6 CONCLUSIONS

The habitat function model provided a useful tool for discovering an assortment of actions with the potential to make the largest improvements in habitat function for juvenile salmonids in the project area. However, even at the subarea scale, only a portion of the opportunities to improve habitat function could be included. The priority recommendations presented in this report represent the best opportunities given the decision system selected for the project, and are representative of several other opportunities that may be available, but offer somewhat smaller potential benefits.

These recommendations have value because they represent an interpretation of current habitat function in the project area, as well as the restoration, rehabilitation, and substitution potential. The recommendations reflect the mosaic of shoreline uses represented in the project area, ranging from particular actions that may be taken in a specific location, to the consideration of actions that may occur over a long stretch of shoreline. Because of multiple shoreline uses, some recommendations were more opportunistic than others, owing to ownership and urban constraints that occur there, while the implementation of others may be part of strategic actions targeting specific habitat goals. In either case, the opportunities identified in this report have a solid justification for restoring habitat function for salmonids migrating through the WRIA 9 marine nearshore.

7 REFERENCES

Aitkin, J. K. 1998. The importance of estuarine habitats to anadromous salmonids of the Pacific Northwest: a literature review. U.S. Fish and Wildlife Service, Olympia, Washington.

Anchor Environmental, L.L.C. (Anchor). 2004. Marine Shoreline Inventory Report, WRIA 9. Prepared for Seattle Public Utilities, WRIA 9. March 2004.

Anchor and Natural Resources Consultants (NRC). 2005. Evaluation and Assessment of Hatchery and Wild Salmon Interactions in WRIA 9. Prepared for WRIA 9 Steering Committee. November 2005.

Beamer, E., A. McBride, R. Henderson, and K. Wolf. 2003. The importance of non-natal pocket estuaries in Skagit Bay to wild chinook salmon: an emerging priority for restoration. Skagit System Cooperative Research Department, La Conner, WA 98257-0368.

Beamish, R. J., and C. Mahnken. 1998. Natural regulation of the abundance of coho and other species of Pacific salmon according to a critical size and critical period hypothesis. NPAFC Doc. No. 319. 26p.

Brennan, J.S., K.F. Higgins, J.R. Cordell, and V.A. Stamatiou. 2004. Juvenile Salmon Composition, Timing, Distribution, and Diet in Marine Nearshore Waters of Central Puget Sound, 2001-2002. King County Department of Natural Resources and Parks, Seattle, WA. 164 pp.

Duffy, E.J. 2003. Early marine distribution and trophic interactions of juvenile salmon in Puget Sound. M.S. Thesis, August 2003. University of Washington School of Aquatic and Fishery Sciences.

Goetz, F.A. and E. Jeanes. 2004. Bull Trout in the Nearshore – Preliminary Draft. Prepared by U.S. Army Corps of Engineers, Seattle District. June 2004.

Hargreaves, B.N. 1997. Early ocean survival of salmon off British Columbia and impacts of the 1983 and 1991-95 El Nino events. *In* Estuarine and ocean survival of Northeastern Pacific

salmon: Proceedings of the workshop, *Edited by* Emmett, R.L., and M.H. Schiewe. NMFS-NWFSC-29.

Healey, M.C. 1982. Juvenile Pacific Salmon in estuaries: the life support system. Pages 315-341 in Kennedy, V. S. editor. Estuarine comparison, Academic Press, New York, New York.

Hirschi, R., T. Doty, A. Keller, and T. Labbe. 2003. Juvenile salmonid use of tidal creek and independent marsh environments in north Hood Canal: summary of first year findings. Port Gamble S'Klallam Tribe Natural Resources.

Holtby, L.B., B.C. Anderson, and R.K. Kadowaki. 1990. Importance of smolt size and early ocean growth to interannual variability in marine survival of coho salmon (*Oncorhynchus kisutch*). Can. J. Fish. Aquat. Sci. 47(11): 2181-2194.

Johannessen, J., A. MacLennan, and A. McBride. 2005. Inventory and Assessment of Current and Historic Beach Feeding Sources/Erosion and Accretion Areas for the Marine Shorelines of Water Resource Inventory Areas 8 and 9. Prepared for The WRIA 9 Steering Committee and King County Department of Natural Resources and Parks. Prepared by Coastal Geologic Services Inc., Bellingham, WA. December 2005.

Kerwin, J. and T.S. Nelson (Eds.). 2000. Habitat Limiting Factors and Reconnaissance Assessment Report, Green/Duwamish and Central Puget Sound Watersheds (WRIA 9 and Vashon Island). Washington Conservation Commission and the King County Department of Natural Resources. December 2000.

Murphy, M.L., H.W. Jaenicke, and E.V. Jr. Farley. 1998. The importance of early marine growth to interannual variability in production of southeastern Alaska pink salmon. NPAFC Tech. Rep. pp. 18-19.

Nelson, T., G. Ruggerone, H. Kim, R. Schaefer, and M. Boles. 2004. Draft – Juvenile Chinook migration, growth and habitat use in the Lower Green River, Duwamish River and Nearshore of Elliott Bay, 2001-2003. Prepared by King County Department of Natural Resources and Parks, Water and Land Resources Division.

Puget Sound Technical Recovery Team (Puget Sound TRT). 2003. Integrated Recovery Planning for Listed Salmon: Technical Guidance for Watershed Groups in Puget Sound.

Shared Strategy. 2005. Regional Nearshore and Marine Aspects of Salmon Recovery in Puget Sound. Compiled and edited by Scott Redmond, Doug Myers, and Dan Averill – Puget Sound Action Team. From contributions by the editors and Kurt Fresh and Bill Graeber, NOAA Fisheries. Delivered to Shared Strategy for Puget Sound for inclusion in their regional salmon recovery plan. June 28, 2005.

Simenstad, C.A. 1983. The ecology of estuarine channels of the Pacific Northwest coast: A community profile. FWS/OBS-83/05. U.S. Fish and Wildlife Service, Olympia, WA.

Simenstad, C. A., K. L. Fresh, and E. O. Salo. 1982. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: An unappreciated function. In: V.S. Kennedy [ed] Estuarine Comparisons. pp.343-365. Academic Press, Toronto.

Simenstad, C.A., and J.R. Cordell. 2000. Ecological assessment criteria for restoring anadromous salmon habitat in Pacific Northwest estuaries. Ecological Engineering 15:283-302.

Sogard, S.M. 1997. Size-selective mortality in the juvenile stage of teleost fishes: A review. Bulletin of Marine Science. 60(3): 1129-1157.

Tovey, C.P. 1999. The relationship between marine survival rates of Robertson Creek chinook salmon (*Oncorhynchus tshawytscha*) and their first marine year lengths and growth rates. M.S. thesis, U. British Columbia. 114 pp.

Washington Department of Fisheries (WDF) et al. 1993. 1992 Washington State Salmon and Steelhead Stock Inventory, appendix one Puget Sound stocks. Prepared by Washington Department of Fisheries, Washington Department of Wildlife, and Western Washington Treaty Indian Tribes, Olympia, Washington.

Washington Department of Fish and Wildlife (WDFW). 1998. 1998 Washington Salmonid Stock Inventory, Appendix Bull Trout and Dolly Varden. Prepared by Washington Department of Fish and Wildlife, Olympia, WA.

WDFW. 2000. 2000 Washington Salmonid Stock Inventory, Appendix Coastal Cutthroat Trout. Prepared by Washington Department of Fish and Wildlife, Olympia, WA.

WDFW. 2002. Washington State Salmon and Steelhead Stock Inventory. Prepared by Washington Department of Fish and Wildlife, Olympia, Washington. Available at SalmonScape at: https://fortress.wa.gov/dfw/salmonscape/ .

WDFW. 2003. Priority Habitats and Species Report. WDFW Office, Olympia, Washington.

Washington Department of Natural Resources (WDNR). 2001. The Washington State ShoreZone Inventory. Washington Department of Natural Resources Nearshore Habitat Program. Available at http://www2.wadnr.gov/nearshore/data/. Olympia, WA.

Washington Trout. 2001. Water Type and Stream Mouth Assessment. Vashon Island. June/July 2001. Information available at: http://www.washingtontrout.org/Vashon/Vashon2001/VashonTitle.shtml .

Water Resource Inventory Area 8 (WRIA 8). 2005. Final Lake Washington Cedar/Sammamish Watershed (WRIA 8) Chinook Salmon Conservation Plan. July 2005.

Water Resource Inventory Area 9 and King County (WRIA 9 and KC). 2004. Draft WRIA 9 Strategic Assessment Report – Scientific Foundation for Salmonid Habitat Conservation. Prepared for Water Resource Inventory Area 9 Steering Committee. June 2004.

WRIA 9. 2005. Salmon Habitat Plan: Making our Watershed Fit for a King. Green/Duwamish and Central Puget Sound Watershed, Water Resource Inventory Area 9. August 2005.

Williams, G.D. and R.M. Thom. 2001. White Paper: Marine and Estuarine Shoreline Modification Issues. Submitted to Washington Department of Fish and Wildlife, Washington Department of Ecology, and Washington Department of Transportation.

Williams, G.D., R.M. Thom, J.E. Starkes, and 14 authors. 2001. Reconnaissance Assessment of the State of the Nearshore Ecosystem: Eastern Shore of Central Puget Sound, Including Vashon and Maury Islands (WRIAs 8 and 9). J.S. Brennan, Editor. Report prepared for King County Department of Natural Resources, Seattle, Washington.

APPENDIX A

FIELD DATA COLLECTION REPORT

Table of Contents

List of Tables

List of Maps

1 FIELD DATA COLLECTION

An identification and prioritization of areas for conservation, restoration, and rehabilitation of juvenile salmonid habitat was performed for the City of Seattle (City) and Water Resource Inventory Area 9 (WRIA 9) (see main report, titled *Prioritization of Marine Shorelines of Water Resource Inventory Area 9 for Juvenile Salmonid Habitat Protection and Restoration*). The prioritization was completed using a Geographic Information System (GIS)-based habitat model. To support this work, a field data collection effort was employed for certain habitat attributes that could not be mapped to sufficient resolution by a previous effort in aerial photo interpretation (Anchor 2004). This appendix presents methods for this effort; resulting data were used in the habitat function model and the prioritization of habitats as described in the main report.

1.1 Data Collection Area

The area for field data collection encompassed the entire project area, including the marine shoreline of Seattle and WRIA 9 (see Map 1, main report). This comprised approximately 90 miles of shoreline, including the entire marine shorelines of the municipalities of Seattle (south of Discovery Point), Burien, Normandy Park, Des Moines, and Federal Way; and the marine shorelines of Vashon and Maury Islands.

1.2 Methods

In this field effort, new data were collected and existing data were refined. New data were collected for habitat features that were either unknown (e.g., groins and marshes) or for which there was insufficient detail following the photo interpretation. "Point" data (single points) were collected for groins and marshes, and "line" data (continuous feature) were collected for shoreline armoring (toe of armoring above, at, or below Ordinary High Water [OHW]).

1.2.1 Boat Survey

Field data collection was completed by proceeding by small boat along the shoreline of the project area, typically in 3 to 4 feet water depth, and collecting location data at points (for groins and marshes) or at line breaks (for shoreline armoring). A laptop loaded with with GIS data layers was used aboard the boat to confirm boat location as well as to groundtruth existing habitat data with observed habitat features. Collected data were

noted in a logbook and input to a project-specific data dictionary in a differential Global Positioning System (DGPS) datalogger (Table A-1).

Table A-1
Data Dictionary Used for Field Data Collection

Feature	Attributes of Feature
Stream Mouth	GPS point feature
	Type (in a pipe, armored, or natural)
	Distance (feet)
	Bearing (magnetic)
Marsh Point	GPS point feature
	Dominant vegetation (text notes – e.g., saltgrass)
	Distance (feet)
	Associated shoreform (text notes – e.g., spit or delta)
	Bearing (magnetic)
Shoreline Armor	GPS line feature
	Armor type/elevation (no armor, armor below OHW, armor above OHW, armor at OHW)
	Distance (feet)
	Bearing (magnetic)
Photo Point	GPS point feature
Data Correction	GPS point feature
	Correction number
	Change To: (insert correct data)
	Distance (feet)
	Bearing (magnetic)

For shoreline armoring, line breaks were recorded for armoring that spanned 50 or more (estimated) continuous feet of shoreline. For example, if the toe of a stretch of armoring was below OHW and adjacent to this there was a different section of armoring with a toe above OHW, a GPS break point was recorded at the point that the above-OHW armoring began. A GPS point was recorded when the boat was approximately perpendicular to the shoreline at the 'new' section of armoring (distance and bearing offsets recorded).

In addition to collecting new information, the field survey ground-truthed data for habitat features that were previously characterized in the photo interpretation. On the boat, the GIS data layers were compared with field conditions and errors in characterization were corrected. For example, if an object was previously characterized in the photo interpretation as a boat ramp, but during the field survey, it was recognized

as a small dock, a GPS location was recorded and the correction was noted. Notes and GPS locations were also recorded for stream mouths that were observed in the field but not present on existing GIS stream data layers. Also, certain areas that were identified as “difficult to interpret” in the previous photo interpretation were visited and characterized.

During the field survey, certain shoreline features were observed that did not fit the data collection categories; these were noted as Unidentified Feature Objects (UFOs). While these features did not fit the shoreline categories being specifically noted in the field survey, the field team included these for completeness of shoreline information in the project area. These constituted unusual configurations of shoreline features such as shoreline armoring, overwater cover, beach structures, marine rails, and boat lifts. In these cases, a GPS location was recorded and a photo was taken of the area. Locations and photos of the UFOs can be viewed further in the GIS layers (Appendix B of the main report).

1.2.2 Decision Rules

In most cases, characteristics of habitat features were immediately obvious to the field crew (i.e., armoring above OHW was visually obvious as armoring above OHW), but some features required interpretation. For example, some stretches of the shoreline exhibited rock piles that could be called armoring, and some shorelines exhibited very short stretches of armoring that did not justify a separate line break. The following sections, pictures, and captions describe the rules used for these habitat features and cases.

1.2.2.1 Armoring and Change in Armoring Elevation

Armoring was not mapped as such if it covered less than 50 linear feet of the shoreline (e.g., Photo 1). In instances of uncertainty whether armoring spanned at least 50 feet, the break location was always collected (as opposed to not collecting a break location). Changes in armoring elevation were not mapped if armoring covered less than 50 linear feet of the shoreline (e.g., Photos 2 and 3). In instances of uncertainty whether the change in armoring elevation spanned at least 50 feet, the break location was always collected (as opposed to not collecting a break location).

Rock armoring was not mapped as such if it was visually uncertain whether the rock was placed rock (and not part of a failing upland wall or naturally occurring boulder pile) (e.g., Photo 4). Piles of wood scraps or derelict wood building remnants were not mapped as armor (e.g., Photo 5), and piles with no bulkhead behind them were not mapped as armor (e.g., Photo 6).

Photo 1
Mainland, South of Des Moines Marina. Unarmored section (approximately 10 feet) too short to map.

Photo 2
Mainland near Normandy Beach Park. Break in "armoring below OHW" to "armoring above OHW" was mapped because stretch of shoreline with change in armoring elevation is approximately at least 50 linear shoreline feet in length.

Photo 3
South end of Vashon Island, near Point Dalco. Shoreline section behind ladder and sailboat not mapped as "armoring above OHW" because section too short to note (less than 50 linear shoreline feet).

Photo 4
Mainland, South of Dash Point. Unclear whether placed rock.

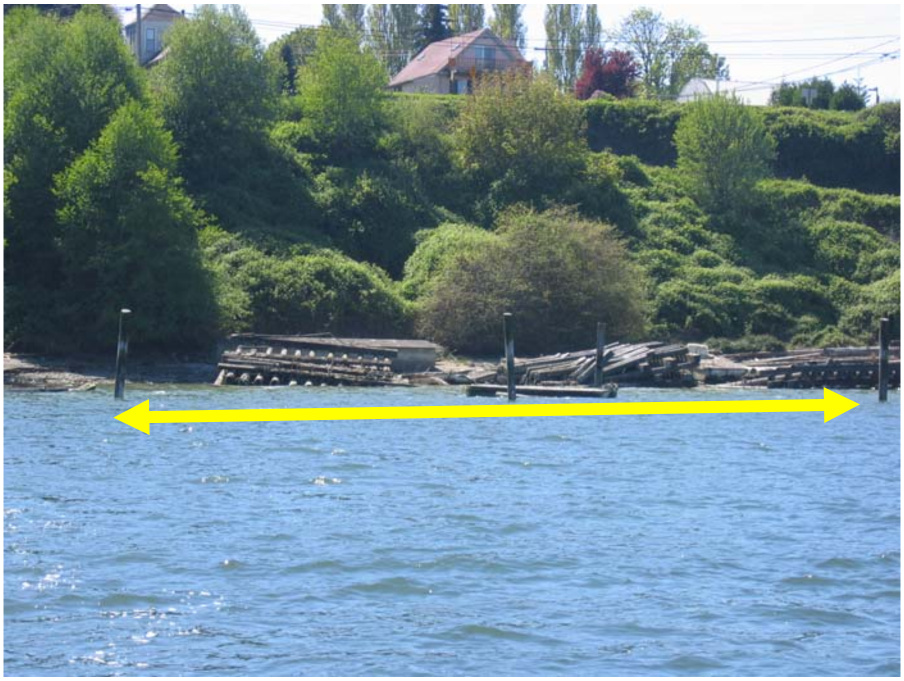


Photo 5
West side of Maury Island, Northeast of Dockton. Debris on shore not mapped as armor.

Photo 6
West side of Vashon Island, near Sandford Point. Piles with no bulkhead behind them not mapped as armor.

1.2.2.2 Groins

During the field survey, groins were defined broadly so as to capture the function and intent of groin-like structures in the project area. Groins were mapped as follows: cross-shore structures appearing to be groins that were impeding or not impeding sediment on one side; or cross-shore structures not intended to be groins that were impeding sediment on one side. For the purpose of the habitat model, groins were grouped into categories of "effective" if impeding sediment or "not effective" if not impeding sediment (e.g., Photos 7 through 9) based on field conditions. Concrete stairs in general showed little to no evidence of sediment impediment and thus for the purposes of the model were not mapped as groins (e.g., Photo 10).

Photo 7
Vashon Island, North end of Quartermaster Harbor. The buttress-like features shown were characterized as "not effective" groins.

Photo 8
East side Vashon Island, North of Point Beals. The failed rock groins shown were characterized as “not effective” groins.

Photo 9
Vashon Island, west side of Quartermaster Harbor. The big rock pile shown was characterized as a "not effective" groin.

Photo 10
West side of Maury Island, near Manzanita. Concrete stairs in intertidal not mapped as groins.

1.2.2.3 Marshes

Some areas in the field survey contained shoreline vegetation that appeared to be marsh on aerial photos, but upon closer inspection were comprised of turfgrass growing close to shore. These areas were not mapped, absent marsh vegetation (e.g., Photo 11).

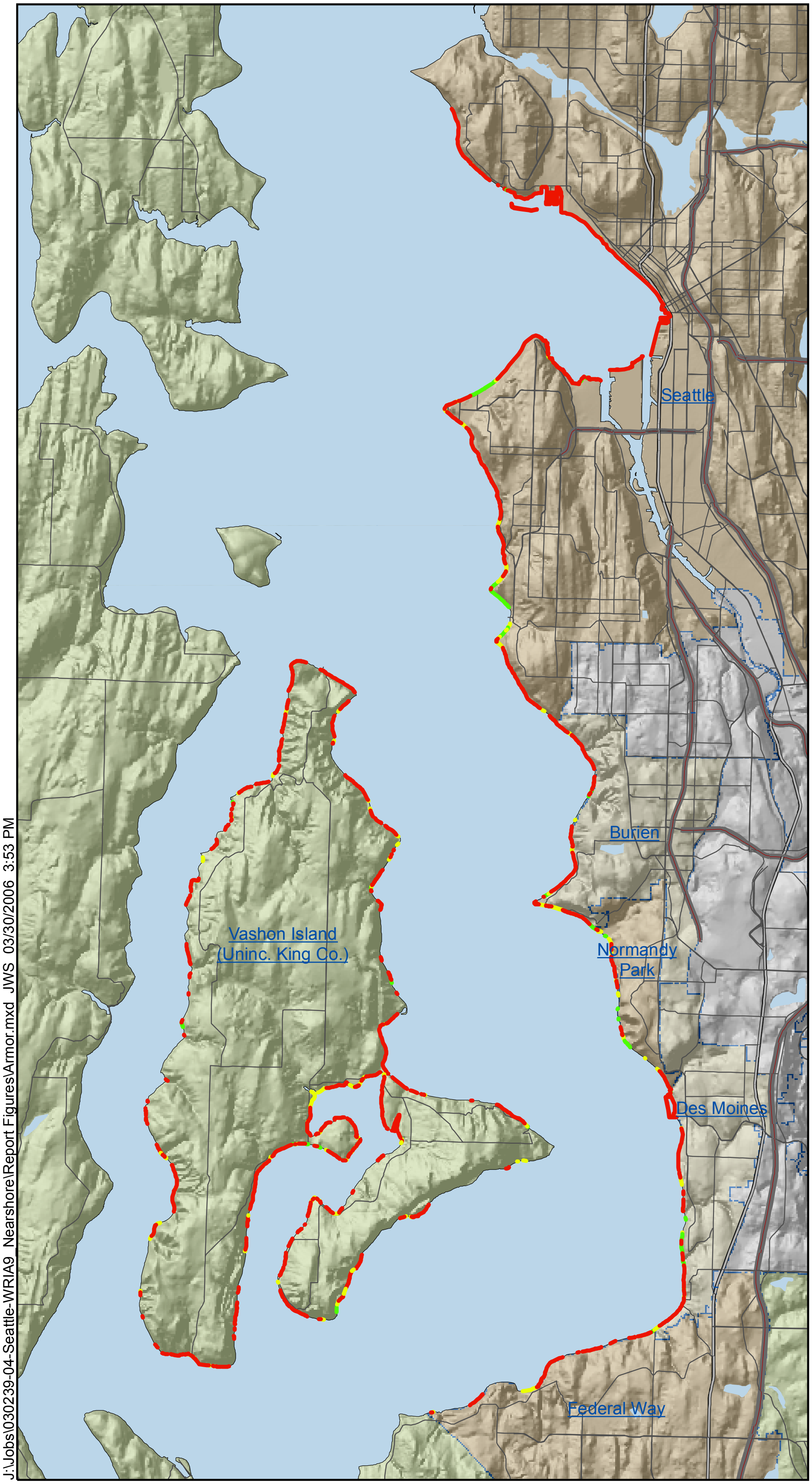
Photo 11
Mainland, South of Dash Point. Turfgrass area not mapped as marsh.

1.3 Results and Use of Data

Results from the field data collection were collated for the purpose of use in the habitat function model developed for the project. Layers were created or updated for the following habitat features:

- Marshes
- Groins
- Shoreline armoring (elevation)
- Docks
- Ramps
- Marine rails

New maps produced using information from the field verification show the location of armoring and its relative elevation to OHW; the location of stream mouths and marshes; and the location of shoreline structures such as ramps, groins, and marine rails (Maps A-1, A-2, and A-3). More data from the field effort described in this appendix can be viewed in ArcGIS format in Appendix B of the main report.



LEGEND

Shoreline Armor

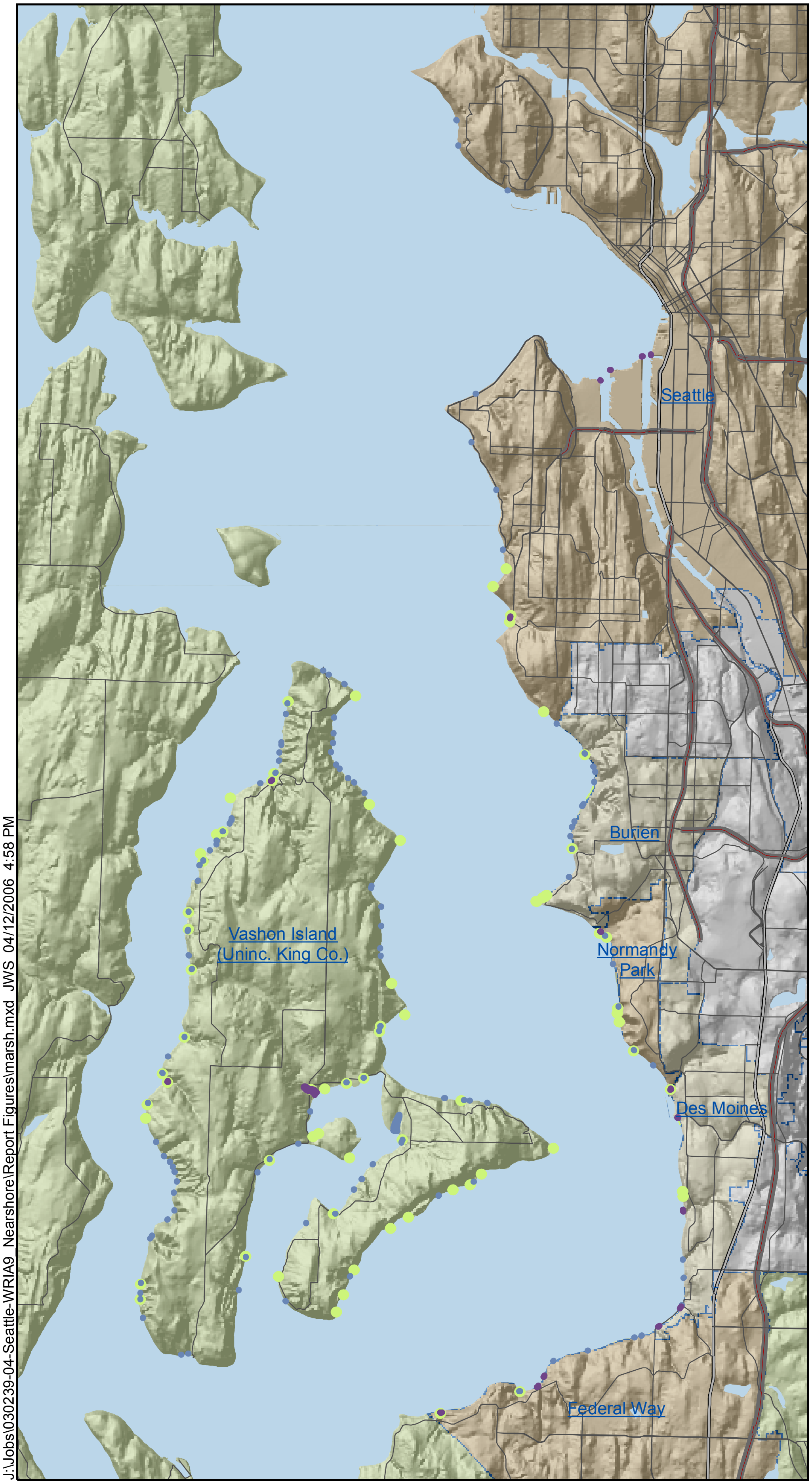
- Armor Above OHW
- Armor At OHW
- Armor Below OHW

J:\Jobs\030239-04-Seattle-WRIA9_Nearshore\Report Figures\Armor.mxd JWS 03/30/2006 3:53 PM

ANCHOR ENVIRONMENTAL, L.L.C.

0 0.5 1 2
Scale in Miles

Map A-1
Shoreline Armor
Field Data Collection Report
WRIA 9 Nearshore Habitat Assessment



LEGEND

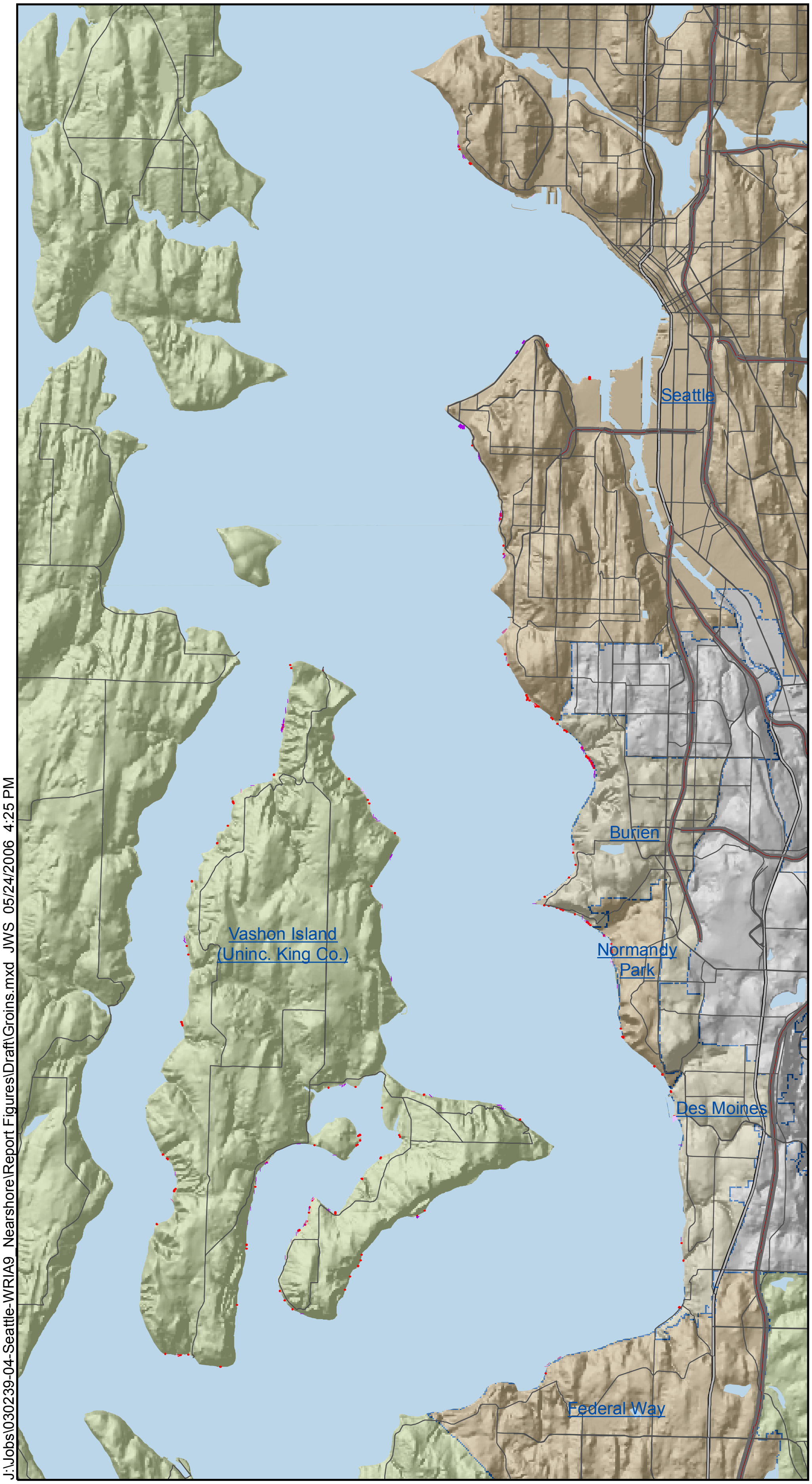
Stream Mouths

- Not Salmon Bearing
- Salmon Bearing
- Marsh Vegetation

J:\Jobs\030239-04-Seattle-WRIA9_Nearshore\Report Figures\marsh.mxd JWS 04/12/2006 4:58 PM

ANCHOR ENVIRONMENTAL, L.L.C.

Map A2
Marshes and Stream Mouths
Field Data Collection Report
WRIA 9 Nearshore Habitat Assessment



LEGEND

- Ramps
- Ineffective Groin
- Effective Groin
- Marine Rails

ANCHOR ENVIRONMENTAL, L.L.C.

0 0.5 1 2
Scale in Miles

N

Map A-3
Groins, Marine Rails, Ramps
Field Data Collection Report
WRIA 9 Nearshore Habitat Assessment

2 REFERENCES

Anchor Environmental, L.L.C. (Anchor). 2004. Marine Shoreline Inventory Report, WRIA 9. Prepared for Seattle Public Utilities, WRIA 9. March 2004.

APPENDIX B

FINAL GIS DATA LAYERS (DATA CD)

APPENDIX C

SCORING SYSTEM FOR HABITAT FUNCTION MODEL

Table of Contents

List of Tables

1 INTRODUCTION

This appendix presents the scoring system of a habitat function model used to characterize marine nearshore shoreline reaches in Water Resource Inventory Area 9 (the Green/Duwamish Watershed; WRIA 9). The habitat function model was one tool used to identify priority areas for conservation, restoration, rehabilitation, and substitution of habitat for juvenile salmonids (see main report, titled *Prioritization of Marine Shorelines of Water Resource Inventory Area 9 for Juvenile Salmonid Habitat Protection and Restoration*).

The scoring system was developed by the project team with collaboration of scientists from multiple entities in WRIA 9 to quantify the relative contribution (beneficial or adverse) of each habitat feature to the overall ecological function of the shoreline for juvenile salmonids. Scores were assigned relative to one another based on scientific literature pertaining to nearshore processes and biological research.

2 MODEL FRAMEWORK

The habitat function model assigns scores for a suite of habitat parameters that contribute to or provide habitat function for juvenile salmonids in the marine nearshore. The basic model scoring formula assigns scores based on current conditions. Shoreline segments with the highest scores for current condition can be interpreted as those with the highest conservation value.

Additional scoring formulas were developed for rehabilitation and restoration. Substitution opportunities were identified through consideration of current habitat function and potential restored habitat function, as well as the apparent feasibility of restoration given an area's infrastructure constraints. The rehabilitation scoring formula modifies the current condition formula by assuming that all potential rehabilitation actions of the habitat parameters used in the model have been conducted. In keeping with the Puget Sound Technical Recovery Team definitions (Puget Sound TRT 2003), rehabilitation actions are those that will improve habitat function, but may have limited or no impact on the underlying processes. An example of a rehabilitation action is the addition of riparian vegetation. Using the Puget Sound TRT definitions, substitution actions are those that create habitat features to replace lost function. Substitution can be applied where habitat function is lost through anthropogenic degradation and restoration or rehabilitation are not possible. An example of a substitution action is the placement of sediment in the intertidal zone to "nourish" the beach where no other potential sediment source could be restored or rehabilitated.

Similarly, the restoration scoring formula assumes that all potential restoration actions of the habitat parameters used in the model have been conducted. An example of a restoration action is the removal of barriers to re-establish sediment connectivity between bluffs and the intertidal zone.

Each scoring formula uses multiple habitat features to characterize habitat function in three components of the nearshore:

- Sediment supply – the availability of sediment from naturally occurring processes such as coastal erosion and stream transport, and the integrity of the process in transporting that sediment along the shore to nourish and create broad, shallow water beaches and to support aquatic vegetation

- Migration corridor – the quality and continuity of the shallow subtidal and intertidal corridor used by juvenile salmon to migrate along the shore, including the ability of the corridor to provide refuge from high energy conditions and predators
- Riparian corridor – the quality of the riparian corridor as it influences the availability of terrestrial or freshwater prey resources and organic matter from the vegetative canopy, and as it provides shade (cover from predators and protection for spawning forage fish)

The habitat features used in this evaluation were selected for their contribution to providing or affecting one or more of the essential ecological functions for juvenile salmonids (see main report). Table C-1 identifies the habitat features and descriptors used to characterize the three nearshore components. Data sources were selected for their ability to provide coverage of the entire study area and to describe the structure and process of the nearshore habitat in terms of the ecological function that habitat provides to juvenile salmon.

Data were input into the model and snapped to the topology of the Mean Higher High Water line of the shoreline modified from the ShoreZone Inventory of Washington (WDNR 2001). Discrete shoreline segments were created by inserting a line break at the point that any feature or attribute of the data changed. Each shoreline segment was given a discrete score for current habitat function. The resulting output was a single polyline shapefile with segments of varying lengths and current function scores, each of which represented a homogeneous condition in relation to all the data describing that segment's habitat function.

Table C-1
Data Used in the Evaluation of the Ecological Function of Habitats

Nearshore Component	Habitat Feature	Habitat Feature Descriptor	Data Source
Sediment Supply	Shore type (including consideration of shoreline armoring [e.g., bulkheads, rock riprap, and seawalls])	Sediment process shore type	Johannessen et al. (2005) with additional armor information from Anchor (2004)
	Obstructions to longshore sediment transport	Presence of groins, boat ramps, and marine rails	Anchor (Appendix A, main report)
Migration Corridor	Aquatic vegetation	Presence of eelgrass, macroalgae, or kelp	ShoreZone (WDNR 2001)
	Forage fish spawning	Documented forage fish spawning	Priority Habitats and Species Data (provided by King County, 2003, from WDFW 2003)
	Beach width	Intertidal beach slope	ShoreZone (WDNR 2001)
	Shoreline armor in intertidal zone	Shoreline armor toe depth	Anchor (Appendix A, main report)
	Overwater structures	Presence of piers, docks, or houses over the water	Anchor (2004)
Riparian Corridor	Riparian vegetation	Condition of riparian vegetation, including vegetation type, location, and continuity	Anchor (2004)
	Marshes	Presence of supratidal salt marsh	Anchor (Appendix A, main report)
	Stream mouths	Location and condition (e.g., piped, armored, unarmored) of stream mouths and use of stream for spawning by anadromous salmonids	King County (2004), Johannessen et al. (2005), Washington Trout (2001), Anchor (Appendix A, main report)

3 HABITAT FUNCTION MODEL SCORING SYSTEM

Table C-2 presents the scoring system used to characterize current conditions, rehabilitated conditions, and restored conditions. The rehabilitation scoring formula assumes that the following improvements can be made:

- Obstructions to longshore transport (groins, boatramps, and marine rails) are removed[1]
- Shoreline armoring elevation is improved such that armoring currently below ordinary high water (OHW) is moved to OHW and armoring at OHW is moved above OHW
- Overwater structures (docks, piers, and houses) are removed
- Riparian vegetation is improved to provide patchy trees adjacent to the intertidal zone, if current conditions provide less function
- Stream mouth conditions are improved such that currently piped stream mouths are daylighted to become armored and currently armored stream mouths become unarmored

The restoration scoring formula assumes that the following improvements can be made:

- Sediment supply connectivity is restored through removal of shoreline armor and historic shoretypes are re-established
- Obstructions to longshore transport (groins, boatramps, and marine rails) are removed
- Overwater structures (docks, piers, and houses) are removed
- Riparian vegetation is improved to provide continuous trees adjacent to and overhanging the intertidal zone with large woody debris (LWD) across the intertidal zone in all areas
- All stream mouth modifications (pipes and armoring) are removed
- Marsh conditions are improved from patchy to continuous

Rehabilitation potential was calculated for each segment as the difference between the rehabilitation score and the current function score. Similarly, restoration potential was calculated for each segment as the difference between the restoration score and the current function score.

---

[1] In general, marine rails in the nearshore can be designed to minimize impacts to longshore sediment transport and reflected wave energy (and can more easily be designed to do so than boat ramps). However, in a rehabilitation scenario, the recommendation includes removing marine rails because of their presence as a physical structure in the nearshore and their general potential to impede sediment.

Table C-2
Scoring System of Habitat Function Model

Nearshore Component		Current Conditions	Rehabilitated Conditions	Restored Conditions
Sediment Supply	Formula	**Shoretype * (1 - Obstructions to longshore transport)**		
	Contributing Habitat Features	Current Shoretype per Johannessen et al. (2005) FBE = 35 FB = 30 AS = 15 TA = 5 NAD = 0 MOD = 0 and if Anchor (2004) armoring.shp indicates armor is present then MOD score applied	Current Shoretype per Johannessen et al. (2005) FBE = 35 FB = 30 AS = 15 TA = 5 NAD = 0 MOD = 0 and if Anchor (2004) armoring.shp indicates armor is present then MOD score applied	Historic Shoretype per Johannessen et al. (2005) FBE = 35 FB = 30 AS = 15 TA = 5 PFB = 5 NFB = 5 NAD = 0
		Obstructions within 0.6 miles downdrift per Anchor (2004) and Anchor (Appendix A, main report) Number of effective groins + (0.5 * number of ineffective groins, boat ramps, marine rails) none = 0.0 1 to 5 = 0.1 5 or more = 0.2	Assumes all groins, boat ramps, and marine rails have been removed, so score = 0.0	Assumes all groins, boat ramps, and marine rails have been removed, so score = 0.0

Nearshore Component		Current Conditions	Rehabilitated Conditions	Restored Conditions
Migration Corridor	Formula	**Aquatic vegetation + Forage fish + (Beach width * (1 – (Armor elevation + Overwater structures)))**		
	Contributing Habitat Features	Aquatic vegetation score is highest single value of the following per WDNR (2001): Eelgrass continuous = 15 Eelgrass patchy = 10 Macroalgae (CHB, GCA, MAC, NER, RED, SAR, SBR) continuous = 10 Macroalgae patchy = 5 Ulva continuous = 5 Ulva patchy = 2	Score is highest single value of the following per WNDR (2001): Eelgrass continuous = 15 Eelgrass patchy = 10 Macroalgae (CHB, GCA, MAC, NER, RED, SAR, SBR) continuous = 10 Macroalgae patchy = 5 Ulva continuous = 5 Ulva patchy = 2	Score is highest single value of the following per WNDR (2001): Eelgrass continuous = 15 Eelgrass patchy = 10 Macroalgae (CHB, GCA, MAC, NER, RED, SAR, SBR) continuous = 10 Macroalgae patchy = 5 Ulva continuous = 5 Ulva patchy = 2
		Forage fish per WDFW (2003) Spawning documented = 5 No spawning documented = 0	Forage fish per WDFW (2003) Spawning documented = 5 No spawning documented = 0	Forage fish per WDFW (2003) Spawning documented = 5 No spawning documented = 0
		Beach slope per WDNR (2001) Slope less than 5^o (BC_Class 24, 26, 28, or 29) = 10 Slope more than 5^o (BC_Class 22, 25, 27, or 30) = 9 Man made (BC_Class 32 or 33) = 2	Beach slope per WDNR (2001) Slope less than 5^o (BC_Class 24, 26, 28, or 29) = 10 Slope more than 5^o (BC_Class 22, 25, 27, or 30) = 9 Man made (BC_Class 32 or 33) = 2	Beach slope per WDNR (2001) Slope less than 5^o (BC_Class 24, 26, 28, or 29) = 10 Slope more than 5^o (BC_Class 22, 25, 27, or 30) = 9 Man made (BC_Class 32 or 33) = 2
		Current armor elevation per Anchor (Appendix A, main report) No armor or elevation above OHW = 0.0 At OHW = 0.1 Below OHW = 0.3	Current armor elevation per Anchor (Appendix A, main report) No armor or elevation above OHW = 0.0 Assumes armor currently at OHW is moved above OHW, so score = 0.0 Assumes armor currently below OHW is move to at OHW, so score = 0.1	Current armor elevation per Anchor (Appendix A, main report) Assumes all armor is removed, so score = 0.0
		Current overwater structures per Anchor (2004) None present = 0.0 Present with total width < 20 ft = 0.2 Present with total width ≥ 20 ft = 0.4	Assumes all overwater structures are removed, so score = 0.0	Assumes all overwater structures are removed, so score = 0.0

<table>
<tr><th>Nearshore Component</th><th></th><th>Current Conditions</th><th>Rehabilitated Conditions</th><th>Restored Conditions</th></tr>
<tr><td rowspan="5">Riparian</td><td>Formula</td><td colspan="3">Riparian vegetation + Marsh + (Streams * (1 - stream mouth condition))</td></tr>
<tr><td rowspan="4">Contributing Habitat Features</td><td><u>Riparian vegetation per Anchor (2004) sum of the following</u>
Type: trees = 3, shrubs = 1, grass = 0
Proximity to intertidal: adjacent =1, separated = 0
Overhanging intertidal: yes = 2, no = 0
Density: continuous = 2, patchy = 1
LWD: yes = 2, no = 0</td><td><u>Riparian vegetation per Anchor (2004) sum of the following</u>
Assumes areas with current riparian vegetation other than trees are improved to having patchy trees adjacent to the intertidal, so score = 5
Areas with current riparian vegetation of continuous trees adjacent to intertidal would still receive a score = 6
Overhanging intertidal: yes = 2, no = 0
LWD: yes = 2, no = 0</td><td><u>Riparian vegetation per Anchor (2004) sum of the following</u>
Assumes all areas are improved to provide continuous trees adjacent to and overhanging the intertidal zone and having LWD, so score = 10</td></tr>
<tr><td><u>Marshes per Anchor (Appendix A, main report)</u>
Continuous marsh at AS = 10
Continuous marsh not at AS = 5
Patchy marsh at AS = 5
Patchy marsh not at AS = 2
No marsh = 0</td><td><u>Marshes per Anchor (Appendix A, main report)</u>
Continuous marsh at AS = 10
Continuous marsh not at AS = 5
Patchy marsh at AS = 5
Patchy marsh not at AS = 2
No marsh = 0</td><td><u>Marshes per Anchor (Appendix A, main report)</u>
Assumes all marshes become continuous, so current condition
Continuous marsh at accretion shoreform (AS) = 10
Continuous marsh not at AS = 5
Patchy marsh at AS = 10
Patchy marsh not at AS = 5
No marsh = 0</td></tr>
<tr><td><u>Stream mouths per Anchor (Appendix A, main report)</u>
Salmon stream within 100 feet = 10
Non-salmon stream within 25 feet = 2</td><td><u>Stream mouths per Anchor (Appendix A, main report)</u>
Salmon stream within 100 feet = 10
Non-salmon stream within 25 feet = 2</td><td><u>Stream mouths per Anchor (Appendix A, main report)</u>
Salmon stream within 100 feet = 10
Non-salmon stream within 25 feet = 2</td></tr>
<tr><td><u>Stream mouth condition per King County (2004), Johannessen et al. (2005), Washington Trout (2001), Anchor (Appendix A, this volume)</u>
Unarmored = 0.0
Armored = 0.3
Piped = 0.9</td><td><u>Stream mouth condition per King County (2004), Johannessen et al. (2005), Washington Trout (2001), Anchor (Appendix A, this volume)</u>
Assumes currently armored stream mouths are improved to be unarmored, so score = 0.0
Assumes currently piped streams are improved to be only armored, so score = 0.3</td><td>Assumes all stream mouths are improved to be unarmored, so score = 0.0</td></tr>
</table>

FBE = feeder bluff exceptional
FB = feeder bluff
AS = accretion shoreform
TA = transition area
NAD = no appreciable drift
MOD = modified
PFB = potential feeder bluff
NFB = not feeder bluff
CHB = chocolate browns
GCA = *Gracilaria*
MAC = M*acrocystis*
NER = *Nereocystis* (kelp)
RED = *Gigartina-Odonthalia-Prionitis-Polysiphonia* and others
SAR = *Sargassum*
SBR = soft browns

4 RATIONALE FOR THE SCORING SYSTEM

This section describes the information used to determine which habitat features to use in the model and the justification for the scoring system. It is important to note that habitat feature selection also required the availability of a consistent dataset for the entire project area.

4.1 Sediment Supply Shoretype

The introduction, movement, and deposition of sediment to the marine nearshore of Puget Sound is a major habitat-forming and habitat sustaining process (Shared Strategy 2005). A key source of sediment to the intertidal zone is through the natural erosion of bluffs. Through the movement of sediment along a beach in sectors called drift cells, a sediment source area (feeder bluff) can provide sediment that feeds the beach over many miles. Shoreline armoring, such as bulkheads, disconnects potential sediment sources from the intertidal zone and through the interruption of the sediment supply can impact beach function over many miles (depending on the size of the drift cell).

The scoring system was developed to emphasize the importance of feeder bluffs as sediment sources and add even greater importance to areas identified by Johannessen et al. (2005) as exceptional feeder bluffs. Accretion shoreforms that are the landform created by the sediment deposition at the downdrift end of a drift cell were given a moderate score. Large, intact accretion shoreforms can provide lagoons and pocket estuaries that provide high quality habitat for juvenile salmon rearing (Hirschi et al. 2003; Beamer et al. 2003). Modified shorelines disconnect shorelines or provide altered transport or depositional conditions, so no score was assigned.

4.2 Obstructions to Longshore Sediment Transport

Shoreline alterations that obstruct the movement of sediment along the beach can impact the supply of sediment to downdrift areas (Ecology 2006). Alterations, such as groins, are intentionally built to restrict sediment movement. The interruption of sediment transport is an indirect effect of shoreline alterations such as boat ramps and groins, and to a lesser degree, marine rails.

The range of impact that groins may have is estimated at 0.6 mile (1 kilometer); that is, a groin within 0.6 miles downdrift of a sediment supply was considered to reduce the

sediment supply's contribution to nearshore habitat function. This distance was estimated using best professional judgment as to a reasonable length of shoreline that may be affected by the presence of a groin located "updrift" in the drift cell.

4.3 Aquatic Vegetation

The importance of eelgrass in the marine nearshore is well documented (e.g., Simenstad et al. 1982; Thom 1985; Williams et al. 2001). Eelgrass productivity exceeds that of most other aquatic vegetation, and the organic carbon produced by eelgrass is particularly important in driving the nearshore food web (Williams et al. 2001). Eelgrass also provides vertical structure that can provide predator refuge for juvenile salmonids.

Other types of aquatic vegetation, such as macroalgae and kelp, can provide similar functions. Kelp and macroalgae support productive prey communities for juvenile salmonids by providing material for grazing by epibenthic prey communities (Northcote et al. 1979; Healey 1982; Brennan et al. 2004). Intertidal vegetation also provides vertical structure that can provide predator refuge for juvenile salmonids. Juvenile chum have been observed using vegetation as a refuge from predators (Tompkins and Leving 1991).
The many types of kelp and macroalgae found in the project area were grouped together because there was not sufficient information to differentiate between the values of the vegetation types for juvenile salmonids. *Ulva* was excluded from this group of kelp and macroalgae and not scored in the model because it was ubiquitous in the project area and would therefore decrease the contribution of the aquatic vegetation parameter to habitat function. The potential negative effects of an overabundance of *Ulva*, such as changes to benthic macroinvertebrate communities and prevention of larval settlement (Frankenstein 2000), also were considered in excluding it from the scoring system.

4.4 Forage Fish Spawning

The importance of forage fish in the diets of juvenile salmonids is well documented (e.g., Bargmann 1998; Healey 1980). However, much of the forage fish spawning survey data in the Washington Department of Fish and Wildlife (WDFW) database is approximately 30 years old and may no longer be applicable. The questionable quality of the existing database was the basis for assigning a lower score to the presence of forage fish spawning compared to other parameters in the model.

4.5 Beach Width

Beach width and beach slope affect the area of the highly productive intertidal and shallow subtidal elevations that provide food and shelter for juvenile salmon. Areas with less than 5° slope were assigned a slightly higher score than areas with greater than 5° slope to account for the larger amount of shallow water habitat available in the lower gradient beaches. Man-made areas are those with no natural substrate in the intertidal zone, and were typically dredged areas providing steep intertidal slopes and little intertidal habitat.

4.6 Armor Elevation

Shoreline structures that encroach upon the intertidal zone can impede forage fish access to the upper intertidal beach elevations where they spawn, thus limiting food resource availability for juvenile salmonids. In addition, shoreline armoring restricts juvenile salmonid access to gently sloping upper intertidal beach habitats that larger predators cannot access. These shoreline structures force juvenile salmonids to move along shorelines in deeper areas than they ideally would, and where they may be more vulnerable to predation (Thom et al. 1994; Pentec 1997). Even in areas where the shoreline armoring does not encroach across the entire upper intertidal zone, the structures tend to reflect wave energy, which causes scour of smaller substrate sizes utilized by forage fish and exacerbates the interruption to sediment transport caused by the structures (Williams and Thom 2001).

4.7 Overwater Structures

Overwater structures, such as docks, can have negative behavioral effects on juvenile salmonids that interrupt their migration and movements along the shoreline (Salo et al. 1980; Pentec 1997; Simenstad et al. 1999; Thom et al. 2006). Overwater structures can also reduce prey availability through the negative impacts on vegetation caused by the lack of light (Penttila and Doty 1990; Fresh et al. 1995; Olson et al. 1996; Haas et al. 2002). The location and width of overwater structures was determined by snapping the polygon shape of each structure to the shoreline. Portions of the shoreline that were intersected by the snapped polygon were considered to have overwater structure, the length of the intersection was considered to be the width of the overwater structure.

4.8 Riparian Vegetation

Riparian vegetation provides the most direct link between terrestrial and aquatic ecosystems (Spence et al. 1996; Levings and Jameson 2001). Riparian vegetation, especially overhanging portions, is an important source for terrestrial input of organic matter and nutrients (Spence et al. 1996; Maser and Sedell 1994; Williams et al. 2001; Brennan et al. 2004; Brennan and Culverwell 2004).

Overhanging riparian vegetation can limit the vulnerability of juvenile salmonids to bird predators by providing shallow areas where flying birds cannot see them. Shallow water areas with cover also provide refuge habitat from larger fish predators.

4.9 Marshes

Juvenile salmonids have been documented to extensively use marsh areas (Simenstad et al. 1982; Healey 1980 and 1982; Levy and Northcote 1981). Marsh habitats are high functioning areas that support primary productivity, the detrital food web, and juvenile salmonid prey production (Levings et al. 1991; Williams et al. 2001).

Juvenile salmonids can utilize marsh habitats as refuge from predators. The smaller fish can move among the marsh vegetation better than their larger potential predators. Simenstad et al. (1999) noted that juvenile salmon in the nearshore prefer to migrate along the edges of refugia.

5 REFERENCES

Anchor Environmental, L.L.C. (Anchor). 2004. Marine Shoreline Inventory Report, WRIA 9. Prepared for Seattle Public Utilities, WRIA 9. March 2004.

Bargmann, G. 1998. Forage Fish Management Plan. Washington Department of Fish and Wildlife. 65pp.

Beamer, E., A. McBride, R. Henderson, and K. Wolf. 2003. The importance of non-natal pocket estuaries in Skagit Bay to wild chinook salmon: an emerging priority for restoration. Skagit System Cooperative Research Department, La Conner, WA 98257-0368.

Brennan, J.S., and H. Culverwell. 2004. Marine Riparian: An Assessment of Riparian Functions in Marine Ecosystems. Published by Washington Sea Grant Program. Seattle, WA.

Brennan, J.S., K.F. Higgins, J.R. Cordell, and V.A. Stamatiou. 2004. Juvenile Salmon Composition, Timing, Distribution, and Diet in Marine Nearshore Waters of Central Puget Sound, 2001-2002. King County Department of Natural Resources and Parks, Seattle, WA. 164 pp.

Frankenstein, G. 2000. Blooms of Ulvoids in Puget Sound. Prepared for the Puget Sound Water Quality Action Team. November 2000.

Fresh, K.L., B. Williams, and D. Penttila. 1995. Overwater structures and impacts on eelgrass (Zostera marina) in Puget Sound, Washington. Pages 537-577 in Puget Sound Research '95 Proceedings. Puget Sound Water Quality Authority, Olympia, Washington.

Haas, M.E., C.A. Simenstad, J.R. Cordell, D.A. Beauchamp, and B.S. Miller. 2002. *Effects of Large Overwater Structures on Epibenthic Juvenile Salmon Prey Assemblages in Puget Sound, Washington*. Technical Report T1803-30, School of Aquatic and Fishery Sciences, University of Washington. Prepared for Washington State department of Transportation (WSDOT).

Healey, M.C. 1980. Utilization of the Nanaimo River estuary by juvenile chinook salmon, *Oncorhynchus tshawytscha*. Fish. Bull. 77(3): 653-668.

Healey, M.C. 1982. Juvenile Pacific Salmon in estuaries: the life support system. Pages 315-341 in Kennedy, V. S. editor. Estuarine comparison, Academic Press, New York, New York.

Hirschi, R., T. Doty, A. Keller, and T. Labbe. 2003. Juvenile salmonid use of tidal creek and independent marsh environments in north Hood Canal: summary of first year findings. Port Gamble S'Klallam Tribe Natural Resources.

Johannessen, J., A. MacLennan, and A. McBride. 2005. Inventory and Assessment of Current and Historic Beach Feeding Sources/Erosion and Accretion areas for the Marine Shorelines of Water Resource Inventory Areas 8 and 9. Prepared for The WRIA 9 Steering Committee and King County Department of Natural Resources and Parks. Prepared by Coastal Geologic Services Inc., Bellingham, WA. December 2005.

King County. 2004. King County GIS Data, CD#3, Standard Data, Shapefile Format, Issued March 2004.

Levings. C.D., K. Conlin and B. Raymond. 1991. Intertidal habitats used by juvenile Pacific salmon rearing in the north arm of the Fraser River estuary. Marine Pollution Bulletin, Volume 22, No 1 pp 20-26.

Levings, C. and G. Jamieson. 2001. Marine and estuarine riparian habitats and their role in coastal ecosystems, Pacific region. Canadian Science Advisory Secretariat, Research Document 2001/109. 41pp.

Levy, T. A. and T.G. Northcote. 1981. The distribution and abundance of juvenile salmon in marsh habitats of the Fraser River Estuary. University of British Columbia, Westwater Research Center, Technical Report 25, Vancouver, British Columbia.

Maser, C. and J.R. Sedell. 1994. From the forest to the sea, the ecology of wood in streams, river, estuaries, and oceans. St. Lucie Press, Delray Beach, Florida.

Northcote, T.G., N.T. Johnston and K. Tsumura. 1979. Feeding relationships and food web structure of Lower Framer River fishes. Technical Report No. 16. Vancouver: Westwater Research Centre, University of British Columbia

Novotny, V., and H. Olem. 1994. Water Quality: Prevention, Identification, and Management of Diffuse Pollution. Van Nostrand Reinhold. New York, NY.

Olson, A.M., S. D. Visconty, and C. M. Sweeny. 1996. A new approach to modeling the shade cast by overwater structures. Abstract for the Pacific Estuarine Research Society 19th Annual Meeting. Washington Department of Ecology, Olympia, WA.

Pentec. 1997. Movement of juvenile salmon through industrialized areas of Everett Harbor. Prepared for the Port of Everett, Washington. Prepared by Pentec Environmental, Edmonds, WA.

Penttila D. and D. Doty. 1990. Results of 1989 eelgrass shading studies in Puget Sound. Progress Report. Marine Fish Habitat Investigation Division, Washington Department of Fish and Wildlife. Olympia, Washington.

Puget Sound Technical Recovery Team (Puget Sound TRT). 2003. Integrated Recovery Planning for Listed Salon: Technical Guidance for Watershed Groups in Puget Sound.

Salo, E.O., N.J. Bax, T.E. Prinslow, C.J. Whitmus, B.P. Snyder, and C.A. Simenstad. 1980. The effects of construction of naval facilitied on the outmigration of juvenile salmonids from Hood Canal, Washington. Final Rep., Fish. Res. Inst., University of Washington, Seattle, WA. FRI-UW-8006. 159 pp.

Shared Strategy. 2005. Redman, S., D. Myers, and D. Averill. Regional Nearshore and Marine Aspects of Salmon Recovery in Puget Sound. Delivered to Shared Strategy for Puget Sound for inclusion in their regional salmon recovery plan. June 28, 2005.

Simenstad, C. A., B. S. Miller, C.F. Nyblade, K. Thornburgh, and L.J. Bledsoe. 1999. Impacts of ferry terminals on juvenile salmon migration along Puget Sound shorelines, phase I, synthesis of state knowledge. Prepared for the Washington State Transportation Commission, Research Project T99903, Task A2, Olympia.

Simenstad, C. A., K. L. Fresh, and E. O. Salo. 1982. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: An unappreciated function. In: V.S. Kennedy [ed] Estuarine Comparisons. pp.343-365. Academic Press, Toronto.

Spence, B. C., G. A. Lomnicky, R. M. Hughes, and R. P. Novitzki. 1996. An ecosystem approach to salmonid conservation. TR-4501-96-6057. ManTech Environmental Research Services Corp., Corvallis, OR.

Thom, R. M. 1985. An oceanographic analysis of odorous beach conditions in Fauntleroy Cove, West Seattle. Report submitted to the City of Seattle.

Thom, R. M., D. K. Shreffler, and K. B. Macdonald. 1994. Shoreline armoring effects on coastal ecology and biological resources in Puget Sound. Coastal Erosion Management Studies, Volume 7. Shorelands and Coastal Zone Management Program, Washington Department of Ecology, Olympia, Washington.

Thom, R.M., G.D. Williams, and seven authors. 2006. Impacts of Ferry Terminals and Ferry Operations on Juvenile Salmon Migrating Along Puget Sound Shorelines. Prepared for the Washington State Department of Transportation. Prepared by Battelle Memorial Institute Pacific Northwest Division (PNWD-3647). March 2006.

Tompkins, A. and C.D. Leving. 1991. Interspecific interactions affecting the survival of chum salmon fry. P. 29-36. In: Proceedings 1991 Pink and Chum Workshop, Parksville, B.C. February 27-March 1, 1991. Department of Fisheries and Oceans and Pacific Salmon Commission, Vancouver, B.C.

Washington Department of Fish and Wildlife (WDFW). 2003. Priority Habitats and Species Report. WDFW Office, Olympia, Washington.

Washington Department of Natural Resources (WDNR). 2001. Nearshore Habitat Program. The Washington State ShoreZone Inventory. CD-ROM. Olympia, WA. Available at http://www2.wadnr.gov/nearshore/data/ .

Washington State Department of Ecology (Ecology). 2006. Shoreline Inventory Analysis on the Shoreline Management Act website. http://www.ecy.wa.gov/programs/sea/sma/st_guide/SMP/inven_analysis/analysis/eco_functions/marine/types/all_m_shore_types.html. Washington Department of Ecology.

Washington Trout. 2001. Water Type and Stream Mouth Assessment. Vashon Island. June/July 2001. Information available at: http://www.washingtontrout.org/Vashon/Vashon2001/VashonTitle.shtml .

Williams, G.D., R.M. Thom, J.E. Starkes, and 14 authors. 2001. Reconnaissance Assessment of the State of the Nearshore Ecosystem: Eastern Shore of Central Puget Sound, Including Vashon and Maury Islands (WRIAs 8 and 9). J.S. Brennan, Editor. Report prepared for King County Department of Natural Resources, Seattle, Washington.

Williams, G.D. and R.M. Thom. 2001. White Paper: Marine and Estuarine Shoreline Modification Issues. Submitted to Washington Department of Fish and Wildlife, Washington Department of Ecology, and Washington Department of Transportation.