary production (NPP). Finally, the width of edges of marshes, where stem lengths for *Carex* are observably longer than those in the interior of the marsh, is approximately 2 m (Thom, unpublished data).

Using the above data, mean patch size and the mean shape index formula (McGarigal and Marks, 1994), total standing crop for an average marsh patch can be calculated for 1877 and for 1995. Total marsh productivity was then estimated by multiplying the average patch values by the number of patches. The data in Table C-2 illustrate the dramatic loss of total marsh productivity (as *Carex*), but also indicate the effect of fragmentation on this loss. Although NPP has declined by 99.9%, losses were proportionally larger in interior production as compared with edge production. This is partially explained by the larger ratio of edge area to interior area in 1995 (0.138) as compared with 1877 (0.001). Ecologically this means that interior species, such as nesting waterfowl, small mammals, and predators of these species were impacted to a slightly greater degree than edge-dependent species such as shorebirds, small estuarine fish, and their predators. However, this difference must be viewed in the context of the overall loss in marsh habitat, which has had overall impacts on all species.

3.3 Historic Condition as a Template for Restoration

A clear understanding of the historic habitat types and conditions is important, both in terms of knowing the acreage of habitat and the associated functions that were lost, but also because the historic condition can be a very useful template for planning and implementing restoration. Using the historic condition as a template, efforts can be made to restore particular habitats to a pre-existing condition at a known point in time, or to create habitats that are expected to resemble the historic habitat in structure and to function in similar ways to support the restoration of injured natural resources or services. The opportunity for successful restoration to historic condition is greatest if the primary structural and functional attributes that delineate the habitat type are still effective at that site (Simenstad and Thom, 1992). Furthermore, design criteria for the restoration, enhancement, or creation of habitat of injured species should be derived to the extent possible from the natural habitat structure and processes that existed prior to habitat destruction and degradation.

Table C-2. **Comparison of Net Primary Productivity (npp) of Marshes in Commencement Bay in 1877 and 1995.**

	1877	1995	Difference
Mean Patch Area (ha)	131	0.3	-99.8%
Edge NPP (kg dry wt)	9,735	248	-97.4
Interior NPP (kg dry wt)	518,804	1,198	-99.8
Total Patch NPP (kg dry wt)	528,539	1,446	-99.7
Total Marsh NPP (kg dry wt)	6,342,468	7,230	-99.9

The 1877 data provide a template of the natural conditions of the landscape. Table C-3 shows values for all metrics for the four major habitats present in the primary study area in 1877, as well as the entire landscape. Each metric is related to an ecological condition of the system that has at least a theoretical relationship to how the system functions (McGarigal and Marks, 1994). We presently do not have empirical or experimental data for Pacific Northwest ecosystems that would allow interpretation of how each metric value relates to a specific function. However, there is a growing research effort in terrestrial and aquatic systems that is beginning to provide an understanding of function/structure relationships.

Values for metrics for the total landscape shown in Table C-3 can be used to characterize the 1877 Commencement Bay landscape. For example, the 4876 ha in 1877 was divided into 29 habitat patches. Mean patch size was 212 ha, with a high coefficient of variation (270.4%) indicating a high degree of variability in the size of patches. Habitat diversity is often referred to as a preferable quality of ecosystems, and generally means the numbers of different types of habitats in a landscape. Diversity indices (Shannon's and Simpson's) incorporate both the number of patches and the variability in their size and type over the landscape.

Below is a comparison of habitat diversity metrics for the Bay landscape in 1877 and 1995. The values indicate the much greater degree of fragmentation in terms of number of patches and greater variability in patch size in 1995. Diversity, as measured by Shannon's index, was somewhat greater in 1995, but a lower evenness value indicates that the increase in diversity was primarily due to the much greater number and types of patches in 1995. Hence, habitat diversity is actually greater in 1995, but is due to anthropogenic fragmentation rather than natural processes. In addition, lower quality "habitats" (e.g., industrial, vacant lots) have replaced natural high quality habitats. In general, disturbed communities have a greater diversity as compared with mature natural communities (e.g., Levin and Paine, 1974).

	1877	1995
No. patches	23	180
Mean patch size (ha)	212.0	27.1
Patch size coefficient of variation(%)	270.4	811.3
Shannon's diversity index	1.029	1.155
Shannon's evenness index	0.742	0.465

Again, the metrics for 1877 provide an indication of the natural conditions in the landscape. Whether these conditions are optimal for certain animals species depends upon the species of interest. The question of optimal vs natural must be considered when evaluating restoration alternatives, setting restoration goals, and designing restoration projects.

Table C-3. Metric Values for Habitats and the Entire Landscape for the Commencement Bay Primary Study Area in 1877. The Metrics are Defined in McGarigal and Marks (1994). -- indicates not applicable.

Metric	Tidal Marsh	Mudflat	Open Water	Forested	Total Landscape
total area (ha)	--	--	--	--	4876
class area (ha)	1569	843	2452	12.4	--
percent of landscape (%)	32.1	17.3	50.3	0.3	--
largest patch index (%)	28.0	17.3	50.2	0.2	50.2
number of patches	12	1	7	3	23
patch density (no.100ha^{-1})	0.25	0.021	0.144	0.062	0.472
mean patch size (ha)	130.8	843.2	350.3	4.1	212.0
patch size standard deviation (ha)	374.3	0	856.7	5.2	573.3
patch size coefficient of variation (%)	286.2	0	244.6	125.8	270.4
total edge (m)	61668.4	64545.2	9950.5	2246.1	69205.1
edge density (m ha^{-1})	12.6	13.2	2.0	0.5	14.2
total edge contrast (%)	54.4	56.5	6.7	33.6	37.9
mean edge contrast (%)	63.1	56.5	18.8	25.7	44.4
area-weighted mean edge contrast (%)	52.8	56.5	5.6	37.5	29.7
landscape shape index	4.2	4.3	2.1	1.8	4.5
mean shape index	1.75	7.03	1.60	2.24	2.00
core of landscape (%)	32.0	17.2	50.2	0.2	--
total core area (ha)	1562.4	836.5	2449.2	12.1	4860.3
number core areas	15	5	7	2	29
core area density (no 100ha^{-1})	0.308	0.103	0.144	0.041	0.595
total core area index (%)	99.6	99.2	99.9	98.3	99.7
mean core area index (%)	96.1	99.2	95.9	64.3	92.0
interspersion/juxtaposition (%)	29.1	32.8	50.4	0	35.1
Shannon's diversity index	--	--	--	--	1.029
Simpson's diversity index	--	--	--	--	0.614

3.3.1 Examples

In developing the Draft Recovery Plan for spring chinook salmon in the White River, the South Puget Sound Spring Chinook Technical Committee (1995) concluded that "Habitat restoration efforts should proceed toward the goal of reestablishing historic conditions". Another example of using the historic condition as a template is the 10 acre (3.9 ha) Gog-le-hi-te wetland in the Puyallup River estuary. In 1985-1986, the Gog-le-hi-te wetland was restored on the former site of a solid-waste landfill to mitigate for habitat lost 1 mile downstream at the 10 acre parcel 5 wetland, which was filled for development (Simenstad and Thom, 1995). Critical to the success of this restoration effort was excavation of approximately 55,000 cubic meters of solid waste landfill and river and mudflat sediments in order to reach the original marsh surface, which was then contoured to conform to the habitat requirements of the desired vegetation. The rationale was that native vegetation and animal communities would more readily colonize the historic tidal marsh sediments. In accordance with criteria established in negotiation with state and federal resource agencies, 50% of the habitat area was designed to support juvenile salmon, 20% waterfowl, 10% shorebirds, 10% raptors, and 10% small mammals; all of these species assemblages were thought to have used the site historically. Similarly, such criteria could be established for other proposed restoration sites to ensure injured natural resources or services are the primary beneficiaries of restoration.

The Gog-le-hi-te wetland is now a persistent, emergent wetland within an intertidal estuarine system. In its present state of development, the restored wetland complex is a regularly flooded, brackish wetland system comprised of tidal channels, mudflats, a transplanted sedge marsh, a cattail marsh, a shrub-scrub swamp, riparian hardwoods, and an upland grassland. Within only a few years, as many as six attributes of wetland function displayed rapid development and equivalency to reference or literature documentation (Simenstad and Thom, 1995). The most rapid response by any organisms was the immediate occupation of the wetland complex by diverse assemblages of birds. Almost 70% (80) of the 112 species documented by 1990 were observed in the wetland in the first year of its development. Residence time (1-9 day for chum, 1-43 day for chinook), prey composition (chironomid larvae and pupae, plecopterans, and adult dipterans) and growth (5.2 milligrams per day for chinook) of juvenile chum and chinook salmon were comparable to that in the meager literature from natural estuarine systems (Shreffler et al., 1990, 1992). Taxa richness of epibenthic organisms and fishes, fish densities, and three indicators of bird usage suggest that the restored wetland complex provided almost instantaneous function, and is functionally equivalent to comparable habitats (Simenstad and Thom, 1995).

However, many parameters indicative of other ecological functions indicate that Gog-le-hi-te is still in an early stage of development or on a separate pathway than comparable brackish wetland communities in this region (e.g., Nisqually River estuary). While this project is often described as one of the most "successful" estuarine restoration projects in the Pacific Northwest, Simenstad and Thom (1995) cautioned that researchers still lack the scientific basis to affirm that functional equivalency trajectories can be used as measures of wetland ecosystem development and mitigation/restoration "success".

3.4 Landscape Perspective on Existing Habitats

As described above, changes in patch size distribution of mudflats and marshes in Commencement Bay from 1877 to 1995 are shown in Figure C-1. In contrast to the vast network of structurally and functionally connected habitats that historically occurred in Commencement Bay, the existing habitats in the Bay are isolated and fragmented. A century of industrial development, railroad construction, waterway dredging and construction, agriculture, and residential development have resulted in direct loss of special aquatic sites and contributed to the present degraded condition of the Bay. The former dendritic tidal channels and mudflats have been dredged and replaced by created waterways, which have allowed Commencement Bay to become a major international port. The once extensive tidal marshes have been filled, providing space for numerous industrial and commercial enterprises. Corridors for fish and wildlife movement from nearshore mudflat and marsh habitats to adjacent watersheds with forested uplands and fringing riparian habitat have been severely altered by dredging and channelizing, which have occurred in portions of all the major streams and rivers in the system. The cumulative effect of these human activities has been fragmentation of the natural landscape into more and smaller pieces with diminished functions and services, and reduced capacity for self-maintenance.

The size and shape of a habitat patch can control the types and number of edge versus interior species that can survive in a particular habitat, as well as processes such as benthic productivity and nutrient flux (Shreffler and Thom, 1993). Smaller habitats are more likely to be isolated and dysfunctional within the larger landscape, whereas larger habitats are more stable, persistent, resilient, and resistant than smaller habitats, and offer predictably more niches for species (Gosselink and Lee, 1989; Noss, 1991). As habitat size decreases and the distance between formerly connected habitats increases, the colonization rates of habitat patches decreases, resulting in decreased species diversity and decreased ability of species to use multiple habitats. Decreasing patch size accelerates extinction rates within habitat patches and magnifies any disturbances along the perimeter of the patch (Orians, 1986). Thus, landscape fragmentation and habitat shrinkage in Commencement Bay and the Puyallup-White River Basin have decreased the flow of energy, materials, and species among habitats, reduced habitat diversity and species diversity, and probably have even resulted in local extinction of some populations.

In addition to the direct loss of habitat resulting from human activities that have fragmented the landscape, sediment and water quality have been significantly degraded through time by the release of hazardous substances and discharges of oil. A summary of contaminants present in the Commencement Bay nearshore tideflats is discussed in section 2.0 of the EIS and provided in Table D-11, Appendix D.

Land uses are encroaching upon the most sensitive remaining estuarine habitats in Commencement Bay, and population growth pressure is sending development farther upstream in most of the expanded study area. The few, undeveloped habitat patches that remain in the Bay are at risk because of the increasing demand for waterfront property to accommodate continuously expanding industrial and commercial activities in the Bay, the ongoing problems with source control, and the diminished functioning of the surrounding industrial landscape. In some areas, remaining habitat patches are no longer even hydraulically connected to the estuary. For example, most of the emergent marshes that remain in the primary study area are located in isolated drainages and depressions, which are not connected to the estuary (Shapiro and Associates, 1992). Nevertheless, there are remaining habitats in Commencement Bay that still function in support of fish and wildlife species and migratory waterfowl, and anadromous fish in particular are still reliant upon both the quantity and quality of habitat in the estuary (Simenstad et al., 1993). Recognizing the existing disturbed condition of the Bay, the Puyallup-White River Basin may offer even greater opportunities for restoration of injured species or services than the estuarine habitats in the primary study area. In addition, acquisition of equivalent resources could be considered if restoration opportunities in both the primary and expanded study areas are too expensive or not technically feasible.

3.5 Changes in Landscape Metrics and Ecological Functions Associated with Restoration Alternatives

To aid in quantifying the effects of habitat restoration under all alternatives with a habitat restoration goal on Commencement Bay resources, an analysis of several restoration scenarios was conducted. This section summarizes results of the analysis of four restoration scenarios implemented in the primary study area, and one scenario for the Hylebos subsystem. The purpose of this analysis is to demonstrate how various restoration actions could affect the ecological conditions in these areas. The restoration scenarios were chosen as examples of large-scale changes that follow the overall goals of habitat function restoration in the system. The scenarios represent four types of habitat conversions that make "ecological sense" in terms of location in the landscape. For example, areas designated vacant in 1995 that were adjacent to the Puyallup River and upstream of tidal and salt water influence (i.e., upstream of Interstate 5), were converted to riverine emergent marsh. These scenarios are only provided here as examples, and are not intended to show precisely or necessarily what should or will be done, or are all feasible. Baseline conditions for the area are shown in Figure 2.2-1 (Section 2 of the EIS). The four scenarios evaluated for the entire primary study area were as follows:

- 151 ha of vacant land adjacent to the Puyallup River and upstream of tidal influence was converted to riverine emergent marsh (Figure C-2)
- 1,418 ha of agricultural land was converted to palustrine emergent marsh (Figure C-3)
- 182 ha of vacant land within tidal and salt water influence was converted to estuarine marsh (Figure C-4)
- 25 ha of agricultural patches within the Hylebos subsystem was converted to palustrine emergent marsh (Figures C-5, C-6).

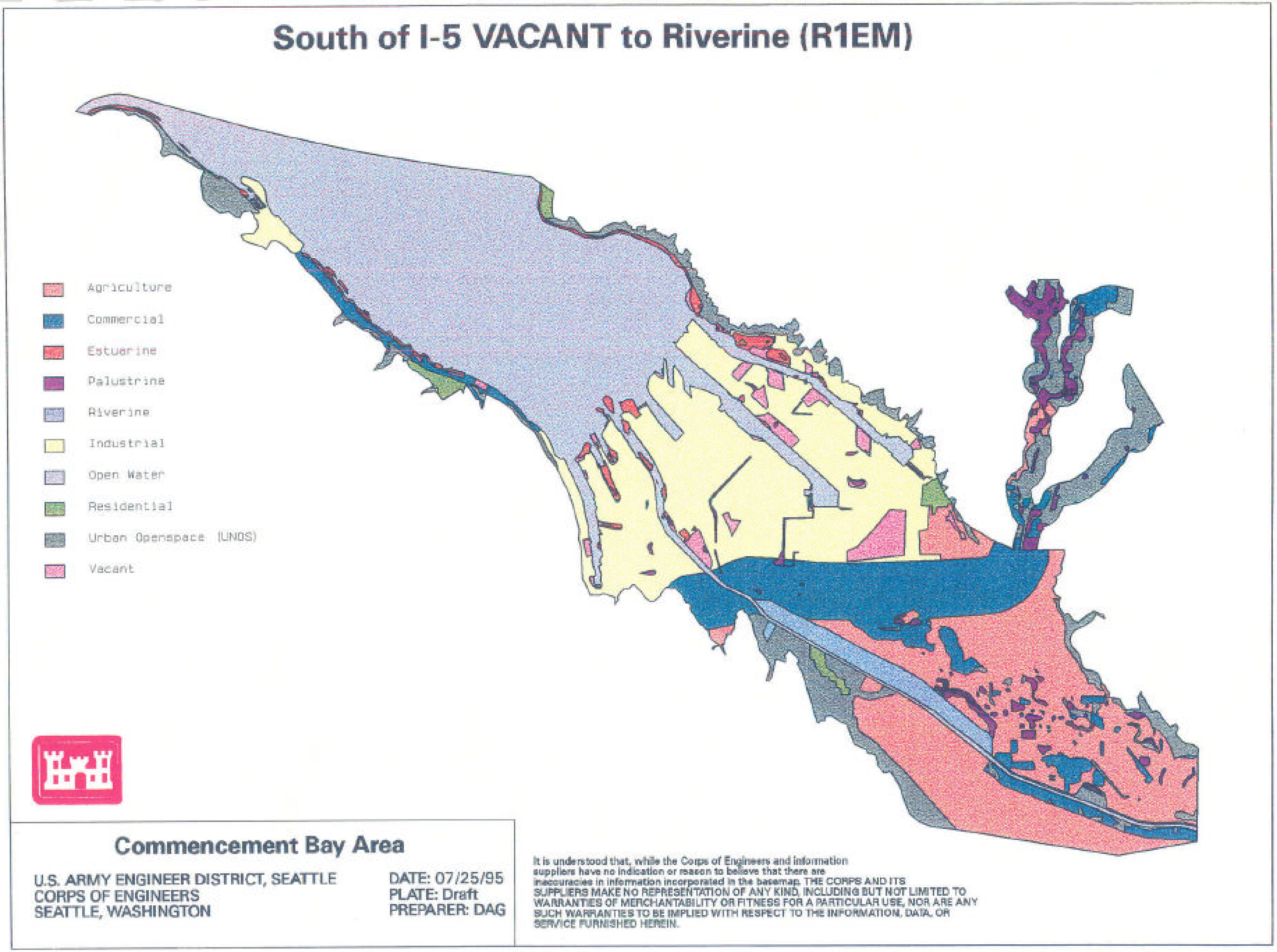


Figure C-2. Habitat map showing the conversion of 151 ha of vacant land south of I-5 to Riverine Emergent Marsh (REM).

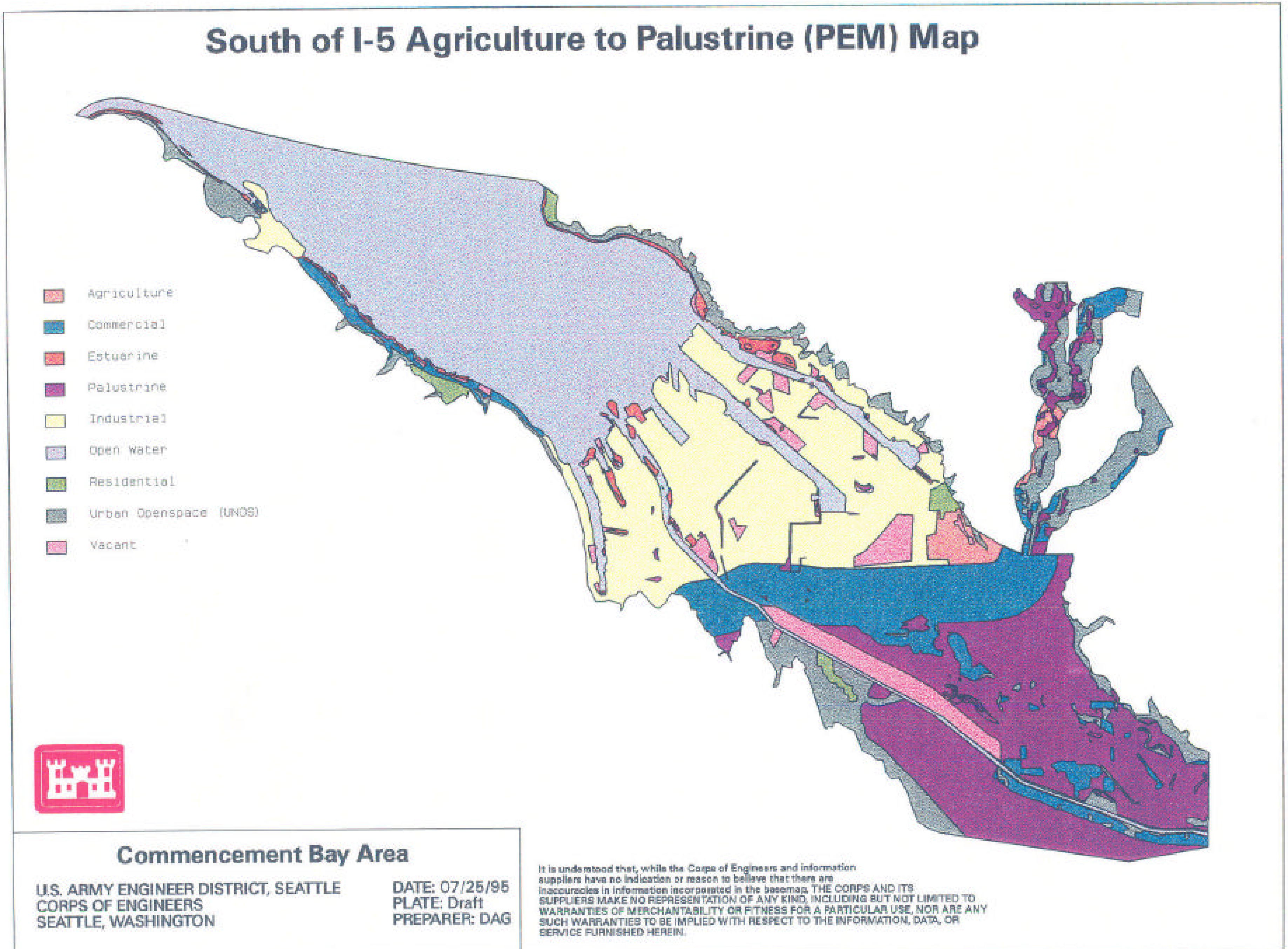


Figure C-3. Habitat map showing the conversion of 1,418 ha of agricultural lands south of I-5 to Palustrine Emergent Marsh (PEM).

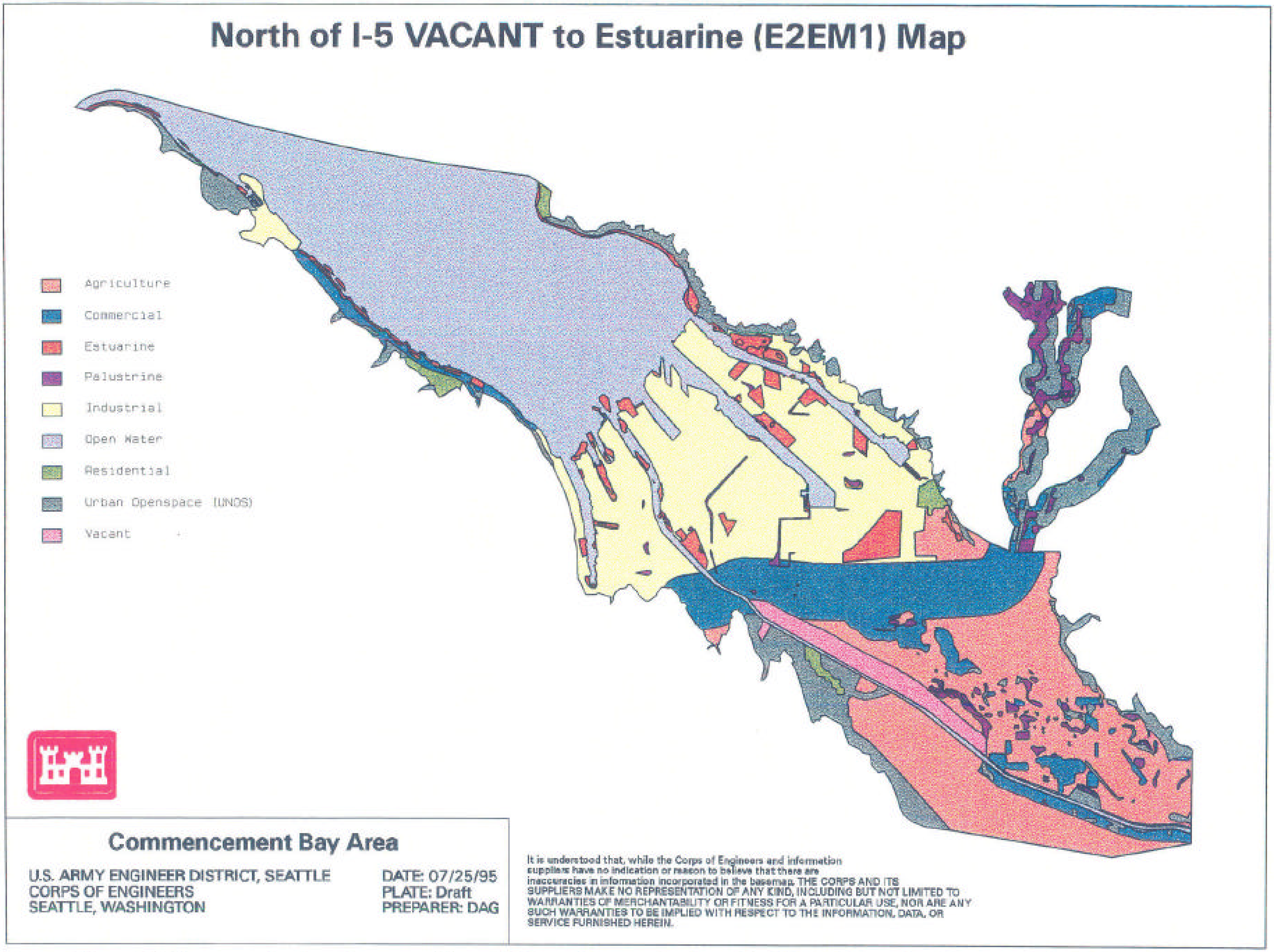


Figure C-4. Habitat map showing the conversion of 182 ha of vacant land north of I-5 to Estuarine Emergent Marsh (E2EM1).

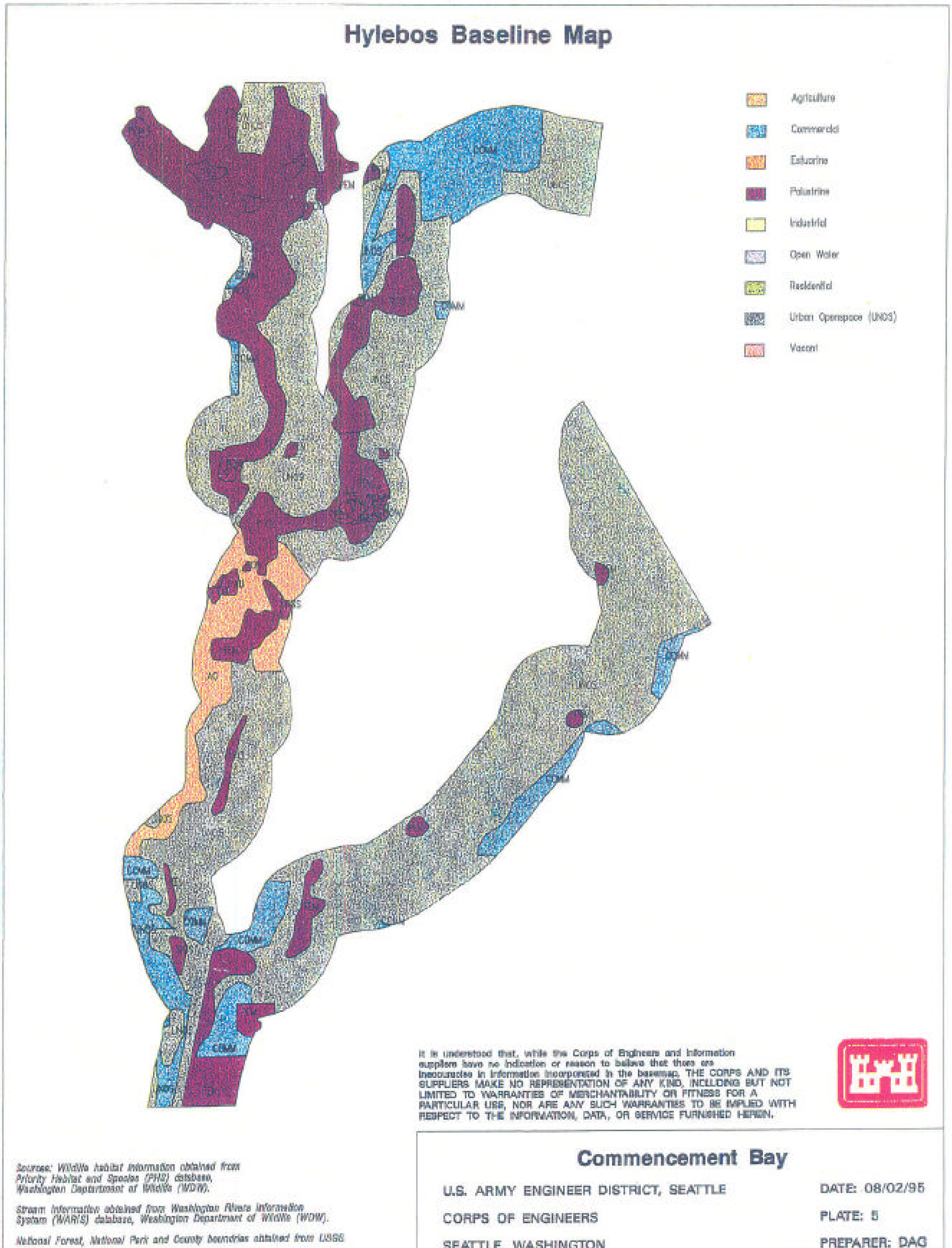
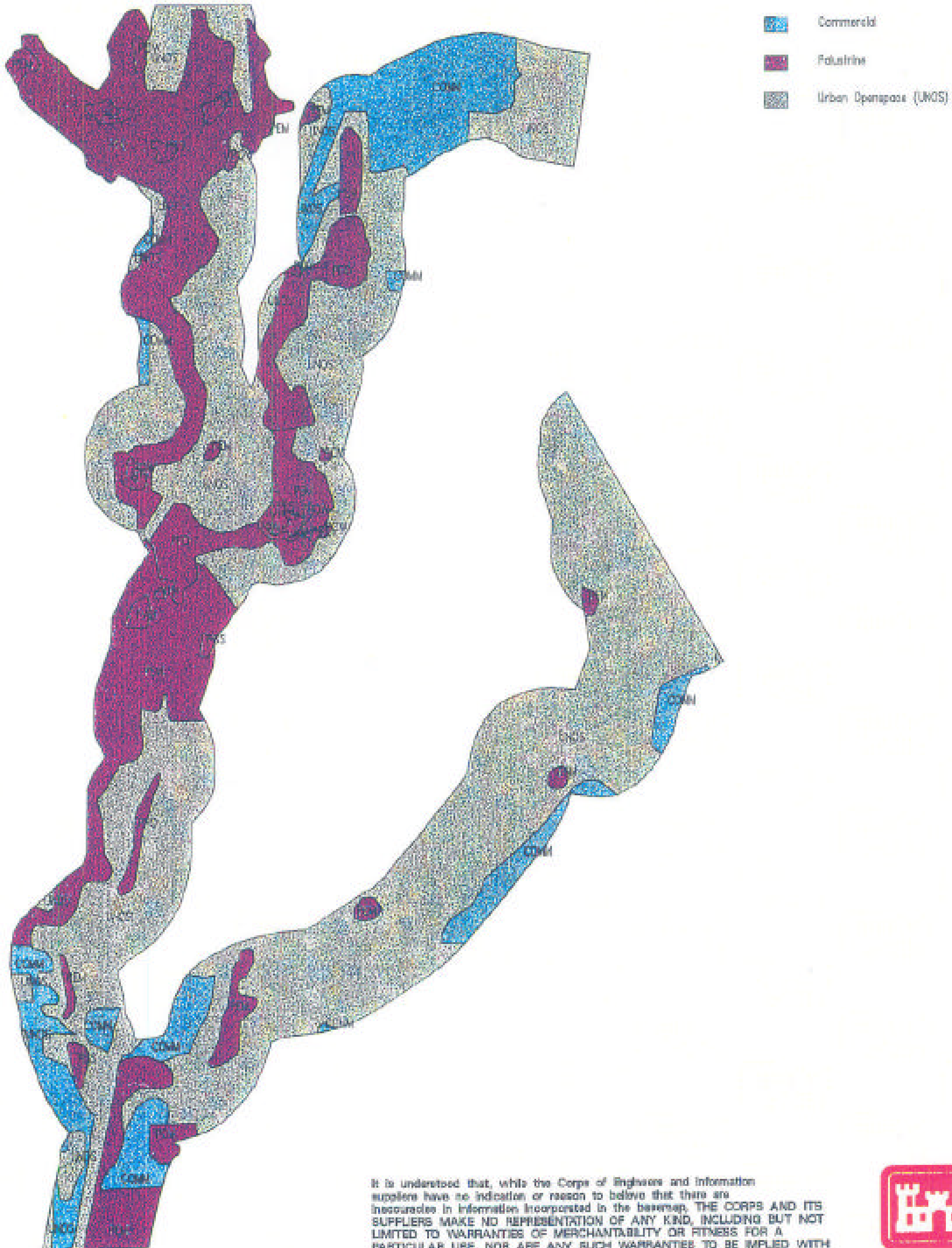


Figure C-5. Habitat map showing Hylebos baseline existing conditions, 1995.

Agriculture to Palustrine (PEM) Map



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Sources: Wildlife habitat information obtained from Priority Habitat and Species (PHS) database, Washington Department of Wildlife (WDW).

Stream information obtained from Washington Rivers Information System (WARIS) database, Washington Department of Wildlife (WDW).

National Forest, National Park and County boundries obtained from USGS.

Commencement Bay

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Figure C-6. Habitat map showing the conversion of 25 ha of agricultural lands in the Hylebos Subsystem to Palustrine Emergent Marsh (PEM).

Finally, a separate analysis was conducted and landscape metrics were calculated for the Hylebos subsystem alone, rather than the entire primary study area. Under this analysis, 25 ha of agricultural land within the Hylebos subsystem was converted to palustrine emergent marsh. This latter example illustrates the potential for carrying out restoration within a component subsystem within the overall landscape.

To facilitate comparison of the results of these scenarios, we employed the computer program FRAGSTATS which quantifies landscape structure. The program computes several values (i.e., metric) that characterize aspects of the landscape such as the number of habitats, the average size of each habitat type, the ratio of the perimeter of a habitat patch to the total area of the patch. Many of the metrics calculated by FRAGSTATS have been shown to have ecological significance to one or more species of fish or wildlife. In addition, certain functions of a habitat change with changes in the shape or size of the habitat patch. The information on habitats used in the analysis were from the GIS developed for Commencement Bay. In the following analysis, we discuss the ecological meaning of the changes in landscape metrics under the various restoration scenarios.

The results of the analysis are illustrated in Figures C-2 to C-6, and the changes in metric values are provided in Tables C-4 and C-5. The metrics can be grouped for interpretation. For example, metrics related to patch size and number of patches indicate the level of fragmentation. Edge metrics (e.g., total edge) are useful in interpreting changes that will affect species such as juvenile salmonids that show a preference for habitat edges (juvenile salmon feed at edges of marshes). Edge contrast metrics indicate the level of difference between adjacent patches. A larger index indicates a larger contrast. This may be important for waterfowl and other avifauna (e.g. bald eagles) that key in on a sharp contrast in canopy height, wind, and light between adjoining habitats. Core area metrics provide information on how the landscape will change to favor interior species (e.g., small mammals such as mice). Diversity and evenness provide measures of the numbers and types of habitats, and how evenly the landscape is divided among habitats. Although it is difficult to definitively conclude the level of change that is significant, a change of 2% in a metric over the entire landscape is regarded as notable here. Changes of >10% are considered substantial on a landscape basis.

Table C-4 shows that conversion of the large patch of vacant property adjacent to the Puyallup River into riverine marsh primarily affected edge measures (Figure C-2). The positive increase in contrast indicates that this conversion would favor species that utilize habitat edges in this portion of the river, including juvenile salmon, and other fish, as well as small mammals and some waterfowl (e.g., great blue heron). This conversion added one very high quality habitat to the landscape that was probably widespread historically.

Converting agricultural land to palustrine emergent marsh resulted in substantial changes in patch size metrics, edge contrast metrics, and core area metrics (Table C-4, Figure C-3). In general, there is a reduction in fragmentation indicated by increased patch size and decreased number of patches. Edge metrics are reduced and core area metrics are increased, which would result in gains for interior species. Although edge metrics were decreased, edge contrast metrics were increased. This means that the remaining edges represent areas of greater between-patch

Table C-4. Changes in Landscape Metrics in the Primary Study Area Under Four Restoration Scenarios. The Percent Change in the Value for Each Metric as Compared to the 1995 Base Condition is Provided

Metrics (units)	1995 Base	Vacant to Riv. Emerg.	Change %	Agriculture FW Marsh	Change %	Vacant to Tidal Marsh	Change %	One Ag to FW Marsh	Change %
total area (ha)	8405	8405	0.00	8405	0.00	8405	0.00	8405	0.00
largest patch index (%)	33.077	33.077	0.00	33.077	0.00	33.077	0.00	33.077	0.00
number of patches	353	353	0.00	311	-11.90	351	-0.57	350	-0.85
patch density (no. 100ha-1)	4.2	4.2	0.00	3.7	-11.90	4.176	-0.57	4.164	-0.86
mean patch size (ha)	23.81	23.81	0.00	27.025	13.50	23.946	0.57	24.014	0.86
total edge (m)	311149.47	311149.47	0.00	297609.625	-4.35	310975	-0.06	309749.91	-0.45
total edge contrast index (%)	8.295	8.568	3.29	9.081	9.48	9.591	15.62	8.354	0.71
total core area (ha)	8360.704	8360.704	0.00	8362.259	0.02	8360.728	0.00	8361.043	0.00
Shannon's diversity index	1.816	1.843	1.49	1.818	0.11	1.842	1.43	1.824	0.44
Simpson's diversity index	0.796	0.797	0.13	0.796	0.00	0.797	0.13	0.797	0.13
Shannon's evenness index	0.641	0.638	-0.47	0.642	0.16	0.65	1.40	0.644	0.47
Simpson's evenness index	0.846	0.844	-0.24	0.846	0.00	0.847	0.12	0.847	0.12

Table C-5. Changes in Landscape Metrics in the Hylebos Subsystem Under One Scenario. The Percent Change in the Value for Each Metric as Compared to the 1995 Base Condition is Provided.

Metrics (units)	Hylebos 1995 Base	Agriculture to FW Marsh	Change (%)
total area (ha)	491	491	0.00
largest patch index (%)	25.613	25.613	0.00
number of patches	68	65	-4.41
patch density (no 100ha-1)	13.849	13.238	-4.41
mean patch size (ha)	7.221	7.554	4.61
total edge (m)	36049.309	34649.754	-3.88
total edge contrast index (%)	10.586	11.041	4.30
total core area (ha)	481.678	481.945	0.06
Shannon's diversity index	1.282	1.2	-6.40
Simpson's diversity index	0.611	0.604	-1.15
Shannon's evenness index	0.616	0.617	0.16
Simpson's evenness index	0.699	0.705	0.86

contrast. Although no new patch types are created under this scenario (and hence no change in diversity), changing agricultural land to palustrine wetland provides obvious positive benefits to a variety of wildlife.

Under the scenario of converting vacant property north of I-5 to estuarine marsh, edge contrast is increased substantially, with only slight decreases in core area metrics (Table C-4, Figure C-4). This conversion would favor estuarine fish species, migratory fish species, shorebirds, edge-dependent waterfowl and mammals. This would increase the presence of a habitat that was extremely important historically (David Evans and Associates, 1991).

Converting a relatively small parcel of agricultural land in the Hylebos to palustrine emergent marsh had very little effect on the landscape metrics for the overall Commencement Bay area (Table C-4). However, the change was measurable. Perhaps the most important contribution of this scenario was a substantial increase in high quality habitat, once present in that subsystem (David Evans and Associates, 1991). Table C-5 shows the changes in metrics within the Hylebos subsystem (Figures C-5 and C-6). In general, all metrics are affected, with a net reduction in habitat fragmentation, and increase in contrast. This change would mean improvement in conditions within this subsystem for palustrine wetland animal species.

To evaluate the effect of these changes on ecosystem functions, the metric values for 1877 provide insight. Between 1877 and present the landscape has become highly fragmented, with substantial reductions in area occupied by marsh and mudflat habitat, largest patch index and mean patch size, and substantial increases in lower quality habitats such as industrial and agricultural lands. Although it was possible to calculate metrics for 1877 conditions north of I-5 only, the direction of change in this area is indicative of changes throughout the primary study area. Hence, restoration efforts designed to reduce fragmentation and restore larger, high-quality, habitat patches at appropriate locations within the landscape appear most appropriate.

The results of the four scenarios suggest that conversion of agricultural land to palustrine marsh, conversion of vacant land to estuarine marsh, and conversion of vacant land to riverine marsh would provide the greatest benefits to injured species. Conversion of agricultural land to palustrine marsh results in the greatest reduction in fragmentation, largest increase in patch area, but primarily benefits palustrine animals. Conversion of vacant land into riverine marsh primarily affected edge measures which would favor species that utilize edges in this portion of the river, including juvenile salmon and other fish, as well as mammals and some waterfowl. Although converting vacant property to tidal marsh does not reduce fragmentation, it does restore very important historical estuarine habitat, and increases the access (indicated by increased edge contrast) and quality of habitat available for estuarine and migratory fish species. This latter scenario perhaps is more realistic in terms of size and availability of property than the former two. However, the analysis does indicate that relatively large parcels of land are needed to predictably measure ecological improvement on the landscape-scale. This analysis also verifies that relatively small sized conversions have little affect on the entire landscape but can have substantial effects on a subsystem.

wetland, which forms a small, quiet, embayment immediately off the mainstem of the Puyallup River, is highly vulnerable to sediment input from these floods. Sediment accretion rates of 2-3 centimeters per year were common in the wetland during the first seven years following construction (Simenstad and Thom, 1995). However, an extreme flood event in 1988 resulted in deposition of over 20 centimeters of sediment on the intertidal flats. The complete lack of floodplain wetlands in the lower Puyallup River forces sediment into Commencement Bay. Any restoration efforts that include hydrological connections with the White or Puyallup Rivers will be subject to catastrophic sedimentation events. These events will threaten restoration efforts and need to be planned for to ensure the long-term survival of restored habitats.

4.1.2 Altered Hydrology

Alterations to hydrology in the Puyallup-White River Basin were summarized by Ecology (1995) and are listed in Section 2.8.2 of the EIS. Dredging, dams, logging, urbanization, rerouting of rivers, irrigation, groundwater withdrawals, and construction of roads or other developments in groundwater recharge zones are a few of the major stressors.

Peak stormwater runoff presently flows relatively quickly from the watershed to the estuary, and is not dissipated in floodplains. Increased erosion can be expected along narrow, diked portions of the main rivers and streams. These erosional forces must be considered when designing riparian and fringe wetland restoration efforts, as well as fish habitat restoration projects along streams and rivers. Alterations also include coastal processes such as erosion and deposition, which have been changed due to filling, dredging, and diking in the estuary. Ship wakes and propeller wash can be significant in slips and channels, where restoration projects could be located.

4.1.3 Altered Water and Sediment Quality

Much of the reason for altered benthic communities and fish diseases in the Commencement Bay area is associated with contaminated water and sediment (Corps et al., 1993). A growing commerce base and population could result in continued contamination of the water and sediments from industrial and domestic discharges. Complete source elimination is impossible, and restoration efforts must consider how existing and future contamination may affect the viability of a proposed restoration site.

4.1.4 Altered Habitat Structure

Filling and diking has resulted in loss of almost 100% of the tidal wetland system in Commencement Bay (David Evans and Associates, 1993). Logging, road building, dredging, altered hydrology, channelization, and a variety of other actions have also caused direct damage to habitats in the primary and expanded study areas. These actions have resulted in burial of habitats, altered structure in terms of numbers and abundances of species, altered functional performance, increased fragmentation, reduction of corridors of movement, and reduction in connectedness among habitats. Restoration plans in a system

Table C-6. **Current Understanding of Anthropogenic Stressors and Potential Effects on the Commencement Bay Ecosystem**

Stressors	Documented and Potential Ecological Effects
Altered Sediment Dynamics •logging (in steep slope terrain) •dams •road and other construction •diking •gravel dredging •stormwater discharges •vegetation removal	-disrupted sediment balance -landslides -reduced habitat complexity -increased fine sediment load -blocked spawning areas
Altered Hydrology •dredging •logging •dams •urbanization •rerouting of rivers •groundwater withdrawals •irrigation and other diversions •road and other construction in groundwater recharge areas	-removal of riparian corridor -increased peak storm runoff -increased frequency/severity of flooding -higher stream velocities -accelerated streambank erosion -altered salinity
Altered Sediment/Water Chemistry •industrial discharges •domestic waste discharges •agriculture •municipal storm/wastewater	-decreased fish survival -increased BOD -increased sediment-associated toxins -increased turbidity, nutrients -expanded temperature extremes
Altered Habitat Structure •logging •dredging •diking/filling •invading species •altered hydrology •dams •urbanization/industrialization •irrigation and other diversions •construction in or affecting fish and wildlife habitats •vegetation removal •draining of wetlands	-lost/altered riparian wetlands -lost/altered fish/shellfish habitat -altered ecological processes -disrupted migration patterns -increased noise -decreased channel sinuosity -altered trophic structure
Fisheries Resource Harvest •commercial •tribal •recreational •in areas outside of the Bay	-shifts in species composition and abundances -depleted key resources

that has been subjected to this level of alteration, must consider how future habitat alterations could affect the functioning of restored habitats. For example, the salmonid mitigation site at the head end of Slip 1 in Blair Waterway has shown good functional performance in terms of salmonid prey production (Thom et al., 1986). However, this beach is within an area that could be filled for development of upland port facilities. There are numerous examples of areas in Puget Sound where mitigation habitats have been either partially damaged or totally lost because of development actions taken after the mitigation habitat was established.

4.1.5 Fisheries Resource Harvest

There is intense pressure on the fisheries resources in the study region from recreational, commercial, and tribal harvesting. Unlike many other harvests, however, Tribal terminal harvests are managed to ensure adequate escapement. Salmon populations have declined dramatically over the past century, partially in response to over-fishing (Puget Sound Water Quality Authority, 1995). Salmon enhancement through hatcheries and limited habitat improvement efforts has been carried out to increase salmon stocks in the system, and also to prevent stock extinction, such as for the White River spring chinook salmon. Restoration efforts in the Bay and Basin need to preserve native salmon runs that can use restored, enhanced, or created spawning, rearing, feeding, refuge and/or acclimation habitats.

Demersal fish, Dungeness crab, shrimp and clam resources could also have been impacted through harvesting actions, but this has not been quantitatively documented in Commencement Bay. Restoration efforts through contaminant source control and construction and rehabilitation of nearshore habitats could enhance populations of these resources, and make their harvest and consumption safe. Improved conditions for these populations may create increased harvest pressure.

4.2 Natural Stressors

Variability in aspects of the natural system can significantly affect the development and/or functioning of newly restored systems. Catastrophic flood events, earthquakes coupled with vertical shoreland movement of up to 1 meter (Atwater and Moore, 1992), sea level rise (Thom, 1992), extended freezes, extended droughts, El Nino events, and a variety of other natural phenomena could decimate a restoration site.

4.3 Recommendations for Dealing with Stressors

A main objective for a restoration effort should be to ensure that a restored, enhanced, or created system is self-sustaining (NRC, 1992). Consideration should be given to the minimum viable populations required to ensure that the restored system develops toward the established goals for the system and that the developing system is resilient to extreme natural events. Although no constructed natural system can resist some catastrophic events, such as the "1,000-year" freeze, most natural systems have the ability to recover from extreme events seen on the order of perhaps a decade, such as floods and wind storms. Restoration efforts should consider development of systems that are self-maintaining and resilient to disturbances after a minimal development period (e.g., five years). To accomplish this, it is recommended that: (1) principles of minimal viable populations (i.e., the amount of plant material to establish and the physical and chemical conditions that will assure development) be used; (2) the system be sited so as to fit into the natural landscape; (3) landscape ecology principles be employed to develop the appropriate structure for the system to maximize desired processes and benefit to target resources; and (4) the influence of all potential major stressors be considered in developing the restoration plan for a site (Shreffler and Thom, 1993). Restoration efforts should also consider what activities will be required to support acquired natural resources if acquisition of equivalent natural resources will be used.

5.0 GLOSSARY

Term	Definition	Ecological implication
Landscape	A heterogeneous land area composed of a cluster of interacting ecosystems that are repeated in a similar pattern throughout.	The composition of a landscape determines what species can live there and how energy and even genes are distributed.
Fragmentation:	The amount (or lack) of heterogeneity within the landscape.	The degree of fragmentation affects the presence and distribution of populations within the landscape.
Patch:	A nonlinear habitat area differing in appearance from its surroundings. A discrete landscape unit.	Change in patch size and distribution over the landscape effects the exchange of energy and nutrients within the landscape.
Edge:	An outer band of a patch that is environmentally different from the interior of the patch. The cutting boundary of a clear-cut forest is a good example.	Have generally higher productivity and greater rates of exchange of material and energy. Certain species are associated with edges. Usually they are more tolerant of disturbance or more adaptive to change. Examples of edge species include starlings and juvenile salmonids.

Core:	The central portion of a patch.	The amount or size of the core area within a patch influences the type of (interior) species that utilize the patch. Small mammals are usually considered interior species.
Diversity:	The number of habitat types or species present within a landscape.	More is not always better in this situation. Mature homogeneous landscapes are typically lower in diversity but higher in "specialist" species (such as large carnivores). Disturbed landscapes have more types of species present.
mean shape: index	Based on the ratio between edge length to interior (of a patch) area.	This gives the approximate shape of a patch and this shape reflects how species will utilize a given patch. A small index value will be perceived as an edge type habitat and favored by edge species.
Connectivity:	A measure of how spatially joined different patches within the landscape are.	Reduction in connectivity limits the exchange of nutrients, energy and species within the landscape.
Corridors:	A strip of land of similar habitat type.	One method for providing connectivity within the landscape. A reduction in corridors or their size reduces the ability of populations to move within the landscape.