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GUIDANCE FOR PROTECTION AND RESTORATION OF THE NEARSHORE ECOSYSTEMS OF PUGET SOUND

Prepared in support of the Puget Sound Nearshore Ecosystem Restoration Program (PSNERP)

By

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I. PREFACE

The Puget Sound Nearshore Ecosystem Restoration Program (PSNERP) was formed to support efforts to improve the condition of the nearshore ecosystems of Puget Sound. In support of PSNERP's efforts, the Nearshore Science Team (NST) is producing inter-related, science based products such as a set of Guiding Principles and a Conceptual Framework or Model for the Program. These products are intended to help identify problems with the nearshore ecosystems of Puget Sound, determine major information needs, and identify potential solutions. The purpose of this particular document is to provide some guidance to the program on the development, selection, and evaluation of projects that are targeted at protecting and restoring the nearshore ecosystems of Puget Sound. It should be regarded as an interim product that reflects our current state of the knowledge about the nearshore and so represents the first step in a longer-term, evolving process. As a result, as we learn more from restoration actions, monitoring, and research, the guidance provided by this document ***may*** also change. Ultimately, our goal is to develop interactive, decision making tools or models that will allow potential outcomes of various actions or combinations of actions to be evaluated. (In this document, we consider actions to be broader scale categories of activities while projects are specific types of actions such as breaching a dike or a purchase of a property.)

This Guidance Document was developed based upon our understanding and knowledge of the best available scientific literature. There are three main parts of this document that follow this preface and an introduction. The first section defines and develops key concepts, principles, definitions, and terms. Second, we describe an initial draft of a framework for a comprehensive, strategic planning process that we propose to employ to guide our development and selection of restoration projects in Puget Sound (further details on this framework will be forthcoming). We believe that such strategic restoration planning is necessary to ensure that all project actions have the appropriate ecological context and is a critical part of developing specific restoration actions. While this planning framework was developed by the NST for PSNERP, we also believe it can be more broadly applied at smaller scales by other practitioners in Puget Sound to design, construct and monitor protection and restoration projects[1].

The third section describes criteria that were developed to help evaluate and select recovery actions in the nearshore ecosystems of Puget Sound. We recognize that the strategic plan and our process based model will take some years to fully develop. However, the degraded condition of portions of Puget Sound suggests there is a compelling need to implement recovery actions before these products are completed. These two concerns can be simultaneously addressed by initiating carefully targeted restoration activities where there is a high amount of certainty in their ecological benefits, there is low risk of damage, and there is opportunity to generate needed information about how to protect and restore the Puget Sound nearshore. We believe there can considerable value from such early action projects. These projects can provide the basis for scientific assessments of new technologies, test alternative approaches to restoration, and develop assessment protocols. We developed these criteria to help PSNERP develop and select these types of early action projects. As with the strategic plan, these criteria can also be more broadly used by other restoration practitioners to help guide their actions.

II. INTRODUCTION

Shallow water environments of Puget Sound estuarine and marine shoreline areas (in this document, we collectively refer to these areas as the *nearshore*) represent the aquatic boundary or interface between freshwater, air, land, and the open marine waters of Puget Sound. Estuaries include the deltatic portions of river mouths encompassing the upper extent of tidal influence (i.e., tidal freshwater or head of tide) to the outer extent of the delta. By definition this includes fjord systems such as the major inland passages of Puget Sound that technically comprise an estuarine complex. The nearshore includes upland and backshore areas that directly influence conditions along the shoreline and extends seaward to the deepest extent of the water column that encompasses the photic zone.

The nearshore consists of a mosaic of ecosystems that supports a variety of valued ecological, economic, cultural and social services. Population growth and human development in the Puget Sound region has resulted in significant degradation in the form and functioning of these ecosystems both as a result of direct impacts on the nearshore landscape and as a result of changes in the freshwater, terrestrial and open water ecosystems that interact with the nearshore. Changes to the freshwater portions of watersheds from timber harvesting, agriculture, and urban development have resulted in significant modifications in the quantity and timing of water, nutrients, woody debris, and sediments entering the nearshore. Water and sediment quality has also been significantly degraded in many areas due to inputs from commercial, industrial, and residential sources. Within the nearshore, diking, dredging, filling, armoring, aquaculture and harvest have displaced, destroyed, or modified nearshore ecosystems. When one considers that much of the marine shoreline was also historically logged, it is clear that most of the Puget Sound's nearshore has been modified in some fashion by people since long before the turn of the 21st Century.

In addition to the physical or structural changes in nearshore ecosystems, many physiochemical functions of nearshore ecosystems important to the maintenance of diverse biota, clean water, and healthy, harvestable organisms have been altered by human development. The loss of estuarine wetlands has altered the ability of estuarine systems to absorb water and has made extreme flooding more likely. Mudflats and eelgrass beds recycle and process nutrients, increasing productivity, and reducing the potential for eutrophication. Nearshore, marsh and riparian ecosystems act as filters for sediments and contaminants that would otherwise concentrate in the Sound. The nearshore is a major supplier of organic matter used in detritus-based food webs that supports biota associated with the nearshore and other ecosystems.

The modification and destruction of nearshore ecosystems have resulted in significant adverse impacts to valuable biological, cultural, and social resources. The depressed status of many species that use Puget Sound nearshore habitats suggests that degradation of the nearshore may be affecting population abundance levels and resilience of the these species. For example, three salmonid species that use these habitats in Puget Sound (chinook salmon, summer chum salmon, and bull trout) are listed as threatened or endangered under the Endangered Species Act (ESA). Pacific herring populations that spawn and rear in the nearshore are in such poor condition that they have not been able to support commercial fisheries for many years. Several species of rockfish that use nearshore areas as nursery habitats have been considered for listing under the ESA. Water quality degradation in some shorelines areas resulting from failures of septic systems has made it unsafe to eat some species of shellfish.

The degraded condition of Puget Sound has prompted considerable interest in restoring the condition of its nearshore ecosystems. The Puget Sound Nearshore Ecosystem Restoration Program (PSNERP) was initiated in 2001 specifically to guide efforts to improve the condition of Puget Sound nearshore ecosystems by identifying significant problems, developing potential solutions, and then implementing and evaluating solutions. The scientific guidance, advice, and direction for this program is being provided the Nearshore Science Team (NST). In support of PSNERP, the NST will produce a variety of products that will help identify problems with the nearshore ecosystems of Puget Sound, determine major information needs, and identify potential solutions.

The purpose of this Guidance Document is to provide direction for PSNERP in the development and selection of restoration projects. Based upon our review and assessment of large scale restoration efforts, the NST believes that for ecosystem-scale restoration of Puget Sound to be successful, strategic, comprehensive planning must occur. The elements of our proposed strategic plan are briefly discussed in one section of this document. Although ecosystem restoration cannot be accomplished piecemeal by purely opportunistic restorations actions, there is considerable value in implementing "early action" projects. These projects can provide the basis for scientific assessments of new technologies, test alternative approaches to restoration, evaluate key uncertainties about nearshore ecosystems, develop assessment and monitoring protocols, and provide ecological benefits. Criteria for developing and evaluating these types of early action projects are provided in another section of this report.

This document should thus be viewed as the first step in an evolving process of developing, implementing and monitoring restoration projects. In the future, we expect to periodically revise this document as we learn more from restoration actions and research. Our long term goal is to develop interactive, decision-making tools or models that will allow outcomes of various actions or combinations of actions proposed by PSNERP (and potentially others) to be evaluated. Although this guidance was developed by the NST for PSNERP, the NST also believes it can be broadly utilized by other restoration practitioners in Puget Sound.

III. DEFINITONS, PRINCIPLES AND CONCEPTS

A. What is an ecosystem?

An ecosystem is a *community of organisms and their physical and chemical environment interacting as an ecological unit*. It thus includes both elements of the physical/chemical environment and living components. Ecosystems possess three general types of features: 1) processes, 2) structural components or habitats which are primarily created and maintained by processes, and 3) outputs or functions such as species which are supported by the habitats.

Nearshore ecosystems are especially dynamic, continuously changing system that naturally evolves over time as a result of the actions of different processes and responses to different types of and intensities of disturbances. An ecosystem does not have easily definable boundaries because linkages in the system occur longitudinally (upstream to downstream), laterally and vertically. As such, the nearshore should be viewed as a suite of overlapping ecosystems that vary in extent as a function of the different environmental and ecological linkages. In addition, ecosystems are explicitly taxa-specific, such that the organisms of interest define the scope of influence of the physical/chemical environment.

B. What are ecosystem processes?

Ecosystems are not naturally static in space and time but are continuously being shaped and reshaped by a variety of physical, chemical, and biotic processes. *Ecosystem processes are any interaction among physiochemical and biological elements of an ecosystem that involve changes in character or "state".* The NST has determined that long-term recovery of nearshore ecosystems will primarily involve recovery of processes rather than habitats or ecosystem structure. Ecosystem processes operate at naturally varying rates, frequencies, durations, and magnitudes that are controlled or constrained by various anthropogenic and natural factors. For example, climate, landform, bathymetry, and geologic setting of an area constrain or control how biota, water, sediment, and organic matter are moved in the system. Processes also operate at various spatial and temporal scales and they can include such things as changes in chemical composition (e.g., nutrient transformations), biomass (e.g., production and consumption) and movement of material (e.g., sediment transport). For example, sediment can be transported over spatial scales of 1 to 100's of km. In an estuary, sediments originate from the watershed, are transported downstream by river flow, and then moved episodically (eroded and deposited) by bidirectional water movements (tides and river flow) through the estuarine gradient. The sediment composition on a beach typically depends upon upland sources of material deposited directly on the beach, movements of material along the beach, and wind and wave action, which are a function of large-scale climate events.

An important factor affecting the structure and shape of an ecosystem are disturbances. *Disturbances are any relatively discrete event in time that disrupts or alters some portion* *or portions of an ecosystem*. In ecologically healthy, nearshore systems, most natural disturbances are relatively short in duration and magnitude and do not thoroughly or permanently change the biophysical or ecological structure of the ecosystem. Because nearshore ecosystems have evolved the ability to accommodate natural disturbance regimes, they appear to recover rapidly to a state similar to the pre-disturbance condition following these events. Small to medium scale floods and winter wind storms are examples of common types of natural disturbances. Some disturbances such as a large earthquake, 100 year flood, or 90 mile/hr windstorm can reshape the ecosystem so that it does not rapidly recover to its pre-disturbance condition.

Human land uses alter the rates, duration, frequency, magnitude, and scales of natural processes. Because land use activities typically operate at large spatial scales and persist for long time periods, they often result in permanent or semi-permanent changes in ecosystem processes. Land use activities affect processes by resetting or reshaping natural disturbance regimes. For example, urbanization increases the magnitude and frequency of floods and creates new peak run off events which can result in the transport of more sediments, more frequently to the estuary. Diking and straightening of channels eliminates floodplain area and constrains water which increases the energy of the water and its ability to erode and transport sediments and organic material. In extreme cases like the Duwamish River, we would predict that the location and extent of salinity intrusion is dramatically different than under historic conditions because of changes to the channel and surrounding wetland.

C. Habitat: What is it and how is it created?

Habitat is *the physical, biological, and chemical characteristics of a specific unit of the environment occupied by a specific plant or animal*. Habitat is unique to specific organisms and basically encompasses all the physiochemical and biological requirements of that organism within a spatial unit. For example, habitat for juvenile salmon is different than habitat for shiner perch, even though both species may occur in the same spatial unit at the same time. To define habitat, it is necessary to know where in the ecosystem that habitat is located, what plant or animal is being specifically considered, and the unique characteristics or attributes of the habitat that support the growth and survival of that organism. The importance or function of nearshore habitats to any biotic element such as juvenile salmon or a species of forage fish (e.g., smelt) depends upon site-specific or local features of that habitat, quantity of habitat, and the landscape context of that habitat in the nearshore. Historically, habitat was primarily measured and evaluated based upon site scale attributes and quantity of that habitat present.

In recent years, we have come to appreciate that the function of habitats within an ecosystem depends upon the landscape context of that habitat. Landscape context refers to the integration of that habitat with all other elements of the landscape, including the arrangement, size, shape, location, connectivity to other habitats, and accessibility of that habitat to resources. As a result, the same type of habitat in two different locations can differ in how it functions for any plant or animal element.

In some cases, organisms directly affect the functions of the habitat that they occupy. For example, eelgrass traps and stabilizes sediments, alters water chemistry through photosynthesis, and alters local current patterns.

D. What is ecosystem recovery?

An important principle of this Guidance Document is that recovery of nearshore ecosystems can best be achieved by re-establishing or significantly improving ecosystem processes. Conceptually, this involves taking actions that make it possible for the system to generate and maintain natural ecosystem processes that in turn generate desirable ecosystem structures (e.g., habitats) and important functions (e.g., salmon production, bivalve production, and clean beaches and water). Clearly, the fundamental assumption of process based restoration is that natural functions will return to some degree if processes are restored in the absence of sustained and significant constraints (e.g., persistent toxic contamination). Other benefits of process based restoration are that we make it possible for the ecosystem to be naturally productive, self sustaining (reducing the amount of long term maintenance needed), and diverse.

One important reason why a process-based, restoration approach has the greatest chance of increasing numbers of valued biota, such as salmon, or improving other functions is that it addresses the causes of degradation, not the symptoms (e.g., loss of eelgrass), by focusing on processes. Organisms such as juvenile salmon utilize habitats which have been damaged because humans have modified the rates, duration, magnitude, and frequency at which habitat forming processes operate. By focusing on repairing these ecosystem processes, we increase our chances of improving the functions we value. Thus, restoration projects that seek to place species-specific habitats, engineered structures, or animals in the landscape are less likely to succeed. Within the Puget Sound nearshore, the problems or causes of degradation are multiple and cumulative and so recovery will also likely involve multiple and cumulative actions. This is distinct from most other large-scale ecosystem recovery efforts such as the Chesapeake Bay, Florida Everglades, and Louisiana programs where a single problem or issue is the focus of ecosystem restoration efforts.

IV. ELEMENTS OF A STRATEGIC PLAN FOR DEVELOPING NEARSHORE ECOSYSTEM RECOVERY ACTIONS

To help guide the development and selection of recovery actions and projects, PSNERP will develop a comprehensive ecosystem restoration plan where potential actions are conceptualized, designed, located, selected, and assessed. We propose that projects developed with this type of planning have a higher probability of benefiting nearshore ecosystems than those that do not incorporate these elements. We refer to the process of developing an ecosystem recovery plan as *strategic planning*.

The overall purpose of a strategic plan is to ensure that projects are conceptualized within ecological and landscape contexts, based upon the goal of recovering ecosystem processes, and target appropriate areas, processes, and habitats. Strategic plans are an essential element for publicly funded restoration actions because such plans help restoration designers understand the complex functions of ecosystems and how to help them recover. In addition, they can fashion complete restoration instructions, assist prudent expenditure of funds, facilitate communications with other restoration practitioners, and document completed actions by monitoring.

Rather than being based simply on opportunities, strategic planning approaches the challenges of restoration through the goals of minimizing uncertainty and optimizing the ecological outcome. A strategic plan should thus ensure that the actions that are taken will have a high probability of successfully improving the condition of the Puget Sound nearshore ecosystems. It will help maximize the probability that we can separate the signal (effect of the restoration actions) from the noise or natural variability in the system. A strategic plan designs projects to be synergistic and complimentary as much as possible rather than isolated and opportunistic. This requires restoration to be formulated as cumulative, integrated actions rather than as individual projects. Once developed, the strategic plan should be continuously revisited, revised and updated as the landscape changes due to our actions (both positive and negative), unexpected disturbances (e.g., a severe winter storm), and our learning about the system derived from monitoring and research.

A major theme of this recovery plan is the perspective that strategic planning for the nearshore must recognize the connectivity of the nearshore with other freshwater (upstream), terrestrial, shoreline, and marine ecosystems. *Recovery of the nearshore cannot be disconnected from these other segments of the landscape*. Examples of this connectivity are numerous. In river deltas, the shaping and structuring of channel habitats depends in part on the amount of freshwater inflow while the transport and delivery of sediments to these areas depends river hydrology. Sediments on a beach can be derived from upland habitats while organisms using nearshore habitats can depend upon food webs that connect to marine waters, uplands, tidal marshes, and rivers. Thus, the elements of a plan should include and integrate the entire freshwater-nearshore gradient because it is comprised of tightly linked and interacting ecosystems.

The following are the major elements of a strategic plan for recovery of the nearshore ecosystems of Puget Sound. We wish to make clear that the following is not a plan but rather are the elements that the NST proposes to include in such a plan.

1. Goals- An important part of recovery planning is the development of goals. Beyond the goal of properly functioning nearshore ecosystem conditions, the PSNERP has not yet finalized its specific goals for the strategic recovery plan. Conceptually, the goals of the strategic plan should incorporate both scientific principles and socioeconomic factors and should be formulated in such a way that they can be directly incorporated into performance measures that can be systematically and quantitatively measured. In addition, goals should be framed in terms of desired future conditions or desired future behaviors for the ecosystem processes, structures and functions that are necessary to sustain the

defined, quantified levels of goods and services we value in the system (e.g., salmon). Goals must also reflect what is realistic and recognize constraints that exist on the system (e.g., additional people added to the landscape) that currently or may exist in the future at local, landscape and regional scales. Such modifications may significantly constrain assumptions about key ecosystem processes upon which the rate and outcome of recovery depends (e.g., sediment transport).

2. Conceptual Model - The strategic plan will be guided by a generalized Conceptual Model (CM) currently under development. The primary purpose of the CM is to organize our understanding of how the nearshore ecosystems of Puget Sound are composed, organized, and operate. Nearshore ecosystems are composed of a variety of structural elements, processes, rates, fluxes, and transformations and include air, land, water, and biology. The CM can help identify how these different components interact with each other, if they interact, and how strong linkages might be. The CM will provide insight how different parts of the ecosystem respond to different types of changes including both stressors and restoration actions. It can thus help identify what types of changes (i.e., resulting from restoration actions) need to occur and where they need to occur in order to achieve a particular outcome (e.g., more salmon); and, it can provide some insight into what actions might be most effective. And, it will help discover what some of the key uncertainties might be in our understanding of nearshore ecosystems. The CM is being designed to be spatially explicit. The spatially explicit aspect of the CM is important because the organization and functions of different units of the nearshore depend upon where they are located. The CM is also being designed to be versatile enough that it can examine the effects of an individual restoration project or a group of projects (actions) and identify whether the expected changes in processes and structural components resulting from the action or actions will achieve a desired goal or output.

3. Identify What Ecosystem Processes are Impaired and Where they are Impaired- In addition to protection of nearshore ecosystems, our approach to restoring nearshore ecosystems of Puget Sound focuses on repairing and restoring damaged ecosystem processes. In order to accomplish this, it is necessary to identify what processes are impaired and where they are impaired. The NST has determined that an evaluation of limiting processes is best accomplished by determining the specific relationship between the structural elements of the nearshore that have changed and the processes than have been sufficiently altered to cause that change. This requires two general sources of knowledge: 1) an analysis of historic and current conditions to identify the changes in habitat that have occurred, and 2) a basic understanding of the ecosystem processes that could account for the observed changes. At this time, the NST has proposed that the ecosystem processes that are **most likely** limiting will be those involving food webs and the movements and distribution of water and sediments and that many recovery

actions will address one or more of these processes. Although the type of analyses that we propose is somewhat analogous to a limiting factors analysis, it is distinguished from this type of approach by focusing on ecosystem processes. The analyses involves the following components:

a. Historic conditions- The historic condition of the nearshore ecosystems probably provides the best template for restoration planning because it indicates where habitats used to occur, their natural, size, shape, community composition, and connectedness to other elements of the ecosystem. The intent of the historic conditions analysis will be to quantitatively "hindcast" with the best available data the condition of the estuarine and nearshore landscapes at some point in time. (Presently, some analyses of historic conditions have been conducted by the University of Washington for some of the major estuaries of Puget Sound.) As part of this work, we need to determine how much uncertainty exists in this type of hindcasting and where data is most limited. The critical question to be addressed in historic analyses is how much of various types of ecosystems were present, where were they located, and how were they organized/arranged. Examples of other questions that can be addressed with this type of analysis include the following.
    - What was the geomorphology?
    - What was the extent of landscape connectivity?
    - What was the extent and landscape position of discrete habitats of important organisms such as salmon?
    - What were the historic inflow, woody debris, sediments loads, and nutrient conditions for Puget Sound?
b. Assess current conditions- In addition to an analysis of historic conditions, an evaluation of current conditions is needed to obtain data that can be used to compare to historic conditions and assess change in ecosystem condition. This type of analysis should address the following types of questions:
    - How much of various types of ecosystems and habitats are now present and where were they located?
    - What was this habitat connected to?
c. Understand ecosystem processes- As we have noted, our hypothesis is hydrology, sediment, and food web processes are the processes that have been most affected by stressors affecting the Puget Sound nearshore. Knowledge of these processes will be critical to understanding where and what damage has occurred. Much research is needed about some of these key processes especially quantitative data on rates, magnitude, scales over which the processes operate, and natural variability.
d. Compare historic and current conditions to document changes that have occurred- Use the results of the change analysis to describe what processes have likely changed. In making this comparison, it will be

necessary to consider what constraints may now exist. For example, the existence of an upstream dam will effect how water and sediment processes function. Important questions to be addressed by this analysis include:

- What quantitative changes have occurred in diversity, landscape structure and connectivity of habitats and ecosystems and why have these changes occurred?
- What are the relative roles of anthropogenic and natural influences in these changes?
- How have the habitats of key organisms changed over time?

4. Knowledge of Critical, Dependant Biota- One of the expected outcomes of the strategic planning process will likely be the conservation of particular organisms that are of value. An obvious example of this is salmon. A strategic plan should provide a summary of the life history requirements of these key organisms including population status, distribution, and so on. One important of this kind of description is the determination of data gaps and research needs relative to these key organisms.

5. Identifying Actions- A major issue in planning recovery is what types of specific actions are needed. The National Research Council and others have identified four general types or categories of ecosystem recovery actions. The strategic plan for the Puget Sound nearshore will likely include some mix of these four types of actions. They are listed in order of the certainty with which they can contribute to ecosystem recovery (most certain to contribute to the least certain):

    a. <u>Protection-</u> In general, protecting portions of ecosystems with functioning natural processes has a high chance of achieving desired goals, such as salmon recovery, because further degradation of important processes and landscape segments can be decelerated. Protecting processes is not necessarily synonymous with protecting habitats. Simply protecting habitats without protecting the underlying processes that create and maintain those habitats will have a low chance of contributing to ecosystem recovery. Protection can be achieved by such tactics as acquisition of land, use of easements, and regulatory actions. Areas targeted for protection will be based upon a thorough analysis of critical or vulnerable natural areas. The priority for protection of portions of the landscape will be based upon identifying those areas that are in imminent risk of being converted to an alternate use. Simply protecting property because it is available for acquisition and affordable is not considered part of ecosystem recovery.

    b. <u>Restoration-</u> We use the NRC definition of restoration as "re-establishment of pre-disturbance aquatic functions and related physical, chemical, and biological characteristics". Here, we propose to focus on restoring the processes that the conditions analysis has identified as being impaired and important to the loss of historic habitat. The NRC has identified two general ways that restoration can be accomplished. First, "passive restoration" can occur by removing anthropogenic constraints and allowing the system to recover through "natural design". Second, "active restoration" involves major intervention intended to not only remove ecosystem constraints also to accelerate or even circumvent natural developmental processes such as sculpting desirable geomorphology or planting vegetation. Examples of restoration actions that can have a high chance of success include reconnecting isolated or fragmented portions of the landscape, recovering areas where historic habitat loss was high, and targeting processes that operate across broad scales of the nearshore.

c. Rehabilitation- Rehabilitation tactics are employed where restoration actions are not considered to be feasible and involves partially re-establishing ecosystem processes. The threshold test for policy decisions on feasibility may include such issues as availability of adequate resources and impacts to other human uses and values. Rehabilitation involves some level of maintenance to achieve project goals. We consider enhancement to be a form of rehabilitation. Given the pervasive constraints on nearshore ecosystems throughout much of Puget Sound, we expect that rehabilitation will be the focus of much our actions.

d. Substitution/Creation. This is defined as the creation of an ecosystem or portion of an ecosystem where it was not historically present. This is applied in situations where other recovery options are considered to not be possible and may even involve "installation" of a typical ecosystem such as a wetland in an upland area. As with rehabilitation, the threshold test for policy decisions on feasibility may include such issues as availability of adequate resources and impacts to other human uses and values. Substitution typically involves engineering manipulations to create or enhance habitat, long term maintenance, and is accompanied by a great deal of uncertainty in the impacts of such actions. Substitution is mostly a temporary or transitory measure.

6. Prioritizing Actions- Clearly, determining what actions to take, where to deploy them, and when they should occur will be a major challenge of the strategic planning. Sequencing and prioritizing actions will depend upon the results of earlier actions and unpredicted changes occurring in the landscape. Thus, monitoring will play an important role in determining what actions are needed over time.

Proposing actions without a strategic plan and the information to support this plan increases the likelihood that recovery goals will not be meet, that resources will not be well spent, and that we will do more harm than good. However, the degraded condition of Puget Sound nearshore ecosystems and many of the associated biological resources argues for taking some immediate action. We propose that both of these concerns can be addressed at this time by initiating carefully targeted restoration activities where there is high confidence in their ecological benefits and where there is a high likelihood that they will enhance our understanding about how to restore the Puget Sound nearshore. Over the near term we propose that high priority actions and projects should be those that we can learn from (high quality monitoring plans are key) and will have a high probability of benefiting the system. Accordingly, projects that incorporate experimental approaches to adaptive management with intensive monitoring, hypothesis testing, and scientific investigation are strongly supported. The NST is in the process of identifying major information needs that can be used to help develop projects.

7. Performance Measures- Performance measures will be needed that directly relate to goals and monitoring efforts. Optimally, performance measures should be focused on processes but insight into responses of habitats and species to process-level changes may be obtained from other types of performance measures that target these structural or functional elements. Examples of performance measures include residence time estimates of juvenile salmon, growth rates or survival of salmon, sedimentation rates, change in recruitment of wood to shorelines, and change in the amount of a specific habitat type.

8. Adaptive Management- Strategic planning for recovery of nearshore ecosystems requires the use of an adaptive management approach. Adaptive management is a key component of PSNERP and is a process whereby research and monitoring are used to allow certain projects and activities to proceed, despite some uncertainty and risk regarding their consequence. Adaptive management provides uncertainty about the system being managed or restored and is a mechanism to increase our understanding by taking restoration actions. The overall intent of this process is to: 1) assure project success, 2) reduce the risk and uncertainty associated with future actions, and 3) gain knowledge. ALL restoration projects should be designed and approached as experiments to evaluate ecosystem response to our actions. The emphasis should be on high quality scientific and technical assessments of ecosystem responses to the restoration actions. Key elements and principles of adaptive management relating to recovery of ecosystems are available from a variety of sources and so are not repeated here.

9. Monitoring- A well-developed and detailed monitoring plan is a critical part of ecosystem recovery planning. Monitoring designs are intended to provide high quality data on the nearshore ecosystem of Puget Sound, including how it

works, how it responds to changes (our actions), and how well we are able to predict what we think is going to happen. Most importantly though, they represent a way to learn how to do a better job at recovering the nearshore ecosystem.

In general three different types of monitoring can be identified. *Implementation monitoring* focuses on determining whether a specific project was designed and built as proposed and so is usually focused at the scale of an individual project. *Effectiveness monitoring* seeks to determine if the expected outcomes of a project or group of projects has been achieved. Effectiveness monitoring typically focuses on structural or functional features of the landscape. The scale of effectiveness monitoring is at the project scale or in the immediate region such as a drift cell. *Validation monitoring* is conducted to examine cause and effect relationships between specific resource conditions that result from recovery actions and the process these actions were focused on. It is usually conducted at large scales such as regional or ecosystem scale. In general, while all three levels of monitoring are needed, the focus of the strategic plan is on validation monitoring. They are intended to provide information used as part of the adaptive management process. All types of monitoring can also include tests for species response to actions that focus on monitoring for quantitative and qualitative population level responses.

Recovery actions should be viewed as testing hypotheses or answering specific questions. Thus, monitoring should be focused on goals and objectives of the recovery plan and include measurable performance criteria that are relevant to the specific questions being asked. Pre project assessments are critical and the use of reference sites will be a key component.

V. CRITERIA FOR DEVELOPING AND SELECTING NEARSHORE ECOSYSTEM RECOVERY ACTIONS

This section of the guidance document provides a set of criteria for developing and evaluating nearshore restoration projects. Proposing projects without a strategic plan and the information to support this plan increases the likelihood that recovery goals will not be meet, that resources will not be well spent, and that we will do more harm than good. However, the degraded condition of Puget Sound nearshore ecosystems and many of the associated biological resources argues for taking some immediate actions. We propose that both of these concerns can be addressed by initiating carefully targeted restoration activities where we have a high amount of certainty in their ecological benefits and where there is a high likelihood that they will enhance our ability to restore the Puget Sound nearshore. Thus, over the near term we propose that high priority projects should generally be those that we can learn from (high quality monitoring plans are key), have a low risk of doing harm, are likely to meet their goals and objectives, and will have a high probability of benefiting the system. Accordingly, projects that incorporate experimental approaches to adaptive management with intensive monitoring and hypothesis testing are strongly supported. Such projects can test approaches to restoration, address key scientific uncertainties, develop new methods, and test key assumptions. We refer to these types of projects as *demonstration* or *early action* projects. Our intent is not to compare between projects but rather to evaluate each project or group of projects on its own merits. We have framed this guidance in the form of a series of questions that should be addressed:

1. **Does the project have clearly stated goals and objectives and are they appropriate for ecosystem recovery?** Each project should have clearly stated goals that help define the expected benefits of the project and what we expect to learn from the project action. A primary purpose of projects will be to learn and enhance our understanding about how to recover the nearshore ecosystems of Puget Sound. Each project should address the causes of ecosystem degradation rather than the symptoms and should contribute to the recovery of the nearshore ecosystems of Puget Sound.

2. **Does the project have a Conceptual Model (CM)?** Each project should employ a conceptual model that demonstrates how the proposed action will lead to the expected outcome(s). Application of the conceptual model should identify which processes the proposed action will affect, what type of effect the action is expected have on processes, what types of structural changes are expected to occur as a result, and ultimately how this will lead to the proposed outcome. In addition, application of the CM should help identify critical uncertainties. Because an objective of projects at this time is learning, the intent of the project could be to increase our understanding about these uncertainties. The NST is developing a general CM that we will employ to develop and evaluate PSNERP projects that can be broadly used by other restoration practitioners.

3. **Does the project contribute significantly to our understanding of the ecosystem or how to restore it?** At present, one of the most important criteria in proposing and evaluating projects is the ability of that project to enhance our understanding about how to restore Puget Sound nearshore ecosystems. This does not mean that we support intentionally destructive, low value, or high-risk actions simply for the sake of learning something. Rather, we believe high priority actions are those from which we can learn (high quality monitoring plans are key). Accordingly, we recommend that projects incorporate extensive experimental approaches to adaptive management with intensive monitoring, hypothesis testing, and scientific investigation. An important element of this criterion is the availability of *reference sites*. Projects are preferred that can be linked to the reference sites during monitoring efforts. The NST is in the process of developing a list of major information needs that will help guide in the development of projects.

4. **What is the likelihood that the project will have significant ecological benefits?** Although learning is a key important element of a recovery project, there should also be a high expectation that the project will deliver ecological benefits - i.e., contribute to an improvement in the condition of nearshore ecosystems. All projects will involve some combination of science based and socioeconomic factors in their selection that will relate directly to their expected benefits.

   Projects can be grouped into one of four categories based upon their potential to contribute to ecosystem recovery: protection of processes, restoration of processes, rehabilitation/enhancement, and substitution/creation. Projects that seek to protect natural processes have the least uncertainty associated with them; we can usually predict the effect of protection projects (i.e., they are designed to prevent further degradation). Clearly, for protection projects to work, they depend upon selecting appropriate areas for protection based upon a thorough analysis of critical or vulnerable natural areas. The priority should be protection of portions of the landscape that are in imminent risk of being converted to an alternate use. We use the NRC definition of restoration as "re-establishment of pre-disturbance aquatic functions and related physical, chemical, and biological characteristics". Much of the uncertainty associated with restoration projects stems from the fact we lack experience in how to restore ecosystems. In general, passive restoration minimizes the uncertainty of negative ecological consequences. Even greater uncertainty exists with rehabilitation or actions designed to improve the condition of habitats or processes. In general, uncertainty associated with this type of action is high because of the need for continuing intervention over perhaps long time scales. Finally, creation or substitution has the most uncertainty associated with it because it typically involves engineering manipulations to create or enhance habitat and is usually accompanied by a great deal of uncertainty in the impacts of such actions. In addition, creation or substitution does not target processes but typically habitats.

5. **What is the landscape context of the project?** The expected benefits of any project and its ability to meet goals and objectives will depend upon the landscape context of the project. Landscape context refers to the integration of that habitat with all other elements of the landscape, including the arrangement, size, shape, location, connectivity to other habitats, and accessibility of that habitat to resources. As a result, the same type of habitat in two different locations can differ in how it functions for any plant or animal element. There is not a correct landscape context. Rather, the expected benefits of any project will depend upon its landscape context. Landscape attributes that need to be incorporated into the development and selection of recovery actions include:

   a. <u>What is the scale and size of the project?</u> Two important landscape attributes that can contribute ecological benefits are the scale and size of the project. All actions should be of a scale and size that is appropriate for the objectives of the project. There is not a correct scale, only a correct scale relative to the action. While scale is the more important of the two factors, size of a project should be considered as well. In general, projects of a large size are more likely to have significant ecological benefits than small, disconnected, and fragmented restoration efforts.

b. <u>What is the connectivity and complexity of the project?</u> Two landscape elements that can contribute to the ecological benefits of a project are its connectivity and complexity. Connectivity refers to the linkage between one habitat and other habitats. A channel complex that is near a main channel may be more likely to be used by large number of juvenile salmon than one that is distant from major distributary channels. Areas of high complexity (e.g., emergent and forested wetlands) are also more likely to deliver significant ecological benefits than areas of low complexity.

6. **Does the action incorporate habitats important to key biota?** An objective of a project may be to learn about to restore a specific component of the ecosystem such as salmon or baitfish. Projects that seek to accomplish this should recognize and integrate the specific needs and requirements of species and other valued ecosystem components into there approach. If a goal is salmon conservation, for example, then the project should recognize the need to support sustainable habitats important to these species.

7. **Is the project part of a portfolio of recovery actions**? One strategic approach to implementing restoration projects that the NST plans to employ is to implement portfolios of recovery actions. Although such an approach has yet to be fully evaluated and developed, implementing a portfolio of projects has several potential advantages that make it a useful approach to restoration. Each group or portfolio consists of a blend of different types of actions (e.g., protection and restoration) targeted throughout the landscape. A portfolio of actions can involve only actions in the nearshore or it could involve an integrated suite of actions across freshwater and nearshore. One major advantage of implementing a portfolio approach is that it should increase our chances of detecting a response to the restoration action at large spatial and temporal scales. Such large scale responses are difficult to detect for individual projects. What is critical is the net effect of the proposed actions in a portfolio. Monitoring would be focused at both individual projects as well as detecting the overall effect of the portfolio on the landscape.

8. **What are the relationships between uncertainty, risk, expected ecological benefits, and potential learning been thoroughly evaluated and considered?** There will be uncertainty and risk associated with each project that must be considered simultaneously with the information, knowledge, and benefits expected from the project. We have already discussed that learning should be a major features of any recovery project. *Uncertainty* is the

likelihood or probability that the project will meet its stated goals while *risk* is the chance that the project will cause further damage to the ecosystem or have unforeseen negative effects. Actions targeted at one ecosystem should not damage processes important to another ecosystem. A number of factors contribute to risk and uncertainty including whether the ecosystem was currently present at the site, whether appropriate controlling factors can be easily re-established, and whether stressors can be easily abated or eliminated.

There is not a clear cut way to weigh risk, uncertainty, value of learning, and anticipated ecological benefits of each project, although at this time, the NST places a high value on learning. Conceptually, the following matrix illustrates how these factors can be related. The ideal project would clearly be one that is of low risk, high amount of certainty (i.e., low uncertainty), high value of learning, and high expected benefits (position A in the Table).

<table>
<tr><th rowspan="7">Risk</th><th colspan="5">Uncertainty</th><th rowspan="7">Value of Learning</th></tr>
<tr><td></td><td>High</td><td>Medium</td><td>Low</td><td></td></tr>
<tr><td>High</td><td></td><td></td><td></td><td>Low</td></tr>
<tr><td>Medium</td><td></td><td></td><td></td><td>Medium</td></tr>
<tr><td>Low</td><td></td><td></td><td>A</td><td>High</td></tr>
<tr><td></td><td>Low</td><td>Medium</td><td>High</td><td></td></tr>
<tr><th colspan="5">Expected Ecological Benefits</th></tr>
</table>

As the uncertainty associated with an action increases, additional justifications are needed to support the project such as a low risk or it addresses an important information need. If the probability of success is low, then the risks associated with the project should also be low and then potential benefits high. A project with a high amount of uncertainty, should only be considered when the potential benefits are very high and risks are low. High-risk actions should be considered only as experiments with intensive monitoring and evaluation and not as demonstrations of approaches that will become institutionalized.

9. **What are the costs of the project relative to other factors?** Project costs relative to such factors as risk, uncertainty and the expected benefits should be considered. For example, a costly project may be acceptable if expected benefits are significant or risk and uncertainty is low. Project success should not be contingent upon finding future sources of funding to “finish the project” once it has been initiated, although the NST recognizes that some projects may require multiple sources of funds. Maintenance, contingency, and monitoring costs should all be considered in the overall costs of any project. Although projects should be sustainable in the sense that they should not require upkeep, there may nevertheless be maintenance or contingency costs associated with a project.

10. **Is the action sustainable within the context of the expected natural evolution of the target ecosystem?** Where possible, projects should result in sustainable ecosystems where the natural evolution of project is an explicit and expected part of the project. Projects should not require significant long term up keep and maintenance.

11. **Does the action have clear performance measures?** Each recovery action must have explicit performance measures that directly relate to the goals of the project. Examples of acceptable performance measures include growth rates or survival of salmon, sedimentation rates, change in recruitment of wood to shorelines, and change in the amount of a specific habitat type.

12. **Does the project have a rigorous monitoring plan?** All projects must have a scientifically rigorous monitoring plan that focuses on evaluating whether the goals and objectives of the project have been met. At a minimum, we expect this to evaluate how well the project was implemented (implementation monitoring) and whether it had the expected results (performance monitoring). Monitoring, goals, and performance measures of each project should all be directly related and integrated.

13. **Does the project have an adaptive management and contingency plan?** Not everything will go as expected with each project. There may be delays or funding shortfalls or other problems with the project. Each project should include an adaptive management type of approach that provides some level of contingency planning. Adaptive management is a process whereby research and monitoring are used to allow certain projects and activities to proceed, despite some uncertainty and risk regarding their consequence. A contingency plan is a demonstration that project proponents have planned beyond the first shovel full of earth that is moved. While we recognize that not everything can be anticipated, we nevertheless believe that this type of approach can help lead to better projects.

14. **Do partnerships exist among communities, organizations, and agencies potentially involved in the action and who owns the land?** It is clear that local community support and participation can be an important part of the success of any action taken. Thus, we believe additional considerations in project selection should include: amount of local support for the project, linkages to local watershed group's goals and objectives, linkages to ongoing restoration efforts, and availability of local sponsors. A non-scientific consideration in any project is land ownership. In general, actions taken on public lands are preferable because of the increased certainty that they can be accessed over time.