Puget Sound Technical Recovery Team Technical Comments:
Combined Template and Probabilistic Network Analysis

Draft Elwha Chinook Recovery Plan

This technical feedback has three components:

- Brief summary of results of our review concerning certainty, and discussion and recommendations of factors we believe are critical to address in order to improve certainty of your plan;

- Consolidation of technical reviewers' composite and detailed comments on your June 30th draft; and

- A description of the methods by which we performed the certainty analysis (i.e., the probabilistic network analysis).

The "near-term steps" suggested in Section 1 of the feedback should occur by April 30th, because they will help you finalize your draft chapter. The "long-term steps" should generally occur as you implement your adaptive management program.

I. SUMMARY OF CERTAINTY ANALYSIS

The content of this section summarizes the results of our probabilistic network analysis (for a description of the approach, see *Section III* of this document.) We suggest using this certainty analysis in an iterative fashion to help you in guiding plan revisions. This analysis also will help us strategically track the elements of your plans and how information at each step affects the overall certainty that the proposed actions in your plan will contribute to population and ESU recovery. This section is divided into separate discussions of the certainty in the habitat, hatchery and harvest management elements of your plan. You will notice that several questions within each "H" encourage us to check how well the habitat, hatchery and harvest strategies are integrated in the plan. We fully expect that the certainty in your plan's outcomes can be increased by providing more information and documentation—we have highlighted areas we think would be particularly fruitful to focus on in near-term revisions in each section below.

Habitat Strategy

Key Issues to Improve Certainty

The most important ways to improve the certainty of an effective habitat strategy in this plan in the near-term are to:

- Better document the data, assumptions, and models used as they relate to the VSP characteristics and potential responses of the population.
- Provide any available empirical support used to relate ecological processes, habitat conditions, and all four VSP relevant to the recovery planning to strengthen the analytical support for the recovery plan.

- Further integrate the habitat strategy with hatchery and harvest management strategies in the planning area
- Use available data and document assumptions for floodplain, estuary, and nearshore habitats protection and restoration actions by type to increase the strength of the empirical support for the actions. Addressing the *Analytical Support* key near-term action item will address this action in regard to the Elwha Project.
- Further develop an adaptive management plan for a more comprehensive habitat recovery strategy explicitly relating the interactions among land use, habitat forming processes, habitat conditions and population VSP responses.

Based on our analysis, developing and implemented the key items above would increase the current moderate likelihood of a "high" level of certainty by approximately 35 percent.

Did the analysis use one or multiple independent models to understand potential fish status and responses?

The Elwha chapter utilizes multiple models to assess the affects of dam removal on fish status and potential VSP responses.

What is the nature of the analytical support for the model linking salmon population status to changes in habitat-forming processes and in-stream habitat conditions? (Analytical Support)?

The analytical support was moderate.

- It appears this support could be readily increased to a high level.

- A well developed *qualitative* model was used to relate ecological processes, habitat conditions, and all four VSP characteristics. Quantitative models were applied to develop understandings of Abundance and Productivity (R:S and capacity estimates), flow and sediment transport processes and sediment effects from dam removal. It is not clear to what extent, if any, the effects of the restoration project have been modeled for the estuary. Lower river floodplain land use management assumptions, and diversity and spatial structure characteristics of the population are also not clear. Reviewers found it hard to track all assumptions in the material provided. A summary of the key assumptions for habitat and VSP in the plan itself would make the supporting evidence more readily available and transparent to various users. Similarly, a synthesis of the empirical support would strengthen the analytical support. Reviewers found no empirical support for productivity and other VSP hypotheses. While there is some empirical support for sediment and flow process hypotheses, linking these processes to VSP characteristics would strengthen the overall analytical support for the recovery plan. There is no explicit discussion provided of sensitivity testing, though some exists in the associated records. The plan also does not discuss empirical testing and validation of the models. Finally, habitat factors beyond the scope of the restoration project have clearly not been assessed.

Key near-term steps to reduce uncertainty:
- Provide better documentation of the data, assumptions, and models used as they relate to the VSP characteristics and potential responses of the population;
- Provide any available empirical support used to relate ecological processes, land use, habitat conditions, and all four VSP characteristics relevant to the recovery planning would also strengthen support.

Key long-term steps to reduce uncertainty:
- Further develop explicit life stage specific linkages relating ecological processes, land use, and habitat conditions to responses in population viability characteristics, and potential responses of the population.

How well supported are the hypotheses for (1) what VSP attributes are most limiting recovery and (2) the habitat-forming processes or conditions that are limiting population response? What is the nature of the watershed-specific data to support either of those 2 hypotheses? (Watershed Data Quality)

Support for the recovery hypothesis using watershed specific data was moderate and could be improved.

- This question asks if the watershed has data that has been used to independently support the results of the qualitative analysis. Multiple lines of evidence were presented to support the hypothesis.

Key near-term steps to reduce uncertainty:
- The support for the hypotheses could be strengthened by linking available data, the strategy, and potential VSP response.

Key long-term action to reduce uncertainty:
- Develop more explicit and quantitative life stage specific model(s) with watershed specific data relating the interactions among land use, habitat forming processes, habitat conditions and population response.

Is the recovery strategy consistent with the recovery hypothesis? (Consistent with Hypothesis)
Yes.
- The strategy is to restore ecological processes, habitat and access to habitat by removing the dams.

Key near-term steps to reduce uncertainty:
- Further integrate the habitat strategy with hatchery and harvest management strategies in the planning area.

Does the habitat recovery strategy preserve options for recovery in all 4 VSP attributes through all of the H's? (Preserves Options)

No.

- Preserving options requires an adaptive management plan that more comprehensively addresses all habitat factors and associated protection and restoration actions for the watershed and that provides a means to respond to changes and uncertainty as they occur.
- Hypotheses beyond the scope of the restoration project and specific to VSP characteristics or ESU persistence will be needed in the long-term to complete the habitat recovery strategy and actions plan.

Key near-term steps to reduce uncertainty:
Further develop an adaptive management plan for a more comprehensive habitat recovery strategy explicitly relating the interactions among land use, habitat forming processes, habitat conditions and population VSP responses.

Key long-term steps to reduce uncertainty:
- Implement an adaptive management plan including more explicit detailed qualitative and quantitative interactions among a comprehensive list of land use, habitat forming processes, habitat conditions and population responses for specific protection and restoration action plans.

Are the recovery actions consistent with the recovery strategy? (Consistent with Strategy)
Yes.

Key near term steps to reduce uncertainty:
- More specific definitions of protection and restoration strategies are needed to better evaluate consistency; many of the actions listed could be applied as detailed strategy statements.

Key long-term action to reduce uncertainty
- Develop better empirical and analytical support for the above relationships between protection and restoration actions and hypotheses specific to VSP characteristics or ESU persistence.

How well have the recovery actions been shown to work? (Empirical Support)
Support for the proposed actions is moderate.

- As noted in the *Analytical Support* discussion, while there is some empirical support for sediment and flow process hypotheses for the Elwha Project, linkages to VSP characteristics and potential responses would strengthen the overall analytical support for that aspect of the recovery plan.
- For other protection and restoration actions in the watershed, general experience suggests that protection and restoration actions may work, although there are some conflicting results and uncertainty. Areas that are especially uncertain are 1) the effectiveness of shoreline regulatory protection programs, 2) validation that habitat actions to restore, rehabilitate, or enhance floodplain, estuary, and nearshore habitats to support chinook life stages.

Key near-term actions to reduce uncertainty:
- Use available data and document assumptions for floodplain, estuary, and nearshore habitat protection and restoration actions by type to strengthen the empirical support. Addressing the *Analytical Support* key near-term action item will address this action.

Key long-term actions to reduce uncertainty:
- Strengthen the empirical support for each type of protection and restoration action by testing for the effectiveness and by validation that the actions result in the predicted responses.

Hatchery Strategy

Key Issues to Improve Certainty
The most important way to improve the certainty of an effective hatchery strategy in this plan is to:
- Improve the adaptive management plan.

Based on our analysis, of the draft plans we examined, the Dungeness and Elwha River hatchery strategies had two of the highest likelihoods of being effective in contributing to recovery. In both watersheds, by improving adaptive management program, the likelihood of a "high" level of certainty for biological effectiveness for this strategy would nearly double

How well supported is the understanding of the links between hatchery actions and population viability (VSP) characteristics used in the planning (Analytical Support)?
The analytical support was moderate.
- The co-managers used a qualitative model (e.g. the Benefit-Risk Assessment Procedure cited in co-managers' resource management plan) to understand the potential affects of the current hatchery actions on populations. The model addressed all VSP criteria. Documentation is available for the basic model structure but not for how local watershed data (as opposed to general information from the scientific literature and expert guesses) were used to calibrate the assessment for the Elwha River populations. The TRT is unaware of a similar systematic analysis for the proposed actions to maintain populations, fisheries, and reintroduce salmon to the upper watershed after the dams are removed.

Key near term steps to reduce uncertainty:
- Develop and use models that will allow managers to understand how different factors affect the certainty of the results from hatchery management decisions (e.g. through a sensitivity analysis). This is especially important for the reintroduction programs and deciding the risks and benefits of different strategies (e.g. natural colonization, adult supplementation, juvenile supplementation) to accomplish it.

How well supported are the recovery hypotheses with watershed specific data? (Watershed Data Quality)
Support for the recovery hypotheses using watershed specific data for was moderate.

- This question asks if the watershed has data that has been used to independently support the results of the hypothesis generated by the qualitative analyses. The current recovery hypotheses for hatcheries in the Elwha River watershed is that hatcheries can provide a demographic buffer until habitat recovers and the salmon have access to habitat above the dams. The second recovery hypothesis is that hatcheries can be used to reintroduce viable populations of salmon to the upper watershed. Demographic data from historical operation of the hatchery indicate that the programs are capable of maintaining abundance. Hypotheses about the potential genetic and ecological affects on productivity, spatial structure, and diversity and the certainty of successful reintroduction are more inferential.

Key near term steps to reduce uncertainty:
- Use available data from other watersheds to increase the analytical support and to document the assumptions.

Is the recovery strategy consistent with the recovery hypotheses? (Consistent with Hypothesis)

Yes
- Overall, using the hatchery to maintain abundance and as a refuge while the dams are being removed to allow access is consistent with the recovery hypothesis. Likewise using hatcheries to buffer populations against catastrophic losses during the removal of the dams and to reintroduce salmon to new habitat are consistent with the recovery hypothesis. The TRT had a number of questions that planners should consider. First, in examining integration of the strategy across management sectors (habitat, harvest, and hatcheries), the TRT had questions about the potential impacts of potentially high harvest rates.

Key near term steps to reduce uncertainty:
- Although there will be no directed fisheries during the removal of the dams, planners should make more clear how non-directed fisheries and international fisheries were factored into the recovery strategy.
- It will be helpful to include a discussion on how the level of hatchery production and release strategies after the dams are removed are consistent with what is known about the capacity of the habitat.

Is the recovery strategy robust by preserving options for recovery? (Preserves Options)

- No.
- Many of the actions taken to implement the recovery strategy are clearly intended to preserve options. Preserving options also requires an adaptive management plan to respond to changes and uncertainty as they occur. Hatchery and genetic management plans (HGMPs) contain a brief description of current monitoring and evaluation, but we would assume that this would change and be expanded during the reintroduction program. There is little detail in the draft plan on this. Reintroducing viable populations in this river will be a major undertaking, with a great deal of uncertainty. This will require significant attention to monitoring and adaptive management to be able to make mid-course corrections in management actions. Although the TRT is aware that watershed planners and co-managers have given considerable thought to

many aspects of adaptive management, these are not well described in the recovery plan.

Key near term steps to reduce uncertainty:
- Further develop and implement an adaptive management program.

Are the recovery actions consistent with the recovery strategy? (Consistent with Strategy)

Yes.
- The recovery strategy is well supported by appropriate actions. The TRT was concerned about whether the overall hatchery strategy included enough redundant backups to catastrophic losses for all life history stages during the period the dams are being removed. For example, maintaining a small population in Morse Creek alone may be assuming an unnecessarily high exposure.

Key near term steps to reduce uncertainty:
- Describing how the mix of hatchery strategies will provide this redundancy is suggested.

How well have the recovery actions been shown to work? (Empirical Support)

- Empirical support for the proposed actions is moderate.
- Experience in other watersheds suggests that hatcheries might be used to maintain populations for time periods longer than should be necessary to remove the Elwha River dams and provide access to good habitat. Likewise, evidence exists that reintroductions into unoccupied, high quality habitat can successfully establish viable populations, although the results are mixed.

Harvest Strategy

NOTE: This evaluation is based on the Elwha Management Unit profile, pages 184-186 of the *Co-managers' Puget Sound Chinook Harvest Management Plan*, as well as material presented in the plan submitted by the Elwha watershed group.

The harvest management portion of the recovery plan states that current habitat cannot support current returns, returning adults are spawned in a hatchery, and that harvest should be kept low to maintain current return levels until habitat is restored.

Near term steps to reduce uncertainty include:

- Developing exploitation rate guidelines based on productivity and abundance estimates of the Elwha Chinook population.
- Broadening the hypothesis to include the effects of harvest on diversity and spatial distribution.
- Broadening the strategy to address diversity and spatial structure.
- Incorporating existing local data pertaining to spatial distribution and diversity to support the expanded hypothesis and the expanded strategy and actions based on it.

Did the analysis use one or multiple independent models to understand potential fish status and responses?

> One – qualitative. The determination of rebuilding exploitation rates not clear.

How well supported is the understanding of the links between harvest actions and population viability (VSP) characteristics used in the planning (Analytical Support)?

> Low
> - The model includes qualitative descriptions of the link between harvest management and abundance and productivity. The effects of harvest on diversity and spatial distribution are not addressed.
> - It is not apparent that quantitative estimates of a rebuilding exploitation rate for the Elwha Chinook population have been developed. No information was presented on the breakout of escapement into natural-origin and hatchery-origin components.

How well supported are the recovery hypotheses with watershed specific data? (Watershed Data Quality)

> Moderate
> - Escapements are estimated but the number of fish spawning naturallly that are hatchery versus natural-origin is not determined. An indicator stock is used to determine exploitation rates.

Is the recovery strategy consistent with the recovery hypotheses? (Consistent with Hypothesis)

> No
> - The strategy places a limit on the exploitation rate in Southern US fisheries but not on the total exploitation rate.
> - The strategy does not address the effect of harvest on the diversity and spatial structure VSP parameters.

Is the recovery strategy robust by preserving options for recovery? (Preserves Options)

> No
> - The harvest strategy does not include any consideration of how diversity and spatial distribution will be protected or enhanced.
> - An adaptive management plan for harvest management is not provided.

Are the recovery actions consistent with the recovery strategy? (Consistent with Strategy)

> Yes

How well have the recovery actions been shown to work? (Empirical Support)

> Moderate
> - The effects of the harvest plan on diversity and spatial structure have not been evaluated. Uncertainties in the effects of habitat and hatchery management have not been incorporated into the analysis used to derive the harvest management guideline.

- When rebuilding exploitation rates linked to the productivity of the Dungeness population are estimated, the maximum exploitation rates allowed under the Pacific Salmon Treaty may be found to be excessive.

II. REVIEW OF TECHNICAL CONTENT

Reviewer's Name: **Technical Reviewers**

Watershed Plan: **Elwha**

Populations or   **Elwha Chinook**
ESUs considered:

Summary

Overview of Shared Strategy questions and how well the watershed plans address the technical aspects of those questions. In particular, what is the watershed's technical basis to the answer to the questions from the Shared Strategy: (1) What are the major physical and biological changes necessary to meet the population planning targets? And (2) What are the expected changes in H's and fish population responses over the next 5-10 years?

Review of Plan—Overview

Overall summary of approach, scope of plan (geography, species, populations, ESUs, included), stated goals, participants in plan development, etc.

Format:	Two documents. Document 1 (Elwha Fish Restoration Plan or "Plan") will be incorporated into a supplemental EIS for dam removal; Document 2 (Elwha Watershed Salmon Recovery Planning Efforts or "Notebook") consists of responses to the Shared Strategy questions.
Scope:	Multi-species restoration plan for the Elwha River
Participants:	Clallam County, Elwha Klallam Tribe, Olympic National Park, WDFW, Point No Point Treaty Council, Jamestown S'Klallam Tribe
Goal:	The goal of the Elwha River Restoration and Fisheries Restoration Act is the" full restoration of the Elwha River ecosystem and native anadromous fisheries". A quantitative goal of 6,900 to 17,000 spawners, derived from spawners/mile in the Hoh River, is under consideration.
Summary of Approach:	The two documents are not integrated at this time. The Fish Restoration Plan focuses primarily upon the sequence, life stage, and numbers of anadromous fish to be reintroduced after removal of the dams with some discussion of habitat restoration needs. Additional habitat hypotheses are provided in the Elwha Watershed Salmon Recovery Planning Efforts document

Brief narrative of how well the plan addresses the following; including strengths and weaknesses:

1. **What biological and physical changes does the plan state are required for the population(s) in the watershed to achieve their targets?**
   For watersheds without targets, what biological and physical changes are needed for the habitat to be considered functioning for anadromous fish?

   The primary needs identified in the Notebook are: 1) restoration of access to the upper watershed; 2) protection of existing functional habitat in lower river; 3) floodplain restoration/constriction abatement and dike removal/modification; 4) estuarine and nearshore protection/restoration; 5) water conservation and instream flow protection, and 6) large woody debris placement.

2. **What biological goals does the plan aim to achieve (in 5-10 years and over longer term)**
   What are fish-based and habitat, hatchery or harvest management-based goals?

The goal of the Elwha River Restoration and Fisheries Restoration Act is the" full restoration of the Elwha River ecosystem and native anadromous fisheries". A quantitative goal of 6,900 to 17,000 spawners, derived from spawners/mile in the Hoh River and an undefined productivity parameter, is under consideration. The goal section mentions the other two VSP parameters—spatial structure and diversity—but does not mention what the goals are for these population attributes.

3. **What is the biological RATIONALE for identified actions in all of the H's (i.e., is the "hypothesis-strategy-action" logic presented in the watershed guidance document used?)**

(a) What is the population's current status for all 4 VSP (this should come out under the hypotheses)?

The average number of total spawners (hatchery plus natural) was 1,323 for the period 1988-2002. Productivity is unknown, but presumed near zero for Chinook salmon spawning in the river. A substantial reduction in spatial structure has resulted from blockage of 95% of the historic range. Diversity may also have been reduced because it appears there is now more uniformity in body sizes than historically. However, the bimodal run timing (spring and summer/fall) characteristic of the historical population existed at least through the early 1990's.

(b) What is the population's predicted status for all 4 VSP over the short- and long-term?

The goal and the predicted abundance are not derived independently. Rather, the goal is the predicted abundance resulting from the application of spawner per mile data from the Hoh River, an assumed productivity, and fishery exploitation rates of 0-78%. It would be good to compare these analyses with the Sanderson et al. potential capacities. Spatial structure and diversity are not addressed.

(c) What are critical threats affecting the populations? Have all been identified and considered in the stated hypotheses? Are there potential threats that are missing from the plan? Be explicit about each threat or potential factor limiting recovery.

The Notebook states potential threats in the H's as hypotheses, which is excellent. Treating information on threats as hypotheses improves both the plan's treatment of certainty in what is known and its vision for implementation (see TRT Watershed Guidance document). Phrasing H factors potentially limiting recovery as hypotheses acknowledges that such a judgment is based on best available (but imperfect) information, and also forces plan authors to treat H factors as potential effects on VSP that need to be monitored to that we can learn over time about the nature and magnitude of the actual effects.

There is an excellent statement in the Notebook of the hypothesized habitat problems and their links to VSP and actions (p. 7ff). The primary habitat impacts in the Basin are: significant reduction/cessation in gravel recruitment below the dams, loss of LWD recruitment below the dams, dike construction and meander truncations, and increased temperatures (p. 55 Plan). The primary needs are listed as: 1) restore access to the upper watershed, 2) protection of existing functional habitat in lower river, 3) floodplain restoration/constriction abatement (and dike removal/modification, etc. projects to address), 4) estuarine and nearshore protection/restoration, 5) water conservation and instream flow protection, and 6) LWD placement.

The rationale for the choice of the six habitat needs as being the critical ones is not well documented in either the Notebook or the Plan. To answer the question of what are critical 'threats', a discussion of both current habitat conditions and processes is needed, and then in turn, what land use or other actions affect the state of the instream conditions or processes (e.g., is sediment a critical problem? Temperature?) For example, what is the basis for the statement that turbidity will be back to "normal" by 2010, when the dams are completely removed? (p. 3 plan).

The Plan (p. 24) discusses the potential habitat problems during implementation of the restoration strategy: sediment transport, fish avoidance, and ecosystem nutrient levels.

The continued existence of the population is likely a result of implementation of the hatchery program. However, 70 plus years of artificial propagation with a limited influx of natural-origin broodstock may have resulted in domesticated broodstock. This critical threat was not discussed in sufficient detail. Other omissions are: 1) the potential effects of the proposed chum, steelhead, and coho programs on Chinook salmon; and 2) the increased risk of catastrophic loss of the hatchery program from sedimentation or flow just before and after the dam is removed.

The Notebook (p. 21) summarizes predictions of fishing mortality as computed by the Fishery Regulation Assessment Model (FRAM). Exploitation rates are predicted to have declined from an average of 76% in the period from 1983 through 1987 to 18% in 2001 through 2003. In 2003, fisheries in Washington and Oregon were predicted to have a 9.1% exploitation rate, with an additional 13% in fisheries in Canada and southeast Alaska. The plan states that the co-managers have "expressed strong reservations" about NMFS' no jeopardy decision for the 1999 annexes of the Pacific Salmon Treaty.

(d) Is the strategy for H management changes consistent with the identified hypotheses for current population status, desired future population status, and primary threats? What elements of the strategy are missing? Be explicit about each threat or potential factor limiting recovery.

This question is addressed in Section I.

(e) How are actions in the H's linked to fish population status? Both existing and future/planned H actions should be addressed. Are these links based on empirical or modeled estimates or both? Be explicit about each threat or potential factor limiting recovery.

This question is addressed in Section I.

(f) What are the plan's stated assumptions about existing habitat conditions or actions outside of the WRIA jurisdictional boundaries covered in the plan (freshwater and estuarine/nearshore)?

The plan and notebook do not describe assumptions for habitat conditions and actions outside of the WRIA.

(g) Are future options preserved in the proposed strategy-action links? How so? Be explicit about each threat or potential factor limiting recovery.

This question is addressed in Section I.

4. **What is the empirical or modeled SUPPORT for the answers to question #3? How well do the assessment data for the population status and the H's support the hypotheses proposed?**

   This question is addressed in Section I.

5. **How are the individual and interacting effects of the H's on the 4 VSP parameters considered for each population? How likely is it that the proposed suites of H actions will achieve the short- and longer-term stated goals? How certain are we in their translation into effects on salmon population VSP?**
   It is important to make note of the assumptions the plan makes about the effects of hatchery and harvest management, existing habitat actions, and survival in the nearshore/ocean.

   A narrative description of integration in the Notebook (p. 26) suggests that "providing access to the pristine habitat located within the Olympic National Park is the key to recovery of a productive, sustainable natural chinook population in the Elwha River." The Chinook hatchery program is a "stopgap" measure that, when linked with harvest control measures, has been successful in "rebuilding the run to maintenance levels." However, the interacting effects of the H's on VSP parameters do not appear to have been formally considered.

6. **How does the plan acknowledge uncertainties and how are they factored into decisions, future actions?**

The plan generally does not discuss uncertainty or how it was addressed in the development of recommended actions. Limited discussion of monitoring and adaptive management is provided. For example, the Notebook (p. 14) does indicate that the co-managers will "monitor, assess and adaptively manage program to meet hatchery objectives and standards and to evaluate the hatchery management hypotheses." The Plan states that "Monitoring the Fish Restoration Plan is the key ingredient to the planned adaptive management approach described in the Plan. Monitoring will provide managers with information needed to evaluate the success or failure of management actions – critical to maintaining a flexible approach to supplementation efforts and the long-term recovery of stocks." However, the monitoring plan is still under development. A clearer description of how uncertainties (in data, model, and analysis) affected decisions and where to prioritize effort is needed.

(a) Uncertainties in data and information?
(b) Uncertainties in environmental conditions in the future?

The Plan identifies and briefly discusses three factors that could affect the success of the restoration strategy: 1) the duration and intensity of sediment transport; 2) fish avoidance of a part of basin or the development of barriers that will limit access; and 3) the oligotrophic status of the river may limit production.

(c) Uncertainties in effectiveness of actions?

7. **Reviewer: What is the estimated overall level of risk for the population(s) included in this plan, relative to low-risk (i.e., viable) population criteria? What is your rationale for this risk estimate? How certain are you in the estimation for each VSP parameter?**

The certainty analysis presented in Section I addresses this question in part. However, additional technical and policy analyses will be required before the risk to the population can be fully assessed.

8. **Make any suggestions for approaches or methods for addressing concerns mentioned above or reducing gaps in the plan.**

This question is addressed in Section I.

Additional comments on the Notebook have been provided by George Pess, an adjunct reviewer.

1. Page 2 – Watershed and salmon recovery planning. Please give us the approximate numbers of juvenile chinook released rather than the number of pounds.
2. Page 4 – Table 1. It was very good to see the actual estimates of both naturally spawning chinook and chinook returning to the hatchery.
3. Page 4 – Abundance. What is the estimate (range) of hatchery chinook naturally spawning?
4. Page 4 – abundance. Changing the hatchery practice to taking fish earlier to reduce pre-spawning mortality is an excellent example of adaptive management.
5. Page 5 – Productivity. Major assumption – most chinook are of hatchery origin. This needs to be verified with an otolith study or something similar.
6. Page 5 – spatial structure. The Hunt's road channel is no longer a side-channel but conveys the majority of flow in the mainstem.
7. Page 6 – Diversity. Temperature data also identifies that the habitat potential for early-run Chinook to utilize the middle (between the two dams) and Upper (above the two dams) is there. See graph below.
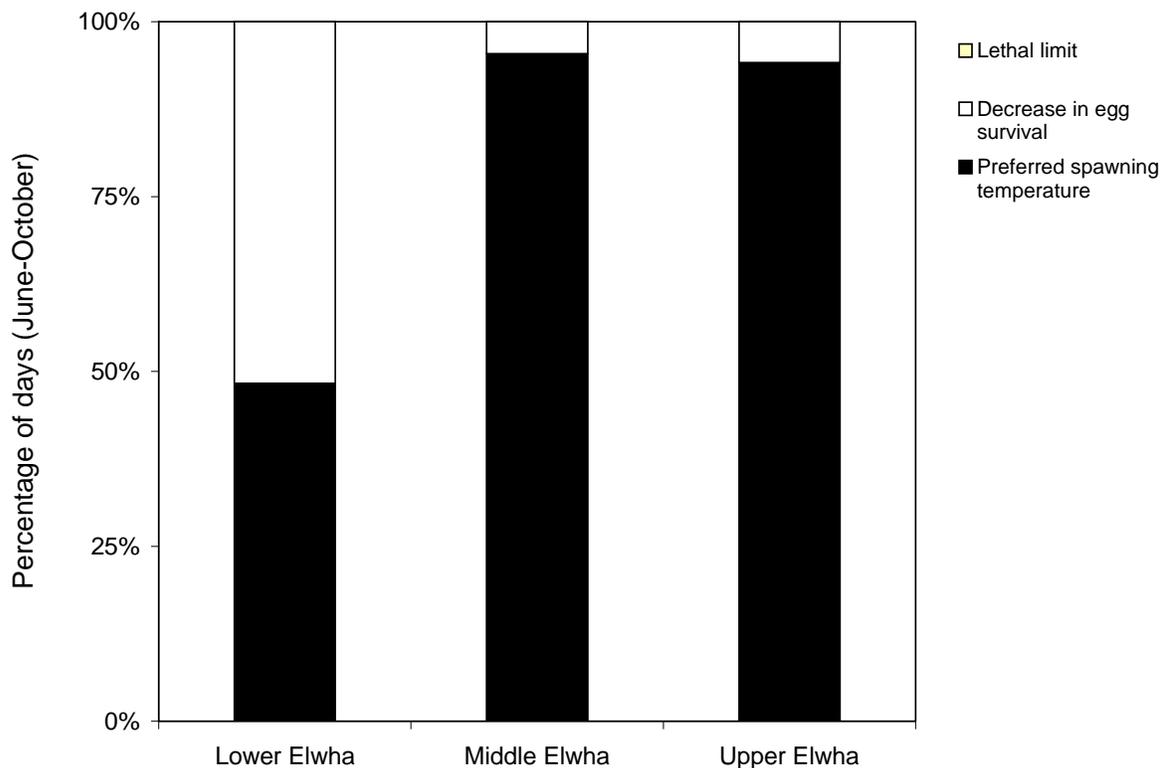
Page 7 – habitat. The loss of spawning habitat has been quantified. Below is a graph that shows how much has been lost below the dams:
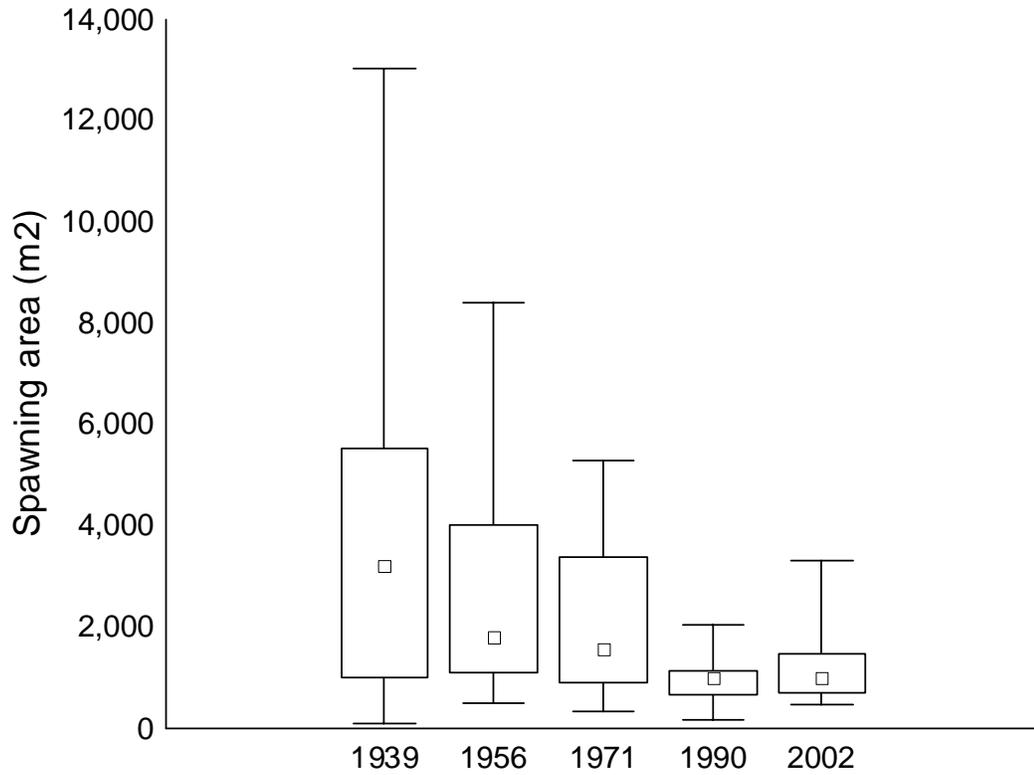
# III. ANALYZING CERTAINTY OF BIOLOGICALLY EFFECTIVE RECOVERY PLANS

All watersheds in the Puget Sound are unique. Not surprisingly, different watershed planning groups identify different long-term and short-term goals and propose different suits of actions to achieve those goals. The certainty that the actions in every watershed will be biologically effective in moving the populations towards recovery is a key factor in the recovery of the whole evolutionarily significant unit (ESU). Consequently, the Puget Sound Technical Recovery Team (TRT) has focused its analysis of watershed recovery plans on identifying ways to increase the certainty of the plans. The TRT hopes that these analyses will encourage watershed groups to improve the certainty of plans before the TRT does it analysis of the final plans next year.

To provide these analyses, the TRT used a probabilistic network (PN). A probabilistic network is a graphical model that shows how different states of the world of interest—in this case the scientific factors that provide certainty of biologically effective actions—are related (Figure 1). The basic approach is to assess certainty by applying conditional probabilities, which can be expressed as "Given event *b*, the likelihood of event *a* is *x*." In Figure 1, for example, the states of the variables in boxes that point to another variable (e.g. "Use of Independent Models" and "Analytical Support") are the events that condition the likelihood of the states for the latter variable (e.g. "High", "Moderate", and "Low" in the Certainty of the General Fish Response Model). Users provide evidence for the initial conditioning events (or diagnostic nodes); software for PNs use a set of sophisticated algorithms for recalculating the joint probability distributions for all the potentials based on tables of conditional probabilities provided by the analyst (Jensen 2001). Using a PN gave the TRT a rigorous, transparent, repeatable method of analyzing certainty across watershed plans and habitat, harvest, and hatchery management sectors.

Methods

The Puget Sound Technical Recovery Team (TRT) used the PN in Figure 1 to assess separately the certainty of biologically effective actions for each plan in four management sectors, 1) freshwater habitat, 2) nearshore habitat, 3) hatchery production, and 4) harvest. Each assessment also considered how well integrated actions were across categories and how the actions affected characteristics of viable salmonid populations (McElhany et al. 2003). The network graphically shows the logic of how different scientific variables affect the biological certainty of effective recovery plans. The model is based on the TRT's *Integrated Recovery Planning for Listed Salmonids: Technical Guidance for Watershed Groups in the Puget Sound* (http://www.sharedsalmonstrategy.org/files). The network shows that the overall biological certainty of an effective recovery plan depends on the certainty of the recovery strategy (Recovery Strategy), the robustness of the strategy (Preserves Options), and the expected effectiveness of actions chosen to implement the strategy. The certainty of the recovery strategy in turn is conditioned by the certainty of how well we understand the biological, physical, and chemical processes that affect the population (i.e. Recovery Hypothesis), which depends on well recognized sources of scientific uncertainty (Lemons 1996), such as model uncertainty (Use of Independent Models), framing uncertainty and stochasticity (Analytical Support), and empirical support for the hypothesis (Watershed Data Quality). After identifying the model structure, the TRT identified and defined different states of the variables (Tables 1-6).

Conditional probabilities may be derived from frequencies from empirical data, simulation results, or subjective probabilities. When data are too few to parameterize simulation models, use of subjective probabilities is important (Bedford and Cooke 2001) and analysts have developed methods for estimating these (e.g. Ayyub 2001). Using experts to estimate subjective probabilities has inherent biases that can be difficult to control (Kahneman et al. 1982, Otway and von Winterfeldt 1992). Using estimates of conditional probabilities within a logical, transparent model such as a PN may reduce these problems compared to asking experts to provide absolute certainty estimates directly without a model. The TRT estimated conditional probabilities using a Delphi process (Helmer 1968, Ayyub 2001) in which TRT members iteratively estimated conditional probabilities individually; the distributions of the results were compiled and shared; and new estimates were generated. Sensitivity of the model was evaluated using the mutual information index (Pearl 1988) which measures the reduction in entropy of variable *A* due to a finding at *B*.
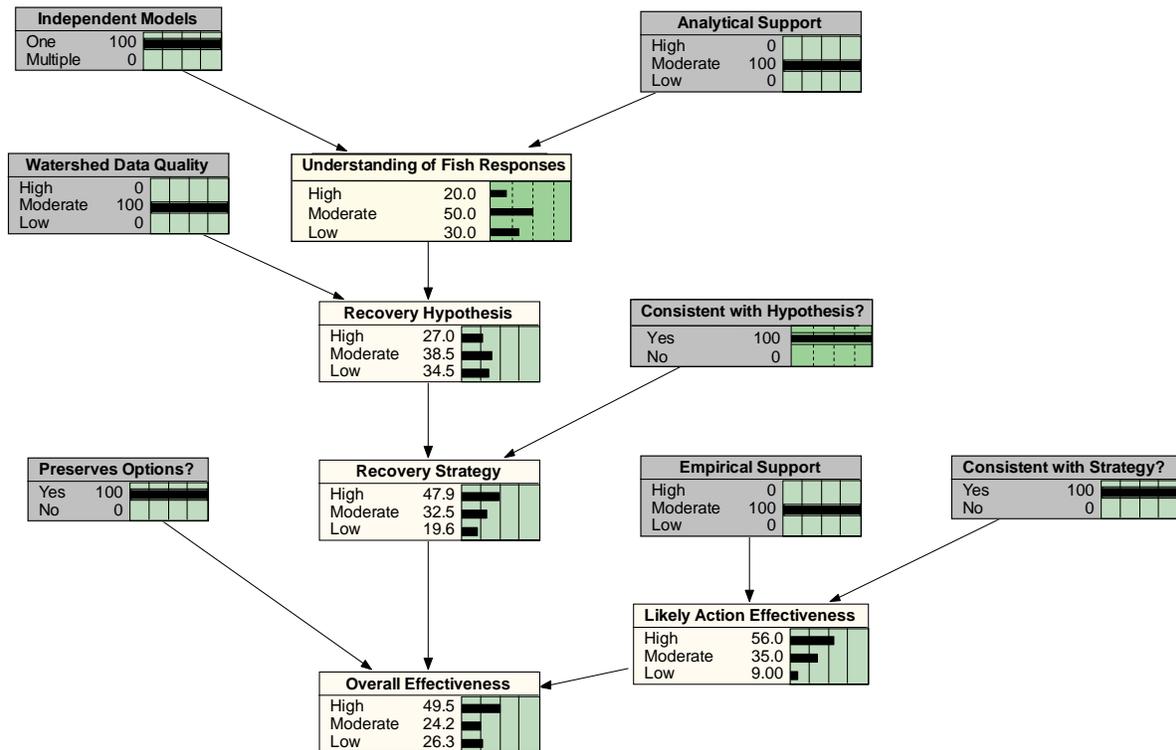
Figure 1. Probabilistic network for evaluating the biological certainty of effective recovery plans illustrating the results of a hypothetical review. Diagnostic nodes are shaded. Numbers at each node are the probabilities for each and the bars show the distribution of the results.

The TRT qualitatively assessed the states of seven diagnostic variables (box titles in parentheses) that address these questions:

1. Did the analysis use one or multiple independent models to understand potential fish responses to actions? (Independent Models)
2. How well supported is the model? (Analytical Support)
3. How well supported is the recovery hypotheses with watershed specific data? (Watershed Data Quality)
4. Is the recovery strategy robust by preserving options for recovery? (Preserves Options)
5. Is the recovery strategy consistent with the recovery hypothesis? (Consistent with Hypothesis)
6. Are the recovery actions consistent with the recovery strategy? (Consistent with Strategy)
7. How well have the recovery actions been shown to work? (Empirical Support)

The possible answers to these questions are in Tables 1-6. Reviewers usually choose one state, but if this is not possible because of uncertainty, reviewers could assign probabilities to different states (e.g., "Low" = 10%; "Moderate" = 90%). Analyses were performed using Netica (Norsys Software Corporation, Vancouver, BC; http://www.norsys.com).

Interpreting the Results

Even the best recovery plan is inherently uncertain because the future is so difficult to predict. Consequently, the quantitative estimates of certainty generated by the TRT are less important than the relative improvement that watershed planners need to make. For similar reasons, the quantitative estimates of certainty generated by the TRT are not relevant to analyses of certainty performed by regulatory agencies, which depend on a different interpretation and standard of certainty. Based on the TRT analyses, watershed planners may be able to increase the certainty of biological effectives several fold by focusing on several key factors. These are described in individual watershed analyses.

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Table 1. Attributes for different states of analytical support for models.

Analysis	Total Score	Attributes (Maximum Possible Score)
Habitat Models High Moderate Low	0.60 -1.00 0.21 - 0.60 0 - 0.20	• Qualitative and/or quantitative description of the relationship landscape processes, land use, and habitat condition – (0.1 for each analysis) • Qualitative and/or quantitative description of the relationship between habitat condition and population viability (VSP) characteristics – (0.1 for each analysis; 025 for each VSP characteristic) • Model structures and parameters for each VSP characteristic documented; assumptions discussed and defended – (0.2) • Sensitivity of model to changes in parameters known – (0.2) • Model tested empirically and calibrated to watershed – (0.2)
Harvest Models High Moderate Low	0.60 -1.00 0.21 - 0.60 0 - 0.20	• Qualitative and/or quantitative description of link between demographic processes, harvest effects, and population viability (VSP) characteristics– (0.2 for each analysis; 0.05 for each VSP characteristic) • Model structures and parameters for each VSP characteristic documented; assumptions discussed and defended – (0.2) • Sensitivity of model to changes in parameters known – (0.2) • Model tested empirically and calibrated to watershed – (0.2)
Hatchery Models High Moderate Low	0.60 -1.00 0.21 - 0.60 0 - 0.20	• Qualitative and/or quantitative description of link genetic and ecological processes, hatchery effects, and population viability (VSP) characteristics – (0.2 for each analysis; 0.05 for each VSP characteristic) • Model structures and parameters for each VSP characteristic documented; assumptions discussed and defended – (0.2) • Sensitivity of model to changes in parameters known – (0.2) • Model tested empirically and calibrated to watershed – (0.2)

Table 2. Attributes for different states of the quality of watershed data (support for hypotheses)

States	Attributes
High	• Used empirical population, habitat, and management data from the local watershed at multiple spatial scales to support hypotheses; sources clearly documented; assumptions explained
Moderate	• Used empirical population, habitat, and management data for watersheds or populations within the species' range OR used local watershed data but data highly uncertain or assumptions not well explained
Low	• Used theoretical support for hypothesis or expert opinion based on biological principles and local knowledge of the watershed

Table 3. Attributes for different states of consistency of recovery strategy with recovery hypothesis.

States	Attributes
Yes	Clear and logical relationship between the recovery hypothesis based on processes and conditions for habitat, harvest, and hatcheries and the recovery strategy as evidenced by • Main elements of strategy organized around dominant recovery hypotheses • Elements of strategy reflect spatial attributes of recovery hypotheses • Elements of strategy reflect temporal attributes and action sequencing of recovery hypotheses
No	No clear and logical relationship between recovery hypotheses and strategy; one or more of attributes listed above missing

Table 4. Attributes for different states of preservation of options in the recovery strategy

States	Attributes
Yes	• Strategy protects existing population viability (VSP) structure and opportunities for future improvement in habitat, harvest, and hatchery conditions; adaptive management & monitoring program maintains options for implementing strategy
No	• Strategy does not protect existing VSP structure or opportunities for future improvement in habitat, harvest, and hatchery conditions; adaptive management & monitoring program does not maintain options for implementing strategy

Table 5. Attributes for states of consistency of actions with recovery strategy.

States	Attributes
Yes	• Clear and logical relationship between the short-term and long-term actions and recovery strategy recovery hypothesis • Elements of strategy reflect spatial attributes of recovery hypotheses • Elements of strategy reflect temporal attributes and action sequencing of recovery hypotheses • No strong relationship between fish response models and recovery hypothesis
No	• Actions generally consistent with recovery strategy but major actions are missing or staging of major is inconsistent with recovery hypothesis • Little relationship between actions and strategy; major short-term and long-term actions do not follow from the recovery hypothesis and strategy

Table 6. Attributes of empirical support of recovery actions.

States	Attributes
High	• Evidence for effects of suites of actions (in habitat, harvest, or hatcheries) is clear and unambiguous; broad applications have been tested with similar results; uncertainty incorporated in assessments
Moderate	• Some empirical evidence of effectiveness in similar settings; few tested applications; some conflicting results; predictions of effect do not incorporate uncertainty
Low	• Little or no empirical evidence of the action being effective or appropriate